Southeast Data, Assessment, and Review

SEDAR 50

Stock Assessment Report

Atlantic Blueline Tilefish

October 11, 2017

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

(Note: Original Stock Assessment Report released Oct 10; minor corrections made to Section VI. Addendum)

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Southeast Data, Assessment, and Review

SEDAR 50

Atlantic Blueline Tilefish

SECTION I: Introduction

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Executive Summary

SEDAR 50 addressed the stock assessment for Atlantic Blueline Tilefish. The assessments consisted of four in-person workshops, as well as a series of webinars. A Stock ID Workshop was held June 28-30, 2016 in Raleigh, NC. The Data Workshop was held January 23-27, 2017 in Charleston, SC. The SEDAR 50 Assessment Process was conducted through a combination of an in-person workshop, held May 23-26, 2017 in Atlantic Beach, NC, and a series of webinars held from March to July 2017. The Review Workshop (RW) took place August 29-31, 2017 in Atlantic Beach, NC.

The Stock Assessment Report is organized into six sections. Section I is the Introduction which contains a brief description of the SEDAR Process, Assessment, and Management Histories for the species of interest, and the management specifications requested by the Cooperator. Section II is the Data Workshop Report. It documents the discussions and data recommendations from the Data Workshop Panel. Section III is the Assessment Report. This section details the assessment model, as well as documents any changes to the data recommendations that may have occurred after the Data Workshop. Consolidated Research Recommendations from all three stages of the process (data, assessment, and review) can be found in Section IV for easy reference. Section V documents the discussions and findings of the Review Workshop. Finally, Section VI is the Addenda and Post-Review Workshop Documentation which consists of any analyses conducted during or after the RW to address reviewer concerns or requests. It may also contain documentation of the final RW-recommended base model, should it differ from the model put forward in the Assessment Report for review.

The final Stock Assessment Report (SAR) for Atlantic Blueline Tilefish was disseminated to the public in October 2017. The South Atlantic and Mid-Atlantic Councils' Scientific and Statistical Committees (SSC) will review the SAR for their stocks. (The jurisdictional line between the SAFMC and MAFMC for Blueline Tilefish is the NC/VA state line.) The SSCs are tasked with recommending whether assessments represent Best Available Science, whether the results presented in the SAR are useful for providing management advice, and developing fishing level recommendations for the Councils. The SSCs may request additional analyses be conducted or may use the information provided in the SAR as the basis for their fishing level recommendations (e.g. Overfishing Limit and Acceptable Biological Catch). The South Atlantic Fishery Management Council's SSC will review the assessment at its October 2017 meeting, followed by the Council receiving that information at its December 2017 meeting. The MAFMC plans to request their SSC provide an ABC recommendation for Blueline Tilefish within their jurisdiction in early 2018. Additionally, MAFMC SSC members and staff will attend the October 2017 SAFMC SSC meeting to begin a dialogue between the two Councils to help ensure the management approaches taken between the two regions are compatible. Documentation on SSC recommendations is not part of the SEDAR process and is handled through each Council.

During the August 2017 Review Workshop (RW), stock assessment scientists from NOAA's Beaufort lab provided different assessment models and results for the areas south of Cape Hatteras (SOH) and north of Cape Hatteras (NOH). The reviewers found that the decisions made by the Data Workshop and Assessment Workshop were generally sound and robust. The RW suggested one significant change to the SOH model, as explained below. The RW did not suggest any significant changes in the NOH model.

The preferred approach of the assessment team for the SOH stock was to use an age-aggregated surplus production model (also known as a Biomass Dynamic Model (BDM)) which was implemented in ASPIC (Prager 1994). A supporting analysis was provided using what the assessment team described as an age-structured production model (ASPM). In contrast, the RW preferred the ASPM over the ASPIC because it has more appropriate population dynamics and it allowed the consequences of uncertainties in the life history parameters to be explored through alternative sensitivity analysis, and hence considered the ASPM the superior base model. The results of the SOH assessment models provide robust evidence that the stock south of Cape Hatteras is not overfished and overfishing is not occurring.

For the stock NOH, only a catch history and some length frequencies were available. Because of this limitation, the R package DLMtool was used to provide TAC range estimates. The DLM analysis of the NOH stock does not provide information about whether the stock is overfished. The medians of the frequency distributions for the three methods that provide catch recommendations based on MSY approximations (Fdem_ML, SPMSY, and YPR_ML) range from 110,000 lbs to 310,000 lbs. In comparison, the average catch for the time period 2006-2015 had a median of 474,000 lbs. Given the high uncertainty in these results, the RW concluded that these results are best interpreted qualitatively, but did agree with the assessment team that the results provide evidence that the recent landings may not be sustainable in the long term. The RW also concluded that the information on potential habitat in the NOH area is insufficient to split the stocks in that area into sustainable landing recommendations along the MAFMC/SAFMC jurisdictional boundary.

During the assessment process several data and modeling topics received a lot of discussion. Some of these topics included:

- *Stock Identification*: Stock structure of Blueline Tilefish was explored during a Stock ID Workshop held in June 2016. Recommendations from this workshop included recommending Blueline Tilefish from the Gulf of Mexico and along the entire US seaboard be considered a single biological population unit. These recommendations were subsequently reviewed by a SSC sub-panel with representatives from the MAFMC, SAFMC, and GMFMC in October 2016 and by a Science and Management Leadership Group in November 2017. The Science and Management Leadership Group accepted the findings of the SSC sub-panel but recommended using the boundary between the

GMFMC and SAFMC as the southwest boundary for the SEDAR 50 assessment unit stock. To help characterize uncertainty in the assessment, exploratory models were developed using Gulf of Mexico data.

- *Age Data*: Following exchanges of reference collections among the three laboratories actively ageing Blueline Tilefish, consistency in age readings was not achieved. An Age Workshop was held in August 2016 to try and resolve these issues. In preparation for the age workshop, a bomb radio carbon study was undertaken to try and validate the opaque zone counts as true ages. Preliminary results from the bomb radio carbon study were considered inconclusive by the Age Workshop participants. The Age Workshop found that age determinations were currently not reliable and recommended not using ages in the SEDAR 50 assessment.
- *Uncertainty in Life History Parameters*:
    - *Growth*: Since age data were not available for the assessment, the DW Panel estimated the growth curve from a meta-analysis. In the ASPM model, the RW Panel suggested estimating the growth parameters in the model which provided estimates consistent with the meta-analysis.
    - *Natural Mortality*: After lengthy discussions by the DW and AW Panels, natural mortality was estimated using an assumed maximum age of 40 years (based in part on the observed max age for Golden Tilefish in the South Atlantic).
    - *Maturity*: Age at 50% maturity was estimated from empirical data, but there were very few immature fish captured making the estimate highly uncertain.
    - Uncertainty in the life history parameters were explored in the South of Hatteras ASPM model through sensitivity analyses.
- *Indices*: Three fishery dependent indices (headboat, commercial handline, and commercial longline) were recommended for potential use in the assessment by the DW Panel. No indices were available past the mid-late 2000's (exact year dependent on index and region) due to regulatory changes and/or changes in targeting and no indices were available for the area north of Cape Hatteras. The South of Hatteras ASPIC model includes the commercial longline and handline indices. The South of Hatteras ASPM model includes all three indices. The effects of including/excluding the available indices are explored through sensitivity runs in the ASPIC and ASPM models.
- *Spatial Mismatch between Indices and Recent Removals:* No indices were available for the area north of Cape Hatteras and in recent years there were large increases in removals from this area. This spatial mismatch led the AW Panel to develop separate models for the areas south of Cape Hatteras and north of Cape Hatteras.
- *Commercial Landings Spike in 1980's*: A spike in commercial landings was seen in the South of Hatteras region in the early 1980's. During this time, most tilefish commercial landings were reported as unclassified (e.g. not broken down by species). The DW Panel developed a method to estimate the Blueline Tilefish landings from the overall unclassified tilefish landings and noted there was larger uncertainty for estimates during these years. Industry representatives stated that many of these landings were likely Golden Tilefish. The RW Panel expressed concern over this large spike in landings and sensitivity analyses were conducted to help explore this uncertainty.

- *South of Cape Hatteras ASPIC – Averaging Run Results*: The AW Panel felt the commercial handline and commercial longline indices were equally plausible. When both indices were fitted within the ASPIC model, the commercial handline index dominated likely due in part to its smaller CV's. This led the AW Panel to recommend fitting each index separately and then averaging the results from these two runs. The RW Panel preferred a single ASPIC model including both the commercial handline and longline indices with all annual CV's set to a constant CV. The constant CV was preferred to the former approach because it incorporates a form of process error and it avoids weighting either index more heavily based on lower CV's. The RW Panel noted if two separate runs are not inconsistent (as in this case), a single run with all of the data is preferred.
- *South of Cape Hatteras – ASPIC vs ASPM models*: The analytical team presented two models for the South of Hatteras region: a surplus production model (ASPIC) and an age-structured production model (ASPM). The AW Panel recommended using the ASPIC model as the base run with the ASPM used as a supplementary model due in large part to the highly uncertain life history data. The RW Panel favored use of the ASPM model since it allowed the sensitivity of results to life history parameters and the robustness of conclusions to be more fully explored and allowed for use of the available length frequency data.

I. Introduction

1. SEDAR Process Description

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

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

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

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

SEDAR Review Workshop Panels consist of a chair, three reviewers appointed by the Center for Independent Experts (CIE), and one or more SSC representatives appointed by each council having jurisdiction over the stocks assessed. The Review Workshop Chair is appointed by the council having jurisdiction over the stocks assessed and is a member of that council's SSC. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers.

2. Management Overview

2.1 Mid-Atlantic

2.1.1 Fishery Management Plan and Amendments

MAMFC Golden Tilefish FMP History (Current Amendment will add bluelines – these actions may have had some indirect impact on blueline tilefish since the directed golden tilefish fishery does catch some blueline tilefish)

Original Tilefish FMP (2001)
Established management of the Golden Tilefish fishery; Limited entry into the commercial fishery; Implemented system for dividing Total allowable landings (TAL) among three fishing categories

Amendment 2 (2007)
Standardized bycatch reporting methodology

Amendment 1 (2009)
Implemented an individual fishing quota (IFQ) program for the commercial fishery;
Established new reporting requirements; Imposed gear modifications;
Addressed recreational fishing issues; Reviewed the EFH components of the FMP.

Amendment 3 (2011)
Established Annual Catch Limits (ACLs) and Accountability Measures (AMs)

Amendment 4 (2015)
New Standardized Bycatch Reporting Methodology

MAFMC Blueline Tilefish Amendment (Action: April-June 2016, effective late 2016)

Note: The Council has scheduled time at its June 2016 meeting to potentially revisit the recreational blueline tilefish specifications (bag limits/seasons).

If approved by the Secretary of Commerce, the amendment would establish a separate blueline tilefish management unit in Federal waters north of the North Carolina/Virginia border extending up to the boundary with Canada. The management objectives for blueline tilefish would be the same as for golden tilefish, with the addition that "management will reflect blueline tilefish's susceptibility of overfishing and the need for an analytical stock assessment."

Based on the recommendation of its Scientific and Statistical Committee (SSC), the Council adopted an Acceptable Biological Catch (ABC) of 87,031 pounds for 2017. The Council voted to allocate 73% of total allowable landings to the recreational fishery and 27% to the commercial sector. This allocation was based on the median of annual commercial-recreational catch ratios from 2009-2013.

For the commercial fishery, the Council adopted a trip limit of 300 pounds gutted weight (head and fins must be attached). In addition, the amendment would require a joint golden/blueline tilefish open access commercial permit to retain blueline tilefish, subject to the applicable trip limit. Standard reporting of catch would be required for commercial vessels and dealers landing blueline tilefish.

For the recreational fishery, the Council recommended an open season from May 1 to October 31. Recreational bag limits would be set at 7 fish per person for inspected for-hire vessels, 5 fish per person for uninspected for-hire vessels, and 3 fish per person for private vessels (Again, this may be re-visited in June 2016). In addition, the Council recommended mandatory permitting and reporting of golden and blueline tilefish for both for-hire and private recreational fishing in order to develop better information on recreational tilefish landings in the Mid-Atlantic.

2.1.2 Emergency and Interim Rules (if any)

Emergency Action effective June 4, 2015-June 3, 2016

http://www.greateratlantic.fisheries.noaa.gov/nr/2015/June/14tileblemergencyactionphl.pdf

Recreational:

-Must hold a valid Greater Atlantic Region open access tilefish charter/party vessel permit to possess or land blueline tilefish, and must follow all recordkeeping and reporting requirements.

-The recreational possession limit for charter/party and private recreational anglers is seven blueline tilefish per person, per trip.

Commercial

-Must hold a valid Greater Atlantic Region open access commercial tilefish vessel permit to possess or land blueline tilefish, and must follow all recordkeeping and reporting requirements.

-The commercial blueline tilefish possession limit is 300 lb whole weight per trip.

2.1.3 Secretarial Amendments (if any)

None

2.1.4 Control Date Notices (if any)

On December 14, 2015, NMFS published a control date for the commercial and party/charter sectors of the blueline tilefish fishery north of the Virginia/North Carolina border: http://www.greateratlantic.fisheries.noaa.gov/nr/2015/December/15bltilefishcontroldatephl.pdf.

2.1.5 General Management Specifications

Table 2.1.5.1 General Management Information
Mid-Atlantic

Species	Blueline Tilefish
Management Unit	Mid-Atlantic/Northeast US
Management Unit Definition	NC/VA border northward to the Canadian boundary
Management Entity	Mid-Atlantic Fishery Management Council
Management Contacts Council/GARFO/NEFSC	MAFMC: Jason Didden GARFO: Doug Potts NEFSC: Paul Nitschke
Current stock exploitation status	?
Current stock biomass status	?

Table 2.1.5.2 Management Parameters

Criteria	Mid-Atlantic SSC		
	Definition	Value	
Acceptable Biological Catch (ABC)	SSC Determination, based on Data Limited Toolbox (DLMTool) for MSE (https://cran.r-project.org/web/packages/DLMtool/DLMtool.pdf)	87,031 pounds for 2017	

Table 2.1.5.3. Stock Rebuilding Information

n/a

Quota Calculation Details

Final Blueline Tilefish Subcommittee Report **-** At its meeting on March 16th, 2016 the SSC reviewed a preliminary draft from a Working Group report and agreed that use of the DLMTool is the most appropriate approach for developing an ABC recommendation for Blueline Tilefish. The SSC also emphasized that the ABC would be for a sub-unit of Blueline Tilefish located in the mid-Atlantic region, and would not be applicable to the entire coast. Based on performance measures determined before simulations were conducted (i.e., a P(overfishing) < 50%, P(overfished) < 50%, and relative yields between 30 – 100%), the SSC Blueline Tilefish Working Group recommended an ABC calculated as the average of the median ABCs derived from the average catch, average catch in the last five years, MCD, and MCD 4010 management procedures as 39,477 kg (87,031 lbs).

2.1.6 State Regulatory History

Virginia– Effective 2007: Commercial: 300 pounds combined tilefish; Recreational: 7 combined tilefish.

Blueline tilefish management history in Virginia's state waters

Table 1: Recreational regulation history for tilefish in Virginia. All regulations refer to the aggregated "tilefish" complex, as defined in Virginia's tilefish-grouper regulation Chapter 4 VAC 20-1120-10 et seq., "Pertaining to Tilefish and Grouper," to be blueline tilefish, golden tilefish, or sand tilefish (unless otherwise noted).

Measure	Year
Establishment of possession limit of 7 per person	2007
Establishment of recreational landing permit and mandatory reporting	2009
Reduce number of requirements for recreational mandatory reporting	2016

Table 2: Commercial regulation history for tilefish in Virginia. All regulations refer to the aggregated "tilefish" complex, as defined in Virginia's tilefish-grouper regulation Chapter 4 VAC 20-1120-10 et seq., "Pertaining to Tilefish and Grouper," to be blueline tilefish, golden tilefish, or sand tilefish (unless otherwise noted).

Measure	Year
Establishment of daily trip limit of 300 pounds	2007
Change daily trip limit to 500 pounds	2012
Establishment of daily trip limit for blueline tilefish of 200 pounds	2012
Change daily trip limit to 500 pounds whole weight or 455 pounds gutted weight	2012
Change daily trip limit for blueline tilefish to 300 pounds whole weight or 273 pounds gutted weight	2012

Maryland – Effective June 28, 2010: Commercial: 300 pounds combined tilefish; Recreational: 7 combined tilefish. The limits for tilefish remained unchanged until March 30, 2015, when the commercial limit for tilefish was changed to 455 pounds gutted weight, which may not include more than 273 pounds of blueline tilefish.

New Jersey – Effective September 8, 2015: Mirrored Federal emergency rule (300 pounds commercial blueline, 7 blueline per person recreational).

Delaware – Effective January 11, 2016: Blueline and golden tilefish in combination carry a recreational limit of seven fish per person per day aboard a vessel, with a commercial harvest combination limit of 300 pounds of tilefish per day (similar to VA).

New York – Regulations likely pending

2.2 South Atlantic

2.2.1 Fishery Management Plan and Amendments

The following summary describes only those management actions that likely affect blueline tilefish fisheries and harvest.

Original SAMFC FMP

The Fishery Management Plan (FMP), Regulatory Impact Review, and Final Environmental Impact Statement for the Snapper Grouper Fishery of the South Atlantic Region, approved in 1983 and implemented in August of 1983, establishes a management regime for the fishery for snappers, groupers and related demersal species of the Continental Shelf of the southeastern United States in the exclusive economic zone (EEZ) under the area of authority of the South Atlantic Fishery Management Council (Council) and the territorial seas of the states, extending from the North Carolina/Virginia border through the Atlantic side of the Florida Keys to 83^{o} W longitude. Regulations apply only to federal waters.

SAFMC FMP Amendments affecting blueline tilefish

Description of Action	FMP/Amendment	Effective Date
-Gear limitations – poisons, explosives, fish traps, trawls -Designated modified habitats or artificial reefs as Special Management Zones (SMZs)	FMP (1983)	08/31/83
-Prohibited trawl gear to harvest fish south of Cape Hatteras, NC and north of Cape Canaveral, FL. -Directed fishery defined as vessel with trawl gear and ≥200 lbs s-g on board. -Established rebuttable assumption that vessel with s-g on board had harvested such fish in EEZ.	Amendment #1 (1988a)	01/12/89

-Required catch and effort reports from selected, permitted vessels; -Required that fish in the snapper grouper fishery be made available, upon request, to an authorized officer; -Required permitted vessels to display their official numbers; -Made vessel operators responsible for ensuring that no fish from the snapper grouper fishery below the minimum size limit or without their heads and fins attached are possessed aboard the vessel	Amendment #3 (1990b)	01/31/91
-Prohibited gear: fish traps except black sea bass traps north of Cape Canaveral, FL; entanglement nets; longline gear inside 50 fathoms; bottom longlines to harvest wreckfish; powerheads and bangsticks in designated SMZs off S. Carolina. -Required permits (commercial & for-hire) and specified data collection regulations -Established an assessment group and annual adjustment procedure (framework) -No retention of snapper grouper spp. caught in other fisheries with gear prohibited in snapper grouper fishery if captured snapper grouper had no bag limit or harvest was prohibited. If had a bag limit, could retain only the bag limit. -charter/headboats and excursion boat possession limits extended	Amendment #4 (1991)	01/01/92
-Set up separate commercial Total Allowable Catch (TAC) levels for golden tilefish and snowy grouper	Amendment #6 (1993)	07/27/94

-Established commercial trip limits for snowy grouper, golden tilefish, speckled hind, and warsaw grouper -Included golden tilefish in grouper recreational aggregate bag limits -Prohibited sale of warsaw grouper and speckled hind -100% logbook coverage upon renewal of permit -Created of the *Oculina* Experimental Closed Area -Specified data collection needs for evaluation of possible future IFQ system		
-Required dealer, charter and headboat federal permits -Allowed sale under specified conditions -Specified allowable gear and made allowance for experimental gear -Allowed multi-gear trips in N. Carolina -Added localized overfishing to list of problems and objectives -Adjusted bag limit and crew specs. for charter and head boats -Modified framework procedure	Amendment #7 (1994a)	01/23/95
-Established program to limit initial eligibility for snapper grouper fishery: Must demonstrate landings of any species in SG FMU in 1993, 1994, 1995 or 1996; and have held valid SG permit between 02/11/96 and 02/11/97. -Granted transferable permit with unlimited landings if vessel landed ≥ 1,000 lbs. of snapper grouper spp. in any of the years -Granted non-transferable permit with 225 lb. trip limit to all other vessels	Amendment #8 (1997a)	12/14/98

-Modified problems, objectives, OY, and overfishing definitions -Expanded Council's habitat responsibility -Allowed retention of snapper grouper spp. in excess of the bag limit on permitted vessels fishing in the EEZ off North Carolina with a sink net -Allowed retention of snapper grouper spp. in excess of bag limit on permitted vessel fishing in the South Atlantic EEZ with a single bait net or cast net on board -Allowed permitted vessels to possess filleted fish harvested in the Bahamas under certain conditions.		
-Specified 5-fish aggregate grouper bag limit, which includes tilefish species, including blueline tilefish. -Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	Amendment #9 (1998b)	2/24/99
-Identified EFH and established HAPCs for species in the SG FMU.	Amendment #10 (1998d)	07/14/00
-MSY proxy = 30% static SPR -OY = 40% static SPR -Approved definitions for overfished and overfishing. MSST = [(1-M) or 0.5 whichever is greater]* B_{MSY}. MFMT = F_{MSY}	Amendment #11 (1998e)	12/02/99
-Extended for an indefinite period the regulation prohibiting fishing for and possessing snapper grouper spp. within the *Oculina* Experimental Closed Area.	Amendment #13A (2003b)	04/26/04
-Established eight deepwater Type II marine protected areas (MPAs) to protect a portion of the population and	Amendment #14 (2007)	2/12/09

habitat of long-lived deepwater snapper grouper species.		
-Prohibited the sale of bag-limit caught snapper grouper species. -Adjusted commercial renewal periods and transferability requirements. -Implemented plan to monitor and assess bycatch.	Amendment #15B (2008b)	2/15/10
-Reduced 5-fish aggregate grouper bag limit, which includes tilefish species including blueline tilefish, to a 3-fish aggregate. -Captain and crew on for-hire trips cannot retain the bag limit of species within the 3-fish grouper aggregate, which includes blueline tilefish.	Amendment # 16 (2009)	7/29/09
-Required use of non-stainless steel circle hooks when fishing for snapper grouper species with hook-and-line gear north of 28 deg. N latitude in the South Atlantic EEZ	Amendment #17A (SAFMC 2010a)	circle hooks March 3, 2011
-Updated the framework procedure for specification of OFL, ABC, ACLs, and ACTs. -Established prohibition on possession of deepwater snapper grouper species, including blueline tilefish, seaward of 240 feet in the South Atlantic EEZ.	Amendment #17B (SAFMC 2010b)	January 31, 2011
-Provided presentation of spatial information for Essential Fish Habitat (EFH) and EFH-Habitat Areas of Particular Concern (EFH-HAPC) designations under the Snapper Grouper FMP - Designated deepwater coral HAPCs	Amendment #19 (Comprehensive Ecosystem-based Amendment 1) (SAFMC 2010c)	7/22/10
-Established species groupings. Blueline tilefish in included in the Deepwater Complex (along with yellowedge grouper, silk snapper,	Comprehensive ACL Amendment (Amendment 25)(SAFMC 2011c)	4/16/12

misty grouper, queen snapper, sand tilefish, black snapper, and blackfin snapper) -Blueline tilefish ABC = 592,6024 based on SSC recommendation. -Blueline tilefish allocations = 47.39% commercial; 52.61% recreational -Established the following for the Deepwater Complex: ABC/ACL= 675,908 pounds ww. Commercial ACL = 343,869 pounds ww. Recreational ACL = 332,039 pounds ww. Recreational ACT = 205,516 pounds ww. In-season and post-season AMs: Commercial - If the commercial sector ACL for the Deepwater Complex is met or projected to be met, all purchase and sale is prohibited and harvest and/or possession is limited to the bag limit. If the commercial sector ACL is exceeded and one of the species in the complex is overfished, the Regional Administrator shall publish a notice to reduce the commercial sector ACL in the following season by the amount of the overage. Recreational - If the recreational sector ACL for the Deepwater Complex is exceeded, the following year's landings would be monitored in-season for persistence in increased landings. The Regional Administrator will publish a notice to reduce the length of the fishing season as necessary.		

- Designated the Deepwater MPAs as EFH-HAPCs	Amendment #23 (Comprehensive Ecosystem-based Amendment 2; SAFMC 2011f)	1/30/12
- Improved the accuracy, timing, and quantity of fisheries statistics	Amendment #18A (SAFMC 2012a)	7/1/12
- Improved the accuracy, timing, and quantity of fisheries statistics	Amendment #18A (SAFMC 2012a)	7/1/12
-Limited participation and effort in the golden tilefish commercial sector through longline endorsement; -Modified trip limits: 4,000 lbs ww for longline and 500 lbs ww for hook-and-line -Specified allocations for gear groups (longline =75% and hook and line = 25%).	Amendment #18B (SAFMC 2013)	5/23/13
Included under the Generic charter/headboat reporting amendment, that required electronic logbook reporting for headboat vessels and modified timeline of reporting to weekly intervals.	Amendment #31 (2014a)	1/27/14
-Ended overfishing of blueline tilefish; -Separated blueline tilefish from the deepwater complex; -Re-defined MSY for blueline tilefish; -Specified ACLs for blueline tilefish and the deepwater complex: 2015: Total ACL=35,632 lbs ww Comm=17,841; Rec = 17,791 2016: Total ACL=53,457 lbs ww Comm=26,766; Rec=26,691 2017: Total ACL=71,469 lbs ww Comm=35,785; Rec=35,685 2018 and beyond: Total ACL=87,974 lbs ww; Comm=44,048; Rec=43,925 -Specified AMs for blueline tilefish;	Amendment #32 (SAFMC 2014b)	3/30/15

-Revised AMs for the deepwater complex; -Specified recreational ACTs for blueline tilefish -Specified 100 lb gw commercial trip limit -Specified 1 blueline tilefish per vessel during May-August		
-Updated the Council's ABC control rule to incorporate methodology for determining the ABC of unassessed species, adjust ABCs for fourteen unassessed snapper-grouper species, adjust ACLs and ACTs for three species complexes, including the Deepwater Complex, and four snapper-grouper species based on revised ABCs; -Modified and implement gray triggerfish minimum size limits; -Established a commercial split season and commercial trip limits for gray triggerfish.	Amendment #29 (2014c)	7/1/15

SAFMC Regulatory Amendments affecting blueline tilefish

Description of Action	Amendment	Effective Date
-Prohibited fishing in SMZs except with hand-held hook-and-line and spearfishing gear.	Regulatory Amendment #1 (1987)	03/27/87
-Established 2 artificial reefs off Ft. Pierce, FL as SMZs.	Regulatory Amendment #2 (1988b)	03/30/89
-Established artificial reef at Key Biscayne, FL as SMZ. Fish trapping, bottom longlining, spear fishing, and harvesting of Goliath grouper prohibited in SMZ.	Regulatory Amendment #3 (1989)	11/02/90
-Established 8 SMZs off S. Carolina, where only hand-held, hook-and-line gear and	Regulatory Amendment #5 (1992c)	07/31/93

spearfishing (excluding powerheads) was allowed.		
-Established 10 SMZs at artificial reefs off South Carolina.	Regulatory Amendment #7 (1998)	01/29/99
-Established 12 SMZs at artificial reefs off Georgia; revised boundaries of 7 existing SMZs off Georgia to meet CG permit specs; restricted fishing in new and revised SMZs	Regulatory Amendment #8 (2000a)	11/15/00
- Eliminated the 240 ft closure for six deepwater species, including blueline tilefish.	Regulatory Amendment # 11 (2011b)	5/10/12
-Adjusted the ACL and OY for golden tilefish; -Revised recreational AMs for golden tilefish.	Regulatory Amendment #12 (2012)	10/9/12
Revised the ABCs, ACLs (including sector ACLs), and ACTs implemented by the Comprehensive ACL Amendment. The revisions may prevent a disjunction between the established ACLs and the landings used to determine if AMs are triggered.	Regulatory Amendment #13 (2013)	7/17/13
Modified the definition of the overfished threshold (MSST) for red snapper, blueline tilefish, gag, black grouper, yellowtail snapper, vermilion snapper, red porgy, and greater amberjack	Regulatory Amendment #21 (2014)	11/6/14
-Increased the recreational and commercial ACLs for snowy grouper;	Regulatory Amendment #20 (2015)	8/20/15

-Adjusted the rebuilding strategy; -Increased the commercial trip limit to 200 lbs gw -Modified the recreational fishing season to 1 fish/vessel/day May-August		
-Adopts new ABC recommendation of 224,100 lbs ww -Sets ACL=OY=78%ABC=174,798 lbs ww -Commercial ACL=87,521; Recreational ACL=87,277 lbs ww -Increases bag limit to 3 fish/person/day during May-August within the aggregate grouper bag limit -Increases commercial trip limit to 300 lbs gw	Regulatory Amendment #25 (2016)	Anticipated to be effective July/August 2016

2.2.2 Emergency and Interim Rules (if any)

Emergency Action effective September 3, 1999: reopen the Amendment 8 Snapper Grouper Permit application process.

Emergency Action Effective 4/17/2014 through 4/18/2015: Separated blueline tilefish from the Deepwater Complex and established annual catch limits for blueline tilefish. Put in place temporary annual catch limits for blueline tilefish based upon the equilibrium yield at 75%F_{MSY} (224,100 lbs ww) and existing sector allocations (50.07% commercial and 49.93% recreational): Commercial ACL =112,207 lbs ww; Recreational ACL=111,893 lbs ww. Put in place temporary in-season AMs for blueline tilefish.

2.2.3 Secretarial Amendments (if any)

None

2.2.4 Control Date Notices (if any)

Notice of Control Date effective July 30, 1991: Anyone entering federal snapper grouper fishery (other than for wreckfish) in the EEZ off S. Atlantic states after 07/30/91 was not assured of future access if limited entry program developed.

Notice of Control Date effective October 14, 2005: The Council is considering management measures to further limit participation or effort in the commercial fishery for snapper grouper species (excluding Wreckfish).

Notice of Control Date effective March 8, 2007: The Council may consider measures to limit participation in the snapper grouper for-hire fishery.

Notice of Control Date effective January 31, 2011: Anyone entering federal snapper grouper fishery off S. Atlantic states after 09/17/10 was not assured of future access if limited entry program is developed.

2.2.5 Management Program Specifications

Table 2.2.5.1. General Management Information

South Atlantic

Species	Blueline Tilefish
Management Unit	Southeastern US
Management Unit Definition	NC/VA border southward to the SAFMC/GMFMC boundary
Management Entity	South Atlantic Fishery Management Council
Management Contacts SERO / Council	SAFMC: Myra Brouwer SERO: Jack McGovern
Current stock exploitation status	Overfishing
Current stock biomass status	Not overfished

Table 2.2.5.2. Management Parameters

Criteria	South Atlantic – Current (SEDAR 32)		
	Definition	Base Run Values	Median of Base Run MCBs
MSST[1] (lbs ww)	75% B_{MSY}[2]	407,745	
MFMT (per year)	F_{MSY}, if available; $F_{30\% SPR}$ proxy [3]	0.302	
F_{MSY} (per year)	F_{MSY}	0.302	

MSY (1000 lb)	Yield at F_{MSY}, landings and discards, pounds and numbers	226.5	
B_{MSY}[1] (metric tons)	Total or spawning stock, to be defined	679.5	
R_{MSY}	Recruits at MSY		
F Target	75% F_{MSY}	0.226	
Yield at F_{TARGET} (equilibrium) (1000 lb)	Landings and discards, pounds and numbers	224.1	
M	Natural mortality, average across ages	0.1	
Terminal F (F_{2011})	Exploitation	0.393	
Terminal Biomass[1] ((SSB_{2011}; metric tons)	Biomass	202	
Exploitation Status	$F_{2009-2011}/F_{MSY}$	2.37	
	F_{2011}/F_{MSY}	1.30	
Biomass Status[1]	SSB_{2011}/MSST	0.909	
	B/B_{MSY}	0.818	
Generation Time			
$T_{REBUILD}$ (if appropriate)			

Criteria	South Atlantic – Proposed (values from SEDAR 50)		
	Definition	Base Run Values	Median of Base Run MCBs
MSST[1]	(75% of SSB_{MSY})		
MFMT	F_{MSY}, if available; $F_{30\%\,SPR}$ proxy [3]		
F_{MSY}	F_{MSY}		
MSY	Yield at F_{MSY}, landings and discards, pounds and numbers		
B_{MSY}[1]	Total or spawning stock, to be defined		
R_{MSY}	Recruits at MSY		
F Target	75% F_{MSY}		
Yield at F_{TARGET} (equilibrium)	Landings and discards, pounds and numbers		

M	Natural mortality, average across ages		
Terminal F	Exploitation		
Terminal Biomass[1]	Biomass		
Exploitation Status	F/MFMT		
Biomass Status[1]	B/MSST		
	B/B_{MSY}		
Generation Time			
$T_{REBUILD}$ (if appropriate)			

1. Biomass values reported for management parameters and status determinations should be based on the biomass metric recommended through the Assessment process and SSC. This may be total, spawning stock or some measure thereof, and should be applied consistently in this table.

2. MSST definition was changed after the completion of SEDAR 32 through Snapper Grouper Regulatory Amendment 21.

3. If an acceptable estimate of F_{MSY} is not provided by the assessment a proxy value may be considered. The current F_{MSY} proxy for this stock is F30% SPR; other values may be recommended by the assessment process for consideration by the SSC.

NOTE: "Proposed" columns are for indicating any definitions that may exist in FMPs or amendments that are currently under development and should therefore be evaluated in the current assessment. Please clarify whether landings parameters are 'landings' or 'catch' (Landings + Discard). If 'landings', please indicate how discards are addressed.

Table 2.2.5.3. Stock Rebuilding Information

n/a

Table 2.2.5.4. General Projection Specifications

South Atlantic

First Year of Management	2018
Interim basis	ACL, if landings are within 10% of the ACL; average landings otherwise
Projection Outputs	
Landings	Pounds and numbers

Discards	Pounds and numbers
Exploitation	F & Probability F>MFMT
Biomass (total or SSB, as appropriate)	B & Probability B>MSST (and Prob. B>B_{MSY} if under rebuilding plan)
Recruits	Number

Table 2.2.5.5. Base Run Projections Specifications. Long Term and Equilibrium conditions.

Criteria	Definition	If overfished	If overfishing	Neither overfished nor overfishing
Projection Span	Years	$T_{REBUILD}$	10	10
Projection Values	$F_{CURRENT}$	X	X	X
	F_{MSY}	X	X	X
	75% F_{MSY}	X	X	X
	$F_{REBUILD}$	X		
	F=0	X		

NOTE: Exploitation rates for projections may be based upon point estimates from the base run (current process) or upon the median of such values from the MCBs evaluation of uncertainty. The critical point is that the projections be based on the same criteria as the management specifications.

Table 2.2.5.6. P-star projections. Short term specifications for OFL and ABC recommendations. Additional P-star projections may be requested by the SSC once the ABC control rule is applied.

Criteria		Overfished	Not overfished
Projection Span	Years	5	5
Probability Values	50%	Probability of stock rebuild	Probability of overfishing

Table 2.2.5.7. Quota Calculation Details
If the stock is managed by quota, please provide the following information
NOTE: Values below are current as of April 2016. Regulatory Amendment 25 is under secretarial review and, if implemented, would make changes to the blueline tilefish ABC, ACLs and commercial and recreational management measures. Expected implementation date is summer 2016.

Current Acceptable Biological Catch (ABC) and Total Annual Catch Level (ACL) Value for Blueline Tilefish	2016 ABC=54,548 pounds whole weight Total ACL for 2016 =98% ABC=53,457 pounds whole weight
Commercial ACL for blueline tilefish for 2016	26,766 pounds whole weight
Recreational ACL for blueline tilefish in 2016	26,691 pounds whole weight
Next Scheduled Quota Change	2017
Annual or averaged quota?	Annual
If averaged, number of years to average	n/a
Does the quota include bycatch/discard?	No

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

The current blueline tilefish ABC was derived from projections at P*=30% based on the SSC's recommendation. Through Amendment 32, the Council set ACL=OY=98%ABC for 2015-2018 and beyond until modified.

Does the quota include bycatch/discard estimates? I f so, what is the source of the bycatch/discard values? What are the bycatch/discard allowances?
Projections include discards but ABC is specified based on landings only.

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

2.2.6 Management and Regulatory Timeline

The following tables provide a timeline of federal management actions by fishery.

Table 2.6.1 South Atlantic Blueline Tilefish Commercial Regulatory History
prepared by: Myra Brouwer

Year	ACL (units)	Days Open	fishing season	reason for closure	season start date (first day implemented)	season end date (last day effective)	Size limit (units and length type, indicate maximum or natural length)	size limit start date	size limit end date	Retention Limit (units)	Retention Limit Start Date	Retention Limit End Date	Aggregate Retention Limit (units)	Aggregate Retention Limit Start Date	Aggregate Retention Limit End Date
1994		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
1995		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
1996		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
1997		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
1998		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
1999		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2000		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2001		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2002		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2003		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2004		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2005		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2006		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2007		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2008		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2009		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2010		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2011		365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2012	343,869 (lbs ww)[A]	251	open		1-Jan	8-Sep	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
			closed	ACL met	9-Sep	31-Dec	None	NA	NA	NA					
2013	376,469 (lbs ww)[A]	365	open		1-Jan	31-Dec	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
2014	376,469 (lbs ww)[A]	76	open		1-Jan	17-Apr	None	NA	NA	NA	1-Jan	17-Apr	None	NA	NA
	112,207 (lbs ww)[B]	67	open		18-Apr	23-Jun	None	NA	NA	NA	18-Apr	31-Dec	None	NA	NA
			closed	ACL met	24-Jun	31-Dec	None	NA	NA						
2015	112,207 (lbs ww)[B]	90	open		1-Jan	29-Mar	None	NA	NA	NA	1-Jan	31-Dec	None	NA	NA
	17,841 (lbs ww)[C]	9	open		30-Mar	7-Apr	None	NA	NA	100 lb gw per trip	31-Mar	7-Apr	None	NA	NA
			closed	ACL met	8-Apr	31-Dec	None	NA	NA						
2016[D]	26,766 (lbs ww)		open		1-Jan		None	NA	NA	100 lb gw per trip			None	NA	NA

Fishing year = Calendar Year

A = ACL is for entire Deepwater Complex (yellowedge grouper, blueline tilefish, silk snapper, misty grouper, queen snapper, sand tilefish, black snapper, and blackfin snapper)
B = Blueline tilefish was removed from Deepwater Complex and given a species specific ACL via temporary emergency rule effective 4/17/14.
C = Amendment 32 permanently removed blueline tilefish from the Deepwater Complex and specified new ACL
D = Regulatory Amendment 25 (under review) would increase com ACL to 87,521 lbs ww and increase commercial trip limit to 300 lbs gw

Note: lbs = pounds; gw = gutted weight

Table 2.6.2 South Atlantic Blueline Tilefish Recreational Regulatory History

prepared by: Myra Brouwer

Year	ACL (pounds ww)	Days Open	fishing season	reason for closure	season start date (first day implemented)	season end date (last day effective)	Size limit	size limit start date	size limit end date	Retention Limit (# fish)	Retention Limit Start Date	Retention Limit End Date	Aggregate Retention Limit[1] (# fish)	Aggregate Retention Limit Start Date	Aggregate Retention Limit End Date
1994	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A]	27-Jun	31-Dec	5/person/day [A]	27-Jun	31-Dec
1995	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A]	1-Jan	31-Dec	5/person/day [A]	1-Jan	31-Dec
1996	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A]	1-Jan	31-Dec	5/person/day [A]	1-Jan	31-Dec
1997	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A]	1-Jan	31-Dec	5/person/day [A]	1-Jan	31-Dec
1998	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A]	1-Jan	31-Dec	5/person/day [A]	1-Jan	31-Dec
1999	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	24-Feb	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2000	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	1-Jan	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2001	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	1-Jan	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2002	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	1-Jan	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2003	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	1-Jan	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2004	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	1-Jan	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2005	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	1-Jan	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2006	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	1-Jan	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2007	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	1-Jan	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2008	NA	365	open		1-Jan	31-Dec	None	NA	NA	5/person/day [A, B]	1-Jan	31-Dec	5/person/day [A, B]	1-Jan	31-Dec
2009 [C]	NA	209	open		1-Jan	28-Jul	None	NA	NA	5/person/day [A, B]	1-Jan	28-Jul	5/person/day [A, B]	1-Jan	28-Jul
		156	open		29-Jul	31-Dec	None	NA	NA	3/person/day [D]	29-Jul	31-Dec	3/person/day [D]	29-Jul	31-Dec
2010 [C]	NA	365	open		1-Jan	31-Dec	None	NA	NA	3/person/day [D]	1-Jan	31-Dec	3/person/day [D]	1-Jan	31-Dec
2011 [C]	NA	365	open		1-Jan	31-Dec	None	NA	NA	3/person/day [D]	1-Jan	31-Dec	3/person/day [D,G]	1-Jan	31-Dec
2012 [C,E, F, I]	NA	107	open		1-Jan	15-Apr	None	NA	NA	3/person/day [D]	1-Jan	15-Apr	3/person/day [D,G]	1-Jan	15-Apr
	332039[H]	261	open		16-Apr	31-Dec	None	NA	NA	3/person/day [D]	16-Apr	31-Dec	3/person/day [D,G]	16-Apr	31-Dec
2013 [C,E]	334556[H]	365	open		1-Jan	31-Dec	None	NA	NA	3/person/day [D]	1-Jan	31-Dec	3/person/day [D,G]	1-Jan	31-Dec
2014 [C, E, J, K]	334556[H]	106	open		1-Jan	16-Apr	None	NA	NA	3/person/day [D]	1-Jan	16-Apr	3/person/day [D,G]	1-Jan	16-Apr
	111,893	259	open		17-Apr	31-Dec	None	NA	NA	3/person/day [D]	17-Apr	31-Dec	3/person/day [D,G]	17-Apr	31-Dec
2015 C [, J, L]	111,893	88	open		1-Jan	29-Mar	None	NA	NA	3/person/day [D]	1-Jan	29-Mar	3/person/day [D,G]	1-Jan	29-Mar
	17,791[L]		closed	implementation of season	30-Mar	30-Apr									
	17,791[L]	40	open		1-May	9-Jun	None	NA	NA	1/vessel/day May-August[L]	1-May	9-Jun	3/person/day [D,G,L,N]	1-May	9-Jun
			closed	ACL met	10-Jun	31-Dec	None	NA	NA						
2016 [C, L,M]	26,691				1-May	TBD	None	NA	NA	1/vessel/day May-August[L]	1-May	TBD	3/person/day [D,G,L,N]	1-May	TBD

Fishing year = Calendar Year

1 = Starting in 1994, the aggregate grouper bag limit included gag, scamp, red grouper, black grouper, speckled hind, snowy grouper, warsaw grouper, rock hind, red hind, coney, graysby, misty grouper, yellowedge grouper, yellowmouth grouper, yellowfin grouper, tiger grouper, golden tilefish, blueline tilefish, and sand tilefish. Unless otherwise noted below (see F & H below) these species remain in the aggregate bag limit throughout the time series.

A = Aggregate grouper bag limit (includes gag, scamp, red grouper, black grouper, speckled hind, snowy grouper, warsaw grouper, rock hind, red hind, coney, graysby, misty grouper, yellowedge grouper, yellowmouth grouper, yellowfin grouper, tiger grouper, golden tilefish, blueline tilefish, and sand tilefish) of 5/person/day; specifies 1 speckled hind and 1 warsaw grouper in 5 grouper aggregate (Amendment 6; effective date 6/27/1994).

B = Aggregate grouper bag limit specifies no more than 2 can be gag or black grouper (Amendment 9; effective date 2/24/1999)

C = Prohibited sale of bag-limit caught snapper grouper species, including blueline tilefish (Amendment 15B; effective date:12/16/2009).

D =Reduce aggregate grouper bag limit of 3/person/day; no more than one fish in aggregate bag may be gag or black grouper; captain and crew may not retain bag limit (Amendment 16; effective date 07/29/2009)

E = Comprehensive ACL Amendment establishes Deepwater Complex: blueline tilefish, yellowedge grouper, silk snapper, misty grouper, queen snapper, sand tilefish, black snapper, and blackfin snapper and specifies rec ACL for DWC = 332,039 lbs ww. (effective April 16, 2012). Tiger grouper removed from FMU (and therefore removed from aggregate bag limit)

F = Prohibits harvest of 6 deepwater species seaward of 240' (yellow edge grouper, misty grouper, snowy grouper, blueline tilefish, queen snapper, silk snapper; Amendment 17B; effective date: 1/31/11)

G = Harvest of speckled hind and warsaw grouper prohibited (e.g. removed from grouper aggregate bag limit; Amendment 17B; effective date: 1/31/11)

H = ACL is for Deepwater Complex not just for Blueline Tilefish

I = Deepwater closure eliminated (Regulatory Amendment 11; effective date 5/10/2012)

J = Emergency rule removes blueline from DWC and specifies ACL effective 4/17/2014

K = Captain and crew on for-hire trips can retain bag limit of snapper grouper species (Amendment 27; effective date 1/27/2014)

L = Amendment 32 permanently removes blueline tilefish from Deepwater Complex and establishes recreational season and 1 fish/vessel trip limit within 3-grouper aggregate (effective 3/30/15)

M = Regulatory Amendment 25 (under review) would increase recreational ACL to 87,277 lbs ww and increase bag limit to 3/person/day within 3 grouper aggregate during May-August (anticipated implementation date is July/August 2016)

N = Blueline tilefish is still included in the snapper grouper 3/person/day aggregate bag limit; however due to Amendment 32, anglers are limited to 1 blueline tilefish/vessel/day

Note:

Table 7. State Regulatory History

North Carolina:

There are currently no North Carolina state-specific regulations for blueline tilefish. North Carolina has complemented federal regulations for all snapper grouper species via proclamation authority since 1991. Between 1992 and 2005, species-specific regulations were added to the proclamation authority contained in rule 15A NCAC 03M .0506. Specific to blueline tilefish, this rule was amended effective May 24, 1999 (following Amendment 9 to the SAFMC Snapper-Grouper FMP, eff. 2/24/99) to include the following Sub-item: (q) It is unlawful to possess any species of the Snapper-grouper complex except snowy, warsaw, yellowedge, and misty groupers; **blueline**, golden and sand tilefishes; while having longline gear aboard a vessel.

In 2002, North Carolina adopted its Inter-Jurisdictional Fishery Management Plan (IJ FMP), which incorporates all ASMFC and council-managed species by reference, and adopts all federal regulations as minimum standards for management. In completing the 2008 update to the IJ FMP, all species-specific regulations were removed from rule 15A NCAC 03M .0506, and proclamation authority to implement changes in management was moved to rule 15A NCAC 03M .0512. An information update to the IJ FMP was completed and approved in November 2015 and contained no additional regulatory changes. Since the 2008 IJ FMP update, all snapper grouper regulations were contained in a single proclamation, which was updated anytime an opening/closing of a particular species in the complex occured, as well as any changes in allowable gear, required permits, etc. Beginning in 2015, commercial and recreational regulations have been contained in separate proclamations. The most current Snapper Grouper proclamations (and all previous versions) can be found using this link: http://portal.ncdenr.org/web/mf/proclamations.

15A NCAC 03M .0506 SNAPPER-GROUPER COMPLEX

(a) In the Atlantic Ocean, it is unlawful for an individual fishing under a Recreational Commercial Gear License with seines, shrimp trawls, pots, trotlines or gill nets to take any species of the Snapper-Grouper complex.

(b) The species of the snapper-grouper complex listed in the South Atlantic Fishery Management Council Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region are hereby incorporated by reference and copies are available via the Federal Register posted on the Internet at www.safmc.net and at the Division of Marine Fisheries, P.O. Box 769, Morehead City, North Carolina 28557 at no cost.

History Note: Authority G.S. 113-134; 113-182; 113-221; 143B-289.52;
Eff. January 1, 1991;
Amended Eff. April 1, 1997; March 1, 1996; September 1, 1991;
Temporary Amendment Eff. December 23, 1996;
Amended Eff. August 1, 1998; April 1, 1997;

Temporary Amendment Eff. January 1, 2002; August 29, 2000; January 1, 2000; May 24, 1999; Amended Eff. October 1, 2008; May 1, 2004; July 1, 2003; April 1, 2003; August 1, 2002.

15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS

(a) In order to comply with management requirements incorporated in Federal Fishery Management Council Management Plans or Atlantic States Marine Fisheries Commission Management Plans or to implement state management measures, the Fisheries Director may, by proclamation, take any or all of the following actions for species listed in the Interjurisdictional Fisheries Management Plan:

(1) Specify size;
(2) Specify seasons;
(3) Specify areas;
(4) Specify quantity;
(5) Specify means and methods; and
(6) Require submission of statistical and biological data.

(b) Proclamations issued under this Rule shall be subject to approval, cancellation, or modification by the Marine Fisheries Commission at its next regularly scheduled meeting or an emergency meeting held pursuant to G.S. 113-221.1.

History Note: Authority G.S. 113-134; 113-182; 113-221; 113-221.1; 143B-289.4;
Eff. March 1, 1996;
Amended Eff. October 1, 2008.

South Carolina:

Sec. 50-5-2730 of the SC Code states:

"Unless otherwise provided by law, any regulations promulgated by the federal government under the Fishery Conservation and Management Act (PL94-265) or the Atlantic Tuna Conservation Act (PL 94-70) which establishes seasons, fishing periods, gear restrictions, sales restrictions, or bag, catch, size, or possession limits on fish are declared to be the law of this State and apply statewide including in state waters."

As such, SC blueline tilefish regulations are (and have been) pulled directly from the federal regulations as promulgated under Magnuson. I am not aware of any separate blueline tilefish regulations that have been codified in the SC Code.

Georgia:

There are currently no GA state regulations for blueline tilefish. However, the authority rests with the GA Board of Natural Resources to regulate this species if deemed necessary in the future.

Florida:

No historical regulatory information for blueline tilefish found. Not aware of Florida ever having state regulations for blueline tilefish.

References

None provided.

2.3 Gulf of Mexico

The following tables summarize the Gulf of Mexico Blueline Tilefish management history.

Harvest Restrictions (Trip Limits*)

*Trip limits do not apply during closures (if season is closed, then trip limit is 0)

Species Affected	First Yr In Effect	Effective Date	End Date	Fishery	Bag Limit Per Person/Day	Bag Limit Per Boat/Day	Region Affected	FR Reference
Blueline Tilefish	1997	Jan 1997	Ongoing	Rec	20/person/day[A]			
Blueline	2010	1/1/2010	Ongoing	Com	NA	IFQ	Gulf of Mexico EEZ	74 FR 44732

Harvest Restrictions (Size Limits*)
*Size limits do not apply during closures

Species Affected	First Yr In Effect	Effective Date	End Date	Fishery	Size Limit	Length Type	Region Affected	FR Reference
Blueline Tilefish								

Harvest Restrictions (Fishery Closures*)

*Area specific regulations are documented under spatial restictions

Species Affected	First Yr In Effect	Effective Date	End Date	Fishery	Closure Type	First Day Closed	Last Day Closed	Region Affected	FR Reference
Blueline Tilefish									

Harvest Restrictions (Spatial Restrictions)

Area	First Yr In Effect	Effective Date	End Date	Fishery	First Day Closed	Last Day Closed	Restriction in Area	FR Reference
Gulf of Mexico Stressed Areas	1984	11/8/1984	Ongoing	Both	Year round		Prohibited powerheads for Reef FMP	49 FR 39548
	1984	11/8/1984	Ongoing	Both	Year round		Prohibited pots and traps for Reef FMP	49 FR 39548
Alabama Special Management Zones	1994	2/7/1994	Ongoing	Both	Year round		Allow only hook-and line gear with three or less hooks per line and spearfishing gear for fish in Reef FMP	59 FR 966
EEZ, inside 50 fathoms west of Cape San Blas, FL	1990	2/21/1990	Ongoing	Both	Year round		Prohibited longline and buoy gear for Reef FMP	55 FR 2078
EEZ, inside 20 fathoms east of Cape San Blas, FL	1990	2/21/1990	4/17/2009	Both	Year round		Prohibited longline and buoy gear for Reef FMP	55 FR 2078
EEZ, inside 50 fathoms east of Cape San Blas, FL	2009	4/18/2009	10/15/2009	Both	18-Apr	28-Oct	Prohibited bottom longline for Reef FMP	74 FR 20229
EEZ, inside 35 fathoms east of Cape San Blas, FL	2009	10/16/2009	4/25/2010	Both	Year round		Prohibited bottom longline for Reef FMP	74 FR 53889
	2010	4/26/2010	Ongoing	Rec	Year round		Prohibited bottom longline for Reef FMP	75 FR 21512
	2010	4/26/2010	Ongoing	Com	1-Jun	31-Aug	Prohibited bottom longline for Reef FMP	75 FR 21512
Madison-Swanson	2000	4/19/2000	6/2/2004	Both	Year round		Fishing prohibited except HMS[1]	65 FR 31827
	2004	6/3/2004	Ongoing	Both	1-May	31-Oct	Fishing prohibited except surface trolling	70 FR 24532 74 FR 17603
	2004	6/3/2004	Ongoing	Both	1-Nov	30-Apr	Fishing prohibited	70 FR 24532 74 FR 17603
Steamboat Lumps	2000	4/19/2000	6/2/2004	Both	Year round		Fishing prohibited except HMS[1]	65 FR 31827
	2004	6/3/2004	Ongoing	Both	1-May	31-Oct	Fishing prohibited except surface trolling	70 FR 24532 74 FR 17603
	2004	6/3/2004	Ongoing	Both	1-Nov	30-Apr	Fishing prohibited	70 FR 24532 74 FR 17603
The Edges	2010	7/24/2009	Ongoing	Both	1-Jan	30-Apr	Fishing prohibited	74 FR 30001
20 Fathom Break	2014	7/5/2013	Ongoing	Rec	1-Feb	31-Mar	Fishing for SWG prohibited[2]	78 FR 33259
Flower Garden	1992	1/17/1992	Ongoing	Both	Year round		Fishing with bottom gears prohibited[3]	56 FR 63634
Riley's Hump	1994	2/7/1994	8/18/2002	Both	1-May	30-Jun	Fishing prohibited	59 FR 966
Tortugas Reserves	2002	8/19/2002	Ongoing	Both	Year round		Fishing prohibited	67 FR 47467
Pulley Ridge	2006	1/23/2006	Ongoing	Both	Year round		Fishing with bottom gears prohibited[3]	70 FR 76216

[1]HMS: highly migratory species (tuna species, marlin, oceanic sharks, sailfishes, and swordfish)

[2]SWG: shallow-water grouper (black, gag, red, red hind, rock hind, scamp, yellowfin, and yellowmouth)

[3]Bottom gears: Bottom longline, bottom trawl, buoy gear, pot, or trap

Harvest Restrictions (Gear Restrictions*)

*Area specific gear regulations are documented under spatial restictions

Gear Type	First Yr In Effect	Effective Date	End Date	Gear/Harvesting Restrictions	Region Affected	FR Reference
Poison	1984	11/8/1984	Ongoing	Prohibited for Reef FMP	Gulf of Mexico EEZ	49 FR 39548
Explosives	1984	11/8/1984	Ongoing	Prohibited for Reef FMP	Gulf of Mexico EEZ	49 FR 39548
Pots and Traps	1984	11/23/1984	2/3/1994	Established fish trap permit	Gulf of Mexico EEZ	50 FR 39548
	1984	11/23/1984	2/20/1990	Set max number of traps fish by a vessel at 200	Gulf of Mexico EEZ	50 FR 39548
	1990	2/21/1990	2/3/1994	Set max number of traps fish by a vessel at 100	Gulf of Mexico EEZ	55 FR 2078
	1994	2/4/1994	2/7/1997	Moratorium on additional commercial trap permits	Gulf of Mexico EEZ	59 FR 966
	1997	3/25/1997	2/6/2007	Phase out of fish traps begins	Gulf of Mexico EEZ	62 FR 13983
	1997	12/30/1997	2/6/2007	Prohibited harvest of reef fish from traps other than permited reef fish, stone crab, or spiny lobster traps.	Gulf of Mexico EEZ	62 FR 67714
	2007	2/7/2007	Ongoing	Traps prohibited	Gulf of Mexico EEZ	62 FR 13983
All	1992	4/8/1992	12/31/1995	Moratorium on commercial permits for Reef FMP	Gulf of Mexico EEZ	68 FR 11914 59 FR 39301
	1994	2/7/1994	Ongoing	Finfish must have head and fins intact through landing, can be eviscerated, gilled, and scaled but must otherwise be whole (HMS and bait exceptions)	Gulf of Mexico EEZ	59 FR 39301
	1996	6/1/1996	12/31/2005	Moratorium on commercial permits for Gulf reef fish.	Gulf of Mexico EEZ	61 FR 34930 65 FR 41016
	2006	9/8/2006	Ongoing	Use of Gulf reef fish as bait prohibited.[1]	Gulf of Mexico EEZ	71 FR 45428
Vertical Line	2008	6/1/2008	Ongoing	Requires non-stainless steel circle hooks and dehooking devices	Gulf of Mexico EEZ	74 FR 5117
	2008	6/1/2008	9/3/2013	Requires venting tools	Gulf of Mexico EEZ	74 FR 5117 78 FR 46820

[1]Except when, purchased from a fish processor, filleted carcasses may be used as bait crab and lobster traps.

GULF OF MEXICO STOCK (COMMERCIAL AND RECREATIONAL)

The information below was pulled from the SERO website at the link below.
http://sero.nmfs.noaa.gov/sustainable_fisheries/acl_monitoring/stock_gulf/historical/index.html

Species Complex	Year	Fishing Season	Recreational Landings	Commercial Landings	Sector Total	ACL/Quota	Units	Percent of ACL	Stock Closure Date
Tilefishes	2015	January 1 - December 31	180,165	537,512	717,677	608,000	gw	118.04	n/a
	2014		25,821	517,268	543,089	608,000		89.32	n/a
	2013		122,826	440,091	562,917	608,000		92.59	n/a
	2012		7,896	451,121	459,017	608,000		75.5	

(a) Tilefishes: golden, goldface, and blueline

Commercial landings from IFQ

GULF OF MEXICO COMMERCIAL ONLY

The information below was pulled from the SERO website at the link below.
http://sero.nmfs.noaa.gov/sustainable_fisheries/acl_monitoring/commercial_gulf/reef_fish_historical/index.html

Species	Fishing Year	Fishing Season	Total Landings	ACT**/Quota	ACL	Units	Quota %	ACL %	Closure Date	Source
Tilefish	2015	Jan 1 - Dec 31	537,512	582,000	606,000	gw	92.36	88.7	n/a	IFQ
	2014		517,268	582,000	606,000		88.88	85.36		
	2013		440,091	582,000	606,000		75.62	72.62		
	2012		451,121	582,000	606,000		77.51	74.44		
	2011		386,134	440,000	n/a		87.76	n/a		
	2010		249,708	440,000			56.75			
	2009		434,945	440,000			98.85		5/15/2009	ACL_FILES_10022015
	2008		316,701	440,000			71.98		5/10/2008	
	2007		287,875	440,000			65.43		4/18/2007	
	2006		280,437	440,000			63.74		7/22/2006	
	2005		522,537	440,000			118.76		11/21/2005	
	2004		417,889	440,000			94.97			

(a) Tilefishes: golden, goldface, and blueline

The ACL quota in the above table (GoM Commercial Only) is just for the commercial fishery. The commercial side has it's own ACL/Quota which is the bulk of the combined ACL/quota. The GMFMC Generic ACL Amendment on pg 64 has more information about this: "Several stocks in Table 2.5.2 have no official commercial:recreational allocations, but do have IFQ shares that can be used to commercially harvest these stocks. These include the other shallow-water grouper complex, deep-water grouper complex, and tilefishes complex. These stock complexes also have a recreational component, albeit small. The amount of annual catch limit that is apportioned to the IFQ program must make allowances for a recreational harvest in order to be fair and equitable to both the commercial and recreational sectors under National Standard 4. This is not intended to change any existing fishing practices. However, under the National Standard 4 guidelines, adoption of management measures that merely perpetuate existing fishing practices may result in an allocation if those practices directly distribute the opportunity to participate in the fishery (50 CFR 600.325(c)(1))." The full Amendment can be found at: http://sero.nmfs.noaa.gov/sustainable_fisheries/gulf_fisheries/generic/archives/generic_acl_am_amend_sept_2011.pdf

**Per email from J. Stephen 12/16/2016 Just wanted to make everyone aware of the change in the Tilefish grouping that occurred in 2012. If you look at the Gulf SEDAR 22 document it lists the following species for tilefish: golden tilefish, blueline tilefish, goldface tilefish, blackline tilefish, and anchor tilefish. IN 2010, when the IFQ program began all 5 species were included in the Tilefish share category. In 2012, both anchor and blackline tilefish were removed from the IFQ share category for tilefish.

3. Assessment History and Review

The distribution of Blueline Tilefish extends into three separate council regions from the Gulf of Mexico near Texas, along the Atlantic Coast to New Jersey. It is therefore managed by three separate entities in their respective regions: Gulf of Mexico, South Atlantic, and Mid-Atlantic, Fishery Management Councils. However, it has only formally been assessed in the South Atlantic Council Region.

In 2004, data relevant to assessment of Blueline Tilefish were assembled, though an official stock assessment was not conducted (SEDAR 2004). The first and only stock assessment of blueline tilefish in the South Atlantic to date was completed in 2013 during SEDAR 32 (2013). The primary model was a statistical catch-at-age model (Beaufort Assessment Model; BAM) coded using AD Model Builder (ADMB), while an age-aggregated surplus production model (using ASPIC software) and an age-structured surplus production model were considered secondary models. The stock was found to be undergoing overfishing, since current fishing mortality toward the end of the assessment (geometric mean F from 2009-2011) exceeded F_{MSY} ($F_{current}/F_{MSY} = 2.37$), and was found to be overfished since the 2011 spawning biomass was below the Minimum Stock Size Threshold ($SSB_{2011}/MSST = 0.909$). Trends in stock status from both production models were similar to the catch-at-age model.

Due to high aging error in Blueline Tilefish identified in early 2016, an aging workshop was held on August 29-30, with participants from multiple labs. Instead of converging on a set of best methods for aging Blueline Tilefish, the assembled team of experts found that problems with aging were more serious than previously thought. As stated in the Aging Workshop Report “The consensus of the participants of the workshop is that Blueline Tilefish could not be precisely aged at this time” (Potts et al. 2016). So although SEDAR 32 used Blueline Tilefish age data, they are now considered unreliable for use in stock assessment models.

Literature Cited

Potts, J., Ostrowski, A., Lytton, A., Spanik, K., Ballenger, J., Robillard, E., Rogers, K., Schmidtke, M., Willett, N., and Klibansky, N. 2016. Blueline Tilefish Age Workshop II. SEDAR50-DW18. SEDAR, North Charleston, SC. 36.

SEDAR. 2004. SEDAR 4: Stock Assessment of the Deepwater Snapper□Grouper Complex in the South Atlantic. Southeast Data, Assessment, and Review (SEDAR), North Charleston, South Carolina.: 594.

SEDAR. 2013. SEDAR 32: South Atlantic Blueline Tilefish Stock Assessment Report. Southeast Data, Assessment, and Review (SEDAR), North Charleston, South Carolina. p. 378.

4. Regional Maps

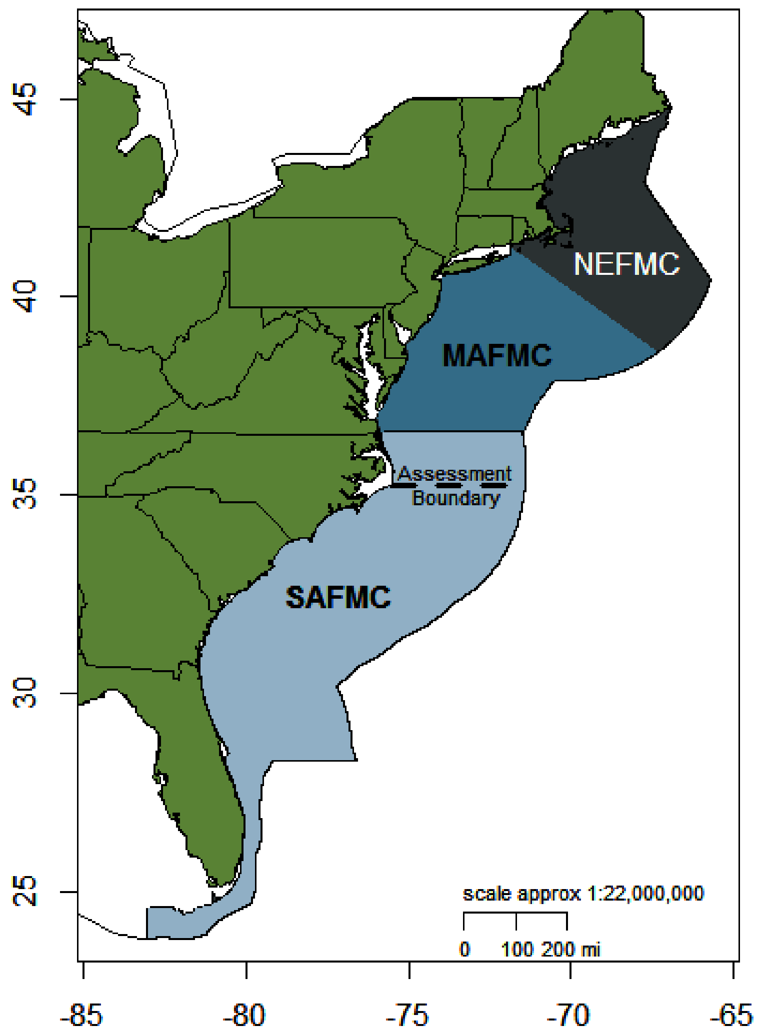

Figure 4.1: SAFMC and MAFMC jurisdictional boundaries. Boundary between MAFMC and NEFMC is for display purposes only. SEDAR 50 developed models for two regions: Cape Hatteras, NC south through the SAFMC/GMFMC jurisdictional line and Cape Hatteras, NC north through the MAFMC jurisdiction.

5. SEDAR Abbreviations

APAIS	Access Point Angler Intercept Survey
ABC	Allowable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
AMRD	Alabama Marine Resources Division
ASMFC	Atlantic States Marine Fisheries Commission
ASPIC	a stock production model incorporating covariates
ASPM	age-structured production model
B	stock biomass level
BAM	Beaufort Assessment Model
BMSY	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort
EEZ	exclusive economic zone
F	fishing mortality (instantaneous)
FMSY	fishing mortality to produce MSY under equilibrium conditions
FOY	fishing mortality rate to produce Optimum Yield under equilibrium
FXX% SPR	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
FMAX	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F0	a fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fish and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	general linear model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network

HMS	Highly Migratory Species
LDWF	Louisiana Department of Wildlife and Fisheries
M	natural mortality (instantaneous)
MAFMC	Mid-Atlantic Fishery Management Council
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MDMR	Mississippi Department of Marine Resources
MFMT	maximum fishing mortality threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MRIP	Marine Recreational Information Program
MSST	minimum stock size threshold, a value of B below which the stock is deemed to be overfished
MSY	maximum sustainable yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	optimum yield
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS Corporation
SC DNR	South Carolina Department of Natural Resources
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	Southeast Data, Assessment and Review
SEFIS	Southeast Fishery-Independent Survey
SEFSC	Fisheries Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Fisheries Southeast Regional Office, National Marine Fisheries Service
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.

TPWD	Texas Parks and Wildlife Department
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 50

Atlantic Blueline Tilefish

SECTION II: Data Workshop Report

March 2017

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

1. Introduction

1.1 Workshop Time and Place

The SEDAR 50 Stock ID Work Group meeting was held June 28-30, 2016 in Raleigh, North Carolina. A Stock ID Joint SSC Sub-panel review, including representatives from the Mid-Atlantic, South Atlantic, and Gulf of Mexico Fishery Management Councils' Science and Statistical Committees, was held via webinar October 28, 2016. A Stock ID Management and Science Leadership conference call was held November 14, 2016 with representatives from NMFS and Mid-Atlantic, South Atlantic, and Gulf of Mexico Leadership.

The SEDAR 50 Data Workshop (DW) was held January 23 – 27, 2017 in Charleston, South Carolina. Two data webinars were held prior to the workshop on November 15 and December 13, 2016 and a post-DW webinar was held February 2, 2017.

1.2 Terms of Reference

1. Define the unit stock for the SEDAR 50 stock assessment to include the entire US Atlantic Seaboard, using the boundary between the Gulf of Mexico and South Atlantic Councils as the southwestern boundary for the stock unit to assess.
2. Review, discuss, and tabulate available life history information.
    - Evaluate age, growth, natural mortality, and reproductive characteristics
    - Provide appropriate models to describe population and fleet specific (if warranted) growth, maturation, and fecundity by age, sex, or length as applicable.
    - Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling.
    - Provide estimates or ranges of uncertainty for all life history information.
3. Recommend discard mortality rates.
    - Review available research and published literature
    - Consider research directed at these species as well as similar species from the SE and other areas.
    - Provide estimates of discard mortality rate by fishery, gear type, depth, and other feasible or appropriate strata.
    - Include thorough rationale for recommended discard mortality rates.
    - Provide justification for any recommendations that deviate from the range of discard mortality provided in the last benchmark or other prior assessment.
    - Provide estimates of uncertainty around recommended discard mortality rates.
4. Provide measures of population abundance that are appropriate for stock assessment.
    - Consider and discuss all available and relevant fishery dependent and independent data sources.
    - Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics.

- Provide maps of fishery and survey coverage.
- Develop fishery and survey CPUE indices by appropriate strata (e.g., age, size, area, and fishery) and include measures of precision and accuracy.
- Discuss the degree to which available indices adequately represent fishery and population conditions.
- Recommend which data sources are considered adequate and reliable for use in assessment modeling.
- Rank the available indices with regard to their reliability and suitability for use in assessment modeling.
- Provide appropriate measures of uncertainty for the abundance indices to be used in stock assessment models.

5. Provide commercial catch statistics, including both landings and discards in both pounds and number.
    - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear.
    - Provide length and age distributions for both landings and discards if feasible.
    - Provide maps of fishery effort and harvest.
    - Provide estimates of uncertainty around each set of landings and discard estimates.
6. Provide recreational catch statistics, including both landings and discards in both pounds and number.
    - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear.
    - Provide length and age distributions for both landings and discards if feasible.
    - Provide maps of fishery effort and harvest.
    - Provide estimates of uncertainty around each set of landings and discard estimates.
7. Consider ecosystem and climate issues that could affect population dynamics. Identify and describe available data sources to investigate the effects of abiotic and biotic factors, for example climate change, predator/prey interactions, etc., on recruitment, growth, geographic distribution and natural mortality.
8. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.
9. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines (Section II. of the SEDAR assessment report).

1.3 List of Participants

Data Workshop Panelists

Joey Ballenger, SCDNR
Alan Bianchi, NCDMF
Ken Brennan, SEFSC-Beaufort
Steve Brown*, FL FWCC
Wally Bubley, SCDNR
Julie Califf*, GADNR
Rob Cheshire, SEFSC-Beaufort
Joe Cimino, VMRC
Wiley Coppersmith, Fisherman
Kevin Craig, SEFSC-Beaufort
Julie DeFilippi-Simpson, ACCSP
Amy Dukes, SCDNR
Skip Feller*, Fisherman
Eric Fitzpatrick, SEFSC-Beaufort
Kelly Fitzpatrick*, SEFSC-Beaufort
David Gloeckner, SEFSC-Miami
Jeff Gutman*, Fisherman
Pat Harris*, ECU
Eric Hiltz, SCDNR
Rusty Hudson, Fisherman
Cynthia Jones*, ODU/MAFMC SSC
Nikolai Klibansky, SEFSC-Beaufort
Kathy Knowlton*, GADNR
Kevin Kolmos, SCDNR
Anne Lange, SAFMC SSC
Lee Lavery, Fisherman
Vivian Matter, SEFSC-Miami
Kevin McCarthy, SEFSC-Miami
Paul Nitschke, NEFSC
Andy Piland, Fisherman
Jennifer Potts, SEFSC-Beaufort
Refik Ohrun*, SEFSC-Miami
Andy Ostrowski, SEFSC-Beaufort
Marcel Reichert, SCDNR/SAFMC SSC
Beverly Sauls*, FL FWCC
Michael Schmidtke, ASMFC
Steve Shelley, Fisherman
Tracey Smart, SCDNR
Tom Sminkey, NMFS S&T
Chris Wilson*, NCDMF
Beth Wrege, SEFSC-Miami
Erik Williams, SEFSC-Beaufort

* Appointees marked with an * were appointed to the workshop panel but did not attend the workshop. Most provided data and reviewed the use of the data, and were available via email or phone for questions as needed.

Council Representatives

Mark Brown, SAFMC
Michelle Duval, SAFMC
Tony DeLernia*, MAFMC
Dewey Hemilright, MAFMC

*Did not attend workshop.

Council and Agency Staff

Julia Byrd, SEDAR Coordinator
Mike Collins, SAFMC staff
John Carmichael, SAFMC staff/SEDAR
Jason Didden, MAFMC staff
Mike Errigo, SAFMC staff

Nick Farmer*, SERO
Jeff Pulver, SERO

*Participated in webinars but did not attend the Data Workshop.

Data Workshop Observers
Michelle Falk, SCDNR
Keilin Gamboa, SCDNR
Heather Konell, ACCSP
Stephen Long, SCDNR
Adam Lytton, SCDNR
Julia Reynolds, SCDNR
Kevin Spanik, SCDNR
Kayla Spry, SCDNR
Michelle Willis, SCDNR
David Wyanski, SCDNR

Webinar Observers
Anna Beckwith, SAFMC
Heather Konell, ACCSP
Stephen Long, SCDNR
Adam Lytton, SCDNR
Anne Markwith, NCDMF
Ryan Rindone, GMFMC staff
Walt Rogers, SEFSC-Beaufort
Kevin Spanik, SCDNR
Kayla Spry, SCDNR
Jessica Stephen, SERO
Michelle Willis, SCDNR
David Wyanski, SCDNR

1.4 List of Data Workshop Working Papers

Atlantic Blueline Tilefish Data Workshop document list. List includes documents submitted for the Stock ID Work Group meeting through the Data Workshop.

Document #	Title	Authors
	Documents Prepared for the Data Workshop (DW)	
SEDAR50-DW01	Brief Summary – Habitat and Developing Spatial Species Information for Blueline Tilefish in the South Atlantic Region	Pugliese 2016
SEDAR50-DW02	Summary of the 2015 Blueline Tilefish cooperative-with-industry data collection project	Kellison 2016
SEDAR50-DW03	A Preliminary Assessment of Reproductive Parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida ****SEE SEDAR50-DW19 FOR FINAL REPRODUCTIVE ANALYSES**	Kolmos et al. 2016
SEDAR50-DW04	Distribution of scientifically collected Blueline Tilefish (*Caulolatilus microps*) in the Atlantic, and associated habitat	Klibansky 2016
SEDAR50-DW05	Summary of the results of a genetic-based investigation of Blueline Tilefish (*Caulolatilus microps*)	McDowell 2016

SEDAR50-DW06	Preliminary Genetic Population Structure of Blueline Tilefish *Caulolatilus microps* along the East Coast of the United States	O'Donnell and Darden 2016
SEDAR50-DW07	Description of age and growth for Blueline Tilefish, *Caulolatilus microps*, caught north and south of Cape Hatteras, NC	Schmidtke and Jones 2016
SEDAR50-DW08	Standard Operative Procedure for Embedding and Sectioning Blueline Tilefish (*Caulolatilus microps*)	Ostrowski 2016
SEDAR50-DW09	Summary of Northeast Fisheries Science Center Blueline Tilefish Survey Data	Nitschke and Miller 2016
SEDAR50-DW10	Summary of Mid-Atlantic Commercial Blueline Tilefish Data	Nitschke and Miller 2016
SEDAR50-DW11	Distribution of Blueline Tilefish (Caulolatilus microps) in the U.S. EEZ from fishery-dependent and fishery-independent data collections	Farmer and Klibansky 2016
SEDAR50-DW12	**Recommendations from the SEDAR 50 (Blueline Tilefish) Stock ID Work Group Meeting**	**SEDAR 50 Stock ID Work Group 2016**
SEDAR50-DW13	Comparison of Blueline Tilefish Otolith Derived Ages: Comparing Increment Counts Derived by Readers from NMFS SEFSC-Beaufort and SCDNR Age Laboratories	Ballenger 2017
SEDAR50-DW14	TBD	TBD
~~SEDAR50-DW15~~	SEDAR 50 Public Comments – visit the following link to view public comments submitted for SEDAR 50 https://safmc.wufoo.com/reports/sedar-50-public-comments/	
SEDAR 50-DW16	**SEDAR 50 Stock Identification Joint SSC Review Webinar Consensus Statements**	**Joint SSC Sub-Panel 2016 (Includes MAFMC, SAFMC, GMFMC representatives)**
SEDAR 50-DW17	**SEDAR 50 Stock Identification – Management/Science Call Recommendations**	**Council, Science Center, and Regional Office Leadership**
SEDAR50-DW18	Blueline Tilefish Age Workshop II	Potts et al. 2016
SEDAR50-DW19	Reproductive parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida	Kolmos et al. 2017

SEDAR50-DW20	Virginia Blueline Tilefish Data Collection Summary	Cimino 2017
SEDAR50-DW21	Summary of the Blueline Tilefish meristic conversions using data from the entire US Atlantic and Gulf of Mexico	Ballew and Potts 2016
SEDAR50-DW22	SEDAR 50 Discard Mortality Ad-hoc Group Working Paper	Discard mortality ad-hoc group
SEDAR50-DW23	Estimating dispersal of Blueline Tilefish (*Caulolatilus microps*) eggs and larvae from drifter data	Klibansky 2017
SEDAR50-DW24	ToR #7 Ad Hoc Work Group Working Paper	ToR #7 Ad-Hoc Work Group
SEDAR50-DW25	Standardized catch rates of Blueline Tilefish (*Caulolatilus microps*) in the South Atlantic and Gulf of Mexico waters of the U.S. from recreational headboat logbook data	SFB-NMFS 2017
SEDAR50-DW26	Standardized catch rates of Blueline Tilefish (*Caulolatilus microps*) in the South Atlantic and Gulf of Mexico waters of the U.S. from commercial logbook handline data	SFB-NMFS 2017
SEDAR50-DW27	Standardized catch rates of Blueline Tilefish (*Caulolatilus microps*) in the South Atlantic and Gulf of Mexico waters of the U.S. from commercial logbook longline data	SFB-NMFS 2017
SEDAR50-DW28	SEDAR 50 additional management actions provided by R. Hudson	Hudson 2017
Final Assessment Reports		
SEDAR50-SAR1	Assessment of Atlantic Blueline Tilefish	To be prepared by SEDAR 50
Reference Documents		
SEDAR50-RD01	SEDAR 32 South Atlantic Blueline Tilefish Stock Assessment Report	SEDAR 32
SEDAR50-RD02	List of documents and working papers for SEDAR 32 (South Atlantic Blueline Tilefish and Gray Triggerfish) – all documents available on the SEDAR website.	SEDAR 32
SEDAR50-RD03	Managing A Marine Stock Portfolio: Stock Identification, Structure, and Management of 25 Fishery Species along the Atlantic Coast of the United States	McBride 2014
SEDAR50-RD04	Workshop to Determine Optimal Approaches for	Carmichael et al.

	Surveying the Deep-Water Species Complex Off the Southeastern U.S. Atlantic Coast	2015
SEDAR50-RD05	Report to Virginia Marine Resources Commission: Grant F-132-R-2 The Population Dynamics of Blueline and Golden Tilefish, Snowy and Warsaw Grouper and Wreckfish	Schmidtke et al. 2015
SEDAR50-RD06	Estimated Catch of Blueline Tilefish in the Mid-Atlantic Region: Application of the Delphi Survey Process	Allen et al. 2016
SEDAR50-RD07	MAFMC Memo: Blueline Tilefish Catch Series – Feb 23, 2016	Didden 2016
SEDAR50-RD08	Reproductive Biology of the Blueline Tilefish, Caulolatilus microps, off North Carolina and South Carolina	Ross and Merriner 1983
SEDAR50-RD09	Fish species associated with shipwreck and natural hard-bottom habitats from the middle to outer continental shelf of the Middle Atlantic Night near Norfolk Canyon	Ross et al. 2016
SEDAR50-RD10	Systematics and Biology of the Tilefishes (Perciformes: Branchiostegidae and Malacanthidae), with Descriptions of Two New Species	Dooley 1978
SEDAR50-RD11	Integrating DNA barcoding of fish eggs into ichthyoplankton monitoring programs	Lewis et al. 2015
SEDAR50-RD12	Age, growth, and reproductive biology of Blueline Tilefish along the southeastern coast of the United States, 1982-1999	Harris et al. 2004
SEDAR50-RD13	Description of the Circulation on the Continental Shelf	Bumpus 1973
SEDAR50-RD14	Spawning Locations for Atlantic Reef Fishes off the Southeastern U.S.	Sedberry et al. 2006
SEDAR50-RD15	Observations and a Model of the Mean Circulation over the Middle Atlantic Bight Continental Shelf	Lentz 2008
SEDAR50-RD16	Modeling larval connectivity of the Atlantic surfclams within the Middle Atlantic Bight: Model development, larval dispersal and metapopulation connectivity	Zhang et al. 2015
SEDAR50-RD17	Tilefishes of the Genus *Caulolatilus* Construct Burrows in the Sea Floor	Able et al. 1987
SEDAR50-RD18	Delineation of Tilefish, *Lopholatilus chamaeleonticeps*, Stocks Along the United States	Katz et al. 1983

	East Coast and in the Gulf of Mexico	
SEDAR50-RD19	Chapter 22: Interdisciplinary Evaluation of Spatial Population Structure for Definition of Fishery Management Units (excerpt from Stock Identification Methods – Second Edition)	Cadrin et al. 2014
SEDAR50-RD20	Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey and its partners	Smart et al. 2015
SEDAR50-RD21	Age, Growth, and Mortality of Blueline Tilefish from North Carolina and South Carolina	Ross and Huntsman 1982
SEDAR50-RD22	Radiocarbon from nuclear testing applied to age validation of black drum, *Pogonias cromis*	Campana and Jones 1998
SEDAR50-RD23	A long- lived life history for a tropical, deepwater snapper (*Pristipomoides filamentosus*): bomb radiocarbon and lead-radium dating as extensions of daily increment analyses in otoliths	Andrews et al. 2012
SEDAR50-RD24	Age and growth of bluespine unicornfish (*Naso unicornis*): a half-century life-span for a keystone browser, with a novel approach to bomb radiocarbon dating in the Hawaiian Islands	Andrews et al. 2016
SEDAR50-RD25	Age, growth and reproduction of the barrelfish *Hyperoglyphe perciformis* (Mitchill) in the western North Atlantic	Filer and Sedberry 2008
SEDAR50-RD26	Age, growth, and spawning season of red bream (*Beryx decadactylus*) off the southeastern United States	Friess and Sedberry 2011
SEDAR50-RD27	Great longevity of speckled hind (*Epinephelus drummondhayi*), a deep-water grouper, with novel use of postbomb radiocarbon dating in the Gulf of Mexico	Andrews et al. 2013
SEDAR50-RD28	Refined bomb radiocarbon dating of two iconic fishes of the Great Barrier Reef	Andrews et al. 2015
SEDAR50-RD29	Age validation of the North Atlantic stock of wreckfish (*Polyprion americanus*), based on bomb radiocarbon (^{14}C), and new estimates of life history parameters	Lytton et al. 2016
SEDAR50-RD30	Stock Complexes for Fisheries Management in the Gulf of Mexico	Farmer et al. 2016
SEDAR50-RD31	Modelling community structure and species co-occurrence using fishery observer data	Pulver et al. 2016
SEDAR50-RD32	Descriptions of the U.S. Gulf of Mexico Reef Fish	Scott-Denton et al.

	Bottom Longline and Vertical Line Fisheries Based on Observer Data	2011
SEDAR50-RD33	Natural mortality estimators for information-limited fisheries	Kenchington 2014
SEDAR50-RD34	The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural systems and aquaculture	Lorenzen 1996
SEDAR50-RD35	Mortality Rate of Fishes in the Pelagic Ecosystem	Peterson and Wroblewski 1984
SEDAR50-RD36	A Mathematical Model of Some Aspects of Fish Growth, Respiration, and Mortality	Ursin 1967
SEDAR50-RD37	MAFMC Memo: Blueline Tilefish Catch Series – Mar 14, 2016	Didden 2016
SEDAR50-RD38	Mid-Atlantic Fishery Management Council SSC Memo: Proposed BLT Subcommittee Report – March 22, 2016	Miller 2016

2. Life History

2.1 Overview (Group Membership, Leader, Issues)

Panel
Jennifer Potts – NOAA Fisheries, Group Leader
Marcel Reichert – SCDNR / SA SSC
Tracey Smart – SCDNR
Wally Bubley – SCDNR
Kevin Kolmos – SCDNR
Michael Schmidtke – ASMFC
Andy Ostrowski – NOAA Fisheries
Nikolai Klibansky – NOAA Fisheries

Observers
Adam Lytton – SCDNR
Kevin Spanik – SCDNR
Michelle Willis – SCDNR
David Wyanski – SCDNR

The main issue for this assessment facing the Life History Group is the decision to not use age data. Following extensive exchanges (n > 1200) of age samples between three laboratories (NOAA Fisheries, SCDNR, and ODU) and an age workshop, the primary age readers could not reach consensus on how to age Blueline Tilefish (*Caulolatilus microps;* blueline). Because of that decision, the group needed to determine if proxies for growth model parameters could be determined and natural mortality estimated. Another issue was the stock definition of the species, despite the final decision made by NOAA fisheries and Fishery Management Council leadership to limit this assessment to Council jurisdictional boundaries.

2.2 Review of Working Papers

SEDAR50-DW02
Summary of the 2015 Blueline Tilefish cooperative-with-industry data collection project

<u>**Synopsis**</u>
This study documents efforts to collect biological samples from fish in the deepwater species complex focusing on blueline, to provide life history data to stock assessment. Field operations were conducted in 2015 by cooperating with fishermen to catch fish with short- or long-bottom longline, or vertical haul lines, while biological sampling was conducted by at-sea observers. Sampling effort was spread over seven latitudinal zones (FL Keys to NJ Hudson Canyon) and three depth strata (250-750+ ft). Biological data obtained from these fish included size data, otoliths for aging, gonads for reproductive studies, and fin clips for genetics work. Otoliths, gonad tissue, and fin clips were sent to NMFS Beaufort, SCDNR, and VIMS, respectively, for processing. The efforts collected 1026 blueline and individuals of many other species. Tables provided in the paper indicate numbers of blueline caught and CPUE by depth stratum, latitudinal zone, and gear type. By far, the highest CPUEs were in 250-500 ft, Cape Hatteras to Norfolk Canyon, with short-bottom longline gear.

Review

The study was well designed and yielded the targeted samples. Some caution should be taken when utilizing the data results. The caveats mentioned in the report: samples were not collected throughout the range, a single cooperating fisherman sampled an entire stratum, and sites were selected to maximize catching target species. Noted that details of sample processing and analysis of genetic samples (SEDAR50-DW05) and reproductive tissues (SEDAR50-DW19)) are not included in the report.

SEDAR50-DW07
Description of age and growth for Blueline Tilefish, *Caulolatilus microps*, caught north and south of Cape Hatteras, NC

Synopsis

This study is a description of a study on the age and growth of blueline. The paper provides growth information, including an evaluation of bias. The sample size (n=2,104) and methodology for collecting and processing otoliths was sound. The paper includes a marginal increment analysis, but the authors remark that the limited range precluded conclusions of formation periodicity.

Review

As SEDAR 50 will not include age data, the majority of information in this working document is no longer relevant for this assessment. If age data can be used in the future, sexual dimorphism should be discussed. Length/ length relationships were provided and these length data were included in the over-all meristic conversion analysis for SEDAR 50.

SEDAR50-DW08
Standard Operative Procedure for Embedding and Sectioning Blueline Tilefish (*Caulolatilus microps*)

Synopsis

The NOAA Fisheries Sustainable Fisheries Branch, Life History Group at the Center for Coastal Fisheries and Habitat Research (Beaufort, NC) described their protocol standardized processing technique for blueline otoliths used for age estimations. Sagittal otoliths were marked on the core and with the associated collection number prior to being embedded in an epoxy resin. The resin block was trimmed, affixed to a microscope slide with crystal bond, and three dorso-ventral transverse sections (~0.4-0.5 mm thickness) were taken using a low-speed Isomet saw. The sections were affixed to labeled slides with crystal bond and polished to 0.32 mm thickness before a liquid coverslip was applied. An appendix is also included to describe in detail how the epoxy is mixed and poured into the molds.

Review

The description appears straightforward and very thorough with images to elucidate procedures. The method is similar in essence to what has been done in other labs that process blueline otoliths and is appropriate for this species. Use of the embedding technique described in this paper, in particular, helps reduce chances of losing or breaking these relatively small and fragile otoliths. Other groups should be able to reproduce these processes though some of the organizational steps may be modified for individual groups for efficiency sake based on lab set-up without affecting the outcomes.

SEDAR50-DW13
Comparison of Blueline Tilefish Otolith Derived Ages: Comparing Increment Counts Derived by Readers from NMFS SEFSC-Beaufort and SCDNR Age Laboratories

Synopsis:
This paper reports the results of an inter-laboratory comparison of blueline otolith ageing to assess potential bias within and among SC-DNR and the NMFS-Beaufort ageing labs. The symmetry test between SCDNR Reader 1 and Reader2 suggests only marginal lack of symmetry between the readers ages ($p = 0.0453$), but the NMFS-Beaufort reader exhibited a significant difference and bias relative to both of the SC-DNR readers.

Review
Methods used were appropriate for the analyses described in this paper, and point out the need for calibration among laboratories engaged in ageing blueline. Further analyses are needed to validate a coastwide aging protocol. Minor edit suggestions below:

- Pdf p. 4: "SEDAR 50-WPXX"
- Pdf p. 4: Should SEDAR 41 be SEDAR 50?

SEDAR50-DW18
Blueline Tilefish Age Workshop II

Synopsis
This document contains a summary of 2016 Blueline Tilefish Ageing Workshop (August 29-32, 2016) and what led to the need for this workshop. This workshop was the second one among NMFS, ODU, and SCDNR, the laboratories actively engaged in ageing blueline from the Atlantic coast. The need for a workshop was due to disagreements among readers from the various labs and new information from a SCDNR bomb radiocarbon study. Workshop participants identified several areas that may have led to reader discrepancies, including 1) variation in increment or annulus count depending on the area of the otolith section that was read, 2) decisions relative to counting groups of opaque zones as a single annulus, or counting each of those opaque zones as an individual annulus, and 3) consistency in identifying the first annulus. Overall, the recommendation by the participants was that they could not produce precise ages in time for the assessment. The report recommended several approaches to address research needs.

Review

The information presented in the report well documents the challenges in ageing blueline. The research recommendations should be given a high priority if the laboratories are to move forward with ageing this fish for stock assessment purposes.

SEDAR50-DW19

Reproductive parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida

Synopsis (quoting Executive Summary from document)

"Blueline analyzed for life history were collected from Virginia to Florida (approximately between 37.5°N and 24.3°N), by fishery-independent and fishery-dependent sources throughout 1979 – 2015 (n= 2,548 to date). If necessary, total length (mm) was converted to fork length (mm) using a meristic conversion from Ballew and Potts (2017; Table 1), producing a range from 307 – 910 mm FL. The reproductive phase of 2,437 samples from males and females was assessed using criteria listed in Brown-Peterson et al. (2011). Observed sex ratio was 1.19:1 (Female: Male). Females reached sexual maturity as small as 312 mm FL and are considered 100% mature by 365 mm FL. Estimates of female length at 50% maturity ranged from 299 - 312 mm FL, with the logit model providing the best fit (305 mm; CV = 0.447). Females with spawning indicators were collected from February – November. Spawning females, with available location data (n=950), were collected largely from South Carolina, North Carolina, and Virginia; however, spawning individuals were found in all states throughout this study. Spawning fraction was calculated based on size, and found to range between 0.24 - 0.40, with an overall fraction of 0.31. The number of spawning events during the spawning season ranged from 57 – 102, with an overall average of 94 events."

Review

Overall, the research methods are solid with a large sample size (n=2,548), wide range in fish size (301-910 mm FL) and locations collected (VA to FL). The results were straightforward and well-presented including sex ratio, reproductive phase and timing, and spawning by size in an understandable way. The executive summary generally does a thorough job describing the results, but could incorporate more of them (i.e. spawning fraction, logistic results).

Overall, this data is very useful and recommend using it in the assessment. A research recommendation should be included to find more fish that are immature.

Some comments/suggestions/questions:

The methods section needs revision for clarity. Total length is described at a later section where it seems more appropriate. What kind of sample was the ODU sampling? Dependent or independent? Also, were microscopic determinations done the same way as SCDNR?

In the Spawning fraction section: is Northern Anchovy the standard species for comparison? I understand since it is in the same temperature range for some of blueline, however, would it be more appropriate to use a more similar species if available?

Sex ratio: the sample size reasoning for significantly different sex ratios seems weak. VA had similar sample size as NC and similar sex ratio as SC, where a bulk of the samples are from; however, that was the reasoning for the significant difference. Could sampling techniques (fisheries dependent vs independent) be a better reason? This should be revisited.

SEDAR50-DW20
Virginia Blueline Tilefish Data Collection Summary

Synopsis

A description of fishery-dependent and fishery-independent sampling efforts for blueline, by Virginia Marine Resources (VMRC) is provided. The Virginia Marine Sportfish Sampling Program is a fishery-dependent program developed by VMRC to sample recreationally important fish species that are not typically sampled in the commercial fishery. This consisted of an incentive based carcass collection program, which included blueline to get lengths, weights, and otoliths from the recreational fishery by distributing freezers at high traffic weigh stations having certified scales, with the freezers emptied as needed. The fishery-independent program was a four year federal grant funded program (2009-2012) to utilize for-hire headboats and charter vessels in an attempt to collect length, weight, age (otoliths), and reproductive (macroscopic sexing and staging) information for blueline. This consisted of 43 sampling trips over this time period. Ageing structures from both fishery-dependent and fishery-independent programs were sent to the Old Dominion University Center for Quantitative Fisheries Ecology (CQFE) for processing and age estimates. A subset of those collected from 2007-2012 were processed and aged, while remaining otoliths collected between 2007 and 2016 have yet to be aged.

Review

This description of the program is very brief and raised some questions in regards to the methodology as well as the numbers of samples attributed to each program. In the fishery-dependent program, privately donated fish from the freezers cannot be considered randomly sampled, are likely subject to selectivity biases. Although length-weight conversions are well supported, there is potential for discrepancies to arise from differences between filleted vs whole fish as well as fresh vs frozen. There is also no description of the locations to inform spatial distribution of sites or the numbers of locations. Data from the fishery-dependent sampling could possibly be used to characterize the biological samples as they may be under-represented size classes at the tails of the distribution, but due to non-random sampling and potential issues with precision of measurements, the data should not be considered for length or age catch characterization of the recreational blueline fishery in VA.

Methods regarding the fishery-independent catch program described in this working paper could benefit from further detail. Specifically, more information on fishing gear and deployment and retrieval protocol, measurements, as well as spatial and temporal sampling description would allow for more accurate assessment of the value of the survey. Additionally, more information on the macroscopic reproductive staging criteria is needed, as there are no citations or descriptions to find the standard methodology utilized by VMRC (Index of Finfish Sexual Maturity).

Further information on the processing and interpretation of ageing samples in this study would be useful in order to compare with other data providers involved in the current assessment. Due to the difficulties interpreting annuli and lack of consensus on blueline otoliths reported from a recent ageing workshop, the life history working group has recommended not using age data for this assessment. While the ageing samples provided from this study will not be immediately utilized, they could provide valuable information for fishery management research endeavors in the future. The summary table would be more useful by breaking out the number of samples obtained/processed/aged individually by each program to inform the panel as to the composition of these data.

SEDAR50-DW21
Summary of the Blueline Tilefish meristic conversions using data from the entire US Atlantic and Gulf of Mexico

<u>Synopsis</u>
This paper describes the data and analysis used for the meristic conversions (length/length, length/weight, and weight/weight) for SEDAR50. Equations and variability were provided for all conversions and this information is critical for the SEDAR Data Workshop.

<u>Review</u>
The paper did a thorough job of exploring the presence and potential differences in meristic conversions by location and reporting these findings. The R^2 values appear to show strong relationships for the respective models and there were no biologically significant differences between the various regions. Whole weight/gutted weight was only available for 190 fish from the Atlantic region. Although the R^2 value was high, more data of a broader geographic range is need.

Note that at the DW, the whole weight gutted weight conversion analysis was adjusted to include a data set that was not included in the data provided prior to the DW but was included in SEDAR32. SEDAR50-DW21 was revised to include these data. This issue also highlights the importance that all data providers provide all data by the data deadlines as outlined in the SEDAR Best Practices guidelines.

SEDAR50-DW22
Discard Mortality Ad-hoc Group Working Paper

<u>Synopsis</u>

A description and findings of commercial and recreational sampling efforts to determine discard mortality rates through surface observations for blueline, by observer programs off the Southeastern US in both Gulf of Mexico and Atlantic waters. Commercial sectors were sampled by NMFS observers in the Gulf of Mexico from July 2006-December 2015. Recreational sectors were sampled region-wide by observers in the for-hire headboat from 2005-2015 and from Florida for charter vessels from 2009-2015, though limited information on discards were available. Depth and barotraumatic stress indicators, and if venting occurred were recorded for the commercial sector. Depth and barotraumatic stress indicators, though correlated, were determined to be major factors in immediate discard mortality for all gears in the commercial sector. An optimistic estimate of mortality of 90% when accounting for delayed mortality (50%) of the fish that resubmerged (20%) was provided, with the potential for discard mortality to be 100%. Longline commercial fishermen fished in deeper depths and had more instances of barotraumatic stress than vertical hook-and-line commercial fishermen. The recreational sector tended to fish in shallower depths, just as the commercial hook-and-line did.

<u>Review</u>

This description of the programs is brief, but citations further explaining the methods are provided. The conclusions regarding discard mortality from the commercial sector take into account barotraumatic affects in delayed mortality. While the numbers (90%-100% discard mortality) are presumably in the general area, there are no data to confirm these values due to limited work done with delayed discard mortality of deep-water species. It is also noted that values for the Atlantic may vary due to gear, depth, water temperatures, etc. The recreational estimates of discard mortality could not be made independently from other sectors due to limited encounters with blueline (70 fish total) and even fewer discards observed (1 fish). In general, there are limited data to determine discard mortality in this deep-water species and these values are reasonable based on available science. The resulting uncertainty should be taken into account in the assessment.

SEDAR50-DW23
Estimating dispersal of Blueline Tilefish (*Caulolatilus microps*) eggs and larvae from drifter data

<u>Synopsis</u>

The analysis of oceanographic currents and distribution of blueline in the U.S. South Atlantic region was considered in regards to a potential mechanism for egg and larval dispersal. Surface drifters deployed in the Gulf of Mexico and along the U.S. Atlantic coast were used to estimate possible transport, assuming buoyant eggs and larvae and a typical pelagic larval duration and using adult areas as starting points. High concentrations of blueline adults were reported off the west FL shelf. The Loop Current in the area could easily deliver pelagic eggs or larvae to Atlantic side of Florida. Model predicts that transport from western Florida can get to eastern Florida in about a week. By week six (6), the larvae could be off the mid-Atlantic coast of the US. The likelihood that larvae from central or western Gulf of Mexico (GOM) go into Atlantic is relatively low. Also, based on surface drifters, there may be very restricted transport from Atlantic to the GOM.

Review
The study presents a plausible way for blueline to be dispersed from the GOM to the US South Atlantic and northward to the mid-Atlantic region. A better understanding of spawning potential and early life history of blueline is needed to be sure of this transport mechanism. These parameters should also be correlated to the densities of tilefish in each area represented by the drifters to proportionally represent larval movements of blueline into and out of each management zone.

2.3 Stock Definition and Description

Stock definition of Blueline Tilefish was explored during the SEDAR 50 Stock ID Workshop held in June 2016 (SEDAR50-DW12). Recommendations from this workshop were reviewed on October 28, 2016 via a webinar by representatives from the Fishery Management Council's SSCs of the Mid-Atlantic, South Atlantic, and Gulf of Mexico (SEDAR50-DW16). The Stock ID workshop recommendations and SSC subcommittee consensus statements were further reviewed on a SEDAR 50 Stock ID management and science leadership call in November 2016 (SEDAR50-DW17). During the stock ID workshop, scientific data on Blueline Tilefish stock structure, was presented from three topic areas: genetics, life history, and spatial distribution. Two separate and independent genetic studies, one from VIMS, and one from SCDNR, presented genetic information on population structure. The studies included samples from Hudson Canyon at the northern end of the range through the Florida Keys, as well as a small set of samples from the west Florida shelf in the Gulf of Mexico. The Stock ID Workshop concluded that:

"there is no scientific evidence of genetic heterogeneity within blueline across sampled locations, despite thorough genetic analysis. The data and analysis support a single, panmictic genetic population extending from the Hudson Canyon south to the Florida Keys with further indication of connectivity in the northeastern Gulf of Mexico (based on smaller sample sizes of fish collected on the West Florida shelf)."

Life history data were limited to information on reproductive biology (sex ratio, spawning seasonality, maturity, and spawning fraction) and were compiled from three studies extending from New Jersey to the Florida Keys [SCDNR, NMFS 2016 study, and ODU (SEDAR50-DW19)]. No reproductive data were available from the GOM. Though the spatial and temporal coverage was limited, the data were consistent with one population of blueline along the U.S. Atlantic Coast. The spatial distribution of blueline was investigated from fishery-dependent and fishery-independent data sources, and in relation to habitat and oceanographic (currents) characteristics that would influence the distribution of adults and the transport of eggs and larvae. Despite the lack of a fishery-independent survey covering the entire geographic range of blueline and the limitations of fishery-dependent data, the workgroup concluded the available evidence suggested that blueline consist of a single population extending from the north Atlantic coast to the GOM. The primary recommendations from the Stock ID Workshop are summarized in SEDAR50-DW12. Collectively, the evidence for genetic homogeneity, continuous nature of the spatial distribution across the range, and lack of spatial variation in life history parameters led to the conclusion that blueline constitute a single panmictic population throughout the US geographic range. This conclusion was supported by the existence of a plausible mechanism, i.e., transport of eggs and larvae from the West Florida shelf (where >95% of the harvest occurs) through the Florida straits and into South and Mid-Atlantic waters via the Loop Current, that could effectively homogenize components of the adult population residing in GOM, South Atlantic, and Mid-Atlantic waters.

Inclusion of Blueline Tilefish from the Gulf of Mexico as part of a single larger stock extending through South and Mid-Atlantic waters was not an anticipated outcome, and GOM scientists were under-represented at the blueline stock ID workshop. As a result, and given that the recommended stock definition now included three fishery management jurisdictions, a joint SSC review was held via webinar to review the findings of the stock ID workshop (SEDAR50-DW16). The consensus statements from the joint SSC review agreed with the findings that the available evidence was consistent with a single panmictic population of blueline extending from at least Mid-Atlantic waters in the north through the northeastern Gulf of Mexico to at least the West Florid shelf, but also recognized the general data limitations and, in particular, the limited genetic data from the GOM. Further, the SSC review noted that sufficient habitat for Blueline Tilefish occurs in the western Gulf of Mexico through the South and Mid-Atlantic and that the Loop Current provides a plausible mechanism for larval connectivity between the regions.

Scientific and management leadership had concerns over how to manage blueline across the jurisdictional boundaries spanned by the recommended stock definition. Science and regional directors, fishery management council chairs, and directors from each region held a phone call to discuss the implications of a blueline stock assessment that crossed jurisdictional boundaries (SEDAR50-DW17). Consensus statements from this phone call indicate that the group accepted the findings of the joint SSC review that available evidence is consistent with a single panmictic population of blueline. However, the recommendation was made to use the existing jurisdictional boundary (i.e., Florida Keys) between the Gulf of Mexico and South Atlantic Fishery Management Councils to define the unit stock (exclude the GOM) for the SEDAR 50 blueline assessment. The basis for this recommendation was the relatively small sample sizes available for genetics of blueline on the West Florida shelf, the lack of genetic data for other regions within the northern Gulf of Mexico, and potential “challenges for developing meaningful scientific advice for the entire GOM Blueline Tilefish fishery.”

Recommendation:

Despite the conclusions of the blueline stock ID workshop and associated SSC review, management and scientific leadership from the NEFSC, SEFSC, MAFMC, SAFMC and GMFMC decided that for the purposes of the SEDAR 50 Blueline Tilefish assessment, the blueline stock definition be one Atlantic unit stock extending from mid-Atlantic waters through the South Atlantic jurisdictional line in the Florida Keys. The GOM blueline stock would have to be assessed in a separate assessment.

2.4 Natural Mortality

Assessments of reef fish species in the Southeast Region often use estimates of M based on the maximum age observed in the population (t_{max}). However, since the SEDAR50 DW Panel decided to not use age data in this assessment, t_{max} is unknown and this method cannot be used. From the bomb radio-carbon study by conducted by SCDNR staff, the LH Group concluded that Blueline Tilefish live to at least 26 years, but expect that t_{max} may be higher. A meta-analysis of other deep water species that co-occur with Blueline Tilefish was completed to estimate growth parameters for Blueline Tilefish. These species tend to be characterized by slow growth, long lives, and low rates of natural mortality in adults. Additional information about the life history of Blueline Tilefish, such as habitat requirements and behavior (e.g., constructing burrows), also suggest that, at least the adults may experience low natural mortality rates.

Literature on methods to estimate natural mortality was reviewed. In the absence of age data, specifically max-age, and directly calculated growth parameters, the LH group explored weight-based equations for calculating M as described in Kenchington (2014), though Kenchington suggested caution in using any of the weight based estimators. The LH group focused on Lorenzen (1996) and Peterson and Wroblewski (1984) estimators and had much discussion on what weight to use in the equations. The LH group chose to use the mean weight of Blueline Tilefish of the smallest fish and largest fish measured in all size data available for SEDAR50 (4250 g). The Lorenzen estimate was 0.27, and Peterson and Wroblewski estimate was 0.16. The Lorenzen estimate of M seemed higher than expected for a fish that we believe to be long-lived, and the Peterson and Wroblewski was the lowest value, but still a little higher than expected based on estimates of M for other species in the Southeast US. The LH group suggested an average of the two estimates with the individual values to be used for sensitivity runs. The SEDAR50 DW Panel commented that an M of 0.21 was too high compared to similar or co-occuring deepwater species. They asked the LH group to investigate the relationship of M to K (von Bertalanffy growth coefficient) and max-age in other fish, which was done as a result of the meta-analysis to estimate blueline growth parameters (see section 2.7).

Following further review of the literature available to estimate natural mortality, the LH group turned to Then et al (2014). Then et al. (2014) recommend using a growth-based method (i.e. based on von Bertalanffy parameters K and L_∞) to estimate M when t_{max} is unknown. Using the growth parameters estimated for Blueline Tilefish (see Section 2.7 below), natural mortality was estimated as 0.13 (Table 2.1, Figure 2.1). A bootstrap procedure, described below in Section 2.7, was used to estimate uncertainty about the growth parameters as well as M. The resulting 95% bootstrap confidence limits for M were 0.04 to 0.40.

Recommendation:

The point estimate of M for Blueline Tilefish is 0.13 computed from the Then et al. (2014) growth-based equation. Estimates of uncertainty about M from the bootstrap procedure (Table 2.1) should be used.

2.5 Discard Mortality

A literature search did not reveal any sources of information on Blueline Tilefish discard mortality and only very limited information for reef fish species deeper than or near 70 m. Prior to the workshop, fishery observer data collected in both the commercial (hook and line only) and recreational sectors were summarized in SEDAR50-DW22. For each sector, total discard mortality was estimated from combining the best available information for immediate and delayed mortality. Commercial hook and line discard information were collected by fishery observers from the Galveston Reef Fish Observer Program in the Gulf of Mexico. The data indicated an immediate mortality estimate of 80% for Blueline Tilefish based on fish that failed to resubmerge. Ranges for delayed mortality were discussed among the ad-hoc panel and a wide range between 50 and 100% was recommended due to the uncertainty at the deep capture depths for Blueline Tilefish. Combining the immediate mortality estimate of 80% with the delayed mortality range resulted in an interval of 90–100%. The panel recommended using the midpoint of the range resulting in a 95% commercial hook and line discard rate and using the upper and lower bounds for sensitivity (Table 1).

Immediate mortality estimates from fishery observers were not available for the recreational sector. Recreational workgroup attendees suggested an immediate discard mortality rate of 40% based on years of observations. As previous, ranges for delayed mortality were discussed among the ad-hoc panel and a wide range between 40 and 100% was recommended due to the uncertainty for Blueline Tilefish. The lower bound was determined using estimates for other reef fish species near or outside 70 m (Rudershausen et al. 2007; Campbell et al. 2014; Sauls 2014). It was agreed the 40% estimate was reasonable for the lower bound since the recreational sector mostly operates in shallower depths compared to the commercial sector. Combining the immediate mortality estimate of 40% with the delayed mortality range resulted in an interval of 64–100%. The panel recommended using the midpoint of the range resulting in an 82% recreational discard rate and using the upper and lower bounds for sensitivity. Finally, no information could be discovered on discard mortality for Blueline Tilefish captured in the commercial trawl fishery. A consensus was reached to use an estimate of 100% as the discard mortality rate with no sensitivity bounds for Blueline Tilefish discarded after capture in commercial trawls.

Recommendation:
The recommended discard mortality rates for each sector with the upper and lower bounds for sensitivity are below.

Sector	Range	Recommendation
Commercial (Hook and Line)	0.90 – 1.00	0.95
Commercial (Trawl)	—	1.00
Recreational	0.64 – 1.00	0.82

Research Recommendations
The working group identified limited peer-reviewed literature for deepwater reef fish species and no information for Blueline Tilefish in either the commercial and recreational fisheries. Future research should attempt to provide estimates of discard mortality through tag-recapture, acoustic tagging, or other methods in both sectors. While some information was available to estimate immediate mortality, research is needed to reduced uncertainty in estimates of delayed mortality. Particular interest was expressed into developing mortality estimates when using descender devices to aid recompression, since these devices may have the potential to substantially lower mortality rates. Cooperative research with either sector represents a robust mechanism available to begin obtaining more estimates of mortality and reduce uncertainty in future assessments.

2.6 Age

The staff from three laboratories actively engaged in ageing Blueline Tilefish have diligently worked together in an attempt in an attempt reach consistency in age readings among labs and to validate those age readings. Following exchanges of reference collections among laboratories, consistency in age readings was not achieved. A systematic bias was noted in the readings, but was not the same between the labs. One lab was under counting opaque zones compared to the other labs. Due to the results of the exchanges, an age workshop was convened (SEDAR50-DW18), which also included staff from NEFSC and NMFS Panama City Laboratory.

In preparation for the age workshop, SCDNR selected 40 otolith samples for bomb radio-carbon testing as a means to validate the opaque zone counts as true age. These data were brought to the age workshop. Since no reference chronology of bomb radiocarbon has been established in the U.S. South Atlantic, the radiocarbon points could not be validated directly. When the radiocarbon readings were plotted against reference chronologies from other areas, including the GOM, northeast Atlantic, and Gulf of Alaska, the results suggested possible under-ageing by all readers. Another explanation is the different environmental radiocarbon availability at different locations and depths, as supported by studies in other species (see Campana et al. 2015). As a result, validation of the Blueline Tilefish age readings were considered inconclusive at the time of the age workshop.

During the age workshop (see Age Workshop Report II review above), the participants reviewed the results of the reference set exchanges and the bomb radiocarbon results to determine a possible way forward with ageing Blueline Tilefish. High within reader variability, new counts compared to previous counts, and difficultly in consensus identification of first annulus accentuated the difficulty in ageing Blueline Tilefish. Also adding to the uncertainty was when age readers grouped opaque zones as one annulus and when each reader decided to count individual zones as annuli. The participants of the age workshop came to consensus agreement that at that time they could not confidently age Blueline Tilefish for the assessment.

Recommendation:

Blueline Tilefish age composition data should not be used in this stock assessment. The bomb radiocarbon study indicates the maximum age is at least 26 years, but expert opinion suggests that they likely live longer than that.

2.7 Growth

Estimates of growth parameters and associated CVs are needed for some stock assessment methods that may be used in SEDAR 50. In the absence of length-at-age data, growth of blueline could not be modeled directly, leading to novel methods for estimating proxies not used in prior assessments. However this approach should be further investigated.

The LH Group felt most confident estimating L_∞ based on extensive length data. In fish growth studies, the L_∞ is usually estimated to be smaller than the largest fish in the sample data. The LH Group concluded that a reasonable estimate of L_∞ could be generated by considering distributions of aggregated length data used in past SEDAR assessments and the relationship between the distribution and the estimate of L_∞ used in that assessment. Specifically, the LH Group determined what percent of the lengths were smaller than L_∞ for each assessment (i.e. the L_∞ quantile) and calculated the average of those values (n = 11 assessments; mean L_∞ quantile = 97%). The LH Group then estimated the L_∞ value associated with this quantile in the distribution of blueline lengths, which was 690 mm FL (Table 2.1, Figure 2.2).

To estimate K and t_0 for the growth model, a meta-analysis of co-occurring fish species and malacanthid species were considered. The LH group considered a list of criteria for each suite of parameters in the analyses. The criteria included the following:

- t_0 is a "reasonable" value (based on experience: $-3 > t_0 < 0.5$)
- Both sexes are represented in the data
- Published or observational data (no meta-analysis derived values)

- Minimum level of age validation (i.e. marginal increment analysis)
- Include related species (other Malacanthidae), and Co-occurring deep-water species
- Uses best available methodology for ageing (i.e. whole vs sectioned)
- Use only data if all von Bertalanffy growth parameters presented (L_∞, K, and t_0)
- Exclude duplicate data (e.g. thesis and publication)

A total of 13 sets of growth parameters, for seven species, were included in the meta-analysis. When available, maximum observed age, and estimates of natural mortality were also listed (Table 2.2). An estimate of t_0 for Blueline Tilefish was calculated as the mean of all t_0 from the meta-analysis (t_0 = -1.33). Since K and L_∞ are correlated, K was estimated from L_∞ adjusting for the dependence of K on L_∞ in the meta-analysis data. Both K and L_∞ were natural log transformed, and fit with a linear model [ln(K) = 6.46-1.26ln(L_∞); r^2=0.67; $SE_{residual}$=0.24; as a power function: K = 639(L_∞)$^{-1.26}$; Figure 2.3]. The K parameter was then estimated from the predicted value from the regression at the estimated value of L_∞=690mm TL, yielding K = 0.16. Note that lengths in the regression were in TL while the measurement of interest was FL, so data were converted back and forth between (natural) TL and FL using meristic equations reported by Ballew and Potts (2017) and table 2.10.

Estimating uncertainty in growth model parameters and M relied largely on a bootstrapping procedure. The steps of this procedure for each of 10,000 bootstrap runs are as follows:

1. Sample SEDAR estimates of L_∞ quantile (n = 11), with replacement, and calculate mean L_∞ quantile,
2. Sample blueline lengths (n = 27,326; from SEDAR 32), with replacement, to produce a bootstrap distribution of lengths,
3. Estimate L_∞ from mean L_∞ quantile and the bootstrap distribution of lengths,
4. Sample t_0 values from meta-analysis data (n = 13), with replacement, and estimate mean t_0 from the bootstrap sample,
5. Estimate K by drawing a value from a normal distribution (with mean equal to the K estimate from the meta-analysis regression, and a standard deviation estimated from the residuals of that regression), and
6. Draw estimates of parameters *a*, *b*, and *c* for the $\text{Pauly}_{\text{nls-T}}$ formula from normal distributions with means equal to the parameter estimates (*a* = 4.118, *b* = 0.73, *c* = -0.33) and standard deviations equal to the "Model SE" values presented by Then et al. (2014; their Table 3; a_{SE} = 0.80, b_{SE} = 0.08 and c_{SE} = 0.08). Use these parameter estimates along with the bootstrap values of K and L_∞ to estimate a bootstrap value of M.

Bootstrap distributions for growth parameters and M are plotted in Figure 2.1; parameter estimates and statistics summarizing these distributions are presented in Table 2.1.

Recommendation:

Use the following von Bertalanffy growth model to describe the growth of Blueline Tilefish in the fished stock along the Atlantic coast for this assessment:

$$L_t = 690*(1 - \exp^{-0.16(t + 1.33)})$$

Use the bootstrap procedure as a measure of uncertainty around the parameters (see Table 2.1; Figure 2.4).

2.8 Reproduction

Data Availability

Reproductive information contains data of Blueline Tilefish from samples that were collected off the East Coast of the U.S., from New Jersey to Florida, between 1979 and 2015 (n=2,548). Briefly, data sources were state, federal, and academic institutions, and the sources were both fishery-independent and fishery dependent. All sex and reproductive phase data were assessed after histological processing and staging was completed using criteria from Brown-Peterson et al. (2011). The working paper SEDAR-DW19 contains in-depth information on collection details and reproductive sampling of blueline.

Sex ratio

The total sample size (n=2,524) was comprised of 1,374 females and 1,150 males collected from Virginia through Florida, with most samples (53%) collected off South Carolina. The overall female:male sex ratio favored females, but this statistical significance was likely due to the large sample size, and the WG does not consider this difference biologically significant (Table 2.3).

Recommendation:

Use a sex ratio of 1:1.

Spawning seasonality

Spawning females with available location data (n=950) were collected largely from South Carolina (55%), followed by Virginia (23%), and North Carolina (13%); however, spawning individuals were collected from all states (Tables 2.4 and 2.5). The frequency of reproductive phase by month is provided in Table 2.6. From 1979 - 2015, spawning females (n=1,030) were observed from February through November (Table 2.5), across all states.

Recommendation:

Spawning season is February 2 – November 30.

Maturity

A total of 1,350 female gonad tissue samples with associated length information were histologically examined and analyzed to estimate length at maturity. Immature fish (n=4) were caught in the months of March, April, June and September and only 2 of the 4 immature females had associated catch location data available. Females reached sexual maturity as small as 312 mm FL and data indicate that they are 100% mature by 365 mm FL. Estimates for female length at 50% maturity ranged from 299-312 mm FL, depending on formula used (Table 2.7). The combination of few immature fish and the lack of small fish under the estimated length at maturity resulted in a high CV.

Recommendation:

Use estimate of $L_{50\%\ mat}$ = 305 mm based on logit regression model (CV=0.447), but the high uncertainty in this estimate should be taken into account in the assessment

Spawning fraction and Events

Spawning indicators for blueline were estimated to last 60 hours based on the temperature (mean $\pm$ 1 sd = 14.9 ± 2.1ºC) at which blueline is reported to spawn (Sedberry et al. 2006), the duration of oocyte maturation, and POC degeneration based on data from the Northern Anchovy (Hunter and Macewicz 1985), a species that spawns at a similar temperature range (13 - 19ºC). Subsequently, spawning fraction was proportionally reduced to a 24-hour period (Figure 2.4). The results of size-based analyses revealed an overall spawning fraction ranging from 0.24 - 0.40. In addition, there was no evidence for latitudinal variation in spawning fraction. The size-based results reveal a sustained moderate spawning fraction (Table 2.8, Figure 2.4). This species has a very long spawning season resulting in a high number of spawning events per year, ranging from 57 - 102 for females in the size range 300 to 700 mm FL (Figure 2.5). On average, female Blueline Tilefish spawn about every 3 days.

Recommendation:

Use an overall spawning fraction of 0.31, and use an overall number of spawning events of 94.

Fecundity Estimates

There were no updated analyses performed on fecundity of blueline.

Recommendation:

Utilize the estimates of batch fecundity from Harris et al. (2004)
BF=7.310 + 0.00701*FL as was used in SEDAR 32.

2.9 Movements & Migration

Little is known about movement and migration of Blueline Tilefish through its life stages that include eggs, larvae, juveniles, and adults. The eggs and larvae are considered to be pelagic based on observation of one egg and four larvae caught in ichthyoplankton studies in the southeastern region, as well as extensive data on pelagic larvae on other malacanthid species. It is assumed that once juveniles settle to the bottom habitat they move to unoccupied habitat to build burrows. No studies have directly investigated movements or migrations of adult blueline, but based on anecdotal information, they are generally believed to be non-migratory, exhibiting minimal large scale movement. Able et al. (1987) observed, via submersible dives, blueline constructing burrows in seafloor sediments, showing an energetic investment into a local habitat, which would support high site fidelity. Blueline Tilefish have also been observed occupying the same burrows as another burrowing malacanthid, Golden Tilefish (Able et al., 1982; Able et al., 1987). Golden Tilefish movements have been directly investigated with results showing minimal movement during the adult life stage (Grimes et al., 1983).

Little to no information is available for the egg and larval life stages of Blueline Tilefish, leading to uncertainty in habitat, egg and larval transport, or larval duration. This has led to recent efforts to synthesize available data of the distribution of adult Blueline Tilefish throughout its range to estimate potential egg and larval information. Various sources of data show that in waters off the West Florida Shelf (100-400m depth), one of the largest concentrations of Blueline Tilefish occurs (Figure 2.6 and 2.8). These concentrations are located adjacent to the fast flowing Loop Current and the Gulf Stream, leading to water movement from the Gulf of Mexico into the South Atlantic, as confirmed by drifter data. In conjunction with this distribution of adults and area currents, it has been determined that Blueline Tilefish is genetically homogenous throughout its range in the Gulf of Mexico to the Mid-Atlantic (O'Donnell and Darden 2016, McDowell 2016), leading to the expectation of a mechanism connecting Blueline Tilefish from these two regions.

Drifter tracks from the Gulf of Mexico to the South and North Atlantic were analyzed over a period of one to six weeks to further investigate dispersal potential of blueline planktonic life stages and the proportions of drifters that originated in confirmed Blueline Tilefish habitat that crossed between council regions (for exact methods see Klibansky 2017). After one week, drifters from all the study regions had passed into other council regions (Figure 2.8), with large migrations of drifters from the Gulf of Mexico into the south Atlantic and from the South Atlantic into the Mid-Atlantic (Figure 2.9). Retention rates of drifters were highest in the western Gulf of Mexico and Mid-Atlantic, with 0.72 and 0.92, respectively, after six weeks, while they were lowest in the eastern Gulf of Mexico and South Atlantic, 0.23 and 0.4, respectively (Table 2.9).

These data and their reflection on Blueline Tilefish egg and larval dispersion relies on several assumptions, which are generally supported by available information. Lewis et al. (2016) found that Blueline Tilefish eggs are pelagic and can be collected with vertical plankton nets between 200m depth and the surface. Similar species of co-occurring tilefish (*Lopholatilus chamaeleonticeps*) eggs and larvae have been caught with similar nets, along the continental shelf (Berrien and Sibunka 1999), and in the upper water column (50-150m, Steimle et al. 1999) despite the deep depths of the adults. Although the Gulf Stream current along the US Southeast

Coast decreases with depth, indicating that the drifter movement may be faster than eggs, it has been found to be rapid at 150m (Tomczak and Godfrey 2013) suggesting that egg and larval movements are probably similar to drifter movements. The planktonic larval period is unknown for blueline, but a review of 256 marine fish species found that fishes similar in size as Blueline Tilefish, and in the same latitudes and depths, exhibited larval durations in the range of 75-100 days (Bradbury et al. 2008), therefore 4-6 week larval duration may actually be considered a low estimate. Bradbury et al. (2008) also showed that more genetically homogeneous species tend to have longer larval durations and we know from recent work that Blueline Tilefish from the West Florida Shelf in the Gulf of Mexico through the Mid-Atlantic are very genetically homogeneous (O'Donnell and Darden 2016; McDowell 2016). Therefore, although egg and larval movement deeper in the water column is probably slower than these drifters moved, it is likely that the planktonic duration of Blueline Tilefish is longer than what was simulated; therefore the net movement observed in the drifter data is probably not an overestimate of egg and larval drift.

The available drifter data and information from related species provide some understanding of larval duration and dispersal potential for Blueline Tilefish. It seems likely that substantial numbers of Blueline larvae are transported out of the eastern Gulf of Mexico, to the South Atlantic, and from the South Atlantic into the Mid-Atlantic over the course of a few weeks.

Recommendation/Findings:
Despite a lack of direct studies of post settlement and adult movement and migration, the LH group recommends that adult Blueline Tilefish be considered non-migratory for this assessment based on auxiliary information and behavioral similarities with golden tilefish.

Based on the spatial distribution of adult Blueline Tilefish, the vertical distribution of eggs and larvae of a closely related species, a meta-analysis of planktonic larval durations of other marine fishes, and oceanic drifter tracks along the U.S. Gulf and Atlantic Coasts, the LH Group concludes that substantial numbers of blueline larvae may be transported from the West Florida Shelf to the Atlantic and northward to mid-Atlantic.

2.10 Meristics & Conversion Factors

The SEDAR50 Panel agreed that fork length (FL) would be the length type used in the assessment. Blueline Tilefish meristic conversion equations were developed based on a compilation of data sources (SEDAR50-DW21). The data were available from the following sources:

- Southeast Region Headboat Survey (SRHS),
- NMFS Trip Interview Program (TIP),
- Marine Recreational Information Program (MRIP),
- Marine Resources Monitoring Assessment and Prediction Program (MARMAP),
- Southeast Fishery Independent Survey (SEFIS),

- NMFS 2015 blueline cooperative-with-industry data collection project (NMFS2015),
- Center for Quantitative Fisheries Ecology – Old Dominion University (CQFE),
- Virginia Marine Resources Commission (VMRC),
- NMFS/NEFSC fishery independent bottom trawl survey (NEFSC),
- Florida Fish and Wildlife Conservation Commission (FWC),
- NMFS Beaufort Laboratory Fishery Resource Grant (FRG),
- North Carolina Division of Marine Fisheries – 2012 Exempted Fishing Permit project (NCDMF)
- Gulf of Mexico Reef Fish Observer Program (GOM-O)
- Gulf of Mexico fishery independent surveys, which include the bottom longline survey, pelagic acoustics survey and SEAMAP, (GOM_FI).

From these data sets, each sample was assigned to regions of the U.S. Atlantic (ATL) and GOM based on area fished or location of landing information. The GOM was treated as one region that included samples from GMFMC jurisdiction, but most samples originated from the West Florida Shelf. The ATL samples were sub-divided into four regions which included all samples north of NC (North-Atl.), samples from NC, SC and GA (South-Atl.), samples from the east coast Florida through Miami-Dade County (FL-Atl.), and samples from Monroe County, FL (FL-Keys). These regions were designated to test for differences in meristic relationships among regions. Most of the paired length weight data for these tests were natural total length (NTL) – FL, and whole weight (WW) – FL. There appeared to be no difference in the relationship of NTL – FL among regions (Figure 2.10). The SEDAR50-DW Panel accepted the recommendation to use all data combined for length – length conversions (Table 2.10). Though there appeared to be subtle differences in the WW – FL relationships along a latitudinal gradient, but the 95% confidence intervals of all the equations overlapped (Figure 2.11). The panel accepted the recommendation to use an Atlantic wide WW=FL equation and a separate GOM WW=FL equation (Table 2.11). The reverse regression, FL = WW, was also available for the two areas (Table 2.11).
To convert gutted weights recorded in fishery landings to whole weight, data were available from the Atlantic area only, but information did cover the full range of Blueline Tilefish. Given that the length-length and WW-FL equations from the various sub-regions were not significantly different, one relationship of WW- GW for the ATL and GOM was recommended (Table 2.10).

Recommendation:
Fork length is used as the universal length measure in the SEDAR 50 assessment. All other lengths should be converted to FL using equations in Table 2.10 based on all data sources combined. Atlantic and GOM specific whole weight – fork length equations (Table 2.10) should be used in the SEDAR50 assessment. The whole weight – gutted weight equation should be based on the all available data, which are from the Atlantic area only.

2.11 Comments on Adequacy of Data for Assessment Analyses

Given the sample size and accepted methodologies, the data used for meristic conversions, sex ratio, spawning seasonality, spawning fraction, and fecundity-at-length are of similar quality to other SEDAR assessments with similar samples sizes. Discard mortality estimates are based on extensive data, though these data were mostly from GOM longline fishery using observers. Though some data sources used to define stock structure were limited, one very important data source, genetics, was based on solid research and yielded clear results; in addition, given that there was a dedicated workshop, there was extensive discussion on the stock definition issue (e.g. SEDAR 50 Stock ID Workshop). Information regarding movement and migration was minimal for Blueline Tilefish and was mostly inferred from other species and drifter analyses. Age data were considered unusable therefore age composition data and direct estimates of growth parameters were deemed inadequate for use in the assessment. Estimated growth model parameters and estimates of natural mortality based on meta-analysis, as such, the uncertainty should be considered high compare to age based assessments. .

2.12 Research Recommendations

Life History Working Group

- Collect and take reproductive tissue samples from smaller fish to improve reproductive parameters estimates.
- Investigate movements and locations for post-settlement smaller/juvenile Blueline Tilefish.
- Investigate adult movement through tagging studies (e.g., breakaway tags; see SEDAR50_DW12)
- Design and implement a regional ichthyoplankton survey to investigate larval transport. Note: taxonomic work needs to be done first to describe the eggs and larvae of Blueline Tilefish.
- Mine existing ichthyoplankton collections be assessed for presence of Blueline Tilefish larvae.
- Collect information/data on reproductive and larval behavior for use in modelling larval dispersal.
- Studies to validate the annulus formation and annulus structure of in blueline.
- Further investigate the potential shift in the Radio Bomb Carbon data and reference curve for Blueline Tilefish age validation (Note that this work is ongoing at SCDNR).
- Develop and recommend use of standardized aging methods as recommended by the SEDAR Best Practices Standing Panel Language in the Data Issue Inventory: **Age determination:** develop best practices for age determination to include processing and reading age structures, age calibration, age variability and bias estimates, validation methods, etc.

- Develop and recommend use of methods to provide growth parameter and natural mortality estimates in cases where no reliable age data are available. Focus should be on acceptable approaches for parameter values and error distributions (e.g. meta analyses, use of related species, use of species with comparable life history strategies, etc.).

Discard Mortality Ad-Hoc Group

- The working group identified limited peer-reviewed literature for deepwater reef fish species and no information for Blueline Tilefish in either the commercial and recreational fisheries. Future research should attempt to provide estimates of discard mortality through tag-recapture, acoustic tagging, or other methods in both sectors. While some information was available to estimate immediate mortality, research is needed to reduced uncertainty in estimates of delayed mortality. Particular interest was expressed into developing mortality estimates when using descender devices to aid recompression, since these devices may have the potential to substantially lower mortality rates. Cooperative research with either sector represents a robust mechanism available to begin obtaining more estimates of mortality and reduce uncertainty in future assessments.

2.13 Data Best Practice Input & Suggestions

New Recommended Best Practices

- Develop and recommend use of standardized aging methods as recommended by the SEDAR Best Practices Standing Panel Language in the Data Issue Inventory: **Age determination:** develop best practices for age determination to include processing and reading age structures, age calibration, age variability and bias estimates, validation methods, etc. (Added Sept. 2016).
- Develop and recommend use of methods to provide growth parameter and natural mortality estimates in cases where no reliable age data are available. Focus should be on acceptable approaches for parameter values and error distributions (e.g. meta analyses, use of related species, use of species with comparable life history strategies, etc.).

Best Practices that were not followed

- SEDAR 50 did not adhere to SEDAR Best Practices timeline. Working under a compressed schedule opened the process to hurried decisions and possible errors. The stock boundary discussion which began in June of 2016 was not finalized and added to the TOR until December 12, 2016, six weeks before the Data Workshop, but after the Data scoping webinar held November 15, 2016. This delay in the stock ID decision led to confusion during the scoping call which may have contributed to late data submission.
- Following the data scoping call, work began on amassing data sets for meristic conversions. Not until the first data webinar was a large data set from the Gulf of Mexico

identified and provided. The data provider had been involved in the scoping call and should have provided the set earlier. All analyses had to be redone in a tight time frame.

  - For those SEDARs already scheduled (as of July 2015), **the available data on meristic conversions should be reviewed no later than the SEDAR Data Workshop Data Scoping Calls**, with input from each of the working groups (i.e., life history, commercial, recreational, indices), and discussions whether or not meristics conversions need to be calculated. (p. 14 of SEDAR_DataBP_LivingDoc_WithAppendices_9.12.2016)

- When data sets are submitted for use in a SEDAR assessment, they need to be in SEDAR Best Practices format with clear metadata to define all values. This format applies to data sets for meristic conversion analyses as well. Data sets should undergo QA/QC before submission to the Life History group. Much time was spent formatting data sets and in particular determining what type of total length, natural or max, were in each set and converting the weight type measurements.
  - All data providers are requested to use a standardized data template (for raw data inputs) when providing data to the data compiler of the SEDAR Data Workshop Life History Working group… (Table 1).
  - In addition to the data submission, a metadata description is requested from each data provider (Table 2). (p. 17-18 of SEDAR_DataBP_LivingDoc_WithAppendices_9.12.2016)

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2.15 Tables

Table 2.1. Estimates of blueline von Bertalanffy growth parameters (L_∞, K, and t_0) and natural mortality (M) from meta-analysis. Modes, CVs, and 95% confidence limits (CL) were based on distributions from 10,000 bootstrap runs. L_∞ is in mm fork length.

Parameter	Estimate	Mode	CV	95% CL (lower, upper)
L_∞	690	686	0.024	(669, 729)
K	0.16	0.15	0.23	(0.10, 0.25)
t_0	-1.33	-1.31	-0.18	(-1.82, -0.88)
M	0.13	0.09	0.65	(0.04, 0.40)

Table 2.2. Species included in meta-analysis for estimating von Bertalanffy growth parameters. Note that natural mortality (M) and Max Age values presented in this table are merely for reference and were not actually used in the meta-analysis.

Common Name	Genus species	Reference	L_∞	Length Type Units	*K*	t_0	M	Max Age
Speckled Hind	*Epinephelus drummondhayi*	Matheson & Huntsman 1984	967	TL mm	0.13	-1.01	0.2	25
Speckled Hind	*Epinephelus drummondhayi*	Ziskin et al. 2011(1977-2007)	888	TL mm	0.12	-1.8	0.13	35
Yellowedge Grouper	*Hyporthodus flavolimbatus*	Manickchand-Heileman & Phillip 2000	963	TL mm	0.099	-0.08	none	35
Snowy Grouper	*Hyporthodus niveatus*	Matheson & Huntsman 1984	1255	TL mm	0.074	-1.92	0.15	25
Snowy Grouper	*Hyporthodus niveatus*	Moore & Labisky 1984, florida keys	1320	TL mm	0.087	-1.013	0.16	19
Snowy Grouper	*Hyporthodus niveatus*	Costa et al. 2012, brazil	1098	TL mm	0.062	-2.68	none	54
Snowy Grouper	*Hyporthodus niveatus*	SEDAR 36	1065	TL mm	0.094	-2.88	0.12	35
Golden Tilefish	*Lopholatilus chamaeleonticeps*	SEDAR 25	825	TL mm	0.189	-0.47	0.1	40
Golden Tilefish	*Lopholatilus chamaeleonticeps*	SEDAR 22	830	TL mm	0.13	-2.14	0.13	40
Red Grouper	*Epinephelus morio*	SEDAR 53	848	TL mm	0.21	-0.67	0.14	26
Red Grouper	*Epinephelus morio*	SEDAR 12	854	TL mm	0.16	-0.19	0.14	25
Red Porgy	*Pagrus pagrus*	SEDAR 1	510	TL mm	0.21	-1.32	0.225	18
Blackfin Snapper	*Lutjanus buccanella*	Burton et al.2016	540	TL mm	0.22	-1.16	0.15	27

Table 2.3. Number of females (F), males (M), and sex ratio for blueline by sampling area, with corresponding p-value denoting level of significance in the Chi square analysis. Data for specimens captured off Georgia were not analyzed due to small sample size (n=15). Data included the 4 immature specimens in the overall data base.

				State		
Overall		**VA**	**NC**	**SC**	**GA**	**FL**
F	1374	274	224	739	7	39
M	1150	212	217	598	8	25
F/M	**1.19**	**1.29**	**1.03**	**1.24**	**0.875**	**1.56**
% F	**54%**	**56%**	**51%**	**55%**	**47%**	**61%**
Chi Sq	**19.88**	**7.91**	**0.11**	**14.87**		**3.063**
P-Value	**<0.001**	**0.005**	**0.739**	**<0.001**		**0.08**

Table 2.4 Observed numbers (A) and proportions (B) of female blueline by reproductive phase and state. None: no catch location data available. Note: Only 2 of the 4 immature females had associated catch location data available.

A.

	State						
Repro. Phase	**FL**	**GA**	**NC**	**SC**	**VA**	**None**	**Total**
Developing	10	2	18	101	16	7	154
Immature				1	1	2	4
Regenerating	10		21	15	5	1	52
Regressing	2	2	30	30	15	1	80
Spawning	12	3	132	568	235	80	1030
Total	**34**	**7**	**201**	**715**	**272**	**91**	**1320**

B.

	State						
Repro. Phase	**FL**	**GA**	**NC**	**SC**	**VA**	**None**	**Total**
Developing	29%	29%	9%	14%	6%	8%	12%
Immature	0%	0%	0%	0%	0%	2%	0%
Regenerating	29%	0%	10%	2%	2%	1%	4%
Regressing	6%	29%	15%	4%	6%	1%	6%
Spawning	35%	43%	66%	79%	86%	88%	78%
Total	100%	100%	100%	100%	100%	100%	100%

Table 2.5. Observed numbers of female blueline by monthly reproductive phase in each state of landing.

Reproductive phase by State	Month 1	2	3	4	5	6	7	8	9	10	11	12	Total
FL								**1**		**33**			**34**
Developing										10			10
Regenerating										10			10
Regressing										2			2
Spawning								1		11			12
GA						**2**	**1**	**1**	**3**				**7**
Developing							1		1				2
Regressing								1	1				2
Spawning						2			1				3
SC	**10**		**14**	**53**	**155**	**99**	**22**	**159**	**146**	**57**			**715**
Developing	5		4	20	14	6	3	17	8	24			101
Immature				1									1
Regenerating	5							2	1	7			15
Regressing				1	1	10		11	3	4			30
Spawning			10	31	140	83	19	129	134	22			568
NC						**2**	**2**	**8**		**137**	**52**		**201**
Developing								1		13	4		18
Regenerating								1		20			21
Regressing						1	1	3		20	5		30
Spawning						1	1	3		84	43		132
VA	**11**			**4**	**4**	**12**	**45**	**26**	**5**	**145**	**12**	**8**	**272**
Developing	5			4	2	4				1			16
Immature						1							1
Regenerating	3											2	5
Regressing	3										6	6	15
Spawning					2	7	45	26	5	144	6		235
None		**2**	**2**	**23**		**2**	**35**		**5**	**22**			**91**
Developing				1			2		1	3			7
Immature			1						1				2
Regenerating			1										1
Regressing							1						1
Spawning		2		22		2	32		3	19			80
Grand Total	**21**	**2**	**16**	**80**	**159**	**117**	**105**	**195**	**159**	**394**	**64**	**8**	**1320**

Table 2.6 Observed numbers (A) and percentages (B) of female Blueline Tilefish by reproductive phase and month, all states combined.

A.

Reproductive	Month											
Phase	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Grand Total**
Developing	10		4	25	16	10	6	18	10	51	4		154
Immature			1	1		1			1				4
Regenerating	8		1					3	1	37		2	52
Regressing	3			1	1	11	2	15	4	26	11	6	80
Spawning		2	10	53	142	95	97	159	143	280	49		1030
Grand Total	**21**	**2**	**16**	**80**	**159**	**117**	**105**	**195**	**159**	**394**	**64**	**8**	**1320**

B.

Reproductive	Month												
Phase	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Grand Total**
Developing	48	0	25	31	10	9	6	9	6	13	6	0	12
Immature	0	0	6	1	0	1	0	0	1	0	0	0	0
Regenerating	38	0	6	0	0	0	0	2	1	9	0	25	4
Regressing	14	0	0	1	1	9	2	8	3	7	17	75	6
Spawning	0	100	63	66	89	81	92	82	90	71	77	0	78
Grand Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 2.7. Logistic regression analysis of fork length (FL; in mm) at maturity for female blueline at maturity. <u>Note:</u> Data includes only 4 immature females with FL of: 307, 312, 320, and 365 mm.

Model	**n**	**AICc**	**L_{50}**	**CV**
Logit Logistic	**1350**	**28.47**	**305**	0.**447**
Probit Logistic	1350	29.00	299	
cloglog Logistic	1350	29.53	301	
Cauchy Logistic	1350	31.29	312	

Table 2.8. Female blueline spawning fraction by fork length (mm FL), with bins centered on the nearest 100 mm. Spawning fraction and resulting spawning events were proportionally adjusted from a 60 to a 24-hour period based on longevity of spawning indicators from Harris et al. 2004 (see text for clarification).

FL mm	Spawners	1st date spawn (Month/Day)	Last Date Spawn (Month/Day)	Spawning Season (days)	# Mature	Spawning Fraction	Spawning Events
300	16	4/22	11/26	218	18	0.36	78
400	138	3/26	11/20	239	231	0.24	57
500	489	2/5	11/30	298	613	0.32	95
600	352	2/3	11/30	300	415	0.34	102
700	29	5/22	11/26	188	33	0.35	66
800	2	9/3	10/22	49	2	0.40	20
Total	**1030**	**2/3**	**11/30**	**300**	**1316**	**0.31**	**94**

Table 2.9. Summary of movement of resampled drifters between council regions, 1, 2, 4, and 6 weeks after release. Rows represent the council region where the drifter originated while columns represent the region where the drifter was found in a subsequent week. Values in each row sum to one, indicating proportions of drifters released in each region, that were present in each region at weeks 1-6.

Origin	GMw	GMe	SA	MA
Week 1				
GMw	0.93	0.07	0.00	0.00
GMe	0.21	0.52	0.27	0.00
SA	0.00	0.01	0.77	0.21
MA	0.00	0.00	0.16	0.84
Week 2				
GMw	0.90	0.10	0.00	0.00
GMe	0.22	0.43	0.34	0.01
SA	0.00	0.00	0.70	0.30
MA	0.00	0.00	0.20	0.80
Week 4				
GMw	0.81	0.16	0.03	0.00
GMe	0.24	0.31	0.39	0.06
SA	0.00	0.01	0.46	0.54
MA	0.00	0.00	0.16	0.84
Week 6				
GMw	0.76	0.17	0.07	0.00
GMe	0.25	0.26	0.38	0.12
SA	0.00	0.01	0.40	0.59
MA	0.00	0.00	0.09	0.91

Table 2.10. Linear regressions for blueline length-length and whole weight-gutted weight for the Atlantic region extending from the Florida Keys north to Maine. MTL = maximum total length – caudal fin compressed (aka pinched total length); NTL = natural total length – caudal fin not compressed; FL = fork length; SL = standard length; GW = gutted weight; and WW = whole weight.

Conversion	N	Units	Intercept (95 CI)	Slope (95 CI)	Model R^2	Range of x
MTL → FL	970	mm	-2.44 (-4.50; -0.38)	0.95 (0.94; 0.95)	0.9962	333 - 854
FL → MTL	970	mm	4.66 (2.49; 6.82)	1.05 (1.05; 1.06)	0.9962	312 - 822
NTL → FL	3653	mm	3.15 (2.31; 3.98)	0.94 (0.94; 0.94)	0.9973	244 - 892
FL → NTL	3653	mm	-1.96 (-2.85; -1.06)	1.06 (1.06; 1.06)	0.9973	220 - 844
SL → FL	1185	mm	26.98 (23.25; 30.70)	1.10 (1.09; 1.10)	0.9831	262 - 716
FL → SL	1185	mm	-16.63 (-20.15; -13.11)	0.90 (0.89; 0.90)	0.9831	312 - 822
GW → WW	295	g	No intercept	1.06 (1.05; 1.06)	0.9991	270 - 5100
WW → GW	295	g	No intercept	0.94 (0.94; 0.95)	0.9991	280 - 5300

Table 2.11. Atlantic blueline conversions from length (mm) to weight (g) using the model Ln(weight) = Ln(length) and conversely from weight (g) to length (mm) using the model Ln(length) = Ln(weight). FL = fork length. NTL = natural total length. WW = whole weight. Whole weight – length converted to a power equation, which included ½ MSE to account for transformation bias.

Conversion	**N**	**Intercept (95 CI)**	**Slope (95 CI)**	**Model R^2**	**Range of x**
FL → WW	4927	-10.95 (-11.10; -10.80)	2.94 (2.92; 2.97)	0.9244	220 – 910 (mm)
WW → FL	4927	3.91 (3.89; 3.93)	0.31 (0.31; 0.32)	0.9244	76 – 9254 (g)
NTL → WW	2286	-11.65 (-11.82; -11.48)	3.04 (3.01; 3.07)	0.9552	206 – 884 (mm)
WW → NTL	2286	3.94 (3.92; 3.96)	0.31 (0.31; 0.32)	0.9552	100 – 9253 (g)

Conversion	**MSE**	**Converted Power Equation ($W = aL^b$)**
FL → WW	0.0295	$W = 1.78x10^{-5}L^{2.94}$
WW → FL	0.0031	$W = 49.83L^{0.31}$
NTL → WW	0.0227	$W = 8.82x10^{-6}L^{3.04}$
WW → NTL	0.0023	$W = 51.56L^{0.31}$

2.16 Figures

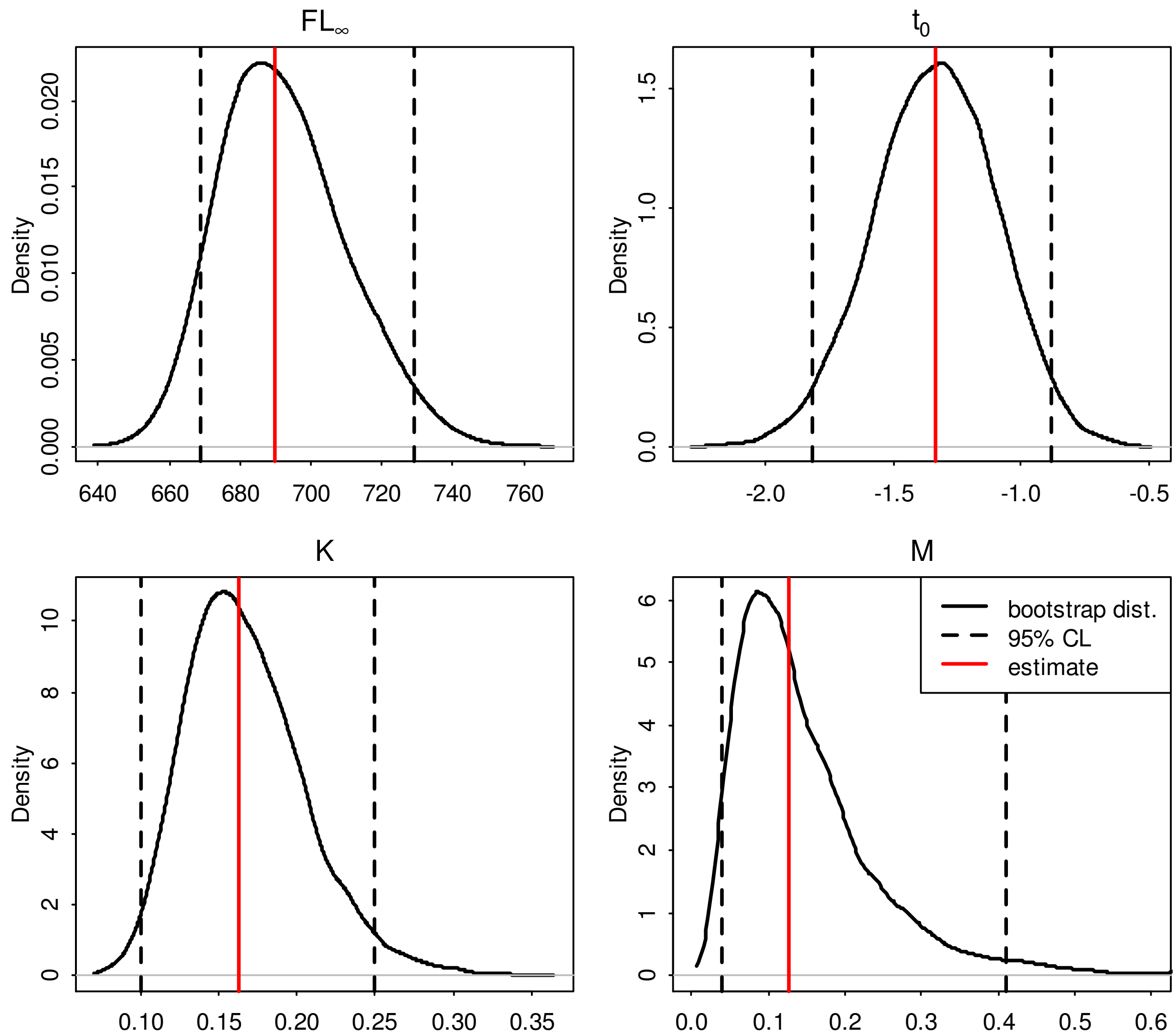


Figure 2.1 Bootstrap distributions for growth parameters (FL_∞, t_0, and K) and for natural mortality (M) of blueline (n = 10,000) plotted as kernel density functions (solid black lines). The estimates (red line) and 95% confidence limits (dashed black lines) are also plotted.

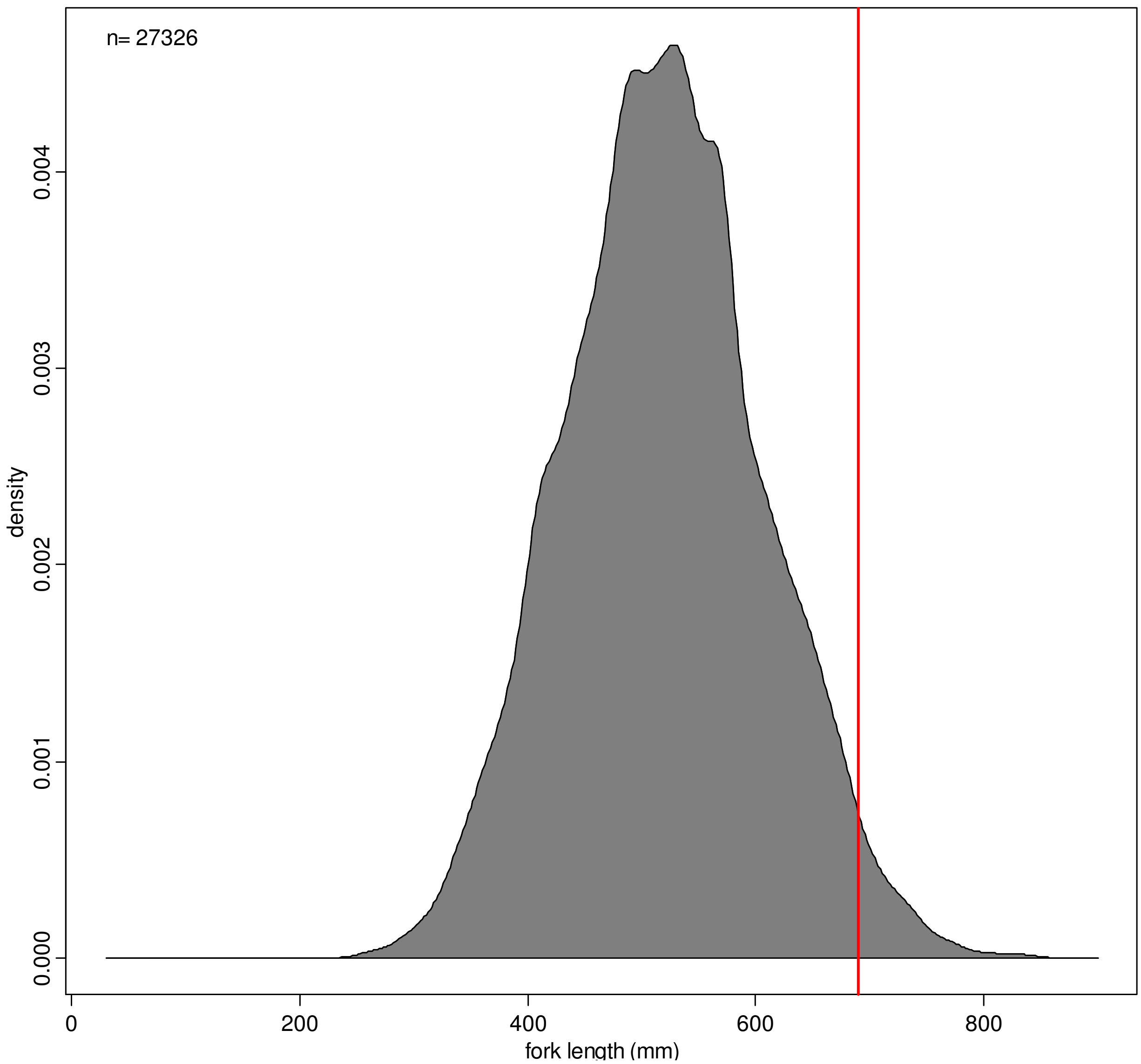


Figure 2.2 Distribution of weighted blueline fork length data from SEDAR 32, combining commercial handline, longline and other gears, as well as lengths from recreational fisheries. The distribution is plotted as a kernel density function. The red line indicates the estimate of L_∞ (690 mm FL) corresponding to the 97th percentile of the distribution.

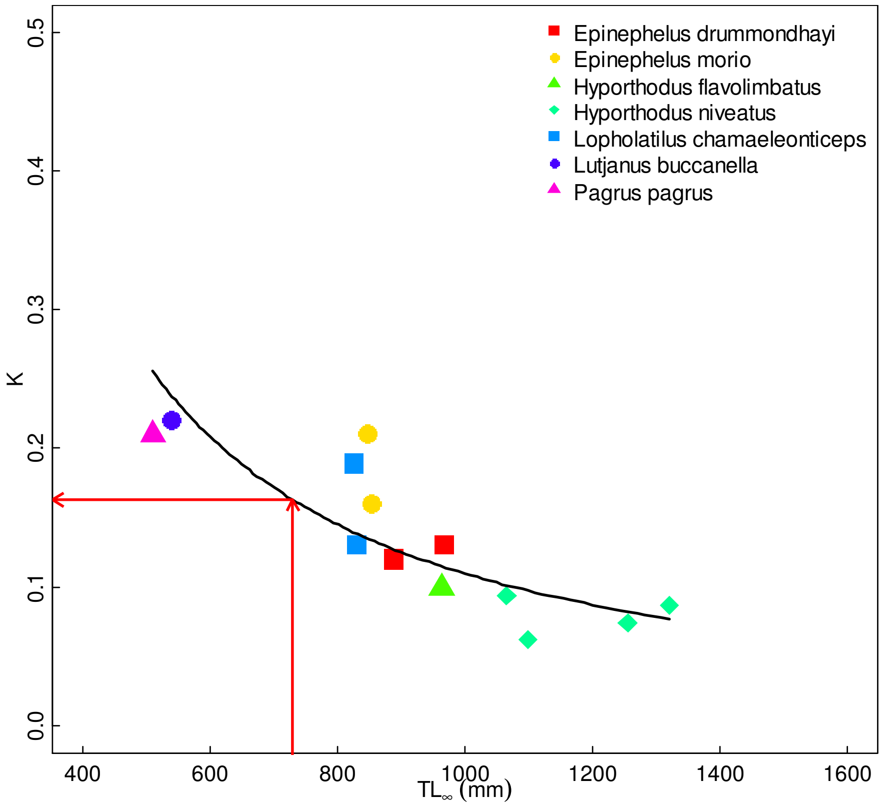


Figure 2.3 Scatterplot of K and L_∞ values from the meta-analysis, and the fitted power function [black line; $K = 639(L_\infty)^{-1.26}$]. Red arrows indicate where the estimate of L_∞ falls along the fitted line, and the corresponding predicted value of K.

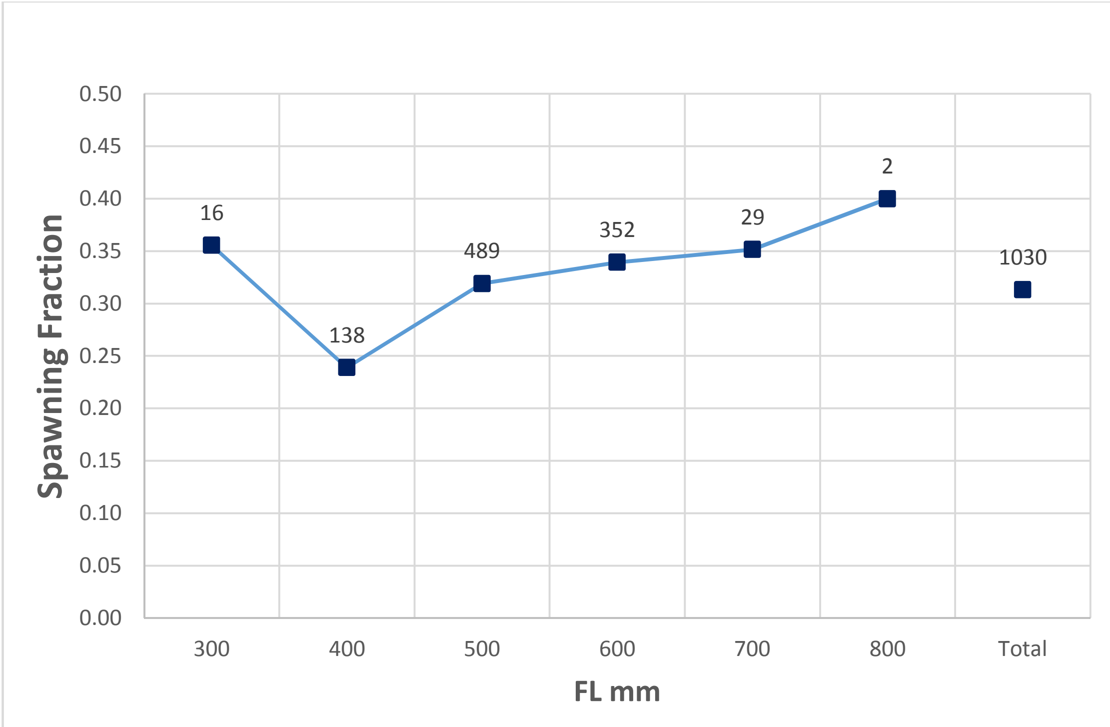


Figure 2.4 Spawning fraction by binned FL (mm) of female Blueline Tilefish. Data labels above data points represent the number of individuals examined. Bins were center rounded to the nearest 100 mm.

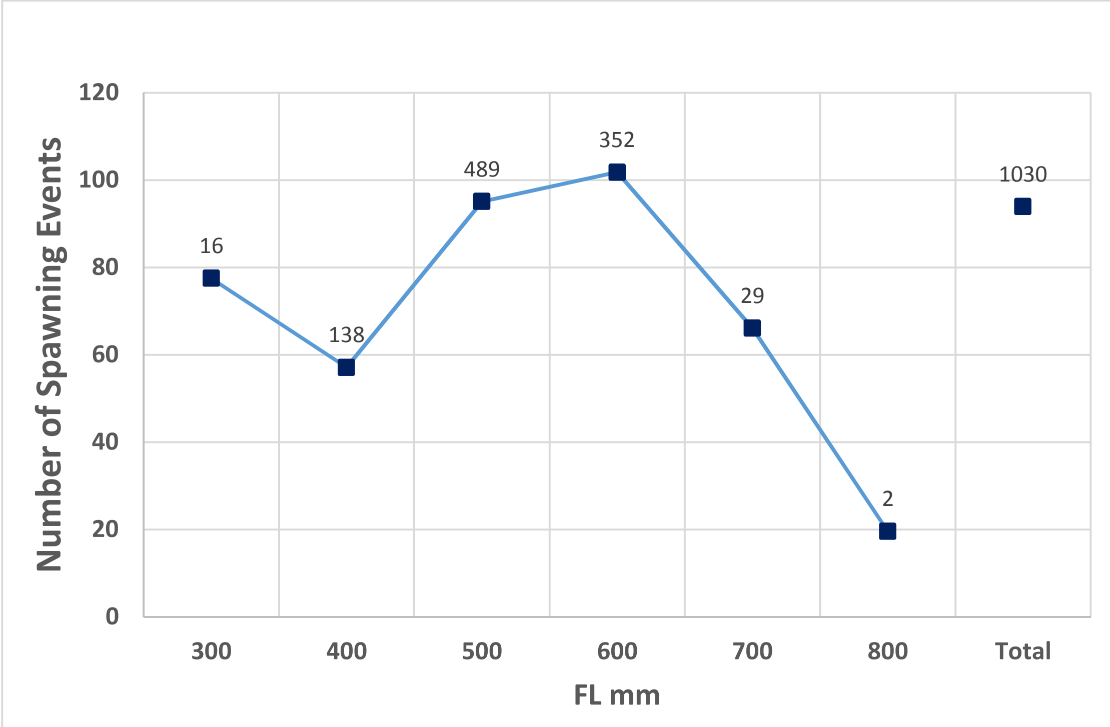


Figure 2.5 Number of spawning events by binned FL (mm) of female Blueline Tilefish. Data labels above points represent the number of individuals examined. Bins were center rounded to the nearest 100 mm.

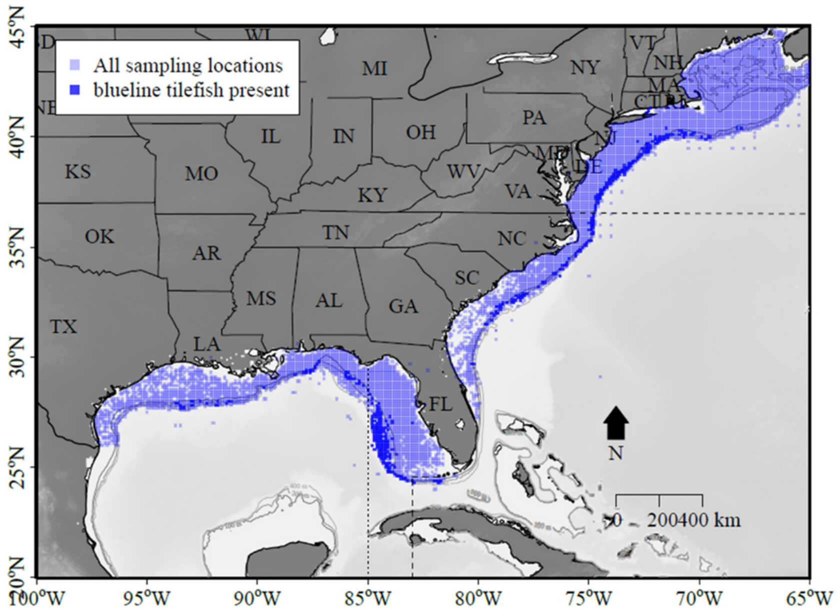


Figure 2.6 Map of all positive Blueline Tilefish collection locations and all sampling locations for data from all sources. Dashed lines indicate council boundaries. A dotted vertical line at 83W in the Gulf of Mexico marks the boundary between the western and eastern Gulf of Mexico.

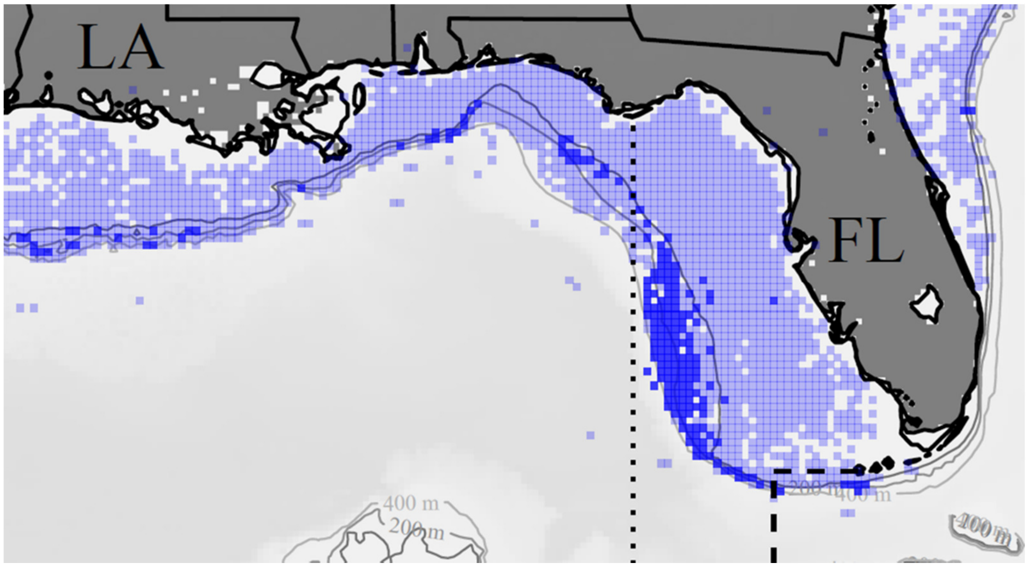


Figure 2.7 A close-up of the West Coast Florida Shelf and Gulf of Mexico positive Blueline Tilefish collection locations across all data sources. Dash line indicated council boundary. The dotted vertical line at 83W in the Gulf of Mexico marks the boundary between the western and eastern Gulf of Mexico.

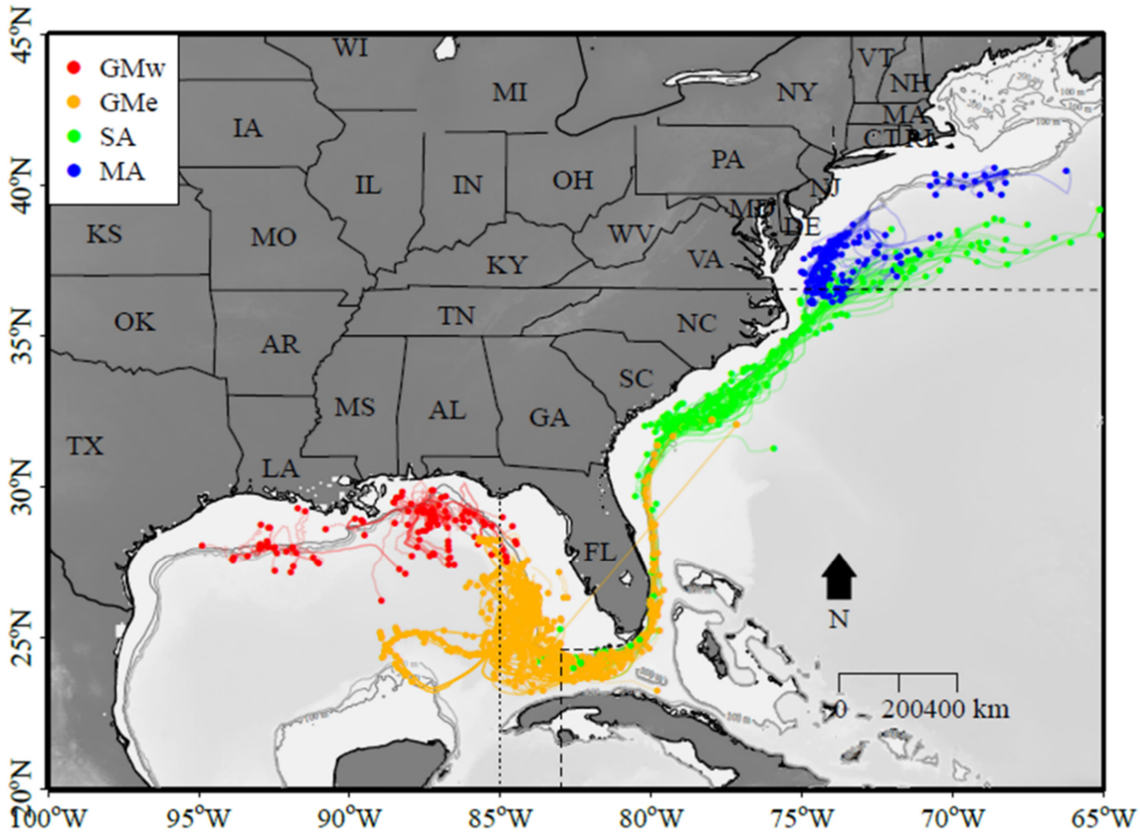


Figure 2.8 Locations of individual drogue (surface water) drifters 1-week (t1) after they were first observed in Blueline Tilefish habitat. Points and drifter tracks are color coded to indicate the council region where the t0 point was located (GM = Gulf of Mexico, SA = South Atlantic, MA = Mid-Atlantic). Dashed lines indicate council boundaries. A dotted vertical line at 83W in the Gulf of Mexico marks the boundary between the western and eastern Gulf of Mexico (GMw and GMe). Note that long straight-line segments in drifter tracks usually indicate missing data between the ends of the segment, and do not usually represent the actual path of movement.

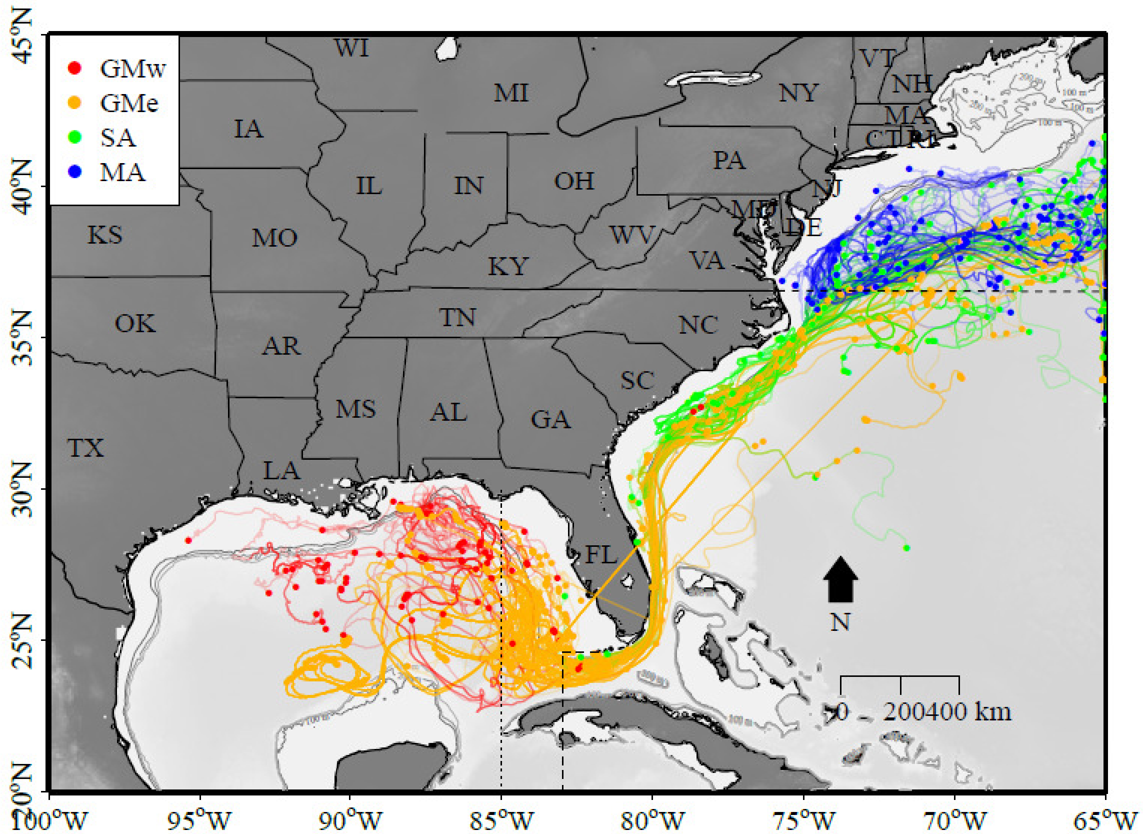


Figure 2.9 Locations of individual drogue (surface water) drifters 6-weeks (t6) after they were first observed in Blueline Tilefish habitat. Points and drifter tracks are color coded to indicate the council region where the t0 point was located (GM = Gulf of Mexico, SA = South Atlantic, MA = Mid-Atlantic). Dashed lines indicate council boundaries. A dotted vertical line at 83W in the Gulf of Mexico marks the boundary between the western and eastern Gulf of Mexico (GMw and GMe) as described in the main text. Note that long straight-line segments in drifter tracks usually indicate missing data between the ends of the segment, and do not usually represent the actual path of movement.

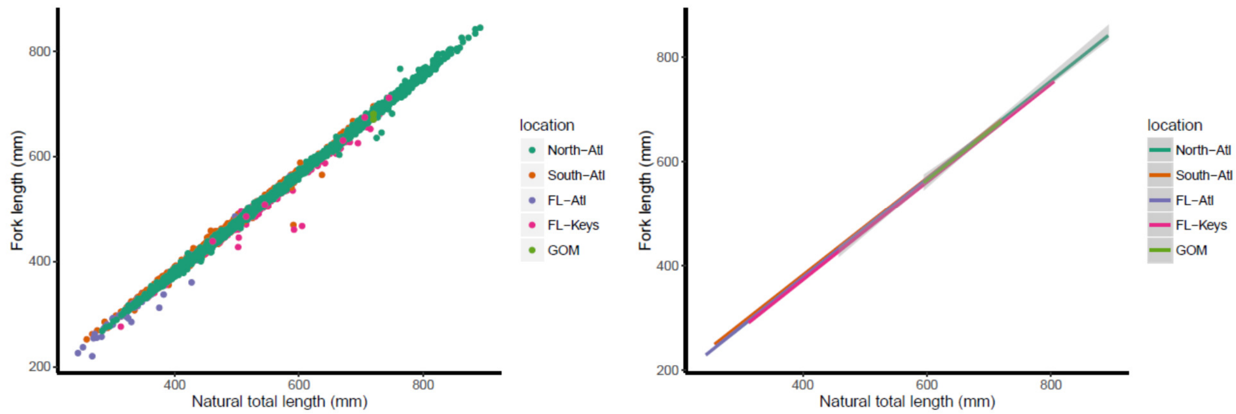


Figure 2.10 Exploring the possibility of different Blueline Tilefish length-length relationships by location. The figure on the left shows each sample while the figure on the right shows the regression line (gray shaded areas around each line indicate 95 CIs) for each location.

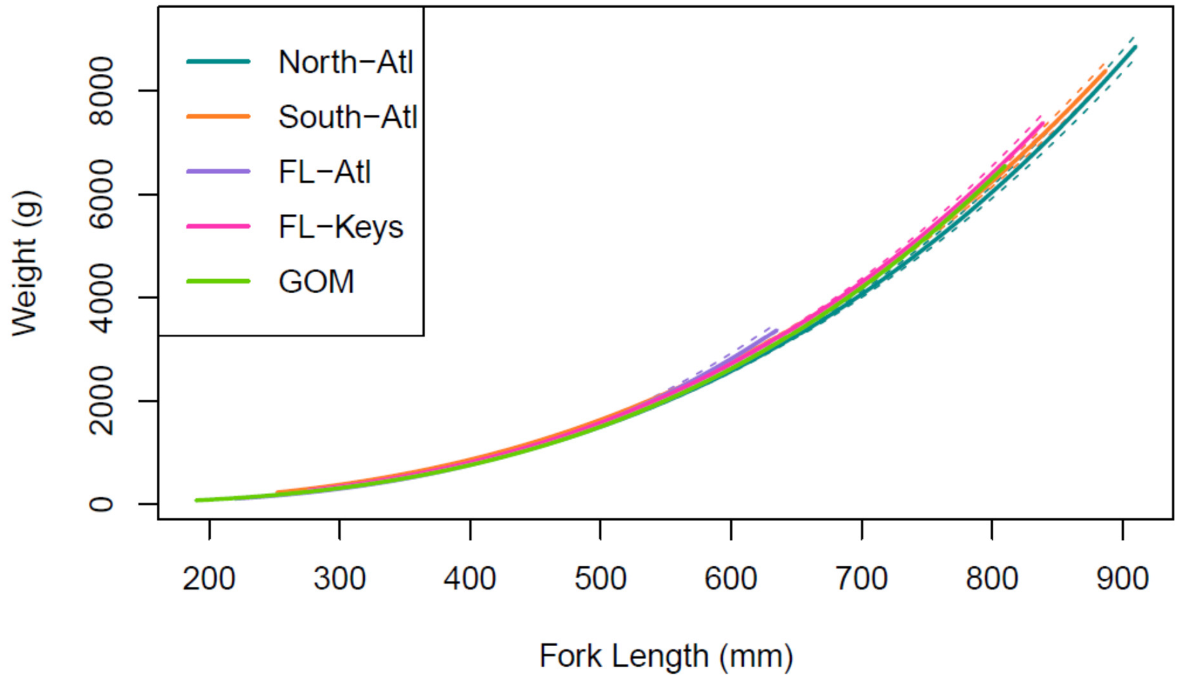


Figure 2.11 Exploration of possible different Blueline Tilefish fork length-whole weight relationships by location. The figure shows the regression line and 95 CI from each location.

3. Commercial Fishery Statistics

3.1 Overview

Commercial landings for the US Atlantic and Gulf of Mexico Blueline Tilefish stock were developed by gear (handlines, longlines, and other) in pounds whole weight for the period 1950–2015 based on federal and state databases. Corresponding landings in numbers were based on mean weights estimated from the Trip Interview Program (TIP) by year, state, and gear.

Commercial discards were calculated from fisher reported discard rates and gear-specific effort from the commercial fishery (South Atlantic) and observer reported discard and kept rates along with region specific commercial landings by gear (Gulf of Mexico).

Sampling intensity for lengths and age by gear and year were considered, and length and age compositions were developed by gear and year for which sample size was deemed adequate.

3.1.1 Commercial Work Group Participants

Kevin McCarthy	Workgroup co-leader	SEFSC Miami
Julie DeFilippi-Simpson	Workgroup co-leader	ACCSP
Alan Bianchi	Rapporteur/Data provider	NC DMF
Steve Brown*	Data provider	FL FWC
Julie Califf*	Data provider	GA DNR
Wiley Coppersmith	Commercial	NC
Amy Dukes	Data provider	SC DNR
Dave Gloeckner	Data provider	SEFSC Miami
Rusty Hudson	Commercial	FL/SFA
Heather Konell	Data Provider	ACCSP
Refik Orhun*	Data provider	SEFSC Miami
Steve Shelley	Commercial	SC
Beth Wrege	Data provider	SEFSC Miami

*Did not attend workshop

3.1.2 Issues Discussed at the Data Workshop

Issues discussed by the commercial workgroup concerning Blueline Tilefish landings included the apportioning of unclassified tilefish, gear groupings, and boundary definitions to align with indices. For discards, the workgroup discussed the limited available data from the CFLP discard logbook.

3.2 Review of Working Papers

SEDAR50-DW10: This working paper provided summary landings by statistical area from NC to Maine. Data are provided from the Vessel Trip Report (VTR) data. A commercial species code for Blueline Tilefish was developed in 2001. Prior to that year, tilefish reported as the tilefish unclassified code were comprised of mostly golden tilefish. These landings were compiled by statistical area, which did not align with the current methodology of compiling landings by year, state, and gear. Additionally, the dataset would fail to include any state-only component of the landings. These landings were useful in comparing the data from VA north from the ACCSP dataset.

SEDAR50-DW20: This working paper provided a summary of the Virginia Marine Sportfish Sampling program designed and conducted by the Virginia Marine Resources Commission staff. Although the project intent is to target recreationally important species in the Chesapeake Bay areas of Virginia, there were just over 50 commercial length samples available. These were deemed useful and provided for use in the length analysis.

3.3 Commercial Landings

Commercial landings of Blueline Tilefish were compiled from 1950 through 2015 for the entire U.S. Atlantic Coast. Sources for landings in the U.S. South Atlantic (Florida through North Carolina) included the Florida Trip Ticket program (FTT), South Carolina Department of Natural Resources (SCDNR), North Carolina Division of Marine Fisheries (NCDMF), and the Atlantic Coastal Cooperative Statistics Program (ACCSP). Landings from the Mid and North Atlantic (north of the NC-VA border) were from ACCSP and the NE Federal VTR (NEFSC). Landings from the Gulf of Mexico were provided by the Southeast Fisheries Science Center (SEFSC). Further discussion of how landings were compiled from the above sources can be found in section 3.3.4.

3.3.1 Commercial Gears

The workgroup investigated reported gears landing Blueline Tilefish from the data sources identified in Section 3.3.4 and determined the predominate gears to be longline or some type of handline. Landings were then categorized into three gear groups: longline, handline, and other. Handlines include hook and line, electric/hydraulic (a.k.a., bandit) reels, and trolling. A list of gears included in the longline and handline categories can be found in Table 3.1.

3.3.2 Stock Boundaries

DW ToR #1*: Define the unit stock for the SEDAR 50 stock assessment to include the entire US Atlantic seaboard, using the boundary between the Gulf of Mexico and South Atlantic Councils as the southwestern boundary for the stock unit to assess.*

Per Data Workshop Term of Reference #1, landings along the entire U.S. Atlantic coast were examined. Several years contain landings of unclassified tilefish. These landings would need to be proportioned out to only include Blueline Tilefish. Proportions are only available for the South Atlantic region and would not be representative of the tilefish species in other regions in the Atlantic and Gulf of Mexico; therefore, and in alignment with the Golden Tilefish assessment in the Mid and North Atlantic, only landings identified as Blueline Tilefish will be used from states north of NC and from Gulf of Mexico states with the exception of FL.

The Commercial Workgroup considered the southwestern boundary, as defined by Data Workshop Term of Reference #1, of the South Atlantic-Gulf of Mexico council boundary along US Highway 1 in Monroe County, FL as the dividing line between the South Atlantic and Gulf of Mexico stocks (see Figure 3.2). Logbook proportions, see Section 3.3.4 (Florida), were used to divide landings in Monroe County.

A harvest map of the area in which landings of Blueline Tilefish were considered can be found in Figure 3.1. A close up of the southern boundary, as determined by the South Atlantic/Gulf of Mexico Council boundary, can be seen in Figure 3.2.

3.3.3 Misidentification and Unclassified Tilefish

Species similar to Blueline Tilefish are landed in each state but markets, habitats, and regulations are different so there should be no misidentification. For SC and FL, all landings of tilefish are reported at the species level. Prior to 1985, all tilefish landings are reported as tilefish, which typically is referred to Golden Tilefish, in the ACCSP data warehouse. After 1985, landings are broken out by species (Golden Tilefish, Blueline Tilefish, Blackline Tilefish, Sand Tilefish, etc.) and also include an unclassified tilefish category. In SEDAR 4 and SEDAR 25, it was assumed that “tilefish” landings prior to 1985 were all Golden Tilefish. For GA, unclassified landings occur between 1985 and 1995. Any unclassified landings will be apportioned using average proportions from existing landings data by gear.

Because of the abrupt appearance of substantial Blueline Tilefish in the database in 1985, testimonies from fishermen catching Blueline Tilefish before 1985, and observed dockside sampling in TIP before 1985, SEDAR 32 treated landings before 1985 as unclassified tilefish and proportioned them to species to account for blueline landings. This approach to the landings prior to 1985 was continued in this workshop. State specific methodologies are further described in Section 3.3.4.

3.3.4 Commercial Landings by Gear and State

Statistics on commercial landings (1950 to present) for all species on the Atlantic coast are maintained in the Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse. The Data Warehouse is an online database of fisheries dependent data provided by the ACCSP state and federal partners. Data sources and collection methods are illustrated by state in Figure

3.3. The Data Warehouse was queried in January 2017 for all tilefish landings (annual summaries by gear category) from 1950 to 2015 from Florida through Maine (ACCSP 2017). Data are presented using the gear categories as determined at the Data Workshop. Commercial landings in pounds (whole weight using the 1.06 conversion provided by the Life History workgroup) were developed based on methodologies for gear as defined by the Workgroup for each state as available by gear for 1950 to 2015.

Virginia to Maine

ACCSP landings were examined and compared to landings in the northeast federal vessel trip report (VTR) system. ACCSP landings were deemed more complete as they included the state component and were more consistent with the methodology used in the remainder of the Atlantic region (Section 3.2, SEDAR50-DW10).

Based on previous assessment methodology and use of data, only landings reported as Blueline Tilefish were included. All tilefish landings were assumed to be Golden Tilefish. Landings were first reported in 1999. Gear proportions were determined by year across all states using matched trips (level A) from the AA tables at the NEFSC. These proportions were applied to all landings without a reported gears, remaining landings used gear as reported.

Florida

Comparisons were made between Florida's commercial trip ticket data (1986-2015) to both the NMFS general canvas (1976-1996) and logbook data (1992-2015). Only a very short time series of Blueline Tilefish exists in the general canvas data between 1992 and 1996 that is not Florida trip ticket. Statewide, those landings were identical to Florida trip ticket. After 1996, general canvas is Florida trip ticket. Blueline Tilefish landings from the NMFS logbook compared well to Florida trip ticket in the Gulf of Mexico beginning in 1996. Earlier years showed much lower landings in the logbook data. In the South Atlantic, logbook landings were generally lower than what was reported in Florida trip ticket. These same trends were also evident in comparisons by gear where hand lines and longlines in the Gulf of Mexico compared well between logbook and trip ticket after 1996, but were lower in the logbook data for most years by each gear type in the South Atlantic. There was more inconsistency in reported landings by gear in the South Atlantic between logbook and trip ticket. For example, two peaks in 2005 and 2008 trip ticket longline landings were in direct contrast to a gradual decline in long line landings from the logbook data during the same period. It was previously shown in SEDAR 32 that those same years in the trip ticket data were likely influenced by landings thought to be from Monroe County, Florida reported Gulf of Mexico landings. The workgroup decided to use the total Blueline Tilefish landings from the Florida trip ticket data over the general canvas and logbook data. The general canvas data were of a much shorter time series, with no Blueline Tilefish reported prior to 1992. Logbook data were also from a shorter time series and there appeared to be underreporting of landings from South Atlantic waters of Florida in logbook until 2009. Blueline Tilefish landings have always been reported to species on Florida trip tickets with no unclassified tilefish category used for the entire time series. All trip ticket landings are reported as gutted pounds.

One issue that arose with regard to trip ticket data was how to partition South Atlantic and Gulf of Mexico landings in Monroe County (Florida Keys). Blueline Tilefish landings in Monroe County are a significant portion of the Florida South Atlantic landings. It was estimated from the NMFS logbook data that the amount of Florida South Atlantic Blueline Tilefish landed in Monroe County was as much as 87% in a given year. The work group recommended using the NMFS logbook data to proportion out South Atlantic Blueline Tilefish in the trip ticket data since it is believed that fisher reported area fished data were generally more accurate than area fished data reported by dealers. Additionally, it was decided to use NMFS logbook data to apportion landings by gear in the trip ticket data. While both programs collected gear by trip over the same time series (since 1993), the workgroup decided that gear reported by fisher would generally be more accurate than dealer reported gears.

The amount of South Atlantic Blueline Tilefish by year in the Florida trip ticket data was determined by calculating the proportion of Monroe County South Atlantic Blueline Tilefish in the logbook data for years 1993 to 2015. This was done by dividing the amount of reported and proportioned South Atlantic Blueline Tilefish into total Blueline Tilefish landings for Monroe County only, then applying those proportions to the corresponding years for Monroe County total Blueline Tilefish landings. An average proportion for South Atlantic Monroe County was calculated from the combined 1993 to 2009 logbook data and applied to corresponding total Monroe Blueline Tilefish landings from 1958 to 1992. South Atlantic Monroe County and non-Monroe South Atlantic landings were then combined into total South Atlantic Blueline Tilefish landings. NMFS logbook data were then used to calculate proportions of Florida South Atlantic Blueline Tilefish harvest by gear. This was done by dividing logbook landings for each gear into total Florida South Atlantic logbook landings, then applying those proportions to the Florida trip ticket South Atlantic landings by year from 1993 to 2015. The average proportion of logbook landings by gear from 1993 to 2009 was then applied to from 1958 to 1992. An analogous approach was used to compile Gulf of Mexico landings. Final adjusted landings are in pounds whole weight, using the 1.06 conversion provided by the Life History group.

Georgia

GA DNR staff examined ACCSP landings and compared them to state held versions. It was determined that ACCSP landings were a match and would be used in place of state provided data for the entire time series.

The proportion of Blueline Tilefish to other tilefish species was determined from the GA data by gear type from landings for 1997 to 1999, 2002. This period includes no unclassified landings and total tilefish species group landings are greater than 1,000 pounds. The average proportion for Blueline Tilefish by gear type was then applied to all landings of tilefish species prior to 1996.

South Carolina

Prior to 1972, commercial landings data were collected by various federal fisheries agents based in South Carolina, either U.S. Fish or Wildlife or National Marine Fisheries Service personnel. In 1972, South Carolina began collecting landings data from coastal dealers in cooperation with federal agents. Mandatory monthly landings reports are required from all licensed wholesale dealers in South Carolina. Until the fall of 2003, those monthly reports were summaries collecting species, pounds landed, disposition (gutted or whole) and market category, gear type and area fished. Since September 2003, landings have been reported by a mandatory trip ticket system collecting landings by species, disposition and market category, pounds landed, ex-vessel prices with associated effort data to include gear type and amount, time fished, area fished, vessel and fisherman information.

SCDNR provided landings data for Blueline Tilefish from 1975 to 2015. Data from 1975 to 2003 were collected in monthly totals through collaborative efforts by SCDNR and the NMFS Cooperative Statistics Program. All data were correlated and confirmed with the ACCSP data warehouse. Data provided from 2004 to 2015 were more comprehensive because SCDNR instituted a mandatory Trip Ticket Program in late 2003.

Between the years 1975 and 1984, landings were assigned to tilefish only. It was assumed that some of those landings included Blueline Tilefish landings. In order to proportion these landings to tilefish species, SCDNR landings data from 1985 to 2010 were used to calculate species specific proportions, by gear. Proportions were calculated as the mean proportion across years, weighted by yearly tilefish landings. Those years were selected to correspond to tilefish species specific reporting in SC (1985) and prior to major regulation changes that may have altered commercial fishing practices (2010). All gutted to whole weight calculations were performed before data from these presumed unclassified tilefish were proportioned.

North Carolina

NCDMF provided landings data for Blueline Tilefish from 1950 to 2015. Data from 1950 to 1993 were provided by the NMFS Cooperative Statistics Program and are also stored in the NCDMF database; data from 1994 to 2015 were provided by the NC Trip Ticket Program. Up to three gears can be listed on a trip ticket therefore, landings were analyzed to look at gear combinations and gear was reassigned where necessary (Table 3.2). Data from NCDMF were also stored in the ACCSP data warehouse. Data were provided by NCDMF to capture all three gears and contained the most recent edits to the data.

Prior to 1985 all tilefish are reported as unclassified tilefish. Unclassified tilefish are reported along with identified Blueline Tilefish from 1985 to 1993. After 1993, there are no unclassified tilefish reported. The proportion of Blueline Tilefish to other tilefish species was determined from the NC trip ticket data by gear type. The time frame used for the handline and other gear categories were from 1994 to 2010 while those for longlines was from 1994 to 2001. The shorter time period for the longline gear was because of noted landings shift in golden tilefish with greatly reduced landings in NC after 2001. The workgroup determined that post-2001 data did not accurately represent the golden tilefish proportion of total landings prior to 2002. The average proportion for Blueline Tilefish by gear type was then applied to all landings of tilefish species prior to 1994. It was assumed, even though some species specific reporting did begin in the early 80s, that tilefish species weren't being recorded correctly.

In order to align with the regions used for commercial indices, landings of Blueline Tilefish were compared between north and south of Cape Hatteras from 1999 to 2007 to determine landings proportion by area and gear type. By 1999 the majority of Blueline Tilefish landings were reported as north or south of Cape Hatteras. The terminal year of 2007 was chosen because in 2008 the landings of Blueline Tilefish rose dramatically in NC as this fishery started to develop. The proportion from this time frame by gear type was used to split the landings north and south of Cape Hatteras for all years prior to 1999. All landings that were already identified and split between north and south of Hatteras prior to 1999 were left as reported (the distinction between north and south of Cape Hatteras started in 1997).

The landings south of Cape Hatteras were split further into north and south of Cape Fear. To do this, the landings data from 1999 to 2010 for Blueline Tilefish reported south of Cape Hatteras by county were analyzed. The New Hanover and Brunswick county lines were used as a proxy for the Cape Fear region. The proportion of Blueline Tilefish from south of Cape Hatteras waters at the New Hanover and Brunswick county lines by gear type was determined and applied to all landings of Blueline Tilefish from south of Cape Hatteras to determine the split at Cape Fear to all of the landings data.

<u>Gulf of Mexico landings for AL-TX</u>

Accumulated Landings System (ALS)

Most of the commercial landings were compiled from the ALS from 1963-2015. All tilefish landings were extracted by year, state, fishing area, species, and gear (handline, longline, and other) where the waterbody was identified as Gulf of Mexico or the landing occurred in a Gulf state when the fishing area was missing. There are several situations where the landings data may not have the desired level of resolution. The following issues were identified:

1. For Louisiana, gear and fishing area are not available for 1990 - 1999
2. For Texas, gear and fishing area are not available for 1990 - 2011.

As gear was available for records from AL, MS, and LA after 1999, the group recommended that the ‘Other’ gear category (including uncoded gear) be grouped with the predominant gear.

Unclassified Groupers

Golden tilefish were reported to species from 1978 on in Gulf States from AL-TX. After 1978 unclassified tilefish can be found to varying degrees depending on the state of reporting. The earliest unclassified tilefish was reported in 1991. To apportion these unclassified tilefish landings to Blueline Tilefish, a proportion of Blueline Tilefish to the total identified tilefish { (blueline tilefish)/(all identified tilefish species) } was developed for each year, gear, and state. The average proportions by gear were then calculated and applied to all unclassified tilefish landings with the corresponding gear to estimate the blueline landings from the unclassified landings.

<u>Combined State Results</u>

Landings by gear category are presented in pounds whole weight (Table 3.3) and shown graphically in Figures 3.4 and 3.5. Longlines are the dominant gear and account for 56% of the total landings in the Atlantic and 83% of the total landings in the Gulf of Mexico for the period of 1950 to 2015. Handlines were used more frequently in the earlier part of the time series in the Atlantic and account for about 37% of the total landings in the Atlantic and 16% of the total landings in the Gulf of Mexico for the period.

The Workgroup reported commercial landings according to the following:

- Landings should be reported as whole weight in pounds and number of fish
- Final landings data came from the following sources:
    - VA-North: 2002-2015 (ACCSP)
    - NC: 1958-2015 (NCDMF)
    - SC: 1975-2015 (SCDNR)
    - GA: 1977-2015 (ACCSP)
    - FL: 1958-1985 (ACCSP)
      1986-2015 (FL Trip Ticket)
    - GOM: 1958-2015 (SEFSC)

<u>Whole vs. Gutted Weight</u>

The majority of Blueline Tilefish in the Atlantic are landed in gutted condition and converted by the states to whole weight. For this analysis, landings by state were converted back to gutted weight using the state/federal conversion and then converted to whole weight using a conversion of 1.06 provided by the Life History Group.

Confidentiality Issues

Landings of Blueline Tilefish were pooled across states by gear to meet the rule of 3 and ensure confidential landings were not presented in this report. Confidential landings for other gear in 1996 have been masked in the Atlantic. Landings for all gears in 1983 and 1984 have been masked in the Gulf of Mexico. Landings by state and gear will be provided to the data compiler for use in the assessment.

Uncertainty

The commercial workgroup estimated uncertainty in commercial fishery landings, after consultation with assessment biologists, by modifying the uncertainty estimates used in SEDAR 41, while using the same methodology. These estimates of uncertainty are not coefficients of variation, but are estimates of possible reporting error; i.e., represent the range in actual commercial landings relative to the reported landings.

In making these uncertainty estimates, two assumptions were made:

1. Landings may be underreported during all years; however, underreporting was likely highest during early years of the time series and were more accurate in recent years. This assumption was based upon the following information and data workshop expert testimony: during the period 1958 (beginning of landings time series) to 1961 landings were summarized annually by state and likely did not include landings from small scale dealers. In the years 1962 to 1977 landings data were collected annually, but under a more all-inclusive program (General Canvass). Monthly landings summaries were collected during the period 1978 to the beginning of trip ticket data collection (starting dates vary among states). The most recent landings data, collected through state trip ticket programs, were assumed to be most reliable and inclusive of all commercial landings.
2. Landings may be overestimated prior to comprehensive species specific reporting because unclassified tilefish are being proportioned to species.

The group agreed, based upon expert opinion, that both an upper and lower bound be used for the period during which unclassified tilefish were present in the landings. The workgroup recommended that an upper bound only be set to account for underreported landings during the period when no unclassified tilefish were reported. See Table 3.4 for state specific uncertainties.

3.3.5 Converting Landings in Weight to Landings in Numbers

Mean weights will be reported in the Assessment Workshop Report.

3.4 Commercial Discards

Available data useful for calculating commercial discards included fisher reported discard rates and gear-specific effort from the commercial fishery (South Atlantic) and observer reported discard and kept rates along with region specific commercial landings by gear (Gulf of Mexico).

South Atlantic

Discard data were available for the years 2002 to 2015 from the discard logbook program. The program data base contains discard reports from a 20 percent sample (by region and gear fished) of all commercial vessels with federal fishing permits. Very few bottom longline trips had reports of Blueline Tilefish discards (4 trips in 2013, 2 in 2015). Blueline Tilefish were never reported as kept for bait from bottom longline trips. No Blueline Tilefish discards were reported from vertical line (handline and electric/hydraulic reel, i.e., bandit rig) trips prior to 2011, but fish kept for bait were reported during 2003 to 05 and 2007. Most vertical line trips with reported discards occurred in 2015 (73 trips). In all other years, 13 or fewer vertical line trips per year had Blueline Tilefish discards reported.

Discard rates were calculated as the nominal discard rate per year by gear during the period 2002-2015. The discard rate was then multiplied by the yearly gear-specific total fishing effort (total hook-hours fished for vertical line; total hooks fished for bottom longline gear) reported to the coastal logbook program. Effort data were available for the period 1993 to 2015. Discards were calculated separately for those fish reported as discarded and those that were reported as "kept as bait or eaten". To calculate discards and kept for bait prior to 2002, mean rates for the years 2002 to 09 were multiplied by the yearly effort during the period 1993 to 2001. Discards and total fish kept for bait could not be calculated for years prior to 1993 because commercial fishing effort data are not available for any earlier years (1993 was the first year of full reporting to the coastal logbook program). Calculated discards and fish reported as "kept as bait" are provided in Table 3.5. Discard and kept for bait total weight was estimated using the mean weight per discard (or fish kept for bait) reported in the Gulf of Mexico reef fish observer program. The large number of discards from vertical line trips in recent years (2012, 2014, 2015) correspond to years with closed fishing seasons, trip limits, or both.

An increase in the number of reports of "no discards" (of any species) over the period 2002-2015 may have resulted in under reporting of commercial discards. To reduce the likelihood of erroneously low discard rates, data filtering followed the recommendations of SEDAR 32. The filter excluded data from vessels that reported more than 19 trips (vertical line) or 16 trips (bottom longline) without reporting discards of any species. Those values represent the mean number of trips prior to the first trip with reported discards plus two standard deviations of that mean. Effort data were also filtered to remove data from trips with landings of mackerel only. This filter was recommended in SEDAR 32 because mackerel only trips were unlikely to have had Blueline Tilefish discards; therefore, including effort from mackerel only trips would be inappropriate. Data were also filtered to remove trips with fishing reported from both regions or that included clearly erroneous data (e.g., fishing more than 24 hours per day).

Due to small sample sizes and suspected underreporting of discards, CVs for South Atlantic discard estimates were assumed to be 0.5.

Gulf of Mexico

Data available for Blueline Tilefish discard calculation in the Gulf of Mexico included reef fish observer vertical line and bottom longline and shark observer bottom longline data. Gear specific landings data were also available for use in discard calculations. The observer data were used to calculate Blueline Tilefish discard rate:kept rate ratios. Those ratios were multiplied by the Gulf of Mexico Blueline Tilefish landings to estimate Blueline Tilefish discards.

Observer data were pooled across years due to small sample sizes. Pooled years were 2007 to 09 (vertical line data, 2007 to 08 bottom longline data) and 2010 to 2015. For bottom longline discard estimations, data from 2009 were considered separately from other years due to a time-area closure implemented for that single year (bottom longline fishing limited to >50 fathoms in the eastern GOM beginning in May, 2009). Prior to 2010, regulations were limited to open and closed seasons, however, an IFQ system for managing tilefish was introduced in 2010. Such different management approaches likely changed fisher behavior (see SEDAR 31 data workshop report); including discarding, such that it was assumed to be inappropriate to calculate mean discard rates over the entire time series of data.

Further data stratification included gear (vertical line, bottom longline), Blueline Tilefish season (open, closed), tilefish IFQ allocation (none, 1+ pounds; used for the period 2010-15), and fishery (shark, reef fish; this stratum was used for bottom longline only and was needed to calculate discards for each observer program). Landings within a particular stratum were estimated based upon logbook reports; e.g., if 10% of Blueline Tilefish landings reported to the logbook program in 2008 were from the reef fish bottom longline fishery during the open season, 10% of the 2008 landings were assumed for that stratum. Stratum specific discard to kept ratios were used along with stratum specific landings to calculate discards within each stratum. Within year stratum specific discards were summed to provide yearly discard totals. Blueline Tilefish kept for bait were calculated following the same methods used to calculate discards. Estimated Blueline Tilefish discards and fish kept for bait are provided in Table 3.6. Discards were calculated in pounds whole weight and converted to numbers of fish using the average weight of a discard (or fish kept for bait) observed for each gear.

Discards prior to 2007 (first year of observer data) were estimated using 2007 to 09 (vertical line; 2007 to 08 bottom longline) open season discard rate:kept rate ratios. Stratum specific landings proportions for the years 1958 to 1992 were assumed to be equal to the mean logbook landings proportions by stratum for the years 1993 to 2002.

Discard calculations using Gulf of Mexico observer data were hindered by small sample size. Due to uncertainty in the representativeness of the observer data, CVs of 0.2 for the years 1993 to 2015) and 0.3 (1958 to 1992) were recommended for the discard estimates.

Mid-Atlantic

Blueline Tilefish discards were estimated for the Mid-Atlantic large and small mesh trawl fisheries following the Standardized Bycatch Reporting Methodology (SBRM, http://www.nefsc.noaa.gov/fsb/SBRM/) from 2001 to 2015. SBRM uses discarded Blueline Tilefish to kept all species ratios on observed trips applied to the kept of all species landed by gear type. Overall incidental discards of Blueline Tilefish in the trawl fisheries tend to be low and variable. Estimated CVs in the large mesh trawl fishery varied from 0.42 to 1.16 and for the small mesh fishery from 0.45 to 1.15. The median Blueline Tilefish discard estimate from the 2001 to 2015 time period was used as the best estimate in each year from 2001 to 2015 for the large mesh and small mesh trawl fisheries in the Mid-Atlantic. The median large mesh estimate was estimated at only 0.16 mt with a median CV estimate of 0.76 and the small mesh trawl fishery estimate was 0.45 mt with a median CV estimate of 0.9.

3.5 Commercial Effort

Maps of the commercial effort from the Commercial Fisheries Logbook Program, for the South Atlantic and Gulf of Mexico, and Vessel Trip Reports, for the Mid and North Atlantic will be provided in the Assessment Workshop Report.

3.6 Biological Sampling

Biological sample data were obtained from the TIP sample data at NMFS/SEFSC. Data were filtered to eliminate those records that included a size or effort bias, non-random collection of length data, were not from commercial trips, fish selected by quota sampling, or data not collected shore-side. These data were further limited to those that could be assigned a year, gear, and state. Data that had an unknown sampling year, gear, or sampling state were deleted from the file. TIP data must also be weighted spatially by the landings for the particular year, state, and gear stratum to correct for differences in sampling intensities across states. TIP data were joined with landings data by year, gear, and state. Landings data were also limited to only those data that could be assigned a year, gear, and state. Landings and biological data were assigned a state based on landing location or sample location if there was no landing location assigned.

Length samples were available from the Northeast Biological Dockside Sampling program in 2015 and from the Virginia Marine Sportfish Sampling program in 2011 and 2012.

3.6.1 Sampling Intensity

The number of trips sampled ranged from a high of 74 for long line gear in 2000 in the Gulf of Mexico to a low of zero for many strata (Table 3.7). The number of trips sampled was consistently greater than 10 trips for handline gear from 1984 to 2011 from Cape Canaveral to the NC/VA border, but was always less than 10 for other gears with no samples collected in many years.

The number of fish sampled had a high of 2,783 for long line gear in 1993 for Cape Canaveral to the NC/VA border to lows of zero for many of the strata (Table 3.8). The number of lengths sampled was consistently greater than 100 from handline gear during 1984 to 1996 and 1998 to 2011 in the region Cape Canaveral to the NC/VA border and for long line in the Gulf of Mexico during 1991 to 2006. For other gears, the numbers of length samples available were below 100 for all years and regions.

The Virginia Marine Sportfish Sampling program provided 53 commercial lengths in 2011 and an additional 5 in 2012. The Northeast Biological Dockside Sampling program provided 480 lengths.

3.6.2 Length/Age Distributions

Length composition will be reported in the Assessment Workshop Report.

3.6.3 Adequacy for Characterizing Catch

Adequacy of length data and length sampling fractions will be reported in the Assessment Workshop Report.

3.7 Comments on Adequacy of Data for Assessment Analyses

Landings data for assessment analyses appear to be mostly adequate. There is a clear landings history for the available time series. Tilefish (blueline or otherwise) landings were nonexistent prior to 1958, so it is likely that any Blueline Tilefish landings made prior to 1950 were negligible, if not nonexistent. There was little issue concerning species identification. Tilefish reported from 1985 forward were mostly reported to the species level. Prior to 1985, all tilefish were reported as ‘Tilefish’. These earlier, and later unclassified, tilefish landings likely contained Blueline Tilefish and were apportioned accordingly. For the period from 1981 to 1985, unclassified landings increase significantly. Expert testimony by commercial fishers has attributed the increased landings to an increase in Golden Tilefish landings specifically, no other data sources are available to source proportions that would vary from other unclassified landings years. Thus, uncertainty in the landings for FL-Atlantic for 1978 to 1985 was increased to 0.2 (Table 3.4). Definition of stock boundaries and landed condition (gutted vs. whole) were not an issue.

Discard calculations are less adequate as there may be issues concerning the quality of self-reported data, especially where ‘no discard’ reports are concerned. While it is generally accepted that a trip without discards, of any kind, can and will happen, there is high level of uncertainty in the accuracy of ‘no discard’ reports. Discard reporting has gone from 67% of reports in early years, indicating discards of some species or another, to only 33% of trips reporting discards in recent years. This is a complete reversal in the reports of "no discards". The numbers are variable, but since 2008 the percentage of "no discards" trips has ranged from 63% to 70%. It is likely that some fishers may simply report 'no discards' to satisfy their reporting requirements. Observer data, available in the Gulf of Mexico, has been considered in prior SEDAR assessments to be more accurate than fisher reported discards. The limited number of observed trips with Blueline Tilefish, however, required pooling of data across years. Variability in yearly discards cannot, therefore, be assumed to be an indication of recruitment (or lack thereof). In addition, the implementation of IFQs in the Gulf of Mexico likely changed fisher behavior with more valuable golden tilefish retained and Blueline Tilefish either discarded or kept for bait. Fishers may also avoid Blueline Tilefish habitat in favor of targeting golden tilefish. Changes in fisher behavior is poorly understood in this fishery and contributes to the uncertainty of the discard estimates.

Some biological sampling data may be inadequate. As discussed in the previous section, length samples are low/nonexistent over the entire time series for 'other' gear, and are low in some years for handline and longline.

3.8 Research Recommendations

- Investigate improvements in proportioning unclassified tilefish to species
    - Investigate alternative methods of determining proportions, e.g. relationship to landings of non-tilefish species such as Snowy Grouper
- Increase observer coverage in the South Atlantic
    - Observer data would improve discard estimation and provide estimates of discard sizes and weights
- Implement electronic monitoring of bycatch
    - Such a program should improve discard estimation accuracy and provide size and weight composition of discards

3.9 Data Best Practices Input & Suggestions

The Commercial Workgroup still supports the recommendation from the Best Practices Report to hold a workshop or meeting to determine specific methods for quantifying uncertainty in commercial landings in such a way that is appropriate and informative to the model.

3.10 Literature Cited

Atlantic Coastal Cooperative Statistics Program. 2017. Annual landings by custom gear category; generated by Julie Defilippi Simpson using ACCSP Data Warehouse, Arlington, VA: accessed January 2017.

3.11 Tables

Table 3.1 Specific ACCSP gears in each gear category for Blueline Tilefish commercial landings.

HANDLINE			
GEAR CODE	**GEAR NAME**	**TYPE CODE**	**GEAR TYPE**
300	HOOK AND LINE	007	HOOK AND LINE
301	HOOK AND LINE, MANUAL	007	HOOK AND LINE
302	HOOK AND LINE, ELECTRIC	007	HOOK AND LINE
303	ELECTRIC/HYDRAULIC, BANDIT REELS	007	HOOK AND LINE
304	HOOK AND LINE, CHUM	007	HOOK AND LINE
305	HOOK AND LINE, JIG	007	HOOK AND LINE
306	HOOK AND LINE, TROLL	007	HOOK AND LINE
307	HOOK AND LINE, CAST	007	HOOK AND LINE
308	HOOK AND LINE, DRIFTING EEL	007	HOOK AND LINE
309	HOOK AND LINE, FLY	007	HOOK AND LINE
310	HOOK AND LINE, BOTTOM	007	HOOK AND LINE
320	TROLL LINES	007	HOOK AND LINE
321	TROLL LINE, MANUAL	007	HOOK AND LINE
322	TROLL LINE, ELECTRIC	007	HOOK AND LINE
323	TROLL LINE, HYDRAULIC	007	HOOK AND LINE
324	TROLL LINE, GREEN-STICK	007	HOOK AND LINE
330	HAND LINE	013	HAND LINE
331	TROLL & HAND LINE CMB	013	HAND LINE
340	AUTO JIG	013	HAND LINE
700	HAND LINE	013	HAND LINE
701	TROLL AND HAND LINES CMB	013	HAND LINE
702	HAND LINES, AUTO JIG	013	HAND LINE
LONGLINE			
GEAR CODE	**GEAR NAME**	**TYPE CODE**	**GEAR TYPE**
400	LONG LINES	008	LONG LINES
401	LONG LINES, VERTICAL	008	LONG LINES
402	LONG LINES, SURFACE	008	LONG LINES
403	LONG LINES, BOTTOM	008	LONG LINES
404	LONG LINES, SURFACE, MIDWATER	008	LONG LINES
405	LONG LINES, TROT	008	LONG LINES
406	LONG LINES, TURTLE HOOKS	008	LONG LINES
407	LONG LINES, DRIFT W/HOOOKS	008	LONG LINES
408	BOUY GEAR	008	LONG LINES

Table 3.2 North Carolina Trip Ticket Program gear code reassignments for Blueline Tilefish (1994 – 2015).

NEW GEAR		GEAR1		GEAR2		GEAR3	
610	Rod-n-Reel	345	Fish Pot	610	Rod-n-Reel		
345	Fish Pot	480	Gill Net Set (sink)	345	Fish Pot		
610	Rod-n-Reel	480	Gill Net Set (sink)	610	Rod-n-Reel		
610	Rod-n-Reel	480	Gill Net Set (sink)	660	Trolling	610	Rod-n-Reel
610	Rod-n-Reel	480	Gill Net Set (sink)	610	Rod-n-Reel	660	Trolling
345	Fish Pot	660	Trolling	345	Fish Pot		
610	Rod-n-Reel	660	Trolling	345	Fish Pot	610	Rod-n-Reel
676	Longline Bottom	660	Trolling	676	Longline Bottom		
610	Rod-n-Reel	660	Trolling	610	Rod-n-Reel		
676	Longline Bottom	660	Trolling	676	Longline Bottom	677	Longline Shark

Table 3.3 Blueline Tilefish landings by gear and region, in whole weight pounds, for all states (ME-TX) by gear. Cells with a '*' indicate confidential data and therefore were removed.

	Atlantic			Gulf of Mexico		
Year	Total HL	Total LL	Total O	Total HL	Total LL	Total O
1958	367			354	846	25
1959	183		92	159	381	11
1960				18	42	1
1961				106	254	8
1962	517	125	446	157	377	11
1963	517	125	263	140	335	10
1964	61	15	650	16	39	1
1965	3,945	970	605	1,069	2,560	77
1966	737	183	113	595	1,424	43
1967	1,729	439	263	708	1,694	51
1968	680	389	64	447	1,070	32
1969	426	357	20	104	249	7
1970	1,469	493	201	214	512	15
1971	3,043	808	456	602	1,440	43
1972	1,789	499	264	485	1,162	35
1973	8,694	685	1,595	738	1,765	53
1974	20,955	1,038	3,956	707	1,692	51
1975	36,230	1,790	6,816	1,593	3,813	114
1976	36,122	1,576	6,684	3,874	9,273	277
1977	26,352	1,914	2,646	6,989	16,727	500
1978	77,461	2,610	22,497	5,276	12,629	378
1979	57,900	3,225	7,434	5,187	12,414	371
1980	142,390	3,600	9,115	4,774	11,426	342
1981	371,861	18,688	44,911	37,149	88,913	2,660
1982	876,490	66,813	139,319	30,399	72,757	2,177
1983	394,130	115,944	61,190	*	*	*
1984	300,108	119,840	31,313	*	*	*
1985	254,188	45,689	36,984	17,043	40,792	1,220
1986	124,519	130,868	8,853	11,276	80,111	779
1987	91,243	47,943	2,417	20,248	143,848	1,399
1988	63,434	55,436	2,268	21,692	155,474	1,492
1989	64,918	56,451	3,800	8,693	61,794	601
1990	104,364	73,362	3,752	15,019	106,478	1,036
1991	120,463	97,064	26,255	15,707	111,598	2,244
1992	119,888	153,610	7,952	16,840	119,686	2,995
1993	56,291	149,678	10,478	26,336	68,525	3,701
1994	73,148	111,853	4,537	31,852	101,452	9,317
1995	66,099	102,200	2,765	15,243	65,790	19

1996	116,603	31,583	*	14,891	45,513	806
1997	142,377	74,182	3,239	15,187	146,183	5,243
1998	73,752	32,773	1,254	14,235	90,317	140
1999	78,998	36,030	1,107	12,949	64,959	50
2000	74,793	34,198	3,369	5,958	94,359	79
2001	89,254	36,773	1,730	14,391	72,705	305
2002	137,662	125,135	71	9,903	54,084	214
2003	78,358	33,913	5,240	9,009	87,576	72
2004	42,069	27,061	7,435	12,245	114,323	22
2005	57,611	19,920	6,384	13,217	78,372	71
2006	105,607	52,061	15,360	13,443	119,945	36
2007	57,722	7,132	8,582	12,692	117,661	68
2008	210,755	185,931	14,445	8,864	163,877	14
2009	259,815	200,170	14,590	11,377	96,108	7
2010	135,812	292,231	8,802	7,039	23,903	589
2011	19,681	114,999	6,848	4,603	37,640	
2012	32,971	311,239	19,602	24,711	64,389	
2013	56,661	217,831	14,537	13,389	39,685	2
2014	57,021	282,328	16,687	11,841	69,822	160
2015	17,795	119,260	7,107	12,887	42,335	20

Table 3.4 Uncertainty in commercial landings by data state/region. Upper and lower bounds prior to dividing (red) line. Upper bound only post diving line.

Year	Mid-Atlantic/NE	NC	SC	GA	FL - Atlantic	FL - GOM	GOM
1958-1961	NA	0.25	NA	NA	0.25	0.25	NA
1962-1977	NA	0.2	0.2	0.2	0.2	0.2	NA
1978-1985	NA	0.1	0.1	0.1	0.2	0.1	0.25
1986-1989	NA	0.1	0.1	0.1	0.05	0.05	0.25
1990-1993	NA	0.1	0.1	0.1	0.05	0.05	0.15
1994	NA	0.05	0.1	0.1	0.05	0.05	0.15
1995-1996	NA	0.05	0.1	0.1	0.05	0.05	0.15
1997-2001	0.25	0.05	0.1	0.1	0.05	0.05	0.1
2002-2003	0.25	0.05	0.05	0.1	0.05	0.05	0.1
2004	0.25	0.05	0.05	0.05	0.05	0.05	0.1
2005-2009	0.1	0.05	0.05	0.05	0.05	0.05	0.1
2010-present	0.1	0.05	0.05	0.05	0.05	0.05	0.05

Table 3.5 Calculated Blueline Tilefish discards and kept discards (bait) from the US South Atlantic commercial fishery.

Year	Bottom longline calculated discards wwt	Bottom longline calculated discards number of fish	Bottom longline calculated kept for bait wwt	Bottom longline calculated kept for bait number of fish	Vertical line calculated discards wwt	Vertical line calculated discards number of fish	Vertical line calculated kept for bait wwt	Vertical line calculated kept for bait number of fish
1993	0	0	0	0	0	0	69	28
1994	0	0	0	0	0	0	86	34
1995	0	0	0	0	0	0	89	36
1996	0	0	0	0	0	0	89	35
1997	0	0	0	0	0	0	91	36
1998	0	0	0	0	0	0	70	28
1999	0	0	0	0	0	0	59	24
2000	0	0	0	0	0	0	59	24
2001	0	0	0	0	0	0	64	26
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	31	12
2004	0	0	0	0	0	0	100	40
2005	0	0	0	0	0	0	103	41
2006	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	189	76
2008	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0
2011	0	0	0	0	6	1	0	0
2012	0	0	0	0	5,069	1,215	0	0
2013	300	64	0	0	0	0	0	0
2014	0	0	0	0	1,970	472	0	0
2015	470	99	0	0	65,246	15,640	0	0

Table 3.6 Calculated Blueline Tilefish discards and kept discards (bait) from the US Gulf of Mexico commercial fishery.

Year	Bottom longline calculated discards wwt	Bottom longline calculated discards number of fish	Bottom longline calculated kept for bait wwt	Bottom longline calculated kept for bait number of fish	Vertical line calculated discards wwt	Vertical line calculated discards number of fish	Vertical line calculate d kept for bait wwt	Vertical line calculated kept for bait number of fish
1958	342	72	349	106	0	0	0	0
1959	154	33	157	48	0	0	0	0
1960	17	4	17	5	0	0	0	0
1961	103	22	105	32	0	0	0	0
1962	152	32	155	47	0	0	0	0
1963	135	29	138	42	0	0	0	0
1964	16	3	16	5	0	0	0	0
1965	1,034	219	1,056	322	0	0	0	0
1966	575	122	587	179	0	0	0	0
1967	684	145	699	213	0	0	0	0
1968	432	91	441	135	0	0	0	0
1969	101	21	103	31	0	0	0	0
1970	207	44	211	64	0	0	0	0
1971	582	123	594	181	0	0	0	0
1972	469	99	479	146	0	0	0	0
1973	713	151	728	222	0	0	0	0
1974	683	145	698	213	0	0	0	0
1975	1,540	326	1,572	480	0	0	0	0
1976	3,745	793	3,824	1,166	0	0	0	0
1977	6,755	1,430	6,898	2,104	0	0	0	0
1978	5,100	1,079	5,208	1,588	0	0	0	0
1979	5,013	1,061	5,119	1,561	0	0	0	0
1980	4,615	977	4,712	1,437	0	0	0	0
1981	35,908	7,599	36,666	11,182	0	0	0	0
1982	29,384	6,219	30,003	9,150	0	0	0	0
1983	23,079	4,884	23,566	7,187	0	0	0	0
1984	19,964	4,225	20,385	6,217	0	0	0	0
1985	16,474	3,486	16,822	5,130	0	0	0	0
1986	32,353	6,847	33,036	10,075	0	0	0	0
1987	58,094	12,295	59,320	18,091	0	0	0	0
1988	62,789	13,288	64,114	19,553	0	0	0	0
1989	24,956	5,282	25,483	7,772	0	0	0	0
1990	43,002	9,101	43,909	13,391	0	0	0	0
1991	45,070	9,538	46,020	14,035	0	0	0	0
1992	48,336	10,230	49,356	15,052	0	0	0	0
1993					0	0	0	0
1994	111	23	113	34	0	0	0	0
1995	35,029	7,413	35,768	10,908	0	0	0	0
1996	28,880	6,112	29,490	8,994	0	0	0	0
1997	92,760	19,631	94,716	28,886	0	0	0	0
1998	56,067	11,866	57,250	17,460	0	0	0	0
1999	25,685	5,436	26,226	7,998	0	0	0	0
2000	33,142	7,014	33,841	10,321	0	0	0	0
2001	18,630	3,943	19,023	5,801	0	0	0	0
2002	16,252	3,440	16,595	5,061	0	0	0	0
2003	27,747	5,872	28,333	8,641	0	0	0	0

Table 3.6 Continued.

Year	Bottom longline calculated discards wwt	Bottom longline calculated discards number of fish	Bottom longline calculated kept for bait wwt	Bottom longline calculated kept for bait number of fish	Vertical line calculated discards wwt	Vertical line calculated discards number of fish	Vertical line calculated kept for bait wwt	Vertical line calculated kept for bait number of fish
2004	38,244	8,094	39,051	11,910	0	0	0	0
2005	24,237	5,129	24,748	7,548	0	0	0	0
2006	42,473	8,989	43,370	13,227	0	0	0	0
2007	44,861	9,494	45,602	13,907	1,449	347	0	0
2008	105,374	22,301	47,056	14,351	2,776	665	0	0
2009	29,986	6,346	29,619	9,033	855	205	0	0
2010	13,231	2,800	808	246	3,622	868	612	245
2011	20,753	4,392	3,346	1,020	2,830	678	505	202
2012	38,024	8,047	6,367	1,942	8,759	2,100	1,249	500
2013	23,491	4,971	4,045	1,234	11,980	2,872	2,323	930
2014	41,838	8,854	8,004	2,441	12,433	2,980	2,473	990
2015	27,327	5,783	9,134	2,786	7,620	1,827	1,346	539

Table 3.7 Number of trips without sampling biases sampled for Blueline Tilefish by year, region, and gear.

	Gulf of Mexico			Keys to Canaveral			Canaveral to NC/VA Border		
YEAR	HAND LINE	LONG LINE	OTHER	HAND LINE	LONG LINE	OTHER	HAND LINE	LONG LINE	OTHER
1983	0	0	0	0	0	0	5	0	0
1984	0	1	0	0	0	0	49	17	0
1985	1	1	1	1	6	0	73	14	0
1986	1	1	0	1	2	0	45	2	0
1987	2	1	0	0	0	0	33	5	0
1988	0	1	0	1	0	0	24	6	0
1989	0	0	0	0	0	0	31	6	0
1990	2	3	1	1	0	0	31	7	0
1991	10	12	4	2	2	0	36	12	0
1992	10	17	1	4	11	0	22	27	0
1993	5	15	1	12	30	0	29	43	0
1994	23	15	1	5	11	0	27	13	0
1995	11	11	3	7	4	0	39	13	0
1996	14	10	0	8	3	0	16	10	0
1997	10	27	2	10	1	0	10	5	0
1998	12	53	0	4	4	0	13	1	0
1999	15	39	0	6	5	0	28	4	0
2000	8	74	1	17	5	0	35	4	0
2001	7	52	0	14	9	0	34	8	0
2002	5	25	2	5	15	1	28	13	0
2003	1	42	3	1	8	0	42	11	0
2004	4	32	3	4	4	0	42	14	0
2005	3	29	0	4	2	0	41	5	0
2006	7	12	0	2	2	0	48	13	0
2007	3	19	0	10	0	0	57	5	0
2008	13	25	0	4	1	0	60	12	0
2009	5	27	1	8	3	3	68	54	0
2010	3	3	0	9	2	2	61	55	2
2011	1	7	3	2	0	0	39	38	0
2012	9	7	1	8	0	0	45	42	1
2013	8	12	0	13	0	4	45	32	0
2014	14	19	3	3	3	1	28	10	0
2015	11	18	0	1	2	0	12	5	1

Table 3.8 Number of fish sampled without sampling biases for Blueline Tilefish by year, region, and gear.

	Gulf of Mexico			Keys to Canaveral			Canaveral to NC/VA Border		
YEAR	HAND LINE	LONG LINE	OTHER	HAND LINE	LONG LINE	OTHER	HAND LINE	LONG LINE	OTHER
1983	0	0	0	0	0	0	22	0	0
1984	0	19	0	0	0	0	404	638	0
1985	1	1	2	5	170	0	553	408	0
1986	8	1	0	34	41	0	244	63	0
1987	3	1	0	0	0	0	200	24	0
1988	0	6	0	7	0	0	126	102	0
1989	0	0	0	0	0	0	136	73	0
1990	3	8	2	1	0	0	262	305	0
1991	47	543	12	6	28	0	157	326	0
1992	86	470	2	34	380	0	153	1113	0
1993	29	136	3	122	880	0	217	2783	0
1994	80	499	81	77	134	0	204	212	0
1995	31	264	88	29	34	0	346	250	0
1996	275	251	0	106	34	0	103	349	0
1997	60	488	16	37	24	0	25	113	0
1998	73	1346	0	14	115	0	142	8	0
1999	142	1192	0	113	16	0	229	56	0
2000	83	2448	2	82	28	0	380	90	0
2001	70	1107	0	126	57	0	208	343	0
2002	60	691	22	15	123	2	106	386	0
2003	26	931	6	8	60	0	329	188	0
2004	13	548	98	24	19	0	600	271	0
2005	7	334	0	32	29	0	431	58	0
2006	14	146	0	19	2	0	890	569	0
2007	13	79	0	24	0	0	305	35	0
2008	64	168	0	22	1	0	189	341	0
2009	8	77	1	28	47	14	333	843	0
2010	10	15	0	38	4	9	172	920	17
2011	1	36	8	8	0	0	128	596	0
2012	38	68	1	33	0	0	143	975	15
2013	25	31	0	92	0	28	172	637	0
2014	41	252	18	73	15	1	159	190	0
2015	31	98	0	27	24	0	43	116	10

3.12 Figures

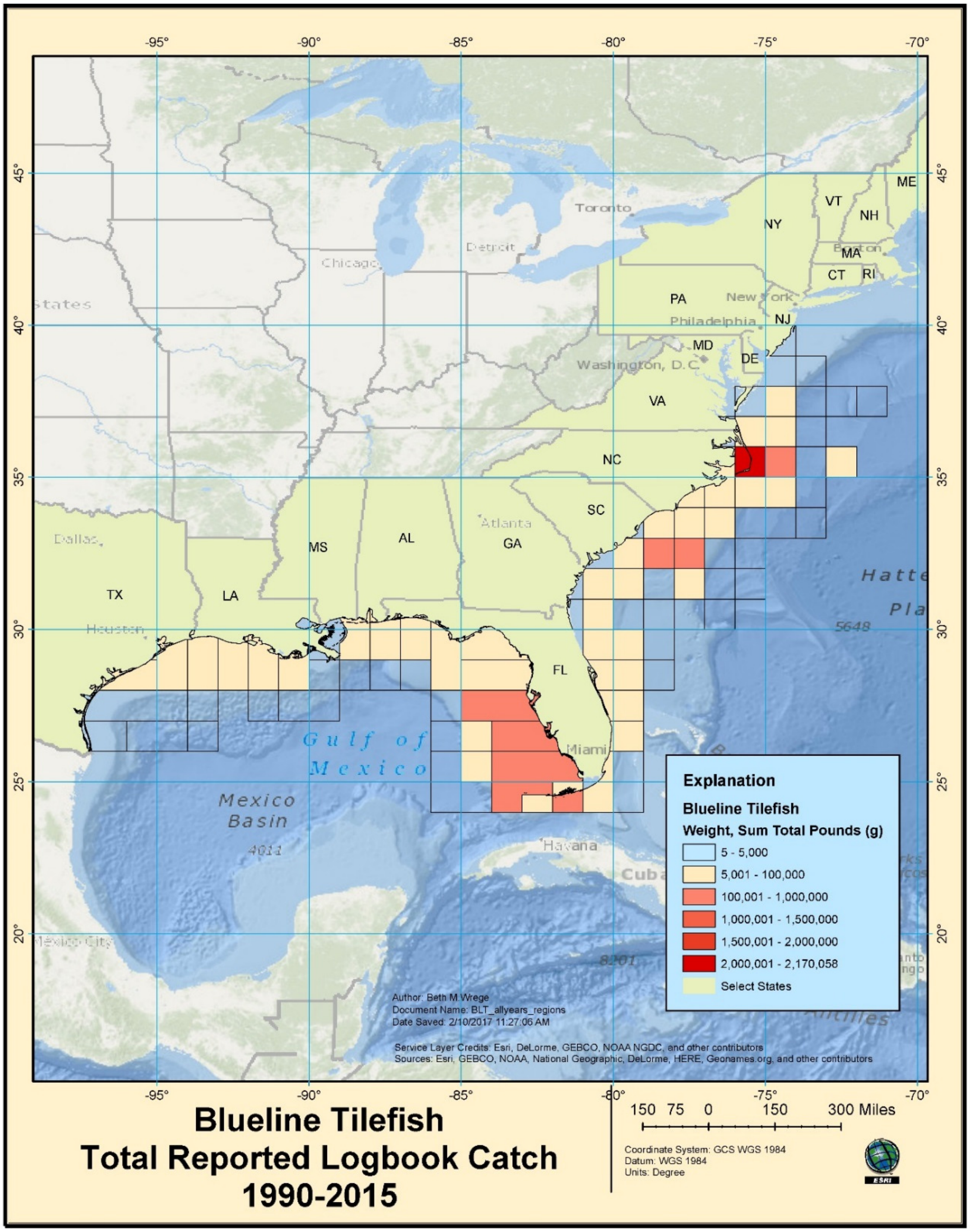


Figure 3.1 Map of Blueline Tilefish harvest in the Atlantic and Gulf of Mexico as reported to the CFLP and VTR

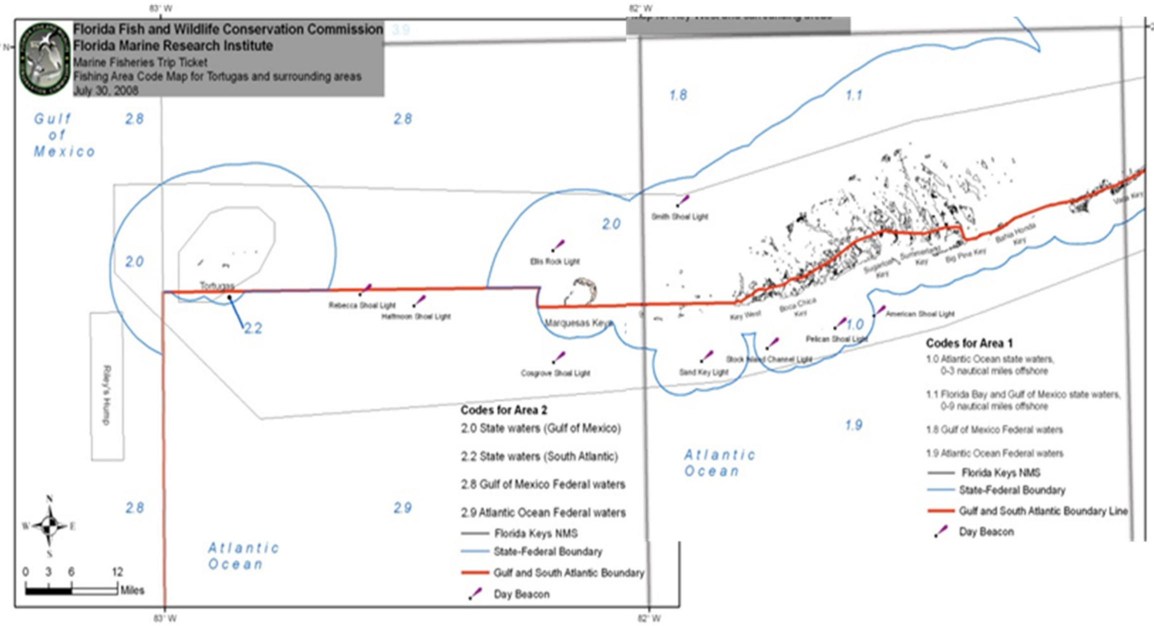


Figure 3.2 Close-up of the southern boundary as defined by the Gulf of Mexico/South Atlantic Council boundary.

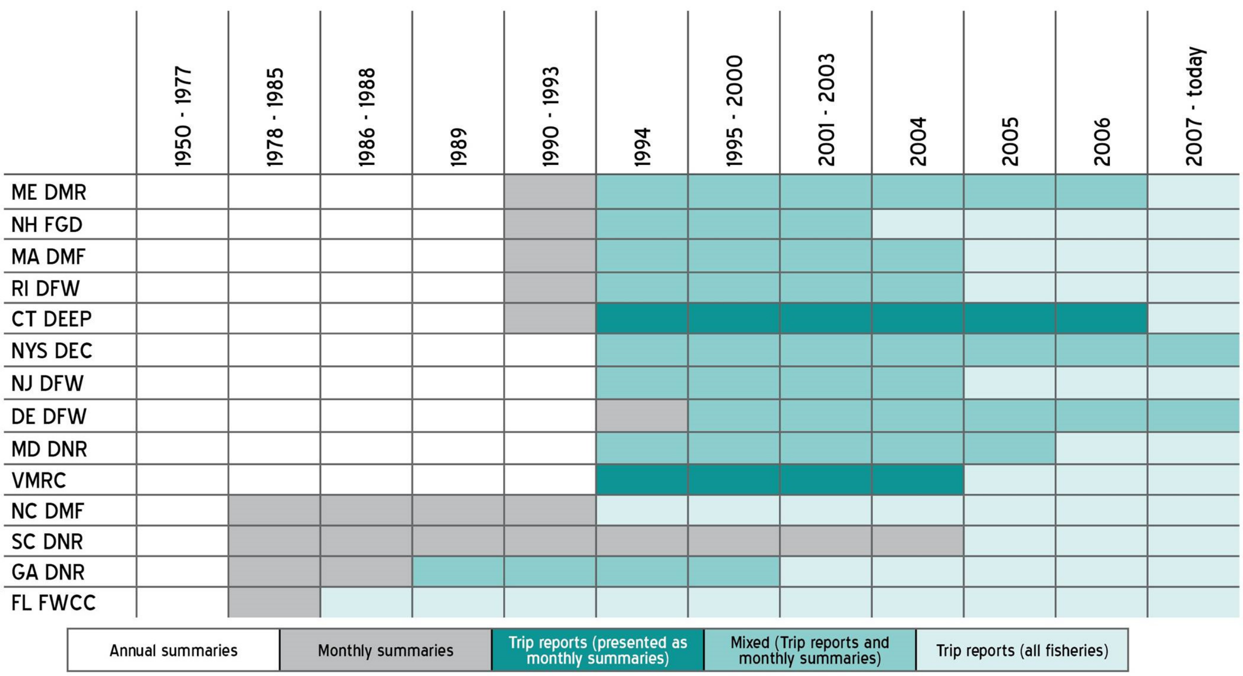


Figure 3. 3 Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse – data sources and collection methods by state. Early summaries provided by NMFS.

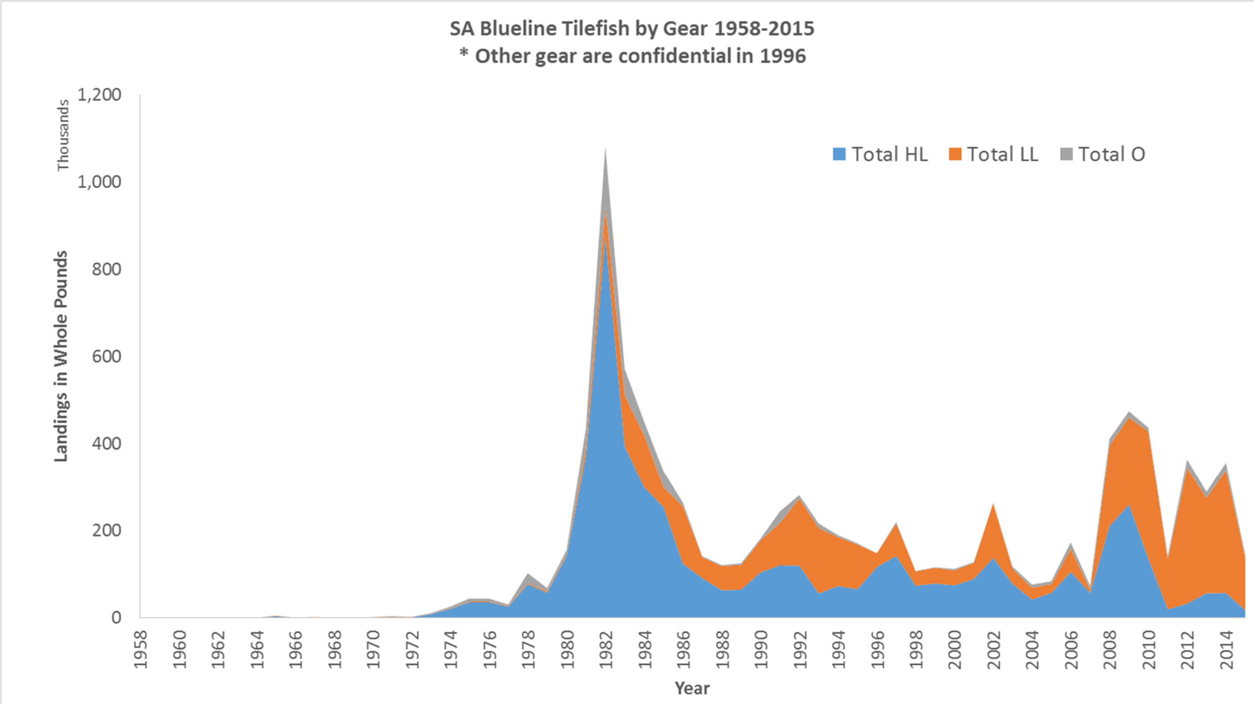


Figure 3.4 Blueline Tilefish landings, in whole weight pounds, for all states (FL-ME) by gear.

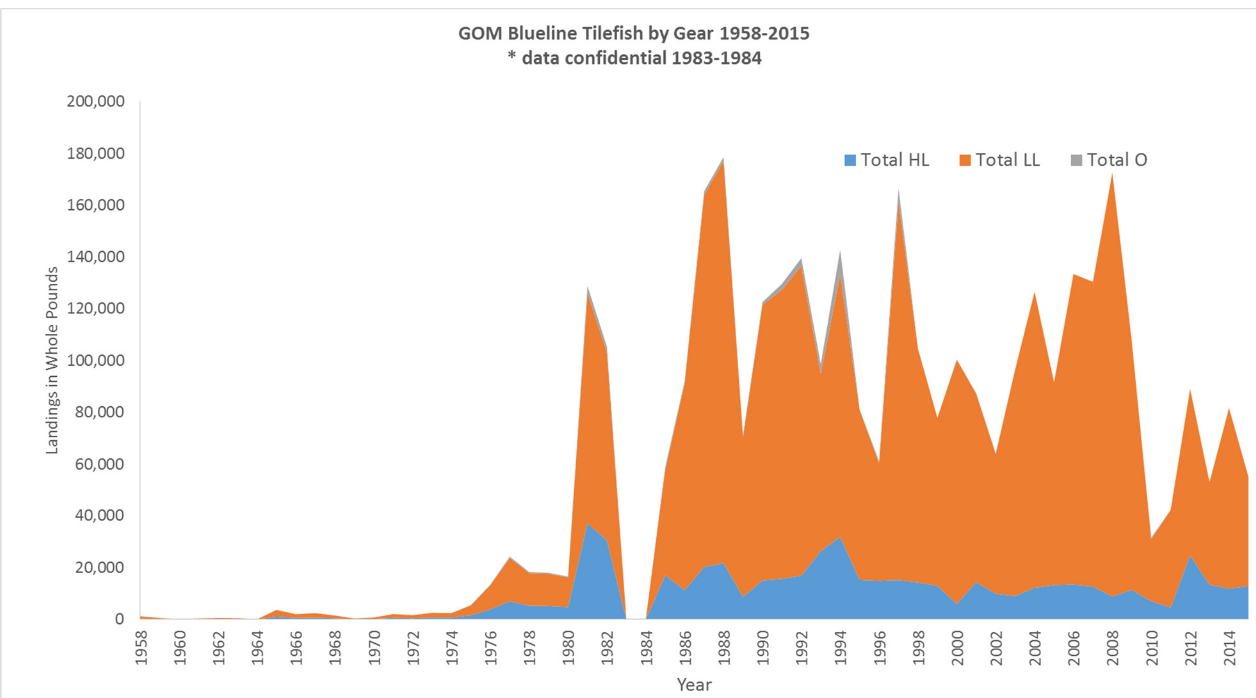


Figure 3.5 Blueline Tilefish landings, in whole weight pounds, for all states (FL-TX) by gear.

4. Recreational Fishery Statistics

4.1 Overview

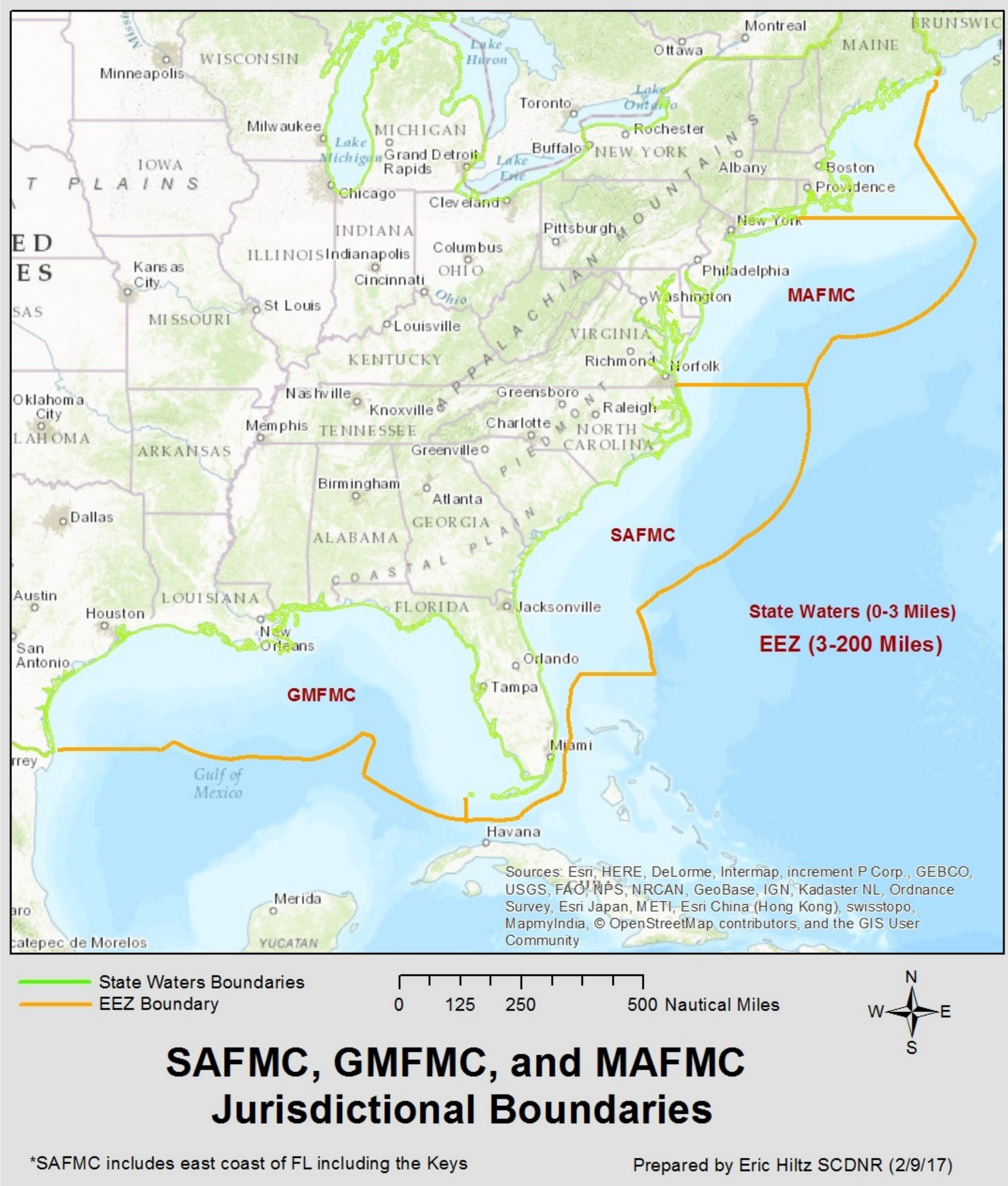
4.1.1 Group Membership

Members- Ken Brennan (Leader South Atlantic\NMFS Beaufort), Joe Cimino (VMRC), Jason Didden (MAFMC), Kelly Fitzpatrick (NMFS Beaufort), Eric Hiltz (SCDNR), Lee Lavery (SAFMC Appointee\ Industry rep FL), Vivian Matter (NMFS SEFSC), Andy Piland (SAFMC Appointee\ Industry rep NC), Tom Sminkey (NMFS Silver Spring), Kayla Spry (SCDNR), Mark Brown (SAFMC Appointee/Industry rep SC, observer, but contributed to the discussion) .

4.1.2 Issues

1) Allocation of Monroe County catches to the Atlantic or the Gulf of Mexico: may vary by data source depending on differing spatial resolutions of the datasets.
2) Headboat estimated landings start in the South Atlantic in 1974; however, there are reported Blueline Tilefish logbook landings from NC and SC for 1973.
3) Headboat discards. Data are available from the SRHS since 2004. Review whether they are reliable for use, and determine if there are other sources of data prior to 2004 that could be used as a proxy to estimate headboat discards.
4) High MRIP charter boat discards from NC in 2007.
5) Charter boat landings: MRFSS charter survey methods changed in 2003 in East Florida and in 2004 for Georgia and north.
6) Combined charter boat/headboat landings, 1981-1985: Official headboat landings are available from the SRHS. Therefore, the headboat component of the MRFSS combined charter boat/headboat mode must be parsed out.
7) Usefulness of historical data sources such as the 1960, 1965, and 1970 U.S. Fish and Wildlife Service (FWS) surveys to generate estimates of landings prior to 1981. Review whether other data sources also available.
8) New MRIP weighted estimates are available for 2004-2015. MRFSS estimates available from 1981-2003.
9) Extremely limited Mid Atlantic MRIP landings
10) ODU lengths from freezer collections for use in Mid – Atlantic length compositions

4.1.3 Fishery Management Council Jurisdictional Boundaries



4.2 Review of Working Papers

SEDAR32-DW02, *MRFSS to MRIP Adjustment Ratios and Weight Estimation Procedures for South Atlantic and Gulf of Mexico Managed Species. Vivian M. Matter and Adyan Rios.*
Ratio estimators were developed to appropriately adjust estimates from the Marine Recreational Fisheries Statistics Survey (MRFSS) to estimates from the Marine Recreational Information Program (MRIP) for all Gulf of Mexico and South Atlantic managed species. Weight estimation procedures are presented.

SEDAR 50 – DW20, *Virginia Blueline Tilefish Data Collection Summary. Joe Cimino 2017.*
The Virginia Marine Sportfish Sampling Program (MSCP) was designed by fisheries management staff at the Virginia Marine Resources (VMRC) to target recreationally important species in the coastal and Chesapeake Bay areas of Virginia that are not readily available for sampling from commercial harvesters. From 2007 through 2016 Blueline Tilefish was among the species targeted by the MSCP.

SEDAR 50-RD06, *Estimated Catch of Blueline Tilefish in the Mid-Atlantic Region. Tom Allen, Andrew Loftus and Rob Southwick 2016.*
The Mid-Atlantic Fishery Management Council contracted with Southwick Associates to conduct a modified Delphi Process with individuals familiar with the Mid- Atlantic blueline recreational tilefish fishery. The goal was to estimate recent Blueline Tilefish landings. The Delphi Process produced Blueline Tilefish landings estimates for 2015 for the headboat, charter, and private Blueline Tilefish fisheries. This report describes the Delphi technique and results of this approach.

SEDAR 50-RD37, *MAFMC Memo: Blueline Tilefish Catch Series - March 24, 2016. Jason Didden 2016.*
To help develop a Mid-Atlantic Blueline Tilefish catch time series, the Council contracted with Southwick Associates to conduct a modified Delphi Process with individuals familiar with the Mid- Atlantic blueline recreational tilefish fishery. The goal was to estimate recent Blueline Tilefish landings. The Delphi Process produced Blueline Tilefish landings estimates for 2015 for the headboat, charter, and private Blueline Tilefish fisheries. A report is forthcoming, but this memo summarizes the Delphi Process findings, as well as staff's recommended use of the results to create a Blueline Tilefish catch time series. This memo also uses the NMFS Northeast Dealer reports to develop a commercial landings time series. Staff intends for this memo to inform work being conducted regarding potential Blueline Tilefish Acceptable Biological Catches (ABCs), and all information should be considered preliminary.

SEDAR50-RD38, *Mid-Atlantic Fishery Management Council SSC Memo: Proposed BLT Subcommittee Report – March 22, 2016. Thomas Miller 2016.*
The MAFMC requested its Scientific and Statistical Committee (SSC) form a working group to evaluate knowledge of the status of Blueline Tilefish in Mid-Atlantic waters. This document summarizes the working group's results regarding development of ABCs for Blueline Tilefish in

the Mid-Atlantic that were presented for consideration by the whole SSC at its March 15-16, 2016 SSC meeting.

4.3 Recreational Landings

Total recreational landings are summarized below by survey. A map and figures summarizing the total recreational Blueline Tilefish landings are included in Figure 4.11.1.

4.3.1 Marine Recreational Fisheries Statistics Survey (MRFSS) and Marine Recreational Information Program (MRIP)

Introduction

The Marine Recreational Fisheries Statistics Survey (MRFSS) and the Marine Recreational Information Program (MRIP) provide a long time series of estimated catch per unit effort, total effort, landings, and discards for six two-month periods (waves) each year. MRFSS/MRIP provides estimates for three recreational fishing modes: shore-based fishing (SH), private and rental boat fishing (PR), and for-hire charter and guide fishing (CH). When the survey first began in Wave 2 (Mar/Apr), 1981, headboats were included in the for-hire mode, but were excluded after 1985 in the South Atlantic and Gulf of Mexico to avoid overlap with the Southeast Region Headboat Survey (SRHS) conducted by the NMFS Beaufort, NC lab.

The MRFSS/MRIP survey covers coastal Atlantic coast states from Maine to Florida. The state of Florida is sampled as two sub-regions. The east Florida sub-region includes counties adjacent to the Atlantic coast from Nassau County south through Miami-Dade County, and the west Florida sub-region includes Monroe County (Florida Keys) and counties adjacent to the Gulf of Mexico. Separate estimates are generated for each Florida sub-region, and those estimates may be post-stratified into smaller regions based on proportional sampling. Sampling is not conducted in Wave 1 (Jan/Feb) north of Florida because fishing effort is very low or non-existent, with the exception of NC, where wave 1 has been sampled since 2006.

The MRFSS/MRIP design incorporates three complementary survey methods for estimating catch and effort. Catch data are collected through angler interviews during dockside intercept surveys of recreational fishing trips after they have been completed. Effort data are collected using two telephone surveys. The Coastal Household Telephone Survey (CHTS) uses random digit dialing of coastal households to obtain detailed information about the previous two months of recreational fishing trips from the anglers. The weekly For-Hire Survey interviews charterboat operators (captains or owners) to obtain the trip information with only one-week recall period. Effort estimates from the two telephone surveys are aggregated to produce total effort estimates by wave. Catch rates from dockside intercept surveys are combined with estimates of effort from telephone interviews to estimate total landings and discards by wave, mode, and area fished (inland, state, and federal waters). Catch estimates from early years of the survey are highly variable with high proportional standard errors (PSE's), and sample size in the dockside intercept portion have been increased over time to improve precision of catch estimates.

Full survey documentation and ongoing efforts to review and improve survey methods are available at: http://www.st.nmfs.gov/st1/recreational.

Survey methods for the for-hire fishing mode have seen the most improvement over time. Catch rate data have improved through increased sample quotas and additional sampling (requested and funded by the states) to the intercept portion of the survey. It was also recognized that the random household telephone survey was intercepting relatively few anglers in the for-hire fishing mode and the For-Hire Telephone Survey (FHS) was developed to estimate effort in the for-hire mode. The new method draws a random sample of known for-hire charter and guide vessels each week and vessel operators are called and asked directly to report their fishing activity. The FHS was officially adopted in the Gulf States in 2000, in East Florida in 2003, and in Georgia through Maine in 2005. The FHS was pilot tested in the Gulf of Mexico in 1998 and 1999 and in Georgia through Maine in 2004. The FHS does not consider the estimates during pilot years as official estimates; however, FHS data for these years have been used in past SEDARs (e.g. SEDAR 7 red snapper, SEDAR 16 king mackerel, SEDAR 25 black sea bass, etc.).

A further improvement in the FHS method was the pre-stratification of Florida into smaller sub-regions for estimating effort. Pre-stratification defines the sample unit on a sub-state level to produce separate effort estimates by these finer geographical regions. The FHS sub-regions include three distinct regions bordering the Atlantic coast: Monroe County (sub-region 3), SE Florida from Dade through Indian River counties (sub-region 4), and NE Florida from Martin through Nassau counties (sub-region 5). The coastal household telephone survey method for the for-hire fishing mode continues to run concurrently with the newer FHS method.

Calibration of traditional MRFSS charter boat estimates

Conversion factors have been estimated to calibrate the traditional MRFSS charterboat estimates with the FHS for 1986-2003 in the South Atlantic (SEDAR16-DW-15, Sminkey, 2008) and for 1981-2003 in the mid-Atlantic (SEDAR17-Data Workshop Report, 2008). 1986-2003 South Atlantic calibration factors were updated in 2011 (SEDAR25-Data Workshop Report, 2011). The relationship between the old charterboat method estimates of angler trips and the FHS estimates of angler trips was used to estimate the conversion factors. Since these factors are based on effort, they can be applied to all species' landings. In the Gulf of Mexico and the South Atlantic, the period of 1981-1985 could not be calibrated with the same ratios developed for 1986+ because in the earlier 1981-1985 time period, MRFSS considered charterboat and headboat as a single combined mode. Thus, in order to properly calibrate the estimates from 1981-1985, headboat data from the Southeast Region Headboat Survey (SRHS) were included in the analysis. To calibrate the MRFSS combined charterboat and headboat mode effort estimates in 1981-1985, conversion factors were estimated using 1986-1990 effort estimates from both modes, in equivalent effort units, an angler trip (SEDAR28-DW-12). These calibration factors were applied to the charterboat estimates and are tabulated in SEDAR32-DW-01.

Separation of SA combined charter/headboat mode

In the South Atlantic, 1981-1985 charter and headboat modes were combined into one single mode for estimation purposes. Since the NMFS Southeast Region Headboat Survey (SRHS) began in this region in 1981, the MRFSS combined charter/headboat mode must be split in order to not double estimate the headboat mode for these years. MRFSS charter/headboat mode was split in these years by using a ratio of SRHS headboat angler trip estimates to MRFSS charter boat angler trip estimates for 1986-1990. This method has been used in the past (SEDAR 28-Spanish mackerel and cobia). The mean ratio was calculated by state (or state equivalent to match SRHS areas to MRFSS states) and then applied to the 1981-1985 estimates to strip out the headboat component. These headboat estimates were then eliminated from the MRFSS estimates.

MRIP weighted estimates and the calibration of MRFSS estimates

The Marine Recreational Information Program (MRIP) was implemented in 2004. The MRIP was developed to generate more accurate recreational catch rates by re-designing the MRFSS sampling protocol to address potential biases including port activity and time of day. Revised catch and effort estimates, based on this improved estimation method, were released on January 25, 2012. These estimates are available for the Atlantic and Gulf Coasts for 2004 through 2011.

Since new MRIP estimates are available for a portion of the recreational time series that the MRFSS covers, conversion factors between the MRFSS estimates and the MRIP estimates were developed in order to maintain one consistent time series for the recreational catch estimates. Ratio estimators, based on the ratios of the means, were developed for Atlantic Blueline Tilefish to hind-cast catch and variance estimates by fishing mode. In order to apply the charterboat ratio estimator back in time to 1981, charterboat landings were isolated from the combined cbt/hbt mode for 1981-1985. The MRFSS to MRIP calibration process is detailed in SEDAR31-DW25 and SEDAR32-DW-02.

Monroe County

Monroe County MRFSS landings from 1981 to 2003 can be post-stratified to separate them from the MRFSS West Florida estimates. Post-stratification proportionally distributes the state-wide (FLE and FLW) effort into finer scale sub-regions and then produces effort estimates at this finer geographical scale. This is needed for the private and shore modes (all years) and charter boat mode (prior to FHS). FHS charter boat mode estimates are already pre-stratified, as discussed above. Monroe County MRIP landings from 2004 to 2011 can be estimated separately from the remaining West Florida estimates using domain estimation. The Monroe County domain includes only intercepted trips returning to that county as identified in the intercept survey data. Estimates are then calculated within this domain using standard design-based estimation which incorporates the MRIP design stratification, clustering, and sample weights.

Although Monroe County estimates can be separated using these processes, they cannot be partitioned into those from the Atlantic Ocean and those from the Gulf of Mexico. Blueline

Tilefish is a deep-water species and Monroe County catches are most likely from the Atlantic side of the Keys. This species would not be associated with the shallow Gulf waters of Monroe County. Therefore, the recreational workgroup decided to allocate the Monroe County landings to the Atlantic.

Unidentified tilefish estimates

The RWG discussed the unidentified tilefish landing estimates from the MRIP survey. A portion of those unidentified tilefish family should be considered Blueline Tilefish. The RWG recommends partitioning those estimates by calculating the percentage of total tilefish landings identified to the species level that are Blueline Tilefish in the MRIP by region. That percentage is them applied to the unidentified tilefish family catch estimates. The percentage in the South Atlantic region, including the Keys is 0.45 and in the Gulf of Mexico, not including the Keys, it is 0.01.

Calculating landings estimates in weight

The MRFSS and the MRIP surveys use different methodologies to estimate landings in weight. To apply a consistent methodology over the entire recreational time series, the Southeast Fisheries Science Center (SEFSC) implemented a method for calculating average weights for the MRIP (and MRIP adjusted) landings. This method is detailed in SEDAR32-DW-02. The length-weight equations developed by the Life History Working Group (W=0.0000178*(L^2.94) in the Atlantic region and W=0.00000862*(L^3.05) in the Gulf of Mexico) were used to convert Blueline Tilefish sample lengths into weights, when no weight was recorded. W is whole weight in grams and L is fork length in millimeters.

1981, wave 1

MRFSS began in 1981, wave 2. Blueline Tilefish estimates from 1981, wave 1 are assumed to be zero due to lack of data in wave 1 from 1982 to 1984.

Texas Parks and Wildlife Department and LA Creel

There are no Blueline Tilefish catch estimates from the Texas Parks and Wildlife Department or the LA Creel Survey.

Alabama Blueline Tilefish 2015 estimate

The RWG investigated the estimated Alabama Blueline Tilefish estimate from 2015 in the private mode and EEZ in wave 5 (September-October). It is for 1,668 fish and has a PSE of 88%. It comes from one boat trip with 5 anglers. Two Blueline Tilefish were caught, landed, examined, and measured. The target species on the trip was Yellowfin Tuna (9 were landed). In addition, 4 Golden Tilefish were landed, examined, and measured. The RWG concluded that the data informing this estimate is correct.

MRIP landings in numbers of fish and in whole weight in pounds are presented in Table 4.10.1. CVs associated with estimated landings in numbers are also shown.

4.3.2 Southeast Region Headboat Survey (SRHS)

Introduction

The Southeast Region Headboat Survey estimates landings and effort for headboats in the South Atlantic and Gulf of Mexico. The Headboat Survey began in 1972 in the South Atlantic and covers from the VA/NC border to Key West, FL. The Gulf of Mexico headboat survey followed, starting in 1986 from Naples, FL to South Padre Island, TX. The South Atlantic and Gulf of Mexico Headboat Surveys generally include 70-80 vessels participating in each region annually.

The Headboat Survey incorporates two components for estimating catch and effort. 1) Biological information: size of the fish landed are collected by port samplers during dockside sampling, where fish are measured to the nearest mm and weighed to the nearest 0.01 kg. These data are used to generate mean weights for all species by area and month. Port samplers also collect otoliths for ageing studies during dockside sampling events. 2) Information about total catch and effort are collected via the logbook, a form filled out by vessel personnel and containing total catch and effort data for individual trips. These logbooks are summarized by vessel to generate estimated landings by species, area, and time strata.

SRHS records indicate that in North Carolina and South Carolina there are some reported Blueline Tilefish landings starting in 1973. However, estimated Blueline Tilefish headboat landings from NC to FL were not calculated until 1974.

Issue 1: Should the time series start in 1974, or 1973?

Option 1: Start headboat time series in 1974 when estimated Blueline Tilefish landings are available for all areas from NC to FLE.

Option 2: Start the headboat time series in 1973 by using a three-year average from estimated landings 1974 – 1976.

Decision: *Option 2*

Catch Estimates

Final SRHS landings estimates are shown in Table 4.10.2. by year and state. Final SRHS landings estimates are shown in Figure 4.11.2 by year and region.

4.3.3 Historic Recreational Landings

Introduction

The historic recreational landings time period is defined as pre-1981 for the charter boat, headboat, private boat, and shore fishing modes, which represents the start of the Marine

Recreational Fisheries Statistics Survey (MRFSS) and availability of landings estimates for Blueline Tilefish.

The Recreational Working Group was tasked with reviewing all available historical sources of Blueline Tilefish landings to evaluate potential methods to compile landings prior to the available time series of MRFSS and headboat estimated landings.

The sources of historical landings that were reviewed for potential use are as follows:

- Salt Water Angler Surveys (SWAS) from 1960, 1965 &1970.
- Anderson, 1965.
- The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey (FHWAR) census method, SEDAR32-RD08.
- SAFMC 1983 Snapper and Grouper Source Document, SEDAR32-RD04.

Salt Water Angler Surveys (SWAS)

The SWAS from 1960, 1965, and 1970 were reviewed for Blueline Tilefish landings. There were no Blueline Tilefish landings recorded in any of the SWAS from 1960 to 1970.

Anderson, 1965

The RWG discussed the Anderson study as a possible source of information for historical Blueline Tilefish landings. The study area designated as the Cape Canaveral area included Brevard and Volusia counties in Florida. The recreational data was obtained from field surveys from February to October, 1963 and was further limited to the southern portion of the study area. After reviewing this document, the RWG determined there were no Blueline Tilefish included in the study.

FHWAR census method

The FHWAR method (SEDAR32-RD08) was used in SEDAR 28 to reconstruct landings back to 1950. The RFWG considered using this same method for Blueline Tilefish, but determined that in order for this method to be applicable, evidence should show that these fish were harvested by anglers historically. After reviewing numerous black and white photos from the east coast of Florida charter boat and headboat fishery (courtesy of R. Hudson and M. Brown) back to the 1950's; there were no tilefish visible in these recreational catches. Consequently, it was concluded by the RFWG; using the MRIP average CPUE for Blueline Tilefish from 1981 – 1985, which is part of the FHWAR method, would not be appropriate.

SAFMC 1983 Snapper and Grouper Source Document

The RFWG reviewed SEDAR32-RD03 and SEDAR32-RD04 as a source of potential landings for Blueline Tilefish prior to 1981. Tilefish landings were present in this document; however, these were limited to 1979 for the MRFSS. The RFWG concluded that these data were limited temporally to one year and did not offer a means to determine landings back in time.

Issue: Available historical Blueline Tilefish landings prior to 1981.

Option 1: Use available recreational time series for the MRFSS\MRIP 1981 - 2015 and headboat estimates 1973 - 2015. Mid-Atlantic recreational landings 2003 – 2015.

Option 2: Use interpolation to complete time series.

Decision: *Option 1.*

4.3.4 Potential Sources for Additional Landings Data

Delphi Approach - Mid-Atlantic Recreational Landings

Introduction
The Delphi approach used by the MAFMC incorporated input from fishery participants identified by Council staff. Council staff used Vessel Trip Reports, the MAFMC's Tilefish Advisory Panel, and internet searching to identify participants.

The Delphi approach used a pre-survey, a workshop, and a post-workshop survey to gather input about likely catch levels, focusing mostly on 2015 but also gathering input to facilitate creation of a time series by Council staff. Details are available in supporting documents, especially the Delphi Report (SEDAR 50 RD-06), staff memos (SEDAR 50 RD-37), and a MAFMC-SSC report (SEDAR 50 RD-38) that used the Delphi-generated numbers to set an Acceptable Biological Catch for Blueline Tilefish north of North Carolina.

Like discussions at the MAFMC's SSC, the recreational working group identified several issues with the time series that MAFMC staff created and the MAFMC SSC accepted for input into a data-limited approach for a Blueline Tilefish ABC.

Landings in numbers from the Delphi approach were converted to weights using data from a biological study conducted by Old Dominion University's Center for Quantitative Fisheries Ecology (CQFE) and the Virginia Marine Resources Commission. Details of sample collection for this study can be found in section 4.5.1. Of 2385 specimens collected from 2009 to 2015 through freezer collections as well as charter and head boat trips targeting this species, whole weights were collected for only 349. Therefore, the MAFMC-SSC, in their original report, converted numbers to weight by multiplying numbers by the weight converted from the average length via a weight-length power equation. Applying this method to the current assessment's data, with an average fork length of 504 mm and using the fork length-total weight conversion defined by the Life History Work Group, would give an average total weight of 3.46 pounds.

Due to the non-normal distribution of lengths, the RWG agreed that a flat average may not best represent the variety of sizes observed in the recreational fishery. Therefore an alternative method for converting numbers to weights was developed. Fork lengths from the CQFE study were grouped into 1 cm bins (for example, the 26 cm bin included measured fork lengths from 255-264 mm). Proportions of the total sample were calculated for each length bin. Fork lengths for each bin were converted to total weights using the fork length-total weight conversion defined by the Life History Work Group. Proportions of the total sample for each length bin were multiplied by their respective converted weights and landings in numbers, then summed across all length bins to estimate landings in weight (Figure 4.11.3). Using this method, the average weight for fish collected by the CQFE study would be 4.08 pounds. The RWG felt that using proportions at length provides a more comprehensive representation of weights seen in the recreational fishery and recommends the use of this method for converting the Delphi-generated numbers from the MAFMC to weights.

Issues include:
Recall problems, representativeness of the Delphi expert group, moral hazard, and the application of a 2015 ratio of charter boat vessel trip reports to 2015 Delphi estimates back through time to create a time series for charter boats (assumes constant level of under-reporting). Nonetheless, the recreational working group concluded that the time series generated by the Delphi process is likely to be closer to actual recreational catch from Virginia north than any other available estimate (mostly zeros from MRIP or unadjusted VTRs that are likely substantially underreports). As such, the recreational working group recommends the use of the 2003-2015 Delphi estimates for estimated Blueline Tilefish catch from Virginia north presented in Table 4.10.3.

Figure 4.11.4 shows total recreational catch from all sources.

4.4 Recreational Discards

Total recreational discards are summarized below by survey. A map and figures summarizing the total recreational Blueline Tilefish discards are included in Figure 4.11.5.

4.4.1 MRFSS/MRIP discards

Discarded live fish are reported by anglers interviewed by the MRIP/MRFSS, so both the identity and quantities reported are unverified. Furthermore, discarded fish sizes are unknown for all fishing modes sampled by the MRFSS/MRIP. As such, lengths and weights of discarded fish are not estimated by the survey.

To characterize the size distribution of live discarded fishes, at-sea sampling of headboat discards was initiated in Atlantic states as part of the improved for-hire survey. However, the Beaufort, NC Logbook program (SRHS) produces estimates of total discards in the headboat fishery since that class of caught fish was added to their logbook (2004).

MRFSS/MRIP estimates of live released fish (B2 fish) were adjusted in the same manner as the landings (i.e. using charterboat calibration factors, MRIP adjustment, substitutions, etc. described above in section 4.3.1).

Discard estimates from MRIP charter boat mode in NC for 2007 are significantly higher than all years.

MRIP time series of discard catch of Blueline Tilefish (b2 catch, live releases, access-point-angler-intercept-survey data)
Wave 4, 2007 South Atlantic sub-region:
estimated live releases: 32,284 (pse=93.1%)
estimated landings: 41,936 (pse=45.2%, all type A catch, available, examined)

Issue:
B2, live releases very high within time series (2007)
Details: NC, Charter Boat mode, federal waters = **32,284 (pse=93.1%)**

Source data: 6 charterboat angler interviews, all one boat party, Aug. 10, 2007 – the six anglers (interviews number 7-12) caught and released live (reported data) 6,5,8,6,6,7 Blueline Tilefish, and no other species, and no landed fish. Identification was accepted as Blueline Tilefish following review of the interviewers work (interviewer id=1069), in aggregate, in August. A subsequent interview (number 7 on Aug. 18) had 'Blueline Tilefish' written on Available Fish section of APAIS form, but the wrong species code recorded. NC reviewing biologist subsequently requested data correction during the raw data review period (fish dump review), and included the following note: 'All T2, T3 & T9 North Carolina Tilefish changed to Blueline Tilefish with species code 168543. I.E., the sampler knew the tilefish were 'Blueline Tilefish' but used the wrong species code. He has been informed of the error.' All records of tilefish catch recorded by this interviewer in August (all from site 150, Oregon Inlet Center) were recoded to Blueline Tilefish, although only the 6 interviews on Aug. 10 were reported catch and released (b2) fish.

Estimation from these few data records: there were 375 Charterboat angler interviews obtained from trips that fished in federal waters (=cell sample size for catch rate computation); 15 of those interviews recorded Blueline Tilefish catches: the 6 previously described were the only b2 catches; the other 9 interviews only had claimed fishes (available, landed = A type catch), or b2=0. The sample weight for those 6 b2 catch records = 850, which is moderately high, hence the total estimate derived from these few catch records.

Without any information to refute the field biologists' records and local knowledge of tilefish catches during this period in NC, the RWG recommended accepting this estimate of live discards within the time series. Any adjustment or smoothing of the value is at the discretion of the Assessment Panel, per the SEDAR Best Practices.

DW Panel Response: Several members of the DW panel present requested the RWG provide the 'adjustment' to this value, as it was perceived to be inaccurate, and not representative of the fishery in 2007, NC. A discussion followed with the result being further investigation of data re-weighting methods which may ameliorate the single-wave high value.

Using a small-area domain estimation procedure, the interview data for all of 2007 (waves 1-6) from the Charter Boat mode, Federal waters cells were reweighted, a new annual b2 catch rate (live released fish) was calculated, and this was multiplied by the annual effort estimate for CH mode, federal waters, NC in 2007 to produce an alternate ANNUAL value to replace the aggregated value (from waves 1-6, which included the anomalous wave 4 value). The new value was only ~2000 fish lower (30,311) so no real benefit from the re-estimation was realized.

Recommendation:
Following a further attempt to use design-based re-weighting and pooling of data to produce an alternate live-release catch estimate, which resulted in no real benefit to the time series, including an anomalous spike in 2007, the RWG recommends the MRIP data and estimates be submitted to the Assessment without further manipulation.

The DW Panel again rejected this recommendation (failed to reach consensus agreement to accept) and suggested a smoothing function using the average of the values from the respective cells of the previous 3 years be used to substitute a new value for the 2007 NC, CH, EEZ b2 catch estimate. The Panel recommended a sensitivity run using the original MRIP discard estimates. The RWG computed the alternate value using APAIS-adjusted annual catch estimates and produced the APAIS-adjusted substitute value of 1560 fish, CV=1.00 (original APAIS –adjusted value was 61,494) shown in Figure 4.11.6. This substitute value will be inserted into the time series of discards for the South Atlantic region.

MRIP discards in numbers of fish and associated CVs by state are presented in Table 4.10.4.

4.4.2 Headboat Logbook Discards

The Southeast Region Headboat Survey logbook form was modified in 2004 to include a category to collect self-reported discards for each reported trip. This category is described on the form as the number of fish by species released alive and number released dead. Port agents instructed each captain on criteria for determining the condition of discarded fish. A fish is considered “released alive” if it is able to swim away on its own. If the fish floats off or is obviously dead or unable to swim, it is considered “released dead”. These self-reported data are currently not validated within the Headboat Survey. Due to low Blueline Tilefish sample sizes in the MRFSS At-Sea Observer Headboat program, it was determined that the logbook discard data would be used from 2004-2015. Discards in the Gulf of Mexico were negligible in the SRHS and assumed to be zero prior to 2004. The RWG considered the MRIP charter boat and private boat modes as possible data sources to be used as a proxy for estimated headboat discards in the South Atlantic. However, due to limited discard information from both sources prior to 2004 the RWG recommended assuming no discards of Blueline Tilefish for the SRHS in 1973-2003 (Figure 4.11.7).

- MRIP APAIS charter boat discard estimates (corrected for FHS adjustment) applied– discards in six years only from 1981-2003.
- MRIP APAIS private boat discard estimates– discards in five years only from 1981-2003.

Issue: *Proxy for estimated headboat discards from 1973 to 2003 in the South Atlantic.*

Option 1: Assume zero discards for the headboat fishery prior to 2004.

Decision: Option 1.

Discard estimates from the recreational fishery are shown in Figure 4.11.8 by year and region. Final discard estimates from the SRHS are shown in Table 4.10.5 by year and state.

4.4.3 Headboat At-Sea Observer Survey Discards

An observer survey of the recreational headboat fishery was launched in NC and SC in 2004 and in GA and FL in 2005 to collect more detailed information on recreational headboat catch, particularly for discarded fish. In the Gulf of Mexico, observer surveys were conducted in Alabama from 2004 to 2007, and in West Florida from 2005 to 2007 and 2009 to present. Headboat vessels are randomly selected throughout the year in each state, and the east coast of Florida is further stratified into northern and southern sample regions. Biologists board selected vessels with permission from the captain and observe anglers as they fish on the recreational trip. Data collected include number and species of fish landed and discarded, size of landed and discarded fish, and the release condition of discarded fish (FL only) Data are also collected on the length of the trip, area fished (inland, state, and federal waters) and, in Florida, the minimum and maximum depth fished. In the Florida Keys (sub-region 3) some vessels that run trips that span more than 24 hours are also sampled to collect information on trips that fish farther offshore and for longer durations, primarily in the vicinity of the Dry Tortugas. Due to low Blueline Tilefish sample sizes the MRFSS At-Sea Observer data was not recommended for use in this assessment.

4.4.4 Alternatives for characterizing discards

Due to low Blueline Tilefish sample sizes in the MRFSS At-Sea Observer data it was concluded that the headboat logbook discard estimates should be used from 2004 to 2015 for the South Atlantic headboat fishery. Further, the group decided to assume no discards prior to 2004 due to limited discard information in both the MRIP charter boat and private boat modes for 1981-2003. As part of the Delphi method, a discard rate of 2% was applied to total landings for the Mid-Atlantic. This rate was calculated based on VTR reports from 2010-2015.

4.5 Biological Sampling

4.5.1 Sampling Intensity Length/Age/Weight

MRFSS/MRIP Biological Sampling

The MRFSS/MRIP angler intercept survey includes the sampling of fish lengths from the harvested (landed, whole condition) catch. Up to 15 of each species landed per angler interviewed are measured to the nearest mm along a center line (defined as tip of snout to center of tail along a straight line, not curved over body). In those fish with a forked tail, this measure would typically be referred to as a fork length, and in those fish that do not have a forked tail it would typically be referred to as a total length with the exception of some fishes that have a single, or few, caudal fin rays that extend further. Weights are typically collected for the same fish measured. When time is constrained a weight may be collected without a length measurement. Aging structures and other biological samples are not collected during MRFSS/MRIP assignments because of concerns over the introduction of bias to survey data collection.

The number of Blueline Tilefish measured and number of trips with measured Blueline Tilefish in the MRIP by year, state, and mode are summarized in Table 4.10.6.

Headboat Survey Biological Sampling

Lengths were collected from 1972 to 2015 by headboat dockside samplers. From 1972 to 1975, only North Carolina and South Carolina were sampled whereas Georgia and northeast Florida were sampled beginning in 1976. The Southeast Region Headboat Survey conducted dockside sampling for the entire range of Atlantic waters along the southeast portion of the US from the NC-VA border through the Florida Keys beginning in 1978. The Gulf of Mexico, excluding Mississippi, was added to the dockside sampling program in 1986. Mississippi was added in 2010. Weights are typically collected for the same fish measured during dockside sampling. Also, biological samples (scales, otoliths, spines, stomachs and gonads) are collected routinely and processed for aging, diet studies, and maturity studies.

Annual numbers of Blueline Tilefish measured for length in the headboat fleet and the number of trips from which Blueline Tilefish were measured are summarized in Table 4.10.7. Dockside mean weights for the headboat fishery are tabulated for 1973-2015 in Table 4.10.8.

Any existing total length measurements without an associated fork length measurement were converted to fork length using the following equation derived for the combined South Atlantic stock in SEDAR50-DW21 (2017).

$FL = 3.15 + 0.94 * TL$

Virginia Marine Resources Commission

The Marine Sportfish Collection Program, run by VMRC began in 2007, and continues to operate to present. The carcasses were collected in coolers or freezers at recreational ports or marinas. For this reason trip information is not available. VMRC in cooperation with Old Dominion University (ODU) also collected Blueline Tilefish samples as part of a study hiring charter boat and head boat vessels. The study provided lengths of Blueline Tilefish landed in Virginia during 2009-2014, from 43 separate fishing trips. The number of Blueline Tilefish measured for length in the ODU study are summarized in Table 4.10.9. These are the only Blueline Tilefish samples that have been identified to represent the harvest for the Mid-Atlantic region. During group discussions there were concerns that freezer collections may have an inherent bias due to anglers selectively choosing which carcasses are donated to these collections. Since nearly 80% of the collections came from cleaning stations servicing mostly headboats, there was no apparent selection of carcasses. Fish cleaner's bagged carcasses as they worked, then placed them directly in freezer at their location. This does not eliminate the possibility that some degree of bias may exist with these lengths.

Issue:

Should ODU lengths from freezer collections be used?

Options:

1. Include all ODU lengths for use in length comps
2. Include only fish not collected through freezer program.

Recommendation:

Option 1. Use all ODU data (including freezer samples) in Mid-ATL length composition; document caveats associated with using data.

Any existing total length measurements without an associated fork length measurement were converted to fork length using the following equation derived for the combined South Atlantic stock in SEDAR50-DW21 (2017).

$FL = 3.15 + 0.94 * TL$

4.6 Recreational Effort

Total recreational effort is summarized below by survey. The Delphi method does not calculate effort estimates and therefore separate effort estimates using this method are not included. Effort is summarized for all marine fishing by mode, regardless of what was caught. A map and figures summarizing MRFSS/MRIP effort in angler trips are included in Figure 4.11.9. A map and figures summarizing SRHS effort in angler days are included in Figure 4.11.10.

4.6.1 MRFSS/MRIP Effort

Effort estimates for the recreational fishery survey are produced via telephone surveys of both anglers (private/rental boats and shore fishers) and for-hire boat operators (charterboat anglers, and in early years, party or charter anglers). The methods have changed during the full time series (see section 4.3 for descriptions of survey method changes and adjustments to survey estimates for uniform time-series of catch estimates). MRFSS effort estimates are presented from 1981 to 2003. MRIP effort estimates are presented from 2004 to 2011. Angler trip estimates are tabulated in Table 4.10.10 by year and state. Effort from the Florida Keys is included with the South Atlantic. An angler-trip is defined as a single day of fishing by a single angler in the specified mode, not to exceed 24 hours.

4.6.2 Headboat Effort

Catch and effort data are reported on logbooks provided to all headboats in the survey. These forms are completed by the captain or designated crew member after each trip and represent the total number and weight of all the species kept, along with the total number of fish discarded for each species. Data on effort are provided as number of anglers on a given trip. Numbers of anglers are standardized, depending on the type of trip (length in hours), by converting number of anglers to “angler days” (e.g., 40 anglers on a half-day trip would yield 40 * 0.5 = 20 angler days). Angler days are summed by month for individual vessels. Each month, port agents collect these logbook trip reports and check for accuracy and completeness. Although reporting via the logbooks is mandatory, compliance is not 100% and is variable by location. To account for non-reporting, a correction factor is developed based on sampler observations, angler numbers from office books and all available information. This information is used to provide estimates of total catch (expanded or corrected for non-reporting) by month and area, along with estimates of effort. Estimated headboat angler days showed a noticeable decreased in the South Atlantic and Gulf of Mexico from 2008-2011. The most obvious factor which impacted the headboat fishery in both the Atlantic and South Atlantic and Gulf of Mexico was the high price of fuel. This, coupled with the economic down turn starting in 2008 resulted in a marked decline in angler days in the South Atlantic and Gulf of Mexico headboat fishery. Reports from industry representatives and port agents indicated fuel prices, the economy and fishing regulations as the factors that most affected the amount of trips, number of passengers, and overall fishing effort. Also important to note, is the decrease in effort in the South Atlantic and Gulf of Mexico in 2010, the year of the Deepwater Horizon oil spill. Estimated angler days have risen in recent years (2012-2015) possibly due to the decrease in fuel price and an improving economy. (Table 4.10.11).

4.7 Comments on Adequacy of Data for Assessment

Regarding the adequacy of the available recreational data for assessment analyses, the RWG discussed the following:

- Recreational landings are low for Blueline Tilefish since this is a limited recreational fishery. Based on the available data sources, the landings represented in this report appear to be adequate for the time period covered.
- Size data are limited but appear to adequately represent the landed catch for the charter and headboat sector.

4.8 Additional Recommendations

4.8.1 Research

- Research and implement rare-event data collection procedures.
  E.g. mandatory reporting, logbooks, reef fish stamp to determine universe.
- Fund research efforts to collect discard length and age data from the private sector.
- Additional data collection in the recreational fishery (gear, depth, angler demographics)
- Pre-stratify MRIP Keys, N-S Canaveral, N–S Hatteras.
- At-sea observers collect surface and bottom temperature.

4.8.2 SEDAR Data Best Practices

- Additional clarification of SEDAR processes for reconciling data outliers.

4.9 Literature Cited

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4.10 Tables

Table 4.10.1. South Atlantic and Gulf of Mexico (NC-LA) Blueline Tilefish landings (numbers of fish and whole weight in pounds) for charter boat and private boat modes (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2015). MRFSS estimates adjusted to MRIP APAIS estimates prior to 2004. CH mode adjusted for FHS conversion prior to 2004. *CVs for CH mode 1981-1985 are unavailable.

	Estimated CH Landings			Estimated PR Landings			ALL MODES Landings		
YEAR	Number	CV*	Pounds	Number	CV	Pounds	Number	CV	Pounds
1981	0		0	0	0.00	0	0	0.00*	0
1982	0		0	1,699	1.97	8,002	1,699	1.97*	8,002
1983	0		0	0	0.00	0	0	0.00*	0
1984	576		2,713	3,524	1.43	16,595	4,100	1.23*	19,308
1985	0		0	0	0.00	0	0	0.00*	0
1986	0	0.00	0	0	0.00	0	0	0.00	0
1987	461	1.51	2,270	3,503	1.40	16,494	3,964	1.25	18,764
1988	0	0.00	0	0	0.00	0	0	0.00	0
1989	0	0.00	0	248	1.00	1,168	248	1.00	1,168
1990	0	0.00	0	0	0.00	0	0	0.00	0
1991	0		0	0	0.00	0	0	0.00	0
1992	0	0.00	0	72	157.34	356	72	157.34	356
1993	2,017	1.27	9,496	1,383	1.02	6,709	3,400	0.86	16,205
1994	0		0	0	0.00	0	0	0.00	0
1995	6,739	1.54	31,736	0	0.00	0	6,739	1.54	31,736
1996	849	1.69	4,000	0	0.00	0	849	1.69	4,000
1997	18,176	1.66	85,658	0	0.00	0	18,176	1.66	85,658
1998	0	0.00	0	0	0.00	0	0	0.00	0
1999	719	0.44	3,543	0	0.00	0	719	0.44	3,543
2000	87	1.27	412	0	0.00	0	87	1.27	412
2001	5,501	1.64	25,931	0	0.00	0	5,501	1.64	25,931
2002	111	0.98	537	239	0.89	1,126	350	0.68	1,663
2003	3,568	1.12	16,925	3,923	0.88	18,472	7,491	0.71	35,397
2004	3,581	0.57	17,036	0	0.00	0	3,581	0.57	17,036
2005	8,507	0.66	33,989	0	0.00	0	8,507	0.66	33,989
2006	44,904	0.42	191,535	15,467	0.53	75,185	60,371	0.34	266,720
2007	81,796	0.41	435,477	13,625	0.72	71,494	95,421	0.36	506,970
2008	59,391	0.33	271,124	23,591	0.56	108,405	82,982	0.29	379,529
2009	12,878	0.36	75,012	12,128	0.52	69,110	25,006	0.31	144,122
2010	6,058	0.33	36,716	4,880	0.59	27,826	10,938	0.32	64,541
2011	7,246	0.49	41,083	1,741	0.80	8,588	8,987	0.42	49,671
2012	15,387	0.33	57,087	5,906	0.72	28,184	21,293	0.31	85,270
2013	5,987	0.39	28,762	69,494	0.59	318,763	75,481	0.54	347,525
2014	8,614	0.26	34,912	8,624	0.30	36,063	17,238	0.20	70,975
2015	1,267	0.52	6,217	6,625	0.46	32,293	7,892	0.40	38,510

Table 4.10.2. Estimated headboat landings of Blueline Tilefish in the South Atlantic and the Gulf of Mexico, 1973-2015.

Year	NC/SC/GA		FLE		South Atlantic		FLW/AL		LA/MS/TX		Gulf of Mexico	
	Number	Pounds	Number	Pounds	Number	Pounds	Number	Pounds	Number	Pounds	Number	Pounds
1973	2,699	14,890	373	1,507	3,072	16,397						
1974	3,389	16,572	481	1,947	3,870	18,519						
1975	1,567	10,212	223	900	1,790	11,112						
1976	3,141	17,886	414	1,674	3,555	19,560						
1977	1,267	6,541	167	675	1,434	7,216						
1978	1,450	8,774	191	773	1,641	9,547						
1979	360	1,812	47	192	407	2,004						
1980	3,516	16,914	565	2,135	4,081	19,049						
1981	945	4,333	676	2,923	1,621	7,257						
1982	2,504	9,056	62	228	2,566	9,284						
1983	2,347	10,406	668	2,998	3,015	13,404						
1984	339	1,098	50	212	389	1,310						
1985	618	2,484	31	112	649	2,596						
1986	627	1,987	52	192	679	2,179	49	138	51	143	100	281
1987	384	1,741	91	412	475	2,153	142	644	6	27	148	671
1988	391	1,077	45	123	436	1,201	243	759	128	254	371	1,013
1989	261	261	171	171	432	431	659	658	20	20	679	678
1990	108	609	101	148	209	758	852	1,388	9	12	861	1,400
1991	83	454	236	348	319	802	197	425	16	36	213	462
1992	66	242	1,327	2,540	1,393	2,781	1	4			1	4
1993	3	11	148	238	151	250	21	78			21	78
1994	11	46	87	100	98	146	19	56			19	56
1995	1	2	253	574	254	576	4	18			4	18
1996	12	55	2,522	11,621	2,534	11,675	16	71			16	71
1997	11	46	129	223	140	269	14	26	1	2	15	28
1998	37	129	57	130	94	259	3	6			3	6
1999	9	23	22	33	31	55	5	5			5	5
2000	6	8	17	24	23	32	40	54	4	6	44	60
2001	1	1	165	220	166	222	8	11			8	11
2002	7	108	150	1,323	157	1,432	56	57	48	71	104	127
2003			57	105	57	105	11	25	3	7	14	32
2004	14	58	41	31	55	90	29	22			29	22
2005	7	26	216	812	223	838	12	26	22	48	34	74
2006	299	848	60	108	359	957	1	2	2	5	3	7
2007	95	180	7	12	102	192						
2008	30	58	4	7	34	65	31	53			31	53
2009	2,393	4,611	10	19	2,403	4,630	2	4	6	13	8	16
2010	2,052	5,952			2,052	5,952						
2011	1,732	4,579	2,223	1,797	3,955	6,375	9	5			9	5
2012	3,017	8,289	3,602	10,173	6,619	18,462	13	37	7	20	20	57
2013	2,825	6,426	2,884	7,676	5,709	14,101	934	2,405	3	7	937	2,412
2014	3,629	8,473	3,911	9,879	7,540	18,352	3,866	12,104	7	16	3,873	12,120
2015	2	4	3,789	15,882	3,791	15,886	1,035	5,045	5	25	1,040	5,070

Table 4.10.3. Estimated recreational landings and discards of Blueline Tilefish in the Mid-Atlantic using the Amended Delphi approach

Year	Adjusted Charter (2014)	Adjusted Headboat Delphi follow-up used for 2004-2011	Private (105.16% of Charter)	Total landings in numbers	Total landings in pounds*	Est C.V.	Total Discards in numbers*	Est C.V.
2003	208	13,500	219	13,927	56,796	0.4	279	0.8
2004	208	13,500	219	13,927	56,796	0.4	279	0.8
2005	208	13,500	219	13,927	56,796	0.4	279	0.8
2006	208	13,500	219	13,927	56,796	0.4	279	0.8
2007	2,995	13,500	3,149	19,644	80,032	0.4	393	0.8
2008	1,294	13,750	1,361	16,405	66,851	0.4	328	0.8
2009	1,875	13,750	1,972	17,597	71,734	0.4	352	0.8
2010	952	13,750	1,001	15,703	64,027	0.4	314	0.8
2011	1,941	13,750	2,041	17,732	72,287	0.4	355	0.8
2012	2,282	13,530	2,400	18,212	74,236	0.35	364	0.7
2013	4,259	15,569	4,479	24,306	99,098	0.35	486	0.7
2014	5,888	20,800	6,192	32,881	133,991	0.35	658	0.7
2015	10,770	16,281	11,326	38,377	156,430	0.3	768	0.6

*Discards set at 2% of landed catch

Table 4.10.4. South Atlantic and Gulf of Mexico (NC-LA) Blueline Tilefish discards (numbers of fish) for charter boat and private boat modes (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2015). MRFSS estimates adjusted to MRIP APAIS estimates prior to 2004. CH mode adjusted for FHS conversion prior to 2004. *CVs for CH mode 1981-1985 are unavailable.

	Estimated CH Discards		Estimated PR Discards		ALL MODES Discards	
YEAR	Number	CV*	Number	CV	Number	CV
1981	0		0	0.00	0	0.00*
1982	0		0	0.00	0	0.00*
1983	0		0	0.00	0	0.00*
1984	0		0	0.00	0	0.00*
1985	0		0	0.00	0	0.00*
1986	0	0.00	0	0.00	0	0.00
1987	0	0.00	0	0.00	0	0.00
1988	0	0.00	0	0.00	0	0.00
1989	0	0.00	0	0.00	0	0.00
1990	0	0.00	0	0.00	0	0.00
1991	0	0.00	5,503	7.63	5,503	7.63
1992	683	16.95	1,245	121.94	1,928	78.95
1993	0	0.00	0	0.00	0	0.00
1994	0	0.00	0	0.00	0	0.00
1995	0	0.00	0	0.00	0	0.00
1996	0	0.00	0	0.00	0	0.00
1997	0	0.00	0	0.00	0	0.00
1998	390	37.46	0	0.00	390	37.46
1999	4,931	22.44	594	0.98	5,525	20.03
2000	136	12.24	0	0.00	136	12.24
2001	0	0.00	0	0.00	0	0.00
2002	283	37.46	163	84.13	446	38.85
2003	5,280	21.24	797	0.56	6,077	18.46
2004	13	1.00	131	1.01	144	0.92
2005	2,813	1.00	6,110	0.60	8,923	0.52
2006	1,750	0.82	118	1.00	1,868	0.77
2007	1,560	1.00	5,030	0.95	6,590	0.76
2008	0	0.00	0	0.00	0	0.00
2009	38	1.00	1,417	0.71	1,455	0.69
2010	3,172	0.97	0	0.00	3,172	0.97
2011	476	1.00	0	0.00	476	1.00
2012	133	0.90	1,465	0.85	1,598	0.79
2013	22	1.12	1,178	0.95	1,200	0.93
2014	94	0.08	4,741	0.59	4,834	0.58
2015	16	1.00	3,203	0.95	3,219	0.95

Table 4.10.5. Estimated Blueline Tilefish discards for SRHS by year and state.†

Year	NC/SC/GA	FLE	South Atlantic	FLW/AL	TX	Gulf of Mexico
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
2003						
2004	0	0	0			
2005	0	0	0	0		0
2006	0	2	2	0	0	0
2007	0	0	0	0	0	0
2008	0	8	8	0		0
2009	2	3	5	0	0	0
2010	6	8	14	0	0	0
2011	44	26	70	0	0	0
2012	131	101	232	4	0	4
2013	31	8	39	0	0	0
2014	7	2	9	0	0	0
2015	7	0	7	0	0	0

†1973-2003 Assume no discards prior to 2004.

Table 4.10.6. Number of Blueline Tilefish measured and number of trips with measured Blueline Tilefish in the MRIP modes by year, state, and mode.

Year	MRIP															
	Fish(N)								Trips(N)							
	AL		FLW	FLE		NCSCGA			AL		FLW	FLE		NCSCGA		
	CH	PR	CH	CH	PR	CH	PR	Total	CH	PR	CH	CH	PR	CH	PR	Total
1972																
1973																
1974																
1975																
1976																
1977																
1978																
1979																
1980																
1981																
1982																
1983																
1984																
1985																
1986																
1987				1				1				1				1
1988																
1989																
1990																
1991																
1992																
1993				2	1			3				1	1			2
1994																
1995						2		2						1		1
1996						7		7						1		1
1997				5		15		20				1		1		2
1998																
1999				19				19				8				8
2000				2		1		3				1		1		2
2001				4		15		19				2		1		3
2002				3				3				2				2
2003				10	10	15		35				6	1	1		8
2004			2	4		5		11			2	3		1		6
2005			2	6		30		38			2	2		2		6
2006			2	1		108	56	167			1	1		11	5	18
2007				16		256	27	299				8		20	4	32
2008				7		326	6	339				5		36	2	43
2009			1	23	2	114	8	148			1	5	1	13	1	21
2010				21		93	2	116				4		18	1	23
2011				19	4	40	2	65				3	1	7	1	12
2012				95	3	94	14	206				14	2	17	2	35
2013	1			1	9	94		105	1			1	3	16		21
2014				7	5	78	7	97				3	2	19	3	27
2015		2		6	3	2	6	19		1		5	3	1	2	12

Table 4.10.7. Number of Blueline Tilefish measured and number of trips with measured Blueline Tilefish in the SRHS by year and state.

	SRHS							
	Fish (N)				Trips (N)			
Year	FLW/AL	FLE	NCSCGA	Total	FLW/AL	FLE	NCSCGA	Total
1972			125	125			33	33
1973			80	80			29	29
1974			77	77			24	24
1975			41	41			20	20
1976			70	70			26	26
1977			49	49			14	14
1978			30	30			13	13
1979		32	29	61		3	7	10
1980		21	24	45		5	13	18
1981		26	10	36		6	6	12
1982			18	18			9	9
1983			43	43			19	19
1984		3	26	29		3	10	13
1985		1	19	20		1	14	15
1986	1	1	29	31	1	1	10	12
1987			9	9			8	8
1988		2	6	8		2	3	5
1989		10		10		3		3
1990		5	1	6		1	1	2
1991								
1992								
1993								
1994								
1995								
1996	1		2	3	1		1	2
1997		26	2	28		5	2	7
1998		6		6		4		4
1999								
2000		36		36		4		4
2001		15		15		2		2
2002								
2003		6		6		4		4
2004		7		7		2		2
2005								
2006								
2007								
2008		2		2		2		2
2009								
2010			42	42			6	6
2011		8	37	45		2	4	6
2012		1	161	162		1	8	9
2013		187	183	370		7	9	16
2014		112	222	334		9	10	19
2015	2	165		167	1	10		11

Table 4.10.8. Mean weight (kg) of Blueline Tilefish measured in the SRHS by year and state, 1972-2015.

	NC/SC/GA				FLE				FLW/AL			
Year	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)
1972	125	2.33	0.55	5.54								
1973	80	2.43	0.36	5.54								
1974	77	2.55	0.55	5.72								
1975	41	3.20	1.00	6.58								
1976	70	2.73	1.23	5.90								
1977	49	2.59	1.36	4.77								
1978	30	3.05	1.60	5.55								
1979	29	2.42	0.54	5.50	32	0.66	0.26	2.50				
1980	24	2.51	0.97	7.75	21	1.08	0.47	2.70				
1981	10	2.08	1.05	4.90	26	1.92	0.45	7.03				
1982	18	1.67	0.41	3.25								
1983	43	2.02	0.43	3.80								
1984	26	1.97	0.70	4.90	3	1.69	0.67	3.00				
1985	19	1.68	0.57	4.15	1	0.43	0.43	0.43				
1986	29	1.61	0.61	3.60	1	3.51	3.51	3.51	1	0.78	0.78	0.78
1987	9	2.06	1.40	3.20								
1988	6	1.21	0.22	2.30	2	0.77	0.14	1.40				
1989					10	0.45	0.10	1.08				
1990	1	3.90	3.90	3.90	5	0.33	0.21	0.42				
1991												
1992												
1993												
1994												
1995												
1996	2	3.17	2.75	3.59					1	0.58	0.58	0.58
1997	2	3.47	2.95	3.98	26	0.71	0.25	1.40				
1998					6	0.36	0.26	0.53				
1999												
2000					36	0.60	0.19	2.81				
2001					15	0.60	0.25	0.93				
2002												
2003					6	0.84	0.29	1.19				
2004					7	1.05	0.71	1.58				
2005												
2006												
2007												
2008					2	0.31	0.27	0.35				
2009												
2010	42	1.10	0.15	3.70								
2011	37	1.16	0.37	3.44	8	0.43	0.24	0.57				
2012	161	1.15	0.24	4.35	1							
2013	183	1.10	0.31	3.19	187	1.62	0.19	5.04				
2014	222	1.23	0.10	3.84	112	1.47	0.21	4.28				
2015					165	1.63	0.24	6.48	2	2.93	1.99	3.87

Table 4.10.9. Number of Blueline Tilefish measured in the ODU study by year (2009-2015). Trip information was not recorded for these data.

Year	Fish (N)
2009	90
2010	271
2011	568
2012	1,118
2013	112
2014	87
2015	79

Table 4.10.10. South Atlantic (NC-FLE) estimated number of angler trips by state (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2015). MRIP effort from the Florida Keys is included.

Year	FLW (Keys)	FLE	GA	SC	NC	Total SA MRIP
1981	2,953,369	5,448,405	326,567	598,055	2,357,129	11,683,525
1982	1,172,117	8,012,842	479,813	1,424,581	3,586,848	14,676,200
1983	2,651,164	8,069,916	467,520	1,164,798	5,110,868	17,464,266
1984	3,209,674	8,810,552	512,838	1,679,782	4,036,918	18,249,764
1985	902,719	9,677,879	423,759	1,525,035	3,666,417	16,195,808
1986	626,712	9,718,812	650,735	1,465,628	3,363,699	15,825,587
1987	2,033,422	10,579,936	756,133	1,665,657	4,017,750	19,052,898
1988	854,800	11,308,011	680,145	1,949,020	4,906,521	19,698,496
1989	1,024,725	10,691,250	635,677	1,126,563	3,962,043	17,440,258
1990	1,186,362	8,024,428	711,356	962,251	3,949,831	14,834,228
1991	2,430,539	11,042,416	744,267	1,835,728	3,847,406	19,900,355
1992	1,795,879	10,282,664	581,902	1,485,561	4,467,758	18,613,764
1993	2,091,997	9,546,759	682,365	1,833,353	4,846,431	19,000,905
1994	1,677,502	11,770,436	964,176	2,039,341	5,377,114	21,828,568
1995	1,659,028	11,555,911	793,229	1,580,020	5,348,783	20,936,970
1996	1,869,420	10,499,349	630,035	1,534,982	5,005,506	19,539,291
1997	1,847,094	11,256,290	585,481	1,661,196	5,220,995	20,571,057
1998	1,036,316	10,033,347	578,994	1,739,486	4,781,357	18,169,499
1999	689,140	8,138,841	476,718	1,229,106	4,799,382	15,333,187
2000	653,696	11,433,832	799,107	1,351,881	6,650,826	20,889,341
2001	832,537	12,421,077	809,741	1,687,024	6,866,643	22,617,023
2002	514,672	10,270,361	623,539	1,267,887	5,796,027	18,472,487
2003	775,508	11,443,784	976,407	2,113,325	6,920,034	22,229,058
2004	1,202,142	10,892,674	969,242	2,447,627	6,912,766	22,424,450
2005	652,138	11,349,041	932,689	2,193,830	6,542,798	21,670,495
2006	592,645	11,627,562	798,250	2,238,488	6,863,981	22,120,925
2007	1,048,814	12,603,110	1,028,696	2,030,174	6,333,377	23,044,172
2008	1,342,169	11,239,819	1,204,060	2,451,345	6,898,425	23,135,817
2009	636,724	10,119,942	842,438	2,413,124	5,308,692	19,320,920
2010	571,935	10,217,715	872,803	2,298,189	5,677,574	19,638,216
2011	513,900	10,156,463	970,147	1,806,449	4,739,744	18,186,702
2012	841,138	9,390,403	892,417	2,206,383	5,303,480	18,633,821
2013	1,394,041	8,980,810	690,362	1,977,432	4,967,753	18,010,399
2014	1,491,124	9,643,563	826,577	2,221,288	4,954,073	19,136,625
2015	1,316,004	8,633,661	590,130	2,670,024	4,645,659	17,855,478

Table 4.10.10 (continued). Gulf of Mexico (FLW-LA) estimated number of angler trips by state (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004-2015). MRIP effort from the Florida Keys is NOT included.

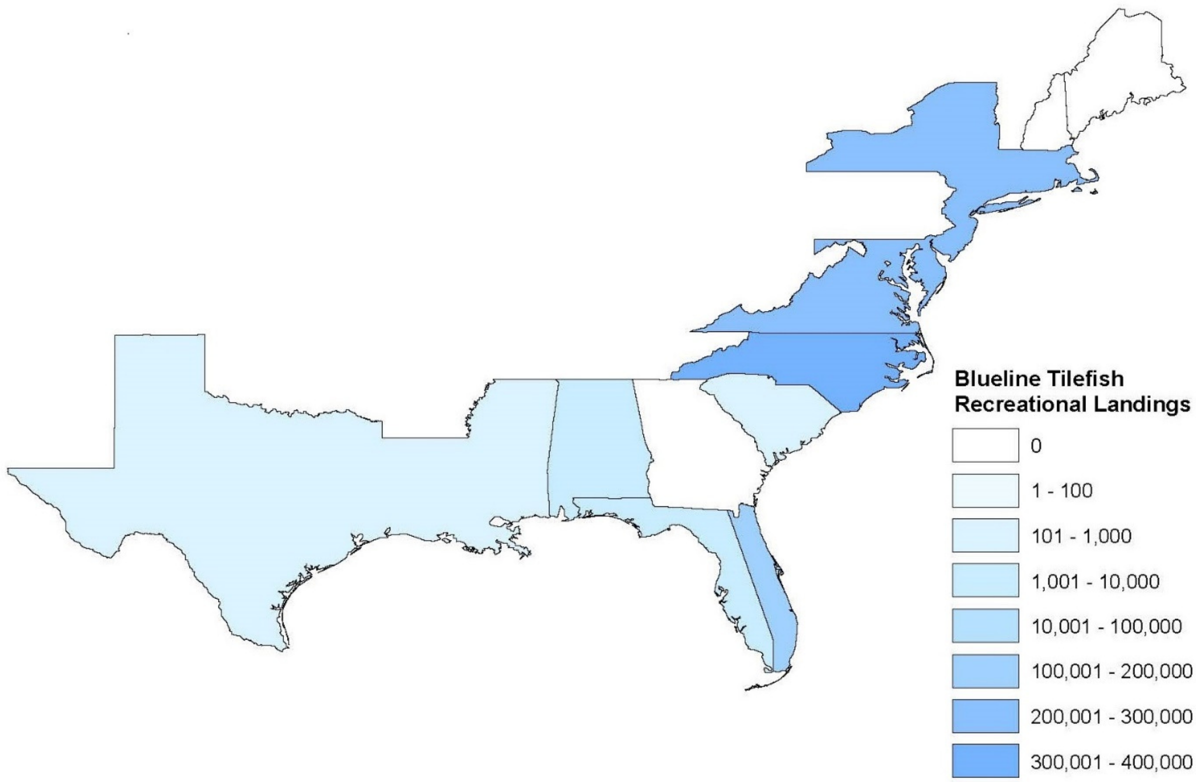
Year	LA	MS	AL	FLW (w/o Keys)	Total GOM MRIP
1981	1,386,220	693,360	523,736	6,562,295	9,165,610
1982	2,603,283	779,065	1,362,929	7,577,560	12,322,837
1983	2,729,264	1,086,195	1,740,182	11,807,419	17,363,060
1984	1,750,442	826,354	612,354	13,258,309	16,447,459
1985	2,582,626	604,478	712,494	10,644,999	14,544,597
1986	3,043,553	811,544	881,666	13,692,071	18,428,834
1987	2,385,256	793,270	629,467	10,160,855	13,968,848
1988	2,973,800	917,534	1,197,906	13,838,360	18,927,600
1989	2,316,720	715,169	629,706	10,969,811	14,631,406
1990	1,989,157	691,634	742,732	8,739,533	12,163,056
1991	2,441,348	849,297	666,469	11,791,244	15,748,358
1992	2,578,108	1,005,831	781,098	11,947,502	16,312,539
1993	2,735,639	871,412	955,127	10,817,639	15,379,816
1994	2,522,991	979,743	907,336	11,450,904	15,860,973
1995	2,996,136	1,089,244	1,029,197	10,743,131	15,857,708
1996	2,896,335	961,034	945,518	10,469,679	15,272,567
1997	3,252,468	1,013,939	1,043,649	11,552,825	16,862,882
1998	2,667,856	817,863	972,549	11,066,276	15,524,545
1999	2,627,440	788,075	1,141,501	10,454,300	15,011,316
2000	3,751,609	1,093,144	1,086,818	14,404,820	20,336,390
2001	3,615,244	1,250,045	1,635,798	15,556,074	22,057,161
2002	3,018,946	1,038,353	1,190,004	13,903,603	19,150,906
2003	4,270,921	1,176,788	1,499,989	15,253,308	22,201,006
2004	5,203,514	1,179,292	2,250,691	16,602,497	25,235,993
2005	4,065,078	925,717	1,604,207	16,047,289	22,642,292
2006	3,763,274	923,967	1,938,270	16,083,180	22,708,691
2007	4,188,282	1,204,457	1,961,012	15,900,475	23,254,225
2008	4,620,056	968,686	1,703,946	16,174,734	23,467,421
2009	4,128,014	1,079,328	1,712,587	15,050,939	21,970,867
2010	3,862,487	1,232,593	1,686,157	13,713,793	20,495,030
2011	4,576,247	1,615,390	2,483,465	13,411,435	22,086,537
2012	4,136,564	1,950,449	2,305,286	13,967,667	22,359,966
2013	4,661,154	1,760,758	2,862,430	14,571,803	23,856,144
2014		1,480,525	2,169,169	13,688,817	17,338,512
2015	3,877,907	1,551,058	2,324,317	12,108,152	19,861,433

Table 4.10.11. Headboat estimated angler days by year and state, 1981-2015.

	South Atlantic			Gulf of Mexico		
Year	FLE	NC/SC/GA	Total	FLW/AL	TX	Total
1981	298,883	78,404	377,287			
1982	293,133	94,478	387,611			
1983	277,863	89,563	367,426			
1984	288,994	96,179	385,173			
1985	280,845	97,385	378,230			
1986	317,058	98,414	415,472	240,077	62,459	302,536
1987	333,041	114,067	447,108	217,049	69,725	286,774
1988	301,775	118,889	420,664	195,948	78,087	274,035
1989	316,864	101,386	418,250	208,325	66,256	274,581
1990	322,895	100,391	423,286	213,906	65,042	278,948
1991	280,022	108,918	388,940	174,312	66,342	240,654
1992	264,523	102,966	367,489	184,802	86,129	270,931
1993	236,973	107,243	344,216	207,898	92,160	300,058
1994	242,296	100,407	342,703	204,562	113,429	317,991
1995	207,500	105,248	312,748	182,410	100,962	283,372
1996	197,173	92,755	289,928	154,913	102,840	257,753
1997	170,367	100,245	270,612	149,442	91,215	240,657
1998	153,339	100,743	254,082	185,331	85,504	270,835
1999	162,195	88,952	251,147	176,117	66,261	242,378
2000	180,097	73,794	253,891	159,331	63,347	222,678
2001	161,052	83,381	244,433	157,243	61,583	218,826
2002	149,274	72,340	221,614	141,831	73,173	215,004
2003	143,585	60,980	204,565	144,211	81,068	225,279
2004	173,701	77,717	251,418	158,430	64,990	223,420
2005	171,078	67,370	238,448	130,233	59,857	190,090
2006	173,604	83,728	257,332	124,049	75,794	199,843
2007	155,184	91,697	246,881	136,880	66,286	203,166
2008	122,369	66,019	188,388	130,176	44,133	174,309
2009	134,329	62,478	196,807	142,438	54,005	196,443
2010	121,705	67,979	189,684	111,018	47,869	158,887
2011	130,927	64,667	195,594	157,025	50,941	207,966
2012	146,638	62,830	209,468	161,975	55,456	217,431
2013	163,789	63,400	227,189	174,731	59,155	233,886
2014	193,823	66,783	260,606	191,365	54,488	245,853
2015	193,202	64,195	257,397	194,383	58,722	253,105

4.11 Figures

a) **Blueline Tilefish Landings by State 1973-2015**



b) **Blueline Tilefish Landings by Source and Year 1973-2015**

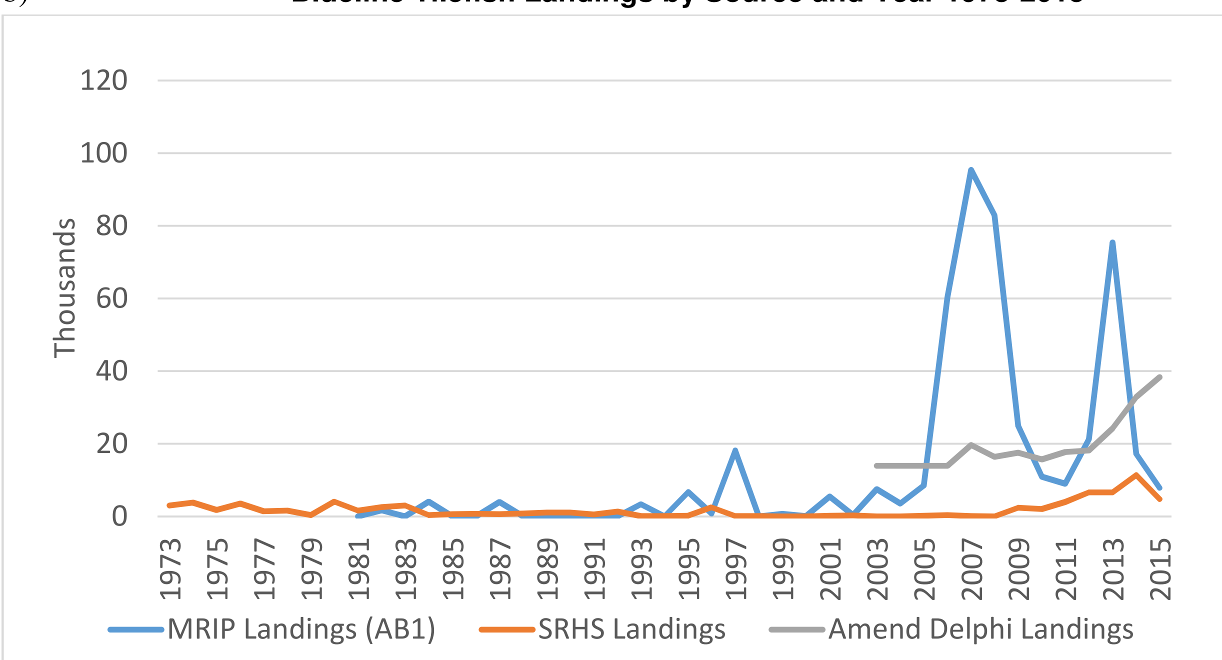


Figure 4.11.1. Estimated number of Atlantic Blueline Tilefish landings from MRFSS/MRIP (1981-2015), SRHS (1973-2015), and Amended Delphi method (2003-2015) by state (a) and by source and year (b).

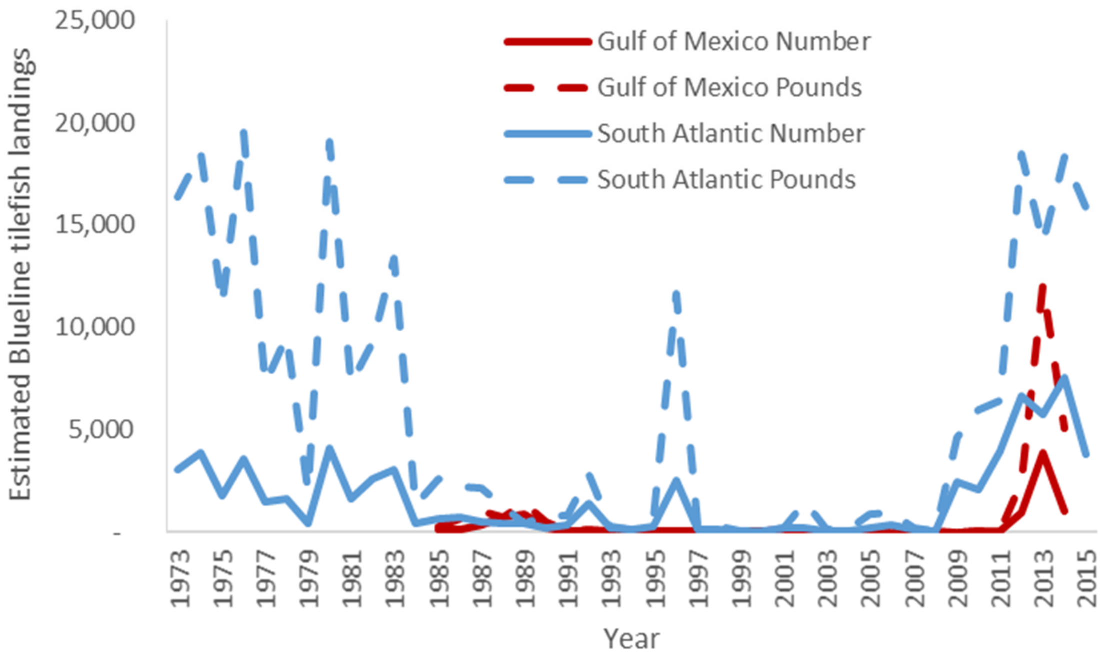


Figure 4.11.2. Estimated Blueline Tilefish landings (number and pounds) for the headboat fishery, 1973-2015.

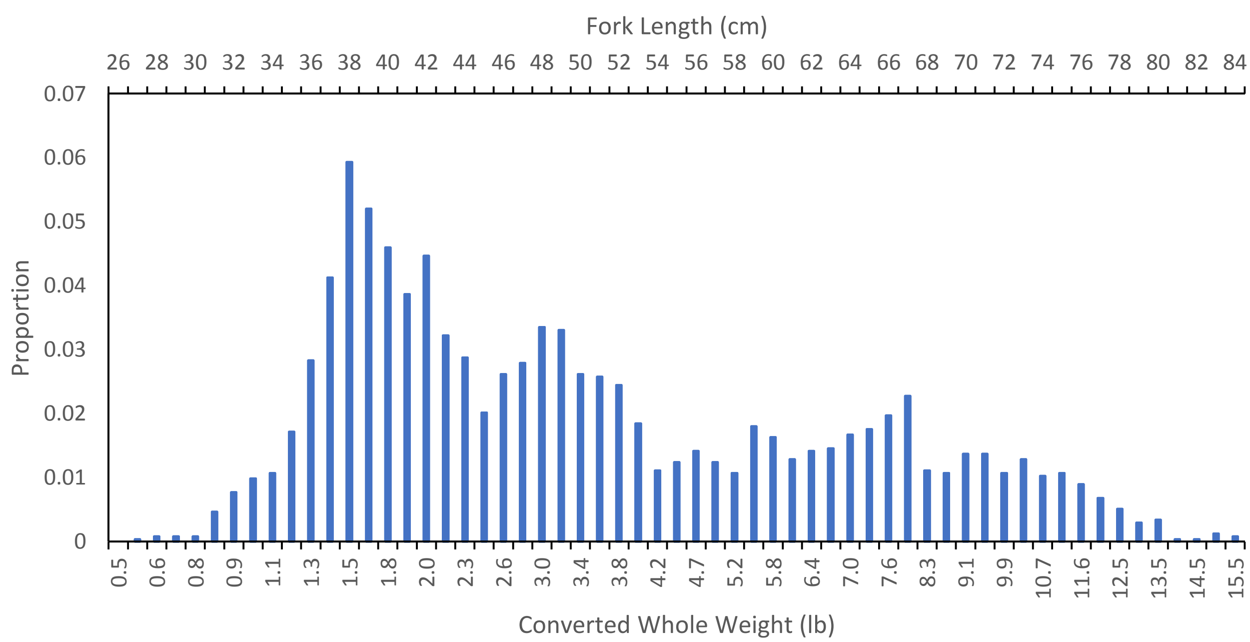


Figure 4.11.3. Proportions at fork length (FL; cm) and converted whole weight (WW; lb) for Blueline Tilefish collected through sampling of the recreational fishery in Virginia from 2009-2015 (n=2325). FL bins are of the form: the 26 cm bin includes measured FLs from 255-264 mm. Converted WWs were calculated via the conversion equation: WW=2.20E-3*1.78E-5*FL^2.94, estimated by the Life History Work Group.

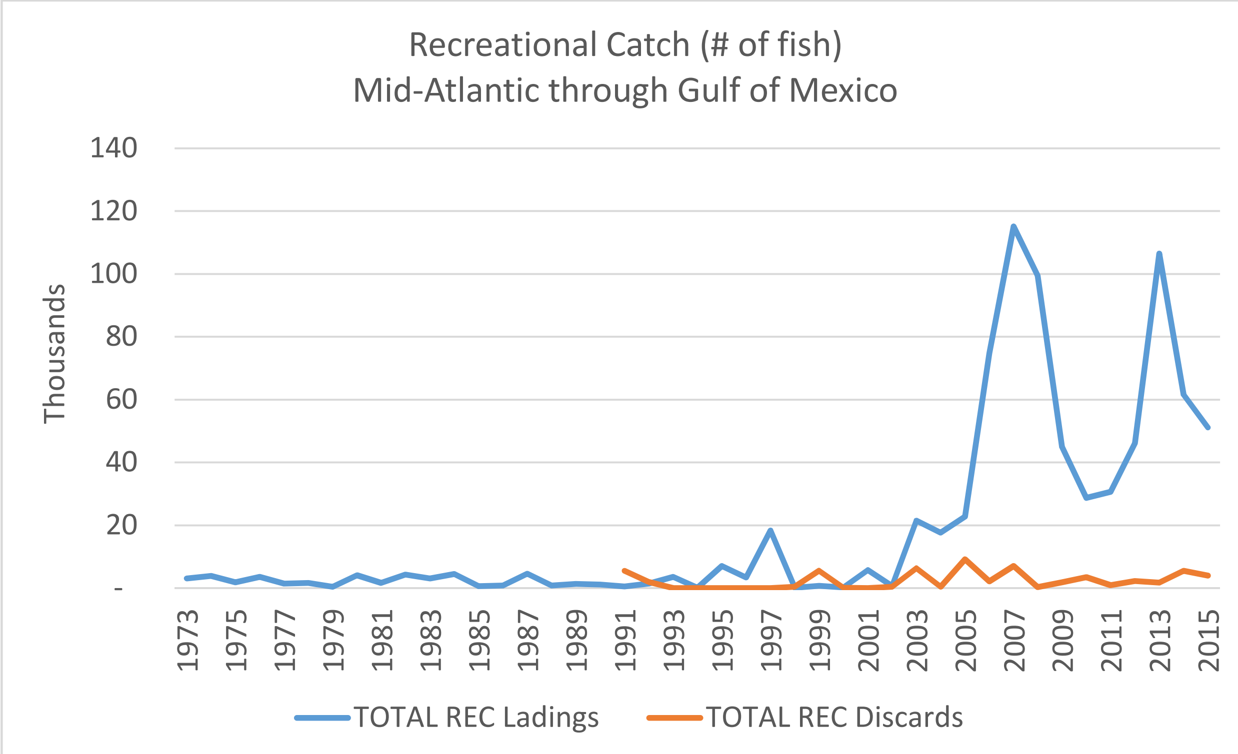
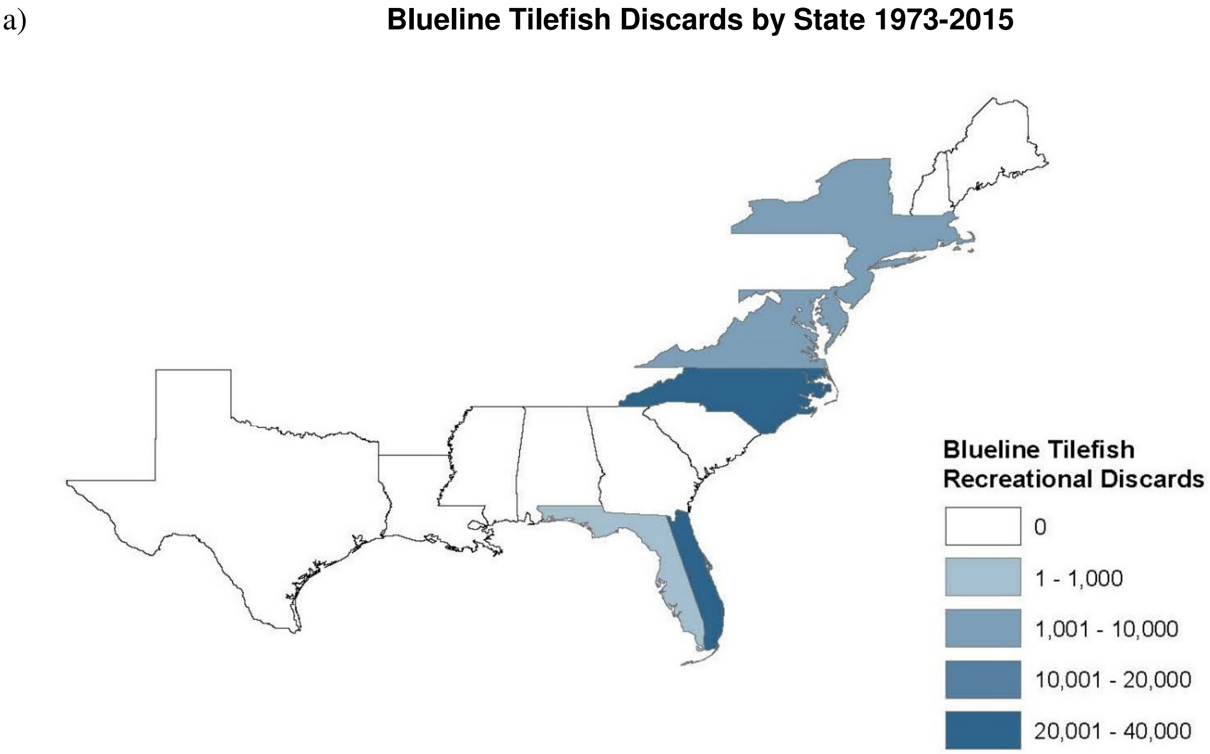


Figure 4.11.4. Total recreational catch (#s of fish) for the Mid-Atlantic through the Gulf of Mexico.

a)



b)

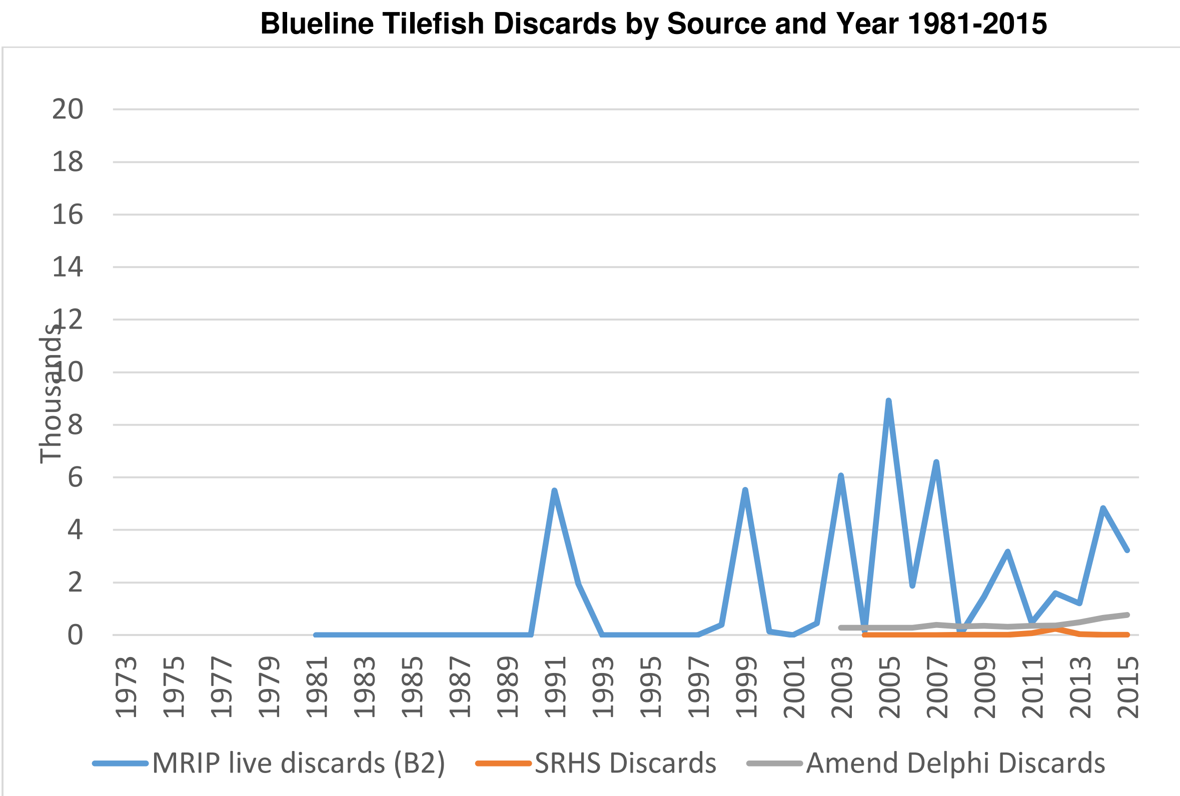


Figure 4.11.5. Estimated number of Atlantic Blueline Tilefish discards from MRFSS/MRIP (1981-2015), SRHS (2004-2015), and Amended Delphi method (2003-2015) by state (a) and by source and year (b).

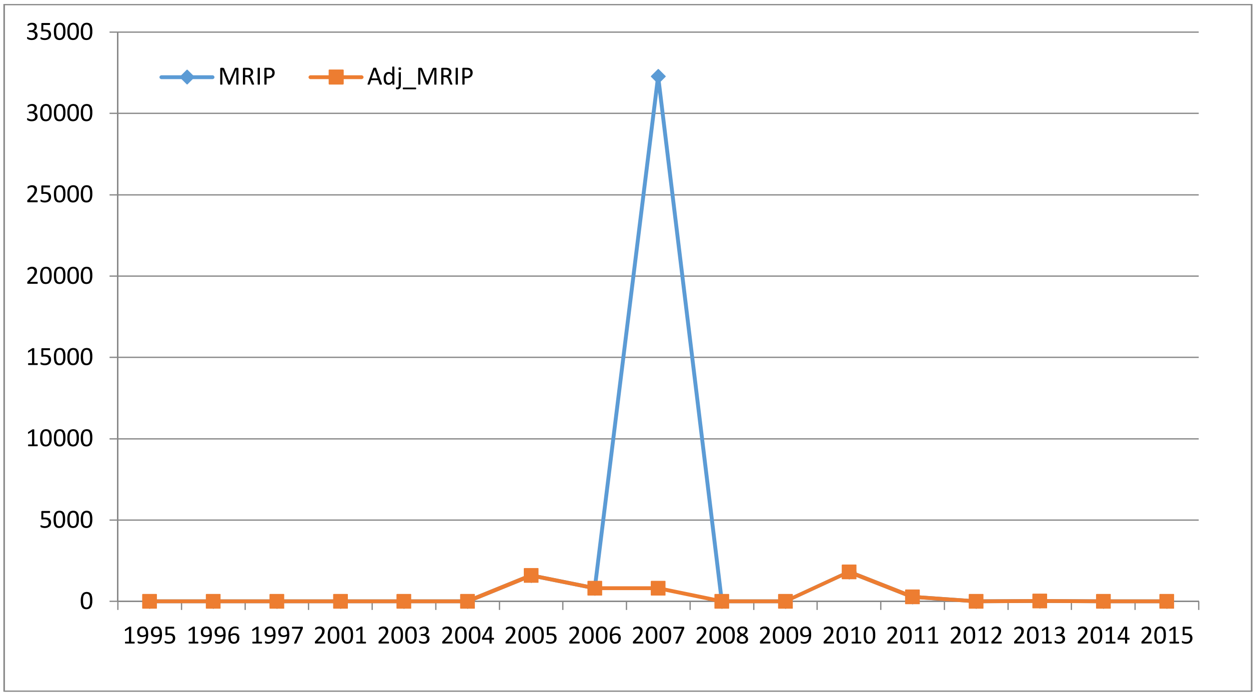


Figure 4.11.6. MRIP charter discards from North Carolina shown in blue. The DW panel requested substitution using the average of the values from the respective cells of the previous 3 years are shown in orange.

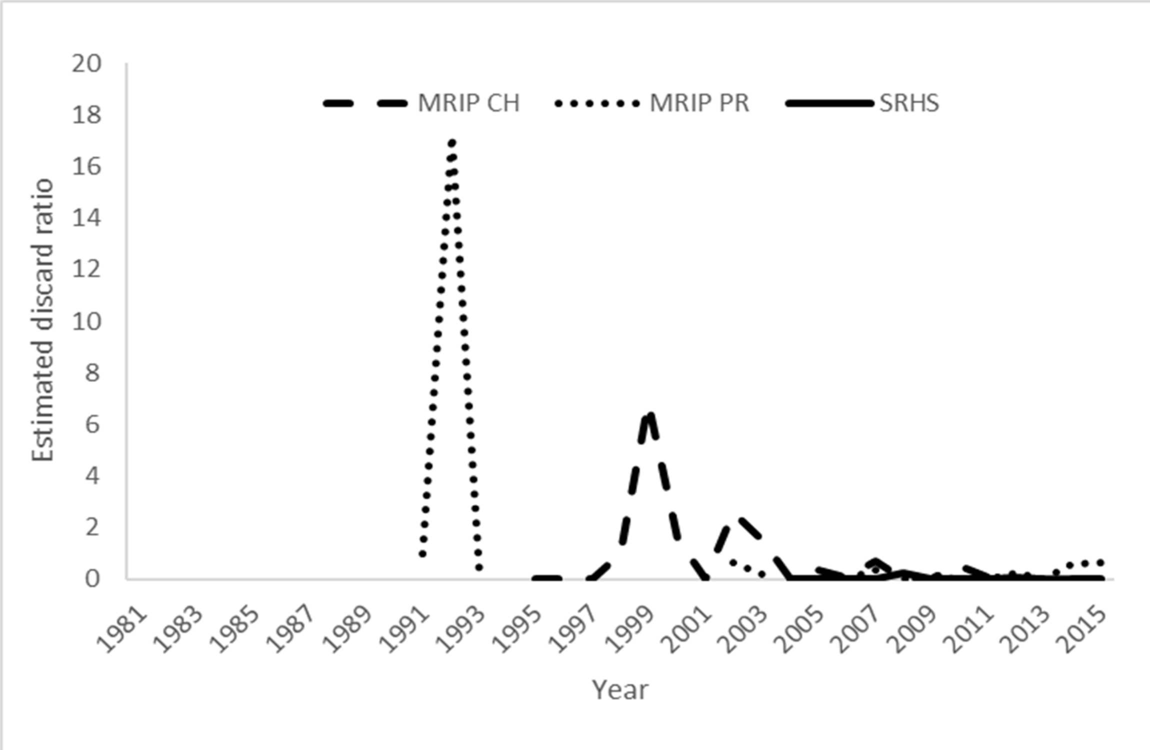


Figure 4.11.7a. Estimated Blueline Tilefish discard ratio in the recreational fishery, 1981-2015.

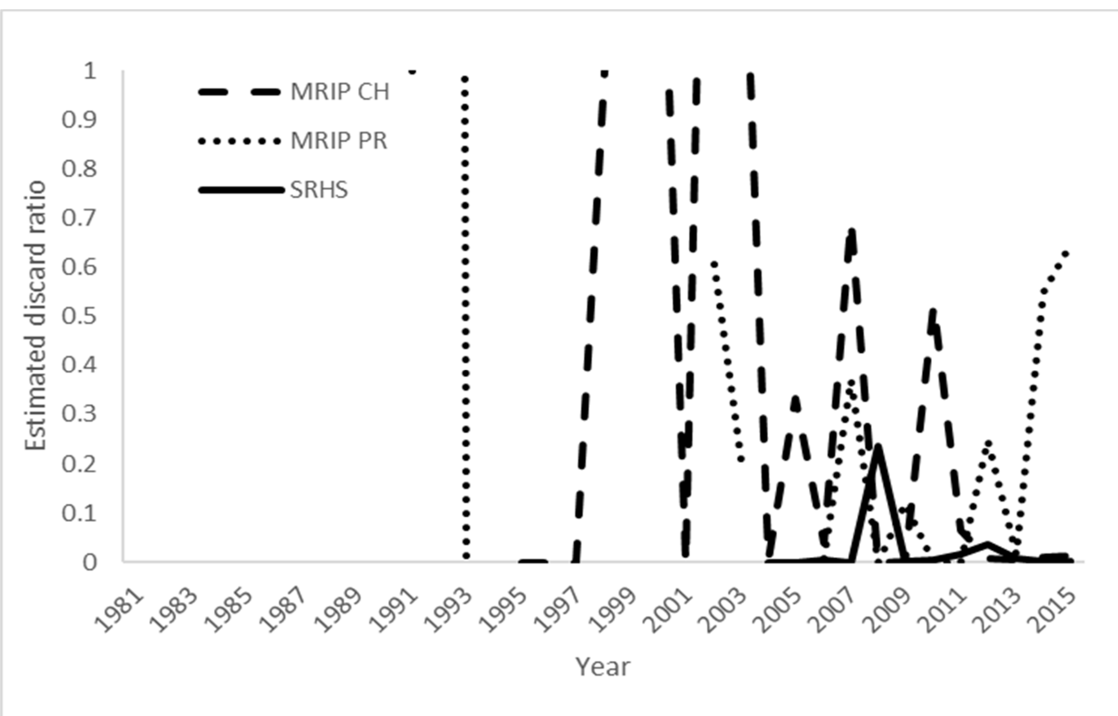


Figure 4.11.7b. Estimated Blueline Tilefish discard ratio in the recreational fishery shown at a reduced scale, 1981-2015.

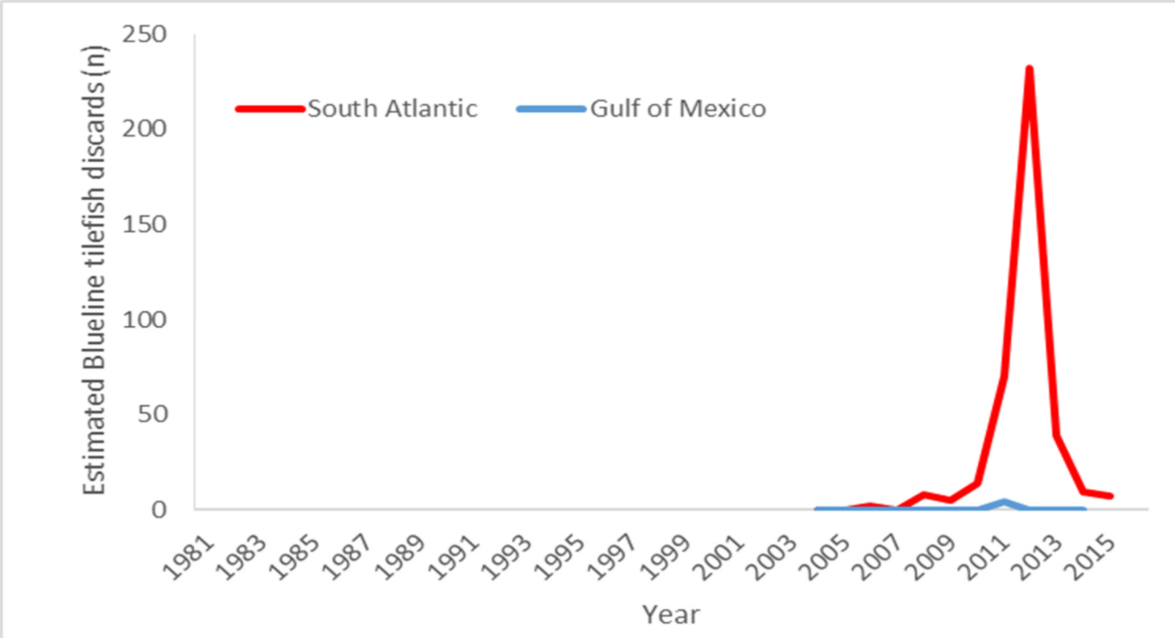
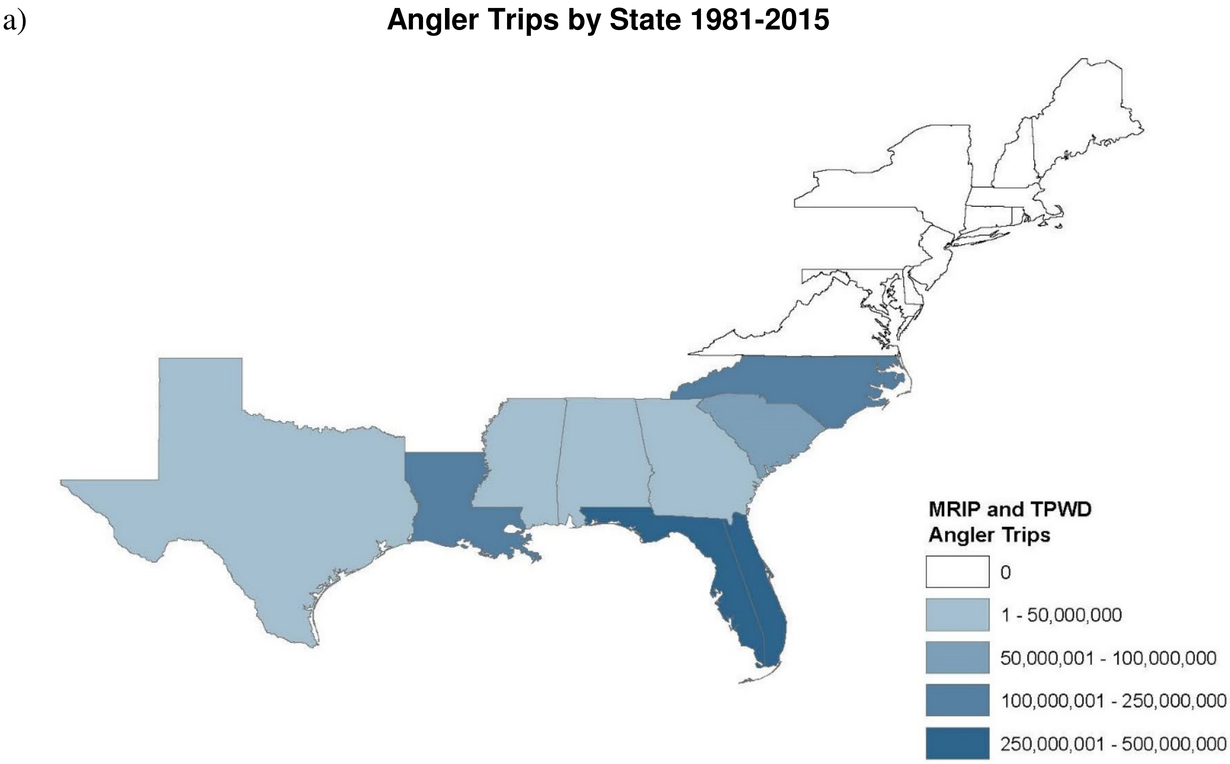


Figure 4.11.8. South Atlantic and Gulf of Mexico estimated Blueline Tilefish discards for the headboat fishery (assume zero discards 1973-2003; SRHS 2004-2015).

a)



b)

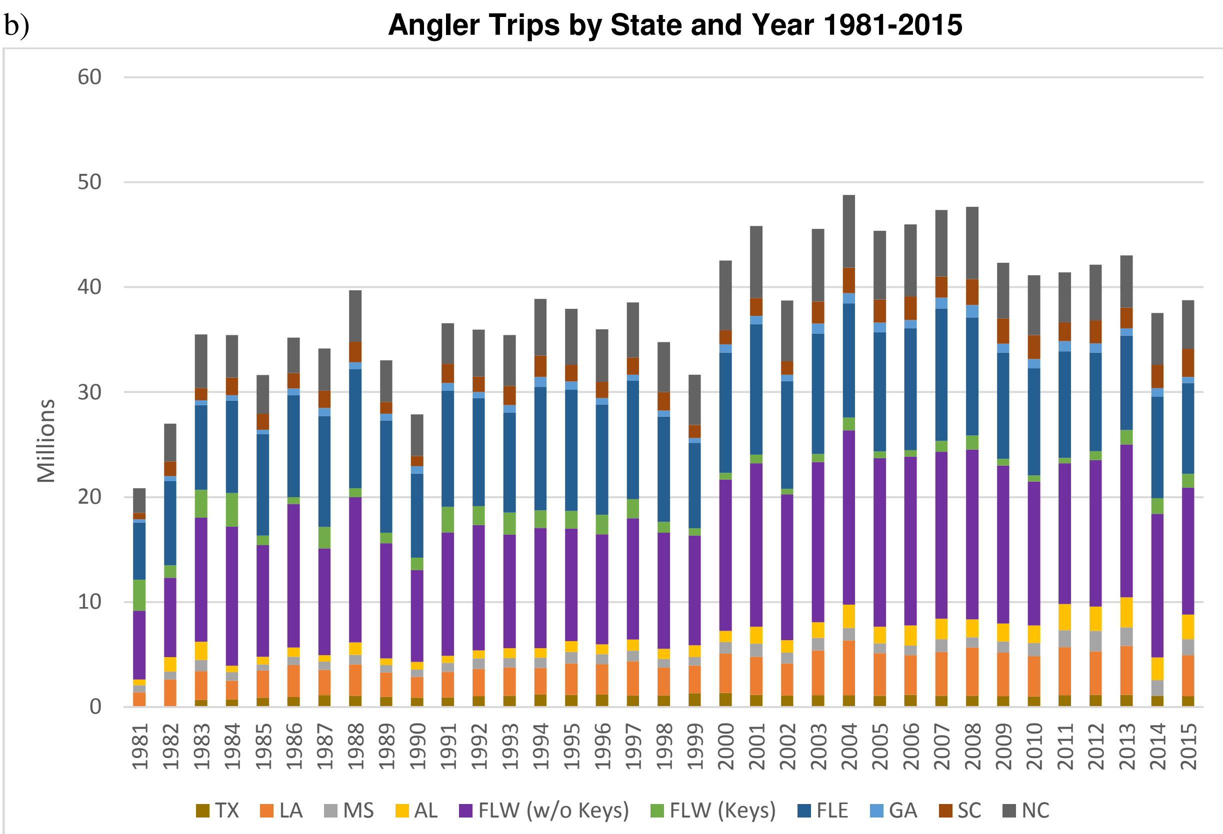
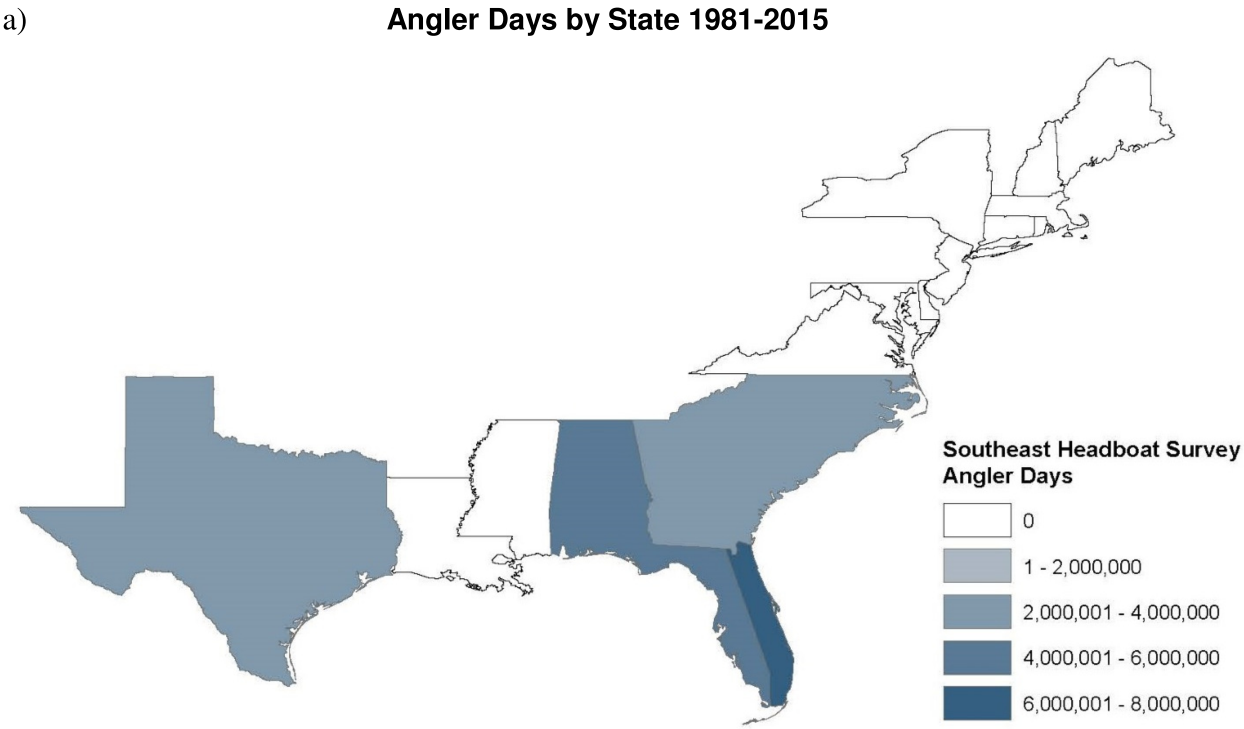


Figure 4.11.9. Atlantic estimated number of angler trips from MRFSS/MRIP (1981-2015) and TPWD (1983-2015) by state (a) and by state and year (b). MRFSS/MRIP data shown from NC to Gulf of Mexico.

a)



b)

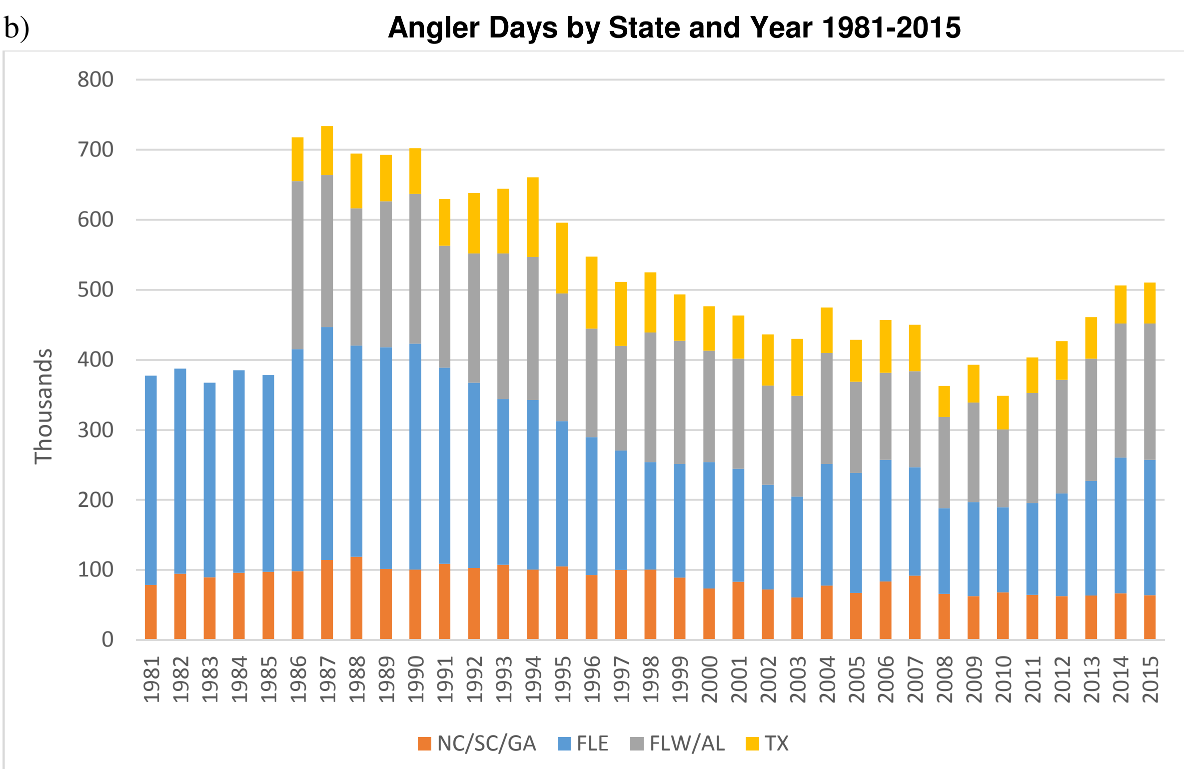


Figure 4.11.10. South Atlantic and Gulf of Mexico estimated number of headboat angler days from SRHS (1981-2015) by state (a) and by state and year (b). Due to confidentiality concerns, effort from some states have been grouped together (Georgia, South Carolina, and North Carolina in the South Atlantic and West Florida and Alabama in the Gulf of Mexico). FLE, includes the Atlantic side of the Florida Keys.

5. Measure of Population Abundance (Indices)

5.1 Overview

The SEDAR 50 Data Workshop (DW) index working group (IWG) panel considered five fishery-independent data sources for developing indices of abundance: the Southeast Reef Fish Survey (SERFS) chevron trap survey, the SERFS video survey, the Marine Resources Monitoring, Assessment and Prediction (MARMAP) program short bottom longline survey, the National Marine Fisheries Service (NMFS) bottom longline survey, and the NMFS Northeast Fisheries Science Center (NEFSC) bottom trawl survey (Table 5.1). During the data webinar prior to the DW, the DW panel discarded three of these datasets because of small samples sizes or limited geographic extent. The SERFS chevron trap and the SERFS video survey were retained for further consideration as a combined index during the DW. The IWG and DW panel recommended not pursuing these two surveys for the development of an index of abundance during SEDAR 50 due to very low sample sizes, short durations (< 5 years), and limited geographic coverage of Blueline Tilefish habitat. The IWG acknowledged that the utility of these surveys as a fishery-independent index of Blueline Tilefish abundance would likely increase as the duration of the time series increased.

The DW panel considered seven fishery-dependent data sets during pre-DW webinars: the Southeast Region Headboat Survey (SRHS), the commercial handline logbook, the commercial longline logbook, the Marine Recreational Fisheries Statistics Survey (MRFSS)/Marine Recreational Information Program (MRIP) catch and effort data, the southeast headboat-at-sea-observer program, the South Carolina Department of Natural Resources (SCDNR) charterboat logbook, and the northeast fishery observer program (NEFOP; Table 5.1). During the data webinar prior to the DW, the DW panel discarded three of these because of inadequate sample sizes for index development, retaining four for further consideration at the DW. Ultimately, the IWG and DW panel recommended three fishery-dependent indices for potential use in the assessment model, the recreational headboat (SRHS) index, the commercial handline logbook index, and the commercial longline logbook index (Table 5.1). Pros and cons of these three indices are identified in Table 5.2.

Group membership

Membership of this DW Index Working Group (IWG) included Joey Ballenger, Rob Cheshire, Kevin Craig (IWG leader), Eric Fitzpatrick, Anne Lange, Paul Nitschke, and Erik Williams. Cynthia Jones was a member of the IWG but was unable to participate in the meeting. Several other DW panelists and observers (Mike Errigo, Michelle Duval, Kevin McCarthy, Joe Cimino, Jason Didden, and Mark Brown) contributed to the IWG discussions throughout the week.

5.2 Review of Working Papers

The IWG discussed any working papers available at the DW that were relevant to indices of abundance, namely SEDAR50-DW9. This working paper describes Blueline Tilefish catches in the NEFSC bottom trawl survey.

The relevant working papers describing index construction are SEDAR50-DW25 (headboats), SEDAR50-DW26 (commercial handlines), and SEDAR50-DW27 (commercial longlines). For each of these indices, initial (pre-DW) modeling attempts were revised throughout the DW, based on discussions and recommendations of the IWG. The working papers were constructed after the DW, and therefore reflect decisions made during the workshop. The index working papers provide information on sample sizes, diagnostics of model fits, and in some cases, maps of catch and effort. Herein, we provide a brief summary of each index below.

5.3 Fishery-Independent Indices

No fishery-independent program sampled sufficient numbers of Blueline Tilefish to support construction of a meaningful index of abundance for use in the assessment. While the SERFS chevron trap index represents a long time series (1990-2015; Table 5.3), only recently has the survey expended effort in areas where Blueline Tilefish are expected to occur. For this reason, the IWG considered only SERFS chevron trap data collected from 2011-2015 for index development. The SERFS video index only began region-wide in 2011. Hence, the SERFS video index considered for index development only represented the years 2011-2015. The IWG discussed the possibility of combining chevron trap and video data from the SERFS chevron trap/video survey to construct a single index over the period 2011-2015. However positive sample sizes were very low for both data sources, Blueline Tilefish were not always captured on video and in traps at the same locations, and positive stations consistently occurred at three to four unique locations near the seaward edge of the survey area and temporally restricted to a few days a year. Because of the limited sampling and the short duration of the time series, the IWG considered the signal to noise ratio of these data for indexing abundance to be very low. However, no other index extends to the end of the assessment period (2015). Therefore, the working group recommended retaining the trap and video nominal indices for possible qualitative comparisons to other data sources but not for formal use in the assessment model during SEDAR 50. Samples sizes and nominal catch rates of Blueline Tilefish from the trap and video data are shown in Table 5.3.

5.4 Fishery-Dependent Indices

Analysts developed fishery-dependent indices of abundance from the SRHS (recreational headboats), commercial handline logbook data, and commercial longline logbook data. Each index was developed for the South Atlantic region defined as the Florida Keys north as far as data were available, typically at least to NC. A separate index was also developed for each data source that combined the South Atlantic (defined above) and Gulf of Mexico (GOM). This index was constructed because a stock identification workshop indicated that Blueline Tilefish were a single panmictic population throughout their geographic range in the South Atlantic and GOM (SEDAR50-DW2). In addition, because Blueline Tilefish are sedentary and potentially subject to localized depletion, regional indices were also developed for each data source. These included a 'northern' index (defined as Cape Canaveral north), a 'southern' index (defined as Cape Canaveral south to the Florida Keys), and a GOM only index (defined as West of the Florida Keys). In total five indices were developed for each of the three data sources. Development of each index is described in detail below for the South Atlantic because this region is considered the unit stock for the purposes of the SEDAR 50 assessment (SEDAR50-DW17). The combined South Atlantic and GOM indices as well as the regional indices were developed using identical methods to that described for the South Atlantic. Cases where the duration of the index or method of standardization for these indices differed from that in the South Atlantic are described below. Additional details regarding index construction can be found in SEDAR50-DW25, SEDAR50-DW26, and SEDAR50-DW27.

5.4.1 Recreational Headboat Index

The headboat fishery in the South Atlantic includes for-hire vessels that typically accommodate 11-70 passengers and charge a fee per angler. The fishery uses hook and line gear, generally targets hard bottom reefs as the fishing grounds, and generally targets species in the snapper-grouper complex. This fishery is sampled separate from other fisheries, and the available SRHS data were used to generate a fishery-dependent index.

Headboats in the South Atlantic are sampled from North Carolina to the Florida Keys (Figure 5.1). Data have been collected since 1972, but logbook reporting did not start until 1973. In addition, only North Carolina and South Carolina were included in the earlier years of the data set. In 1976, data were collected from North Carolina, South Carolina, Georgia, and northern Florida, and starting in 1978, data were collected from southern Florida.

Variables reported in the data set include year, month, day, area, location, trip type, number of anglers, species, catch, and vessel id. Biological data and discard data were recorded for some trips in some years. Blueline Tilefish represent a small fraction of the overall catch in the south Atlantic headboat fleet (<1%).

The IWG discussed inclusion of headboat data from the mid-Atlantic Vessel Trip Reports (VTRs) for areas north of North Carolina with that from the SRHS for index development. The mid-Atlantic VTR data is a limited time series (10 years) compared to the SRHS (28 years). In addition, the survey covered a limited number of headboats in the region and there were concerns about both inconsistent reporting across much of the fleet as well as under-reporting, particularly in the early years of the survey. There were also concerns about the units (weight vs. numbers) of reported catch from the VTRs. Therefore, these data were excluded from index development so that the northern limit of the headboat index is the Virginia/North Carolina border.

The IWG discussed the years over which to compute the SRHS index. Starting in 1980, Blueline Tilefish were included on the list of species in catch record forms in all South Atlantic states. Prior to 1980, Blueline Tilefish would have been reported as write-in species, which was not done consistently across vessels. Also, headboat fishermen from Cape Hatteras and areas north as well as near Cape Canaveral reported shifts in targeting to deepwater species and Blueline Tilefish in particular, beginning in 2005. Because of the shift in targeting in the mid-2000s this index was created for the years 1980–2005. This is the only index for Blueline Tilefish that spans the 1980s.

5.4.1.1 Methods of Estimation

Data Filtering

Several methods were considered during the DW to subset trips for effective effort (S50-DW25). These attempts included the Stephens and MacCall (2004) approach, use of core vessels, and use of one (e.g., Snowy Grouper) or a group (e.g., deepwater species) of co-occurring species. Stephens and MacCall (2004) was not useful due to the loss of a large number of positive Blueline Tilefish trips. Identifying core vessels was not useful because few vessels consistently caught Blueline Tilefish over time. Because Blueline Tilefish are a deepwater species, the IWG recommended defining effective effort based on trips that caught other deepwater species. These co-occurring deepwater species included: Yellowedge Grouper, Silk Snapper, Misty Grouper, Queen Snapper, Black Snapper, Blackfin Snapper, Bigeye Snapper, and Blackbelly Rosefish. Effective effort for Blueline Tilefish was defined as trips that caught Blueline Tilefish or at least one of these deepwater species.

Model Description

Response and explanatory variables

CPUE – catch per unit effort (CPUE) has units of fish/angler-hour and was calculated as the number of Blueline Tilefish caught divided by the number of anglers times the number of trip hours.

Year **–** Because year is the explanatory variable of interest, it was necessarily included in the analysis. Years included in this analysis were 1980–2005.

Season — All months were pooled due to small sample sizes.

Area – Data were pooled into two regions, North Carolina to Cape Canaveral (“northern region”) and Cape Canaveral to Florida Keys (“southern region”).

Trip Type – Half day, ¾ day, full day, and multi-day trips were pooled for analysis due to small sample sizes.

Party – Two categories for the party size (number of anglers per boat) were considered in the standardization process. The categories were ≤30 anglers and >30 anglers.

Standardization

CPUE was modeled using the delta-GLM approach (Lo *et al*. 1992; Dick 2004; Maunder and Punt 2004). This approach combines two separate generalized linear models (GLMs), one to describe presence/absence of the focal species and one to describe catch rates of trips that caught Blueline Tilefish. Fits of lognormal and gamma models were compared using AIC. Predictor variables that explained variation in Blueline Tilefish abundance were chosen based on a backwards stepwise selection algorithm using stepwise AIC to eliminate those that did not improve model fit (Venables and Ripley 1997). All predictor variables were modeled as factors rather than continuous variables. All analyses were performed in the R programming language (R Development Core Team 2012), with much of the code adapted from Dick (2004).

5.4.1.2 Sampling Intensity

The annual numbers of trips used to compute the index are shown in Table 5.4.

5.4.1.3 Size/Age Data

The sizes/ages represented in this index should be the same as those of landings from the corresponding fleet (See section 4 of the DW report).

5.4.1.4 Catch Rates

Standardized catch rates and associated uncertainty are shown in Figure 5.2 and are tabulated in Table 5.4. The units on catch rates were number of fish landed per angler-hour.

5.4.1.5 Uncertainty and Measures of Precision

Estimates of variance were based on 1,000 bootstrap runs where trips were chosen randomly with replacement (Efron and Tibshirani 1994). Annual CVs of catch rates are tabulated in Table 5.4 and applied to the estimated index to develop error estimates.

5.4.1.6 Additional Indices from the Headboat Survey

The SRHS index that combined data from the South Atlantic and GOM was computed from 1986-2005 because the SRHS did not begin in the GOM until 1986. An additional level of the area factor (GOM) was included in the standardization. Annual sample sizes, nominal CPUE and standardized CPUE for the combined South Atlantic and GOM index are shown Table 5.5 and Figure 5.3. The northern regional index (north of Cape Canaveral) was computed from 1973-2005 because the SRHS started earlier in this region than in the rest of the South Atlantic. The southern regional index (south of Cape Canaveral) was computed from 1980-2005 similar to that for the South Atlantic only. The GOM index was computed from 1986-2005, again because the SRHS in the GOM began in 1986. No area factor was included in the standardization of these three region indices; otherwise the standardization process was the same as that described above for the South Atlantic. CVs could not be computed for the three regional indices due to the low number of observations of Blueline Tilefish. Annual sample sizes, nominal CPUE and standardized CPUE for the three regional indices are shown in Tables 5.6-5.8 and Figures 5.4-5.6.

5.4.1.7 Comments on Adequacy for Assessment

The index of abundance created from the headboat data was considered by the IWG to be adequate for use in the assessment. The data cover a wide geographic range relative to most of the stock, and logbooks represent a census of the headboats. For the duration of the index, sampling was consistent over time, and some of the data were verified by port samplers and observers. Furthermore, the index spans a long time period (1980–2005) compared to other indices and is the only index that covers the 1980s.

The two primary caveats concerning this index are that sample sizes are small relative to other species caught by headboats, and that the index was derived from fishery-dependent data. Headboat effort generally targets snapper-grouper species and not necessarily the focal species, which should minimize changes in catchability relative to fishery dependent indices that target more effectively. The index was truncated in 2005 due to increased targeting of Blueline Tilefish and other deepwater species near this time. In addition, defining effective effort for Blueline Tilefish was difficult because information on depth fished or the proportion of a trip spent in different habitats was not available. Therefore, effective effort was defined based on other deepwater species that were caught. The regional indices show high annual variability, most likely due to the limited samples available at these smaller spatial scales, and no estimates of uncertainty (CVs) could be computed.

5.4.2 Commercial Handline Index

Landings and fishing effort of commercial vessels operating in the southeast U.S. Atlantic have been monitored by the NMFS Southeast Fisheries Science Center through the Coastal Fisheries Logbook Program (CFLP). The program collects information about each fishing trip from all vessels holding federal permits to fish in waters managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. Initiated in the Gulf in 1990, the CFLP began collecting logbooks from Atlantic commercial fishers in 1992, when 20% of Florida vessels were targeted. Beginning in 1993, sampling in Florida was increased to require reports from all vessels permitted in coastal fisheries, and since then has maintained the objective of a complete census of federally permitted vessels in the southeast U.S.

Catch per unit effort (CPUE) from the logbooks was used to develop an index of abundance for Blueline Tilefish landed with vertical lines (manual handline and electric reel). The time series used for construction of the index spanned 1993–2007. The start year (1993) was based on when vessels with federal snapper-grouper permits were required to submit logbooks on each fishing trip. The IWG recommended excluding years after 2007 because recent fishing trends and changes in regulations called into question the relationship between CPUE and abundance after this time. North of Cape Hatteras, NC, Blueline Tilefish have increasingly and effectively been targeted by commercial fishermen in recent years. South of Cape Canaveral FL, Blueline Tilefish are more typically a bycatch of snowy grouper trips, and regulations on snowy grouper since the mid-2000s have likely de-coupled Blueline Tilefish CPUE and abundance. In addition, a deepwater closure (≥240 ft) in 2011 and several years where the fishery was closed due to accountability measures precluded the inclusion of later years in the abundance index for this stock.

The IWG discussed inclusion of handline data from commercial VTRs for areas north of North Carolina. Handline data was extremely limited north of North Carolina and only available for the most recent ten years, a time period when increased targeting of Blueline Tilefish was occurring and regulations were also changing. There were also questions on gear type with some vessels being defined as both longline and handline vessels. Therefore, these data were excluded from index development so that the northern limit of the headboat index is the Virginia/North Carolina border.

5.4.2.1 Methods of Estimation

Data Treatment

For each fishing trip, the CFLP database included a unique trip identifier, the landing date, fishing gear deployed, areas fished, number of days at sea, number of crew, gear-specific fishing effort, species caught, and weight of the landings. Fishing effort data available for vertical line gear included number of lines fished, hours fished, and number of hooks per line.

Data were restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip. Reporting delays beyond 45 days likely resulted in less reliable effort data (landings data may be reliable even with lengthy reporting delays if trip ticket reports were referenced by the reporting fisher). Also excluded were records reporting multiple areas or gears fished, which prevents designating catch and effort to specific locations or gears. Therefore, only those trips that reported one area and one gear fished were included in the analyses.

Clear outliers (>99.5 percentile) in the data were also excluded from the analyses. These outliers were identified for manual handlines as records reporting more than 20 lines fished, 15 hooks per line fished, 16 days at sea, or 4 crew members, and they were identified for electric reels as records reporting more than 7 lines fished, 13 hooks per line fished, 16 days at sea, or 6 crew members. Records with greater than 4.07 pounds/hook-hr were excluded.

Subsetting of trips was initially attempted by applying the Stephens and MacCall method, with the intent to apply a delta-GLM for standardization. However, the Stephens and MacCall method removed many positive trips from an already relatively low sample size. Thus, the IWG recommended against using Stephens and MacCall, and instead recommended using the trips that caught at least one of the species in the deepwater complex as the measure of effective effort for Blueline Tilefish. These species were the same as those used for the headboat index (section 5.4.1) and included: Yellowedge Grouper, Silk Snapper, Misty Grouper, Queen Snapper, Black Snapper, Blackfin Snapper, Bigeye Snapper, and Blackbelly Rosefish.

Standardization

The response variable, CPUE, was calculated for each trip as,

CPUE = pounds of Blueline Tilefish/hook-hour

where hook-hours is the product of number of lines fished, number of hooks per line, and total hours fished. All explanatory variables were categorical and are described below. All analyses were programmed in R (R Development Core Team 2012), with much of the code adapted from Dick (2004).

The explanatory variables considered were year, season, area, crew size, and days at sea, each described below:

Year — Year was necessarily included, as standardized catch rates by year are the desired outcome. Years modeled were 1993–2007.

Season — Four seasons were considered in the model with the months pooled as Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Nov.

Area — Areas reported in the logbook (Figure 5.7) were pooled into the broader geographic levels: Cape Canaveral north to NC, and Cape Canaveral south to FL Keys.

Crew size — Crew size (crew) was pooled into two levels: one or two, and three or more.

Days at sea — Days at sea (sea days) were pooled into three levels: one or two days, three to four days, and five or more days.

Proportion of deepwater species – Two categories for proportion of deepwater species were considered in the standardization process. The categories were ≤ 50% and > 50%.

CPUE was modeled using the delta-GLM approach (Lo *et al*. 1992; Dick 2004; Maunder and Punt 2004). The Bernoulli component of the delta-GLM is a logistic regression model of the probability of catching or not catching Blueline Tilefish on any given trip. For the positive CPUE submodel, two parametric distributions, the lognormal and the gamma, were considered. The two distributions, each with their best set of explanatory variables, were compared using AIC. For both submodels, all explanatory variables were initially included as main effects, and then stepwise AIC with a backwards selection algorithm was used to eliminate those variables that did not improve model fit (Venables and Ripley 1997).

5.4.2.2 Sampling Intensity

The annual numbers of trips used to compute the index was between 400 and 1383, as shown in Table 5.9.

5.4.2.3 Size/Age Data

The sizes/ages represented in this index should be the same as those of landings from the corresponding fleet (See section 3 of the DW report).

5.4.2.4 Catch Rates

Standardized catch rates and associated error bars are shown in Figure 5.8 and are tabulated in Table 5.9. The units on catch rates were pounds of fish landed per hook-hour.

5.4.2.5 Uncertainty and Measures of Precision

Estimates of variance were based on 1,000 bootstrap runs where trips were chosen randomly with replacement (Efron and Tibshirani 1994). Annual CVs of catch rates are tabulated in Table 5.9 and applied to the estimated index to develop error estimates.

5.4.2.6 Additional Indices from the Commercial Handline Data

The handline index that combined data from the South Atlantic and GOM was computed from 1993-2007, the same period as for the South Atlantic only index. This time period encompassed years where the coastal logbook program had adequate spatial coverage but prior to changes in targeting and regulatory effects. An additional level of the area factor (GOM) was included in the standardization. Annual sample sizes, nominal CPUE and standardized CPUE for combined South Atlantic and Gulf of Mexico index are shown in Table 5.10 and Figure 5.9. The northern regional (north of Cape Canaveral) and southern regional (south of Cape Canaveral to the Florida Keys) indices were also computed from 1993-2007. The regional GOM index was computed from 1993-2009. The terminal year of 2009 was chosen for the GOM index because major changes in targeting were associated with the development of an individual fishing quota (IFQ) management system beginning in 2010. No area factor was included in the standardization of the region indices; otherwise the standardization process was the same as that described above for the South Atlantic. Annual sample sizes, nominal CPUE and standardized CPUE for the regional indices are shown in Tables 5.11-5.13 and Figures 5.10-5.12.

5.4.2.7 Comments on Adequacy for Assessment

The index of abundance created from the commercial handline data was considered by the IWG to be adequate for use in the assessment. The data cover a wide geographic range relative to that of the stock, and logbooks represent a census of the fleet. The data set has an adequate sample size and a long enough time series to provide potentially meaningful information for the assessment.

The primary caveat concerning this index was that it was derived from fishery-dependent data. Fishery-dependent effects on CPUE appeared most pronounced north of Cape Hatteras, where fishermen have increasingly targeted Blueline Tilefish in recent years, and south of Cape Canaveral, where regulations on Snowy Grouper have likely de-coupled Blueline Tilefish CPUE from abundance. These effects were addressed by truncating the index in 2007 prior to when major changes in targeting are thought to have occurred. In addition, defining effective effort for Blueline Tilefish was difficult because information on depth fished or the proportion of a trip spent in different habitats was not available. Therefore, effective effort was defined based on other deepwater species that were caught.

5.4.3 Commercial Longline Index

Landings and fishing effort of commercial vessels operating in the southeast U.S. Atlantic have been monitored by the NMFS Southeast Fisheries Science Center through the Coastal Fisheries Logbook Program (CFLP). The program collects information about each fishing trip from all vessels holding federal permits to fish in waters managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. Initiated in the Gulf in 1990, the CFLP began collecting logbooks from Atlantic commercial fishers in 1992, when 20% of Florida vessels were targeted. Beginning in 1993, sampling in Florida was increased to require reports from all vessels permitted in coastal fisheries, and since then has maintained the objective of a complete census of federally permitted vessels in the southeast U.S.

Catch per unit effort (CPUE) from the logbooks was used to develop an index of abundance for Blueline Tilefish landed with longlines. The time series used for construction of the index spanned 1993–2006, when all vessels with federal snapper-grouper permits were required to submit logbooks on each fishing trip. The years after 2006 were excluded because of a shift in effort to almost entirely north of Cape Hatteras, NC, where Blueline Tilefish can be more effectively targeted by this gear. Additionally, the 2011 deep-water closure ($\geq$240 ft) and several subsequent years where the ACL was met and the fishery closed prevented inclusion of these later data for an abundance index of this stock.

Similar to the CFLP handline data, The IWG discussed inclusion of longline data from commercial VTRs for areas north of North Carolina. Longline data were limited north of North Carolina and only available for the most recent ten years, a time period when increased targeting of Blueline Tilefish was occurring and regulations were also changing. There were also questions about whether these trips represented directed effort for Golden Tilefish rather than Blueline Tilefish, which occupy different habitats. There was also uncertainty about gear type, with some vessels being defined as both longline and handline vessels. Give these problems and the limited amount of data, longline records from the commercial VTR data were excluded from index development.

5.4.3.1 Methods of Estimation

Data Treatment

For each fishing trip, the CFLP database included a unique trip identifier, the landing date, fishing gear deployed, areas fished, number of days at sea, number of crew, gear-specific fishing effort, species caught, and weight of the landings. Fishing effort data available for longline gear included number of lines fished and number of hooks per line. The number of trips reporting Blueline Tilefish dropped after 2004 in areas south of Cape Hatteras, and increased substantially in approximately 2006 north of Cape Hatteras. Because of the drop in sample size and shift in effort, the index used a terminal year of 2006.

Data were restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip. Reporting delays beyond 45 days likely resulted in less reliable effort data (landings data may be reliable even with lengthy reporting delays if trip ticket reports were referenced by the reporting fisher). Also excluded were records reporting multiple areas or gears fished, which prevents designating catch and effort to specific locations or gears. Therefore, only those trips that reported one area and one gear fished were included in the analyses.

Clear outliers (>99.5 percentile) in the data were also excluded from the analyses. These outliers were identified for commercial longline as records reporting more than 40 lines fished, 4000 hooks per line fished, 16 days at sea, or 7 crew members. Trips with greater than 0.8 pounds/hook were excluded.

Subsetting of trips was initially attempted by applying the Stephens and MacCall method, with the intent to apply a delta-GLM for standardization. However, the Stephens and MacCall method removed many positive trips from an already relatively low sample size. Thus, the IWG recommended against using Stephens and MacCall, and instead recommended standardizing trips that caught any one of a complex of deepwater species (Yellowedge Grouper, Silk Snapper, Misty Grouper, Queen Snapper, Black Snapper, Blackfin Snapper, Bigeye Snapper, and

Blackbelly Rosefish), similar to the commercial handline (Section **5.4.2**) and recreational headboat (Section **5.4.1**) indices.

Standardization
The response variable, CPUE, was calculated for each trip as,

CPUE = pounds of Blueline Tilefish/hook

where hook is the product of number of lines fished and number of hooks per line. Explanatory variables, all categorical, are described below. All analyses were programmed in R (R Development Core Team 2012), with much of the code adapted from Dick (2004).

The explanatory variables considered were year, season, region, crew size, days at sea, and proportion of deepwater species caught each described below:

Year — Year was necessarily included, as standardized catch rates by year are the desired outcome. Years modeled were 1993–2006.

Season — Four seasons were considered in the model with the months pooled as Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Nov.

Region — Areas reported in the logbook (Figure 5.7) were pooled into three geographic regions: Cape Hatteras NC to Cape Fear NC, Cape Fear NC to Cape Canaveral, and Cape Canaveral south to the FL Keys.

Crew size — Crew size (crew) was pooled into two levels: one or two, and three or more.

Days at sea — Days at sea (sea days) were pooled into four levels: one to three days, four to six days, seven to nine days, and ten or more days.

Proportion of deepwater species – Two categories for proportion of deepwater species were considered in the standardization process. The categories were ≤ 50% and > 50% anglers.

CPUE was modeled using the delta-GLM approach (Lo *et al*. 1992; Dick 2004; Maunder and Punt 2004). The Bernoulli component of the delta-GLM is a logistic regression model of the probability of catching or not catching Blueline Tilefish on any given trip. For the positive CPUE submodel, two parametric distributions, the lognormal and the gamma, were considered. The two distributions, each with their best set of explanatory variables, were compared using AIC. For both submodels, all explanatory variables were initially included as main effects, and then stepwise AIC with a backwards selection algorithm was used to eliminate those variables that did not improve model fit (Venables and Ripley 1997).

5.4.3.2 Sampling Intensity

The annual numbers of trips used to compute the index is typically between 52 and 272, as shown in Table 5.14.

5.4.3.3 Size/Age Data

The sizes/ages represented in this index should be the same as those of landings from the corresponding fleet (See section 3 of the DW report).

5.4.3.4 Catch Rates

Standardized catch rates and associated error bars are shown in Figure 5.13 and are tabulated in Table 5.14. The units on catch rates were pounds of fish landed per hook-hour.

5.4.3.5 Uncertainty and Measures of Precision

Estimates of variance were based on 1000 bootstrap runs where trips each year were chosen randomly with replacement from that year's samples, and sample size each year was maintained at the level of the original data set (Efron and Tibshirani 1994). Annual CVs of catch rates are tabulated in Table 5.14 and applied to the estimated index to develop error estimates.

5.4.3.6 Additional Indices from the Commercial Longline Data

The longline index that combined data from the South Atlantic and GOM was computed from 1993-2006, the same period as for the South Atlantic only index. This time period encompasses years where the CFLP had adequate spatial coverage but prior to changes in targeting and regulatory effects. An additional level of the area factor (GOM) was included in the standardization. Annual sample sizes, nominal CPUE and standardized CPUE for combined South Atlantic and Gulf of Mexico index are shown in Table 5.15 and Figure 5.14. The northern regional (north of Cape Canaveral) and southern regional (south of Cape Canaveral to the Florida Keys) indices were also computed from 1993-2006. The regional GOM index was computed from 1993-2008. The terminal year of 2008 was chosen for the GOM index because major changes in targeting were associated with the development of an individual fishing quota (IFQ) management system beginning in 2010. No area factor was included in the standardization of the region indices; otherwise the standardization process was the same as that described above for the South Atlantic. CVs on the "southern" regional index (Cape Canaveral to FL Keys) could not be computed due to the low number of observations of Blueline Tilefish. Annual sample sizes, nominal CPUE and standardized CPUE for the regional indices are shown in Tables 5.16-5.18 and Figures 5.15-5.17.

5.4.3.7 Comments on Adequacy for Assessment

The index of abundance created from the commercial longline data was considered by the IWG to be adequate for use in the assessment. The data cover a wide geographic range relative to that of the stock, and logbooks represent a census of the fleet.

The primary caveat concerning this index was that it was derived from fishery-dependent data. Fishery-dependent effects were potentially minimized by truncating the index in 2006 prior to major shifts in longline fishing effort, mostly to north of Cape Hatteras. Additional caveats are that the data set has a relative small sample size and that the computation of effort for longline data has coarse resolution (does not include trip duration). As for the other indices, the effective effort for Blueline Tilefish was defined based on other deepwater species that were caught.

5.5 Consensus Recommendations and Survey Evaluations

The DW recommended the three fishery-dependent indices (recreational headboat (SRHS), commercial handline, and commercial longline) for potential use in the Blueline Tilefish stock assessment. All recommended indices and their CVs are tabulated in Table 5.19-5.23 for each of the five geographic scales (South Atlantic only, combined South Atlantic and GOM, North of Cape Canaveral, South of Cape Canaveral, GOM only). The indices are compared graphically in Figure 5.18-5.22 and a correlation matrix among the indices is shown in Figure 5.23.
The IWG discussed relative ranking of the ability of each index to represent true population abundance. Based on these discussions, there was no clear consensus on ranking of the indices. All three indices are fishery-dependent and have relatively low sample sizes. All three indices suffer from a similar problem of defining effective effort for index construction. A bulleted list of discussion points for each index is listed below (drawn mostly from Table 5.2). Index rankings are of limited utility when based solely on *a priori* information about each index. The assessment panel, with all data in hand, will be in a better position to judge the indices for use in the assessment.

1. Headboat index
    - Fishery-dependent
    - Operates in a manner more similar to fishery-independent data collection because the fishery targets the snapper-grouper complex in general rather than the focal species specifically
    - Small sample sizes relative to other species in the SRHS data set; most samples from SC and FL
    - Primarily samples shoreward extent of depth range
2. Commercial handline index
    - Fishery-dependent
    - Commercial fishermen more skillful than general recreational fishermen at targeting focal species
3. Commercial longline index

- Fishery-dependent
- Commercial fishermen more skillful than general recreational fishermen at targeting focal species
- Effort only to level of trip or hook, does not include trip duration
- Effort limited to 50+ fathoms (excludes some blueline habitat)

5.6 Research Recommendations

The IWG discussed future research recommendations for Blueline Tilefish. The unanimous consensus was that a coastwide fishery-independent survey is needed for Blueline Tilefish. In the absence of a fishery-independent index, additional information on the targeting behavior of fishermen, in particular the depth or geographic locations fished within a given trip as well as more refined information on fishing effort is needed.

5.7 Data Best Practices Input & Suggestions

The IWG addressed existing data best practices in the following manner:

1. Issue 1: Index Report Card Revision / Removal
   Following the data best practices guidance, no index report cards were generated.
2. Issue 2: Convert Index to Weight for Surplus Production Model
   Both handline and longline commercial indices are being computed in weight units. The headboat index cannot easily be computed in weight units due to very low sample sizes, leaving just a straight re-scaling of the index from numbers to weight, which in a stock assessment will be absorbed by the catchability (q) parameter.
3. Issue 3: Common Criteria for Inclusion and Ranking of Indices
   The ICCAT 2012 flowchart was not used, but instead a similar index vetting process was applied during IWG discussions. Potential indices were evaluated based on similar/identical criteria as found in the ICCAT 2012 flowchart.
4. Issue 4: Fishery-Dependent Index Development
   Best practices were followed in the development of fishery-dependent indices, which included accounting for regulatory effects on catchability and applying recommended approaches for standardizing CPUE indices.
5. Issue 5: Timing (process)
   Management histories were complete and provided on time. Commercial logbook data (for the handline and longline indices) were received late (January 4, 2017; 2.5 weeks before the data workshop). This delay was related to the delay in identifying the unit stock (). Data best practices states that the stock be defined 22 weeks prior to the Data Workshop. For SEDAR 50, the stock boundary was defined approximately eight weeks prior to the data workshop
6. Issue 6: Working Papers (process and content)
   Following best practices, working papers for each recommended index of abundance were submitted.

7. Issue 7: Data Workshop Report Chapters
   The data workshop report contains more text than recommended primarily due to having not seen the final working papers because the two have the same due date. The due date for the final working papers and the workshop report should be staggered.
8. Issue 8: Procedural Expectations
   In general the procedures for obtaining, analyzing, and reporting the indices of abundance were followed according to best practices once the data were received.

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5.9 Tables

Table 5.1. Table of the data sources considered for indices of abundance. **Area** and **Years** designations are for the South Atlantic only index and differ slightly for the combined South Atlantic/Gulf and regional indices (see text for details).

Fishery Type	Data Source	Area	Years	Units	Standardization Method	Issues	Use?
Recreational	Headboat	NC-FL	1980-2005	num kept/ angler-hour	GLM	Fishery dependent, self reported	Yes
Commercial	Commercial Logbook Handline	NC-FL	1993-2007	lb kept/ hook-hour	GLM	Fishery dependent, self reported	Yes
Commercial	Commercial Logbook Longline	NC-FL	1993-2006	lb kept/ hook	GLM	Fishery dependent, self reported, effort unit to level of trip	Yes
Independent	MARMAP/ SERFS: chevron traps	SC	1990-2015			Few samples (0-11 fish per yr, typically 1 or 2	No
Independent	MARMAP/ SERFS: Video survey	NC-FL	2010-2015			Few samples	No
Independent	MARMAP: short bottom longline	SC	1996-2015			Few samples (0-12 fish per yr), small geographic coverage	No
Independent	NMFS bottom longline	NC-FL	1995-2015			Only one blueline observed in South Atlantic	No
Independent	NEFSC bottom	ME-Hatteras	1982-			Few blueline observed	No

	trawl		2015				
Recreational	MRFSS	ME-FL	1982-2015			Few samples (several years with no blueline). Fishery dependent.	No
Recreational	Headboat-at-sea-observer	NC-FL	2004-2015			Few blueline observed	No
Recreational	SCDNR Charterboat logbook	SC	1993-2015			No blueline observed	No
Commercial	NEFOP	ME-Cape Hatteras	2007-2015			Few blueline observed	No

Table 5.2. Table of the pros and cons for each data set recommended for use at the data workshop. Note that several data sources were considered (Table 5.1), but discarded, prior to the DW.

<u>Fishery independent index</u>
None

<u>Fishery dependent indices</u>
Recreational Headboat (SRHS) (*Recommended for use*)
Pros:
- Complete census
- Spans the management area
- Some data are verified by port samplers and observers
- Covers the 1980s when no other indices are available
- Mostly non-targeted for focal species, which should minimize changes in catchability relative to fishery dependent indices that target specific species

Cons:
- Fishery dependent
- Small sample size relative to other species in SRHS data set
- Mostly SC and FL
- No information on discard rates
- Catchability may vary over time or with abundance
- Standardization based only on trips successful for a pre-defined set of deepwater species

Commercial Logbook – Handline (*Recommended for use*)
Pros:
- Complete census
- Covers nearly the entire management area
- Large sample size relative to other Blueline Tilefish indices

Cons:
- Fishery dependent
- Data are self-reported and largely unverified
- Catchability may vary over time or with abundance
- Potential shifts in species targeted; commercial fishermen more skillful than general recreational fishermen at targeting focal species
- Standardization based only on trips successful for a pre-defined set of deepwater species

Commercial Logbook – Longline
Pros:
- Complete census

- Covers nearly the entire management area

Cons:

- Fishery-dependent
- Data are self-reported and largely unverified
- Catchability may vary over time or with abundance
- Effort only to level of trip or hook, does not include trip duration
- Effort limited to 50+ fathoms (excludes some Blueline Tilefish habitat)
- Potential shifts in species targeted; commercial fishermen more skillful than general recreational fishermen at targeting focal species
- Standardization based only on trips successful for a pre-defined set of deepwater species

Table 5.3. Sampling effort and nominal catch rates for Blueline Tilefish from the SERFS chevron trap and video survey. The sampling effort and geographic extent of the chevron trap survey expanded in 2010.

		Trap Survey		Video Survey		
Year	No. Traps	No. Pos. Traps	No. Fish	No. Traps	No. Pos. Traps	Mean of SumCount
1990	5	2	2			
1991	3	1	1			
1992	0	0	0			
1993	4	0	0			
1994	8	2	2			
1995	0	0	0			
1996	20	2	5			
1997	28	0	0			
1998	26	1	1			
1999	4	0	0			
2000	9	1	1			
2001	14	2	4			
2002	12	1	2			
2003	6	2	3			
2004	35	2	3			
2005	16	0	0			
2006	21	2	2			
2007	24	3	5			
2008	10	0	0			
2009	28	1	1			
2010	41	1	1	2	0	0
2011	45	7	11	47	7	5.85
2012	92	17	32	98	8	3.5
2013	74	9	13	70	9	4.78
2014	88	17	30	81	12	6.17
2015	114	5	12	76	5	12.4

Table 5.4. The relative nominal CPUE, number of trips (N), standardized index, and CV for Blueline Tilefish from headboat (SRHS) logbook data from the South Atlantic only.

Year	N	Relative nominal	Standardized CPUE	CV
1980	1342	1.182	1.804	0.123
1981	1438	0.274	0.503	0.176
1982	1660	0.239	0.543	0.143
1983	1788	0.284	0.690	0.131
1984	1444	0.068	0.156	0.202
1985	1743	0.089	0.183	0.172
1986	877	0.813	0.971	0.221
1987	955	0.962	0.995	0.255
1988	664	1.857	1.723	0.273
1989	1145	0.223	0.234	0.199
1990	1248	0.057	0.112	0.195
1991	599	1.751	1.709	0.268
1992	935	1.096	0.953	0.246
1993	828	1.445	1.316	0.219
1994	641	0.925	1.309	0.260
1995	381	1.310	1.144	0.327
1996	225	2.268	1.461	0.464
1997	320	1.523	1.654	0.278
1998	328	0.931	0.778	0.370
1999	199	1.075	0.881	0.458
2000	227	1.848	2.095	0.422
2001	214	0.956	0.815	0.428
2002	192	1.679	1.083	0.436
2003	188	1.479	1.340	0.488
2004	225	1.012	0.902	0.379
2005	206	0.654	0.647	0.395

Table 5.5. The relative nominal CPUE, number of trips (N), standardized index, and CV for Blueline Tilefish from the headboat (SRHS) logbook data from combined South Atlantic and Gulf of Mexico data.

Year	N	Relative nominal	Standardized CPUE	CV
1986	1026	0.776	0.744	0.220
1987	1078	0.955	0.854	0.235
1988	908	1.537	1.244	0.210
1989	1568	0.259	0.469	0.154
1990	1783	0.200	0.389	0.160
1991	1016	1.268	1.101	0.211
1992	1406	0.854	0.802	0.181
1993	1391	1.095	0.970	0.165
1994	1127	0.633	0.995	0.189
1995	688	0.841	0.808	0.255
1996	475	1.610	1.057	0.356
1997	593	1.063	1.321	0.250
1998	517	0.743	0.794	0.300
1999	277	1.909	1.471	0.463
2000	337	1.415	1.816	0.350
2001	297	0.778	0.820	0.318
2002	254	1.415	0.995	0.381
2003	270	1.237	1.500	0.394
2004	333	0.784	0.983	0.289
2005	320	0.627	0.867	0.328

Table 5.6. The relative nominal CPUE, number of trips (N), standardized index, and CV for Blueline Tilefish from the headboat (SRHS) logbook data from north of Cape Canaveral. CVs could not be computed due to low number of Blueline Tilefish observed.

Year	N	Relative nominal	Standardized CPUE	CV
1973	414	0.637	1.154	-
1974	503	1.386	1.410	-
1975	448	1.006	1.390	-
1976	501	1.559	2.297	-
1977	404	0.850	0.696	-
1978	488	0.773	0.896	-
1979	462	0.231	0.347	-
1980	456	2.125	2.522	-
1981	445	0.722	0.994	-
1982	608	0.766	0.984	-
1983	608	0.860	1.315	-
1984	516	0.184	0.271	-
1985	575	0.298	0.335	-
1986	180	1.701	1.113	-
1987	226	0.917	0.467	-
1988	167	0.539	0.628	-
1989	293	0.116	0.250	-
1990	296	0.103	0.147	-
1991	118	0.436	0.722	-
1992	224	0.840	0.564	-
1993	215	0.643	0.626	-
1994	203	2.139	1.577	-
1995	93	0.306	0.279	-
1996	83	2.288	1.648	-
1997	132	1.724	1.690	-
1998	136	0.286	0.374	-
1999	97	0.491	0.799	-
2000	99	0.986	1.034	-
2001	101	1.946	1.332	-
2002	99	0.526	0.320	-
2003	112	2.575	2.295	-
2004	132	1.878	1.730	-
2005	113	1.161	0.795	-

Table 5.7. The relative nominal CPUE, number of trips (N), standardized index, and CV for Blueline Tilefish from the headboat (SRHS) logbook data from south of Cape Canaveral to Florida Keys. CVs could not be computed due to low number of Blueline Tilefish observed.

Year	N	Nominal CPUE	Relative nominal	Standardized CPUE	CV
1980	886	0.013	0.852	0.979	-
1981	993	0.002	0.125	0.189	-
1982	1053	0.000	0.012	0.030	-
1983	1180	0.001	0.063	0.124	-
1984	928	0.000	0.021	0.046	-
1985	1167	0.000	0.011	0.037	-
1986	697	0.010	0.633	0.677	-
1987	729	0.015	0.984	0.997	-
1988	497	0.034	2.234	1.832	-
1989	852	0.004	0.255	0.182	-
1990	951	0.001	0.046	0.076	-
1991	479	0.030	2.011	1.663	-
1992	711	0.018	1.172	0.982	-
1993	612	0.026	1.695	1.395	-
1994	437	0.007	0.495	0.698	-
1995	287	0.024	1.587	1.531	-
1996	142	0.036	2.387	1.381	-
1997	188	0.023	1.529	1.698	-
1998	190	0.021	1.379	1.127	-
1999	102	0.025	1.640	1.106	-
2000	126	0.039	2.579	3.894	-
2001	113	0.005	0.362	0.543	-
2002	93	0.043	2.878	3.175	-
2003	75	0.008	0.519	0.609	-
2004	91	0.004	0.249	0.618	-
2005	91	0.004	0.281	0.410	-

Table 5.8. The relative nominal CPUE, number of trips (N), standardized index, and CV for Blueline Tilefish from the headboat (SRHS) logbook data from the Gulf of Mexico. CVs could not be computed due to low number of Blueline Tilefish observed. No index value is calculated for 1987 because there were two or less positive reports of Blueline Tilefish in the SRHS logbook data from the Gulf of Mexico.

Year	N	Relative nominal	Standardized CPUE	CV
1986	149	0.163	0.508	-
1987	-	-	-	-
1988	241	0.375	0.917	-
1989	423	1.061	1.721	-
1990	536	1.901	1.640	-
1991	417	1.075	0.925	-
1992	472	0.474	0.955	-
1993	562	1.259	0.886	-
1994	484	0.387	0.676	-
1995	306	0.286	0.598	-
1996	245	0.361	0.624	-
1997	272	1.188	0.768	-
1998	188	0.864	1.233	-
1999	72	5.982	2.376	-
2000	109	0.349	1.084	-
2001	81	0.168	0.619	-
2002	62	0.066	0.225	-
2003	81	1.121	1.201	-
2004	103	0.284	0.773	-
2005	114	1.637	1.272	-

Table 5.9. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial handline data from the South Atlantic only.

Year	N	Relative nominal	Standardized CPUE	CV
1993	400	0.600	0.925	0.117
1994	840	0.560	0.783	0.087
1995	886	0.622	0.753	0.095
1996	1008	0.892	0.992	0.074
1997	1383	0.700	1.106	0.064
1998	1003	0.465	0.751	0.081
1999	1169	0.769	0.735	0.070
2000	1081	1.085	0.819	0.073
2001	1120	1.056	1.086	0.074
2002	1136	1.095	0.908	0.075
2003	929	1.251	0.946	0.084
2004	761	0.954	0.965	0.092
2005	768	1.034	1.089	0.095
2006	597	2.439	1.681	0.090
2007	886	1.477	1.460	0.081

Table 5.10. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial handline data from the combined South Atlantic and Gulf of Mexico data**.**

Year	N	Relative nominal	Standardized CPUE	CV
1993	562	0.385	0.942	0.114
1994	1019	0.541	0.887	0.089
1995	1122	0.577	0.737	0.092
1996	1152	0.921	0.966	0.072
1997	1634	0.841	1.156	0.066
1998	1262	0.529	0.766	0.081
1999	1409	0.806	0.740	0.075
2000	1257	0.960	0.754	0.077
2001	1380	1.327	1.112	0.075
2002	1343	1.213	0.880	0.075
2003	1142	1.325	0.927	0.078
2004	954	0.980	0.927	0.086
2005	941	1.266	1.187	0.084
2006	846	1.900	1.597	0.079
2007	1061	1.428	1.422	0.077

Table 5.11. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial handline data from north of Cape Canaveral**.**

Year	N	Relative nominal	Standardized CPUE	CV
1993	214	0.575	1.067	0.167
1994	420	0.544	0.748	0.130
1995	436	0.576	0.662	0.156
1996	532	0.876	0.629	0.112
1997	633	0.529	0.796	0.111
1998	459	0.303	0.534	0.130
1999	513	0.651	0.616	0.127
2000	383	0.913	0.921	0.135
2001	481	1.036	1.162	0.116
2002	436	1.061	0.885	0.122
2003	346	1.263	0.826	0.129
2004	287	0.869	1.119	0.134
2005	314	1.174	1.330	0.122
2006	288	2.929	1.655	0.124
2007	358	1.701	2.049	0.095

Table 5.12. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial handline data from South of Cape Canaveral to Florida Keys**.**

Year	N	Relative nominal	Standardized CPUE	CV
1993	185	0.787	0.835	0.161
1994	419	0.737	0.779	0.116
1995	447	0.812	0.863	0.128
1996	474	1.387	1.504	0.084
1997	750	1.282	1.507	0.074
1998	544	0.849	1.017	0.098
1999	656	1.069	0.913	0.092
2000	697	1.078	0.883	0.088
2001	638	1.098	1.056	0.089
2002	700	1.025	0.966	0.089
2003	580	1.180	1.088	0.103
2004	473	1.035	0.887	0.113
2005	454	0.643	0.818	0.126
2006	308	1.149	1.145	0.132
2007	528	0.869	0.739	0.108

Table 5.13. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial handline data from Gulf of Mexico.

Year	N	Relative nominal	Standardized CPUE	CV
1993	157	0.424	0.801	0.248
1994	174	0.599	1.426	0.263
1995	233	0.232	0.565	0.231
1996	140	0.550	0.681	0.259
1997	248	1.120	1.353	0.211
1998	256	0.910	0.818	0.209
1999	235	0.915	0.799	0.240
2000	176	0.314	0.362	0.342
2001	260	1.872	1.152	0.241
2002	202	0.775	0.753	0.271
2003	211	0.927	0.790	0.212
2004	187	1.208	0.669	0.253
2005	172	2.023	1.629	0.211
2006	249	1.367	1.552	0.179
2007	175	1.654	1.093	0.194
2008	121	1.683	1.748	0.283
2009	164	0.428	0.809	0.299

Table 5.14. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial longline data from the South Atlantic only.

Year	N	Relative nominal	Standardized CPUE	CV
1993	189	0.787	1.388	0.270
1994	272	0.977	0.673	0.282
1995	187	0.836	1.354	0.333
1996	163	0.413	0.512	0.355
1997	143	1.231	1.064	0.257
1998	128	0.919	0.595	0.314
1999	141	0.529	0.796	0.294
2000	191	0.508	0.460	0.303
2001	157	0.600	0.566	0.304
2002	122	2.112	2.468	0.255
2003	86	0.538	0.903	0.292
2004	74	0.684	0.659	0.347
2005	52	1.143	1.431	0.330
2006	79	2.724	1.132	0.459

Table 5.15. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial longline data from the combined South Atlantic and Gulf of Mexico data.

Year	N	Relative nominal	Standardized CPUE	CV
1993	317	0.744	0.843	0.227
1994	485	1.034	0.756	0.161
1995	394	0.731	0.583	0.248
1996	331	0.413	0.441	0.262
1997	449	1.285	1.133	0.177
1998	436	0.733	0.641	0.193
1999	438	0.631	0.710	0.197
2000	496	0.797	0.849	0.196
2001	437	0.694	0.773	0.180
2002	343	1.714	1.702	0.174
2003	366	0.744	0.910	0.193
2004	353	1.375	1.269	0.210
2005	322	1.313	1.774	0.211
2006	341	1.790	1.616	0.205

Table 5.16. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial longline data north of Cape Canaveral.

Year	N	Relative nominal	Standardized CPUE	CV
1993	51	0.930	0.946	0.306
1994	90	1.025	0.835	0.268
1995	60	0.877	1.096	0.301
1996	51	0.426	0.376	0.372
1997	74	1.070	1.325	0.235
1998	54	0.912	0.807	0.299
1999	42	0.592	0.957	0.265
2000	68	0.494	0.461	0.259
2001	68	0.591	0.599	0.267
2002	63	2.112	1.887	0.236
2003	38	0.544	0.818	0.254
2004	49	0.600	0.836	0.325
2005	23	1.223	1.906	0.264
2006	49	2.606	1.149	0.402

Table 5.17. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial longline data south of Cape Canaveral to the Florida Keys. No index values were calculated for 2004 and 2006 because there were two or less positive reports of Blueline Tilefish in the SRHS logbook data south of Cape Canaveral to the Florida Keys.

Year	N	Relative nominal	Standardized CPUE	CV
1993	137	1.95	2.70	-
1994	182	1.24	0.68	-
1995	126	2.30	3.02	-
1996	112	0.75	1.30	-
1997	68	0.16	0.39	-
1998	74	0.01	0.02	-
1999	99	1.36	0.35	-
2000	122	1.31	0.49	-
2001	89	3.31	1.44	-
2002	59	0.35	1.11	-
2003	48	1.19	0.45	-
2004	25	0.03		-
2005	29	0.03	0.06	-
2006	30	0.01		-

Table 5.18. The number of trips (N), relative nominal CPUE, standardized index, and CV for Blueline Tilefish from commercial longline data from the Gulf of Mexico.

Year	N	Relative nominal	Standardized CPUE	CV
1993	129	0.481	0.307	0.403
1994	213	0.532	0.670	0.253
1995	207	0.371	0.245	0.380
1996	168	0.272	0.288	0.503
1997	305	1.106	0.973	0.276
1998	308	0.553	0.503	0.281
1999	297	0.596	0.568	0.308
2000	304	0.765	1.017	0.285
2001	279	0.572	0.684	0.278
2002	221	0.809	0.959	0.292
2003	280	0.738	0.756	0.262
2004	279	1.499	1.302	0.291
2005	271	1.355	1.444	0.286
2006	263	1.357	1.324	0.278
2007	233	1.875	1.364	0.335
2008	226	3.119	3.596	0.268

Table 5.19. Blueline Tilefish indices of abundance and annual CVs for the South Atlantic only recommended for potential use in the stock assessment. HB=headboats, cHL=commercial handline, and cLL=commercial longline. Each index is scaled to its mean.

	INDEX VALUE			CV		
Year	HB	cHL	cLL	HB_cv	cHL_cv	cLL_cv
1980	1.804			0.123		
1981	0.503			0.176		
1982	0.543			0.143		
1983	0.690			0.131		
1984	0.156			0.202		
1985	0.183			0.172		
1986	0.971			0.221		
1987	0.995			0.255		
1988	1.723			0.273		
1989	0.234			0.199		
1990	0.112			0.195		
1991	1.709			0.268		
1992	0.953			0.246		
1993	1.316	0.925	1.388	0.219	0.117	0.270
1994	1.309	0.783	0.673	0.260	0.087	0.282
1995	1.144	0.753	1.354	0.327	0.095	0.333
1996	1.461	0.992	0.512	0.464	0.074	0.355
1997	1.654	1.106	1.064	0.278	0.064	0.257
1998	0.778	0.751	0.595	0.370	0.081	0.314
1999	0.881	0.735	0.796	0.458	0.070	0.294
2000	2.095	0.819	0.460	0.422	0.073	0.303
2001	0.815	1.086	0.566	0.428	0.074	0.304
2002	1.083	0.908	2.468	0.436	0.075	0.255
2003	1.340	0.946	0.903	0.488	0.084	0.292
2004	0.902	0.965	0.659	0.379	0.092	0.347
2005	0.647	1.089	1.431	0.395	0.095	0.330
2006		1.681	1.132		0.090	0.459
2007		1.460			0.081	

Table 5.20. Blueline Tilefish indices of abundance and annual CVs for the combined South Atlantic and Gulf of Mexico recommended for potential use in the stock assessment. HB=headboats, cHL=commercial handline, and cLL=commercial longline. Each index is scaled to its mean.

	INDEX VALUE			CV		
Year	HB	cHL	cLL	HB_cv	cHL_cv	cLL_cv
1986	0.744			0.220		
1987	0.854			0.235		
1988	1.244			0.210		
1989	0.469			0.154		
1990	0.389			0.160		
1991	1.101			0.211		
1992	0.802			0.181		
1993	0.970	0.942	0.843	0.165	0.114	0.227
1994	0.995	0.887	0.756	0.189	0.089	0.161
1995	0.808	0.737	0.583	0.255	0.092	0.248
1996	1.057	0.966	0.441	0.356	0.072	0.262
1997	1.321	1.156	1.133	0.250	0.066	0.177
1998	0.794	0.766	0.641	0.300	0.081	0.193
1999	1.471	0.740	0.710	0.463	0.075	0.197
2000	1.816	0.754	0.849	0.350	0.077	0.196
2001	0.820	1.112	0.773	0.318	0.075	0.180
2002	0.995	0.880	1.702	0.381	0.075	0.174
2003	1.500	0.927	0.910	0.394	0.078	0.193
2004	0.983	0.927	1.269	0.289	0.086	0.210
2005	0.867	1.187	1.774	0.328	0.084	0.211
2006		1.597	1.616		0.079	0.205
2007		1.422			0.077	

Table 5.21. Blueline Tilefish indices of abundance and annual CVs for the northern region (Cape Canaveral to NC) recommended for potential use in the stock assessment. HB=headboats, cHL=commercial handline, and cLL=commercial longline. Each index is scaled to its mean.

	INDEX VALUE			CV		
Year	HB	cHL	cLL	HB_cv	cHL_cv	cLL_cv
1973	1.154			-		
1974	1.410			-		
1975	1.390			-		
1976	2.297			-		
1977	0.696			-		
1978	0.896			-		
1979	0.347			-		
1980	2.522			-		
1981	0.994			-		
1982	0.984			-		
1983	1.315			-		
1984	0.271			-		
1985	0.335			-		
1986	1.113			-		
1987	0.467			-		
1988	0.628			-		
1989	0.250			-		
1990	0.147			-		
1991	0.722			-		
1992	0.564			-		
1993	0.626	1.067	0.946	-	0.167	0.306
1994	1.577	0.748	0.835	-	0.130	0.268
1995	0.279	0.662	1.096	-	0.156	0.301
1996	1.648	0.629	0.376	-	0.112	0.372
1997	1.690	0.796	1.325	-	0.111	0.235
1998	0.374	0.534	0.807	-	0.130	0.299
1999	0.799	0.616	0.957	-	0.127	0.265
2000	1.034	0.921	0.461	-	0.135	0.259
2001	1.332	1.162	0.599	-	0.116	0.267
2002	0.320	0.885	1.887	-	0.122	0.236
2003	2.295	0.826	0.818	-	0.129	0.254
2004	1.730	1.119	0.836	-	0.134	0.325
2005	0.795	1.330	1.906	-	0.122	0.264
2006		1.655	1.149		0.124	0.402
2007		2.049			0.095	

Table 5.22. Blueline Tilefish indices of abundance and annual CVs for the southern region (Cape Canaveral to FL Keys) recommended for potential use in the stock assessment. HB=headboats, cHL=commercial handline, and cLL=commercial longline. Each index is scaled to its mean.

	INDEX VALUE			CV		
Year	HB	cHL	cLL	HB_cv	cHL_cv	cLL_cv
1980	0.979			-		
1981	0.189			-		
1982	0.030			-		
1983	0.124			-		
1984	0.046			-		
1985	0.037			-		
1986	0.677			-		
1987	0.997			-		
1988	1.832			-		
1989	0.182			-		
1990	0.076			-		
1991	1.663			-		
1992	0.982			-		
1993	1.395	0.835	2.70	-	0.161	-
1994	0.698	0.779	0.68	-	0.116	-
1995	1.531	0.863	3.02	-	0.128	-
1996	1.381	1.504	1.30	-	0.084	-
1997	1.698	1.507	0.39	-	0.074	-
1998	1.127	1.017	0.02	-	0.098	-
1999	1.106	0.913	0.35	-	0.092	-
2000	3.894	0.883	0.49	-	0.088	-
2001	0.543	1.056	1.44	-	0.089	-
2002	3.175	0.966	1.11	-	0.089	-
2003	0.609	1.088	0.45	-	0.103	-
2004	0.618	0.887		-	0.113	-
2005	0.410	0.818	0.06	-	0.126	-
2006		1.145			0.132	-
2007		0.739			0.108	

Table 5.23. Blueline Tilefish indices of abundance and annual CVs for the Gulf of Mexico recommended for potential use in the stock assessment. HB=headboats, cHL=commercial handline, and cLL=commercial longline. Each index is scaled to its mean.

	INDEX VALUE			CV		
Year	HB	cHL	cLL	HB_cv	cHL_cv	cLL_cv
1986	0.508			-		
1987						
1988	0.917			-		
1989	1.721			-		
1990	1.640			-		
1991	0.925			-		
1992	0.955			-		
1993	0.886	0.801	0.307	-	0.248	0.403
1994	0.676	1.426	0.670	-	0.263	0.253
1995	0.598	0.565	0.245	-	0.231	0.380
1996	0.624	0.681	0.288	-	0.259	0.503
1997	0.768	1.353	0.973	-	0.211	0.276
1998	1.233	0.818	0.503	-	0.209	0.281
1999	2.376	0.799	0.568	-	0.240	0.308
2000	1.084	0.362	1.017	-	0.342	0.285
2001	0.619	1.152	0.684	-	0.241	0.278
2002	0.225	0.753	0.959	-	0.271	0.292
2003	1.201	0.790	0.756	-	0.212	0.262
2004	0.773	0.669	1.302	-	0.253	0.291
2005	1.272	1.629	1.444	-	0.211	0.286
2006		1.552	1.324		0.179	0.278
2007		1.093	1.364		0.194	0.335
2008		1.748	3.596		0.283	0.268
2009		0.809			0.299	

5.10 Figures

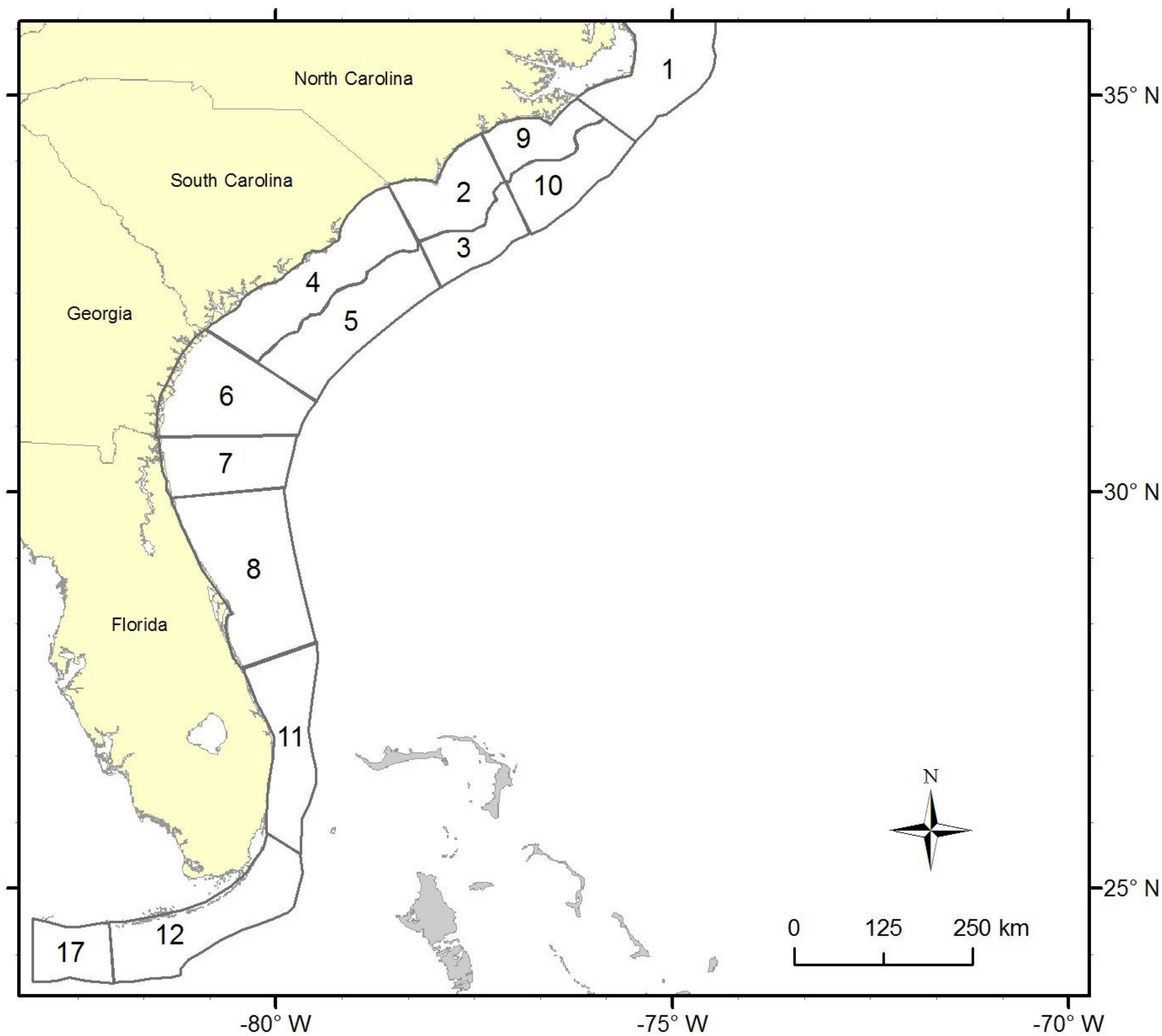

Figure 5.1. Map of headboat (SRHS) sampling area definitions. For analysis, areas were pooled as described in the text.

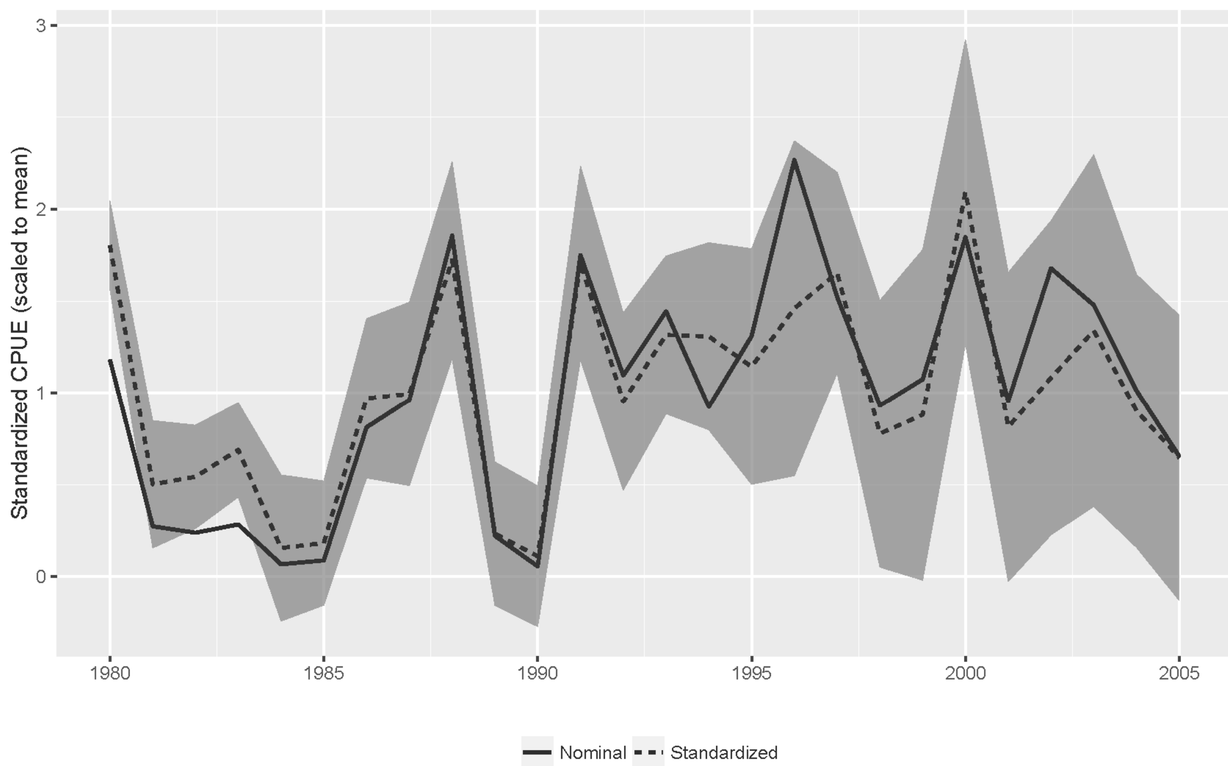

Figure 5.2. The nominal and standardized index for Blueline Tilefish computed from headboat (SRHS) data for the South Atlantic only. Error bars represents approximate 95% confidence intervals.

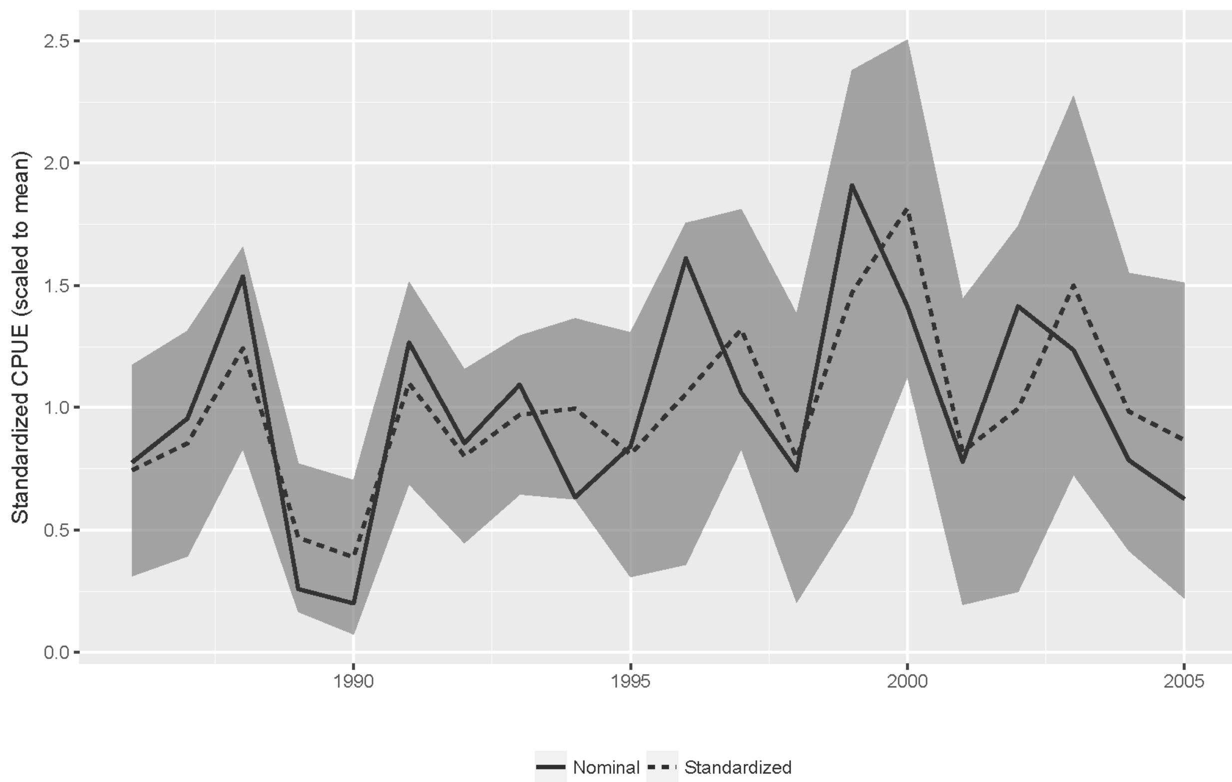

Figure 5.3. The nominal and standardized index for Blueline Tilefish computed from headboat (SRHS) data for the combined South Atlantic and Gulf of Mexico data. Shaded region represents approximate 95% confidence intervals.

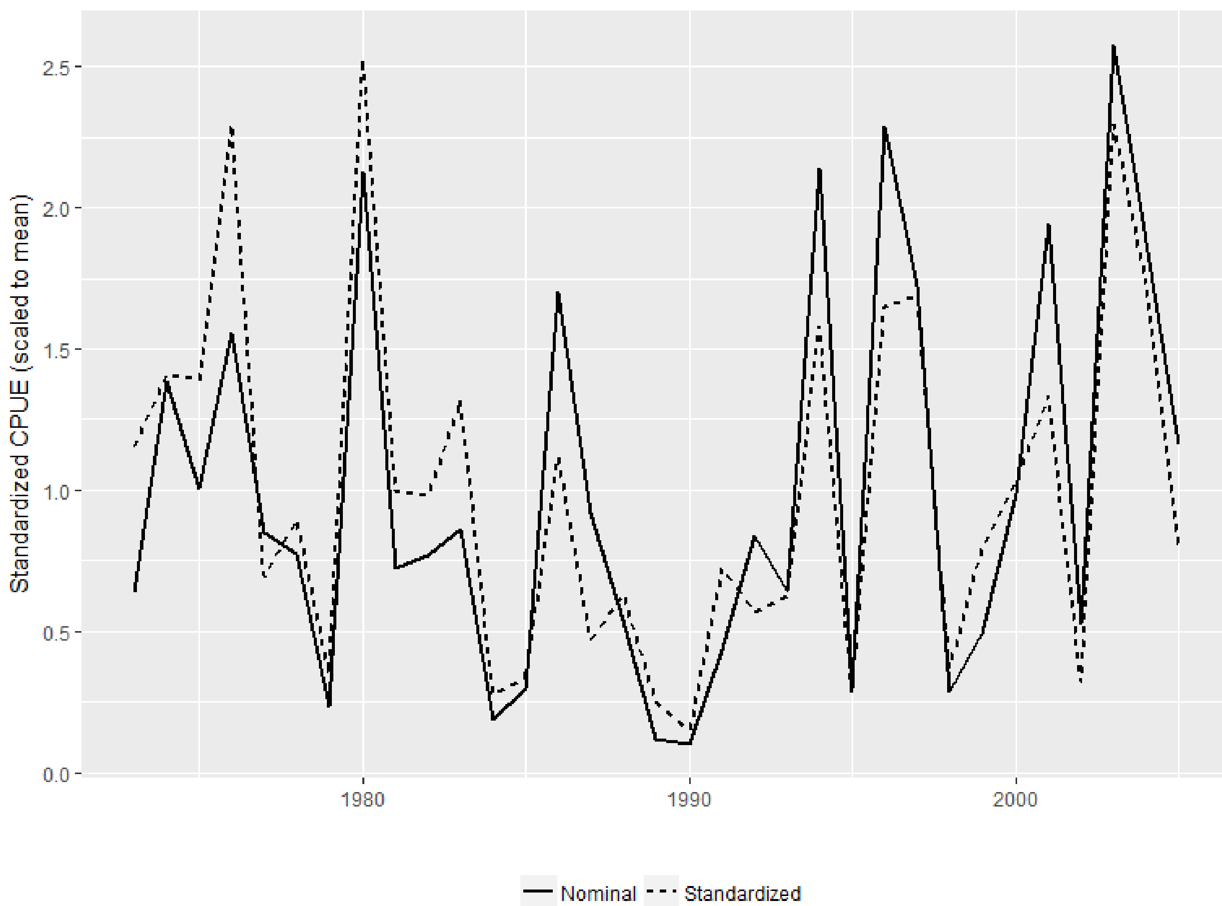

Figure 5.4. The nominal and standardized index for Blueline Tilefish computed from headboat (SRHS) data north of Cape Canaveral. Shaded regions were not computed due to low sample sizes.

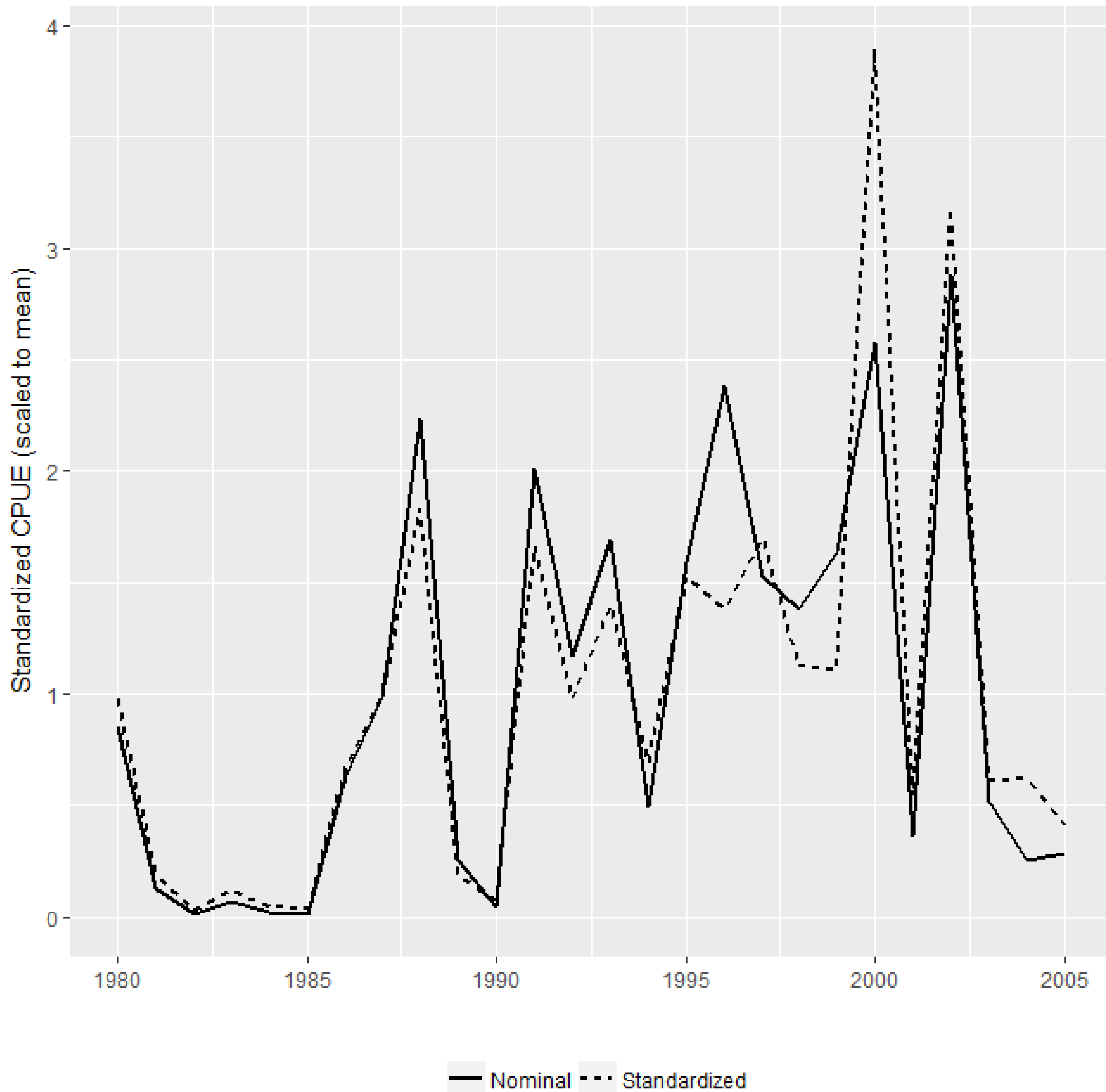

Figure 5.5. The nominal and standardized index for Blueline Tilefish computed from headboat (SRHS) data south of Cape Canaveral to the Florida Keys. Shaded regions were not computed due to low sample sizes.

Figure 5.6. The nominal and standardized index for Blueline Tilefish computed from headboat (SRHS) data from the Gulf of Mexico. Shaded regions were not computed due to low sample sizes.

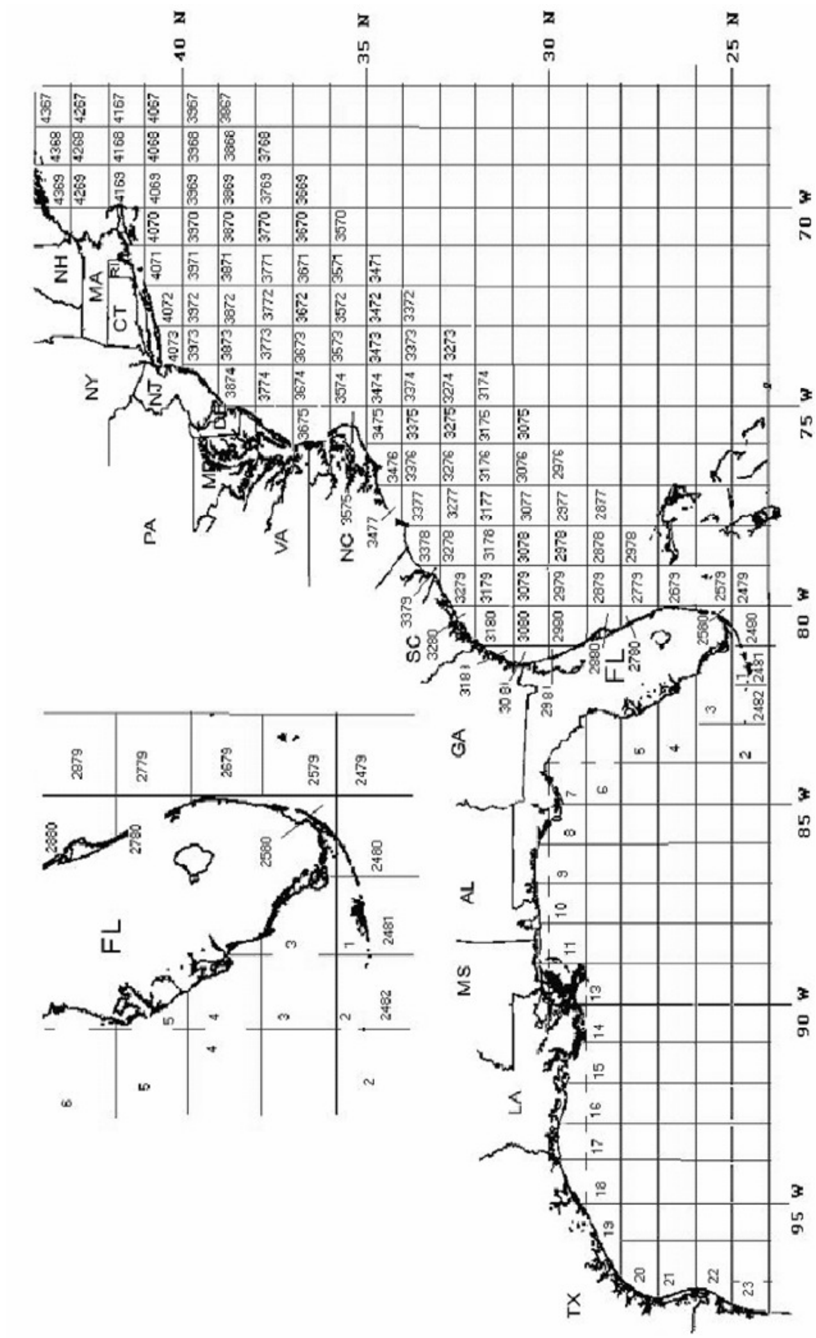

Figure 5.7. Areas reported in commercial logbooks. First two digits signify degrees latitude, second two degrees longitude.

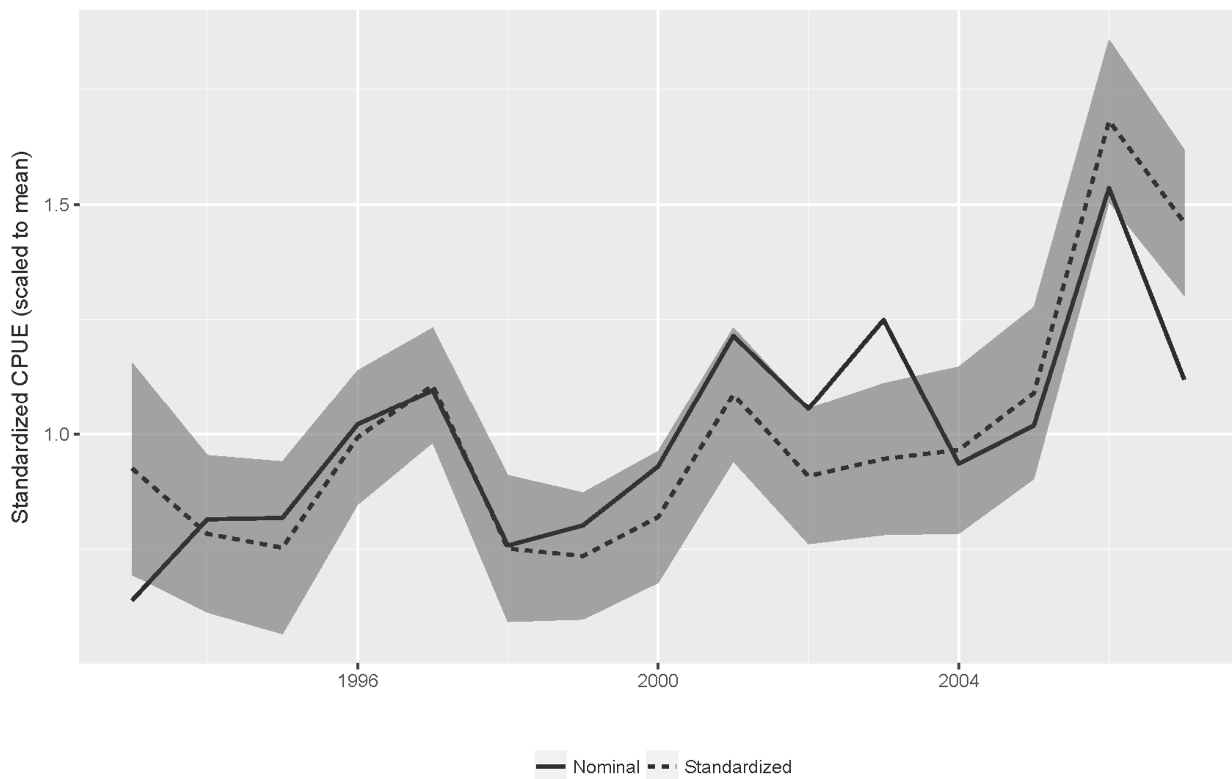

Figure 5.8. The nominal and standardized index for Blueline Tilefish computed from handline data for the South Atlantic only. Error bars represent approximate 95% confidence intervals.

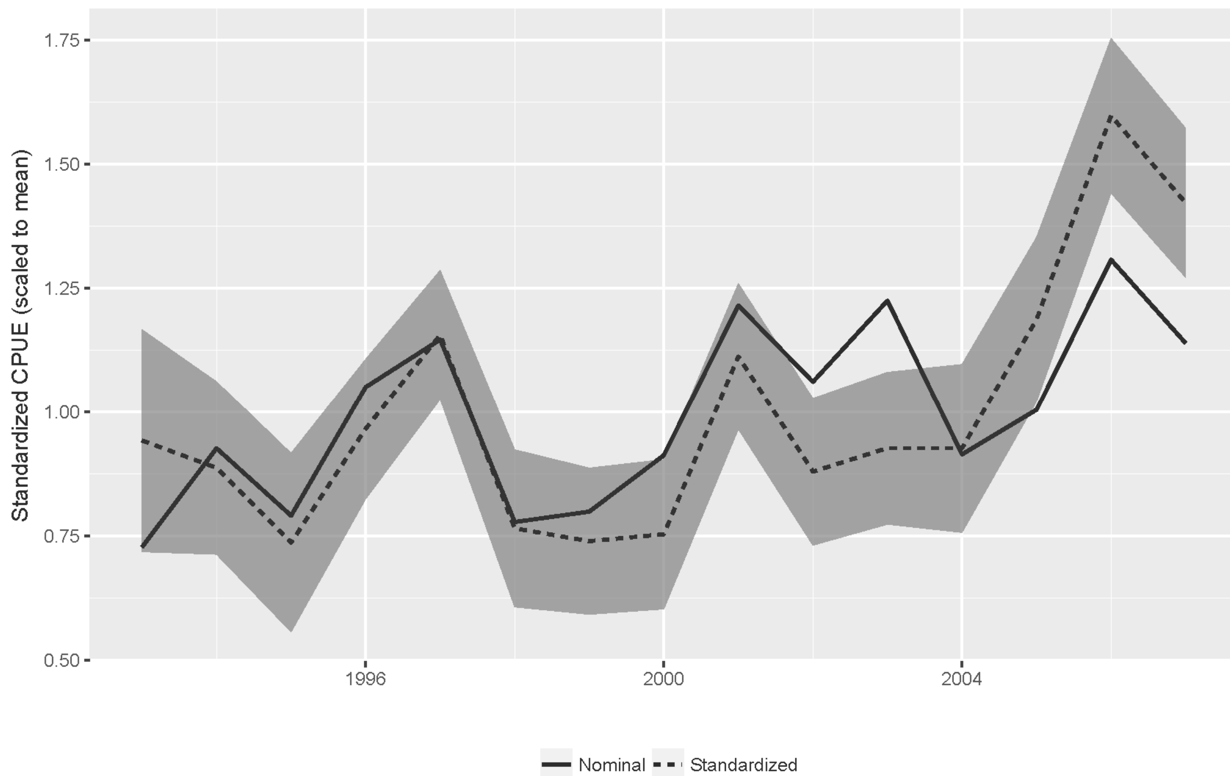

Figure 5.9. The nominal and standardized index for Blueline Tilefish computed from handline data combined for the South Atlantic and Gulf of Mexico. Error bars represent approximate 95% confidence intervals.

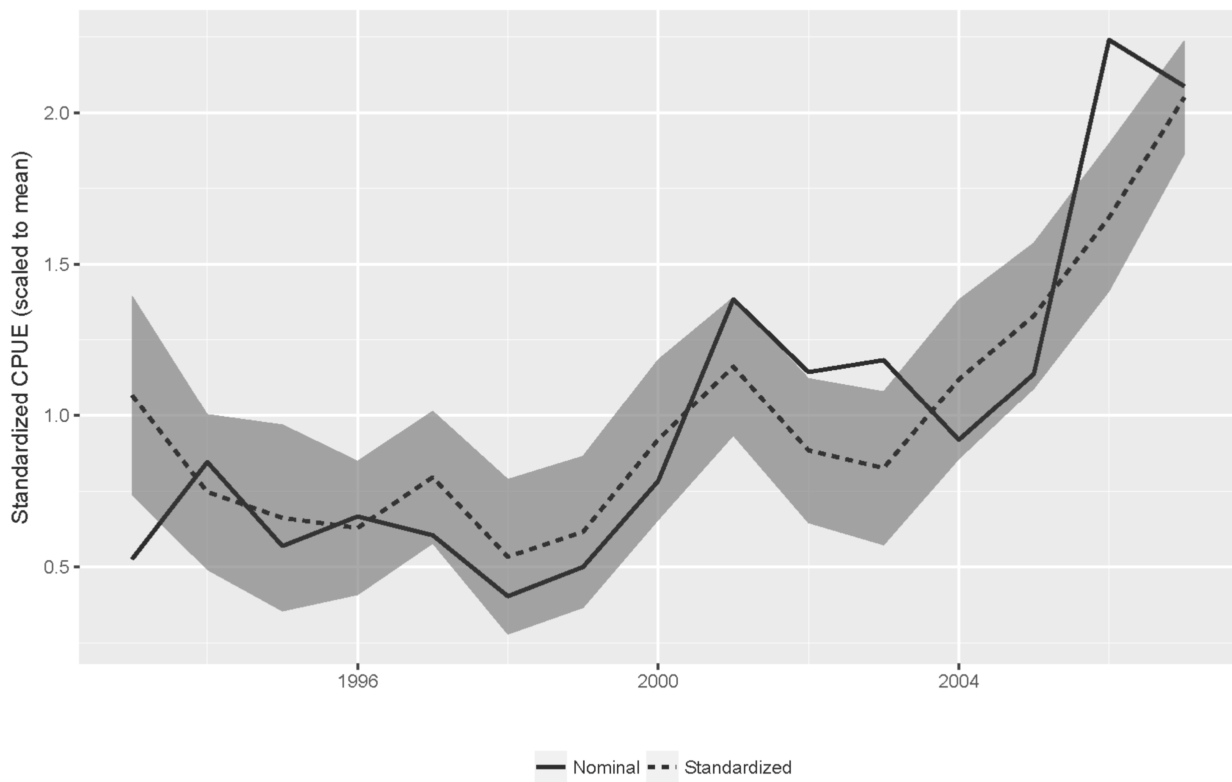

Figure 5.10. The nominal and standardized index for Blueline Tilefish computed from handline data from north of Cape Canaveral. Error bars represent approximate 95% confidence intervals.

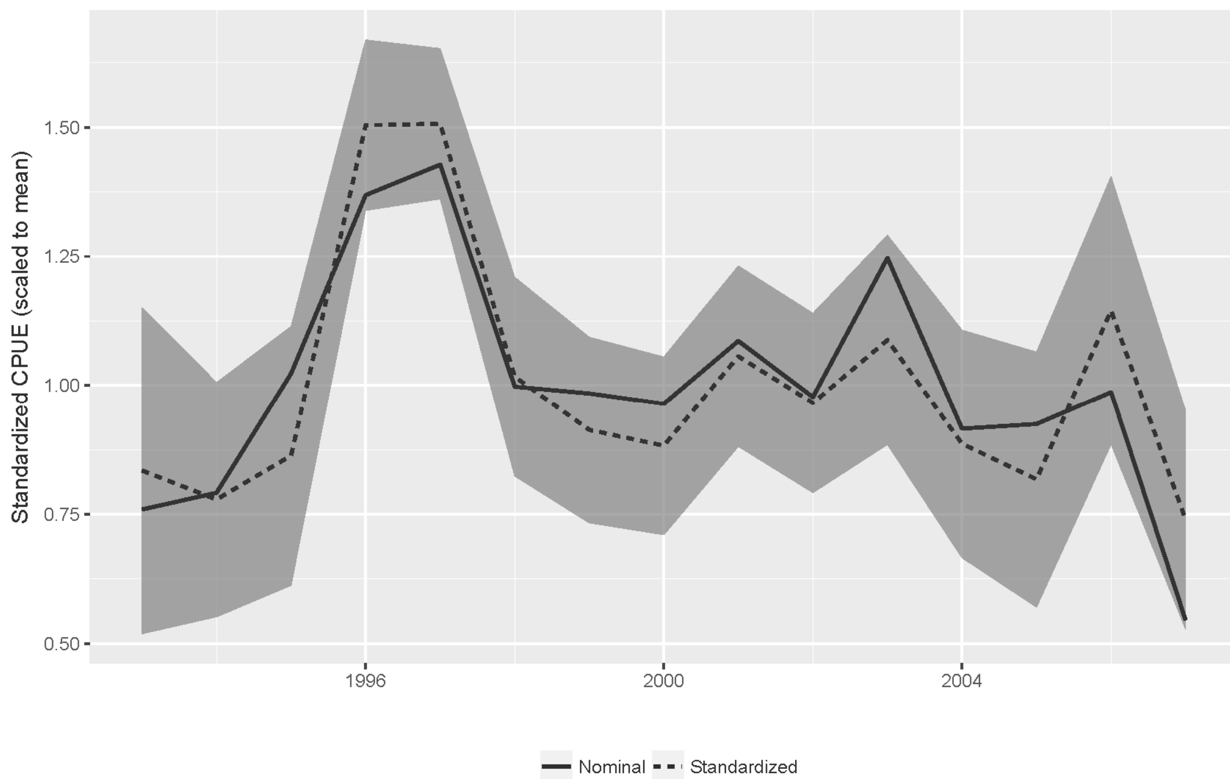

Figure 5.11. The nominal and standardized index for Blueline Tilefish computed from handline data from south of Cape Canaveral to the Florida Keys. Error bars represent approximate 95% confidence intervals.

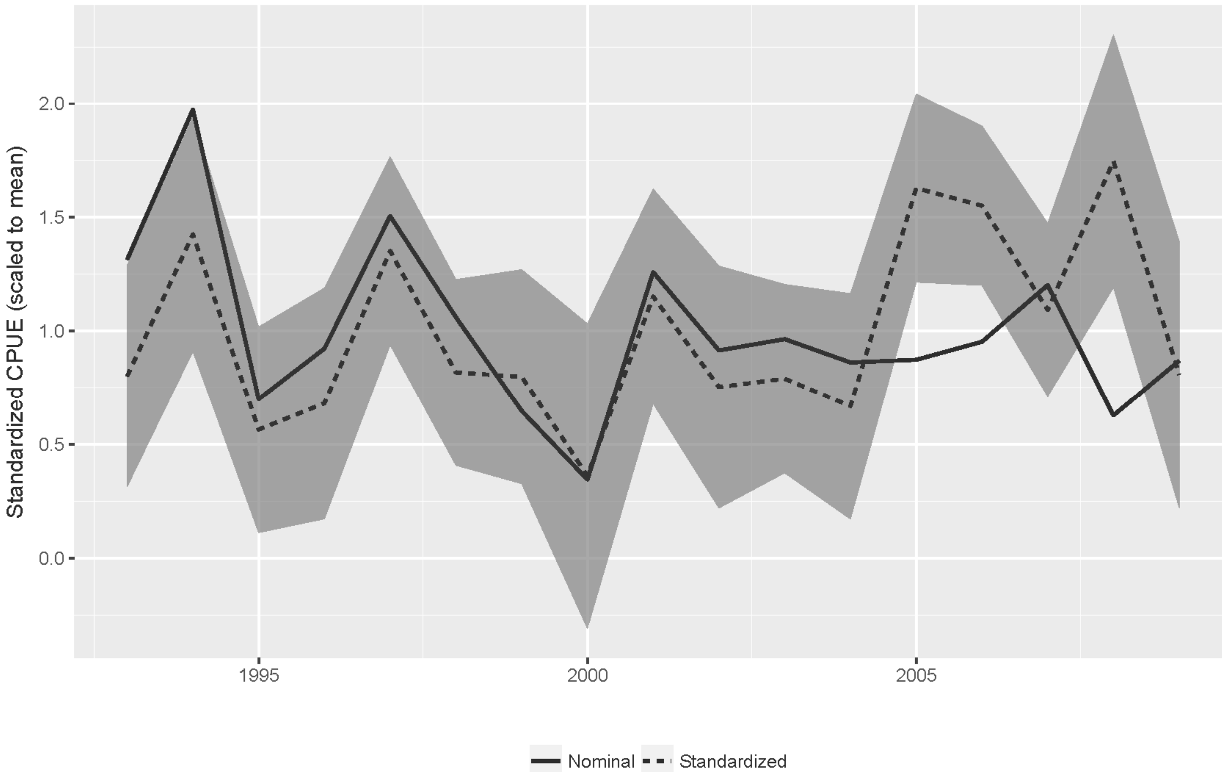

Figure 5.12. The nominal and standardized index for Blueline Tilefish computed from handline data from the Gulf of Mexico. Error bars represent approximate 95% confidence intervals.

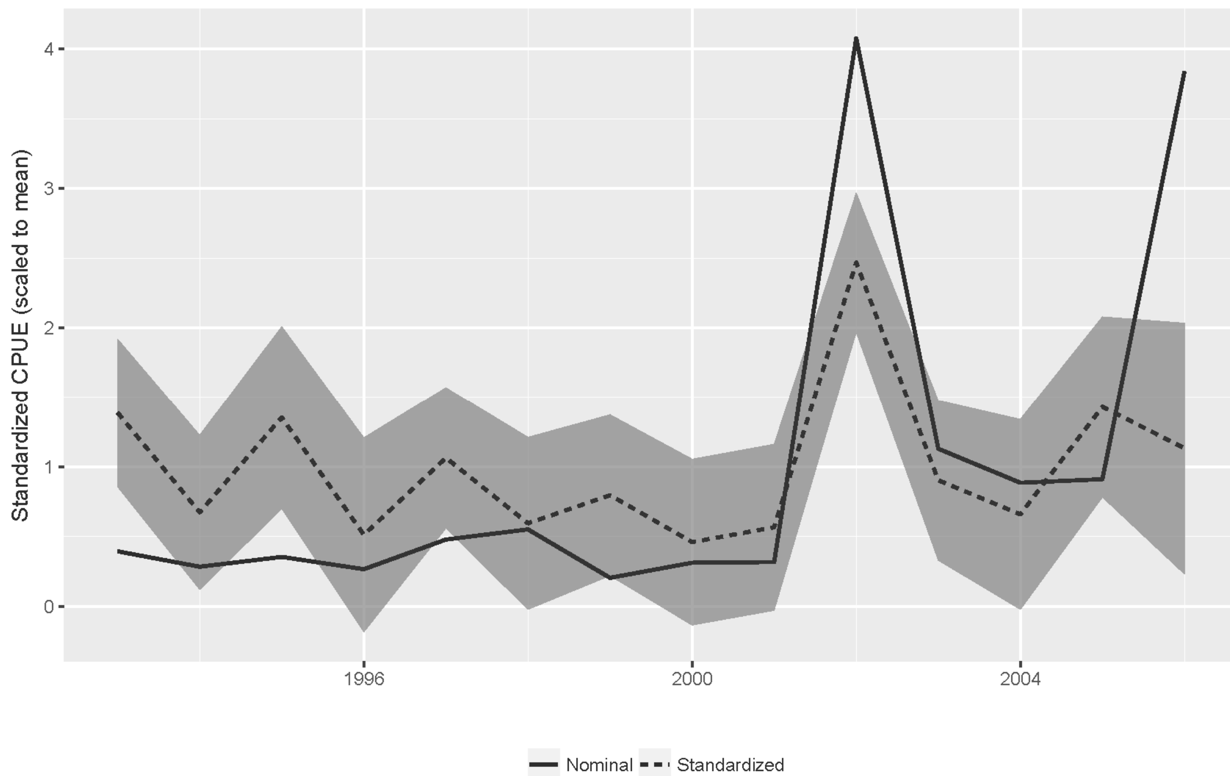

Figure 5.13. The nominal and standardized index for Blueline Tilefish computed from commercial longline data from the South Atlantic only. Error bars represent approximate 95% confidence intervals.

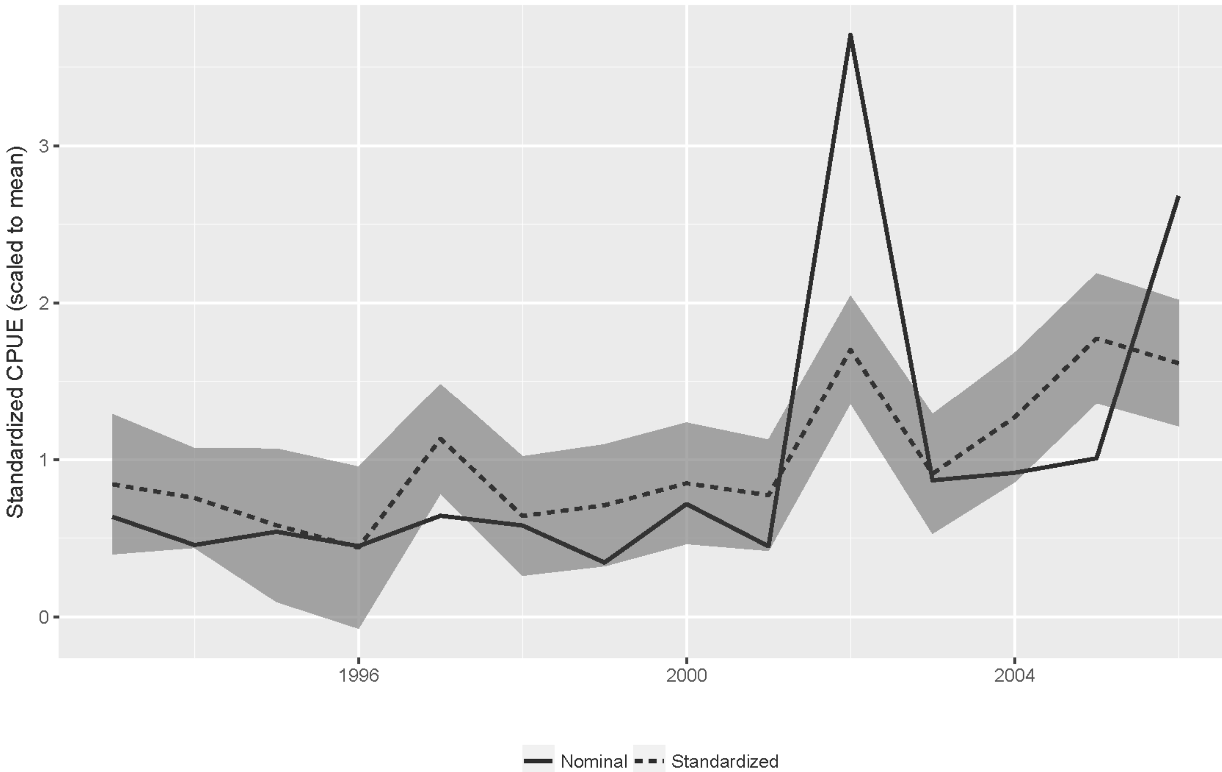

Figure 5.14. The nominal and standardized index for Blueline Tilefish computed from commercial longline data combined from the South Atlantic and Gulf of Mexico. Error bars represent approximate 95% confidence intervals.

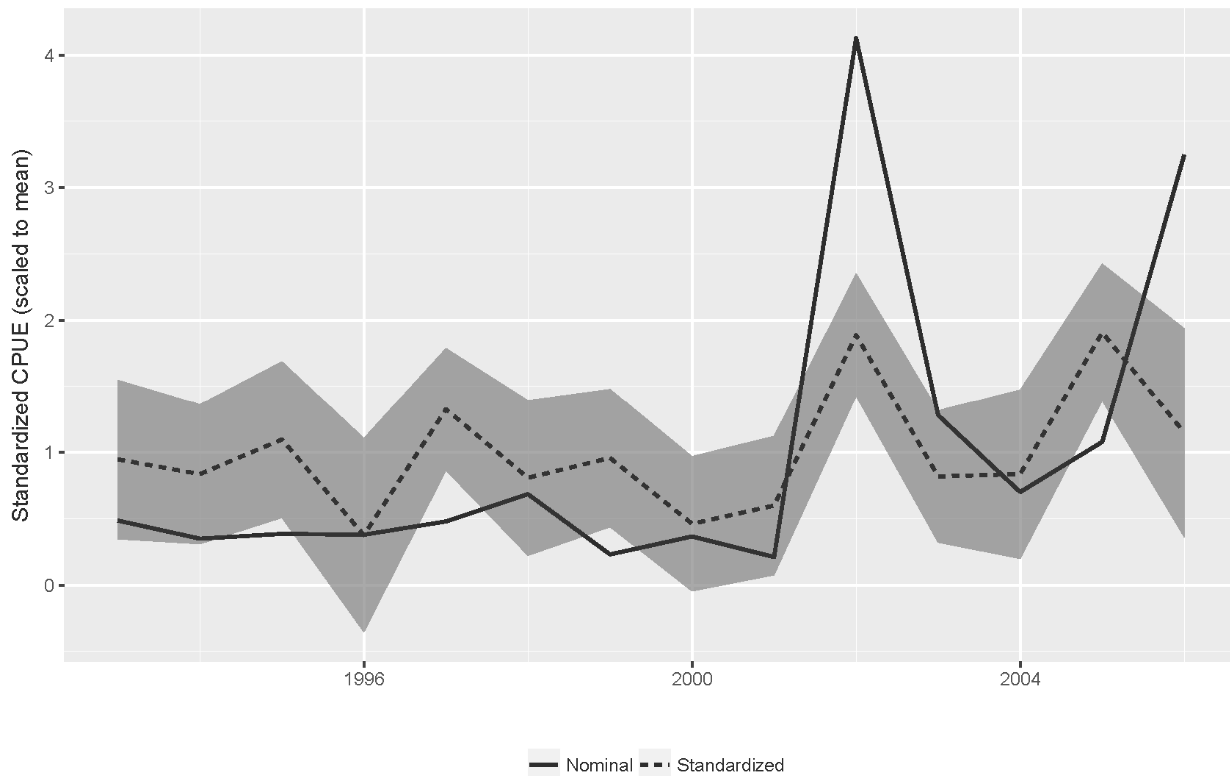

Figure 5.15. The nominal and standardized index for Blueline Tilefish computed from commercial longline data combined from north of Cape Canaveral. Error bars represent approximate 95% confidence intervals.

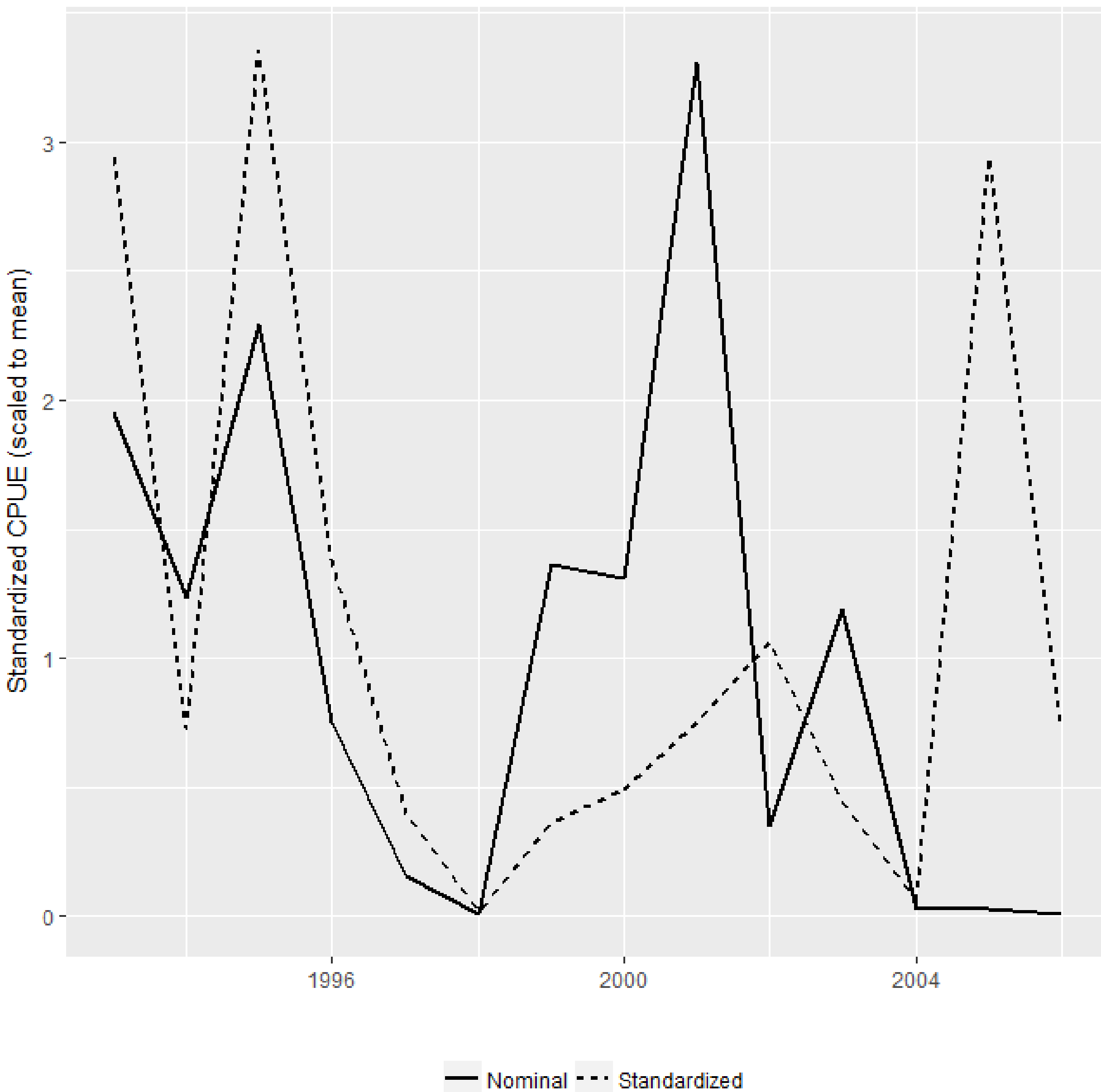

Figure 5.16. The nominal and standardized index for Blueline Tilefish computed from commercial longline data combined from south of Cape Canaveral to the Florida Keys. Error bars were not computed due to low sample sizes.

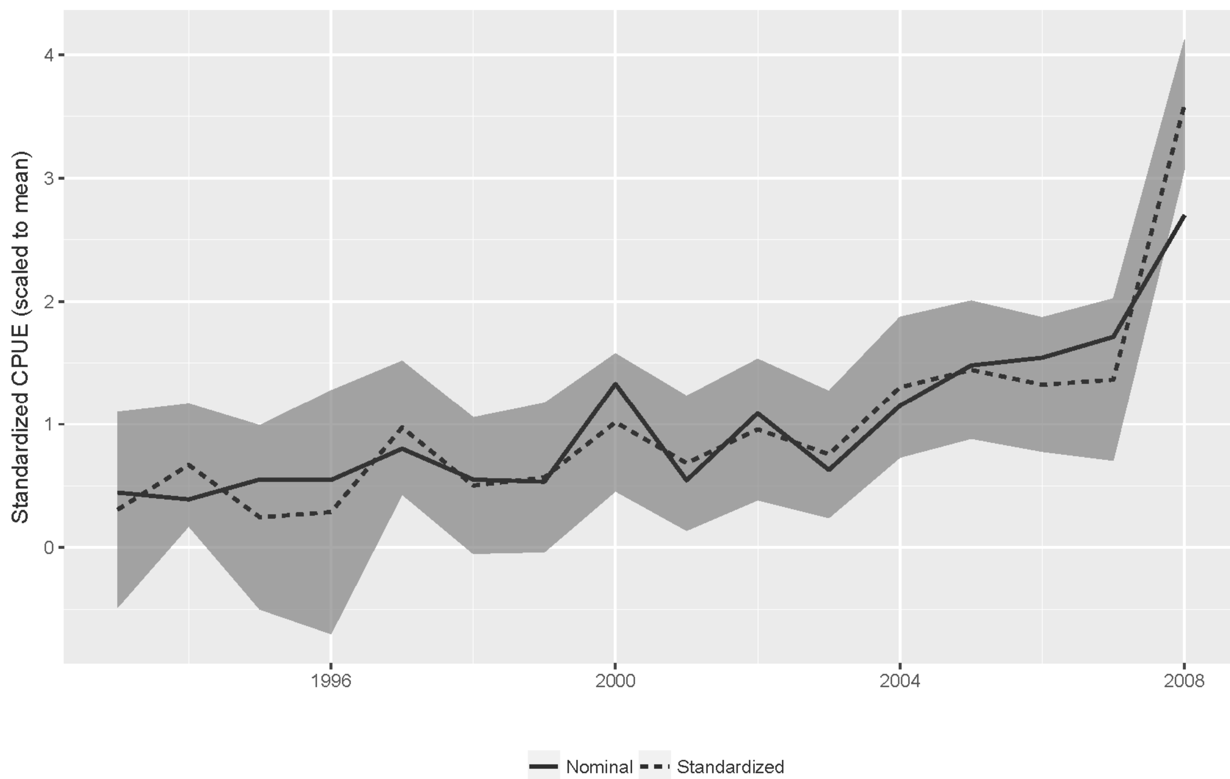

Figure 5.17. The nominal and standardized index for Blueline Tilefish computed from commercial longline data combined from the Gulf of Mexico. Error bars represent approximate 95% confidence intervals.

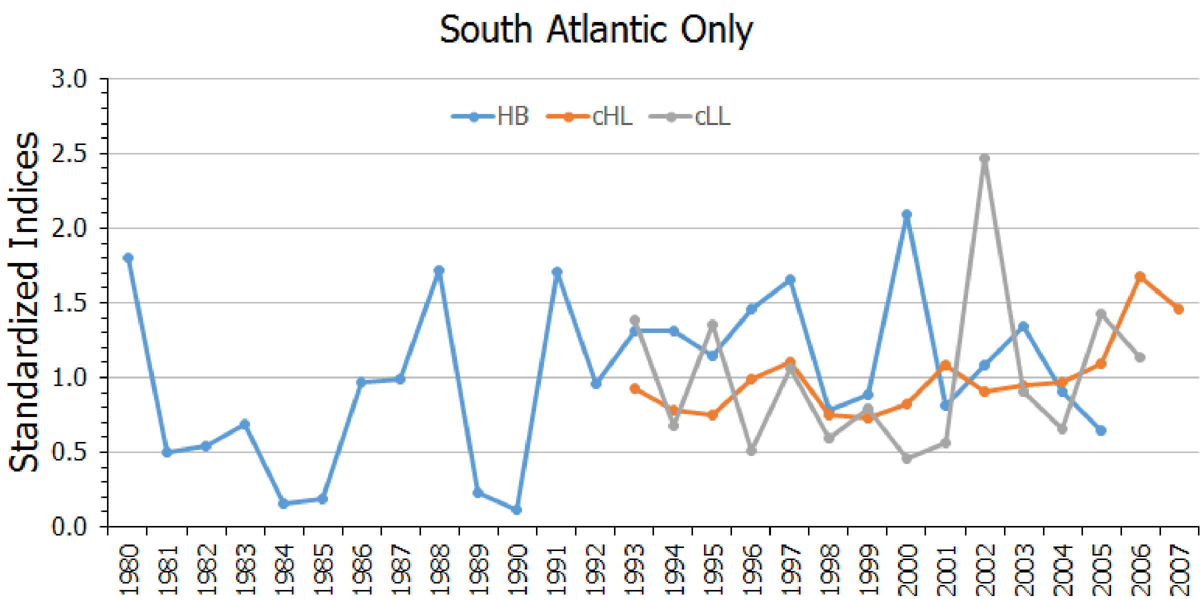

Figure 5.18. All indices (scaled to respective means) for the South Atlantic only recommended for potential use in the Blueline Tilefish stock assessment at the SEDAR50 Data Workshop. HB=Headboat, cHL=commercial handline, and cLL=commercial longline.

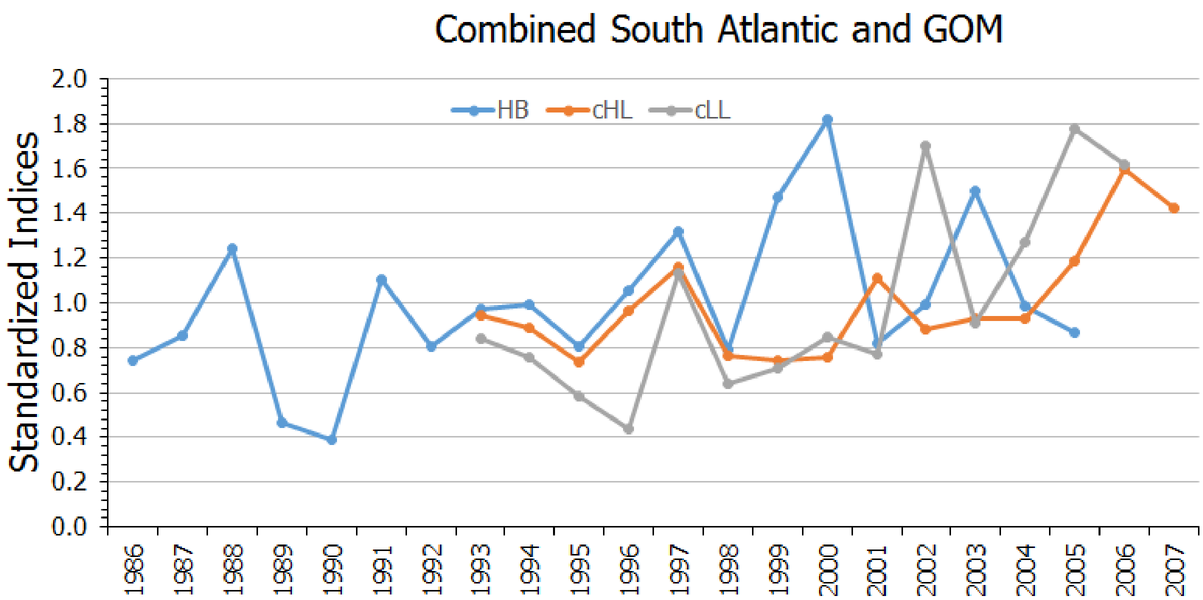

Figure 5.19. All indices (scaled to respective means) for the combined South Atlantic and Gulf of Mexico recommended for potential use in the Blueline Tilefish stock assessment at the SEDAR50 Data Workshop. HB=Headboat, cHL=commercial handline, and cLL=commercial longline.

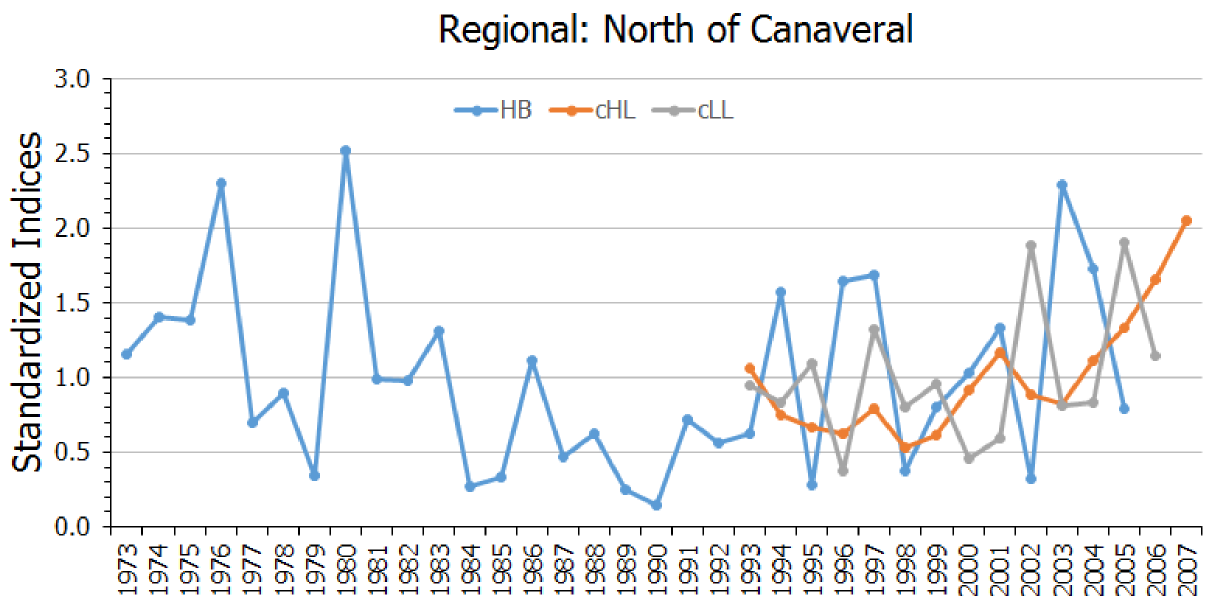

Figure 5.20. All indices (scaled to respective means) for north of Cape Canaveral recommended for potential use in the Blueline Tilefish stock assessment at the SEDAR50 Data Workshop. HB=Headboat, cHL=commercial handline, and cLL=commercial longline.

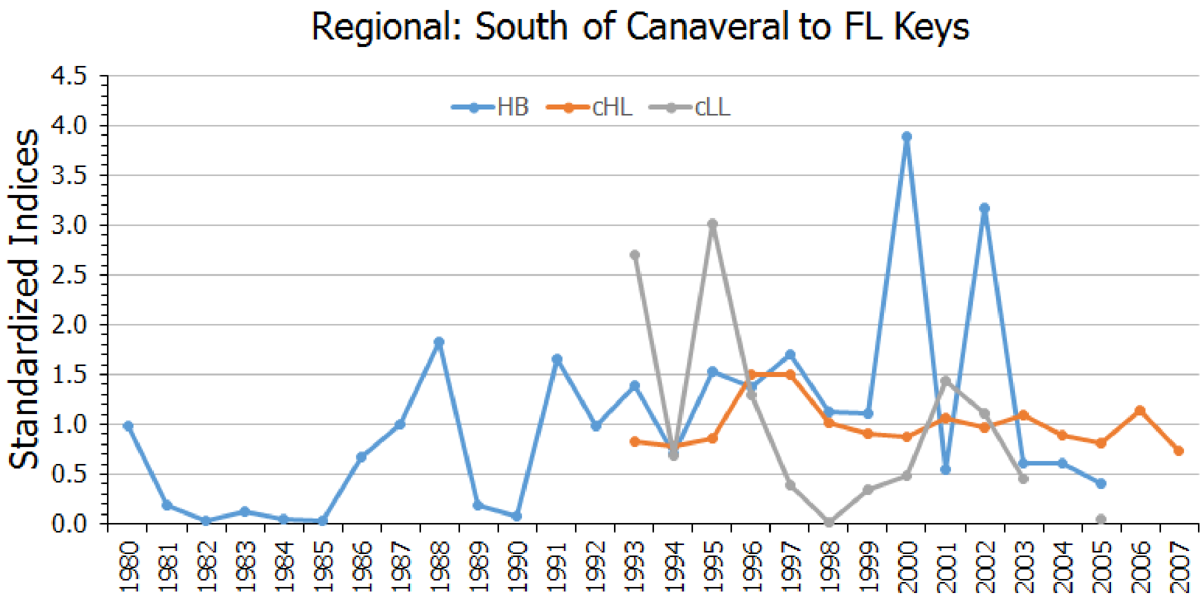

Figure 5.21. All indices (scaled to respective means) for Cape Canaveral south to the Florida Keys recommended for potential use in the Blueline Tilefish stock assessment at the SEDAR50 Data Workshop. HB=Headboat, cHL=commercial handline, and cLL=commercial longline.

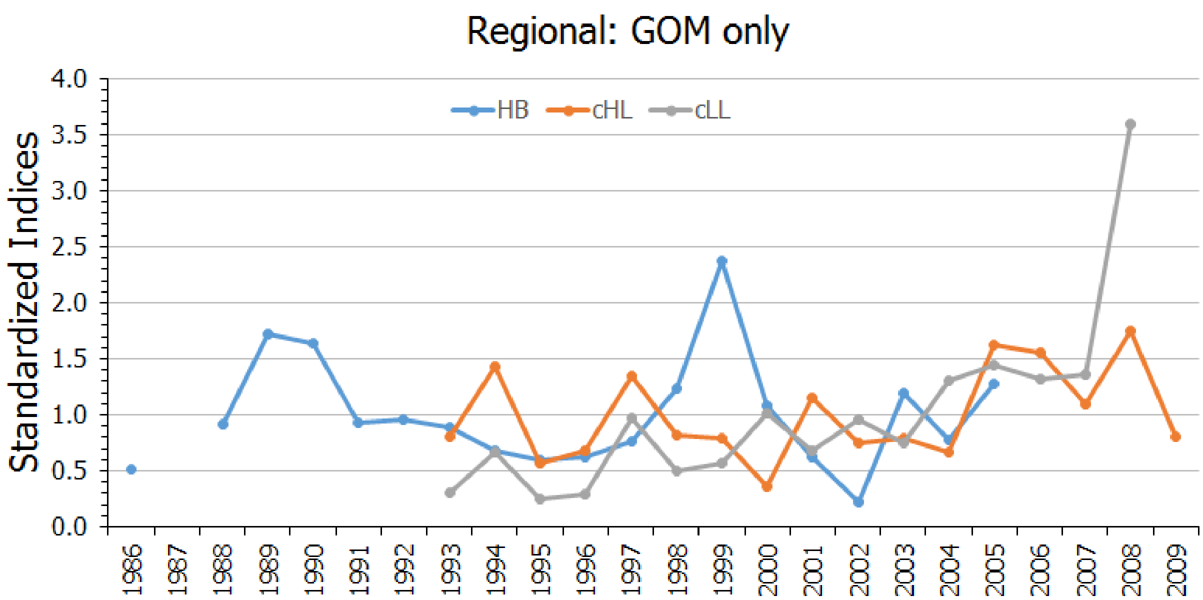

Figure 5.22. All indices (scaled to respective means) for the Gulf of Mexico recommended for potential use in the Blueline Tilefish stock assessment at the SEDAR50 Data Workshop. HB=Headboat, cHL=commercial handline, and cLL=commercial longline.

Index	HB_CC-north	HB_SA	HB_SA+GOM	HB_CC-south	HL_GOM	HL_CC-north	HL_SA	HL_SA+GOM	HL_CC-south	L_CC-nort	LL_GOM	LL_SA	LL_SA+GOM	LL_CC-south
HB_CC-north	-	0.181	0.044	0.231	0.845	0.156	0.078	0.122	0.642	0.209	0.223	0.162	0.553	0.280
HB_SA	0.181	-	0.010	0.029	0.181	0.415	0.668	0.986	0.655	0.316	0.803	0.505	0.789	0.255
HB_SA+GOM	0.044	0.010	-	0.405	0.415	0.415	0.901	0.873	0.748	0.541	0.344	0.494	0.590	0.668
HB_CC-south	0.231	0.029	0.405	-	0.082	0.734	0.364	0.144	0.289	0.887	0.517	0.887	0.694	0.271
HL_GOM	0.845	0.181	0.415	0.082	-	0.762	0.297	0.035	0.655	0.316	0.603	0.364	0.517	0.494
HL_CC-north	0.156	0.415	0.415	0.734	0.762	-	0.247	0.394	0.354	0.325	0.859	0.354	0.734	0.789
HL_SA	0.078	0.668	0.901	0.364	0.297	0.247	-	0.000	0.024	0.762	0.094	0.789	0.074	0.915
HL_SA+GOM	0.122	0.986	0.873	0.144	0.035	0.394	0.000	-	0.058	0.803	0.231	0.694	0.156	0.845
HL_CC-south	0.642	0.655	0.748	0.289	0.655	0.354	0.024	0.058	-	0.529	0.015	0.505	0.005	0.943
LL_CC-north	0.209	0.316	0.541	0.887	0.316	0.325	0.762	0.803	0.529	-	0.364	0.000	0.061	0.681
LL_GOM	0.223	0.803	0.344	0.517	0.603	0.859	0.094	0.231	0.015	0.364	-	0.775	0.000	0.033
LL_SA	0.162	0.505	0.494	0.887	0.364	0.354	0.789	0.694	0.505	0.000	0.775	-	0.098	0.721
LL_SA+GOM	0.553	0.789	0.590	0.694	0.517	0.734	0.074	0.156	0.005	0.061	0.000	0.098	-	0.188
LL_CC-south	0.280	0.255	0.668	0.271	0.494	0.789	0.915	0.845	0.943	0.681	0.033	0.721	0.188	-

Figure 5.23. Pearson correlation matrix among indices recommended for potential use in the Blueline Tilefish stock assessment at the SEDAR50 Data Workshop. HB = Headboat, HL = handline, LL = Longline; CC = Cape Canaveral, SA = South Atlantic, GOM = Gulf of Mexico.

6. ToR #7

Ad-Hoc Work Group Participants:
Beth Wrege
Tracy Smart
Rusty Hudson
Anne Lange

ToR #7 *Consider ecosystem and climate issues that could affect population dynamics. Identify and describe available data sources to investigate the effects of abiotic and biotic facto*rs, for *example climate change, predator/prey interactions, etc., on recruitment, growth, geographic distribution, and natural mortality.*

- This TOR encourages exploration for and inclusion of any environmental or climate issues or data sets that might better inform the assessment, or allow more detailed modeling for a stock's assessment.
- Blueline Tilefish may be expanding their range northward, based on increasing landings in areas further to the north. This species has not been observed from bottom water temperatures of less than 8 ^{o}C. However, there is a need for a better understanding of temperature tolerance.
- Adult Blueline Tilefish inhabit burrows, which may suggest the species does not migrate over long distances during its adult life. However, little is known about adult movement, in general.
- Mechanisms for potential transport of eggs and larval Blueline Tilefish (the Gulf Stream, eddies and gyres, especially in general areas where spawning females have been identified) are fairly well understood. However, lack of information on larval characteristics, planktonic egg and larval distribution, and larval behavior hinder use of these ocean current data in identifying nursery grounds for Blueline Tilefish early life stages.
- Not knowing where these early life stages naturally occur hampers the ability to identify or describe the effects of abiotic and biotic factors on those life stages.

<u>Recommendations:</u>

Initiate studies to:

- describe movements/migration of adult Blueline Tilefish,
- investigate possibility of range expansion using recent statistical models and available data,
- determine thermal tolerance of Blueline Tilefish,
- identify Blueline Tilefish larvae,
- investigate larval duration and larval dispersal,
- identify juvenile habitat or movement,
- collect temperature within the water column,

- collect information on location of life stage activities.

Reference:

Report of the ad hoc TOR# 7 working group, S50-DW24. 2017. 7p.

7. Analytical Approach

Based on recent findings that aging Blueline Tilefish is unreliable, age data will not be used in this assessment, and a statistical catch-at-age model [e.g. the Beaufort Assessment Model (BAM)] will not be used, diverging from the previous Blueline Tilefish assessment (SEDAR 32). However, indices of abundance and landings series are available, so a surplus production model will be considered, likely using ASPIC software as in SEDAR 32. A variety of data poor methods will be also considered, such as Depletion-Based Stock Reduction Analysis (DBSRA) and Depletion Corrected Average Catch (DCAC), using the R package DLMtool.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 50

Atlantic Blueline Tilefish

SECTION III: Assessment Workshop Report

August 2017

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

NOTE: Modifications to the model results reported in this report were made during the Review Workshop held August 29-31, 2017. For complete results reflecting those changes, please see the Addendum of the Stock Assessment Report (Section VI).

Document History

August, 2017 Original release.

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1 Workshop Proceedings

1.1 Introduction

1.1.1 Workshop Time and Place

The SEDAR 50 Assessment Process was conducted through a combination of an in-person workshop and series of webinars held from April 2017 to July 2017. The in-person workshop was held May 23-26, 2017 in Atlantic Beach, NC. Four assessment webinars were held, two pre-workshop and two post-workshop, on the following dates: April 20, May 8, June 19, and July 10, 2017.

1.1.2 Terms of Reference

1. Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.
2. Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered.
   - Consider spatially explicit modeling approaches to address potential stock overlap of the management jurisdictions of the MAFMC-SAFMC.
   - Provide a means of developing management reference points and fishing level recommendations for each management jurisdiction in the event a single unit stock overlaps Council jurisdictions.
   - Fully document and describe the impacts (on population parameters and management benchmarks) of any changes to the model structure, methods, application or fitting procedures made between this assessment and the prior assessment (SEDAR 32).
3. Provide estimates of stock population parameters, if feasible.
   - Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship (if applicable), and other parameters as necessary to describe the population.
   - Include appropriate and representative measures of precision for parameter estimates.
   - Compare and contrast population parameters and time series estimated in this assessment with values from the previous (SEDAR 32) assessment, and comment on the impacts of changes in data, assumptions or assessment methods on estimated population conditions.
4. Provide estimates of yield and productivity.
   - Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.
5. Provide estimates of population benchmarks or management criteria consistent with the available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards. Include values for fishing mortality (including assumed discard mortality if appropriate), spawning stock biomass, fishery yield, SPR and recruitment for potential population benchmarks.
   - Evaluate existing or proposed management criteria as specified in the management summary.

- Evaluate potential management benchmarks including F_{max}, F_{MSY}, and $F_{20\%}$, $F_{30\%}$, and $F_{40\%}$ SPR. Comment on the reliability of MSY estimates and possible proxy values given available data and ability to estimate necessary parameters such as steepness.
- Compare and contrast reference values estimated in this assessment with values from the previous (SEDAR 32) assessment, and comment on the impacts of changes in data, assumptions or assessment methods on reference point differences.

6. Characterize uncertainty in the assessment and estimated values
   - Consider uncertainty in input data, modeling approach, and model configuration.
   - Provide a continuity model consistent with the prior assessment configuration, if one exists, updated to include the most recent observations. Alternative approaches to a strict continuity run that distinguish between model, population, and input data influences on findings, may be considered.
   - Consider other sources as appropriate for this assessment
   - Provide appropriate measures of model performance, reliability, and 'goodness of fit'
   - Provide measures of uncertainty for estimated parameters and model output.
   - Consider exploratory models based on the Stock ID work group and Joint SSC Stock ID Review Panel recommendations to 1) characterize and describe the impact of the stock unit definition on risk and uncertainty, and 2) illustrate approaches for assigning productivity by existing Council management units.
7. Consider incorporating applicable abiotic and biotic factors, for example climate change, predator/prey interactions, etc., in the assessment model and discuss impacts on recruitment, growth, geographic distribution, and natural mortality.
8. Perform a probabilistic analysis of proposed reference points, stock status, and yield.
   - Provide the probability of overfishing at various harvest or exploitation levels.
   - Provide a probability density function for biological reference point estimates.
   - If the stock is overfished, provide the probability of rebuilding within mandated time periods as described in the management summary or applicable federal regulations.
9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:
   A) If stock is overfished: F=0, F=F_{current}, F=F_{MSY}, F_{target}, F=F_{rebuild}(max that rebuild in allowed time)
   B) If stock is not overfished: F=F_{current}, F=F_{MSY}, F= F_{target}
   C) If data limitations preclude standard projections (i.e. A, B above), explore alternate models to provide management advice.
10. Provide recommendations for future research and data collection.
    - Be as specific as practicable in describing sampling design and sampling intensity.
    - Emphasize items which will improve future assessment capabilities and reliability.
    - Consider data, monitoring, and assessment needs.
11. Complete the Assessment Workshop Report in accordance with project schedule deadlines (Section III of the SEDAR Stock Assessment Report).

1.1.3 List of Participants

ASSESSMENT PANELISTS
Nikolai Klibansky - Lead Analyst Atlantic Blueline Tilefish, SEFSC Beaufort
Robert Ahrens, UFL / South Atlantic SSC
Joseph Ballenger, SCDNR
Rob Cheshire, SEFSC Beaufort
Kevin Craig, SEFSC Beaufort
Eric Fitzpatrick, SEFSC Beaufort
Anne Lange, South Atlantic SSC
Paul Nitschke, NEFSC
Michael Schmidtke, ASMFC
Alexei Sharov, MD DNR / South Atlantic SSC*
Kyle Shertzer, SEFSC Beaufort
Erik Williams, SEFSC Beaufort

APPOINTED OBSERVERS
Skip Feller, VA*
Jeff Gutman, NJ*
Rusty Hudson, FL
Andy Piland, NC

APPOINTED COUNCIL REPRESENTATIVES
Anna Beckwith, SAFMC
Mark Brown, SAFMC*
Tony DeLernia, MAFMC*
Dewey Hemilright, MAFMC

COUNCIL AND AGENCY STAFF
Julia Byrd, SEDAR Coordinator
Kimberly Cole, SEDAR / SAFMC
Jason Didden, MAFMC
Mike Errigo, SAFMC
Nick Farmer, SERO*
Jeff Pulver, SERO*
Matt Seely, MAFMC

WORKSHOP ATTENDEES
Alan Bianchi, NCDMF
Rob Cheshire, SEFSC Beaufort
Michelle Duval, NCDMF / SAFMC
Kate Siegfried, SEFSC Beaufort
Amanda Tony, NCDMF

WEBINAR ATTENDEES
Peter Barile, SFA-ECFS
Alan Bianchi, NCDMF
Walter Bubley, SCDNR
Rob Cheshire, SEFSC Beaufort
Joe Cimino, VMRC
Scott Crosson, SEFSC Miami
Michelle Duval, NCDMF
Anne Markwith, NCDMF
Marcel Reichert, SCDNR
McLean Seward, NCDMF
Tom Sminkey, NOAA

*Appointees marked with a * did not attend the in-person workshop, but participated in webinars and/or were available via email or phone for questions as needed.

1.1.4 List of Assessment Workshop Working Papers

SEDAR 50 assessment working papers and reference document list.

Document #	Title	Authors
Documents Prepared for the Assessment Workshop		
SEDAR50-AW01	South Atlantic U.S. Blueline Tilefish (*Caulolatilus microps*) length composition from the recreational fisheries	SFB-NMFS 2017
SEDAR50-AW02	Commercial length composition weighting for U.S. Blueline Tilefish (*Caulolatilus microps*)	SFB-NMFS 2017
SEDAR50-AW03	Additional Commercial Fishery Statistics: Landings in Weight and Number, Mean Weights, Update to Uncertainty, and Catch and Effort Maps	SEDAR 50 Commercial WG
Final Assessment Reports		
SEDAR50-SAR1	Assessment of Atlantic Blueline Tilefish	To be prepared by SEDAR 50
Reference Documents		
SEDAR50-RD01	SEDAR 32 South Atlantic Blueline Tilefish Stock Assessment Report	SEDAR 32
SEDAR50-RD02	List of documents and working papers for SEDAR 32 (South Atlantic Blueline Tilefish and Gray Triggerfish) – all documents available on the SEDAR website.	SEDAR 32
SEDAR50-RD03	Managing A Marine Stock Portfolio: Stock Identification, Structure, and Management of 25 Fishery Species along the Atlantic Coast of the United States	McBride 2014
SEDAR50-RD04	Workshop to Determine Optimal Approaches for Surveying the Deep-Water Species Complex Off the Southeastern U.S. Atlantic Coast	Carmichael et al. 2015
SEDAR50-RD05	Report to Virginia Marine Resources Commission: Grant F-132-R-2 The Population Dynamics of Blueline and Golden Tilefish, Snowy and Warsaw Grouper and Wreckfish	Schmidtke et al. 2015
SEDAR50-RD06	Estimated Catch of Blueline Tilefish in the Mid-Atlantic Region: Application of the Delphi Survey Process	Allen et al. 2016
SEDAR50-RD07	MAFMC Memo: Blueline Tilefish Catch Series –	Didden 2016

	Feb 23, 2016	
SEDAR50-RD08	Reproductive Biology of the Blueline Tilefish, Caulolatilus microps, off North Carolina and South Carolina	Ross and Merriner 1983
SEDAR50-RD09	Fish species associated with shipwreck and natural hard-bottom habitats from the middle to outer continental shelf of the Middle Atlantic Night near Norfolk Canyon	Ross et al. 2016
SEDAR50-RD10	Systematics and Biology of the Tilefishes (Perciformes: Branchiostegidae and Malacanthidae), with Descriptions of Two New Species	Dooley 1978
SEDAR50-RD11	Integrating DNA barcoding of fish eggs into ichthyoplankton monitoring programs	Lewis et al. 2015
SEDAR50-RD12	Age, growth, and reproductive biology of blueline tilefish along the southeastern coast of the United States, 1982-1999	Harris et al. 2004
SEDAR50-RD13	Description of the Circulation on the Continental Shelf	Bumpus 1973
SEDAR50-RD14	Spawning Locations for Atlantic Reef Fishes off the Southeastern U.S.	Sedberry et al. 2006
SEDAR50-RD15	Observations and a Model of the Mean Circulation over the Middle Atlantic Bight Continental Shelf	Lentz 2008
SEDAR50-RD16	Modeling larval connectivity of the Atlantic surfclams within the Middle Atlantic Bight: Model development, larval dispersal and metapopulation connectivity	Zhang et al. 2015
SEDAR50-RD17	Tilefishes of the Genus *Caulolatilus* Construct Burrows in the Sea Floor	Able et al. 1987
SEDAR50-RD18	Delineation of Tilefish, *Lopholatilus chamaeleonticeps*, Stocks Along the United States East Coast and in the Gulf of Mexico	Katz et al. 1983
SEDAR50-RD19	Chapter 22: Interdisciplinary Evaluation of Spatial Population Structure for Definition of Fishery Management Units (excerpt from Stock Identification Methods – Second Edition)	Cadrin et al. 2014
SEDAR50-RD20	Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey and its partners	Smart et al. 2015
SEDAR50-RD21	Age, Growth, and Mortality of Blueline Tilefish	Ross and Huntsman

	from North Carolina and South Carolina	1982
SEDAR50-RD22	Radiocarbon from nuclear testing applied to age validation of black drum, *Pogonias cromis*	Campana and Jones 1998
SEDAR50-RD23	A long- lived life history for a tropical, deepwater snapper (*Pristipomoides filamentosus*): bomb radiocarbon and lead-radium dating as extensions of daily increment analyses in otoliths	Andrews et al. 2012
SEDAR50-RD24	Age and growth of bluespine unicornfish (*Naso unicornis*): a half-century life-span for a keystone browser, with a novel approach to bomb radiocarbon dating in the Hawaiian Islands	Andrews et al. 2016
SEDAR50-RD25	Age, growth and reproduction of the barrelfish *Hyperoglyphe perciformis* (Mitchill) in the western North Atlantic	Filer and Sedberry 2008
SEDAR50-RD26	Age, growth, and spawning season of red bream (Beryx decadactylus) off the southeastern United States	Friess and Sedberry 2011
SEDAR50-RD27	Great longevity of speckled hind (*Epinephelus drummondhayi*), a deep-water grouper, with novel use of postbomb radiocarbon dating in the Gulf of Mexico	Andrews et al. 2013
SEDAR50-RD28	Refined bomb radiocarbon dating of two iconic fishes of the Great Barrier Reef	Andrews et al. 2015
SEDAR50-RD29	Age validation of the North Atlantic stock of wreckfish (*Polyprion americanus*), based on bomb radiocarbon (^{14}C), and new estimates of life history parameters	Lytton et al. 2016
SEDAR50-RD30	Stock Complexes for Fisheries Management in the Gulf of Mexico	Farmer et al. 2016
SEDAR50-RD31	Modelling community structure and species co-occurrence using fishery observer data	Pulver et al. 2016
SEDAR50-RD32	Descriptions of the U.S. Gulf of Mexico Reef Fish Bottom Longline and Vertical Line Fisheries Based on Observer Data	Scott-Denton et al. 2011
SEDAR50-RD33	Natural mortality estimators for information-limited fisheries	Kenchington 2014
SEDAR50-RD34	The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural systems and aquaculture	Lorenzen 1996
SEDAR50-RD35	Mortality Rate of Fishes in the Pelagic Ecosystem	Peterson and

		Wroblewski 1984
SEDAR50-RD36	A Mathematical Model of Some Aspects of Fish Growth, Respiration, and Mortality	Ursin 1967
SEDAR50-RD37	MAFMC Memo: Blueline Tilefish Catch Series – Mar 14, 2016	Didden 2016
SEDAR50-RD38	Mid-Atlantic Fishery Management Council SSC Memo: Proposed BLT Subcommittee Report – March 22, 2016	Miller 2016
SEDAR50-RD39	Hierarchical analysis of multiple noisy abundance indices	Conn 2010
SEDAR50-RD40	Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding	McAllister et al. 2001
SEDAR50-RD41	Evaluating methods for setting catch limits in data-limited fisheries	Carruthers et al. 2014
SEDAR50-RD42	Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act	Restrepo et al. 1998
SEDAR50-RD43	A simple method for estimating MSY from catch and resilience	Martell and Froese 2012
SEDAR50-RD44	Estimating mortality from mean length data in nonequilibrium situations, with application to the assessment of goosefish	Gedamke and Hoenig 2006

1.2 Statements Addressing Each Term of Reference

NOTE: Original ToRs are in normal font. Statements addressing ToRs are in italics.

1. Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

   The data review and data updates are provided in §2. Tables, figures and written justification are provided for each data change.

2. Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered.

   - Consider spatially explicit modeling approaches to address potential stock overlap of the management jurisdictions of the MAFMC-SAFMC.
   - Provide a means of developing management reference points and fishing level recommendations for each management jurisdiction in the event a single unit stock overlaps Council jurisdictions.
   - Fully document and describe the impacts (on population parameters and management benchmarks) of any changes to the model structure, methods, application or fitting procedures made between this assessment and the prior assessment (SEDAR 32).

   Blueline Tilefish was modeled in three separate regions. These models are presented in separate sections: Atlantic south of Cape Hatteras (§4.1-4.3), Atlantic north of Cape Hatteras (§4.4), Gulf of Mexico (§4.5). Potential for connectivity among regions is discussed in §3 and 4.6.

   The configuration of the primary stock assessment model for Atlantic Blueline Tilefish south of Cape Hatteras is described in §4.1.1.4 through 4.1.1.6. Further documentation is provided in Prager (2015)

   Data limited methods were the primary methods used for the Atlantic north of Cape Hatteras. The methodology is described in §4.3.1 and 4.4.1.1

   Recommendations for each region are provided in the section indicated above.

   Differences between the model structure between SEDAR 32 and SEDAR 50 are primarily discussed in §3 and 4.6

3. Provide estimates of stock population parameters, if feasible.

   - Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship (if applicable), and other parameters as necessary to describe the population.
   - Include appropriate and representative measures of precision for parameter estimates.
   - Compare and contrast population parameters and time series estimated in this assessment with values from the previous (SEDAR 32) assessment, and comment on the impacts of changes in data, assumptions or assessment methods on estimated population conditions.

   The most appropriate estimates of stock population parameters for Atlantic Blueline Tilefish south of Cape Hatteras are those presented in Table 4 for the age-aggregated production models. Estimates are also presented for the age-structured production model (Table 21) but these are presented in a supplementary analysis and are not recommended for management use.

   See Table 4 and Figures 12-16.

The main comparison with SEDAR 32 is presented in §4.1.2.7.

For Atlantic Blueline Tilefish north of Cape Hatteras only data limited methods were applicable, thus few population level parameters were estimable. Median values of MSY *proxies (TACs) from the* `DLMtool` *R package, and associated uncertainty are presented in Table 25. The distributions of these TACs is shown in Figure 61. Estimates of change in mean length over time and recent Z (total mortality) are shown in Figure 62.*

4. Provide estimates of yield and productivity.

   - Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.

   Yield-per-recruit, spawner-per-recruit, and stock-recruitment estimates are presented for the age-structured production model for Atlantic Blueline Tilefish south of Cape Hatteras (Figures 43, 44, and 45), though this model was not recommended for management use.

   For Atlantic Blueline Tilefish north of Cape Hatteras only data limited methods were applicable, thus few population level parameters were estimable. Median values of MSY *proxies (TACs) from the* `DLMtool` *R package, and associated uncertainty are presented in Table 25. The distributions of these TACs is shown in Figure 61. Estimates of change in mean length over time and recent Z (total mortality) are shown in Figure 62.*

5. Provide estimates of population benchmarks or management criteria consistent with the available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards. Include values for fishing mortality (including assumed discard mortality if appropriate), spawning stock biomass, fishery yield, SPR and recruitment for potential population benchmarks.

   - Evaluate existing or proposed management criteria as specified in the management summary.
   - Evaluate potential management benchmarks including $F_{\max}$, F_{MSY}, and $F_{20\%}$, $F_{30\%}$, and $F_{40\%}$ SPR. Comment on the reliability of MSY estimates and possible proxy values given available data and ability to estimate necessary parameters such as steepness.
   - Compare and contrast reference values estimated in this assessment with values from the previous (SEDAR 32) assessment, and comment on the impacts of changes in data, assumptions or assessment methods on reference point differences.

   The most appropriate estimates of benchmarks for Atlantic Blueline Tilefish south of Cape Hatteras are those presented in Table 4 for the age-aggregated production models. Estimates are also presented for the age-structured production model (Table 21) but these are presented in a supplementary analysis and are not recommended for management use.

   For Atlantic Blueline Tilefish north of Cape Hatteras only data limited methods were applicable, thus neither the status of the stock nor the fishery could be estimated. However, median values of MSY *proxies (TACs) from the* `DLMtool` *R package, and associated uncertainty are presented in Table 25. The distributions of these TACs is shown in Figure 61. Estimates of change in mean length over time and recent Z (total mortality) are shown in Figure 62.*

6. Characterize uncertainty in the assessment and estimated values

   - Consider uncertainty in input data, modeling approach, and model configuration.
   - Provide a continuity model consistent with the prior assessment configuration, if one exists, updated to include the most recent observations. Alternative approaches to a strict continuity run that distinguish between model, population, and input data influences on findings, may be considered.
   - Consider other sources as appropriate for this assessment
   - Provide appropriate measures of model performance, reliability, and 'goodness of fit'

- Provide measures of uncertainty for estimated parameters and model output.
- Consider exploratory models based on the Stock ID work group and Joint SSC Stock ID Review Panel recommendations to 1) characterize and describe the impact of the stock unit definition on risk and uncertainty, and 2) illustrate approaches for assigning productivity by existing Council management units.

The primary characterization of uncertainty for Atlantic Blueline Tilefish south of Cape Hatteras is presented in §4.1.2.7, but see also Table 4 and Figures 12-16.

For Atlantic Blueline Tilefish north of Cape Hatteras only data limited methods were applicable. Median values of MSY *proxies (TACs) from the* `DLMtool` *R package, and associated uncertainty are presented in Table 25. The distributions of these TACs is shown in Figure 61.*

The potential impact of the current stock definition is noted in various locations throughout this report. The general structure of this report reflects the need to assess Blueline Tilefish separately by region. The main discussion of the potential impacts of the stock unit definition on uncertainty in assessment results is presented in §3 and 4.6 but also in the separate discussions for each region.

7. Consider incorporating applicable abiotic and biotic factors, for example climate change, predator/prey interactions, etc., in the assessment model and discuss impacts on recruitment, growth, geographic distribution, and natural mortality.

   A similar ToR was addressed by an Ad-Hoc Work Group at the SEDAR 50 Data Workshop. They generally found limited information was available documenting the relationship between environmental factors and Blueline Tilefish life history or distribution (SEDAR50 DW Report 2017). Through the process of this assessment, Blueline Tilefish has been determined to be more data poor than previously recognized. As explicitly incorporating environmental factors into stock assessments is a difficult task even in data rich scenarios, no attempt was made to try to incorporate biotic or abiotic factors into the current assessment of Blueline Tilefish. However, potential impacts of major ocean currents on the geographic distribution of eggs and larvae, and ultimately recruits is discussed in §3 and 4.6.

8. Perform a probabilistic analysis of proposed reference points, stock status, and yield.

   - Provide the probability of overfishing at various harvest or exploitation levels.
   - Provide a probability density function for biological reference point estimates.
   - If the stock is overfished, provide the probability of rebuilding within mandated time periods as described in the management summary or applicable federal regulations.

   The probability of overfishing is provided in Figures 12 and 16. Probability density functions of biological reference point estimates are provided in Figure 12. The stock is not currently overfished.

   For Atlantic Blueline Tilefish north of Cape Hatteras only data limited methods were applicable. Median values of MSY *proxies (TACs) from the* `DLMtool` *R package, and associated uncertainty are presented in Table 25. The distributions of these TACs is shown in Figure 61.*

9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:

   A) If stock is overfished: F=0, F=F_{current}, F=F_{MSY}, F_{target}, F=F_{rebuild}(max that rebuild in allowed time)

   B) If stock is not overfished: F=F_{current}, F=F_{MSY}, F= F_{target}

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

The stock is estimated to be neither overfished nor undergoing overfishing, therefore three standard projections were performed: $F = F_{\text{current}}$, $F = F_{\text{MSY}}$, $F = F_{\text{target}}$. *The results are presented in Tables 7, 6 and, 8; and Figures 25, 24, and 26.*

For Atlantic Blueline Tilefish north of Cape Hatteras, no projections were performed from the data limited methods.

10. Provide recommendations for future research and data collection.
    - Be as specific as practicable in describing sampling design and sampling intensity.
    - Emphasize items which will improve future assessment capabilities and reliability.
    - Consider data, monitoring, and assessment needs.

    Research recommendations applicable to Blueline Tilefish throughout its range are provided in §4.7

11. Complete the Assessment Workshop Report in accordance with project schedule deadlines (Section III of the SEDAR Stock Assessment Report).

    The Assessment Workshop Report was completed and submitted on time.

2 Data Review and Update

The input data for this assessment are described below, with focus on modifications from the SEDAR 50 DW.

2.1 Data Review

In this benchmark assessment, models were fitted to data sources developed during the SEDAR 50 DW with some modifications and additions.

- Life history: Life history meristics, population growth, female maturity, proportion female, size-dependent batch fecundity, and discard mortality
- Landings and discards: commercial handline, commercial longline, general recreational
- Indices of abundance: commercial handline, commercial longline, headboat
- Length composition: commercial handline, commercial longline, general recreational

2.2 Data Update

2.2.1 Life History

The fecundity equation was incorrect in the Data Workshop Report (SEDAR50 DW Report 2017) and corrected prior to the Assessment workshop.

The estimate of constant natural mortality (M) was re-estimated using a different method and was changed from 0.13 to 0.17. This occurred after discovering that one of the parameters in the equation used to estimate M from Von Bertalanffy growth parameters (L_∞ and K) was incorrectly reported in the literature (Then et al. 2014, ; $Pauly_{nls-T}$ parameter a should be 8.87 not 4.118). Thus the estimate of M agreed upon at the Data Workshop was then effectively multiplied by a factor of 2.154, resulting in $M = 0.28$. Members of both the SEDAR 50 Data Workshop Life History Working Group and the Assessment Panel discussed this revised estimate via webinar, and agreed that this value was unreasonably high for Blueline Tilefish. They then agreed to a revised approach for estimating M, using an assumed maximum age of 40 (based in part on the observed maximum age for Golden Tilefish in the US South Atlantic stock) and the $Hoenig_{nls}$ equation from Then et al. (2014). Note that this equation was verified to be correct using the same method that discovered the error in the $Pauly_{nls-T}$ equation (Klibansky, N. 2017 unpublished).

Life history information is summarized in Table 1.

2.2.2 Landings and Discards

Between the data workshop and the Assessment workshop the landings were split regionally. A regional group was duplicated in the data workbook and has since been corrected. The region duplicated was from Hatteras to Cape Fear and represented $< 3\%$ of the landings in any given year.

During the Assessment Workshop, it was necessary to examine the recreational landings north and south of Cape Hatteras, North Carolina but the MRIP landings provided at the DW were not available at this spatial scale. The MRIP landings (from the website) were examined by county in NC to determine an appropriate ratio of landings north and south of Cape Hatteras. This ratio was then applied to the North Carolina data from the DW report. Total removals used in the assessment are in Table 2.

2.2.3 Indices of Abundance

All indices and their corresponding CVs are shown in Table 3.

2.2.4 Length Compositions

Length compositions for all data sources were developed in 3-cm bins over the range 21–99 cm (labeled at bin center). All lengths below and above the minimum and maximum bins were pooled. The commercial handline, longline and general recreational lengths were weighted by the region and landings (SFB-NMFS 2017). For inclusion, length compositions in any given year had to meet the sample size criteria of $n_{\text{fish}} > 30$ and $n_{\text{trips}} \geq 10$.

3 Stock Assessment Approach

3.1 Stock Structure

Though Blueline Tilefish are found from the Campeche Bank off of the Yucatán Peninsula, Mexico, throughout the Gulf of Mexico, and up to Georges Bank off of Massachusetts, US, fish in the Gulf of Mexico and the Atlantic were considered separate stocks for management purposes. In 2013, a stock assessment was conducted on Blueline Tilefish in the Atlantic (SEDAR 32 2013). Due primarily to interest in the possibility of a stock split at the North Carolina-Virginia state line (i.e. the South and Mid-Atlantic Councils' boundary), a SEDAR 50 Stock ID Work Group Meeting was held June 28-30, 2016. The Work Group considered genetics, life history data, adult distributions, oceanographic features, and data on drifter movement to identify the stock structure of Blueline Tilefish in US waters, focusing largely on the Atlantic coast.

Conclusions of two studies clearly supported the existence of one genetic population of Blueline Tilefish from the Gulf of Mexico, to New Jersey (McDowell 2016; O'Donnell and Darden 2016, n=510 and n=259 fish, respectively); the authors further concluded that Blueline Tilefish was genetically very homogeneous at large and small spatial scales. Though few fish were actually sampled from the Gulf of Mexico (n = 15), a large number of fish (n = 60) were collected near Key West, quite close to the Gulf and South Atlantic Councils' boundary. In pairwise comparisons, even these fish were not genetically different from Blueline Tilefish collected in waters off of New York (n = 80), over 1800 km away. The lack of genetic stock structure in the Atlantic was not surprising, as the spatial distribution of Blueline Tilefish appeared to be continuous across the hypothesized break at the NC-VA line, and even across Cape Hatteras (Klibansky 2016), which forms a biogeographic break for other populations, such as Black Sea Bass (*Centropristis striata*; McCartney et al. 2013). However, the lack of genetic differentiation between the Gulf of Mexico and the Atlantic was unexpected, and led the Work Group to try to understand the mechanistic link between these regions.

By investigating the distribution of landings and scientific collections of Blueline Tilefish in the Gulf of Mexico, the Work Group showed that the vast majority of Blueline Tilefish in the Gulf of Mexico have been caught on the West Florida Shelf, over an area that extends across the Council boundary (Farmer and Klibansky 2016). Though they found no available information documenting movement of Blueline Tilefish at any life stage, limited information on a similar species Golden Tilefish (*Lopholatilus chamaeleonticeps;* Grimes et al. 1983), suggests that adults do not move very far. This work, as well as the knowledge that Blueline Tilefish build and inhabit burrows (Able et al. 1987), led the Work Group to conclude that adult Blueline Tilefish are probably not moving long distances and driving genetic homogeneity. However, Blueline Tilefish are known to have pelagic eggs (Lewis et al. 2016). Data show that Golden Tilefish eggs and larvae are pelagic and are distributed over a large range of depths, primarily in the upper water column (50-150m; Steimle et al. 1999; Berrien and Sibunka 1999). Therefore early life stages of Blueline Tilefish should be expected to travel on ocean currents occurring in the upper water column. The apparent concentration of Blueline Tilefish on the West Florida Shelf is immediately adjacent to the strong Loop Current that flows from the Gulf of Mexico around the Florida peninsula into the Atlantic. Drifter data examined at the Work Group Meeting (Farmer and Klibansky 2016) confirmed that planktonic objects are carried on these currents from the West Florida Shelf into the Atlantic. Based on this information the Work Group concluded it is likely that substantial numbers of Blueline Tilefish eggs and/or larvae are transported from the Gulf of Mexico into the Atlantic by ocean currents.

Though the Work Group was aware of limitations of the available data, they were tasked with making "recommendations on biological stock structure", and concluded that the data did "not support the existence of separate biological populations at either the MAFMC/SAFMC or SAFMC/GMFMC jurisdictional boundaries" (SEDAR 50 Stock ID Work Group 2016). Strong evidence showed that Blueline Tilefish were genetically homogeneous from Key West to New York and limited genetic evidence showed that Atlantic collections were also homogeneous with fish collected in the Gulf of Mexico, a relatively short distance away from the Key West samples. In addition, the depth stratum where Blueline Tilefish are found is continuous over the entire range, and adult Blueline Tilefish appear to be more or less continuous over this range. Finally, strong Loop and Gulf Stream currents that flow from the West Florida Shelf up to Cape Hatteras often along this depth stratum form a possible mechanism for transporting eggs and larvae. Although the Work Group was concerned about the small genetics sample size in the Gulf of Mexico, the remaining information made it seem likely that the large concentration of fish in the Gulf of Mexico, potentially contribute a substantial amount of eggs and larvae to the South Atlantic.

The results of the Stock ID Work Group Meeting were reviewed by a panel of scientists from the Gulf of Mexico, South Atlantic, and Mid-Atlantic Science and Statistics Committees (SSCs), and a webinar was held on October 28, 2016 to discuss them. This panel effectively accepted the results of the Stock ID Work Group. In the list of consensus statements documenting this webinar, the SSC Panel noted the genetic support for one continuous stock, but also the small sample size in the Gulf of Mexico; the continuous distribution of Blueline Tilefish from the Mid-Atlantic to the Gulf of Mexico; and the Loop Current as a mechanism for larval connectivity between the Gulf of Mexico and the US South Atlantic (Joint SSC Sub-Panel 2016). Later, on November 14, 2016, members of the Council, Science Center, and Regional Office leadership convened a call to discuss the Stock ID Work Group Report and the subsequent SSC Webinar. This Leadership Group accepted the findings of the SSC Panel, but focused on the small sample size of genetics samples in the Gulf of Mexico. They found that the few genetics samples in the eastern Gulf of Mexico and the lack of genetics samples from the western Gulf of Mexico were insufficient to support the existence of a single stock of Blueline Tilefish spanning both the Gulf of Mexico and Atlantic. The group then recommended "using the boundary between the Gulf of Mexico and South Atlantic Council as the Southwestern boundary for the SEDAR 50 stock assessment of Blueline Tilefish" (Council, Science Center and Regional Office Leadership 2016).

A more thorough analysis of drogue drifter data over the known range of Blueline Tilefish was completed following these meetings (made available at the time of SEDAR 50 Data Workshop, held January 23-27, 2017), and it further supported the potential for substantial larval transport between Council regions (Klibansky 2017). This analysis identified drifters that had passed near locations where Blueline Tilefish had been caught, and determined where they were located in the following weeks. This analysis showed that 27% of drifter tracks originating in the eastern Gulf of Mexico near known Blueline Tilefish catch locations had moved into the US South Atlantic after only one week; at four weeks that number was up to 39%. Of drifters that originated in the US South Atlantic near known Blueline Tilefish catch locations, 21% had moved into the Mid-Atlantic council region after one week, and 54% after four weeks. Movement of drifters in the other direction, from the South Atlantic into the Gulf of Mexico was almost nonexistent, while 16% of drifters originating in the Mid-Atlantic had moved into the South Atlantic after one week. This analysis suggested that if planktonic stages of Blueline Tilefish behave like drogue drifters then there would likely be substantial movement from the Gulf of Mexico into the South Atlantic, but little movement in the opposite direction, and there would likely be substantial movement of eggs and larvae between the South and Mid-Atlantic, with somewhat higher net movement from south to north.

Despite indications that egg and larval movement between Council regions may be considerable, the Gulf of Mexico and South Atlantic Council boundary (SAFMC/GMFMC boundary) remains the southern boundary for SEDAR 50. Investigations into Gulf of Mexico data provided at the SEDAR 50 Data Workshop were relegated to consideration in uncertainty analysis (SEDAR 50 AW ToR 6).

Following the Stock ID Work Group Meeting and subsequent SSC and Leadership meetings, the northern boundary was expected to extend through the Mid-Atlantic. However, early attempts to model the population from the SAFMC/GMFMC boundary through the Mid-Atlantic failed to produce realistic results, suggesting biomass to be near zero in recent years. During the SEDAR 50 AW, the Assessment Panel reconsidered the spatial range of the data going into the assessment and proposed that the source of the problem might be the spatial mismatch between catch-per-unit-effort based indices of abundance and the removals. Due to recent large increases in fishing effort in all fleets north of Cape Hatteras, the abundance indices ended prior to this spatial shift in effort (SEDAR50 DW Report 2017). Thus, the existing indices predominantly represent trends in the population south of Cape Hatteras, while removals extended up through the Mid-Atlantic. When removals were restricted to the same spatial range as the indices, model results were more stable and realistic. Thus the Assessment Panel concluded that the main stock assessment effort proceed with models including removals restricted to areas between the SAFMC/GMFMC boundary and Cape Hatteras, NC. Noting that this also restricts the spatial range of the advice being derived from these models, the panel also proceeded with separate efforts to investigate the available data for the region north of Cape Hatteras, to provide advice for management of Blueline Tilefish in that region.

3.2 Modeling Framework

At the time this benchmark assessment was scheduled, it was expected that the primary model would be a statistical catch-age model implemented using the Beaufort Assessment Model (BAM) software (Williams and Shertzer 2015), however data limitations prevented its use. Versions of BAM have been used in previous SEDAR assessments in the U.S. South Atlantic (e.g. Red Porgy, Black Sea Bass, Golden Tilefish) as well as in the previous SEDAR assessment of Blueline Tilefish (SEDAR 32 2013). However, during Blueline Tilefish Age Workshop II, held August 29-31, 2016, a group of experts determined that the primary ageing laboratories had not achieved high enough across laboratory precision in age estimates of Blueline Tilefish, and that the available age data were not reliable. One factor contributing to this imprecision was that marks on otoliths representing annuli were not being consistently identified. The lack of precision means inclusion of the age data in a stock assessment may not allow for tracking of cohorts in the age compositions, which could have deleterious effects to the assessment (Potts et al. 2016). The age workshop had originally been convened to resolve some apparent disagreements in aging between labs, though the severity of the problem was not anticipated. Given the lack of congruence in ageing methodologies between the labs and the pre-determined assessment timeline, production of reliable age estimates for SEDAR 50 was not feasible. Future work may allow for the use of Blueline Tilefish ages in future stock assessments. In the absence of reliable ages, age composition data, growth curves, maximum age estimates, and subsequently estimates of natural mortality used in the previous assessment were rendered invalid, and could not be used in the current assessment. Nonetheless, the assessment proceeded with the available data.

Following the unexpected results of the age workshop, the analytical team considered alternative modeling approaches in preparation for the SEDAR 50 Data Workshop, held January 23-27, 2017. Though it is impossible to know what approaches can be used prior to examining the available data, the analytical team expected to apply age-aggregated surplus production models (AAPM) using ASPIC software and data limited methods (DLM) using R package DLMtool. The Data Workshop proceeded with these approaches in mind. At the Data Workshop, a meta-analysis of growth parameters from species related to Blueline Tilefish yielded estimates of Von Bertalanffy growth parameters for Blueline Tilefish. Estimates of natural mortality were later calculated from these parameters. Though these growth parameters are not used by age-aggregated surplus production models, they are used in a variety of data limited approaches. Extensive length composition data were also presented at the Data Workshop, leading the analytical team to consider the use of age-structured surplus production model (ASPM) approaches as supporting analyses as well. Such ASPM approaches have been used as supporting analyses in several previous SEDAR assessments (e.g. SFB-NMFS 2016*b*;*a*). Stochastic stock reduction analysis (SSRA) was also considered as a supplementary (Walters et al. 2015).

During the SEDAR 50 Assessment Workshop, held May 23-26, 2017, the assessment panel recommended using the age-aggregated surplus production model as the primary model for management advice of Blueline Tilefish from the SAFMC/GMFMC border to Cape Hatteras, and considered DLM, ASPM, and SSRA as supporting analyses. Limited data north of Cape Hatteras restricted available approaches to those found in the `DLMtool` R package (Carruthers and Hordyk 2016; R Core Team 2016). Data for the Gulf of Mexico was more extensive and allowed for analysis with the ASPIC model as well as DLM.

4 Stock Assessment Models and Results

4.1 South Atlantic: Age-aggregated Production Model (ASPIC)

4.1.1 Methods

4.1.1.1 Overview

An age-aggregated logistic surplus production model, implemented in ASPIC (Version 7.03; Prager 2015), was used to estimate stock status of Blueline Tilefish off the southeastern U.S. This model focuses on the dynamics of the removals as they relate to the indices of abundance, while ignoring any age data or age-structure in the population.

4.1.1.2 Data Sources

Data sources supplied to an AAPM include a time series of removals (i.e. landings plus dead discards) and one or more indices of abundance (i.e. catch per unit of effort). These inputs should be in units of biomass (i.e. weight), therefore some of the data developed at the SEDAR50 DW required additional formatting. These changes are detailed below.

4.1.1.3 Removals

As noted in §3, the spatial range of removals (landings plus dead discards) included in early versions of this assessment extended from the SAFMC/GMFMC boundary north through the Mid-Atlantic. But in the current version of the assessment, removals north of Cape Hatteras were excluded in order to match the spatial range represented by the indices. Figure 2 shows the large increases in landings north of Cape Hatteras after 2005, which drove this decision. Figure 4 shows that a large portion of that increase is recreational landings beginning in the mid-2000s. The major increase in commercial landings didn't occur until 2008.

The removals actually used in the assessment of South Atlantic Blueline Tilefish were restricted to the area south of Cape Hatteras to the SAFMC/GMFMC boundary (Figure 5). These removals are comprised primarily of commercial landings (85%, calculated as a percentage of total removals for all years; 1958-2015) followed by recreational landings (12%; 1973-2015). Most of the recreational landings are MRIP landings from the Florida east region from 2013. The remaining 3% of the removals are commercial (1.7%; 1993-2015) and recreational (0.71% ; 1991-2015) dead discards. The majority of removals are from Florida ($\approx$ 56%) with similar proportions from South Carolina ($\approx$ 23%) and North Carolina south of Cape Hatteras ($\approx$ 18%), and a small portion from Georgia ($\approx$ 2.6%); Figure 6).

Commercial

The SEDAR50 DW reported commercial landings and discards in pounds, thus these data did not need to be modified for the AAPM.

Recreational The SEDAR50 DW reported recreational landings in pounds, thus these data did not need to be modified for the AAPM. However, recreational discards were provided in numbers and needed to be converted to weight.

Recreational discards were converted from numbers to pounds by multiplying by a smoothed vector of annual mean weights. This conversion was done with mean weight vectors that were specific to that fleet and region, since fish of different sizes may be caught by each fleet and area combination. Each mean weight vector was generated by first dividing annual recreational landings in pounds by annual recreational landings in numbers. These data weren't available for every year that discards were present, so missing values for early years were filled with the value from the first available year and missing values for late years were filled with the value from the last available year. Data gaps between years were filled with linear interpolation. This filled vector was then smoothed using a 9 year moving average to reduce noise in the time series.

Dead Discards

Discard estimates were provided in numbers at the SEDAR-50 DW. Since some discarded fish survive after release, discard mortality rates were applied to discards in numbers to calculate dead discards. For commercial discards, a discard mortality rate of 0.95 was applied for all years. For recreational discards, a discard mortality rate of 0.82 for all years. These discard mortality rates were specified at the Data Workshop.

Indices of Abundance

Three indices of abundance were produced at the SEDAR-50 DW for Blueline Tilefish: commercial handline, commercial longline, and recreational headboat (Figure 7). The commercial indices were already in units of weight (pounds) and did not need to be converted. The headboat index was generated in numbers. In early runs, the headboat index was converted to pounds using annual mean weight vectors, as indicated above for recreational discards. However, the mean weight vector for headboat exhibited an extremely large decrease over time (roughly 4.6 lbs decreasing to 2.0 lbs over 30 years). This decrease was judged by the Assessment Workshop Panel not to represent the true change in size in the Blueline Tilefish caught by the headboat fleet, and was thought to be an artifact of variation in sampling over time. Thus it was recommended that the unreliable temporal trend not be incorporated into the index. The headboat index could have been multiplied by a constant mean weight instead, though this would have no effect once the index was re-standardized to a mean of one, and because the conversion would be absorbed by ASPIC's estimate of catchability. Thus it remained unchanged from the version generated in numbers.

The headboat index also had other problems which ultimately led to it not being included in base model runs. Sample sizes for this index were very small in the 1990s. The spatial range of the headboat fleet also tended to cover only part of the spatial range of Blueline Tilefish distribution, and there were concerns of spatial range of the index varying over time. Despite work to restrict the trips used to develop this index based on presence of co-occurring species, effective effort was difficult to characterize when developing this index. In the final index, large swings in estimated abundance in the early part of the time series seemed uncharacteristic of a species expected to be long-lived. Overall the headboat index was negatively correlated with the commercial indices, which can also be problematic for the ASPIC model.

4.1.1.4 Model Configuration and Equations

Production modeling used the model formulation and ASPIC software (version 7.03) of Prager (1994; 2015). This is an observation-error estimator of the continuous-time form of the Schaefer (logistic) production model (Schaefer 1954; 1957). Estimation was conditioned on catch. The logistic model for population growth is the simplest form of a differential equation which satisfies a number of ecologically realistic constraints, such as a carrying capacity (a consequence of limited resources). When written in terms of stock biomass, this model specifies that

$$\frac{dB_t}{dt} = rB_t - \frac{r}{K}B_t^2 \tag{1}$$

where B_t is biomass in year t, r is the intrinsic rate of increase in absence of density dependence, and K is carrying capacity (Schaefer 1954; 1957). This equation may be rewritten to account for the effects of fishing by introducing an instantaneous fishing mortality term, F_t :

$$\frac{dB_t}{dt} = (r - F_t)B_t - \frac{r}{K}B_t^2 \tag{2}$$

By writing the term F_t as a function of catchability coefficients and effort expended by fishermen in different fisheries, Prager (1994) showed how to estimate model parameters from time series of yield and effort.

The AAPM was configured using various combinations of removals, indices, starting dates, prior distributions and starting values, resulting in hundreds of configurations. Many of these runs were completed during early model development while others incorporated small changes to data inputs or model specifications suggested by AW panel members during the Assessment Workshop. While most SEDAR stock assessments identify a single base run, the SEDAR50 AW Panel judged two runs to be equally plausible, so both are presented below.

4.1.1.5 Biological reference points

Biological reference points (benchmarks) were calculated based on maximum sustainable yield (MSY). Computed benchmarks included MSY, fishing mortality rate at MSY (F_{MSY}), and total biomass at MSY (B_{MSY}).

4.1.1.6 Configuration of base runs

The AW Panel identified two runs that were considered equally plausible, serving as essentially two base runs:

- Run 55 Include only handline index.
- Run 56 Include only longline index.

These configurations do not necessarily represent reality better than other possible configurations, and thus this assessment attempted to portray uncertainty in point estimates through sensitivity analyses and through a bootstrap approach (described below). The two model configurations differed in the indices that they included. Run 55 included only the commercial handline index while run 56 included only the commercial longline index. Both runs contained removals from 1958 to 2015, and since removals were minimal prior to 1973, the value of B_1/K in the model was fixed a 1.0. All other fitted parameters were initialized with the same starting values and were allowed to vary over wide ranges during the fitting process.

4.1.1.7 Sensitivity analyses

Sensitivity runs were intended to demonstrate directionality of results with changes in inputs or simply to explore model behavior, and not all were considered equally plausible. These model runs vary from the base run as follows:

- S1: (Run 51) Include handline, longline, and headboat indices.
- S2: (Run 52) Include only handline and headboat indices.
- S3: (Run 53) Include only longline and headboat indices.
- S4: (Run 54) Include only handline and longline indices.
- S5: (Run 57) Include only headboat index.
- S6: (Run 74) Continuity run, similar to SEDAR 32 configuration: include handline, longline, and headboat indices; include all Atlantic landings (Key West through Mid-Atlantic); start year 1974.
- S7: (Run 75) Include handline, longline, and headboat indices; include all Atlantic landings (Key West through Mid-Atlantic); start year 1958.

4.1.1.8 Parameters Estimated

The ASPIC model fits three main parameters (B_1/K, MSY, and F_{MSY}) as well as catchability coefficients (q_i) for each index i. Note that in most models presented here, $B_1/K$was fixed at 1.0 to reflect that removals prior to the start of the time series used were likely to have resulted in limited impact on stock abundance. Several other parameters can then be derived from these estimates: $r = 2F_{\mathrm{MSY}}$, $K = 2\mathrm{MSY}/F_{\mathrm{MSY}}$ and $B_{\mathrm{MSY}} = K/2$. These parameters were estimated in both the handline and longline models, and then the model estimates were averaged to produce final estimates.

4.1.1.9 Benchmark/Reference Point Methods

The maximum fishing mortality threshold (MFMT) is defined by the SAFMC as F_{MSY}, and the minimum stock size threshold (MSST) is defined as $75\%B_{\mathrm{MSY}}$. Overfishing is defined as $F >$ MFMT. Overfished status was defined as $B <$ MSST. See Management Overview section of this report (section I 2) for further details.

Current status of the stock is represented by B in the terminal year of the assessment (2015), and current status of the fishery is represented by the geometric mean of F from the last three years (2013–2015; F_{current}). Recent SEDAR assessments have considered the mean over the terminal three years to be a more robust metric. Since this assessment resulted in two equally plausible models, the status determinations were made by comparing average B with average B_{MSY}, and average $F_{\mathrm{current}}$with average F_{MSY}.

4.1.1.10 Uncertainty and Measures of Precision

To evaluate the uncertainty in the model fit and parameter estimates of the base runs, 1000 bootstrap runs were conducted for each of the two models. Percentile confidence intervals were also then calculated for parameters from all 2000 runs (i.e. 1000 runs from each of the two base runs).

4.1.1.11 Projections

Projections were run to predict stock status up to five years after the assessment (2016–2020).

The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment. Three different sets of projections were run, with F held constant during the projection period at F_{MSY}, F_{current}, or F_{target}, where $F_{\text{target}} = 0.75\% F_{\text{MSY}}$

Uncertainty in future time series was quantified through stochastic projections that extended the bootstrap fits of the stock assessment model. The data input to the projections includes the F and B time series from the observed run and each bootstrap run, and the corresponding B_{MSY} and F_{MSY} values from each. In this case, the projection procedure was supplied with B and F data from all bootstrap runs, as well as average B and F series from the observed handline and longline runs (i.e. runs 55 and 56). Further details of the projection procedure used by ASPIC are provided in detail by the ASPIC User's Guide (Prager 2015).

Central tendencies were represented by the deterministic projections of the average B and F series, as well as by medians of the bootstrap projections. Precision of projections was represented graphically by the 5^{th} and 95^{th} percentiles of the replicate projections.

4.1.2 Results

4.1.2.1 Model Fit

For the ASPIC base runs of Blueline Tilefish south of Cape Hatteras, trends in predicted indices were very similar (Figure 8, 9). The predicted indices follow the general trend in the indices for both models, though do not follow most of the short term increases and decreases.

4.1.2.2 Parameter Estimates

Average estimates of the main ASPIC model parameters as well as benchmarks and status indicators are presented in Table 4.

4.1.2.3 Total biomass

Average estimated biomass was at virgin levels until the early 1970s when landings began to increase (Figure 10). Estimated biomass then decreased gradually for a about a decade before a spike in landings occurred, primarily comprised of commercial landings caught south of Cape Canaveral, Florida, and to a lesser degree, increased commercial landings off South Carolina (Figure 6). The peak of this spike in 1982, at approximately 10 times pre-1980 levels, drove a drop in estimated biomass. After 1982, landings in south Florida and South Carolina decreased rapidly until the late 1980s, at which point they were similar to levels observed in the early years of the fishery. The indices begin in the early 1990s, as landings gradually decreased. Landings continued to decrease to a low in 2011, caused by a deepwater closure for Blueline Tilefish (which lasted from January 31, 2011 to May 10, 2012). Landings jumped back up in the last three years of the assessment. A large landings spike in 2013 was driven by recreational landings (MRIP) in the Florida east region (Florida counties from Miami-Dade north).

4.1.2.4 Fishing mortality

The time series of average estimated fishing mortality (Figure 11) generally reflects the pattern in the removals time series (Figures 5 and 6). Estimated F remained very low until the early 1980s, spiking in 1982, then decreasing rapidly until 1988. Another substantial increase followed, peaking in the mid 1990s at about half the peak in 1982, before gradually decreasing to a low in 2011, the year of the deepwater closure. The F series also shows the 2013 landings spike, and return to moderate levels of landings in 2014 and 2015. Geometric mean F from 2013 to 2015 is relatively low for the time series (F_{current}= 0.134).

4.1.2.5 Benchmarks / Reference Points

Reference points estimated were F_{MSY}, MSY, and B_{MSY}. Based on F_{MSY}, three possible values of F at optimum yield (OY) were considered ($F_{\text{OY}} = 65\% F_{\text{MSY}}$, $F_{\text{OY}} = 75\% F_{\text{MSY}}$, and $F_{\text{OY}} = 85\% F_{\text{MSY}}$). Standard errors of benchmarks were approximated as those from bootstrap analysis (§4.1.1.10).

Average estimates of benchmarks from the handline and longline runs and median values from the bootstrap analysis are summarized in Table 4. Estimates of MSY-related quantities were $F_{\text{MSY}} = 0.146$, MSY = 212 klb, and $B_{\text{MSY}} =$ 1467 klb. Distributions of these benchmarks are shown in Figure 12.

4.1.2.6 Status of the Stock and Fishery

Time series of estimated stock status (B_{2015}/B_{MSY} and B_{2015}/MSST) showed a nearly unexploited stock until the early 1980s when stock status dropped from near $2B_{\text{MSY}}$ to below $0.5B_{\text{MSY}}$ by 1987 (Figure 13). Biomass subsequently remained below B_{MSY} until recently. Following a bump above $0.5B_{\text{MSY}}$ by 1991, biomass gradually decreased again until 1998, and then increased exponentially until exceeding B_{MSY} in 2012 and reaching a peak in 2013. Biomass has decreased in the last two years following a landings spike in 2013, but remains above B_{MSY} in 2015 and is not currently considered overfished ($B_{2015}/B_{\text{MSY}} = 1.06$, B_{2015}/MSST = 1.41). Though these estimates are highly uncertain, nearly 95% of bootstrap runs show B_{2015}/MSST > 1.0 (Figure 12).

The time series of estimated F/F_{MSY} suggests that fishing mortality of Blueline Tilefish in the US South Atlantic had been above F_{MSY} for most years between 1981 and 2003, a period of over 20 years. Since then F has been below F_{MSY} in all years except 2013. Based on the three most recent years, $F_{\text{current}} < F_{\text{MSY}}$, and overfishing is not currently occurring ($F_{2013-2015}/F_{\text{MSY}} = 0.92$). However, this estimate is highly uncertain with 90% confidence bootstrap confidence intervals containing both 0.5 and 1.5. Nearly 50% of bootstrap runs resulted in estimates of $F_{2013-2015}/F_{\text{MSY}} > 1.0$ (Figure 12).

4.1.2.7 Sensitivity

Distributions of main model parameters from combined handline and longline model bootstrap runs show moderate uncertainty, while distributions of status indicators tended to show large uncertainty (Figure 12). All distributions were bimodal with the median of distribution close to the peak of the taller mode. Average estimates from the handline and longline models were always close to the median and taller mode of the bootstrap runs. None of the bootstrap runs for the handline model had convergence issues, while 4.9% of longline model runs were rejected due to parameter estimates hitting upper and lower bounds (4% F_{MSY}; 0.9% MSY).

Main model parameters and status indicators for all sensitivity runs are presented in Table 5. Across all runs, inclusion of the headboat index had a large effect on model parameter and status estimates. The likelihood component for the headboat index was very large compared to the handline and longline indices, perhaps due to the length of the time series. The headboat index also did not show the same trend as the two commercial indices (Figure 7), but rather showed a general decline in abundance since about 1991. Including handline and longline indices in the same model (Run 54) resulted in a model that was very similar to the handline only model (Run 55) in terms of both parameter estimates and status trends (Table5; Figures 8 and 20). This is apparently due to the much smaller error bars around the handline index versus the longline index, which causes it to be fit much more more closely when the indices are included in the same run.

The sensitivity runs include continuity run (Run 74) which most closely mimics the ASPIC model presented in SEDAR 32 (SEDAR 32 2013, ; their Figures 3.52-3.54). They include the same start year (1974), B_1/K fixed at 1.0, the same spatial range of removals (all Atlantic removals to the GMFMC/SAFMC boundary), and the same set of indices (commercial handline, commercial longline, and recreational headboat). Note however that the removals series and indices themselves were developed separately and that the indices span different ranges of years. Both the current Run 74 and the SEDAR 32 ASPIC model estimate B/B_{MSY} and F/F_{MSY} to be below one in the terminal year of SEDAR 32 (2011). Trends in F/F_{MSY} were very similar for both models, and trends in B/B_{MSY} were generally similar. However, in the current Run 74 B/B_{MSY} increased substantially between the mid-1980s and the mid-2000s, while the SEDAR 32 ASPIC model estimated B/B_{MSY} to be very flat during that period. This may be explained by the different time spans in the headboat index. In the current assessment, the headboat index spans 1980-2005 and the two commercial indices begin in 1993. It shows a substantial decline from 1980-1984, but then a similarly rapid increase to 1988. The index drops quickly to low values in 1989 and 1990, but then rapidly increases again by the next year, and remains relatively high for the rest of the time series. The commercial indices are relatively flat for most of the time series, increasing only in the last few years. For the first 12 years of the headboat index, it is the only index of abundance ASPIC is fitting to. The model seems to follow it's early decline and increase up until the other indices before gradually increasing to fit the late increase observed in the commercial indices. In SEDAR 32 the commercial indices also started in 1993, but the headboat index only spanned 1980-1992. The headboat index showed a decline from 1980-1990, before increasing rapidly until 1992. After then commercial indices begin in 1993, the longline index shows a decrease until in ends in 2004, while the handline index shows a gradual increase until it ends in 2010. This disagreement in the commercial indices probably led the model to fit a relatively flat line through them. Increased landings after 2005 led B/B_{MSY} both the SEDAR 32 ASPIC model and the current Run 74 to decrease rapidly.

Run 75 was nearly identical to Run 74, but started the model in 1958, like the current base runs. Comparison with Run 51, which included the same handline, longline, and headboat indices, demonstrates sensitivity to the inclusion of removals north of Cape Hatteras (compare Figures 2&4 with 6&5). The production model parameters are determined primarily during the years before the indices end, which precede the increase in removals which occurred in North Carolina north of Cape Hatteras, and before most of the known removals in the Mid-Atlantic. Including the removals from an area not represented by the indices leads to rapid decline in stock status and increase in fishing mortality. Estimates of F_{MSY} for this model are within the range of the other runs. Estimates of MSY are about 25% higher than the upper end of the range for the other model runs.

4.1.2.8 Projections

Projections all show B/B_{MSY} above 1.0 for all years from 2016-2021, whether considering the expected value or the median of the projections (Figures 24, 25, and 26). The probability of $B > B_{\mathrm{MSY}}$ in 2021 ranged from 0.61 when F was fixed at F_{MSY} to 0.80 when F was fixed at F_{target}, starting in 2017 (Tables 6,7, and 8).

4.1.3 Discussion

4.1.3.1 Comments on the Assessment

The averaged estimates from the ASPIC handline and longline models indicate that Blueline Tilefish from the SAFMC/GMFMC boundary to Cape Hatteras, NC, is neither overfished nor undergoing overfishing. However, there remains notable uncertainty in overfishing status. Results of uncertainty analysis showed that nearly 35% of bootstrap runs found Blueline Tilefish in this region to be undergoing overfishing (Figure 16).

Several of the sensitivity runs also showed status that was neither overfished nor undergoing overfishing, however models including only the handline index (Run 55) or both the handline and longline index in a single model (Run 54) resulted in overfishing and in $B_{2015}/B_{\mathrm{MSY}}$ below 1.0 (Table 5). Any run that included the headboat index showed very different F and B trends. Models excluding the headboat index showed a population which had been greatly reduced following high levels of landings in the early 1980s, and then remained below B_{MSY} for over two decades. Models including the headboat index showed the same drop in biomass after large landings in the early 1980s, but estimated that the population was only below B_{MSY} for a few years before recovering rapidly to abundances greater than $1.5B_{\mathrm{MSY}}$.

The model was even more sensitive to including removals north of Cape Hatteras. This is particularly evident when comparing Runs 51 and 75. Both runs include all three indices, but the latter includes all Atlantic landings. Run 75 shows a much more moderate dip in biomass after the landings spike in the early 1980s that never goes below B_{MSY}. Following that dip, the population gradually recovers until 2006 before quickly dropping through the end of the assessment (Figure 23). The comparison between these runs suggested that the inability to include data from the recent increase or expansion of the fishery north of Cape Hatteras may greatly impact the uncertainty in stock status.

A continuity run, parameterized similar to the ASPIC model used in SEDAR 32 (Run 74), shows a relatively similar pattern in F and B status trends between SEDAR 32 and the current assessment. Both models show a large dip following the increase in removals in the early 1980s, but remain above B_{MSY}. In SEDAR 32, biomass was then steady until 2006, before decreasing gradually to just below B_{MSY} in 2011 (i.e. the terminal year of the assessment; SEDAR 32 2013). In the current continuity run, biomass gradually increased after the 1980s dip until 2006, then rapidly dropped. In 2011, biomass estimated by Run 74 was also below B_{MSY}, and was about 20% lower than in SEDAR 32. After 2011, with continuing high levels of removals, biomass estimated in Run 74 continued to drop (Figure 22).

In this assessment there was a mismatch between the spatial range of the data that could be modeled effectively, and the apparent spatial range of the biological population. Though the available data were imperfect, the Stock ID Work Group observed (SEDAR 50 Stock ID Work Group 2016) and the SSC Panel recognized (Joint SSC Sub-Panel 2016) that Blueline Tilefish may exist as a single biological population from the Gulf of Mexico through their northern range in the Mid-Atlantic. However, concerns over genetics sample size in Gulf of Mexico lead the Leadership group to recommend that the SAFMC/GMFMC council boundary be used as the southern extent of the current assessment (Council, Science Center and Regional Office Leadership 2016). And though initial runs of an Atlantic only model of Blueline Tilefish were conducted, an important mismatch between the spatial range of the indices and the removals series led the removals series to be truncated at Cape Hatteras. The current assessment must therefore assume exchange of adults and offspring between the modeled region and the adjacent regions are negligible, though this is likely not the case.

4.1.3.2 Comments on the Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- In general, projections of fish stocks are highly uncertain, particularly in the long term (e.g., beyond 5–10 years).
- Projections conducted in ASPIC only included uncertainty in indices, based on bootstrapping residuals, and did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics.
- F_{current} was assumed to be equal to the geometric mean F from the last three years of the assessment period (2013-2015).

4.2 South Atlantic: Age-structured Production Model (ASPM)

4.2.1 Methods

4.2.1.1 Overview

An age-structured production model was built by modifying code for the Beaufort Assessment Model (BAM) similar to what was done in previous SEDAR assessments (e.g. SFB-NMFS 2016*b*;*a*). The ASPM models age-structured processes (e.g. growth, mortality, reproduction) but does not utilize age-composition data and models recruitment with a deterministic Beverton-Holt stock recruit function. Though an age workshop found aging data to be invalid for blueline tilefish, extensive length data were available for Blueline Tilefish, as well as fecundity and maturity-at-length information (SEDAR50 DW Report 2017). At the SEDAR 50 data workshop, growth parameters, constant natural mortality, and stock recruit model parameters were estimated using meta-analysis, allowing an ASPM to be parameterized. Model structure and equations of the BAM are detailed by Williams and Shertzer (2015). A general description of the assessment model follows.

The assessment time period was 1970–2015. New biomass was acquired through growth and recruitment, while abundance of existing cohorts experienced exponential decay from fishing and natural mortality. The population was assumed closed to immigration and emigration. The model included age classes $1 - 20^{+}$, where the oldest age class 20^{+} allowed for the accumulation of fish (i.e., plus group).

4.2.1.2 Data Sources and model structure

A growth model was estimated for Blueline Tilefish based on available length data and a meta-analysis of growth models for related species ($L_{\infty} = 690$ mm TL, $K = 0.16\text{yr}^{-1}$, $t_0 = -1.33$ yr; Figure 27). The Charnov method was used to estimate age-dependent M, scaled by constant M. Constant natural mortality was calculated from estimated maximum age ($t_{\max}$) for related species, and the $t_{\max}$-based estimation equation recommended by Then et al. (2014; $t_{\max} = 40$ yr; $M = 0.17$). Female maturity was a knife edged function with length at 50% maturity (L_{50}) of 305. When converted to age, this resulted in females maturing at age-1 (Figure 27). Batch fecundity (f_b) was a function of length ($f_b = e^{7.31+0.00701\text{L}}$) which was multiplied by the average number of batches females produce per year ($n_b = 94$) to calculate annual fecundity at length. Parameters of a Beverton-Holt stock recruit function were also derived from meta-analysis (steepness parameter $h = 0.836$, $log(R_0) = 12.9$). Spawning stock was modeled using population fecundity (eggs) measured at the time of peak spawning. For Blueline Tilefish, peak spawning was considered to occur in May. Expected recruitment of age-1 fish was predicted deterministically from spawning stock using the Beverton–Holt spawner-recruit model.

The ASPM included the same landings and discard data as the ASPIC model, and assumed the same rates of discard mortality, but was modeled removals (landings and dead discards combined by fleet) as three separate fleets: commercial handlines (hook-and-line) combined with commercial other (a small portion of total removals; 1970-2015), commercial longlines (1970-2015), and general recreational (headboat and MRIP; 1973-2015; Table 2). The model was fitted to these data on annual removals (in numbers for the recreational fleets, in whole weight for commercial fleets); annual length compositions of removals (commercial handline, 1983-2015; commercial longline, 1984-2015; and general recreational, 1972-2015; Table 9); and the three fishery dependent indices of abundance available to ASPIC (commercial handline, 1993-2007; commercial longline, 1993-2006; and recreational headboat, 1980-2005; Table 3; Figure 7).

The combined landings and discards were modeled with the Baranov catch equation (Baranov 1918) and were fitted in units of weight (1000 lb whole weight, commercial) or numbers of fish (1000 fish, recreational).

For each time series of landings, the assessment model estimated a separate full fishing mortality rate (F). Age-specific rates were then computed as the product of full F and selectivity at age. Apical F was computed as the maximum of F at age summed across fleets.

Selectivity curves applied to landings and CPUE series were estimated using a parametric approach. This approach applies plausible structure on the shape of the curves, and achieves greater parsimony than occurs with unique parameters for each age. Selectivity of landings from the commercial and recreational fleets were modeled as flat-topped, using a two parameter logistic function. Selectivities of the fishery dependent indices (handline, longline, and headboat) were assumed the same as the respective fisheries. Two selectivity blocks were used for the general recreational fleet (1970-1990, 1991-2015), due to trends in residuals in the length composition data.

Biological reference points (benchmarks) were calculated based on maximum sustainable yield (MSY) estimates from the Beverton–Holt spawner-recruit model with bias correction (expected values in arithmetic space). Computed benchmarks included MSY, fishing mortality rate at MSY (F_{MSY}), and spawning stock at MSY (SSB_{MSY}). In this assessment, spawning stock measures total number of eggs produced by mature females (i.e. population fecundity). These benchmarks are conditional on the estimated selectivity functions and the relative contributions of each fleet's fishing mortality. The selectivity pattern used here was the effort-weighted selectivities at age, with effort from each fishery estimated as the full F averaged over the last three years of the assessment.

The fitting criterion was a penalized log-likelihood approach in which combined removals series were fit closely, and observed composition data and abundance indices were fit to the degree that they were compatible. Landings and indices were fitted using lognormal likelihoods. Length composition data were fitted using Dirichlet-multinomial likelihoods.

4.2.1.3 Sensitivity analyses

Sensitivity runs were intended to demonstrate directionality of results with changes in inputs or simply to explore model behavior, and not all were considered equally plausible. These model runs vary from the base run as follows:

- ASPM S1: 100% female maturity at age-6.
- ASPM S2: 100% female maturity at age-12 (based on Charnov and Berrigan 1990).
- ASPM S3: Constant $M = 0.1$ ($t_{\max} = 40$; use Hoenig 1983 equation).
- ASPM S4: Constant $M = 0.248$ ($t_{\max} = 26$; use Then et al. 2014 equation).
- ASPM S5: 100% female maturity at age-6 and constant $M = 0.1$.
- ASPM S6: South Atlantic Golden Tilefish life history (Von Bertalanffy growth model, M, and female maturity vector).
- ASPM S7: South Atlantic Golden Tilefish Von Bertalanffy growth model only.
- ASPM S8: SEDAR 32 Blueline Tilefish life history (Von Bertalanffy growth model, M, and female maturity vector).
- ASPM S9: SEDAR 32 Blueline Tilefish life history (Von Bertalanffy growth model, M, and female maturity vector), include length composition data and removals both north and south of Cape Hatteras.
- ASPM S10: SEDAR 32 Blueline Tilefish life history (Von Bertalanffy growth model, M, and female maturity vector), include length composition data and removals both north and south of Cape Hatteras, fit recruitment deviations.
- ASPM S11: Include length composition data and removals both north and south of Cape Hatteras.

- ASPM S12: Include only handline and longline indices.
- ASPM S13: Include only handline index.
- ASPM S14: Include only longline index.
- ASPM S15: Include only headboat index.

4.2.2 Results

Fits to annual length composition data are presented in Figure 28. Fits to removals series are presented in Figures 29, 30, and 31. Fits to indices of abundance are presented in Figures 32, 33, and 34.

Estimated abundances and biomass-at-age are shown in Tables 10, 11, and 12, and Figures 35 and 36. The estimated recruitment time series is presented in 37. The estimated total and spawning stock biomass (eggs) time series are shown in Figure 38. Predicted and average selectivities are plotting in Figures 39 and 40.

Estimated trends in stock status are presented in Figure 46 and Table 13. Benchmarks are presented in Table 21. Status trends from sensitivity runs are compared with the base run in Figures 47, 48, 49, 50, and 51). The results of all ASPM sensitivity runs are summarized in Table 22 and Figure 54.

4.2.3 Discussion

Though the BAM age-structured production model was much more complex than the ASPIC model, most of the life history data that went into it was highly uncertain. The AW Panel therefore recommended that it be used only as a supplementary. As mentioned above growth model, estimate of natural mortality, and stock-recruit parameters were based on meta-analyses of other species. The estimate of L_{50} was based on a fairly large data set, but including only four immature fish. Coupled with the meta-analysis based growth model, this resulted in all females maturing by age-1. Blueline Tilefish is thought to be fairly long-lived based on its deepwater environment, and ages of related species, and was assumed to have a maximum age of 40 years. The AW Panel found this maturity schedule to be unrealistic for Blueline Tilefish for a long-lived fish. It was also discussed that many of the samples used for maturity analysis were from fisheries that may be targeting spawning aggregations.

The model fits to the indices were generally poor, but not unreasonable for this type of model. The fits to the annual length composition data were generally good. The trends in estimated B/B_{MSY} and F/F_{MSY} from the ASPM (Figure 46) are very similar to trends in any ASPIC model runs that included the headboat index (17, 18, 19, and 21). However the ASPM results estimate that B/B_{MSY} has never been below one and F/F_{MSY} has never been above one.

Several runs which incorporated other plausible values of life history parameters supplied to the model showed that the ASPM was very sensitive to life history assumptions (Table 22 and Figure 54; S01-08). This is demonstrated best in ASPM sensitivity runs S05 and S06, which produced results most different from the base run among the runs where only life history traits were modified. In S05, the model was supplied with an age at 100% maturity (age-6) near the age of 50% selectivity, as well as an estimate of constant natural mortality based on a maximum age of 40, but using an equation from Hoenig (1983) instead of the more recent Then et al. (2014) equation. Note that this estimate of M was used in previous SEDAR assessments for Blueline Tilefish (SEDAR 32 2013) and Golden Tilefish (SEDAR 25 2016). In S06, the model was supplied with the main life history parameters used for Golden Tilefish (i.e. Von Bertalanffy growth parameters, M, and maturity-at-age vector). Both runs portrayed a stock with $F_{2013-2015}/F_{\mathrm{MSY}}$ above one, and $\mathrm{SSB}_{2015}/\mathrm{SSB}_{\mathrm{MSY}}$ below one, though only S06 had a $\mathrm{SSB}_{2015}/\mathrm{MSST}$ less than one. These runs help demonstrate that the status determinations from the ASPM were highly dependent upon life history assumptions, and was therefore not recommended to be used as a basis for management.

4.3 South Atlantic: data limited methods (DLMtool)

Though data limited methods were not necessary to apply to Blueline Tilefish south of Cape Hatteras, they were useful in other regions. An analysis of Blueline Tilefish south of Cape Hatteras using data limited methods is presented here, primarily for comparison with analogous results for areas north of Cape Hatteras and in the Gulf of Mexico.

4.3.1 Methods

The series of length composition data used in this analysis was restricted to the fleet and time period with the most apparent signal (commercial handline 1984-1995; Figure 55). The time series of removals used here was restricted to a period when ASPIC models indicated that biomass was stable (1994-2005; 56). Life history data used for ASPM south of Cape Hatteras were also used in analysis with data limited methods. Analyses were conducted using the R package `DLMtool` (Carruthers and Hordyk 2016; R Core Team 2016).

All available data were entered into a `DLMtool` data object (for R users, it's essentially a big list). Though the list of data types entered into this object was broader, the data types that were ultimately relevant to the analysis were the following: Beverton-Holt steepness parameter estimate and CV, catch at length matrix, catch time series and CV, the series of years associated with the catch series, L_{50}, length at full selection estimate and CV, maximum age $t_{\max}$, M estimate and CV, Von Bertalanffy growth parameter estimates (L_∞, K, and t_0) and CVs, and weight-length equation parameters (a and b; $W = aL^b$).

The `TAC` function is then run on that data object. This function first determines what methods (`DLMtool` refers to these as MPs, or management procedures) can be used given the data, then it applies those methods. Each of the MPs is actually run a number of times, and in each run makes random draws of each of the main input data types (e.g. M, L_{50}) from a statistical distribution. The spread of these distributions is determined by user specified CVs. For each MP, the function outputs not a single estimate, but rather a distribution of MSY proxies which `DLMtool` refers to these as TACs.

After applying `DLMtool` functions with 1000 replicates, and filtering out methods that yielded something other than an MSY proxy, there were six MPs that were appropriate for use here. The data types required by each MP are presented in Table 24. These methods are listed by their `DLMtool` abbreviations and briefly described below:

- AvC: Average catch over entire catch time series
- CC1: Average catch over most recent 5 years of catch time series
- CC4: 70% of average catch over most recent 5 years of catch time series
- Fdem.ML: Demographic F_{MSY} method that uses mean length data to estimate recent Z. Uses Gedamke and Hoenig (2006) non-equilibrium mean length method to estimate recent Z, then subtracts M to estimate F_{recent}. Then calculates B_{current} as the most recent year of catch divided by 1-exp(-F_{recent}). Then using life history data, uses the Euler-Lotka equation and solves for r. Then calculates $r/2 = F_{\text{MSY}}$. This estimate of F_{MSY} is then multiplied by B_{current} to estimate a TAC.
- SPMSY: Catch trend Surplus Production MSY MP. Quoting `DLMtool` help file: "An MP that uses Martell and Froese (2013) method for estimating MSY to determine the OFL. Since their approach estimates stock trajectories based on catches and a rule for intrinsic rate of increase it also returns depletion. Given their surplus production model predicts K, r and depletion it is straightforward to calculate the OFL based on the Schaefer productivity curve. OFL = dep x (1-dep) x r x K x 2".

- YPR.ML: Uses Gedamke and Hoenig (2006) non-equilibrium mean length method to estimate recent Z, then subtracts M to estimate F_{recent}. Next, this method conducts a yield-per-recruit analysis to determine the value of F at which the slope of the $YPR = f(F)$ curve is 10% of the slope of this curve at the origin; this value, termed $F_{0.1}$, is used as the F_{MSY} proxy. A TAC is then calculated as the product of this F_{MSY} proxy and the estimate of current abundance.

The two of these methods that use estimates using Gedamke and Hoenig's (2006) method do so by internally calling the `bhnoneq` function from the R package `fishmethods` (Nelson 2016). To better understand the results of these methods, `fishmethods:bhnoneq` function was also run separate from its use in in the `DLMtool:TAC` function.

4.3.2 Results

Distributions of TACs from south of Cape Hatteras DLM analysis are plotted in Figure 57. Quantiles of these distributions for each MP are summarized in Table 23. The observed and estimated mean length series from the `fishmethods:bhnoneq` function are plotted in Figure 58.

4.3.3 Discussion

Distributions of TACs from the three catch based methods as well as SPMSY were quite narrow, while both of the length-based methods were quite broad. However the modes and medians (Table 23) of the length-based methods were closer to the MSY estimated from ASPIC. All TACs estimated with `DLMtool` were lower than the estimate of MSY from the ASPIC models. The median of the medians of all TAC distributions was approximately half of MSY from the ASPIC models. This may be largely dependent on the range of years we included for the average catch calculations. Further discussion of the merits and flaws of these data limited methods is presented in a working paper (Ahrens 2017)

4.4 North of Cape Hatteras: Data limited methods (DLMtool) and spatial measurements of habitat area

As mentioned above, none of the indices of abundance available for SEDAR 50 effectively represented trends in abundance north of Cape Hatteras. Therefore the main stock assessment of Blueline Tilefish in the Atlantic was restricted to areas south of Cape Hatteras to the SAFMC/GMFMC boundary. This section of the Report documents analyses of available data for Blueline Tilefish north of Cape Hatteras attempting to provide guidance to management of the resource in that region.

4.4.1 Methods

4.4.1.1 DLMtool

Data available for the area north of Cape Hatteras were a subset of the available data originally produced for the Atlantic assessment of Blueline Tilefish for SEDAR 50. Therefore the same limitations apply to these data. In particular, this area also lacks valid age data, and age-dependent life history estimates remain highly uncertain. The data north of Cape Hatteras also faces other limitations. Most importantly, there are no indices of abundance that can be used in models north of Cape Hatteras. Therefore production models cannot be used for this region. The primary useful data specific to the area north of Cape Hatteras are therefore a series of length composition data (commercial longline 2007-2015; Figure 59 and a time series of removals (1978-2015; Figure 60). Life history data used for `DLMtool` south of Cape Hatteras were also used in analyses north of Cape Hatteras, though these values were dependent on meta-analysis (e.g. growth, natural mortality), or directly estimated for Blueline Tilefish but primarily based on fish caught south of Cape Hatteras (e.g. maturity, fecundity).

Analyses were conducted using the R package `DLMtool` (Carruthers and Hordyk 2016; R Core Team 2016) in a manner very similar to what was described above for the area south of Cape Hatteras. All the same methods were applied, though the AvC method was applied to three different time series: the entire time series when removals were consistently greater than zero (AvC, 1978-2015), the early part of this time series before the spatial shift in effort (AvC.early, 1978-2005), and during the more recent period after the increase in landings (AvC.late, 2006-2015).

4.4.1.2 Annual removals by potential habitat area

In a separate analysis, removals time series of Blueline Tilefish for the entire Atlantic were grouped by major region (Figure 2). Blueline Tilefish habitat has been described in various ways, relative to depth, temperature, and sediment type, but during the SEDAR 50 Stock ID Workshop, and later at the Assessment Workshop, it was determined that the best way available to define potential Blueline Tilefish habitat was to simply identify areas within the narrow depth range from which most Blueline Tilefish have been caught (73-183 m; 40-100 fathoms). The stratum defined by this depth range was computed using Geographic Information Systems (GIS) software. The amount of potential Blueline Tilefish habitat (area in km^2) within each region was then determined by calculating how much of that depth stratum fell within the polygon bounding each region (Figure 1). The annual removals series for each region was then divided by the potential habitat area of that region, resulting in estimates of removals per unit of potential habitat per (lbs/km^2; Figure 3).

4.4.2 Results

Distributions of TACs from north of Cape Hatteras DLM analysis are plotted in Figure 61. Quantiles of these distributions for each MP are summarized in Table 25. The observed and estimated mean length series from the `fishmethods:bhnoneq` function are plotted in Figure 62.

4.4.3 Discussion

For Blueline Tilefish north of Cape Hatteras AvC and AvC.early produced very tight distributions of TACs, though former was nearly twice the latter, since it includes the high recent catches. AvC.late, based on only a few recent years, tended to produce TACs that were higher than any other methods. AvC, CC1, and CC4, which all drew upon a more erratic series of catches were all more broadly distributed than the other catch-based methods. Still the distributions of TACs from the length-based methods were even broader.

It also seems apparent from the data that the median TAC estimated from AvC.early (52,000 lbs) represents a catch level that was sustained in this region for over two decades. This analysis cannot determine if the recent high levels of catch can be sustained, but it does show that a TACs based solely on high recent catches (AvC.late) tend to be much higher than most of the other methods. The mean length analysis also shows that mean length of fish fully recruited to the fishery has been declining by $\approx$1 cm per year since 2010, which could be a concern if it continued at this rate. Plots of removals by year and region show that this recent increase in landings north of Cape Hatteras is quite substantial compared to historical landings around the Atlantic (Figure 2). The recent increase appears similar to the spike in landings observed in Florida during the early 1980s. The ASPIC models, and the ASPM for the area south of Cape Hatteras both agree that these landings were quite impactful on the population south of Cape Hatteras. Calculations of removals per habitat area seem to emphasize the magnitude of these recent landings even more (Figure 3). In terms of removals per habitat area, the recent landings in North Carolina north of Cape Hatteras appear to be unprecedented, even compared to the 1980s spike in Florida. Though these analyses make a number of assumptions, taken together, they seem to suggest that such high landings over such a small region may be a cause for concern going forward.

4.5 Gulf of Mexico: Age-aggregated production model (ASPIC) and data limited methods (DLMtool)

An ASPIC age-aggregated surplus production model and data limited methods were conducted for Blueline Tilefish in the Gulf of Mexico. These analyses were intended to be used to compare with similar analyses on Blueline Tilefish in the Atlantic south of Cape Hatteras. The main purpose in conducting these analyses was to help understand how trends in the Gulf of Mexico population might affect Blueline Tilefish in the Atlantic south of Cape Hatteras, given the potential for large numbers of eggs and larvae to be transported from the former to the latter.

4.5.1 Methods

Methods used here were nearly identical to what was done in the Atlantic south of Cape Hatteras. Notable differences are described below.

Three indices were available for the Gulf of Mexico from the same fleets (commercial handline 1993-2009, commercial longline 1993-2008, and recreational headboat 1998-2005; Figure 65) though the indices were developed independently from the appropriate regional data. Annual CVs were not available for the headboat index, so it was modeled using the mean CV for the other two indices. The removals series was also compiled in the same way (1958-2015; Figures 63 and 64). Note that in this model, indices also ended several years before the terminal year of the assessment. ASPIC runs for the Gulf of Mexico were completed with all combinations of indices as in the Atlantic, however, in most cases priors were placed on MSY or F_{MSY} due to bounding issues. The model started in 1958 while landings were quite low until the early 1980s, so B_1/K was again fixed at 1.

For `DLMtool` analysis the series of length composition data was from commercial longline from 1991 to 2009 (Figure 72 and the time series of removals was from 1981-2009 (Figure 73) during a period of stable landings prior to recent regulations. Life history data were the same as what were used for `DLMtool` analysis in the Atlantic.

4.5.2 Results

Generally, the models did not fit very well, and the ASPIC model including only the commercial handline index was the only model that converged freely without requiring any priors to be put on MSY or F_{MSY} (Table 26). Thus further analysis continued with the handline model only. The fit to the handline index is generally poor. The model suggested that Blueline Tilefish in the Gulf of Mexico were neither overfished nor undergoing overfishing. The trend in relative biomass suggests that the population was gradually reduced from a virgin state when landings increased in the 1980s, leveled off near $1.5B_{\text{MSY}}$ in the early 1990s , and have been fairly consistent ever since (Figure 66). Bootstrap analyses showed that terminal status estimates and F_{MSY} are particularly uncertain, while MSY is within a range comparable to Blueline Tilefish in the Atlantic 68. A large number of bootstrap runs did not converge (MSY bound issues = 341, F_{MSY} bound issues = 246) and had to be replaced to achieve 1000 runs, showing model instability. Relative B and F series are also very uncertain over time, particularly in recent years (Figures 69 and

70). Phase plots showed that nearly 40% of bootstrap runs showed an overfished status, while slightly over 20% showed the stock to be undergoing overfishing.

Distributions of TACs from Gulf of Mexico DLM analysis are plotted in Figure 74. Quantiles of these distributions for each MP are summarized in Table 27. The observed and estimated mean length series from the `fishmethods:bhnoneq` function are plotted in Figure 75.

4.5.3 Discussion

Estimates of MSY from ASPIC and `DLMtool` analyses generally agreed, except for `DLMtool` length-based MPs, which tended to be higher. ASPIC output suggests that the population has been quite stable since landings picked up in the early 1980s. Landings have been noisy but generally stable since then, though have decreased in recent years since regulations took place in the Gulf. The fit to the mean length data suggest a slight decline in mean size since the early 1990s, but the fit is very poor and the observed data seem to suggest stable mean sizes.

The general pattern in biomass in the Gulf of Mexico ASPIC handline model is similar to that of the combined handline and longline models from the Atlantic south of Cape Hatteras: a decline in biomass in the early 1980s following increased exploitation, which levels out in the by the early 1990s. The major difference is that Gulf of Mexico model suggests that stock was never overfished, perhaps because the increase in landings was never as dramatic as in the south Atlantic.

It is difficult to know if or to what degree production from the Gulf of Mexico stock might contribute to Blueline Tilefish in the Atlantic. But ASPIC model for both regions, and simple estimates of average catch during stable periods in the catch history suggest that the magnitudes the stocks is similar. If a substantial proportion of the egg and larval production from the Gulf of Mexico were to flow into the south Atlantic, it could be an important source of recruitment for south Atlantic Blueline Tilefish.

4.6 Assessment summary discussion

The SEDAR 50 Stock ID Work Group found support for a continuous biological population of Blueline Tilefish from the Gulf of Mexico through the Mid-Atlantic. However the data structure did not support a dataset linking the population (e.g. no single index representing the full range of the stock). Instead the current assessment focused on the region between the SAFMC/GMFMC boundary near Key West, FL and Cape Hatteras, NC. In part because of data availability, Blueline Tilefish in the Gulf of Mexico was assessed separately. Since the available abundance indices were not representative of population trends north of Cape Hatteras, the Assessment Workshop Panel concluded that Blueline Tilefish in the Atlantic should be separately assessed north and south of Cape Hatteras. In the end, the spatial structure of the models in this report was largely driven by data availability and constraints. Accompanying the conclusions from these models needs to be the appreciation of the underlying conceptual model of potential biological linkages described in §3.

A statistical catch-age model implemented using the Beaufort Assessment Model (BAM) had been used in a previous SEDAR assessment of Blueline Tilefish (SEDAR 32 2013), but since then the available age data were determined to be unreliable (Potts et al. 2016). Therefore this assessment relies most heavily on models that do not require ages.

4.6.1 South Atlantic

An average of two ASPIC runs was determined to be the best available information for US South Atlantic Blueline Tilefish population dynamics. Each model run included only one index of abundance, either commercial handline or commercial longline. Averaging the models was preferred to using a single run including both indices since neither abundance index was considered to be better. Fitting the model to both indices simultaneously tends to give more weight to the index with the lower annual CVs. These annual CVs are derived from the standardization process and therefore may not appropriately characterize the uncertainty. The results of the two separate models were generally similar. The averaged estimates indicated that South Atlantic Blueline Tilefish is neither overfished nor undergoing overfishing, though there was considerable uncertainty in this status. The estimate of MSY was 212 klb. It is also important to recognize the additional uncertainty in the dynamics of Blueline Tilefish due to potential movement of adults and/or early life stages into or out of the area assessed. The potential importance of this factor is supported by evidence of genetic homogeneity in Blueline Tilefish over a wide range, distributions, and patterns of drifter movement (SEDAR 50 Stock ID Work Group 2016).

An ASPM for US South Atlantic Blueline Tilefish is provided as supplementary to the ASPIC model. The ASPM model has the advantage of representing age-dependent processes in the population and is able to utilize available length composition data. The major disadvantage of this model was that it also requires life history information, most of which was either based on limited data (e.g. maturity) or derived from meta-analysis (e.g. growth curve, natural mortality, stock-recruit relationship). Landings and abundance indices available to ASPM were the same as for ASPIC. However, the headboat index was included in the main ASPM run out of consideration that it might provide information about a different portion of the population, in concert with length composition data. The rationale for dropping the headboat index didn't apply because it could be accommodated by age-based selectivity. The ASPM estimates indicated that South Atlantic Blueline Tilefish has never been overfished or undergone overfishing. Terminal status estimates were much higher than the ASPIC, as was the estimate of MSY (316 klb). However, sensitivity analyses show large changes in status trends when using life history parameter values previously considered or used for this species, or used in stock assessment of a closely related species (Golden Tilefish; Figures 47, 48, 49, 50, and 51).

Data limited methods were applied to the data from the US South Atlantic (south of Cape Hatteras) primarily for comparison with similar analysis conducted for areas north of Cape Hatteras. These methods were not useful for determining stock status, but estimated distributions of MSY proxies and their medians. The median values of most methods were below the ASPIC estimate of MSY ($58-119$ klb; Table 23; Figure 57), though methods estimating recent Z from length composition data were higher ($263-278$ klb; note that these "ML" methods also incorporate the uncertain estimates of life history parameters used in the ASPM).

4.6.2 North of Cape Hatteras

No indices of abundance effectively represented population trends for Blueline Tilefish in Atlantic waters north of Cape Hatteras. Therefore data limited methods were the primary means used to provide management advice in this region. Available methods estimated MSY proxies that ranged widely (medians $51-474$ klb; Table 25; Figure 61) with minimum and maximum estimates corresponding to average catches during an earlier period of fairly stable catches (1978-2005; AvC.early) and more variable recent period (2006-2015; AvC.late). The other methods attempted include variations on average catch and several methods that employ life history information. Average catch calculated from recent years estimated much higher TACs than other methods. The "ML" methods tended to result in very uncertain estimates, with distributions that were extremely right-skewed. The median TAC estimate from average catches during the earlier 28 year period was the lowest (51 klb), but provides a useful reference as a catch level that was sustainable for nearly three decades. Removals in this region were much higher during the last ten years of the assessment (2006-2015), with a deepwater area closure and catch limits leading to seasonal closures in several years since 2011 affecting the most recent years of landings.

It is not clear if these recent landings are sustainable in the long term, but there is reason to suspect not. The median AvC.late estimate (474 klb) is more than double the estimate of MSY for the area south of Cape Hatteras (ASPIC MSY = 212 klb) or for the Gulf of Mexico (ASPIC Gulf of Mexico Run 10 MSY = 177 klb). In fact, removals north of Cape Hatteras exceeded these MSY values for all individual years between 2006 and 2015 ($245-807$ klb). The recent spike in removals north of Cape Hatteras appears similar only to the removals spike south of Cape Hatteras (Florida) in the early 1980s. ASPIC model runs estimate that that spike drove biomass south of Cape Hatteras below B_{MSY} for almost three decades. Removals of Blueline Tilefish have never exceeded 276 klb in any one year in the Gulf of Mexico. For comparison, total removals of Blueline Tilefish north of Cape Hatteras from 2006-2015 ($4,797$ klb) are approximately 97% of total removals from the Gulf of Mexico from 1958-2015 ($4,942$ klb). Recent removals north of Cape Hatteras also appear to be causing decreases in mean length, at approximately 1cm per year since 2010 (Figure 62).

Relative to potential habitat area, removals in North Carolina north of Cape Hatteras appear to be especially heavy, which may suggest the potential for localized depletion in that area (Figure 3). Removals in the Mid-Atlantic appear low relative to potential habitat area, though this may be somewhat deceptive for two reasons. For one, the estimate of potential habitat area is largely dependent upon the northern boundary used in the calculation. The second reason is that much of that potential habitat area lies north of Hudson Canyon, while most Blueline Tilefish were probably caught south of there.

4.6.3 Gulf of Mexico

The main ASPIC model considered in the Gulf of Mexico (handline index only; Run 10) estimated that the stock was neither overfished nor undergoing overfishing at the end of the assessment. It also suggested it had never been overfished and that overfishing only occurred in one year (Figure 66). Bootstrap results showed uncertainty around the status of the stock and the fishery (Figures 68, 69, 70, and 71) though nearly all ASPIC sensitivity runs produced similar estimates of B/B_{MSY} and F/F_{MSY} (Table 26). Length composition data also suggested that mean lengths of Blueline Tilefish in the Gulf of Mexico have been relatively stable during years since the fishery developed (Figures

72 and 75). Thus it appears that biomass of Blueline Tilefish in the Gulf of Mexico has been relatively steady since the 1990s.

The size and status of the Gulf of Mexico Blueline Tilefish stock may be relevant to management of Blueline Tilefish in the Atlantic, if substantial numbers of eggs and larvae are flowing from the West Florida Shelf into the US South and Mid-Atlantic, as drifters do (SEDAR 50 Stock ID Work Group 2016; Farmer and Klibansky 2016; Klibansky 2017). It is unknown if adult Blueline Tilefish move across Council boundaries, though the distribution of Blueline Tilefish in the Gulf of Mexico appears to be relatively continuous across the SAFMC/GMFMC jurisdictional boundary (Klibansky 2017). Thus Blueline Tilefish wouldn't have to move far to cross this boundary. Genetic homogeneity from the Gulf of Mexico through the Mid-Atlantic suggests that Blueline Tilefish at some life stage are mixing, over at least longer time scales (SEDAR 50 Stock ID Work Group 2016; McDowell 2016; O'Donnell and Darden 2016).

The ASPIC models estimate the Gulf of Mexico Blueline Tilefish stock to have a relatively lower B_{MSY} ($1,000$ klb) than in the Atlantic south of Cape Hatteras ($1,467$ klb). However estimated biomass trends suggest the size of the Gulf of Mexico stock contained more Blueline Tilefish biomass than that Atlantic south of Cape Hatteras for most years since 1983 (Figures 10 and 67). The relatively large estimated size of the Gulf of Mexico stock in recent years further supports the possibility that Blueline Tilefish from the Gulf of Mexico may contribute a substantial amount to recruitment of Blueline Tilefish in the US Atlantic south of Cape Hatteras. If the Gulf of Mexico stock remains at stable levels, this potential source of recruitment may also be expected to stay constant. However, if there was a substantial decline in the Gulf of Mexico, this may have an adverse effect on Blueline Tilefish in the Atlantic.

4.7 Research Recommendations

- Reliable fishery independent indices should be developed, though this would first require a fishery independent survey that samples Blueline Tilefish effectively.
- Aging techniques should continue to be developed for Blueline Tilefish so that future stock assessments may be done using age structured models.
- Genetics samples should be collected from the West Florida Shelf and other areas throughout the Gulf of Mexico to more convincingly determine whether or not Blueline Tilefish in the Gulf of Mexico are part of the same population as Atlantic Blueline Tilefish.
- The search for small blueline tilefish ($< 25cm$), as well as eggs and larvae, should continue. Blueline Tilefish $< 25cm$ are bound to be much more abundant than larger individuals and yet they are rarely encountered by any gear. Eggs and larvae can effectively be identified using genetic techniques, and there are apparently many samples that have been collected but have not yet been genotyped (Lewis et al. 2016). A good place to start would be genotyping more of the available samples. This would also benefit the science on other species.
- Any information on movement of adult Blueline Tilefish, especially movement across Council boundaries would be valuable (e.g. tagging studies). It has been shown that other deepwater tilefish species can be tagged and recaptured (Grimes et al. 1983).
- The possible movement of Blueline Tilefish eggs and larvae between Council regions via ocean currents should be invested further, perhaps with particle tracking models, or more in depth drifter analysis.

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4.9 Tables

*Table 1. Life history traits at age used in the age-structured production model for the Atlantic south of Cape Hatteras, and certain data limited methods in all regions. Length (FL, mm), weight (kg), proportion female (PFemale), proportion of females mature (PMature), Fecundity (millions of eggs), reproductive output, (Reprod=fecundity*PFemale*PMature), and natural mortality (M) at age.*

ages	Age	Length	Weight	PFemale	PMature	Fecundity	Reprod	M
1	1	251	0.20	0.5	0.0		0.00	0.71
2	2	316	0.40	0.5	1.0	1.29	0.64	0.50
3	3	371	0.64	0.5	1.0	1.90	0.95	0.40
4	4	419	0.91	0.5	1.0	2.64	1.32	0.33
5	5	459	1.19	0.5	1.0	3.50	1.75	0.29
6	6	493	1.47	0.5	1.0	4.45	2.22	0.26
7	7	522	1.74	0.5	1.0	5.46	2.73	0.24
8	8	547	1.99	0.5	1.0	6.50	3.25	0.22
9	9	568	2.23	0.5	1.0	7.54	3.77	0.21
10	10	586	2.44	0.5	1.0	8.55	4.28	0.20
11	11	601	2.64	0.5	1.0	9.52	4.76	0.19
12	12	615	2.81	0.5	1.0	10.44	5.22	0.19
13	13	626	2.96	0.5	1.0	11.29	5.64	0.18
14	14	635	3.10	0.5	1.0	12.07	6.03	0.18
15	15	643	3.21	0.5	1.0	12.77	6.39	0.17
16	16	650	3.32	0.5	1.0	13.41	6.70	0.17
17	17	656	3.41	0.5	1.0	13.97	6.99	0.17
18	18	661	3.48	0.5	1.0	14.47	7.24	0.17
19	19	665	3.55	0.5	1.0	14.91	7.46	0.16
20	20	669	3.61	0.5	1.0	15.30	7.65	0.16

Table 2. Observed time series of total removals (landings and dead discards) for the Atlantic south of Cape Hatteras by fleet for commercial handlines (cH), commercial longlines (cL), and general recreational (GR). Commercial values are in units of 1000 lb whole weight. Recreational values are in units of 1000 fish.

Year	cH	cL	GR
1970	1.670	0.493	.
1971	3.499	0.808	.
1972	2.052	0.499	.
1973	10.289	0.685	3.072
1974	24.911	1.038	3.870
1975	43.046	1.790	1.790
1976	42.806	1.576	3.555
1977	28.997	1.914	1.434
1978	68.474	2.610	1.641
1979	55.398	3.225	0.407
1980	141.016	3.470	4.081
1981	391.378	18.688	1.621
1982	990.604	66.813	4.265
1983	425.335	114.194	3.015
1984	299.258	109.907	4.489
1985	276.871	38.774	0.649
1986	120.911	122.526	0.679
1987	72.664	42.710	4.439
1988	49.334	42.098	0.436
1989	51.250	45.728	0.680
1990	78.913	59.214	0.209
1991	105.970	75.152	5.822
1992	89.244	114.836	3.124
1993	54.194	122.781	3.551
1994	54.982	92.208	0.098
1995	47.038	93.014	6.993
1996	82.098	28.988	2.534
1997	92.855	68.553	0.449
1998	55.821	32.591	0.484
1999	46.745	35.998	6.275
2000	59.218	32.736	0.245
2001	71.157	36.030	0.298
2002	50.530	34.328	0.652
2003	47.726	27.511	5.555
2004	31.609	26.249	3.664
2005	39.125	19.367	6.888
2006	40.336	25.548	1.387
2007	40.180	1.787	3.147
2008	29.666	5.708	3.648
2009	35.299	12.141	8.397
2010	30.014	35.404	5.657
2011	4.547	4.606	5.874
2012	18.102	7.289	15.493
2013	33.687	36.642	75.288
2014	24.694	66.195	15.906
2015	61.198	38.248	11.922

Table 3. Observed indices of abundance and CVs for the Atlantic south of Cape Hatteras from commercial handline (cH), commercial longline (cL), and headboat (HB).

Year	cH	cH_{CV}	cL	cL_{CV}	HB	HB_{CV}
1980	.	.	.	.	1.80	0.12
1981	.	.	.	.	0.50	0.18
1982	.	.	.	.	0.54	0.14
1983	.	.	.	.	0.69	0.13
1984	.	.	.	.	0.16	0.20
1985	.	.	.	.	0.18	0.17
1986	.	.	.	.	0.97	0.22
1987	.	.	.	.	1.00	0.26
1988	.	.	.	.	1.72	0.27
1989	.	.	.	.	0.23	0.20
1990	.	.	.	.	0.11	0.20
1991	.	.	.	.	1.71	0.27
1992	.	.	.	.	0.95	0.25
1993	0.92	0.12	1.39	0.27	1.32	0.22
1994	0.78	0.09	0.67	0.28	1.31	0.26
1995	0.75	0.10	1.35	0.33	1.14	0.33
1996	0.99	0.07	0.51	0.36	1.46	0.46
1997	1.11	0.06	1.06	0.26	1.65	0.28
1998	0.75	0.08	0.60	0.31	0.78	0.37
1999	0.74	0.07	0.80	0.29	0.88	0.46
2000	0.82	0.07	0.46	0.30	2.10	0.42
2001	1.09	0.07	0.57	0.30	0.82	0.43
2002	0.91	0.08	2.47	0.26	1.08	0.44
2003	0.95	0.08	0.90	0.29	1.34	0.49
2004	0.96	0.09	0.66	0.35	0.90	0.38
2005	1.09	0.10	1.43	0.33	0.65	0.40
2006	1.68	0.09	1.13	0.46	.	.
2007	1.46	0.08	.	.	.	.

Table 4. Estimated status indicators, benchmarks, and related quantities from ASPIC, averaged between the handline and longline models for the Atlantic south of Cape Hatteras. Also presented are median values and measures of precision (standard errors, SE) from the bootstrap analysis. Rate estimates (F) are in units of y^{-1}*; status indicators are dimensionless; and biomass estimates are in units of 1000 pounds, as indicated.*

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.146	0.148	0.106
$85\%F_{\mathrm{MSY}}$	y^{-1}	0.124	0.126	0.090
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.109	0.111	0.080
$65\%F_{\mathrm{MSY}}$	y^{-1}	0.095	0.096	0.069
B_{MSY}	1000 lb	1467	1452	1225
MSST	1000 lb	1100	1089	918
MSY	1000 lb	212	216	85
$F_{2013-2015}/F_{\mathrm{MSY}}$	—	0.92	0.86	0.96
B_{2015}/MSST	—	1.41	1.55	0.41
$B_{2015}/B_{\mathrm{MSY}}$	—	1.06	1.16	0.31

Table 5. Parameter estimates from selected ASPIC surplus production model runs for the Atlantic south of Cape Hatteras. B_{MSY} and MSY are in units of 1000 pounds. Likelihood components (Lik) are presented for each index and as a total (Lik_{total}). The numerator in F/F_{MSY} is the geometric mean F from the last three years of the assessment (2013-2015) and the numerator in B/B_{MSY} and B/MSST is biomass in the terminal year of the assessment (2015). Abbreviations in Run Name are as follows: HL = handline index, LL = longline index, Hb = headboat index, Atl. = all Atlantic removals are included, 1974 or 1958 indicates the model start year.

Run	RunName	F/F_{MSY}	B/B_{MSY}	B/MSST	B_{MSY}	MSST	MSY	F_{MSY}	Lik_{total}	Lik_{HL}	Lik_{LL}	Lik_{Hb}
51	HLLLHb	0.41	1.67	2.23	1263	947	301	0.238	167.2	23.2	15.7	128.2
52	HLHb	0.41	1.67	2.23	1260	945	299	0.238	151.4	23.2		128.2
53	LLHb	0.39	1.68	2.24	1186	889	316	0.266	143.5		15.7	127.8
54	HLLL	1.06	0.99	1.32	1538	1153	199	0.129	16.9	4.1	12.8	
55	HL	1.07	0.99	1.32	1554	1165	196	0.126	4.1	4.1		
56	LL	0.81	1.13	1.51	1380	1035	228	0.165	12.7		12.7	
57	Hb	0.40	1.68	2.23	1190	892	312	0.262	127.8			127.8
74	Atl.HLLLHb.1974	8.71	0.22	0.30	1769	1327	378	0.214	205.2	46.0	15.1	144.1
75	Atl.HLLLHb.1978	11.27	0.19	0.26	2076	1557	330	0.159	202.3	40.9	15.0	146.5

Table 6. Projection results with fishing mortality fixed at $F = F_{\text{MSY}}$ starting in 2017 from ASPIC for the So. Atl. For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B = median biomass (1000 lbs) estimate of among projections.

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B
2016	0.134	0.77	0.95	1702
2017	0.146	0.76	0.95	1682
2018	0.146	0.72	0.95	1652
2019	0.146	0.69	0.94	1630
2020	0.146	0.65	0.93	1612
2021		0.61	0.92	1593

Table 7. Projection results from ASPIC for the Atlantic south of Cape Hatteras with fishing mortality fixed at $F = F_{\mathrm{current}}$ starting in 2016. F = fishing mortality rate (per year), $P(B > B_{\mathrm{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \mathrm{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B = median biomass (1000 lbs) estimate of among projections.

Year	F(per yr)	$P(B > B_{\mathrm{MSY}})$	$P(B > \mathrm{MSST})$	B
2016	0.134	0.77	0.95	1702
2017	0.134	0.76	0.95	1682
2018	0.134	0.74	0.95	1668
2019	0.134	0.72	0.94	1659
2020	0.134	0.70	0.94	1653
2021		0.67	0.93	1644

Table 8. Projection results with fishing mortality fixed at $F = F_{\text{target}}$ starting in 2017 from ASPIC for the So. Atl. For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B = median biomass (1000 lbs) estimate of among projections.

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B
2016	0.134	0.77	0.95	1702
2017	0.109	0.76	0.95	1682
2018	0.109	0.77	0.96	1704
2019	0.109	0.79	0.96	1723
2020	0.109	0.79	0.96	1736
2021		0.80	0.96	1744

Table 9. Sample sizes (number of trips) of length compositions (len) compositions by fleet used in the ASPM for the So. Atl. Data sources are commercial handline (cH), commercial longlines (cL), and general recreational (GR).

year	len.cH	len.cL	len.GR
1972	.	.	33
1973	.	.	29
1974	.	.	23
1975	.	.	19
1976	.	.	22
1977	.	.	14
1978	.	.	13
1979	.	.	10
1980	.	.	18
1981	.	.	12
1982	.	.	9
1983	5	.	19
1984	49	17	13
1985	71	20	15
1986	40	.	11
1987	31	5	9
1988	25	6	5
1989	31	6	.
1990	32	7	.
1991	38	14	.
1992	26	38	.
1993	40	73	.
1994	31	24	.
1995	42	17	.
1996	24	13	.
1997	20	6	8
1998	17	5	.
1999	34	9	8
2000	52	9	6
2001	48	17	.
2002	33	28	.
2003	43	19	11
2004	46	18	6
2005	45	7	.
2006	49	15	.
2007	62	5	8
2008	64	5	10
2009	69	8	7
2010	65	8	.
2011	40	.	6
2012	53	.	17
2013	58	7	16
2014	28	7	15
2015	13	5	18

Table 10. Estimated total abundance at age (1000 fish) at start of year from the ASPM for the So. Atl.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1970	1157.79	568.65	343.52	231.17	165.92	124.09	95.37	74.80	59.61	48.13	39.21	32.20	26.60	22.08	18.41	15.39	12.91	10.85	9.13	49.55	3105.37
1971	1157.79	568.65	343.52	231.17	165.92	124.09	95.38	74.81	59.62	48.14	39.21	32.20	26.60	22.09	18.41	15.39	12.91	10.85	9.13	49.56	3105.47
1972	1157.79	568.65	343.52	231.17	165.92	124.08	95.33	74.77	59.59	48.11	39.19	32.18	26.59	22.08	18.40	15.39	12.90	10.84	9.13	49.53	3105.18
1973	1157.78	568.65	343.52	231.17	165.92	124.09	95.36	74.78	59.59	48.11	39.20	32.19	26.59	22.08	18.40	15.39	12.90	10.84	9.13	49.54	3105.23
1974	1157.73	568.65	343.52	231.17	165.90	124.02	95.14	74.56	59.40	47.95	39.07	32.08	26.50	22.01	18.34	15.34	12.86	10.81	9.10	49.38	3103.53
1975	1157.50	568.62	343.52	231.16	165.86	123.85	94.65	73.92	58.85	47.50	38.69	31.77	26.25	21.79	18.17	15.19	12.74	10.70	9.01	48.90	3098.65
1976	1157.11	568.51	343.51	231.17	165.93	123.95	94.36	73.28	58.13	46.88	38.18	31.35	25.90	21.50	17.93	14.99	12.57	10.56	8.89	48.25	3092.95
1977	1156.64	568.32	343.44	231.15	165.87	123.81	94.21	72.86	57.47	46.18	37.58	30.85	25.49	21.16	17.64	14.75	12.37	10.39	8.75	47.48	3086.41
1978	1156.29	568.09	343.32	231.12	165.94	124.06	94.68	73.31	57.59	46.02	37.32	30.61	25.28	20.99	17.50	14.63	12.27	10.31	8.68	47.09	3085.08
1979	1155.90	567.92	343.18	231.04	165.90	123.89	93.91	72.61	57.09	45.43	36.63	29.94	24.71	20.51	17.09	14.29	11.99	10.07	8.48	46.02	3076.61
1980	1155.36	567.73	343.08	230.96	165.90	124.06	94.22	72.45	56.89	45.31	36.38	29.57	24.32	20.17	16.81	14.05	11.78	9.90	8.34	45.23	3072.49
1981	1154.35	567.45	342.96	230.86	165.65	123.19	91.79	70.04	54.64	43.46	34.93	28.27	23.12	19.10	15.91	13.30	11.15	9.37	7.89	42.80	3050.24
1982	1150.77	566.96	342.80	230.79	165.55	121.83	84.92	61.44	47.39	37.45	30.05	24.34	19.83	16.29	13.52	11.29	9.46	7.95	6.70	36.33	2985.65
1983	1138.04	565.20	342.49	230.61	164.91	116.49	64.62	38.67	27.90	21.77	17.36	14.04	11.44	9.37	7.73	6.43	5.39	4.53	3.81	20.67	2811.46
1984	1120.94	558.95	341.43	230.42	165.00	118.31	69.04	33.41	19.82	14.46	11.39	9.15	7.45	6.10	5.01	4.15	3.46	2.91	2.45	13.27	2737.10
1985	1110.86	550.55	337.65	229.69	164.78	118.47	71.22	36.10	17.27	10.35	7.62	6.05	4.89	4.00	3.29	2.71	2.25	1.88	1.58	8.58	2689.78
1986	1105.21	545.60	332.59	227.20	164.55	119.19	73.11	39.88	20.22	9.79	5.92	4.39	3.51	2.85	2.34	1.93	1.60	1.33	1.11	6.03	2668.34
1987	1103.68	542.83	329.60	223.81	162.92	120.89	80.00	43.61	23.44	12.01	5.86	3.58	2.67	2.14	1.75	1.44	1.19	0.99	0.82	4.43	2667.66
1988	1106.27	542.07	327.91	221.75	160.33	120.12	86.42	55.33	30.32	16.50	8.53	4.20	2.58	1.93	1.56	1.27	1.05	0.87	0.72	3.87	2693.61
1989	1111.52	543.35	327.47	220.68	159.17	119.41	88.76	62.68	40.44	22.44	12.32	6.42	3.18	1.96	1.48	1.19	0.98	0.81	0.67	3.55	2728.47
1990	1116.59	545.93	328.24	220.38	158.39	118.56	88.45	64.69	46.06	30.08	16.84	9.32	4.89	2.43	1.51	1.14	0.92	0.76	0.63	3.29	2759.08
1991	1120.22	548.42	329.80	220.90	158.18	117.81	86.68	63.03	46.40	33.44	22.04	12.44	6.92	3.65	1.82	1.13	0.86	0.70	0.57	2.97	2777.97
1992	1121.92	550.11	330.84	220.94	157.64	116.74	84.40	59.84	43.70	32.56	23.67	15.73	8.93	5.00	2.64	1.32	0.82	0.63	0.51	2.60	2780.53
1993	1122.24	550.98	332.08	222.11	158.10	116.72	83.83	57.50	40.74	30.10	22.63	16.59	11.08	6.32	3.55	1.89	0.95	0.59	0.45	2.24	2780.69
1994	1122.60	551.14	332.57	222.87	158.89	117.31	85.09	58.19	39.87	28.58	21.30	16.14	11.90	7.99	4.58	2.58	1.37	0.69	0.43	1.97	2786.06
1995	1123.83	551.37	332.94	223.80	159.98	118.39	86.45	60.65	41.61	28.85	20.87	15.68	11.95	8.86	5.97	3.43	1.94	1.03	0.52	1.82	2799.96
1996	1125.37	551.87	332.54	222.87	159.59	118.49	87.09	61.70	43.45	30.17	21.10	15.39	11.63	8.91	6.63	4.48	2.58	1.46	0.78	1.78	2807.88
1997	1127.10	552.69	333.19	223.37	159.61	118.59	87.42	63.81	45.72	32.60	22.84	16.11	11.81	8.97	6.90	5.15	3.49	2.02	1.15	2.01	2824.55
1998	1128.62	553.57	333.85	224.16	160.27	118.69	86.67	62.31	45.78	33.21	23.89	16.87	11.97	8.82	6.73	5.19	3.89	2.64	1.53	2.39	2831.06
1999	1130.18	554.32	334.38	224.60	160.87	119.59	88.88	64.77	47.10	35.05	25.65	18.60	13.22	9.42	6.97	5.34	4.13	3.10	2.11	3.14	2851.41
2000	1132.45	555.00	334.39	224.00	160.34	119.47	89.47	66.45	48.98	36.07	27.09	19.98	14.58	10.41	7.45	5.53	4.24	3.29	2.47	4.20	2865.88
2001	1134.36	556.20	335.26	225.01	160.80	119.68	89.60	67.06	50.40	37.63	27.96	21.16	15.71	11.52	8.26	5.93	4.41	3.39	2.64	5.36	2882.37
2002	1135.95	557.14	335.99	225.58	161.51	119.95	89.39	66.73	50.53	38.46	28.97	21.70	16.52	12.32	9.07	6.52	4.70	3.51	2.70	6.38	2893.62
2003	1137.35	557.91	336.53	226.01	161.88	120.60	90.35	67.44	50.95	39.07	30.01	22.79	17.17	13.14	9.84	7.27	5.24	3.78	2.83	7.35	2907.51
2004	1138.80	558.54	336.64	225.60	161.49	120.39	90.69	68.27	51.62	39.50	30.56	23.66	18.08	13.69	10.52	7.90	5.85	4.23	3.06	8.25	2917.31
2005	1140.21	559.27	337.15	225.98	161.48	120.43	91.26	69.30	52.87	40.49	31.27	24.39	18.99	14.58	11.09	8.54	6.44	4.78	3.46	9.27	2931.26
2006	1141.60	559.92	337.37	225.83	161.30	120.05	90.94	69.58	53.57	41.40	31.99	24.90	19.54	15.29	11.79	8.99	6.95	5.25	3.90	10.43	2940.58
2007	1142.76	560.68	338.16	226.83	161.97	120.50	91.02	69.49	53.88	42.03	32.77	25.52	19.99	15.76	12.39	9.58	7.33	5.67	4.29	11.75	2952.36
2008	1144.02	561.23	338.49	227.09	162.45	120.85	91.55	70.21	54.43	42.76	33.65	26.45	20.73	16.31	12.91	10.18	7.89	6.05	4.70	13.31	2965.27
2009	1145.34	561.84	338.79	227.25	162.58	121.23	92.07	70.83	55.16	43.32	34.34	27.24	21.54	16.96	13.40	10.64	8.42	6.54	5.02	14.99	2977.47
2010	1146.32	562.42	338.83	226.72	162.03	120.79	91.76	70.61	55.13	43.48	34.46	27.54	21.97	17.46	13.81	10.94	8.72	6.91	5.38	16.50	2981.77
2011	1146.83	562.94	339.37	227.17	162.04	120.67	91.53	70.06	54.61	43.19	34.37	27.46	22.07	17.70	14.12	11.20	8.91	7.11	5.64	17.92	2984.92
2012	1147.61	563.19	339.67	227.51	162.35	120.85	92.49	71.52	55.60	43.91	35.04	28.11	22.59	18.25	14.70	11.76	9.36	7.45	5.96	19.81	2997.70
2013	1148.46	563.44	339.16	226.27	161.29	120.01	91.48	71.20	55.91	44.03	35.09	28.22	22.78	18.40	14.92	12.05	9.67	7.71	6.15	21.34	2997.58
2014	1147.08	563.03	335.08	216.88	152.33	112.96	85.44	65.57	51.70	41.11	32.67	26.24	21.24	17.23	13.97	11.36	9.21	7.40	5.91	21.15	2937.58
2015	1144.77	563.16	338.98	223.03	153.58	112.36	84.56	63.89	49.55	39.57	31.75	25.43	20.55	16.71	13.61	11.07	9.03	7.33	5.91	21.66	2936.50
2016	1144.17	562.09	339.35	226.25	158.47	113.51	83.72	63.11	48.27	37.92	30.55	24.71	19.91	16.17	13.21	10.79	8.80	7.20	5.85	22.06	2936.12

Table 11. Estimated biomass at age (mt) at start of year from the ASPM for the South Atlantic

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1970	234.7	226.4	219.7	210.0	197.3	182.3	165.9	149.2	132.9	117.6	103.4	90.5	78.8	68.4	59.2	51.1	44.0	37.8	32.4	178.7	2580.1
1971	234.7	226.4	219.7	210.0	197.3	182.3	165.9	149.2	132.9	117.7	103.4	90.5	78.8	68.4	59.2	51.1	44.0	37.8	32.4	178.8	2580.4
1972	234.7	226.4	219.7	210.0	197.3	182.3	165.8	149.1	132.9	117.6	103.4	90.4	78.8	68.4	59.2	51.0	44.0	37.8	32.4	178.7	2579.7
1973	234.7	226.4	219.7	210.0	197.3	182.3	165.9	149.1	132.9	117.6	103.4	90.4	78.8	68.4	59.2	51.0	44.0	37.8	32.4	178.7	2579.8
1974	234.7	226.4	219.7	210.0	197.3	182.2	165.5	148.7	132.4	117.2	103.0	90.2	78.5	68.2	59.0	50.9	43.8	37.6	32.3	178.1	2575.6
1975	234.6	226.4	219.7	210.0	197.2	181.9	164.6	147.4	131.2	116.1	102.0	89.3	77.8	67.5	58.4	50.4	43.4	37.3	32.0	176.4	2563.6
1976	234.5	226.4	219.7	210.0	197.3	182.1	164.1	146.1	129.6	114.6	100.7	88.1	76.7	66.6	57.6	49.7	42.8	36.8	31.6	174.1	2549.1
1977	234.4	226.3	219.6	210.0	197.2	181.9	163.9	145.3	128.1	112.9	99.1	86.7	75.5	65.5	56.7	48.9	42.1	36.2	31.1	171.3	2532.8
1978	234.4	226.2	219.5	209.9	197.3	182.3	164.7	146.2	128.4	112.5	98.4	86.0	74.9	65.0	56.2	48.5	41.8	35.9	30.8	169.9	2528.8
1979	234.3	226.1	219.4	209.9	197.3	182.0	163.3	144.8	127.3	111.1	96.6	84.1	73.2	63.5	55.0	47.4	40.8	35.1	30.1	166.0	2507.3
1980	234.2	226.0	219.4	209.8	197.3	182.2	163.9	144.5	126.8	110.7	96.0	83.1	72.0	62.5	54.0	46.6	40.1	34.5	29.6	163.2	2496.4
1981	234.0	225.9	219.3	209.7	197.0	181.0	159.7	139.7	121.8	106.2	92.1	79.4	68.5	59.2	51.1	44.1	38.0	32.6	28.0	154.4	2441.8
1982	233.2	225.7	219.2	209.6	196.8	179.0	147.7	122.5	105.7	91.5	79.3	68.4	58.7	50.5	43.5	37.4	32.2	27.7	23.8	131.1	2283.6
1983	230.7	225.0	219.0	209.5	196.1	171.1	112.4	77.1	62.2	53.2	45.8	39.5	33.9	29.0	24.8	21.3	18.3	15.8	13.5	74.6	1872.9
1984	227.2	222.5	218.3	209.3	196.2	173.8	120.1	66.6	44.2	35.3	30.0	25.7	22.1	18.9	16.1	13.8	11.8	10.1	8.7	47.9	1718.6
1985	225.2	219.2	215.9	208.6	195.9	174.0	123.9	72.0	38.5	25.3	20.1	17.0	14.5	12.4	10.6	9.0	7.7	6.6	5.6	31.0	1632.9
1986	224.0	217.2	212.7	206.4	195.7	175.1	127.2	79.5	45.1	23.9	15.6	12.3	10.4	8.8	7.5	6.4	5.4	4.6	3.9	21.7	1603.6
1987	223.7	216.1	210.8	203.3	193.7	177.6	139.1	87.0	52.3	29.4	15.5	10.1	7.9	6.6	5.6	4.8	4.1	3.4	2.9	16.0	1609.8
1988	224.2	215.8	209.7	201.4	190.6	176.5	150.3	110.3	67.6	40.3	22.5	11.8	7.6	6.0	5.0	4.2	3.6	3.0	2.6	14.0	1667.2
1989	225.3	216.3	209.4	200.5	189.3	175.4	154.4	125.0	90.2	54.8	32.5	18.0	9.4	6.1	4.7	4.0	3.3	2.8	2.4	12.8	1736.6
1990	226.3	217.4	209.9	200.2	188.3	174.2	153.8	129.0	102.7	73.5	44.4	26.2	14.5	7.5	4.8	3.8	3.1	2.6	2.2	11.9	1796.4
1991	227.0	218.4	210.9	200.7	188.1	173.1	150.8	125.7	103.5	81.7	58.1	34.9	20.5	11.3	5.9	3.8	2.9	2.4	2.0	10.7	1832.4
1992	227.4	219.0	211.6	200.7	187.4	171.5	146.8	119.3	97.4	79.6	62.4	44.2	26.5	15.5	8.5	4.4	2.8	2.2	1.8	9.4	1838.4
1993	227.5	219.4	212.3	201.8	188.0	171.5	145.8	114.7	90.8	73.6	59.7	46.6	32.8	19.6	11.4	6.3	3.2	2.1	1.6	8.1	1836.6
1994	227.5	219.4	212.7	202.4	188.9	172.3	148.0	116.0	88.9	69.9	56.2	45.4	35.3	24.8	14.7	8.6	4.7	2.4	1.5	7.1	1846.7
1995	227.8	219.5	212.9	203.3	190.2	173.9	150.4	120.9	92.8	70.5	55.0	44.1	35.4	27.4	19.2	11.4	6.6	3.6	1.9	6.6	1873.4
1996	228.1	219.7	212.6	202.4	189.8	174.1	151.5	123.0	96.9	73.7	55.7	43.2	34.5	27.6	21.3	14.9	8.8	5.1	2.8	6.4	1892.1
1997	228.4	220.1	213.1	202.9	189.8	174.2	152.1	127.2	101.9	79.7	60.2	45.3	35.0	27.8	22.2	17.1	11.9	7.0	4.1	7.2	1927.2
1998	228.8	220.4	213.5	203.6	190.6	174.4	150.8	124.3	102.1	81.2	63.0	47.4	35.5	27.3	21.6	17.2	13.2	9.2	5.4	8.6	1938.0
1999	229.1	220.7	213.8	204.0	191.3	175.7	154.6	129.2	105.0	85.7	67.7	52.3	39.2	29.2	22.4	17.7	14.1	10.8	7.5	11.3	1981.1
2000	229.5	221.0	213.8	203.5	190.6	175.5	155.6	132.5	109.2	88.2	71.4	56.1	43.2	32.2	24.0	18.4	14.5	11.5	8.8	15.2	2014.7
2001	229.9	221.5	214.4	204.4	191.2	175.8	155.9	133.7	112.4	92.0	73.8	59.5	46.5	35.7	26.5	19.7	15.0	11.8	9.4	19.3	2048.3
2002	230.2	221.8	214.8	204.9	192.0	176.2	155.5	133.1	112.7	94.0	76.4	61.0	49.0	38.2	29.2	21.6	16.0	12.2	9.6	23.0	2071.5
2003	230.5	222.1	215.2	205.3	192.5	177.2	157.2	134.5	113.6	95.5	79.2	64.0	50.9	40.7	31.6	24.1	17.9	13.2	10.0	26.5	2101.6
2004	230.8	222.4	215.3	204.9	192.0	176.9	157.7	136.1	115.1	96.6	80.6	66.5	53.6	42.4	33.8	26.2	19.9	14.7	10.9	29.7	2126.1
2005	231.1	222.7	215.6	205.3	192.0	176.9	158.7	138.2	117.9	99.0	82.5	68.5	56.3	45.2	35.6	28.3	21.9	16.6	12.3	33.5	2158.1
2006	231.4	222.9	215.7	205.1	191.8	176.4	158.2	138.7	119.5	101.2	84.4	70.0	57.9	47.4	37.9	29.8	23.7	18.3	13.8	37.6	2181.6
2007	231.6	223.2	216.2	206.0	192.6	177.0	158.3	138.6	120.1	102.7	86.4	71.7	59.2	48.8	39.8	31.8	25.0	19.8	15.2	42.4	2206.6
2008	231.9	223.5	216.4	206.3	193.2	177.5	159.2	140.0	121.4	104.5	88.8	74.3	61.4	50.5	41.5	33.8	26.9	21.1	16.7	48.0	2236.8
2009	232.1	223.7	216.6	206.4	193.3	178.1	160.1	141.3	123.0	105.9	90.6	76.5	63.8	52.5	43.1	35.3	28.7	22.8	17.8	54.1	2265.7
2010	232.3	223.9	216.7	206.0	192.7	177.4	159.6	140.8	122.9	106.3	90.9	77.4	65.1	54.1	44.4	36.3	29.7	24.1	19.1	59.5	2279.1
2011	232.4	224.1	217.0	206.4	192.7	177.3	159.2	139.7	121.8	105.6	90.7	77.2	65.4	54.8	45.4	37.2	30.3	24.8	20.0	64.6	2286.5
2012	232.6	224.2	217.2	206.7	193.0	177.5	160.9	142.6	124.0	107.3	92.4	79.0	66.9	56.5	47.2	39.0	31.9	26.0	21.2	71.5	2317.6
2013	232.8	224.3	216.9	205.5	191.8	176.3	159.1	142.0	124.7	107.6	92.5	79.3	67.5	57.0	48.0	40.0	33.0	26.9	21.8	77.0	2323.9
2014	232.5	224.2	214.3	197.0	181.1	165.9	148.6	130.8	115.3	100.5	86.2	73.7	62.9	53.4	44.9	37.7	31.4	25.8	21.0	76.3	2223.4
2015	232.0	224.2	216.8	202.6	182.6	165.1	147.1	127.4	110.5	96.7	83.7	71.5	60.9	51.8	43.8	36.7	30.8	25.5	21.0	78.1	2208.7
2016	231.9	223.8	217.0	205.5	188.4	166.8	145.6	125.9	107.6	92.7	80.6	69.4	59.0	50.1	42.5	35.8	30.0	25.1	20.8	79.6	2198.0

Table 12. Estimated biomass at age (1000 lb) at start of year from the ASPM for the South Atlantic.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1970	517.4	499.1	484.4	463.0	435.0	401.9	365.7	328.9	293.0	259.3	228.0	199.5	173.7	150.8	130.5	112.7	97.0	83.3	71.4	394.0	5688.1
1971	517.4	499.1	484.4	463.0	435.0	401.9	365.7	328.9	293.0	259.5	228.0	199.5	173.7	150.8	130.5	112.7	97.0	83.3	71.4	394.2	5688.8
1972	517.4	499.1	484.4	463.0	435.0	401.9	365.5	328.7	293.0	259.3	228.0	199.3	173.7	150.8	130.5	112.4	97.0	83.3	71.4	394.0	5687.3
1973	517.4	499.1	484.4	463.0	435.0	401.9	365.7	328.7	293.0	259.3	228.0	199.3	173.7	150.8	130.5	112.4	97.0	83.3	71.4	394.0	5687.5
1974	517.4	499.1	484.4	463.0	435.0	401.7	364.9	327.8	291.9	258.4	227.1	198.9	173.1	150.4	130.1	112.2	96.6	82.9	71.2	392.6	5678.2
1975	517.2	499.1	484.4	463.0	434.8	401.0	362.9	325.0	289.2	256.0	224.9	196.9	171.5	148.8	128.7	111.1	95.7	82.2	70.5	388.9	5651.8
1976	517.0	499.1	484.4	463.0	435.0	401.5	361.8	322.1	285.7	252.6	222.0	194.2	169.1	146.8	127.0	109.6	94.4	81.1	69.7	383.8	5619.8
1977	516.8	498.9	484.1	463.0	434.8	401.0	361.3	320.3	282.4	248.9	218.5	191.1	166.4	144.4	125.0	107.8	92.8	79.8	68.6	377.7	5583.9
1978	516.8	498.7	483.9	462.7	435.0	401.9	363.1	322.3	283.1	248.0	216.9	189.6	165.1	143.3	123.9	106.9	92.2	79.1	67.9	374.6	5575.0
1979	516.5	498.5	483.7	462.7	435.0	401.2	360.0	319.2	280.6	244.9	213.0	185.4	161.4	140.0	121.3	104.5	89.9	77.4	66.4	366.0	5527.6
1980	516.3	498.2	483.7	462.5	435.0	401.7	361.3	318.6	279.5	244.1	211.6	183.2	158.7	137.8	119.0	102.7	88.4	76.1	65.3	359.8	5503.6
1981	515.9	498.0	483.5	462.3	434.3	399.0	352.1	308.0	268.5	234.1	203.0	175.0	151.0	130.5	112.7	97.2	83.8	71.9	61.7	340.4	5383.2
1982	514.1	497.6	483.3	462.1	433.9	394.6	325.6	270.1	233.0	201.7	174.8	150.8	129.4	111.3	95.9	82.5	71.0	61.1	52.5	289.0	5034.5
1983	508.6	496.0	482.8	461.9	432.3	377.2	247.8	170.0	137.1	117.3	101.0	87.1	74.7	63.9	54.7	47.0	40.3	34.8	29.8	164.5	4129.0
1984	500.9	490.5	481.3	461.4	432.5	383.2	264.8	146.8	97.4	77.8	66.1	56.7	48.7	41.7	35.5	30.4	26.0	22.3	19.2	105.6	3788.9
1985	496.5	483.3	476.0	459.9	431.9	383.6	273.2	158.7	84.9	55.8	44.3	37.5	32.0	27.3	23.4	19.8	17.0	14.6	12.3	68.3	3599.9
1986	493.8	478.8	468.9	455.0	431.4	386.0	280.4	175.3	99.4	52.7	34.4	27.1	22.9	19.4	16.5	14.1	11.9	10.1	8.6	47.8	3535.3
1987	493.2	476.4	464.7	448.2	427.0	391.5	306.7	191.8	115.3	64.8	34.2	22.3	17.4	14.6	12.3	10.6	9.0	7.5	6.4	35.3	3549.0
1988	494.3	475.8	462.3	444.0	420.2	389.1	331.4	243.2	149.0	88.8	49.6	26.0	16.8	13.2	11.0	9.3	7.9	6.6	5.7	30.9	3675.5
1989	496.7	476.9	461.6	442.0	417.3	386.7	340.4	275.6	198.9	120.8	71.7	39.7	20.7	13.4	10.4	8.8	7.3	6.2	5.3	28.2	3828.5
1990	498.9	479.3	462.7	441.4	415.1	384.0	339.1	284.4	226.4	162.0	97.9	57.8	32.0	16.5	10.6	8.4	6.8	5.7	4.9	26.2	3960.4
1991	500.4	481.5	465.0	442.5	414.7	381.6	332.5	277.1	228.2	180.1	128.1	76.9	45.2	24.9	13.0	8.4	6.4	5.3	4.4	23.6	4039.7
1992	501.3	482.8	466.5	442.5	413.1	378.1	323.6	263.0	214.7	175.5	137.6	97.4	58.4	34.2	18.7	9.7	6.2	4.9	4.0	20.7	4053.0
1993	501.6	483.7	468.0	444.9	414.5	378.1	321.4	252.9	200.2	162.3	131.6	102.7	72.3	43.2	25.1	13.9	7.1	4.6	3.5	17.9	4049.0
1994	501.6	483.7	468.9	446.2	416.5	379.9	326.3	255.7	196.0	154.1	123.9	100.1	77.8	54.7	32.4	19.0	10.4	5.3	3.3	15.7	4071.3
1995	502.2	483.9	469.4	448.2	419.3	383.4	331.6	266.5	204.6	155.4	121.3	97.2	78.0	60.4	42.3	25.1	14.6	7.9	4.2	14.6	4130.1
1996	502.9	484.4	468.7	446.2	418.4	383.8	334.0	271.2	213.6	162.5	122.8	95.2	76.1	60.8	47.0	32.8	19.4	11.2	6.2	14.1	4171.4
1997	503.5	485.2	469.8	447.3	418.4	384.0	335.3	280.4	224.7	175.7	132.7	99.9	77.2	61.3	48.9	37.7	26.2	15.4	9.0	15.9	4248.7
1998	504.4	485.9	470.7	448.9	420.2	384.5	332.5	274.0	225.1	179.0	138.9	104.5	78.3	60.2	47.6	37.9	29.1	20.3	11.9	19.0	4272.6
1999	505.1	486.6	471.3	449.7	421.7	387.4	340.8	284.8	231.5	188.9	149.3	115.3	86.4	64.4	49.4	39.0	31.1	23.8	16.5	24.9	4367.6
2000	506.0	487.2	471.3	448.6	420.2	386.9	343.0	292.1	240.7	194.4	157.4	123.7	95.2	71.0	52.9	40.6	32.0	25.4	19.4	33.5	4441.6
2001	506.8	488.3	472.7	450.6	421.5	387.6	343.7	294.8	247.8	202.8	162.7	131.2	102.5	78.7	58.4	43.4	33.1	26.0	20.7	42.5	4515.7
2002	507.5	489.0	473.6	451.7	423.3	388.5	342.8	293.4	248.5	207.2	168.4	134.5	108.0	84.2	64.4	47.6	35.3	26.9	21.2	50.7	4566.9
2003	508.2	489.6	474.4	452.6	424.4	390.7	346.6	296.5	250.4	210.5	174.6	141.1	112.2	89.7	69.7	53.1	39.5	29.1	22.0	58.4	4633.2
2004	508.8	490.3	474.7	451.7	423.3	390.0	347.7	300.0	253.8	213.0	177.7	146.6	118.2	93.5	74.5	57.8	43.9	32.4	24.0	65.5	4687.2
2005	509.5	491.0	475.3	452.6	423.3	390.0	349.9	304.7	259.9	218.3	181.9	151.0	124.1	99.6	78.5	62.4	48.3	36.6	27.1	73.9	4757.8
2006	510.1	491.4	475.5	452.2	422.8	388.9	348.8	305.8	263.5	223.1	186.1	154.3	127.6	104.5	83.6	65.7	52.2	40.3	30.4	82.9	4809.6
2007	510.6	492.1	476.6	454.2	424.6	390.2	349.0	305.6	264.8	226.4	190.5	158.1	130.5	107.6	87.7	70.1	55.1	43.7	33.5	93.5	4864.7
2008	511.3	492.7	477.1	454.8	425.9	391.3	351.0	308.6	267.6	230.4	195.8	163.8	135.4	111.3	91.5	74.5	59.3	46.5	36.8	105.8	4931.3
2009	511.7	493.2	477.5	455.0	426.2	392.6	353.0	311.5	271.2	233.5	199.7	168.7	140.7	115.7	95.0	77.8	63.3	50.3	39.2	119.3	4995.0
2010	512.1	493.6	477.7	454.2	424.8	391.1	351.9	310.4	270.9	234.4	200.4	170.6	143.5	119.3	97.9	80.0	65.5	53.1	42.1	131.2	5024.5
2011	512.4	494.1	478.4	455.0	424.8	390.9	351.0	308.0	268.5	232.8	200.0	170.2	144.2	120.8	100.1	82.0	66.8	54.7	44.1	142.4	5040.9
2012	512.8	494.3	478.8	455.7	425.5	391.3	354.7	314.4	273.4	236.6	203.7	174.2	147.5	124.6	104.1	86.0	70.3	57.3	46.7	157.6	5109.4
2013	513.2	494.5	478.2	453.0	422.8	388.7	350.8	313.1	274.9	237.2	203.9	174.8	148.8	125.7	105.8	88.2	72.8	59.3	48.1	169.8	5123.3
2014	512.6	494.3	472.5	434.3	399.3	365.7	327.6	288.4	254.2	221.6	190.0	162.5	138.7	117.7	99.0	83.1	69.2	56.9	46.3	168.2	4901.8
2015	511.5	494.3	478.0	446.7	402.6	364.0	324.3	280.9	243.6	213.2	184.5	157.6	134.3	114.2	96.6	80.9	67.9	56.2	46.3	172.2	4869.3
2016	511.3	493.4	478.4	453.0	415.4	367.7	321.0	277.6	237.2	204.4	177.7	153.0	130.1	110.5	93.7	78.9	66.1	55.3	45.9	175.5	4845.8

Table 13. Estimated time series of status indicators, fishing mortality, and biomass from the ASPM for the So. Atl. Fishing mortality rate is apical F. Total biomass (B, mt) is at the start of the year, and spawning biomass (SSB, mt) at the time of peak spawning (mid-year). The MSST *is defined by* $\mathrm{MSST} = 0.75\mathrm{SSB}_{\mathrm{MSY}}$.

Year	F	F/F_{MSY}	B	B/B_{unfished}	SSB	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	SSB/MSST
1970	0.005	0.006	2580	0.979	3559918	4.36	5.81
1971	0.006	0.007	2580	0.979	3559814	4.36	5.81
1972	0.005	0.006	2580	0.978	3559217	4.36	5.81
1973	0.008	0.010	2580	0.979	3556040	4.35	5.80
1974	0.015	0.017	2576	0.977	3542400	4.34	5.78
1975	0.018	0.022	2564	0.972	3518744	4.31	5.74
1976	0.021	0.025	2549	0.967	3490813	4.27	5.70
1977	0.013	0.016	2533	0.961	3470621	4.25	5.66
1978	0.028	0.033	2529	0.959	3448265	4.22	5.63
1979	0.022	0.026	2507	0.951	3417095	4.18	5.58
1980	0.060	0.072	2496	0.947	3361043	4.11	5.49
1981	0.169	0.201	2442	0.926	3175499	3.89	5.18
1982	0.569	0.677	2284	0.866	2648501	3.24	4.32
1983	0.448	0.533	1873	0.710	2155211	2.64	3.52
1984	0.441	0.524	1719	0.652	1937331	2.37	3.16
1985	0.359	0.427	1633	0.619	1832014	2.24	2.99
1986	0.312	0.371	1604	0.608	1805213	2.21	2.95
1987	0.142	0.169	1610	0.611	1850871	2.27	3.02
1988	0.092	0.110	1667	0.632	1950348	2.39	3.18
1989	0.087	0.103	1737	0.659	2055901	2.52	3.36
1990	0.111	0.132	1796	0.681	2138078	2.62	3.49
1991	0.145	0.173	1832	0.695	2178691	2.67	3.56
1992	0.164	0.195	1838	0.697	2186658	2.68	3.57
1993	0.146	0.173	1837	0.697	2195445	2.69	3.58
1994	0.114	0.136	1847	0.700	2226140	2.73	3.63
1995	0.113	0.134	1873	0.711	2265865	2.77	3.70
1996	0.078	0.093	1892	0.718	2311766	2.83	3.77
1997	0.111	0.132	1927	0.731	2353647	2.88	3.84
1998	0.058	0.069	1938	0.735	2398377	2.94	3.92
1999	0.058	0.069	1981	0.751	2466037	3.02	4.03
2000	0.055	0.065	2015	0.764	2525651	3.09	4.12
2001	0.062	0.073	2048	0.777	2577261	3.15	4.21
2002	0.048	0.057	2071	0.786	2624783	3.21	4.28
2003	0.046	0.054	2102	0.797	2675198	3.27	4.37
2004	0.034	0.040	2126	0.806	2726452	3.34	4.45
2005	0.036	0.042	2158	0.819	2778568	3.40	4.54
2006	0.034	0.040	2182	0.827	2823688	3.46	4.61
2007	0.022	0.026	2207	0.837	2873908	3.52	4.69
2008	0.019	0.023	2237	0.848	2928499	3.58	4.78
2009	0.029	0.034	2266	0.859	2970497	3.64	4.85
2010	0.035	0.042	2279	0.864	2992919	3.66	4.88
2011	0.009	0.011	2287	0.867	3027277	3.71	4.94
2012	0.024	0.029	2318	0.879	3066063	3.75	5.00
2013	0.098	0.117	2324	0.881	3003560	3.68	4.90
2014	0.059	0.070	2223	0.843	2904806	3.56	4.74
2015	0.059	0.070	2209	0.838	2879964	3.52	4.70
2016	.	.	2198	0.834	.	.	.

Table 14. Selectivity at age from the ASPM for the So. Atl. for commercial handlines (cH), commercial longline (cL), and two time blocks for the headboat fleet, (HB1: 1980-1990 and HB2: 1991-2005).

Age	cH	cL	HB (1980-1990)	HB (1991-2005)
1	0.000	0.000	0.000	0.000
2	0.000	0.000	0.003	0.003
3	0.000	0.000	0.024	0.024
4	0.007	0.002	0.163	0.163
5	0.110	0.025	0.604	0.604
6	0.687	0.260	0.923	0.923
7	0.975	0.829	0.989	0.989
8	0.999	0.985	0.999	0.999
9	1.000	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000

Table 15. Selectivity of removals averaged across fleets and time blocks (avg) for landings (L) and total (Tot.) from the ASPM for the So. Atl.

Age	L.avg	Tot.avg
1	0.010	0.010
2	0.085	0.085
3	0.276	0.276
4	0.350	0.350
5	0.396	0.396
6	0.641	0.641
7	0.930	0.930
8	0.994	0.994
9	1.000	1.000
10	1.000	1.000
11	1.000	1.000
12	1.000	1.000
13	1.000	1.000
14	1.000	1.000
15	1.000	1.000
16	1.000	1.000
17	1.000	1.000
18	1.000	1.000
19	1.000	1.000
20	1.000	1.000

Table 16. Estimated instantaneous fishing mortality rate (per yr) at age from the ASPM for the So. Atl.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1970	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
1971	0.000	0.000	0.000	0.001	0.003	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
1972	0.000	0.000	0.000	0.001	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
1973	0.000	0.000	0.000	0.001	0.003	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
1974	0.000	0.000	0.000	0.001	0.004	0.011	0.014	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1975	0.000	0.000	0.000	0.001	0.003	0.013	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
1976	0.000	0.000	0.000	0.001	0.005	0.015	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
1977	0.000	0.000	0.000	0.000	0.002	0.009	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
1978	0.000	0.000	0.000	0.001	0.004	0.019	0.027	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
1979	0.000	0.000	0.000	0.000	0.003	0.015	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
1980	0.000	0.000	0.000	0.001	0.010	0.042	0.059	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
1981	0.000	0.000	0.000	0.002	0.019	0.113	0.164	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169
1982	0.000	0.000	0.000	0.005	0.063	0.375	0.549	0.568	0.569	0.569	0.569	0.569	0.569	0.569	0.569	0.569	0.569	0.569	0.569	0.569
1983	0.000	0.000	0.000	0.004	0.044	0.264	0.422	0.446	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448
1984	0.000	0.000	0.000	0.004	0.043	0.249	0.410	0.438	0.440	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441
1985	0.000	0.000	0.000	0.003	0.036	0.224	0.342	0.358	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359
1986	0.000	0.000	0.000	0.002	0.020	0.140	0.279	0.309	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312
1987	0.000	0.000	0.000	0.003	0.017	0.077	0.131	0.141	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
1988	0.000	0.000	0.000	0.001	0.007	0.044	0.083	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092
1989	0.000	0.000	0.000	0.001	0.007	0.041	0.078	0.086	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087
1990	0.000	0.000	0.000	0.001	0.008	0.054	0.101	0.110	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
1991	0.000	0.001	0.005	0.006	0.016	0.075	0.133	0.144	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145
1992	0.000	0.001	0.002	0.004	0.013	0.072	0.146	0.162	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
1993	0.000	0.001	0.003	0.004	0.010	0.057	0.127	0.144	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146
1994	0.000	0.000	0.000	0.001	0.006	0.046	0.101	0.113	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
1995	0.000	0.002	0.005	0.007	0.012	0.048	0.099	0.112	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113
1996	0.000	0.001	0.002	0.003	0.009	0.045	0.073	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
1997	0.000	0.000	0.000	0.001	0.008	0.055	0.101	0.110	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
1998	0.000	0.000	0.000	0.001	0.005	0.030	0.053	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
1999	0.000	0.001	0.005	0.006	0.010	0.031	0.053	0.057	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
2000	0.000	0.000	0.000	0.000	0.004	0.029	0.050	0.054	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
2001	0.000	0.000	0.000	0.001	0.005	0.033	0.057	0.061	0.061	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
2002	0.000	0.000	0.000	0.001	0.004	0.024	0.044	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
2003	0.000	0.001	0.004	0.005	0.008	0.026	0.042	0.045	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
2004	0.000	0.001	0.003	0.003	0.005	0.018	0.031	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
2005	0.000	0.001	0.005	0.006	0.008	0.022	0.033	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
2006	0.000	0.000	0.001	0.001	0.004	0.018	0.031	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
2007	0.000	0.001	0.002	0.003	0.005	0.016	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
2008	0.000	0.001	0.002	0.003	0.005	0.013	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
2009	0.000	0.002	0.006	0.007	0.009	0.020	0.027	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
2010	0.000	0.001	0.004	0.005	0.007	0.018	0.032	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
2011	0.000	0.001	0.004	0.005	0.005	0.007	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
2012	0.000	0.003	0.010	0.013	0.014	0.019	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
2013	0.002	0.016	0.051	0.065	0.068	0.081	0.095	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098
2014	0.000	0.003	0.011	0.014	0.016	0.031	0.053	0.058	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
2015	0.000	0.003	0.008	0.011	0.014	0.035	0.054	0.058	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059

Table 17. Estimated time series of landings in number (1000 fish) from the ASPM for the So. Atl. for commercial handlines (L.cH), commercial longline (L.cL), and recreational (L.GR).

Year	L.cH	L.cL	L.GR	Total
1970	0.32	0.09	2.79	3.20
1971	0.67	0.15	2.79	3.60
1972	0.39	0.09	2.79	3.27
1973	1.97	0.12	3.07	5.16
1974	4.77	0.19	3.87	8.82
1975	8.24	0.32	1.79	10.36
1976	8.21	0.29	3.55	12.05
1977	5.57	0.35	1.43	7.35
1978	13.15	0.47	1.64	15.27
1979	10.67	0.59	0.41	11.66
1980	27.11	0.63	4.08	31.82
1981	75.04	3.43	1.62	80.08
1982	187.66	12.37	4.26	204.29
1983	88.51	21.95	3.01	113.47
1984	67.38	22.43	4.49	94.30
1985	65.37	8.35	0.65	74.37
1986	29.43	27.28	0.68	57.39
1987	17.88	9.69	4.44	32.02
1988	12.00	9.52	0.44	21.95
1989	12.23	10.20	0.68	23.11
1990	18.47	12.96	0.21	31.64
1991	24.38	16.18	5.82	46.38
1992	20.33	24.47	3.12	47.92
1993	12.30	26.06	3.55	41.90
1994	12.44	19.51	0.10	32.05
1995	10.58	19.59	7.00	37.17
1996	18.42	6.05	2.54	27.00
1997	20.84	14.33	0.45	35.62
1998	12.41	6.74	0.48	19.63
1999	10.26	7.39	6.28	23.93
2000	12.86	6.65	0.25	19.75
2001	15.31	7.26	0.30	22.86
2002	10.78	6.87	0.65	18.30
2003	10.09	5.46	5.55	21.11
2004	6.63	5.17	3.66	15.47
2005	8.14	3.79	6.88	18.81
2006	8.34	4.97	1.39	14.70
2007	8.27	0.35	3.15	11.76
2008	6.07	1.10	3.65	10.82
2009	7.18	2.33	8.40	17.91
2010	6.08	6.75	5.66	18.49
2011	0.92	0.88	5.87	7.67
2012	3.64	1.38	15.49	20.51
2013	6.74	6.91	75.27	88.92
2014	4.94	12.46	15.91	33.30
2015	12.24	7.20	11.92	31.36

Table 18. Estimated time series of landings in whole weight (1000 lb) from the ASPM for the So. Atl. for commercial handlines (L.cH), commercial longlines (L.cL), and recreational (L.GR).

Year	L.cH	L.cL	L.GR	Total
1970	1.67	0.49	13.07	15.23
1971	3.50	0.81	13.07	17.37
1972	2.05	0.50	13.07	15.62
1973	10.29	0.68	14.39	25.36
1974	24.89	1.04	18.11	44.03
1975	42.98	1.79	8.36	53.13
1976	42.73	1.58	16.57	60.88
1977	28.96	1.91	6.67	37.55
1978	68.23	2.61	7.62	78.46
1979	55.21	3.22	1.88	60.32
1980	139.92	3.47	18.80	162.19
1981	384.76	18.67	7.38	410.80
1982	940.56	66.56	18.53	1025.64
1983	418.24	113.53	12.03	543.80
1984	298.78	109.61	16.75	425.15
1985	276.14	38.74	2.32	317.20
1986	120.82	122.32	2.38	245.52
1987	72.85	42.76	15.65	131.27
1988	49.51	42.22	1.57	93.30
1989	51.47	45.90	2.51	99.89
1990	79.22	59.40	0.79	139.41
1991	106.18	75.28	15.19	196.64
1992	89.37	115.09	8.17	212.63
1993	54.29	123.29	9.30	186.89
1994	55.15	92.70	0.26	148.11
1995	47.16	93.51	18.60	159.28
1996	82.64	29.05	6.81	118.50
1997	94.25	69.30	1.22	164.77
1998	56.45	32.81	1.32	90.59
1999	47.07	36.20	17.41	100.69
2000	59.51	32.83	0.69	93.03
2001	71.42	36.10	0.84	108.36
2002	50.63	34.38	1.86	86.88
2003	47.74	27.52	16.01	91.27
2004	31.58	26.23	10.66	68.47
2005	39.03	19.35	20.22	78.60
2006	40.25	25.52	4.11	69.87
2007	40.16	1.79	9.39	51.34
2008	29.67	5.71	10.99	46.37
2009	35.30	12.14	25.48	72.93
2010	30.02	35.41	17.24	82.67
2011	4.55	4.61	18.00	27.15
2012	18.10	7.29	47.80	73.19
2013	33.69	36.64	232.05	302.38
2014	24.69	66.20	48.53	139.42
2015	61.20	38.25	36.06	135.50

Table 19. Estimated total removals (landings and dead discards) at age in numbers (1000 fish) from the ASPM for the So. Atl.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1970	0.00	0.01	0.03	0.13	0.36	0.45	0.40	0.32	0.26	0.21	0.17	0.14	0.12	0.10	0.08	0.07	0.06	0.05	0.04	0.22
1971	0.00	0.01	0.03	0.13	0.37	0.50	0.46	0.37	0.30	0.24	0.20	0.16	0.13	0.11	0.09	0.08	0.07	0.06	0.05	0.25
1972	0.00	0.01	0.03	0.13	0.36	0.46	0.41	0.33	0.26	0.21	0.18	0.14	0.12	0.10	0.08	0.07	0.06	0.05	0.04	0.22
1973	0.00	0.01	0.03	0.15	0.44	0.72	0.68	0.55	0.44	0.36	0.29	0.24	0.20	0.17	0.14	0.12	0.10	0.08	0.07	0.38
1974	0.00	0.01	0.04	0.19	0.63	1.22	1.20	0.97	0.78	0.63	0.52	0.43	0.35	0.29	0.25	0.21	0.17	0.15	0.12	0.66
1975	0.00	0.00	0.02	0.10	0.47	1.41	1.49	1.21	0.97	0.79	0.64	0.53	0.44	0.36	0.30	0.25	0.21	0.18	0.15	0.82
1976	0.00	0.01	0.04	0.19	0.70	1.67	1.70	1.37	1.09	0.88	0.72	0.60	0.49	0.41	0.34	0.29	0.24	0.20	0.17	0.93
1977	0.00	0.00	0.02	0.08	0.35	1.01	1.07	0.86	0.68	0.55	0.45	0.37	0.31	0.26	0.21	0.18	0.15	0.13	0.11	0.58
1978	0.00	0.00	0.02	0.11	0.61	2.11	2.27	1.82	1.44	1.16	0.94	0.78	0.64	0.53	0.45	0.37	0.31	0.26	0.22	1.21
1979	0.00	0.00	0.01	0.05	0.38	1.60	1.77	1.42	1.13	0.90	0.73	0.60	0.49	0.41	0.34	0.29	0.24	0.20	0.17	0.93
1980	0.00	0.01	0.05	0.27	1.38	4.52	4.78	3.79	3.00	2.40	1.94	1.58	1.30	1.08	0.90	0.76	0.63	0.53	0.45	2.44
1981	0.00	0.01	0.04	0.30	2.74	11.63	12.36	9.78	7.69	6.14	4.95	4.02	3.30	2.73	2.28	1.90	1.60	1.34	1.13	6.15
1982	0.00	0.02	0.12	1.00	8.86	33.84	32.26	24.11	18.74	14.86	11.97	9.72	7.93	6.53	5.43	4.54	3.81	3.20	2.70	14.65
1983	0.00	0.01	0.09	0.74	6.19	23.96	19.95	12.59	9.16	7.18	5.75	4.66	3.81	3.12	2.58	2.15	1.80	1.52	1.28	6.93
1984	0.00	0.02	0.12	0.85	6.09	23.06	20.84	10.72	6.42	4.70	3.72	3.00	2.44	2.00	1.65	1.37	1.14	0.96	0.81	4.39
1985	0.00	0.01	0.05	0.49	5.05	21.02	18.48	9.80	4.73	2.85	2.10	1.67	1.36	1.11	0.91	0.76	0.63	0.53	0.44	2.40
1986	0.00	0.00	0.03	0.30	2.88	13.73	15.91	9.57	4.92	2.39	1.45	1.08	0.86	0.70	0.58	0.48	0.40	0.33	0.28	1.50
1987	0.00	0.02	0.09	0.49	2.36	7.87	8.74	5.17	2.81	1.45	0.71	0.43	0.32	0.26	0.21	0.18	0.15	0.12	0.10	0.54
1988	0.00	0.00	0.01	0.11	0.93	4.52	6.15	4.35	2.42	1.32	0.69	0.34	0.21	0.16	0.13	0.10	0.09	0.07	0.06	0.32
1989	0.00	0.00	0.02	0.12	0.91	4.24	5.96	4.65	3.04	1.70	0.93	0.49	0.24	0.15	0.11	0.09	0.08	0.06	0.05	0.27
1990	0.00	0.00	0.01	0.11	1.10	5.51	7.56	6.07	4.38	2.87	1.62	0.90	0.47	0.23	0.15	0.11	0.09	0.07	0.06	0.32
1991	0.13	0.60	1.24	1.19	2.16	7.47	9.61	7.62	5.68	4.11	2.72	1.54	0.86	0.45	0.23	0.14	0.11	0.09	0.07	0.37
1992	0.07	0.32	0.68	0.69	1.71	7.17	10.21	8.06	5.97	4.47	3.26	2.17	1.24	0.69	0.37	0.18	0.11	0.09	0.07	0.36
1993	0.08	0.37	0.77	0.75	1.42	5.71	8.93	6.94	5.00	3.71	2.80	2.06	1.38	0.79	0.44	0.24	0.12	0.07	0.06	0.28
1994	0.00	0.01	0.03	0.10	0.86	4.67	7.26	5.60	3.90	2.81	2.10	1.60	1.18	0.79	0.46	0.26	0.14	0.07	0.04	0.20
1995	0.15	0.71	1.48	1.35	1.70	4.90	7.29	5.76	4.01	2.79	2.03	1.53	1.17	0.87	0.59	0.34	0.19	0.10	0.05	0.18
1996	0.06	0.26	0.53	0.54	1.24	4.61	5.47	4.15	2.95	2.06	1.45	1.06	0.80	0.62	0.46	0.31	0.18	0.10	0.05	0.12
1997	0.01	0.05	0.10	0.18	1.14	5.55	7.46	5.97	4.33	3.10	2.18	1.54	1.14	0.86	0.67	0.50	0.34	0.20	0.11	0.19
1998	0.01	0.05	0.10	0.14	0.67	3.11	4.01	3.14	2.34	1.70	1.23	0.87	0.62	0.46	0.35	0.27	0.20	0.14	0.08	0.12
1999	0.13	0.62	1.27	1.15	1.33	3.23	4.08	3.24	2.39	1.78	1.31	0.95	0.68	0.48	0.36	0.28	0.21	0.16	0.11	0.16
2000	0.01	0.02	0.05	0.09	0.62	2.97	3.91	3.15	2.35	1.74	1.31	0.97	0.71	0.51	0.36	0.27	0.21	0.16	0.12	0.21
2001	0.01	0.03	0.06	0.11	0.71	3.40	4.40	3.57	2.72	2.04	1.52	1.15	0.86	0.63	0.45	0.33	0.24	0.19	0.15	0.30
2002	0.01	0.06	0.13	0.16	0.57	2.55	3.42	2.79	2.14	1.64	1.24	0.93	0.71	0.53	0.39	0.28	0.20	0.15	0.12	0.28
2003	0.11	0.53	1.09	0.98	1.14	2.74	3.33	2.68	2.05	1.58	1.22	0.93	0.70	0.54	0.40	0.30	0.22	0.16	0.12	0.30
2004	0.07	0.34	0.71	0.64	0.76	1.89	2.46	2.02	1.55	1.19	0.93	0.72	0.55	0.42	0.32	0.24	0.18	0.13	0.09	0.25
2005	0.14	0.64	1.32	1.18	1.19	2.30	2.66	2.17	1.67	1.28	1.00	0.78	0.61	0.47	0.36	0.27	0.21	0.15	0.11	0.30
2006	0.03	0.13	0.27	0.26	0.51	1.87	2.47	2.06	1.61	1.25	0.97	0.76	0.59	0.47	0.36	0.27	0.21	0.16	0.12	0.32
2007	0.06	0.29	0.60	0.55	0.68	1.66	1.73	1.37	1.07	0.84	0.66	0.51	0.40	0.32	0.25	0.19	0.15	0.11	0.09	0.24
2008	0.07	0.33	0.69	0.62	0.66	1.38	1.50	1.20	0.94	0.74	0.59	0.46	0.36	0.29	0.23	0.18	0.14	0.11	0.08	0.24
2009	0.17	0.76	1.57	1.39	1.29	2.06	2.21	1.80	1.41	1.11	0.89	0.71	0.56	0.44	0.35	0.28	0.22	0.17	0.13	0.39
2010	0.11	0.51	1.06	0.94	0.95	1.93	2.56	2.17	1.72	1.36	1.08	0.87	0.69	0.55	0.44	0.35	0.28	0.22	0.17	0.53
2011	0.12	0.53	1.09	0.95	0.75	0.74	0.71	0.57	0.45	0.36	0.29	0.23	0.18	0.15	0.12	0.09	0.08	0.06	0.05	0.15
2012	0.30	1.39	2.86	2.50	1.99	2.05	1.91	1.54	1.20	0.96	0.77	0.62	0.50	0.40	0.32	0.26	0.21	0.16	0.13	0.44
2013	1.51	6.90	13.99	12.08	9.25	8.22	7.39	5.97	4.73	3.74	2.99	2.42	1.95	1.58	1.28	1.04	0.83	0.67	0.53	1.85
2014	0.33	1.50	3.05	2.59	2.15	3.00	3.90	3.32	2.66	2.12	1.69	1.36	1.11	0.90	0.73	0.59	0.48	0.39	0.31	1.11
2015	0.24	1.13	2.32	2.02	1.90	3.43	4.00	3.24	2.54	2.04	1.64	1.32	1.07	0.87	0.71	0.58	0.47	0.38	0.31	1.14

Table 20. Estimated landings at age in whole weight (1000 lb) from the ASPM for the So. Atl.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1970	0.00	0.00	0.04	0.26	0.94	1.47	1.53	1.41	1.26	1.12	0.99	0.87	0.76	0.66	0.57	0.49	0.43	0.37	0.31	1.74
1971	0.00	0.00	0.04	0.26	0.97	1.63	1.76	1.63	1.46	1.30	1.15	1.01	0.88	0.76	0.66	0.57	0.49	0.42	0.36	2.01
1972	0.00	0.00	0.04	0.26	0.95	1.50	1.57	1.45	1.30	1.15	1.02	0.89	0.78	0.68	0.59	0.51	0.44	0.38	0.32	1.79
1973	0.00	0.01	0.04	0.29	1.16	2.33	2.62	2.42	2.17	1.93	1.71	1.50	1.31	1.14	0.98	0.85	0.73	0.63	0.54	2.99
1974	0.00	0.01	0.06	0.38	1.64	3.95	4.62	4.27	3.84	3.41	3.01	2.64	2.31	2.01	1.74	1.50	1.29	1.11	0.96	5.28
1975	0.00	0.00	0.03	0.21	1.23	4.55	5.73	5.31	4.76	4.23	3.73	3.28	2.86	2.49	2.16	1.86	1.61	1.38	1.19	6.54
1976	0.00	0.01	0.05	0.38	1.83	5.41	6.54	6.01	5.37	4.77	4.21	3.69	3.22	2.80	2.43	2.10	1.81	1.56	1.34	7.37
1977	0.00	0.00	0.02	0.17	0.92	3.26	4.10	3.77	3.35	2.97	2.62	2.29	2.00	1.74	1.51	1.30	1.12	0.97	0.83	4.58
1978	0.00	0.00	0.03	0.23	1.59	6.83	8.71	8.01	7.09	6.24	5.48	4.80	4.19	3.65	3.16	2.73	2.35	2.02	1.74	9.59
1979	0.00	0.00	0.01	0.10	0.99	5.19	6.78	6.25	5.54	4.85	4.24	3.70	3.23	2.81	2.43	2.10	1.81	1.56	1.34	7.38
1980	0.00	0.01	0.07	0.54	3.61	14.64	18.32	16.68	14.76	12.94	11.26	9.78	8.50	7.38	6.39	5.52	4.76	4.10	3.52	19.41
1981	0.00	0.00	0.05	0.61	7.18	37.66	47.40	42.98	37.79	33.09	28.80	24.91	21.53	18.63	16.13	13.93	12.00	10.33	8.87	48.92
1982	0.00	0.02	0.17	2.00	23.23	109.60	123.71	105.99	92.10	80.09	69.60	60.23	51.83	44.60	38.46	33.19	28.60	24.59	21.12	116.51
1983	0.00	0.01	0.13	1.48	16.21	77.59	76.51	55.34	45.05	38.71	33.42	28.88	24.87	21.32	18.28	15.72	13.53	11.64	9.99	55.12
1984	0.00	0.02	0.17	1.70	15.96	74.69	79.93	47.11	31.56	25.35	21.62	18.56	15.96	13.69	11.69	10.00	8.58	7.37	6.33	34.89
1985	0.00	0.01	0.07	0.98	13.23	68.09	70.87	43.07	23.23	15.34	12.22	10.37	8.86	7.59	6.48	5.52	4.71	4.03	3.46	19.08
1986	0.00	0.00	0.05	0.61	7.55	44.48	61.01	42.06	24.16	12.88	8.44	6.69	5.64	4.80	4.10	3.49	2.97	2.53	2.16	11.90
1987	0.00	0.01	0.12	0.97	6.18	25.48	33.53	22.71	13.82	7.80	4.12	2.69	2.12	1.78	1.51	1.29	1.09	0.93	0.79	4.32
1988	0.00	0.00	0.02	0.22	2.44	14.63	23.57	19.12	11.87	7.12	3.99	2.10	1.36	1.07	0.89	0.76	0.64	0.54	0.46	2.51
1989	0.00	0.00	0.02	0.23	2.38	13.74	22.84	20.44	14.94	9.13	5.43	3.02	1.58	1.02	0.80	0.67	0.56	0.48	0.40	2.17
1990	0.00	0.00	0.02	0.22	2.88	17.85	29.00	26.70	21.53	15.49	9.39	5.55	3.08	1.60	1.03	0.81	0.67	0.56	0.48	2.54
1991	0.06	0.53	1.75	2.39	5.65	24.18	36.84	33.49	27.91	22.15	15.81	9.53	5.61	3.10	1.61	1.03	0.80	0.67	0.56	2.96
1992	0.03	0.28	0.95	1.39	4.49	23.22	39.16	35.45	29.35	24.09	18.98	13.47	8.08	4.74	2.60	1.35	0.86	0.67	0.56	2.89
1993	0.04	0.32	1.08	1.49	3.73	18.49	34.24	30.53	24.56	19.99	16.28	12.75	9.00	5.38	3.14	1.72	0.89	0.57	0.44	2.24
1994	0.00	0.01	0.04	0.19	2.24	15.13	27.82	24.62	19.15	15.12	12.21	9.88	7.70	5.42	3.23	1.88	1.03	0.53	0.34	1.57
1995	0.07	0.63	2.08	2.71	4.44	15.86	27.95	25.31	19.71	15.06	11.79	9.47	7.63	5.92	4.15	2.46	1.43	0.78	0.40	1.43
1996	0.02	0.22	0.75	1.08	3.24	14.92	20.98	18.24	14.51	11.10	8.41	6.55	5.23	4.20	3.25	2.27	1.34	0.78	0.42	0.98
1997	0.00	0.04	0.14	0.36	2.99	17.98	28.61	26.25	21.30	16.73	12.69	9.57	7.41	5.90	4.72	3.64	2.54	1.50	0.87	1.55
1998	0.00	0.04	0.15	0.28	1.77	10.09	15.39	13.82	11.49	9.18	7.16	5.40	4.05	3.13	2.48	1.98	1.52	1.06	0.62	0.99
1999	0.06	0.54	1.79	2.31	3.49	10.47	15.64	14.24	11.73	9.61	7.62	5.90	4.43	3.31	2.55	2.01	1.60	1.23	0.85	1.29
2000	0.00	0.02	0.08	0.19	1.62	9.63	14.98	13.86	11.57	9.38	7.63	6.02	4.64	3.47	2.58	1.98	1.56	1.24	0.95	1.64
2001	0.00	0.03	0.09	0.22	1.87	11.02	16.88	15.70	13.35	10.98	8.84	7.15	5.61	4.31	3.21	2.38	1.82	1.43	1.14	2.35
2002	0.01	0.05	0.19	0.31	1.49	8.25	13.11	12.27	10.52	8.82	7.20	5.76	4.64	3.62	2.77	2.06	1.52	1.16	0.92	2.20
2003	0.05	0.46	1.53	1.97	3.00	8.86	12.77	11.80	10.08	8.52	7.08	5.75	4.58	3.67	2.86	2.18	1.62	1.19	0.91	2.40
2004	0.03	0.30	1.00	1.29	1.98	6.12	9.42	8.89	7.61	6.42	5.38	4.45	3.59	2.85	2.28	1.77	1.34	0.99	0.73	2.01
2005	0.06	0.56	1.87	2.36	3.11	7.44	10.22	9.52	8.21	6.92	5.79	4.83	3.97	3.19	2.52	2.01	1.56	1.18	0.87	2.38
2006	0.01	0.11	0.38	0.52	1.34	6.06	9.49	9.07	7.90	6.73	5.63	4.68	3.88	3.18	2.55	2.01	1.60	1.23	0.94	2.54
2007	0.03	0.25	0.84	1.09	1.78	5.37	6.64	6.01	5.26	4.51	3.81	3.17	2.63	2.17	1.77	1.42	1.11	0.88	0.68	1.90
2008	0.03	0.29	0.97	1.24	1.74	4.48	5.74	5.29	4.63	4.01	3.42	2.87	2.38	1.96	1.61	1.31	1.05	0.82	0.65	1.87
2009	0.07	0.67	2.22	2.79	3.37	6.68	8.49	7.90	6.94	6.00	5.15	4.37	3.65	3.01	2.47	2.03	1.65	1.31	1.03	3.12
2010	0.05	0.45	1.49	1.89	2.49	6.26	9.83	9.54	8.44	7.33	6.29	5.37	4.53	3.77	3.10	2.54	2.08	1.69	1.34	4.18
2011	0.05	0.47	1.54	1.91	1.96	2.39	2.73	2.52	2.22	1.93	1.67	1.42	1.21	1.01	0.84	0.69	0.56	0.46	0.37	1.20
2012	0.14	1.22	4.04	5.01	5.21	6.63	7.34	6.75	5.92	5.15	4.45	3.82	3.24	2.74	2.30	1.90	1.55	1.27	1.03	3.49
2013	0.67	6.05	19.72	24.19	24.24	26.62	28.34	26.26	23.26	20.17	17.41	14.96	12.76	10.80	9.10	7.60	6.27	5.11	4.16	14.68
2014	0.15	1.32	4.30	5.18	5.63	9.72	14.97	14.60	13.06	11.44	9.85	8.45	7.23	6.14	5.18	4.35	3.62	2.98	2.43	8.83
2015	0.11	0.99	3.27	4.05	4.98	11.10	15.32	14.26	12.51	11.00	9.56	8.18	6.99	5.95	5.04	4.23	3.55	2.95	2.43	9.04

Table 21. Estimated status indicators, benchmarks, and related quantities from the ASPM south of Cape Hatteras, conditional on estimated current selectivities averaged across fleets. Monte Carlo/Bootstrap analysis was not conducted for this model, so median values and measures of precision (standard errors, SE) are unavailable. Rate estimates (F) are in units of y^{-1}*; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured as population fecundity (number of eggs)*

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.841	—	—
$85\%F_{\mathrm{MSY}}$	y^{-1}	0.715	—	—
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.630	—	—
$65\%F_{\mathrm{MSY}}$	y^{-1}	0.546	—	—
$F_{30\%}$	y^{-1}	0.628	—	—
$F_{40\%}$	y^{-1}	0.337	—	—
B_{MSY}	1000 lb whole	1997	—	—
$\mathrm{SSB}_{\mathrm{MSY}}$	million eggs	816899	—	—
MSST	million eggs	612674	—	—
MSY	1000 lb whole	316	—	—
R_{MSY}	number fish	990100	—	—
$L_{85\%\mathrm{MSY}}$	1000 lb whole	315	—	—
$L_{75\%\mathrm{MSY}}$	1000 lb whole	313	—	—
$L_{65\%\mathrm{MSY}}$	1000 lb whole	310	—	—
$F_{2013-2015}/F_{\mathrm{MSY}}$	—	0.08	—	—
$\mathrm{SSB}_{2015}/\mathrm{MSST}$	—	4.70	—	—
$\mathrm{SSB}_{2015}/\mathrm{SSB}_{\mathrm{MSY}}$	—	3.53	—	—

Table 22. Estimated status indicators, benchmarks, and related quantities for sensitivity runs for the ASPM south of Cape Hatteras. Rate estimates (F) are in units of y^{-1}*; status indicators are dimensionless; and biomass estimates are in units of 1000 pounds, Beverton-Holt* R_0 *is in units of 1000 fish. Spawning stock biomass (SSB) is measured as population fecundity (millions of eggs).* F/F_{MSY} *is based on the geometric mean F for the last three years of the assessment.* $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$ *and* SSB/MSST *are based on the terminal year of the assessment. steep = Beverton Holt steepness.* Lik_{total} *= total likelihood for the model. See text for full description of sensitivity runs.*

Run	Description	F_{MSY}	$\mathrm{SSB}_{\mathrm{MSY}}$	B_{MSY}	MSY	F/F_{MSY}	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	SSB/MSST	steep	R_0	Lik_{total}
Base	–	0.841	816899	1997	316	0.07	3.53	4.70	0.84	1159	5708
S01	FMat=6	0.296	466217	2600	246	0.21	3.74	4.98	0.84	1142	5705
S02	FMat=12	0.143	199398	3090	179	0.50	2.71	3.61	0.84	1142	5694
S03	M=0.1	0.182	810436	1331	139	0.55	1.79	2.38	0.84	228	5699
S04	M=0.248	6.000	1494072	5896	980	0.01	3.61	4.81	0.84	6319	5719
S05	FMat=6, M=0.1	0.157	592599	1417	125	1.21	0.94	1.26	0.84	217	5680
S06	GT Life	0.130	1056703	1398	134	2.71	0.37	0.49	0.84	163	5935
S07	GT VB	0.256	688452	1272	169	0.41	2.28	3.04	0.84	469	5931
S08	BT32 Life	0.185	683401	1297	158	0.44	2.15	2.86	0.84	141	5673
S09	BT32 Life; N lc,L	0.208	1315956	2540	324	1.48	0.87	1.16	0.84	278	6992
S10	BT32 Life; N lc,L; RDev	0.224	968895	1881	244	3.56	0.50	0.67	0.84	206	6799
S11	N lc,L	1.511	1330051	3286	525	0.16	2.12	2.82	0.84	1890	7016
S12	HL,LL ind	0.822	869822	2126	336	0.06	3.59	4.78	0.84	1235	5581
S13	HL ind	0.826	861466	2105	333	0.07	3.58	4.77	0.84	1223	5562
S14	LL ind	0.817	894096	2185	346	0.06	3.62	4.82	0.84	1270	5542
S15	HB ind	0.849	807506	1974	312	0.07	3.51	4.68	0.84	1146	5650

Table 23. TAC quantiles for all DLM methods for the So. Atl.

Quantile	AvC	CC1	CC4	Fdem.ML	SPMSY	YPR.ML	TOTAL
2.5%	80	68	48	41	5	60	21
5%	85	71	51	54	9	72	37
10%	93	75	53	75	16	97	53
25%	105	82	57	130	33	152	69
50%	119	90	63	263	58	278	98
75%	135	99	69	553	85	592	158
90%	153	107	75	1187	113	1591	477
95%	170	113	79	2168	130	2810	949
97.5%	177	117	82	4597	147	5801	1764

Table 24. Data required by each data limited method. These methods were applied to all regions.

Data.type	AvC	CC1	CC4	Fdem.ML	SPMSY	YPR.ML
Bev. Holt. steepness				X		
Bev. Holt. steepness (CV)				X		
Catch at length matrix				X		X
Catch time series	X	X	X	X	X	X
Catch time series (CV)		X	X	X		X
Length at 50% maturity					X	
Length at full selection						X
Length at full selection (CV)						X
Maximum age				X	X	X
Natural mortality				X		X
Natural mortality (CV)				X		X
Von. Bert. K				X	X	X
Von. Bert. K (CV)				X		X
Von. Bert. L_∞				X	X	X
Von. Bert. L_∞ (CV)				X		X
Von. Bert. t_0				X	X	X
Von. Bert. t_0 (CV)				X		X
weight-length parameter a				X		X
weight-length parameter b				X		X
Years of catch time series		X	X			

Table 25. TAC quantiles for all DLM methods North of Cape Hatteras

Quantile	AvC	CC1	CC4	Fdem.ML	SPMSY	YPR.ML	AvC.early	AvC.late	TOTAL
2.5%	109	104	78	23	9	26	35	326	30
5%	116	129	93	31	15	41	37	350	40
10%	126	157	106	52	25	59	40	371	49
25%	142	215	147	117	60	135	45	416	103
50%	164	309	214	290	110	310	51	474	193
75%	188	456	311	805	170	743	58	540	413
90%	211	620	437	2085	217	1628	67	597	619
95%	226	748	526	3798	240	2911	72	647	998
97.5%	239	857	628	5847	254	5353	78	690	1854

Table 26. Parameter estimates from selected ASPIC surplus production model runs in the Gulf of Mexico. Likelihood components (Lik) are presented for each index and as a total (Lik_{total}). The numerator in F/F_{MSY} is the geometric mean F from the last three years of the assessment (2013-2015) and the numerator in B/B_{MSY} and B/MSST is biomass in the terminal year of the assessment (2015). Abbreviations in Run Name are as follows: HL = handline index, LL = longline index, Hb = headboat index, priMSY = a normal prior was put on MSY, priFmsy = a normal prior was put on F_{MSY}, rmLLU2008 = the extreme value in the longline index in 2008 was removed for this run.

Run	RunName	F/F_{MSY}	B/B_{MSY}	B/MSST	B_{MSY}	MSST	MSY	F_{MSY}	Lik_{total}	Lik_{HL}	Lik_{LL}	Lik_{Hb}
9	HLLLpriMSY	0.35	1.60	2.13	1123	842	197	0.176	45.7	14.2	31.5	
10	HL	0.40	1.53	2.04	1002	752	177	0.177	14.2	14.2		
12	LLpriMSY	0.35	1.60	2.13	1055	791	196	0.186	31.5		31.5	
13	LLrm2008	3.21	0.32	0.43	225	169	152	0.674	8.7		8.7	
17	HLLLrmLLU2008	0.62	1.23	1.64	320	240	144	0.452	26.5	15.6	10.9	
26	HLLLHbpriMSY	0.26	1.69	2.25	2160	1620	245	0.114	73.8	14.2	31.6	27.76
28	LLHbpriMSY	0.27	1.68	2.25	2496	1872	243	0.097	59.6		31.7	27.60
30	HbpriMSYFmsy	0.32	1.62	2.16	2517	1888	209	0.083	28.1			27.55
31	HLHbpriMSYFmsy	0.29	1.66	2.21	1982	1486	227	0.115	42.5	14.3		27.85

Table 27. TAC quantiles for all DLM methods in the Gulf of Mexico

Quantile	AvC	CC1	CC4	Fdem.ML	SPMSY	YPR.ML	TOTAL
2.5%	95	124	88	50	6	68	24
5%	104	132	92	62	10	87	43
10%	111	140	99	83	17	105	69
25%	126	154	109	152	39	171	110
50%	144	172	122	306	69	303	147
75%	168	194	136	725	96	629	206
90%	187	211	148	1769	115	1409	551
95%	202	228	157	3315	127	2623	1120
97.5%	216	237	165	6172	136	5805	2012

4.10 Figures

Figure 1. Map of potential Blueline Tilefish habitat in the Atlantic, divided into major regions, from the GMFMC/SAFMC boundary (near Key West) north through the Mid-Atlantic. Potential habitat was defined based on the depth range (73-183 m; 40-100 fathoms) that Blueline Tilefish are found in. The sizes of the potential habitat area within each major region are (km^2 units): 0. FL south of Cape Canaveral = 4,394; 1. FL north of Cape Canaveral = 1763; 2. GA = 1,020; 3. SC = 3,999; 4. NC south of Cape Hatteras = 1,274; NC north of Cape Hatteras = 984; 6. Mid-Atlantic (north of Cape Hatteras)=32,060.

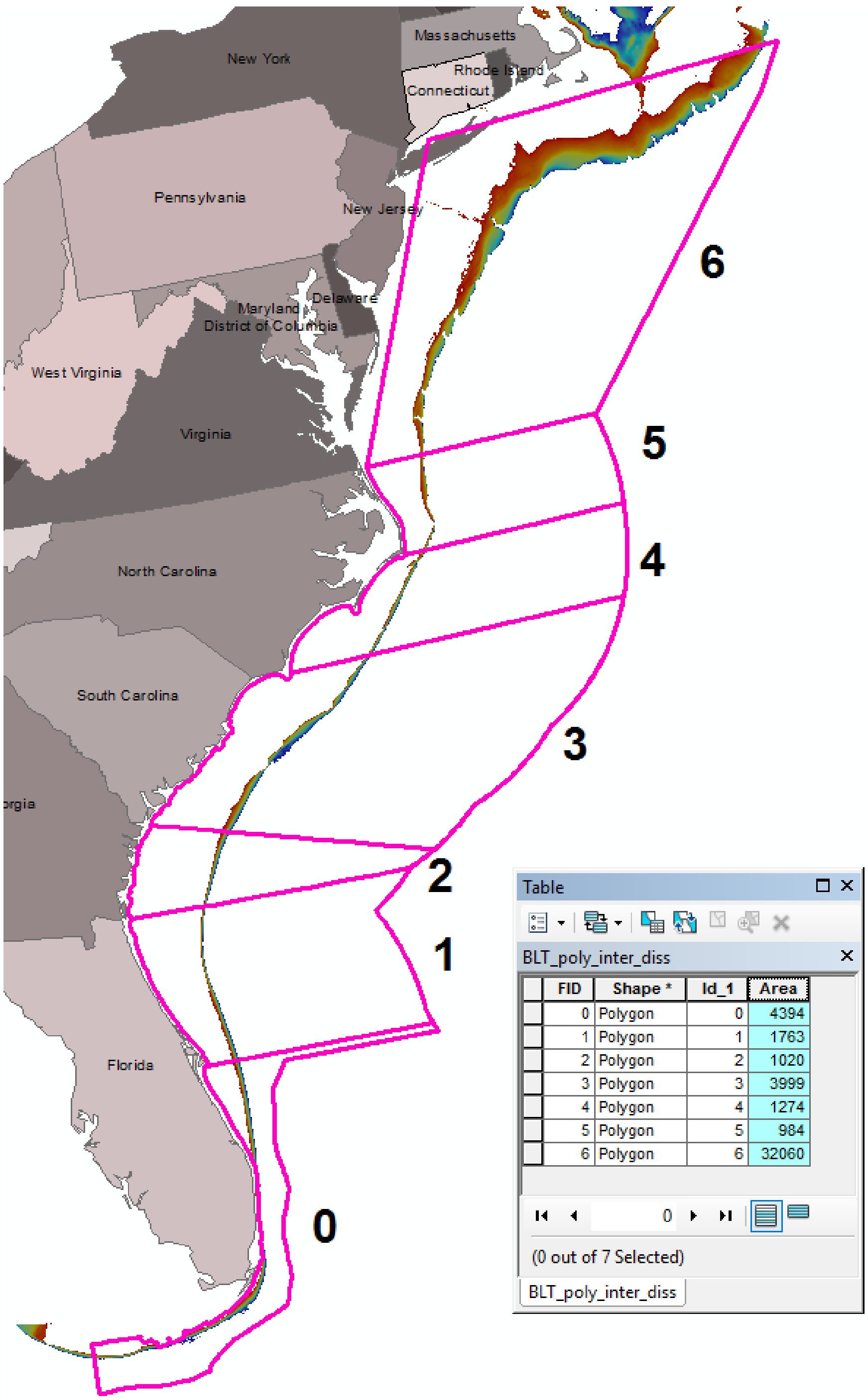


Figure 2. Atlantic removals by aggregated area, from the GMFMC/SAFMC boundary (near Key West) north through the Mid-Atlantic. Removals include commercial and recreational landings and dead discards, which were provided at the data workshop in different spatial groupings, often finer than what is shown here. They are aggregated here into the smallest common areas that most (99%) of the removals could be aggregated into. The proportion of total removals for all years combined, from each area, is presented in the legend in parentheses next to the name of the area.

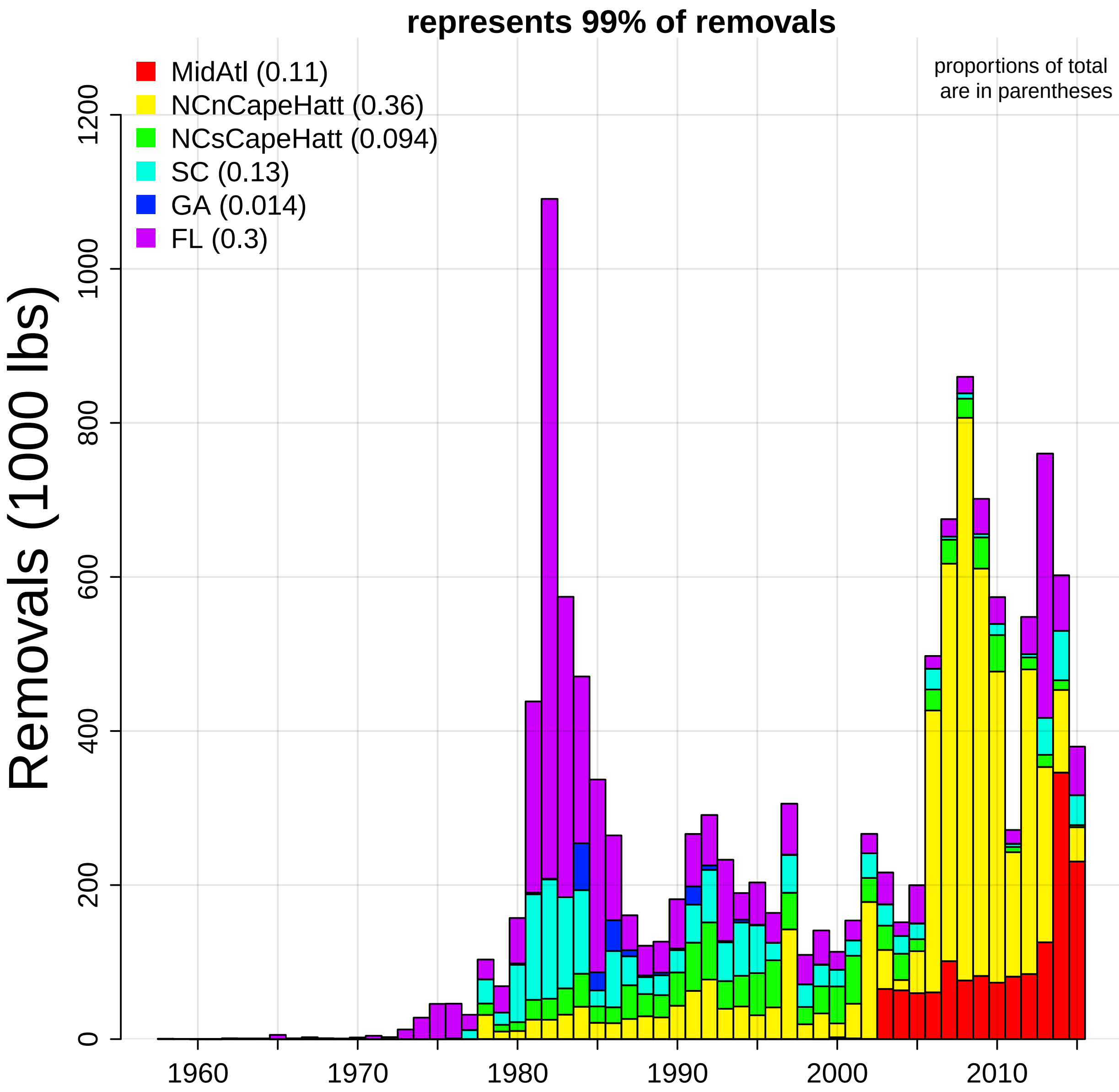


Figure 3. Atlantic removals per square km of potential habitat, by aggregated area, from the GMFMC/SAFMC boundary (near Key West) north through the Mid-Atlantic. Removals include commercial and recreational landings and dead discards, which were provided at the data workshop in different spatial groupings, often finer than what is shown here. They are aggregated here into the smallest common areas that most (99%) of the removals could be aggregated into. Potential habitat was defined based on the depth range (73-183 m; 40-100 fathoms) that Blueline Tilefish are found in. The proportion of total removals per square km for all years combined, from each area, is presented in the legend in parentheses next to the name of the area.

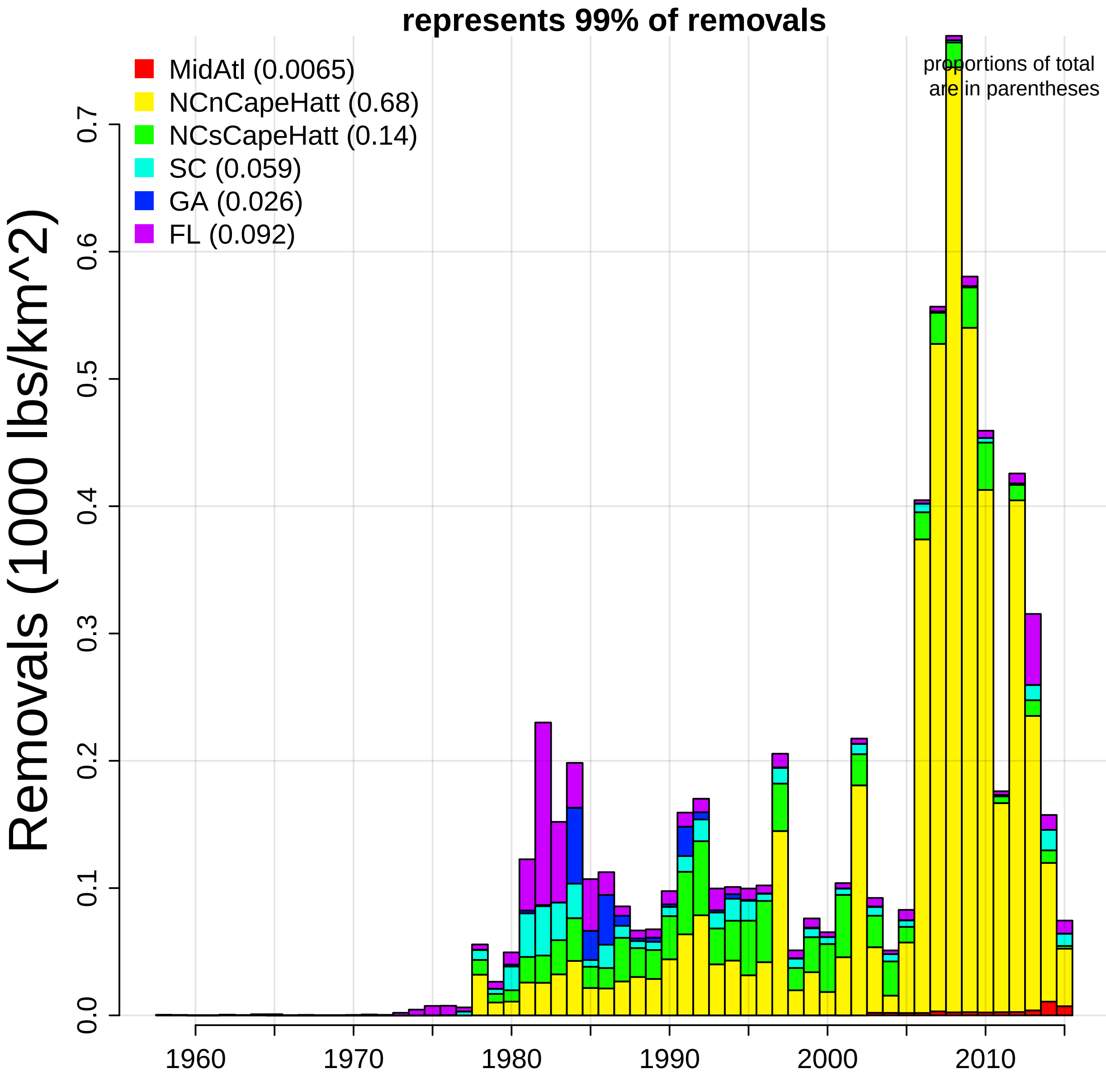


Figure 4. All Atlantic removals by fleet, from the GMFMC/SAFMC boundary (near Key West) north through the Mid-Atlantic. The proportion of total removals for all years combined, from each area, is presented in the legend in parentheses next to the name of the area. Land = landings, Disc = dead discards, Com = commercial, Rec = recreational.

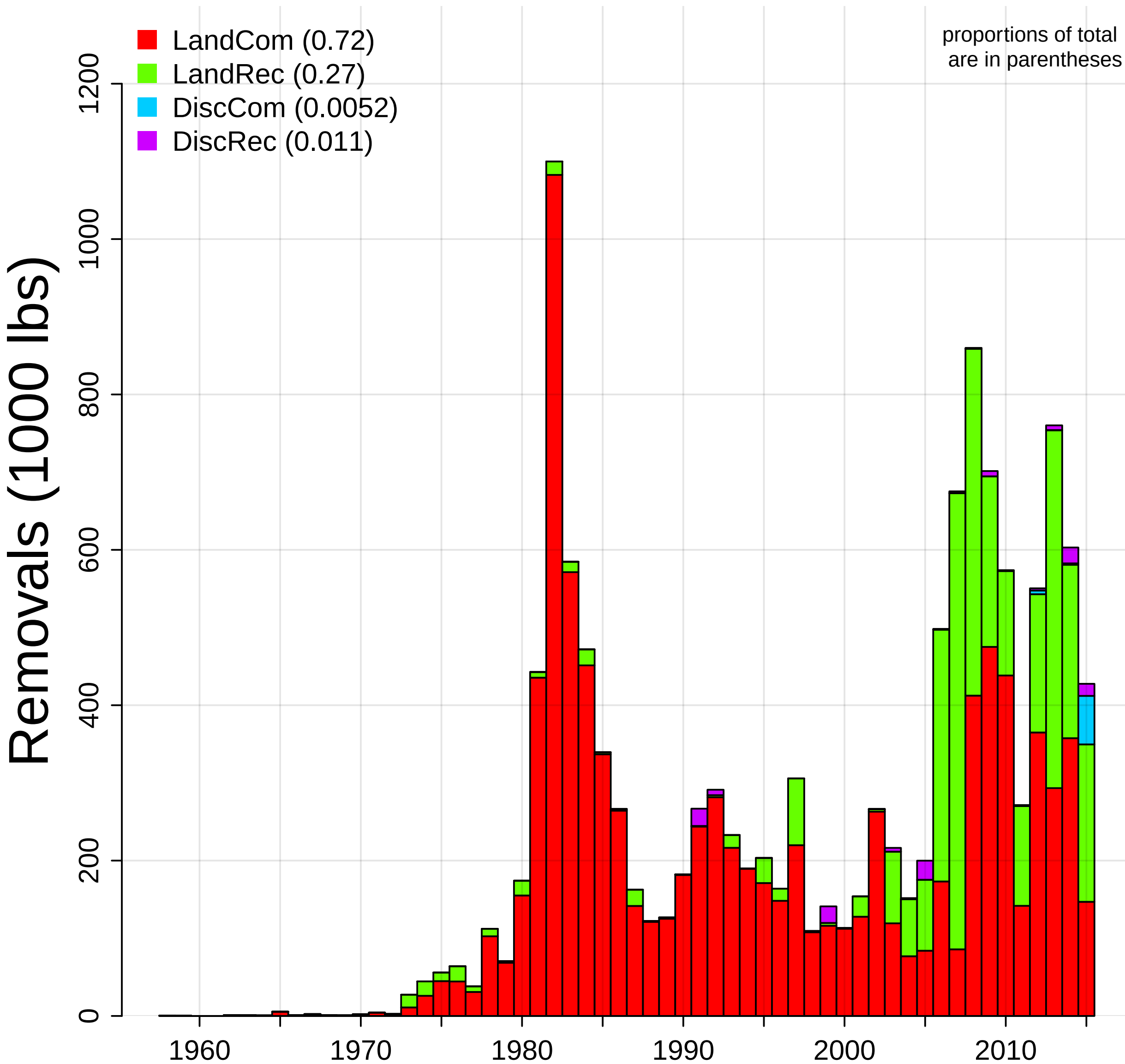


Figure 5. Removals south of Cape Hatteras, by fleet, supplied to the ASPIC models. The proportion of total removals for all years combined, from each area, is presented in the legend in parentheses next to the name of the area. Land = landings, Disc = dead discards, Com = commercial, Rec = recreational.

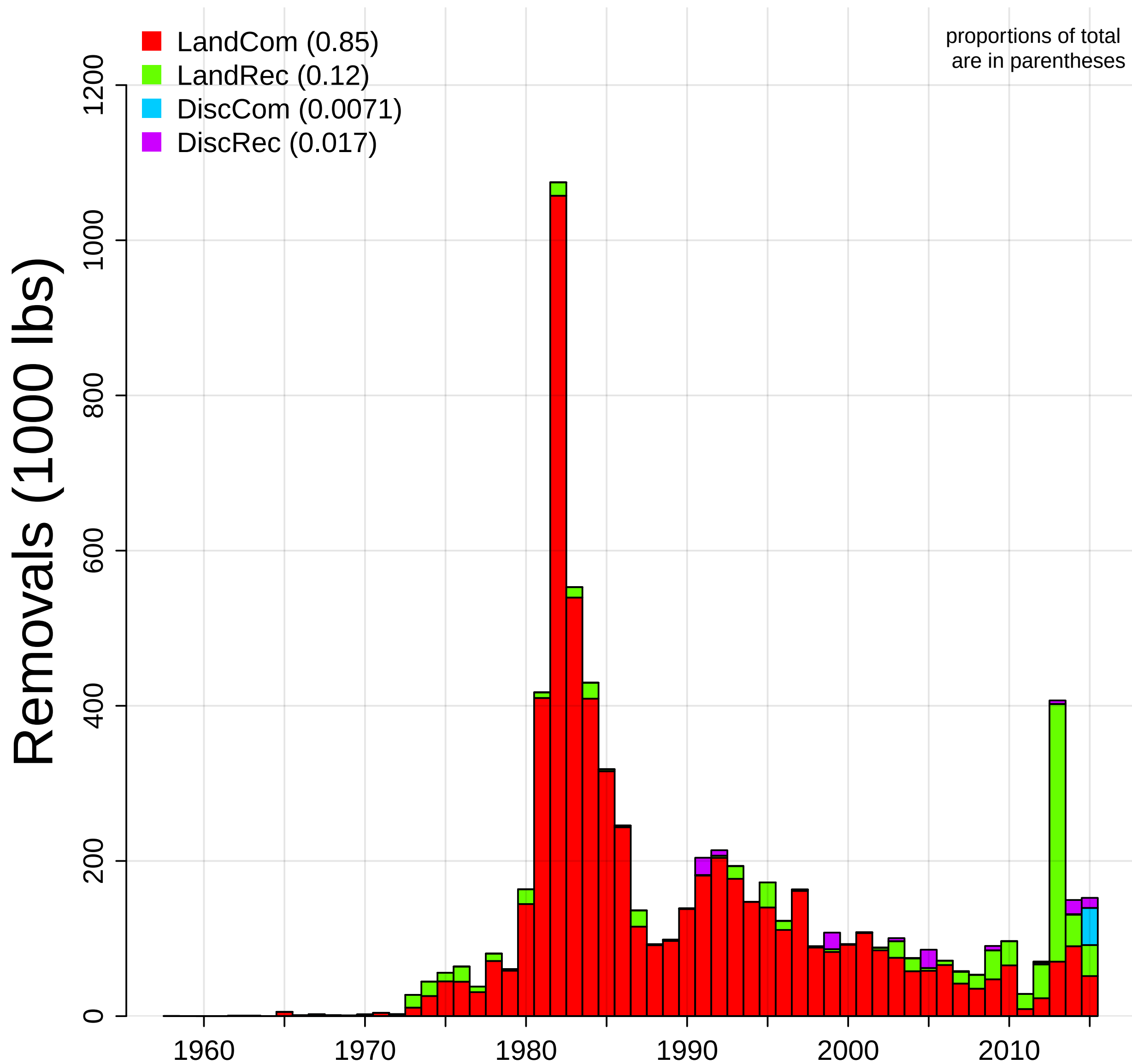


Figure 6. Removals from Cape Hatteras south to the GMFMC/SAFMC boundary (near Key West), by aggregated area, supplied to the ASPIC models. Removals include commercial and recreational landings and dead discards, which were provided at the data workshop in different spatial groupings, often finer than what is shown here. They are aggregated here into the smallest common areas that most (98%) of the removals could be aggregated into. The proportion of total removals per square km for all years combined, from each area, is presented in the legend in parentheses next to the name of the area.

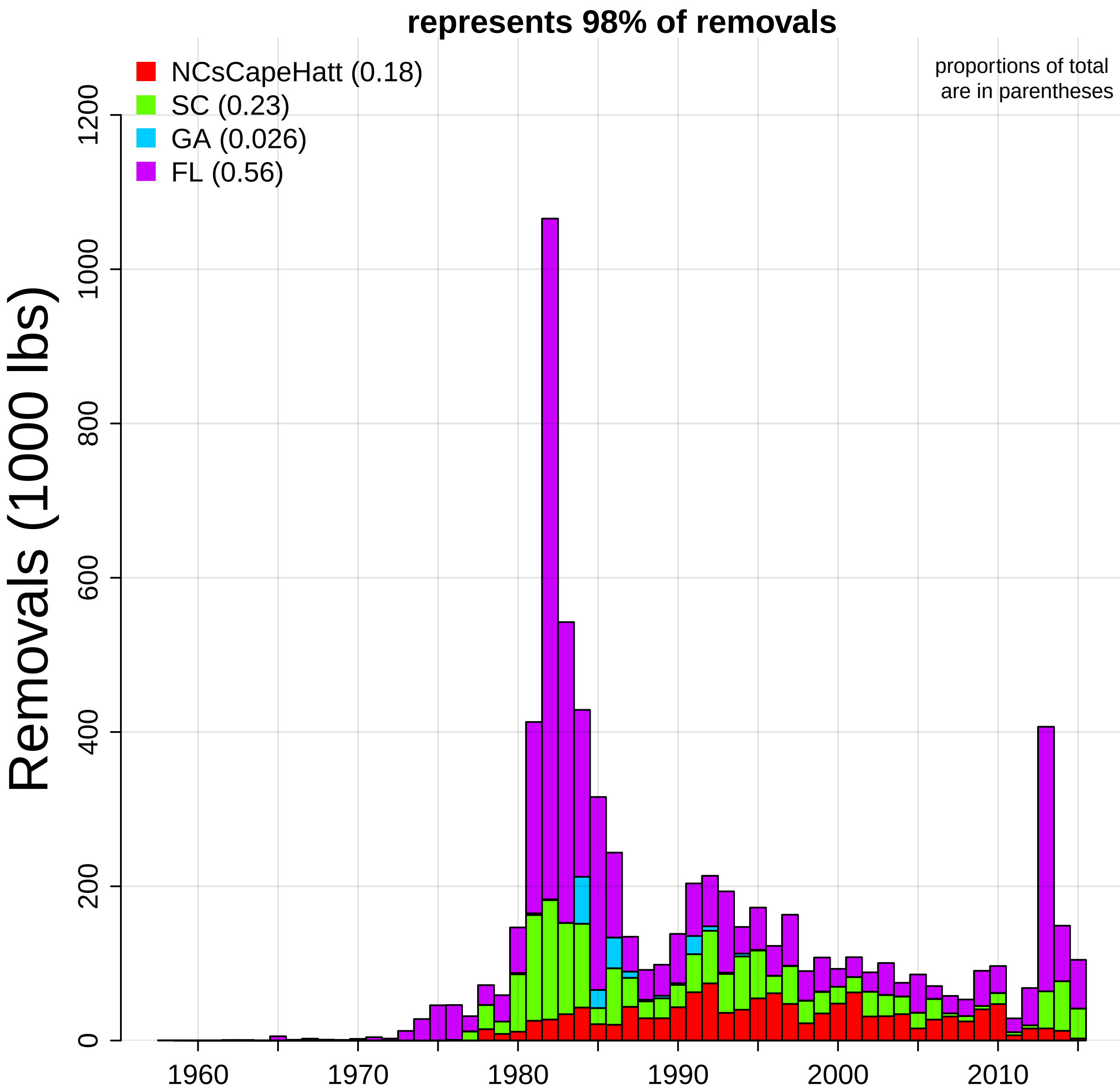


Figure 7. Indices of abundance and error bands used in fitting the ASPIC models for the So. Atl., including the commercial handline index (ComHL), commercial longline index (ComHL), and recreational headboat index (RecHb). Shaded areas represent ±2 standard errors (SE) for each year of each index, calculated from annual CVs. The headboat index was not used in the ASPIC base models.

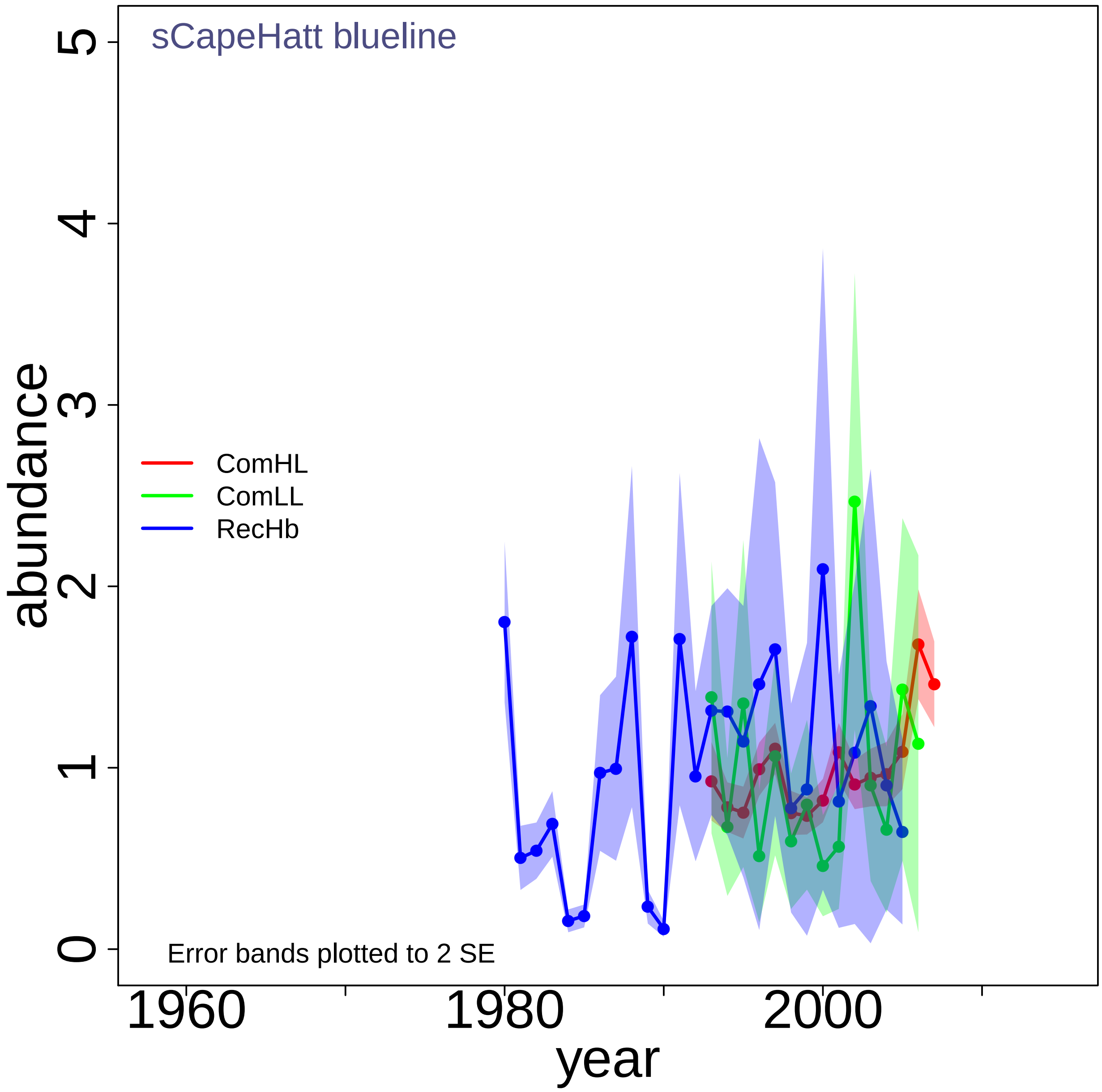
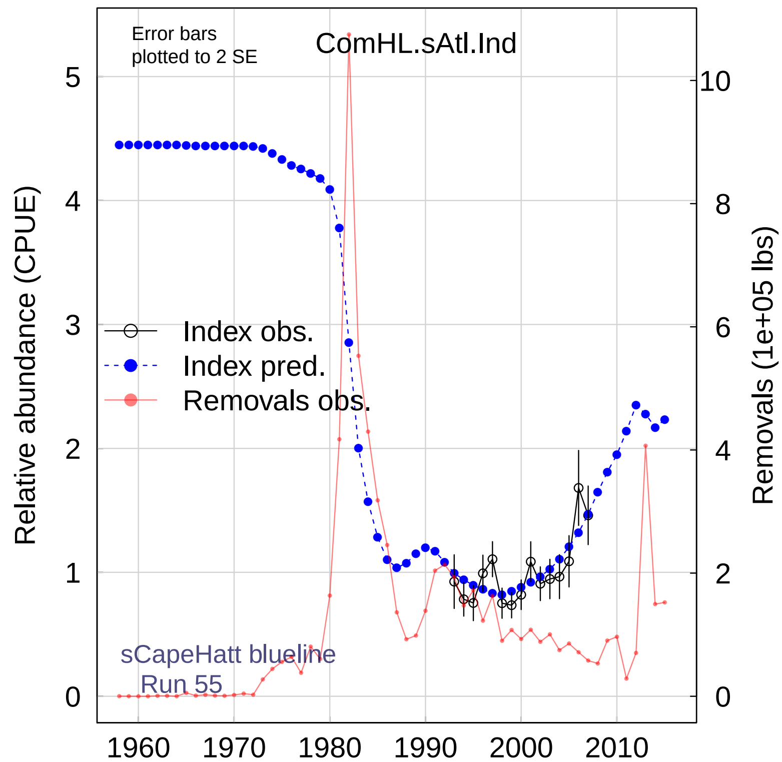


Figure 8. ASPIC handline model (Run 55) for the So. Atl. Fits to indices (upper panel) and B and F ratio plots (lower panel) for ASPIC Run 55. Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015). The B and F trends plotted here were not used directly to make status determinations, but are shown to enable comparisons with the sensitivity runs.



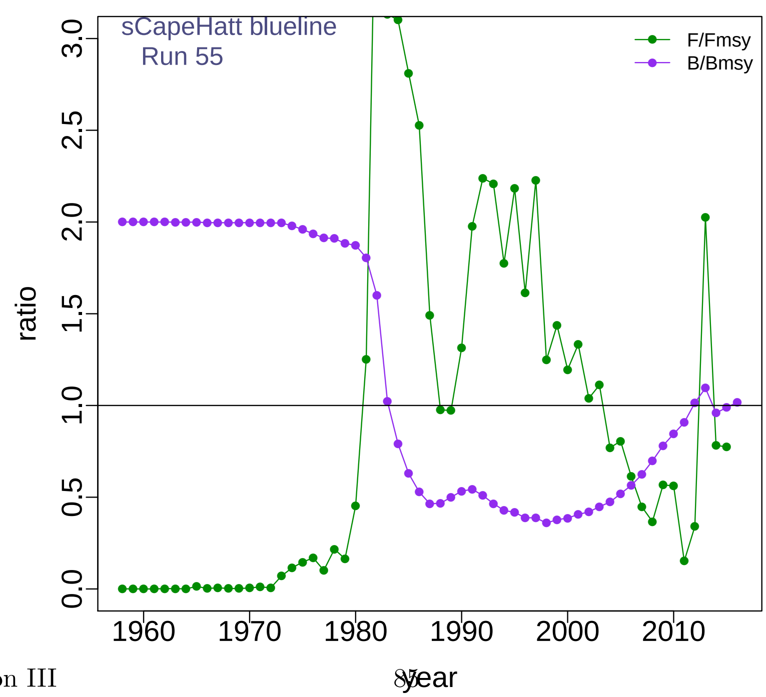


Figure 9. ASPIC longline model (Run 56) for the So. Atl. Fits to indices (upper panel) and B and F ratio plots (lower panel) for ASPIC Run 56. Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015). The B and F trends plotted here were not used directly to make status determinations, but are shown to enable comparisons with the sensitivity runs.

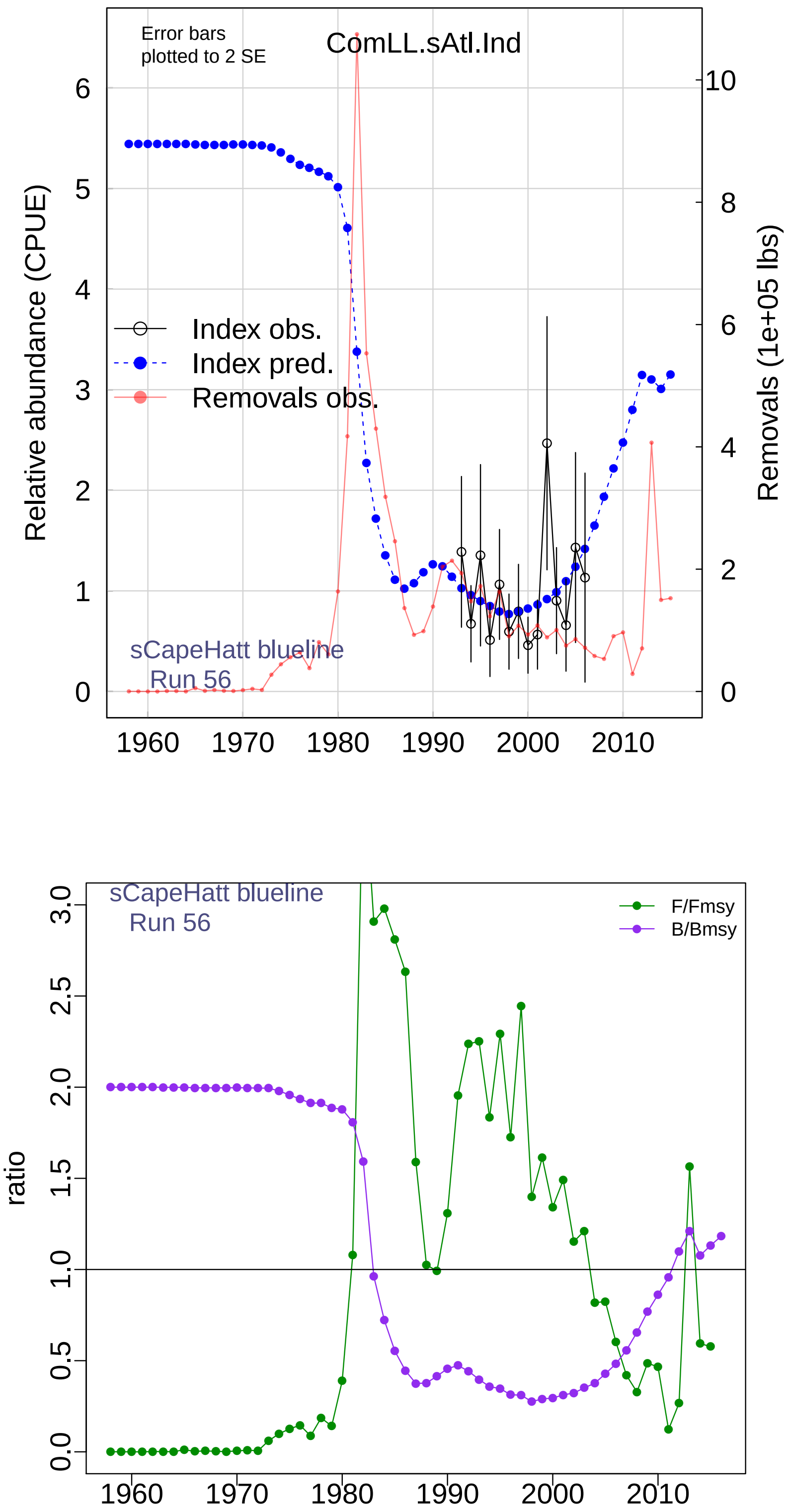


Figure 10. Estimated biomass series (B) combining Runs 55 and 56) from ASPIC for the So. Atl. Solid line indicates average B series for handline and longline models. The jagged dashed line represents the median B and blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials. Horizontal dashed and dotted lines indicate average B_{MSY} and MSST for combined handline and longline models.

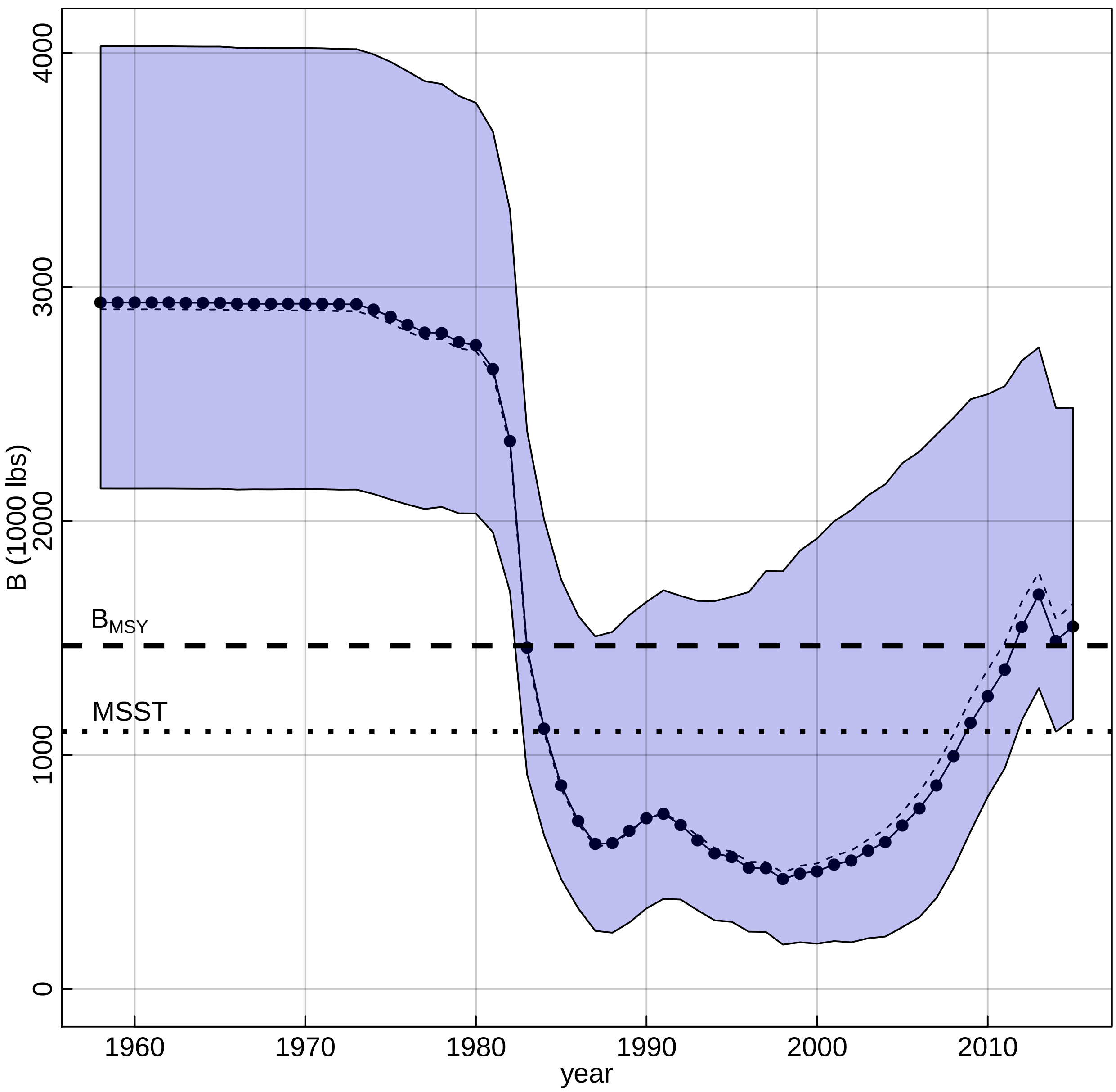


Figure 11. Estimated fishing mortality series (F) combining Runs 55 and 56) from ASPIC for the So. Atl. Solid line indicates average F series for handline and longline models. The jagged dashed line represents the median F and blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials. Horizontal dashed and dotted lines indicate average F_{MSY} and $F_{2013-2015}$ (F_{current}; geometric mean F from 2013-2015) for handline and longline models

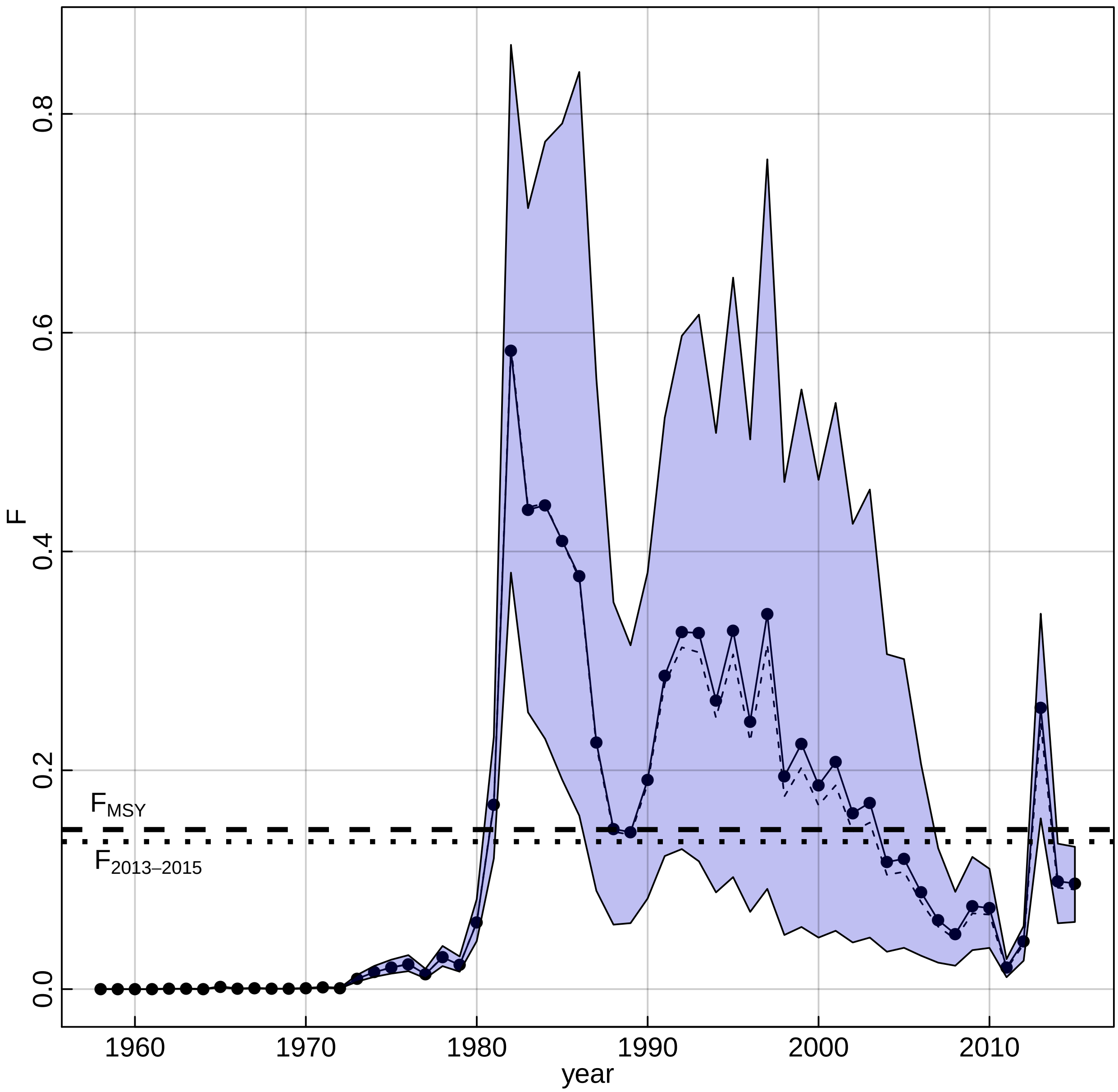


Figure 12. Distribitions of ASPIC parameter estimates for combined bootstrap runs associated with both base runs (Run 55 and 56) for the So. Atl.. Bootstrapping was conducted for each model separately, then the resulting bootstrap results were merged to create composite distributions. Note however that the estimates from this assessment (plotted here as thick vertical orange lines) represent mean values from Runs 55 and 56. Dotted lines represent 5^{th} *and* 95^{th} *percentiles, dashed line represents the median of the bootstrap runs.*

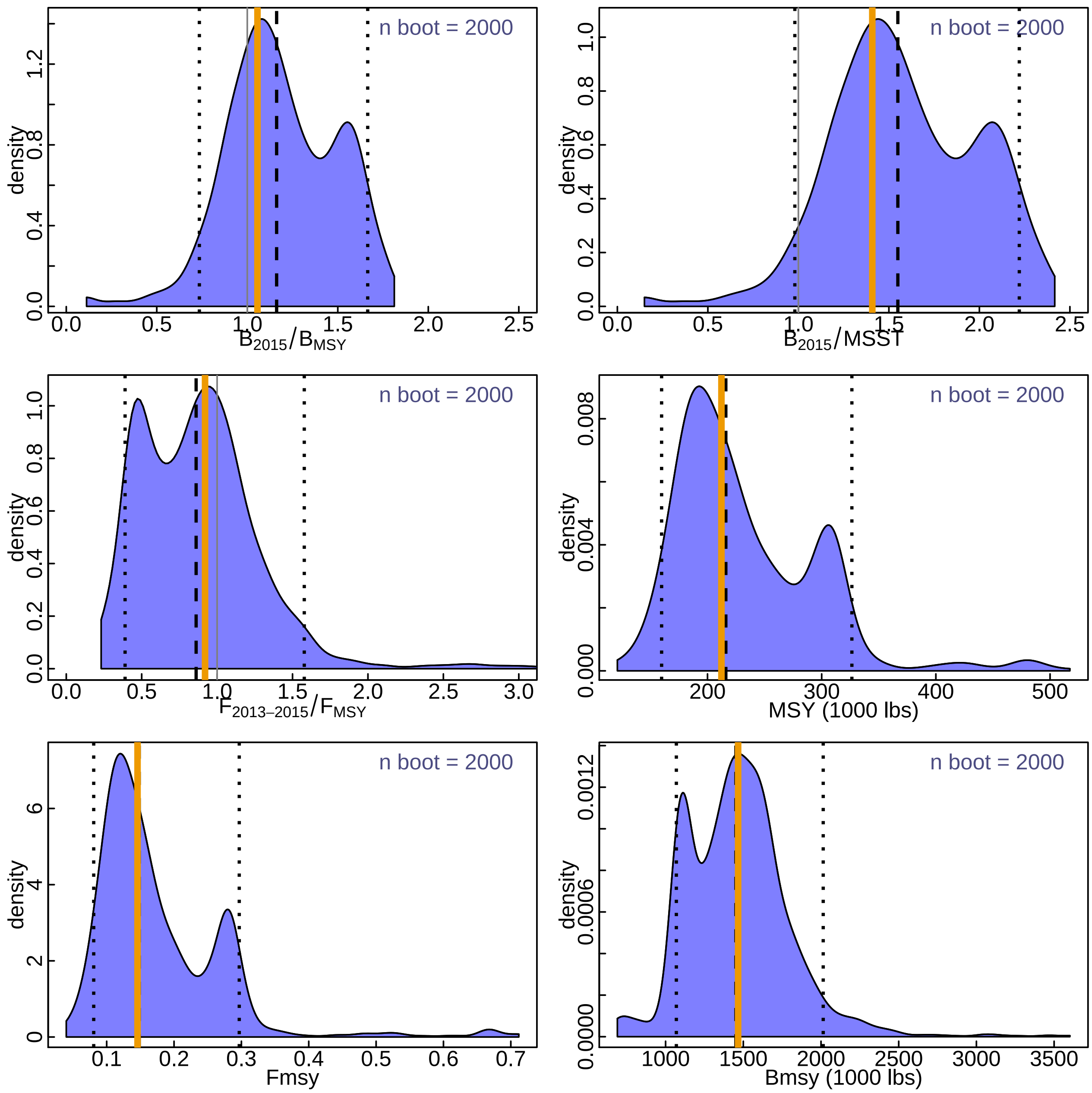


Figure 13. Estimated biomass series (B) relative to B_{MSY} combining Runs 55 and 56) from ASPIC for the So. Atl. Solid line indicates average B series relative to average B_{MSY}, for handline and longline models. The dashed line represents the median B/B_{MSY} and blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials.

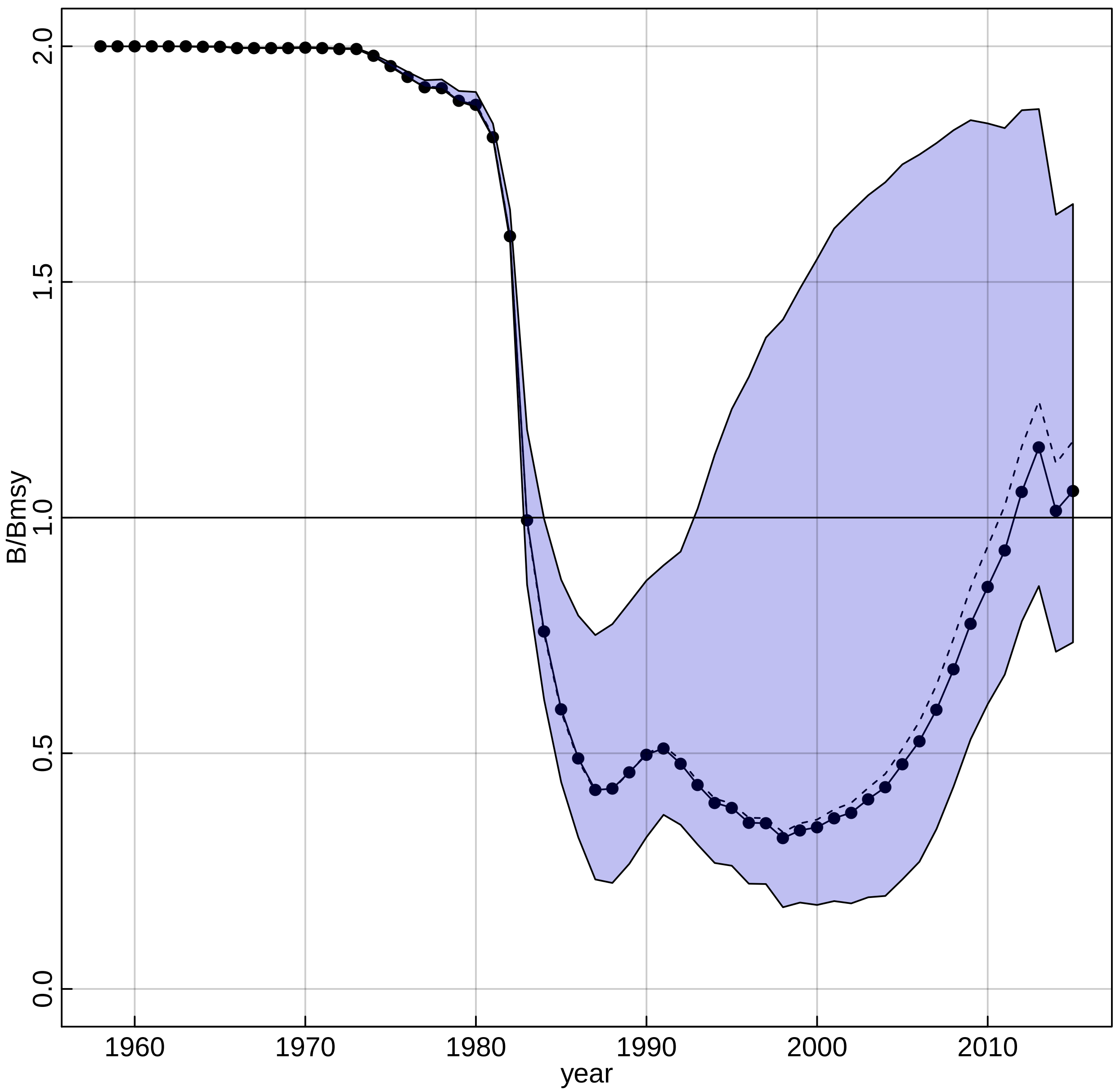


Figure 14. Estimated biomass series (B) relative to MSST *combining Runs 55 and 56) from* ASPIC *for the So. Atl. Solid line indicates average B series relative to average* MSST *(*$0.75B_{\mathrm{MSY}}$*), for handline and longline models. The dashed line represents the median* MSST *and blue error bands indicate* 5^{th} *and* 95^{th} *percentiles of the combined bootstrap trials.*

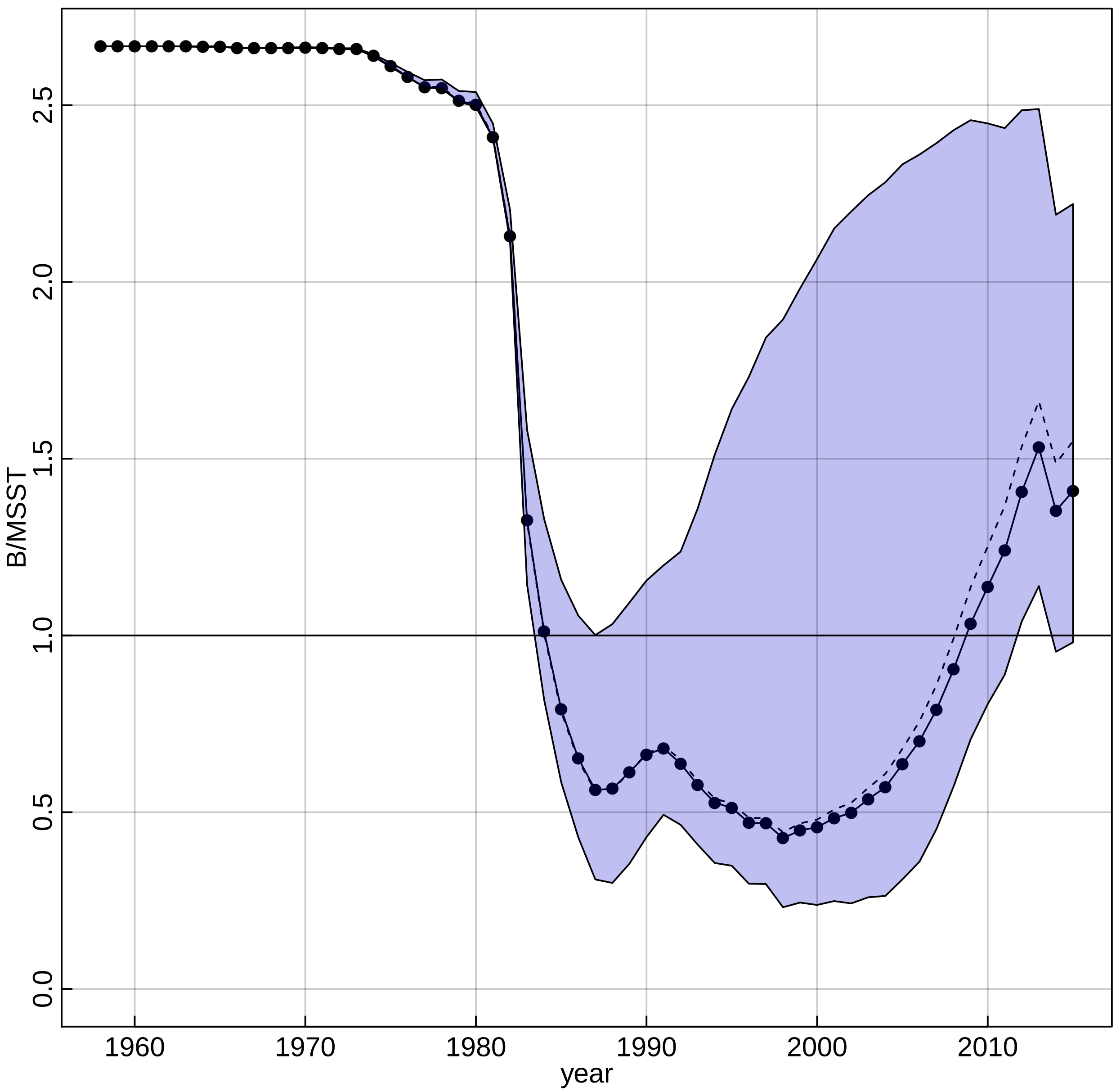


Figure 15. Estimated fishing mortality series (F) relative to F_{MSY} combining Runs 55 and 56) from ASPIC for the So. Atl. Solid line indicates average F series relative to average F_{MSY}, for handline and longline models. The dashed line represents the median F/F_{MSY} and blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials.

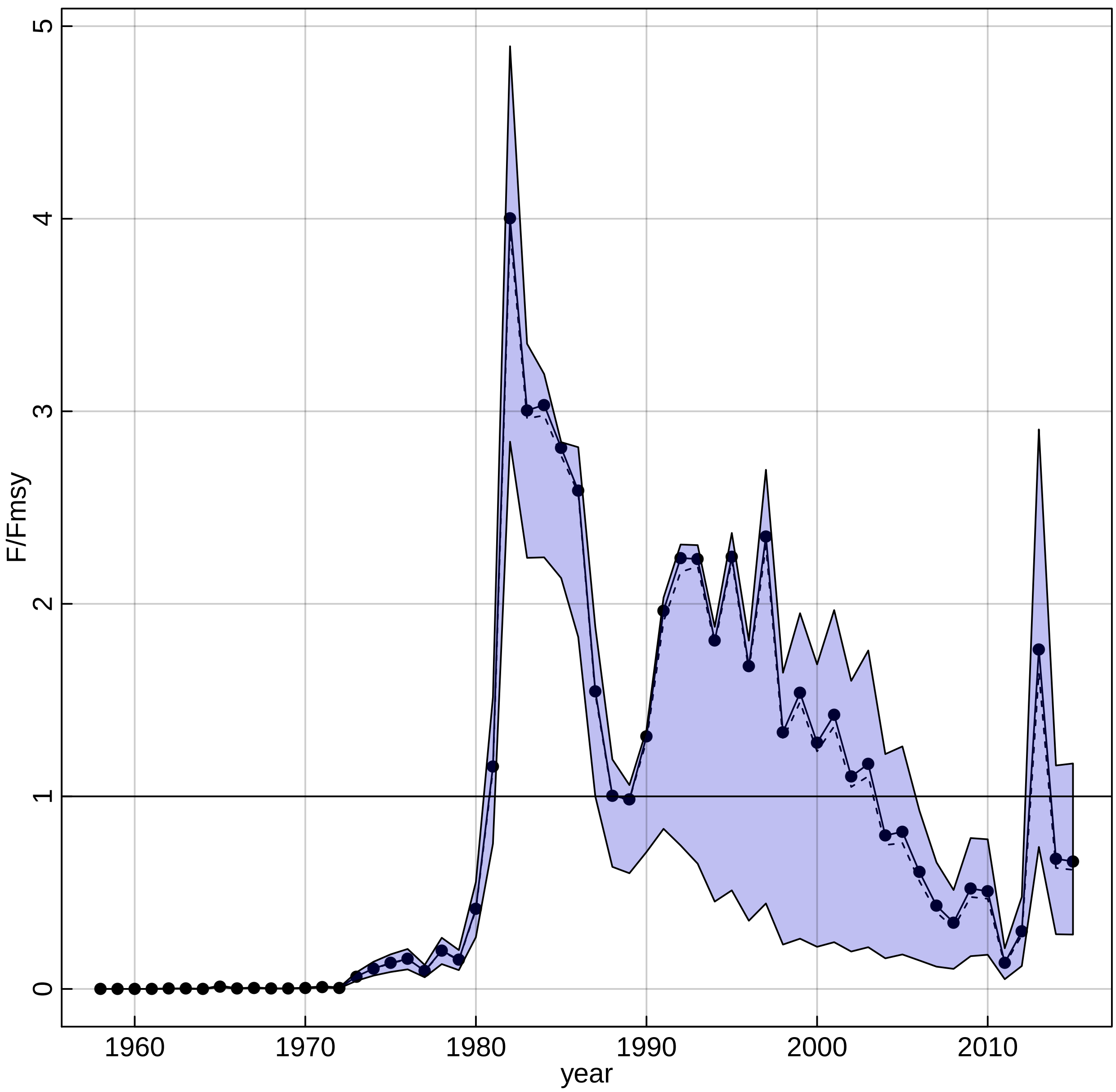


Figure 16. Phase plots of ASPIC F and B status estimates for combined bootstrap runs associated with both base runs (Run 55 and 56) from ASPIC for the So. Atl. Bootstrapping was conducted for each model separately, then the resulting bootstrap results were added together to create composite distributions. The intersection of crosshairs indicates average estimate from the base runs; lengths of crosshairs defined by 5^{th} and 95^{th} percentiles. Percent of runs falling in each quadrant indicated.

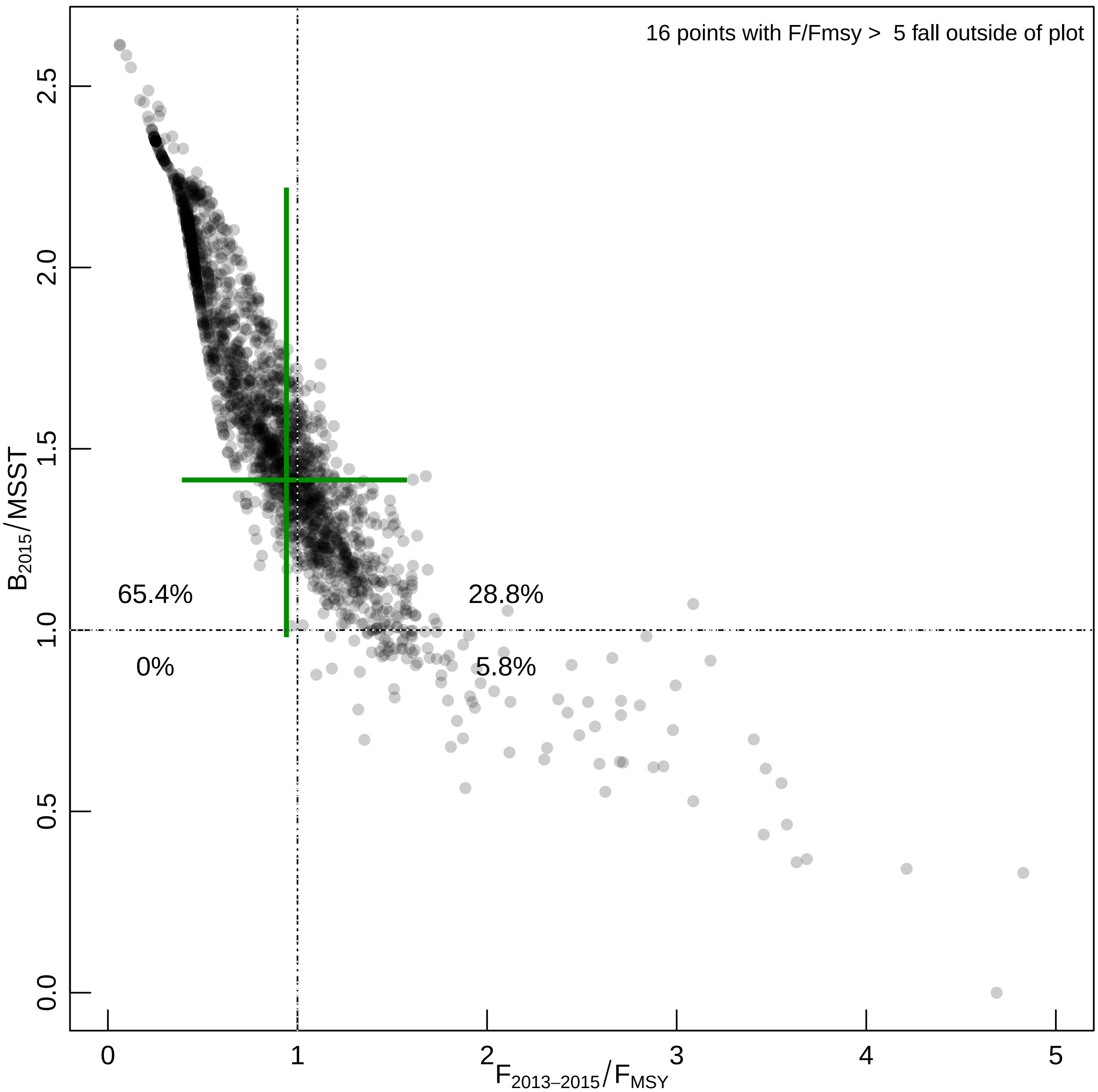
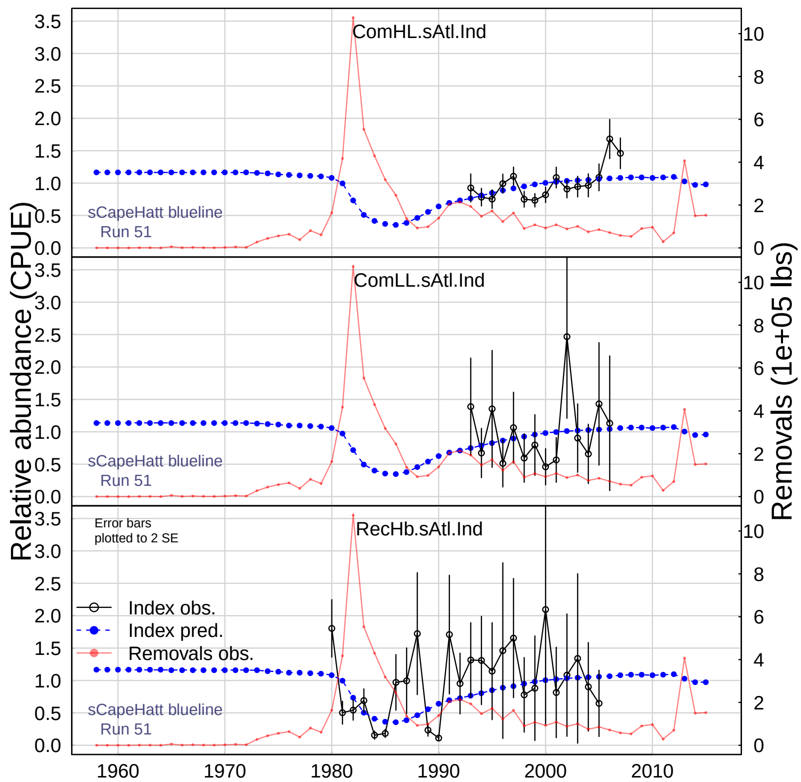


Figure 17. Sensitivity to indices: ASPIC Run 51 for the So. Atl. Fits to indices (upper panel) and B and F ratio plots (lower panel) for ASPIC Run 51. Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015).



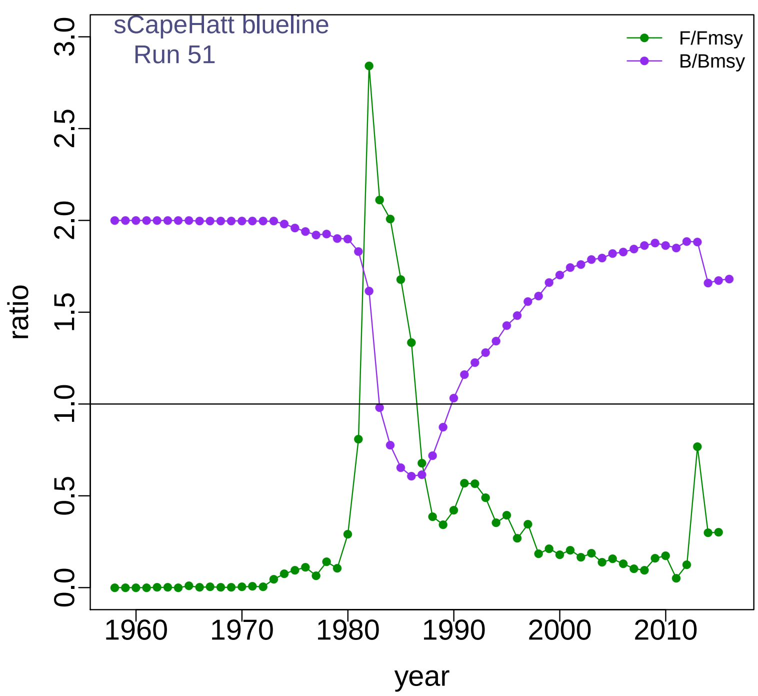
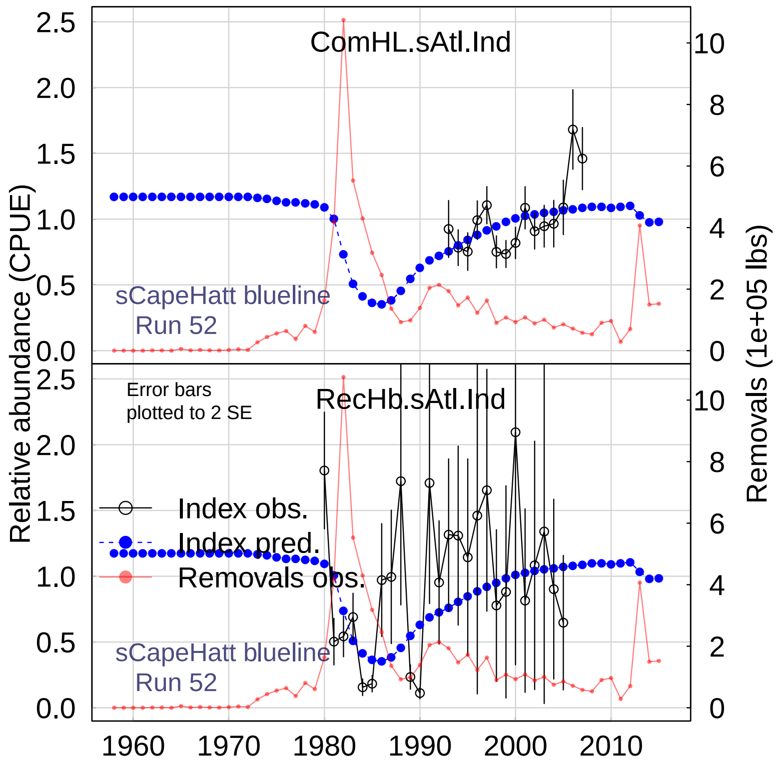


Figure 18. Sensitivity to indices: ASPIC Run 52 for the So. Atl. Fits to indices (upper panel) and B and F ratio plots (lower panel) for ASPIC Run 52. Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015).



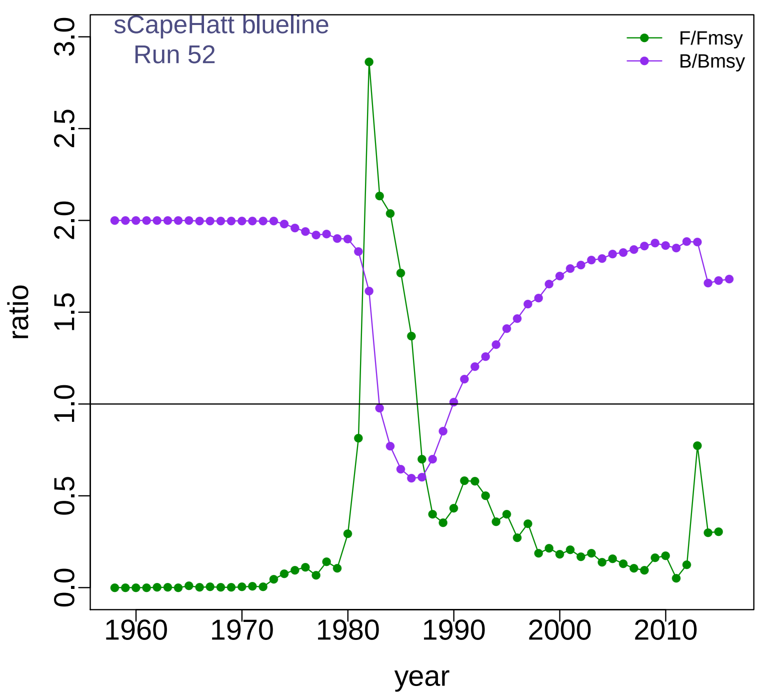
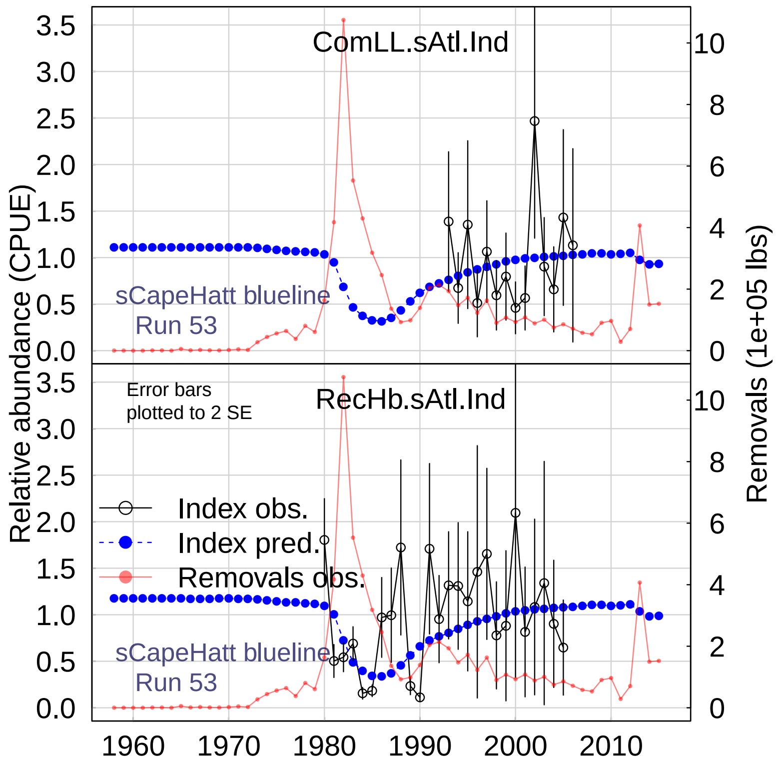


Figure 19. Sensitivity to indices: ASPIC Run 53 for the So. Atl. Fits to indices (upper panel) and B and F ratio plots (lower panel) for ASPIC Run 53. Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015).



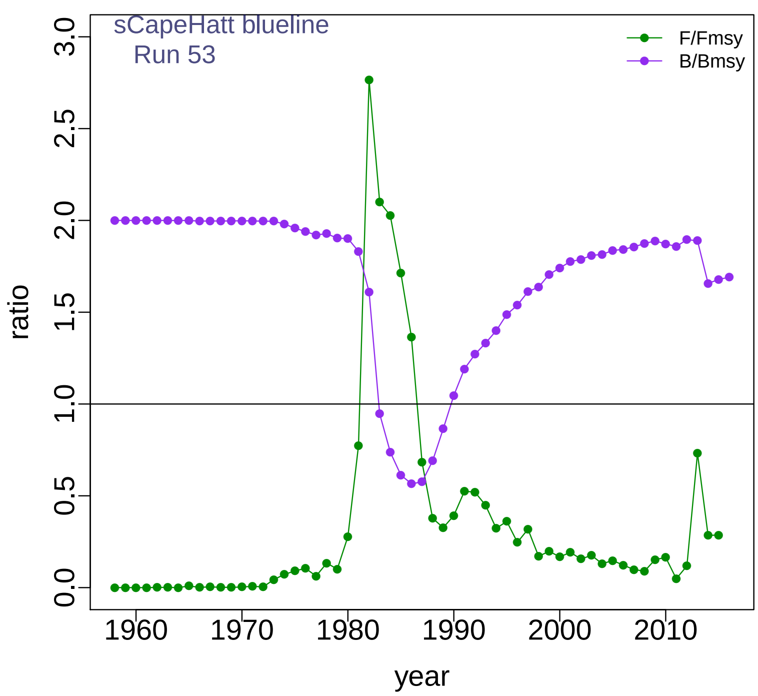
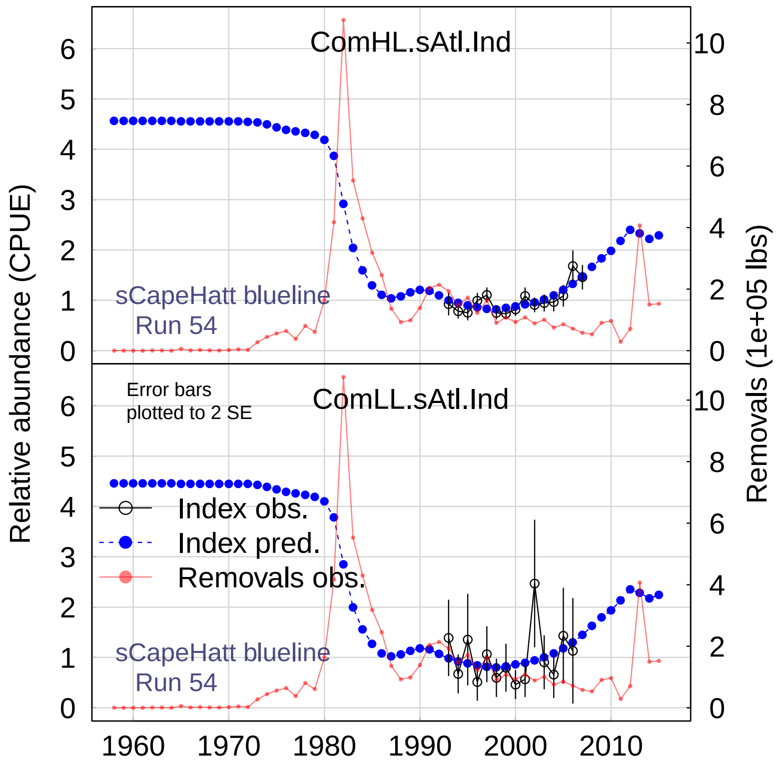


Figure 20. Sensitivity to indices: ASPIC Run 54 for the So. Atl. Fits to indices (upper panel) and B and F ratio plots (lower panel) for ASPIC Run 54. Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015).



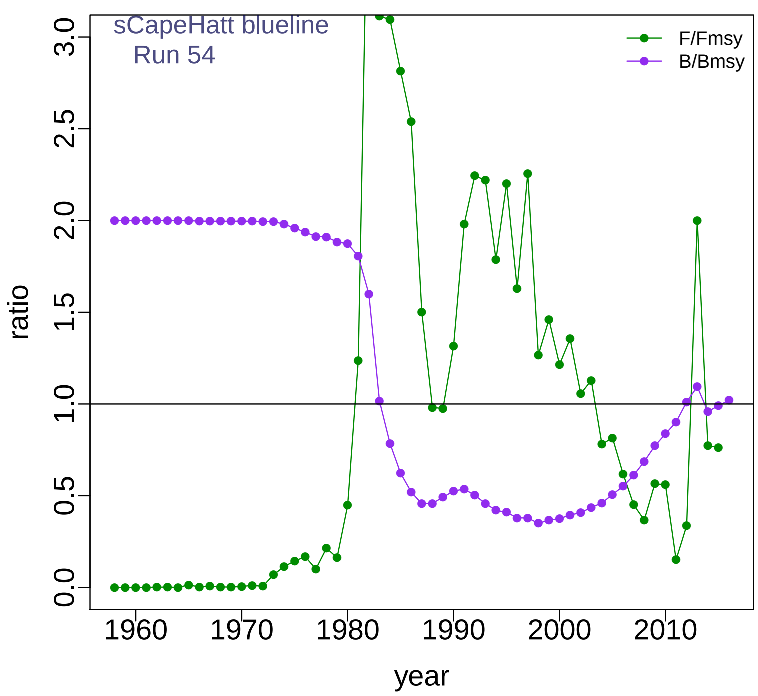
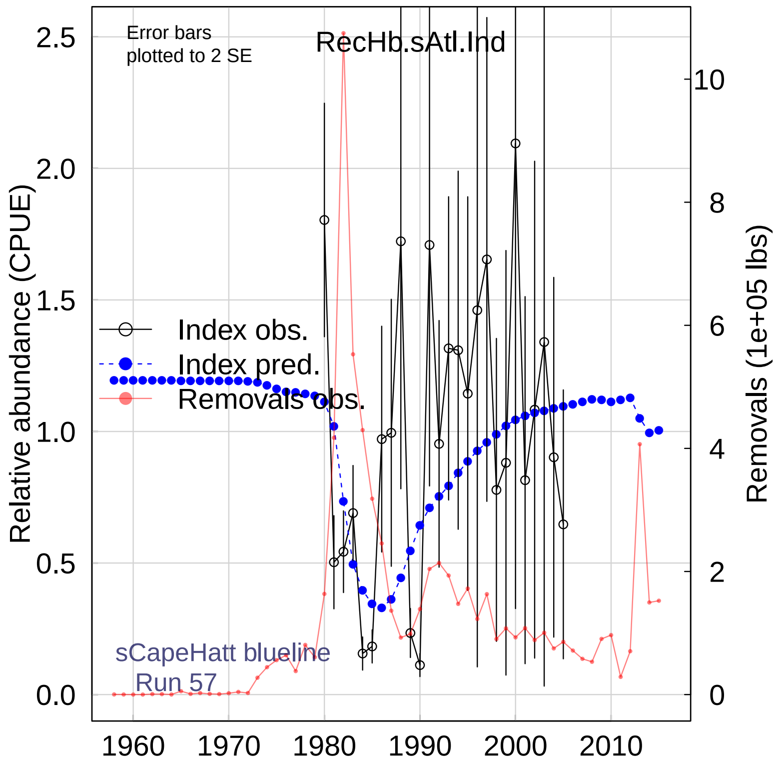


Figure 21. Sensitivity to indices: ASPIC Run 57 for the So. Atl. Fits to indices (upper panel) and B and F ratio plots (lower panel) for ASPIC Run 57. Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015).



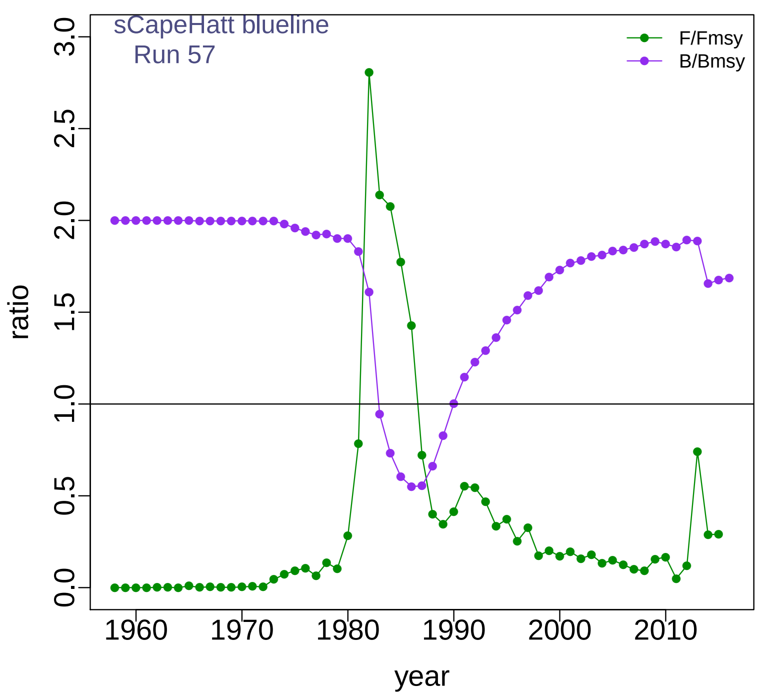
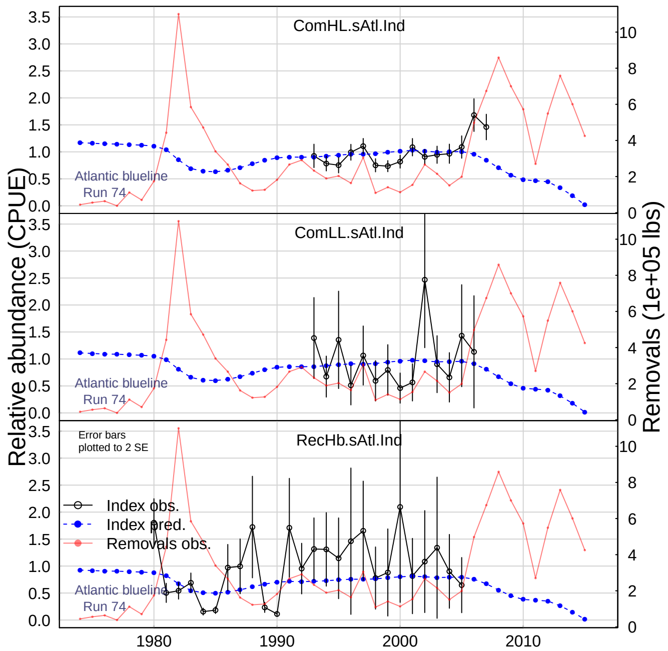


Figure 22. This run (ASPIC Run 74 for the So. Atl.) was set up similar to SEDAR 32 to serve as a continuity run. Fits to indices (upper panel) and B and F ratio plots (lower panel) for ASPIC Run 74. Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015). Data included in this run were those supplied to SEDAR 50, but settings are meant to mimic SEDAR 32. This run includes commercial handline and longline, and recreational headboat indices, landings extending from the GM/SA council boundary through the Mid-Atlantic, and a model start year of 1974.



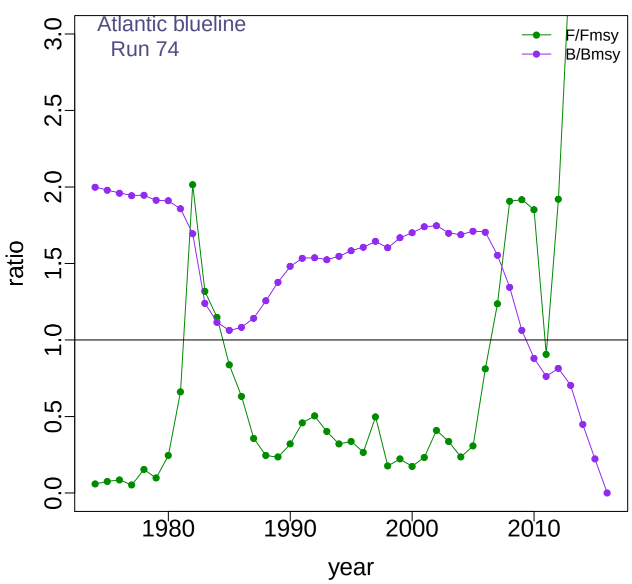
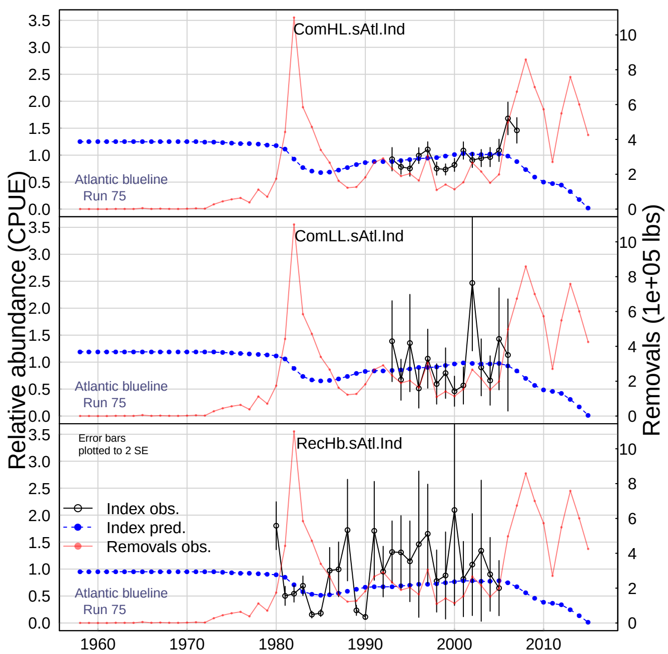


Figure 23. This run (ASPIC Run 75 for the So. Atl.) is similar to the main continuity run but has a start year of 1958 as in the main models for SEDAR 50. This run can be compared with Run 51 to observe the effect of including landings north of Cape Hatteras. Fits to indices (upper panel) and B and F ratio plots (lower panel) for ASPIC Run 75. Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015). Data included in this run were those supplied to SEDAR 50, but settings are meant to mimic SEDAR 32. This run includes commercial handline and longline, and recreational headboat indices, landings extending from the GM/SA council boundary through the Mid-Atlantic, and a model start year of 1958.



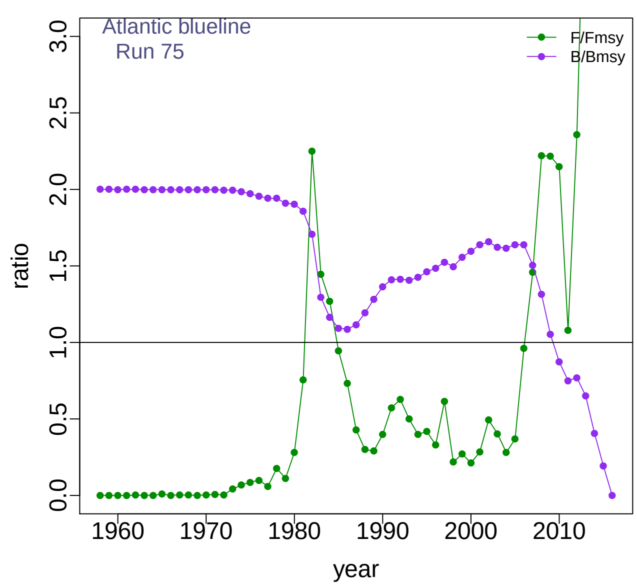
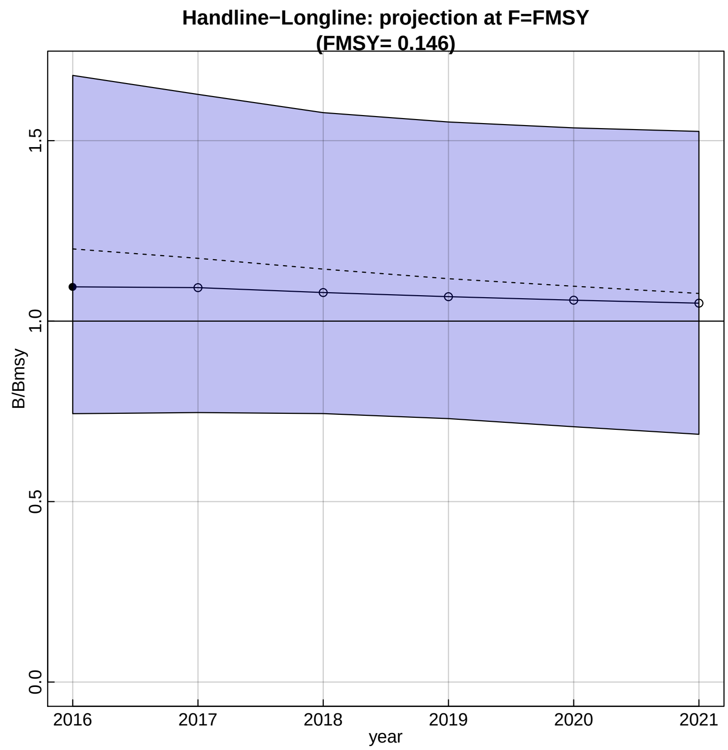


Figure 24. Plot of B/B_{MSY} and B/MSST for five year projections from ASPIC for the South Atlantic region with F set at F_{MSY} beginning the year after the terminal year of the assessment. Solid circles represent values projected by the assessment model while open circles represent values produced by the projection code. The solid and dashed lines are the expected value and median of the bootstrap projections, respectively. The blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials.



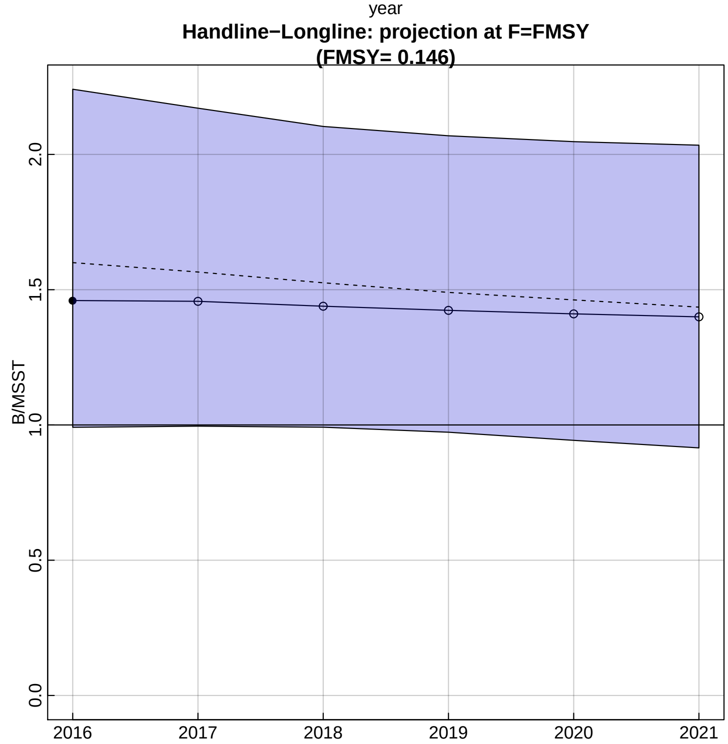


Figure 25. Plot of B/B_{MSY} *and* B/MSST *for five year projections from* ASPIC *for the South Atlantic region with F set at* F_{current} *beginning the year after the terminal year of the assessment. Solid circles represent values projected by the assessment model while open circles represent values produced by the projection code. The solid and dashed lines are the expected value and median of the bootstrap projections, respectively. The blue error bands indicate* 5^{th} *and* 95^{th} *percentiles of the combined bootstrap trials.*

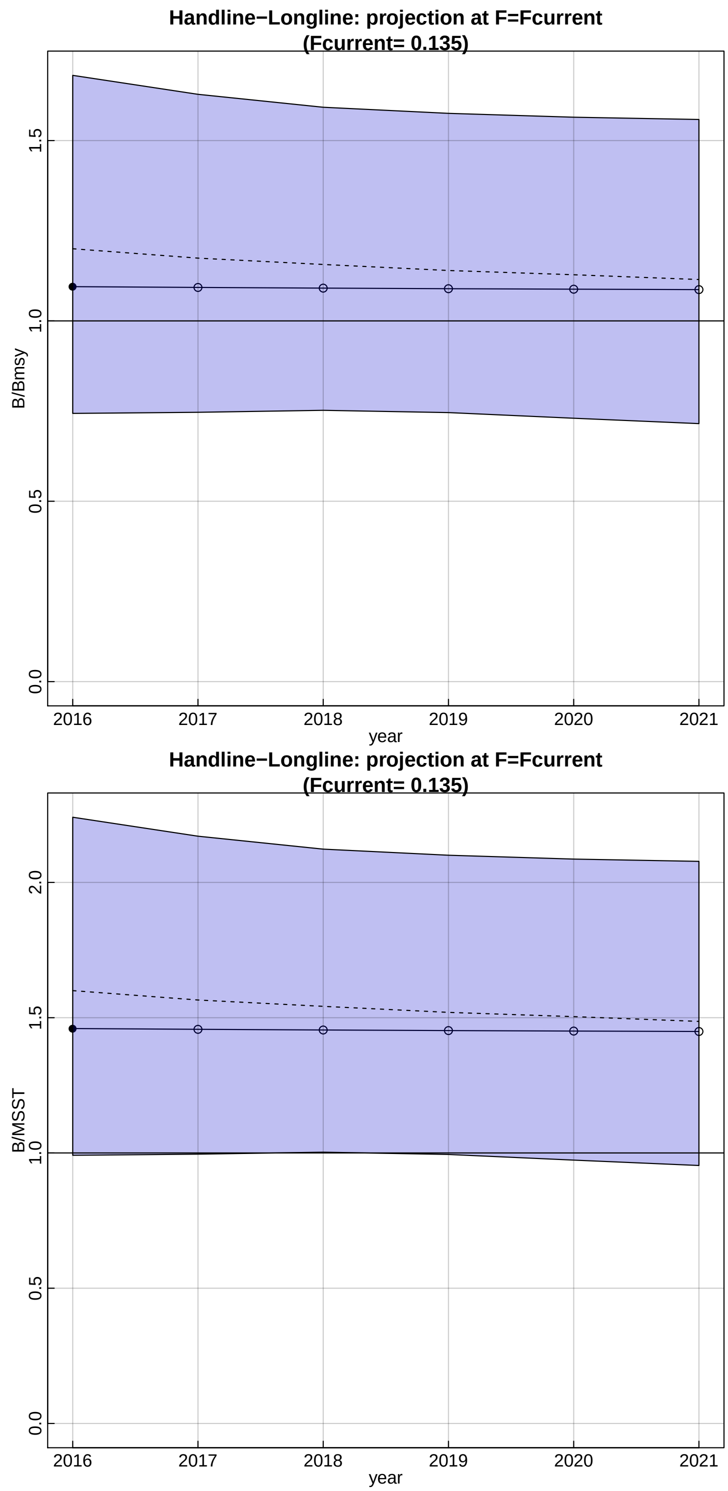
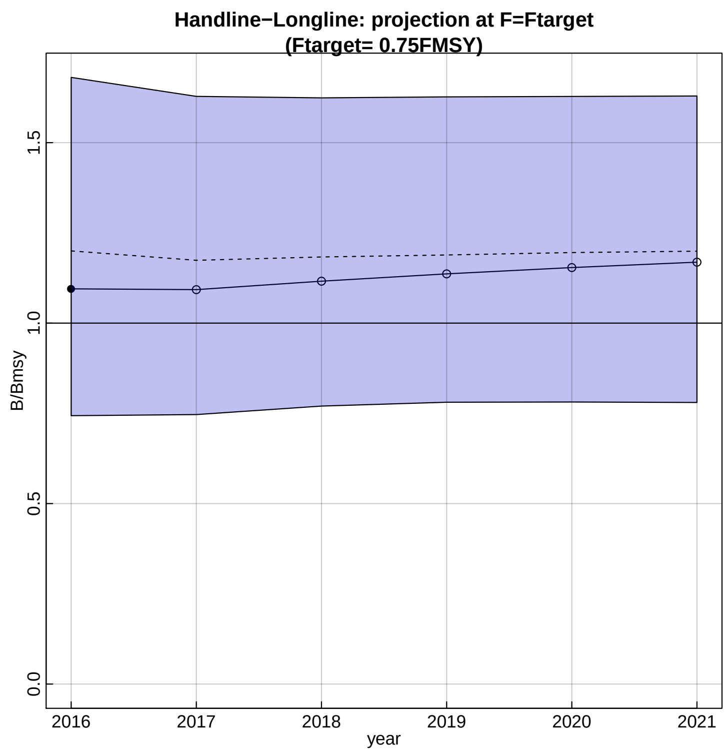


Figure 26. Plot of B/B_{MSY} and B/MSST for five year projections from ASPIC for the South Atlantic region with F set at F_{target} beginning the year after the terminal year of the assessment. Solid circles represent values projected by the assessment model while open circles represent values produced by the projection code. The solid and dashed lines are the expected value and median of the bootstrap projections, respectively. The blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials.



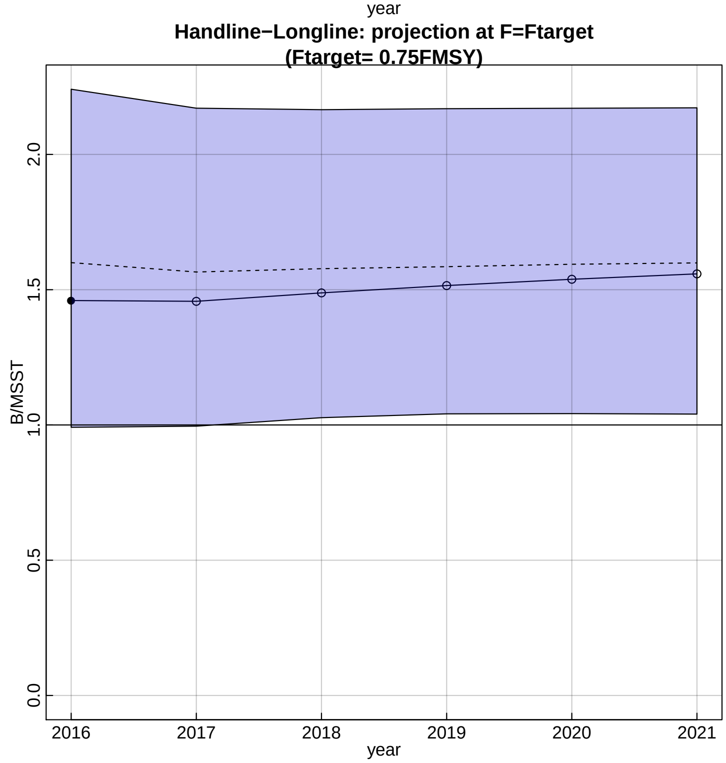


Figure 27. Length, female maturity, and reproductive output at age. Top panel: Mean length at age (mm) and estimated 95% confidence interval of the population. Middle panel: Female maturity by age. Bottom panel: Reproductive output by age (million eggs).

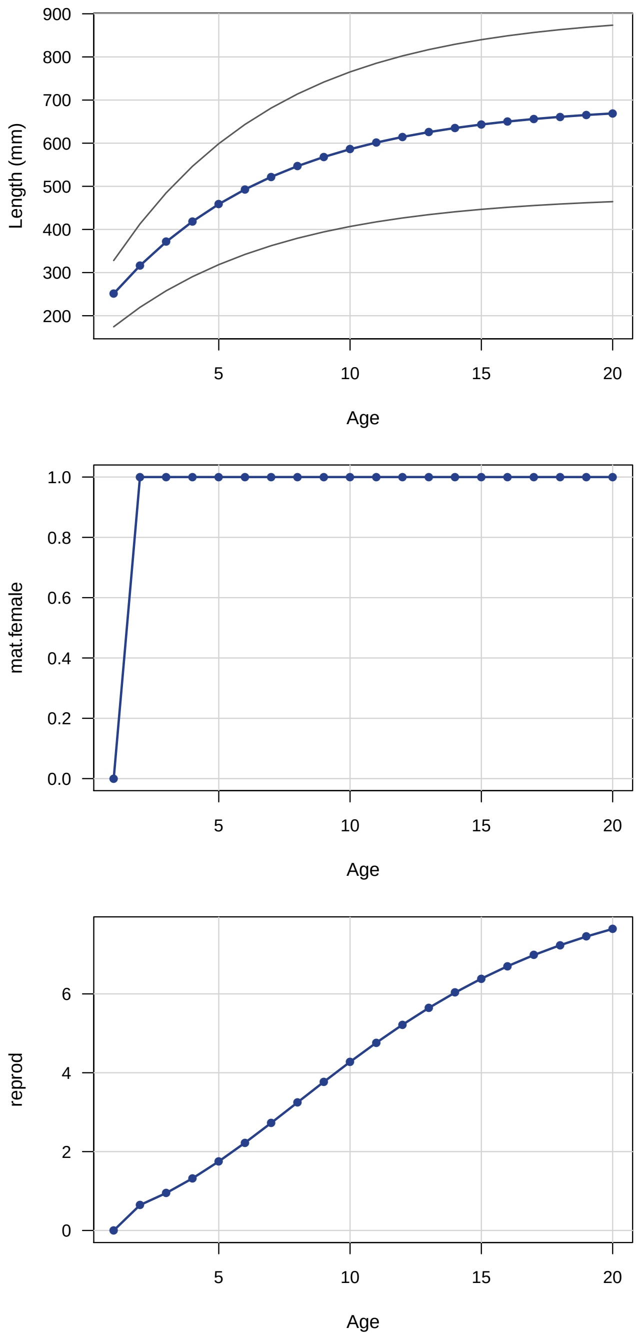


Figure 28. Observed (open circles) and estimated (solid line) annual length compositions by fleet. In panels indicating the data set: lcomp = length compositions, cH = commercial handline, cL = commercial longline, GR = general recreational, including MRIP and headboat samples. N indicates the number of trips from which individual fish samples were taken. Four digit number in upper right corner of each panel indicates year of sampling (e.g. 1983, 1984).

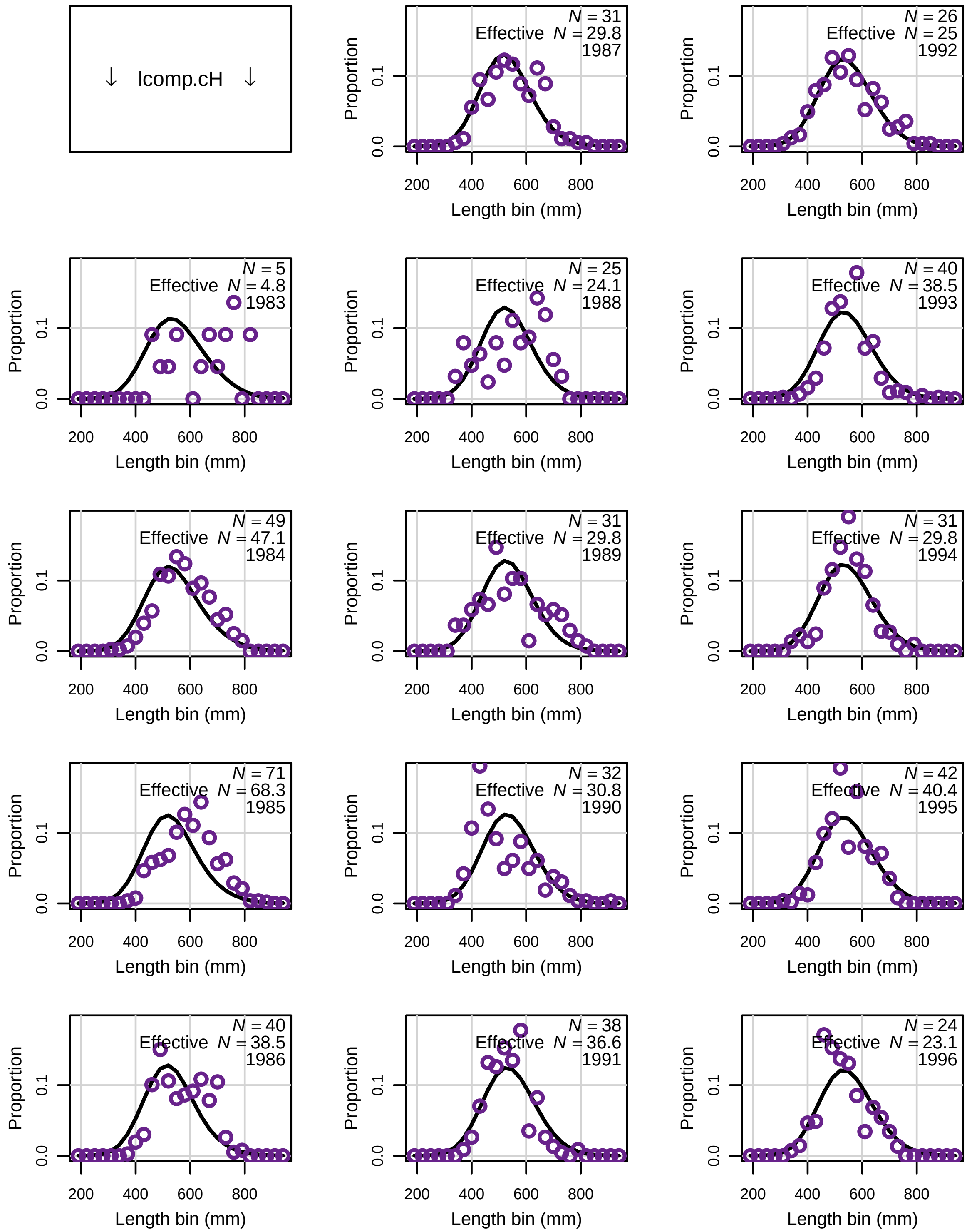


Figure 28. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet.

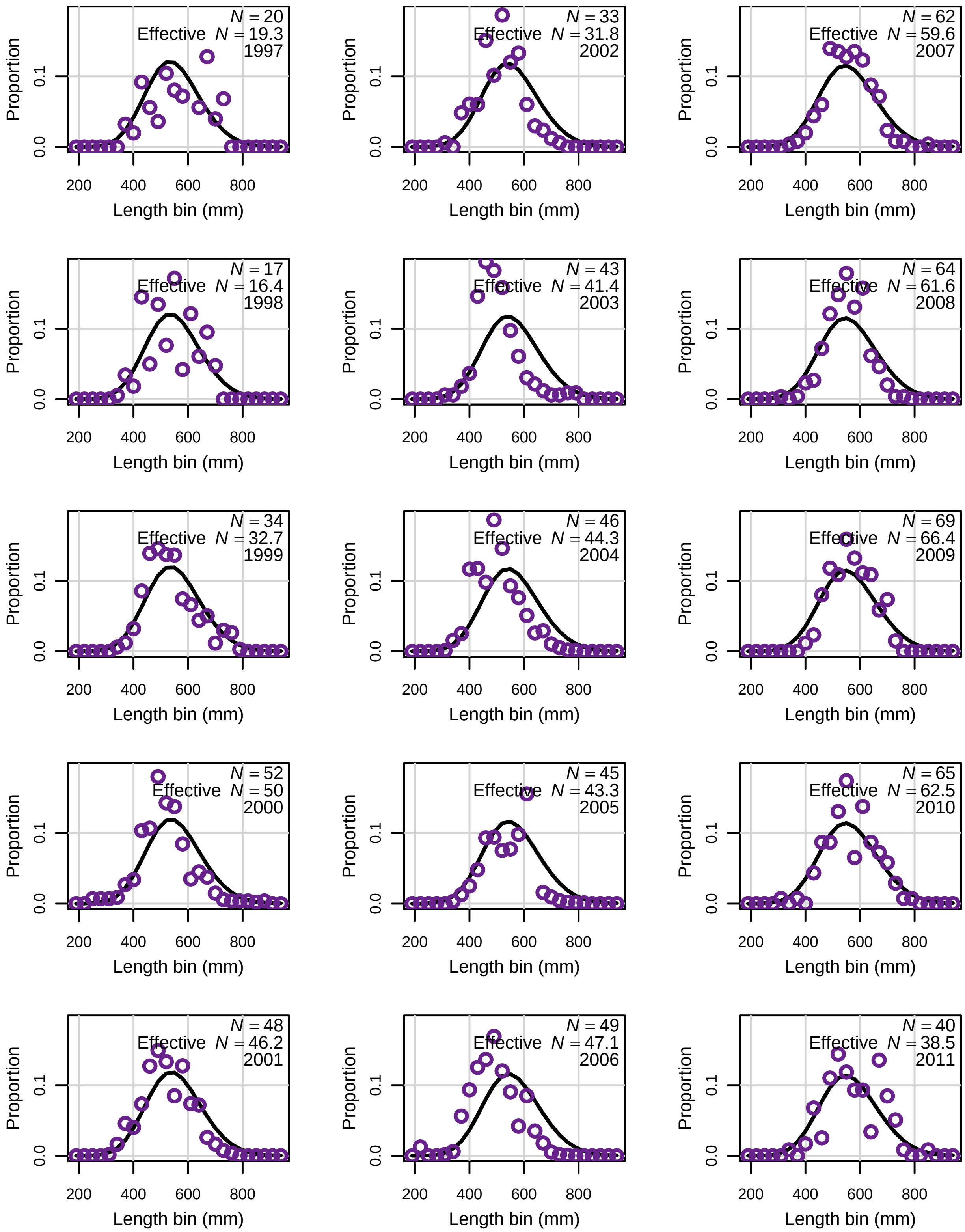


Figure 28. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet.

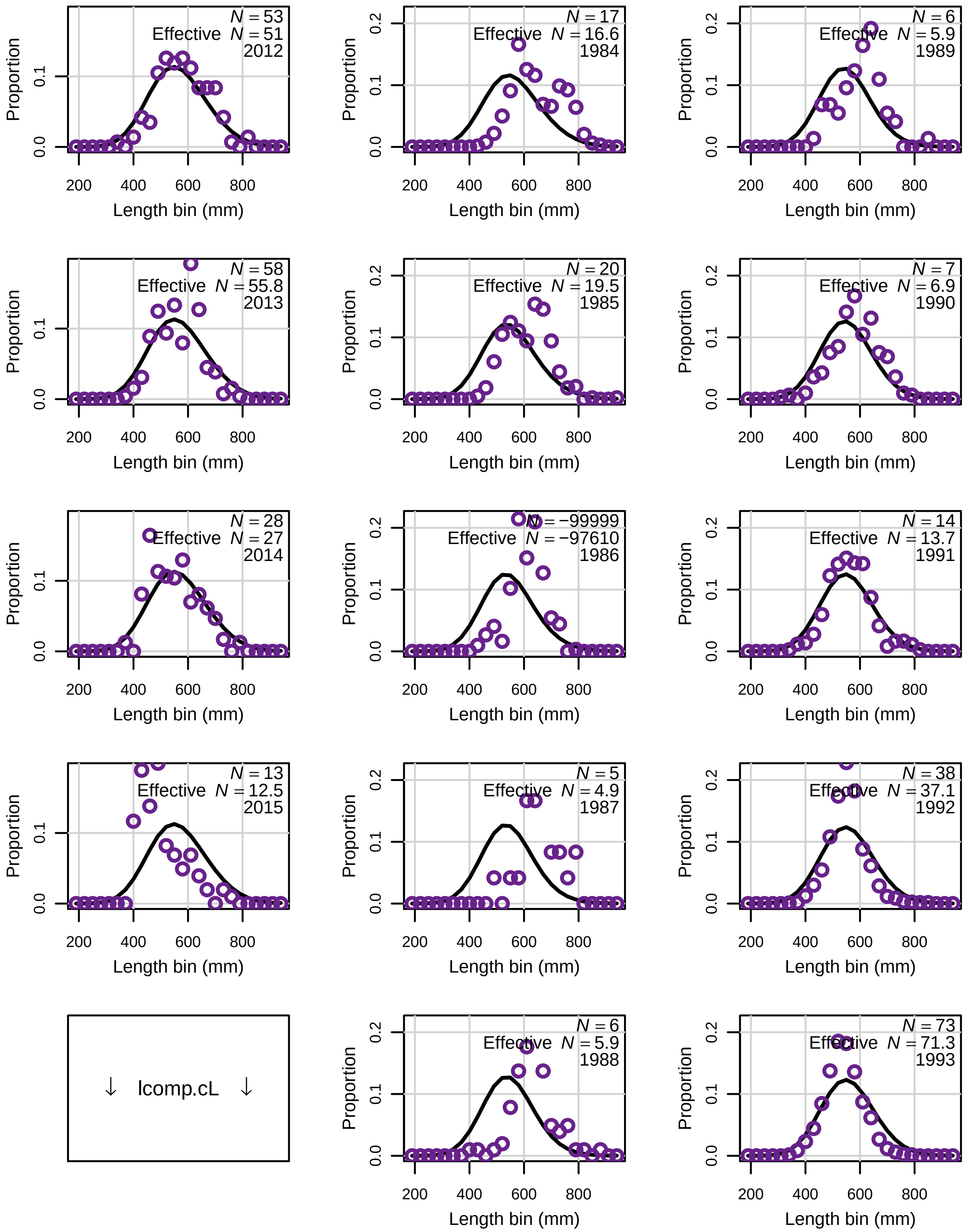


Figure 28. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet.

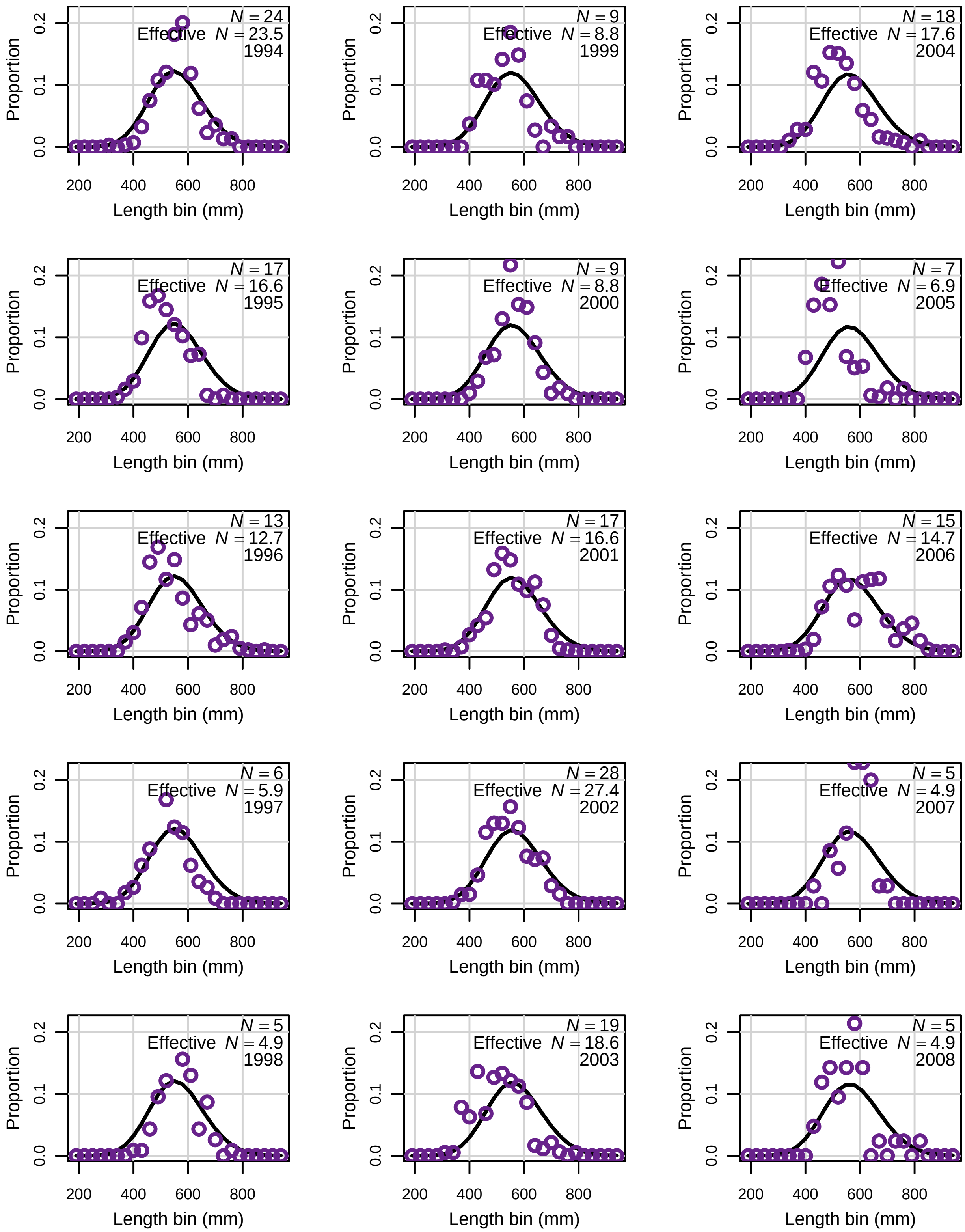


Figure 28. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet.

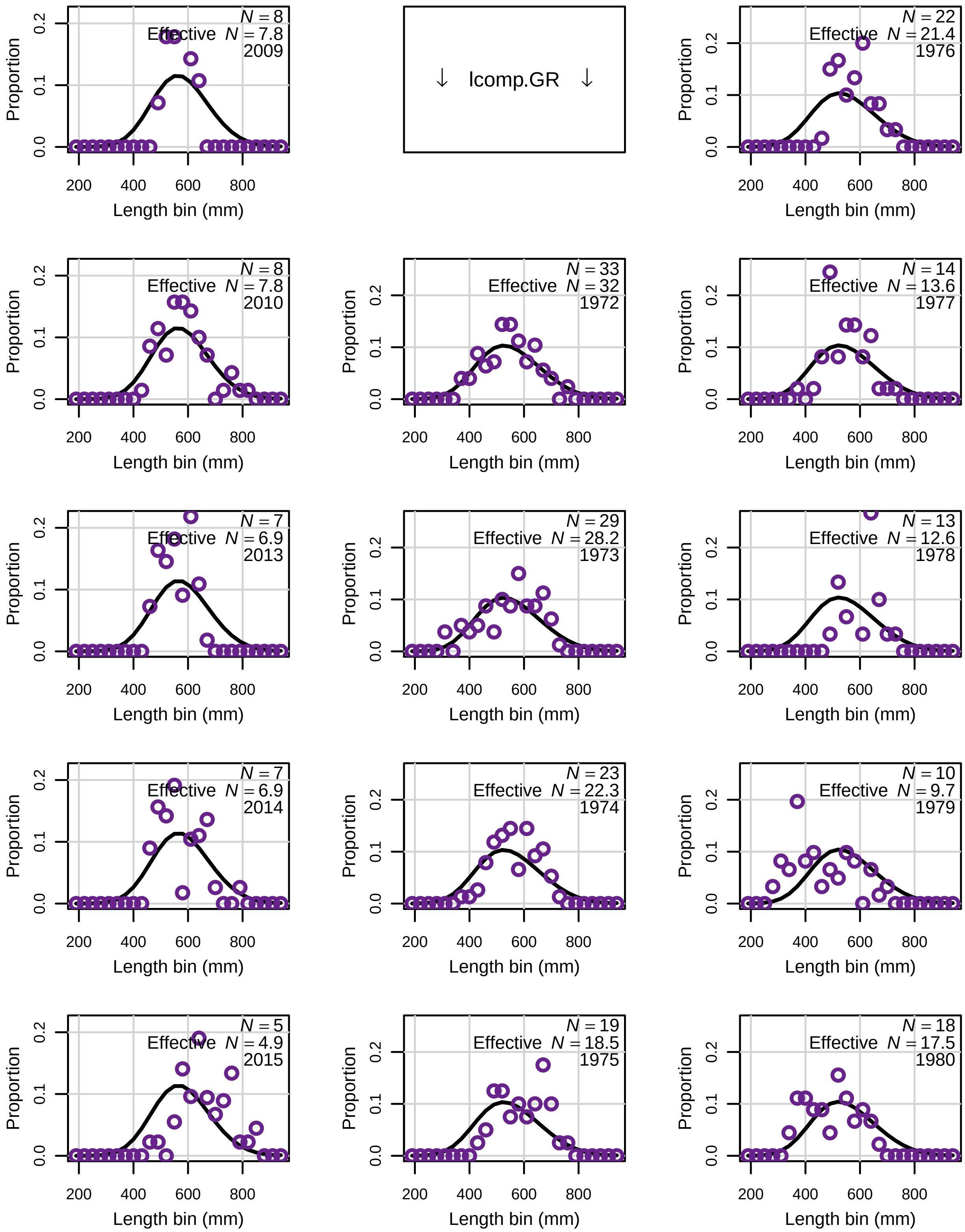


Figure 28. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet.

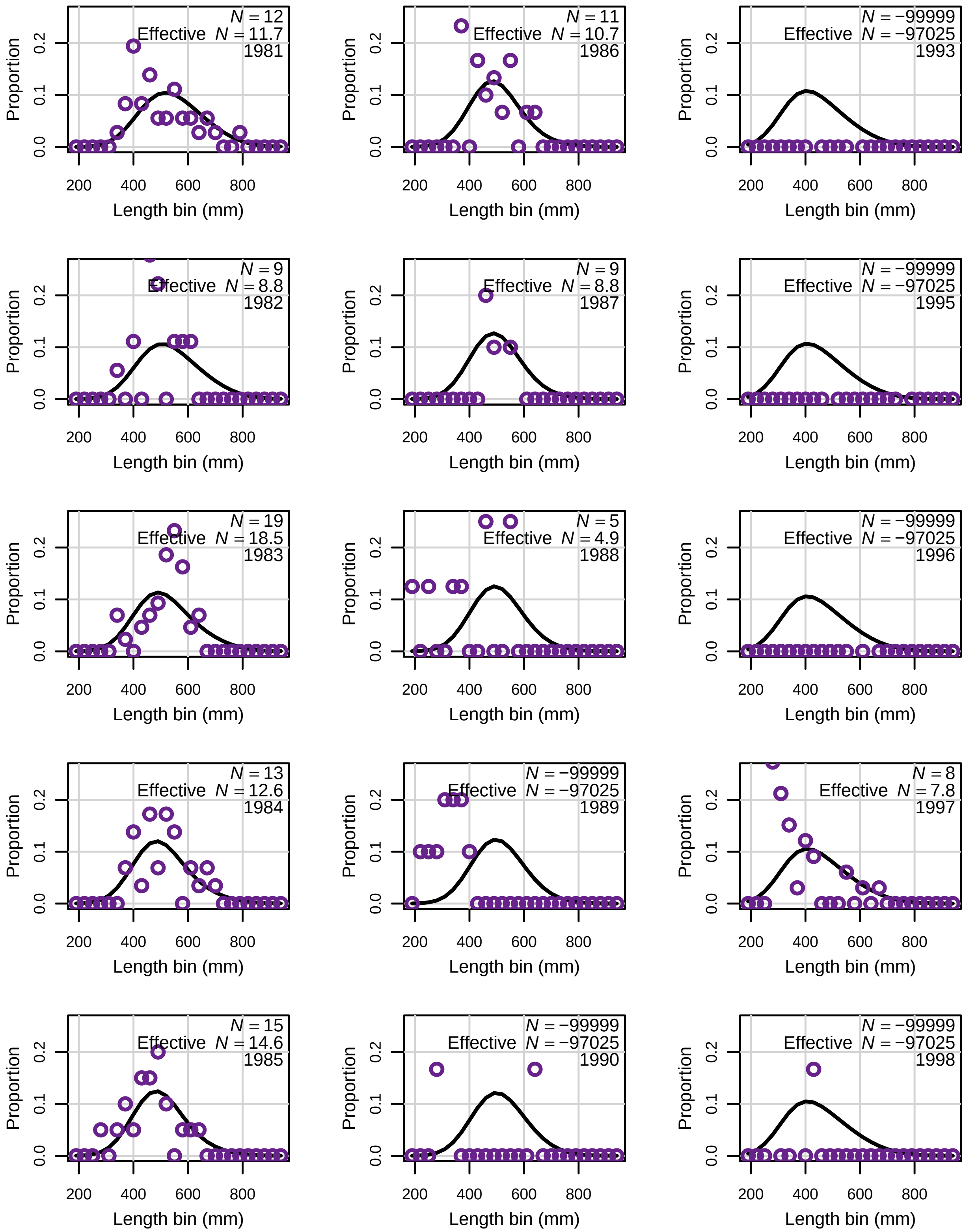


Figure 28. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet.

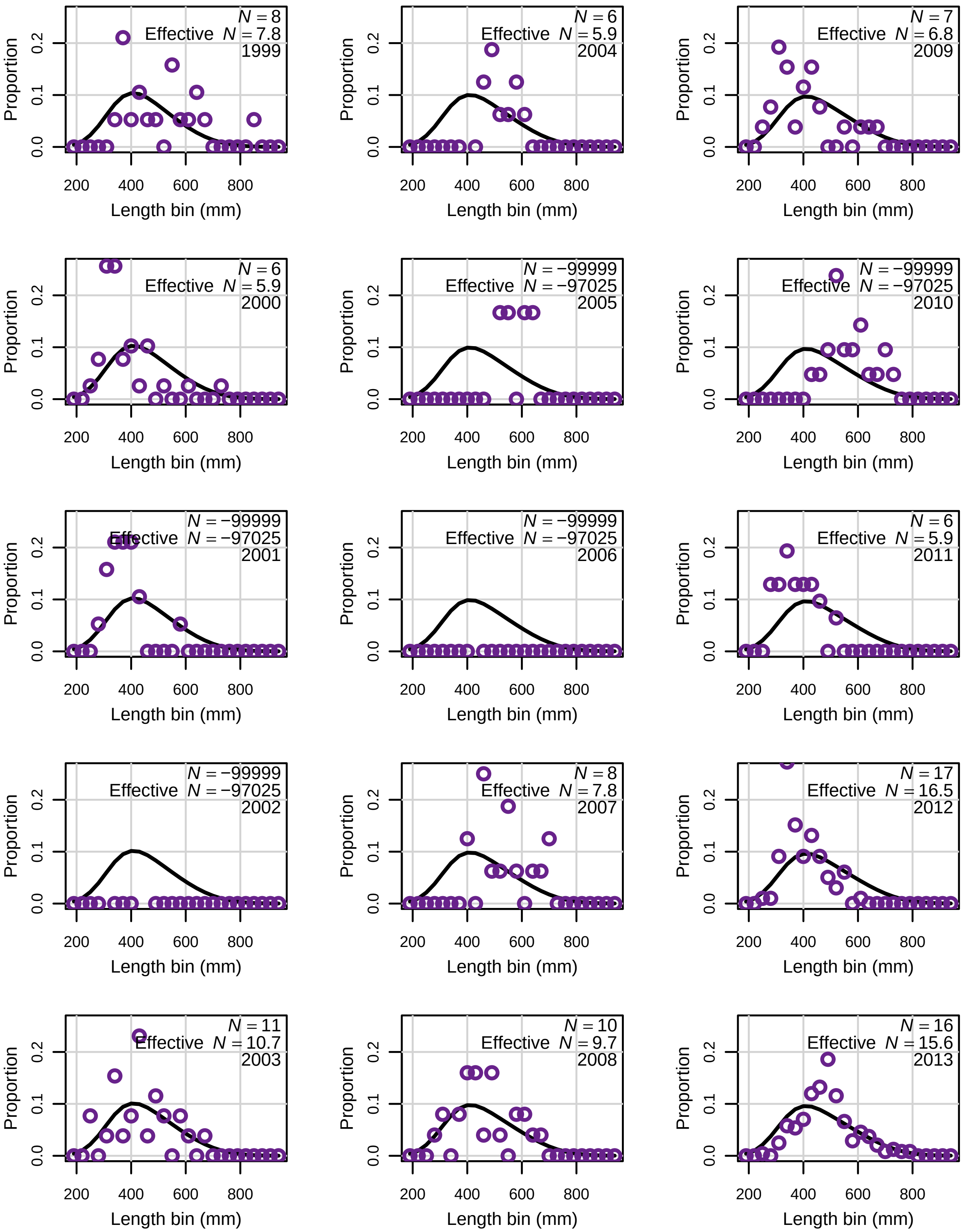
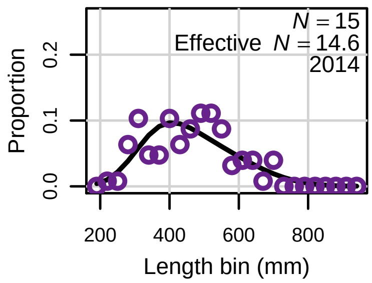


Figure 28. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet



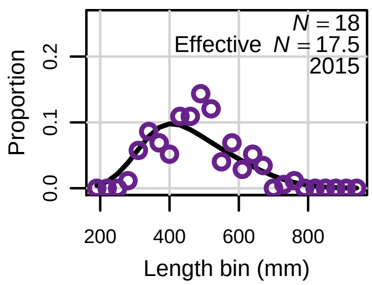


Figure 29. Observed (open circles) and estimated (line, solid circles) combined commercial handline and commercial 'other' landings and discards (1000 lb whole weight).

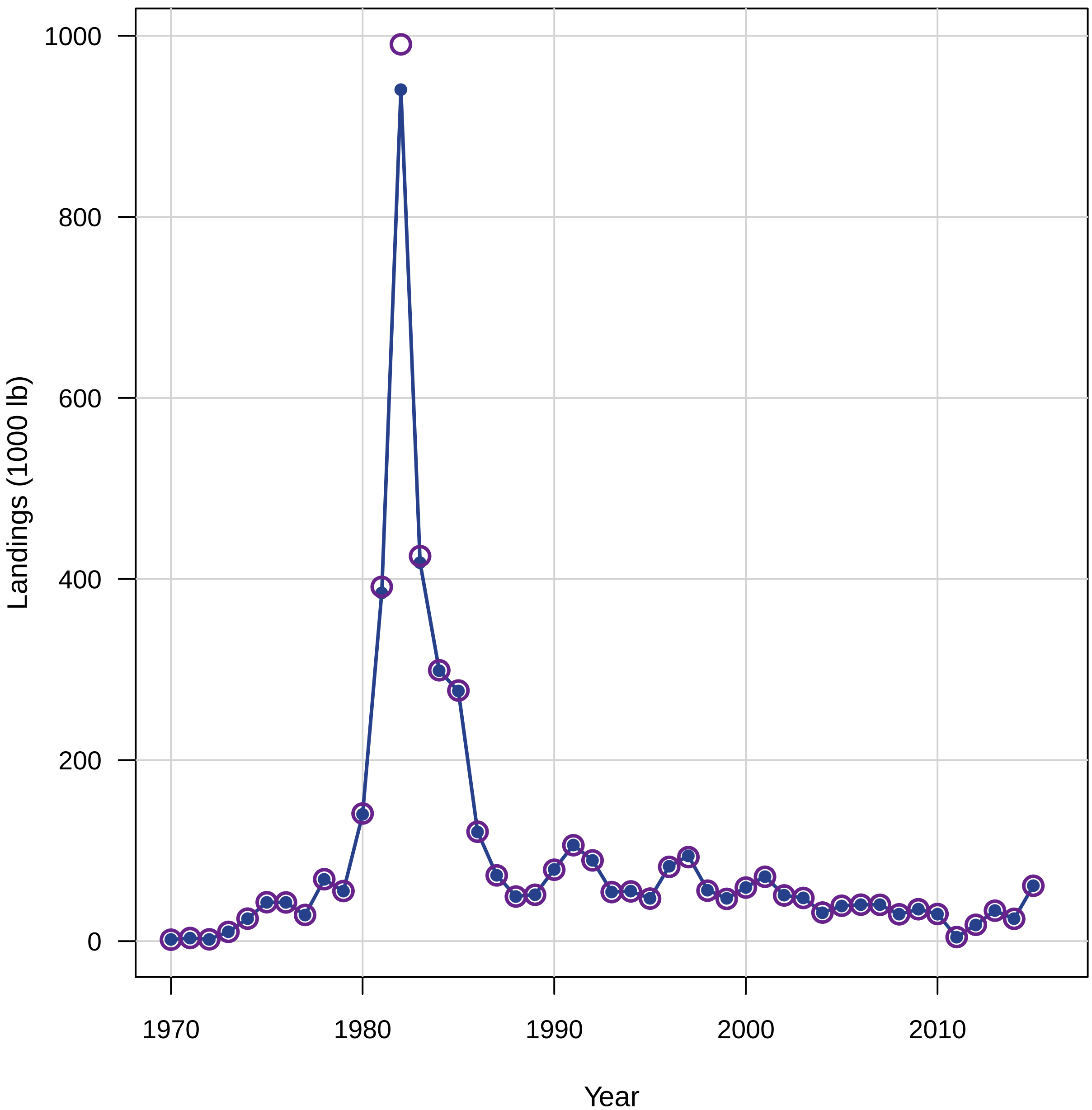


Figure 30. Observed (open circles) and estimated (line, solid circles) commercial longline landings and discards (1000 lb whole weight).

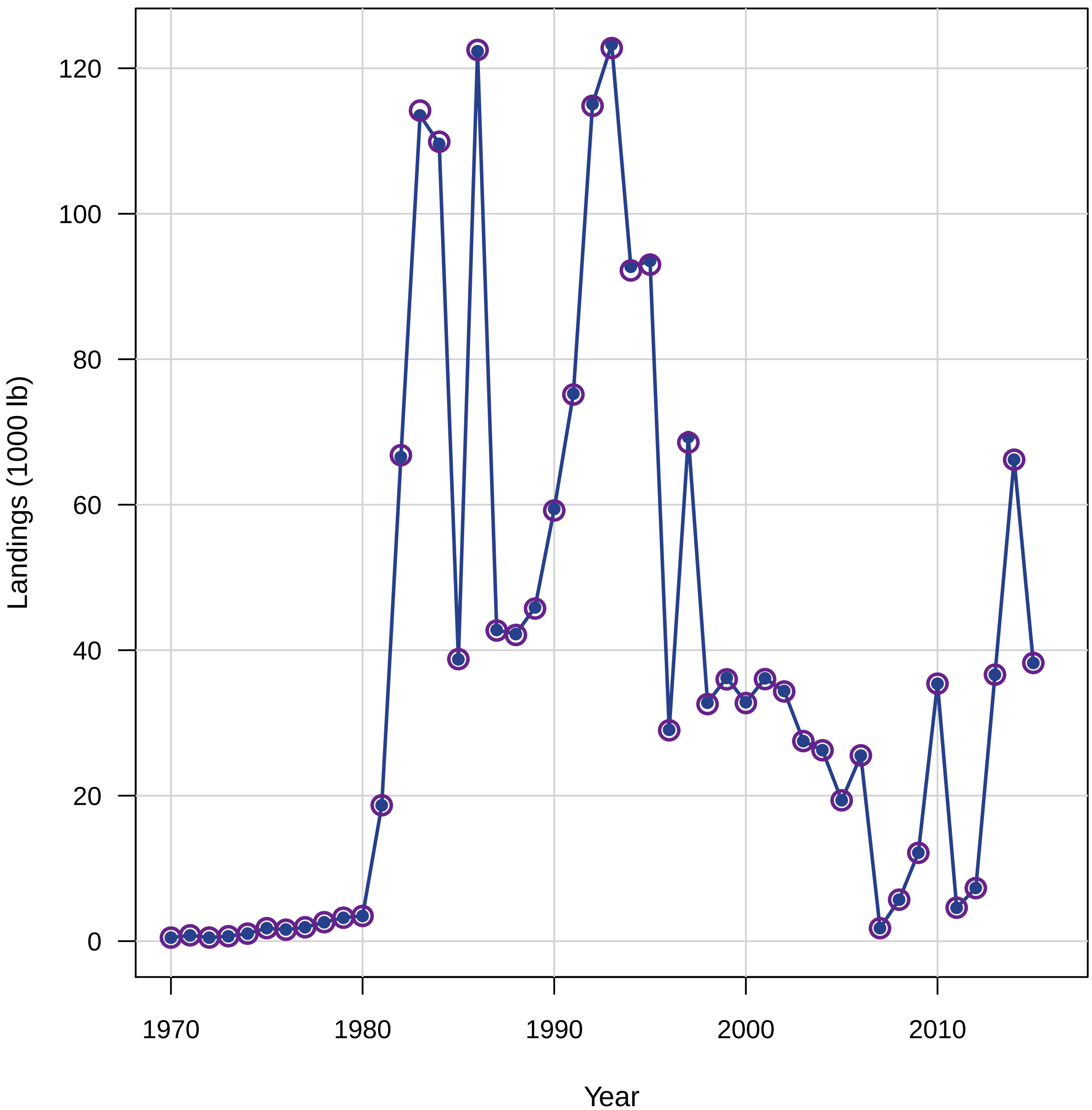


Figure 31. Observed (open circles) and estimated (line, solid circles) combined general recreational (headboat and MRIP) landings and discards (1000 fish).

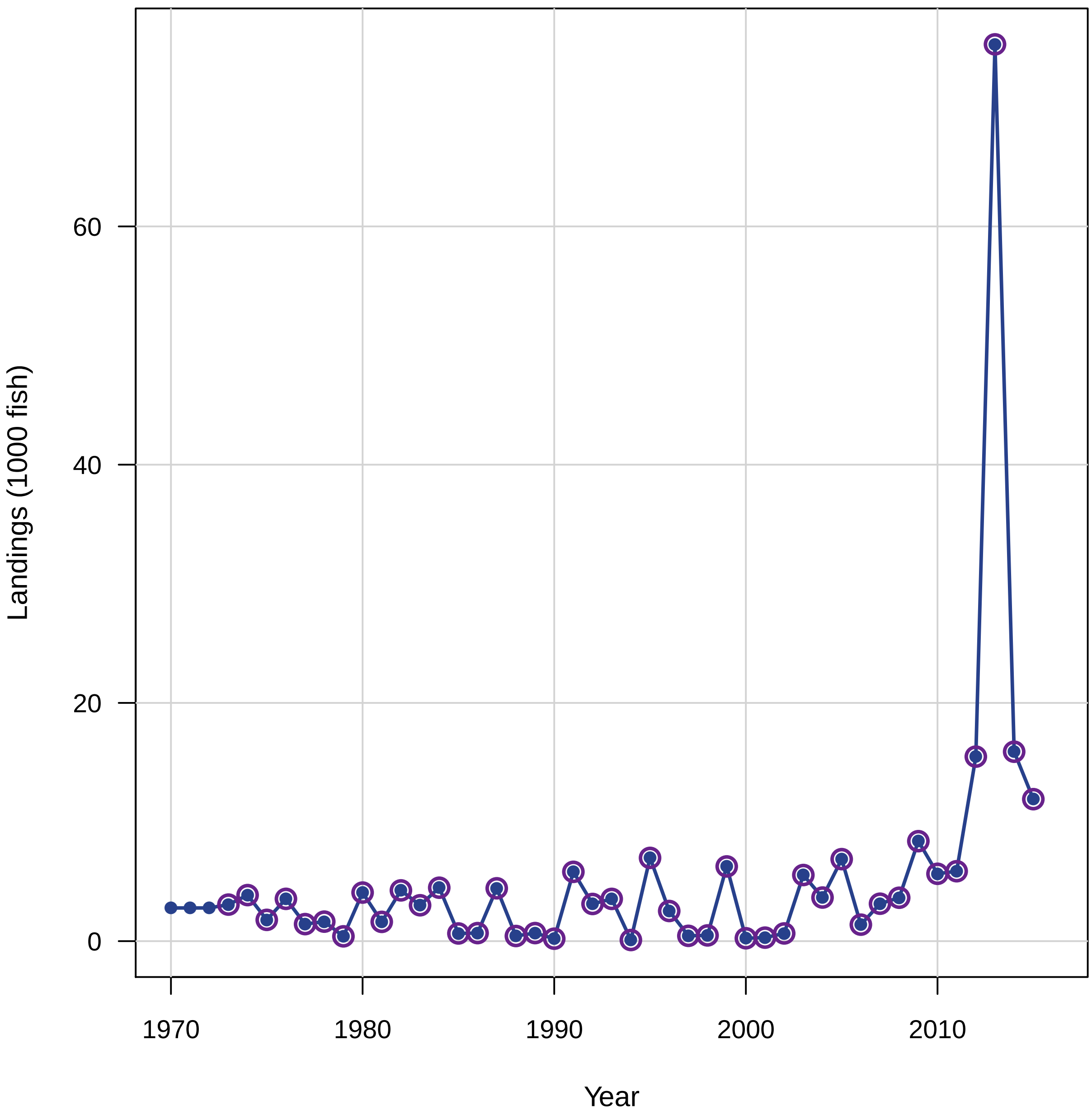


Figure 32. Observed (open circles) and estimated (line, solid circles) index of abundance- commercial handline.

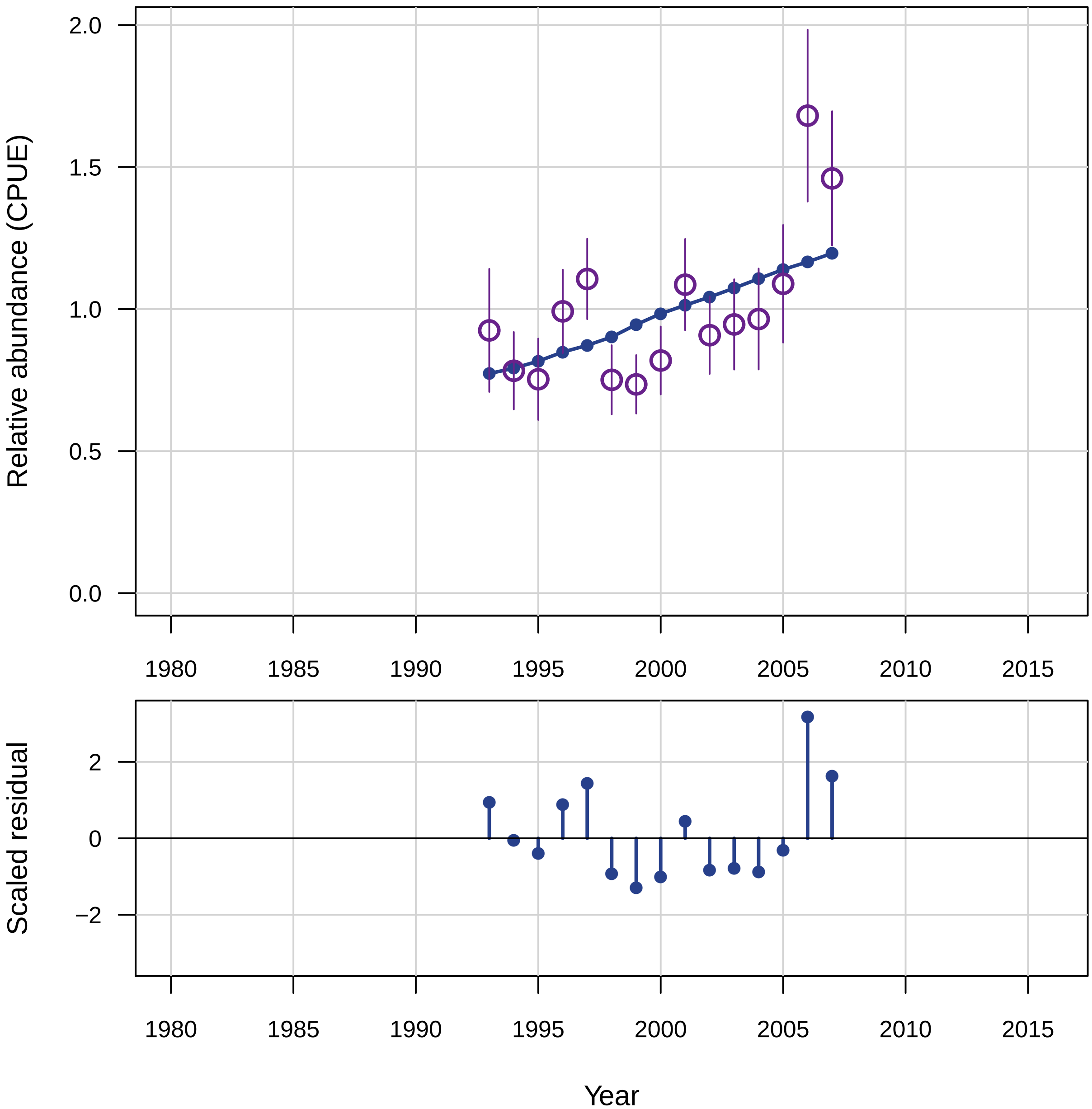


Figure 33. Observed (open circles) and estimated (line, solid circles) index of abundance- commercial longline.

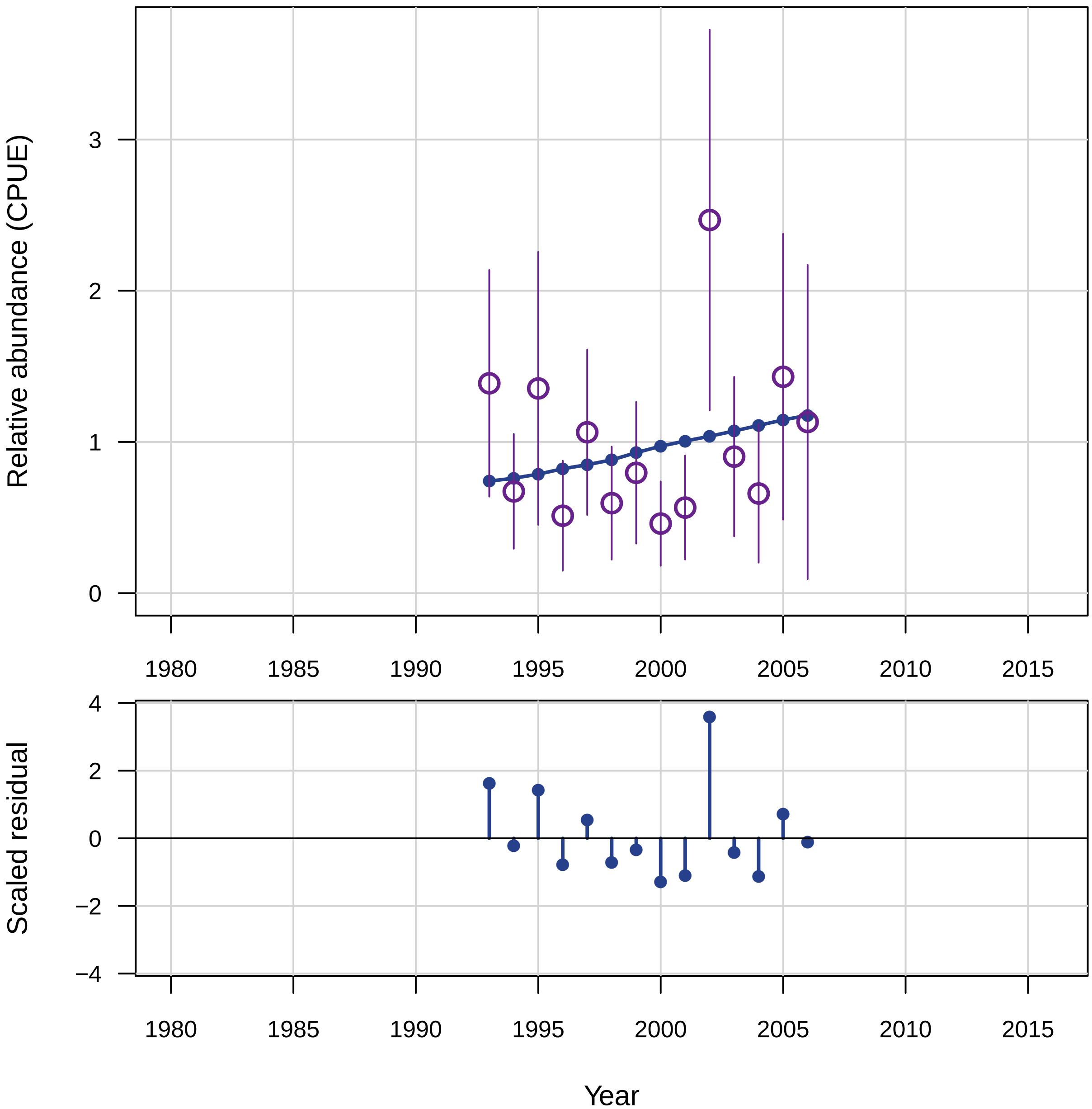


Figure 34. Observed (open circles) and estimated (line, solid circles) index of abundance- recreational headboat.

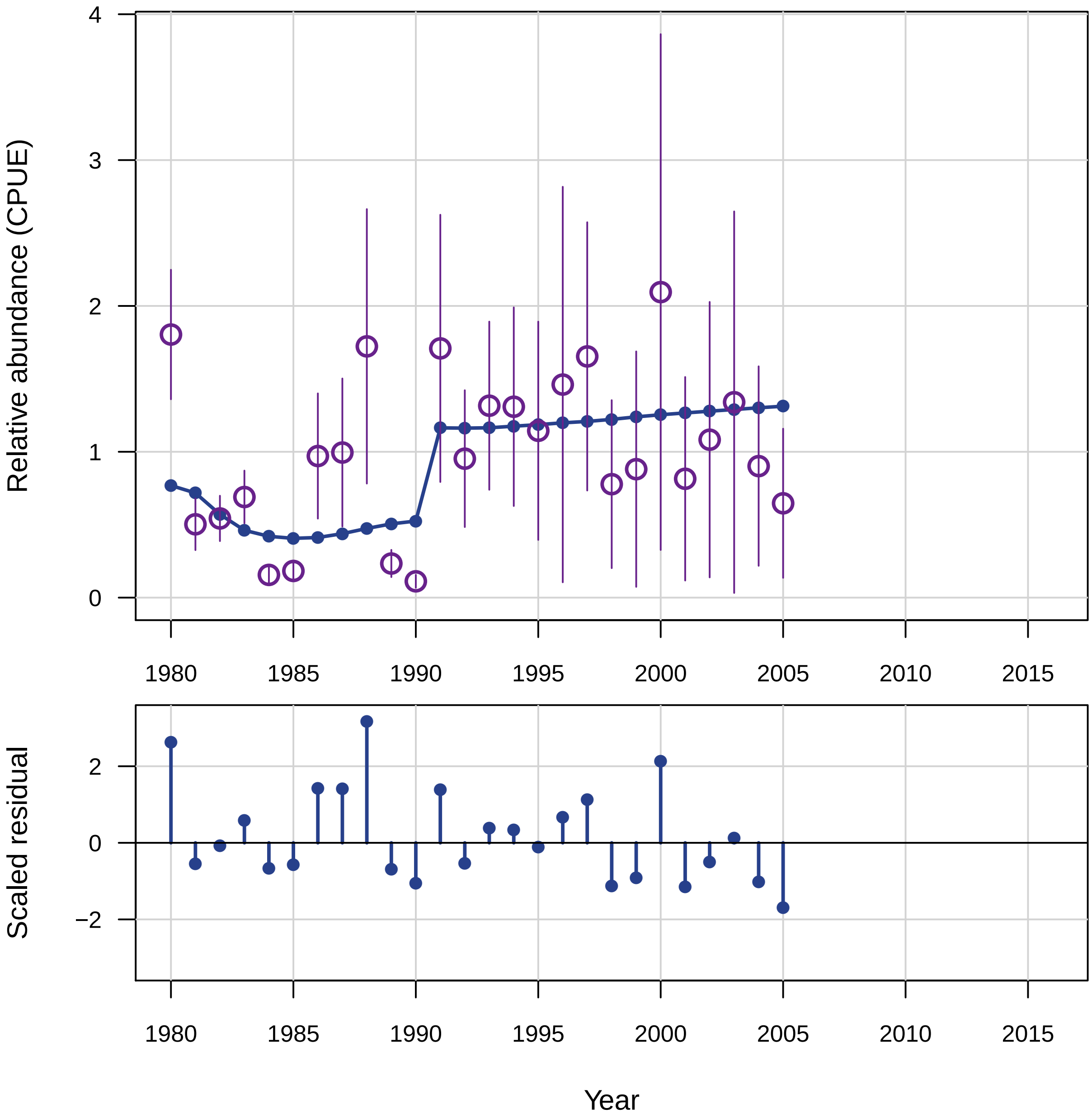


Figure 35. Estimated abundance at age at start of year

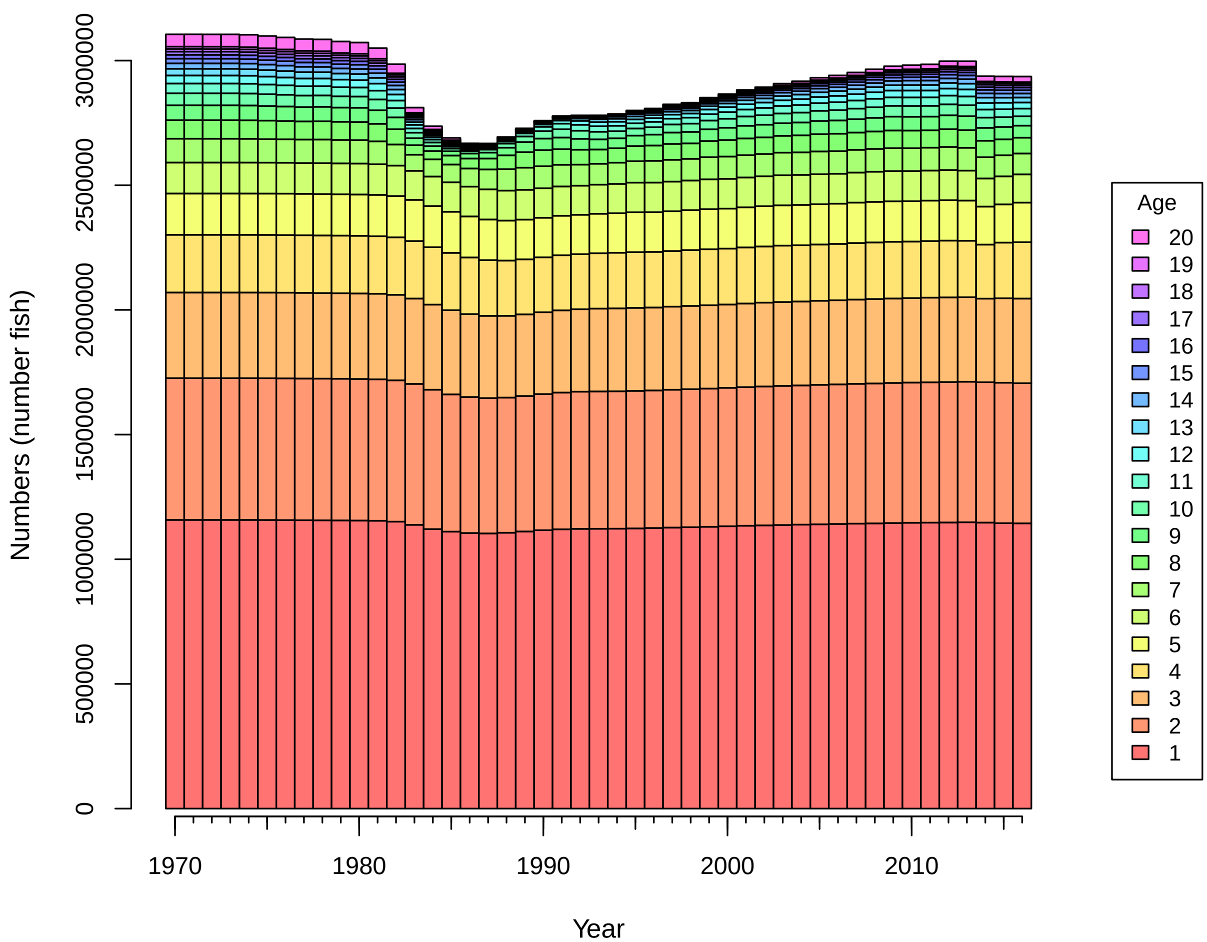


Figure 36. Estimated biomass at age at start of year.

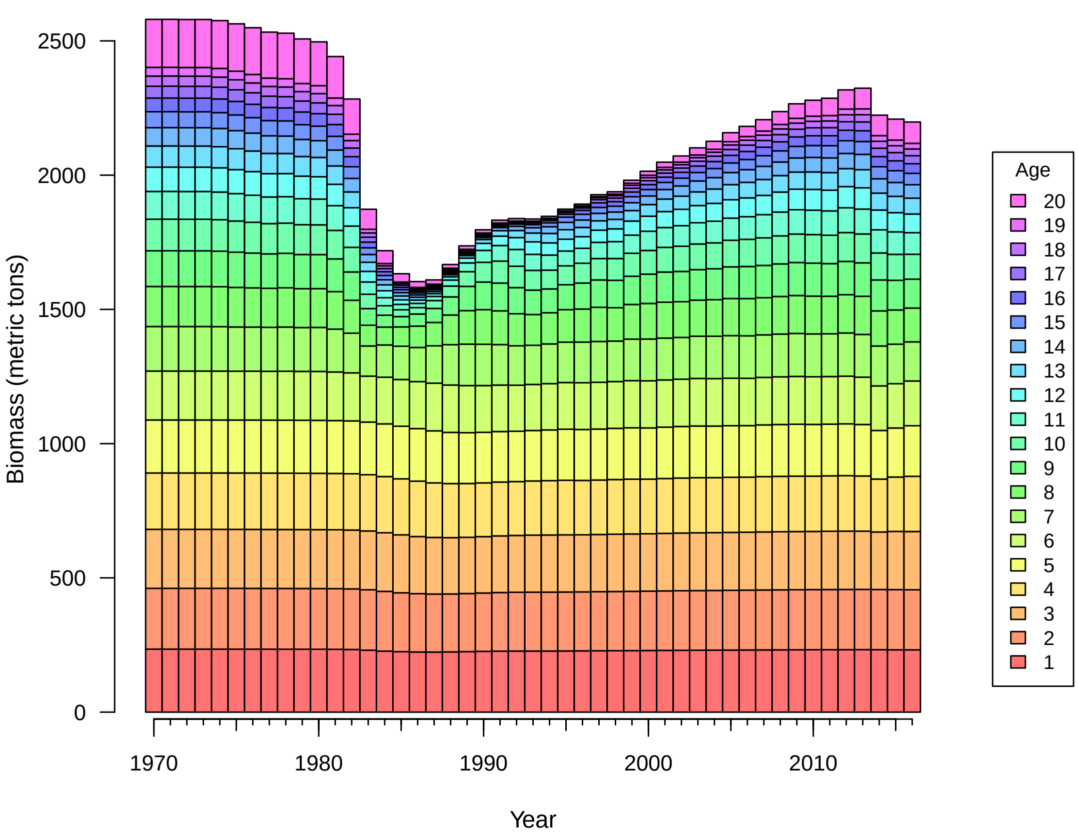


Figure 37. Estimated recruitment time series. Top panel: Estimated recruitment of age-1 fish. Horizontal dashed line indicates R_{MSY}. Bottom panel: log recruitment residuals.

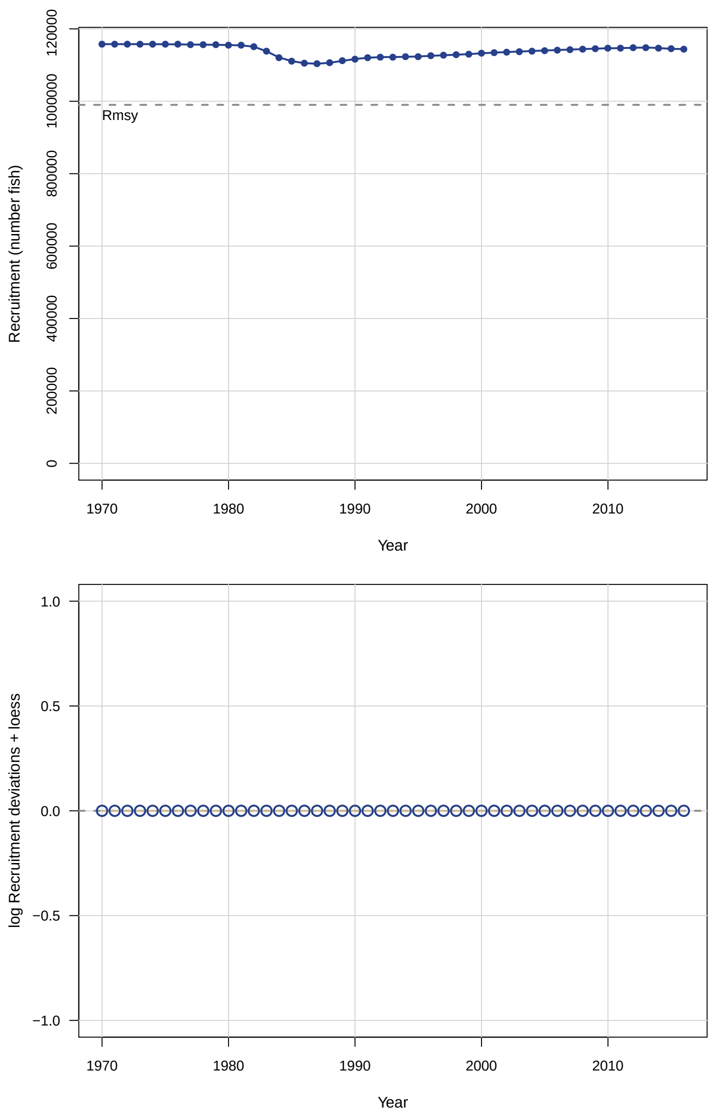


Figure 38. Estimated total biomass and spawning stock time series. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates B_{MSY}. Bottom panel: Estimated spawning stock (million eggs) at time of peak spawning.

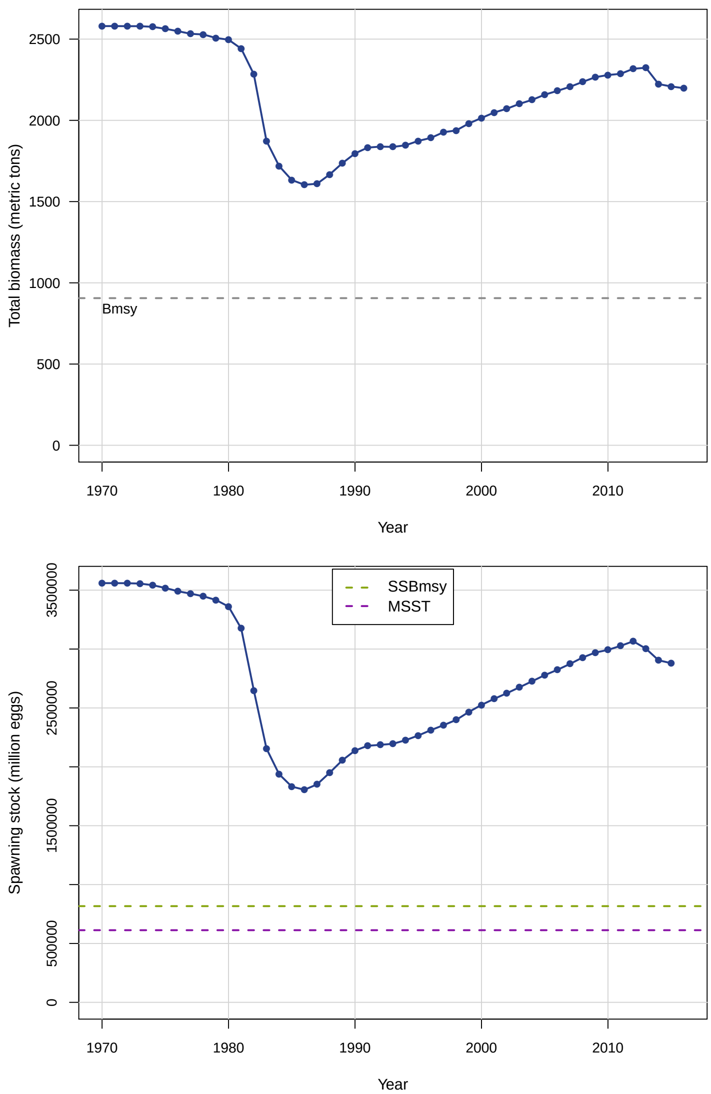


Figure 39. Selectivities of fleets 1970–2015. Top panel: commercial handline and commercial other, including landings and discards. Middle panel: commercial longline including landings and discards. Bottom panel: general recreational (headboat and MRIP) including landings and discards.

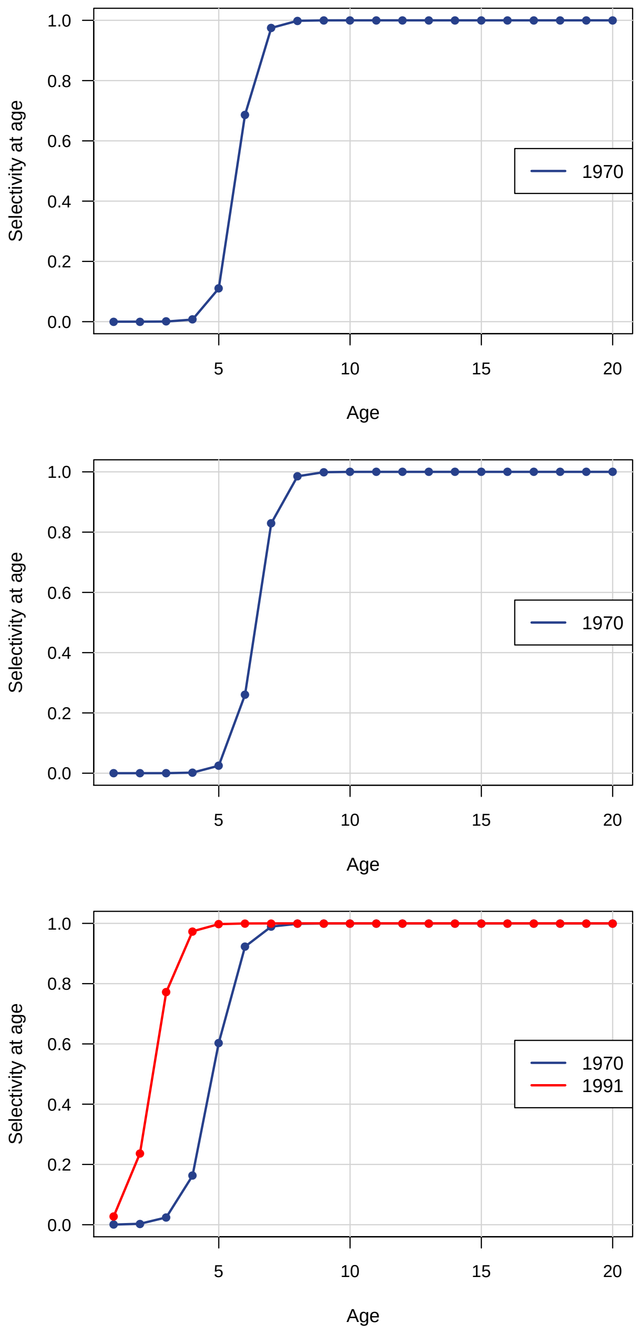


Figure 40. Average selectivity from the terminal assessment year weighted by geometric mean Fs from the last three assessment years, and used in computation of benchmarks and central-tendency projections.

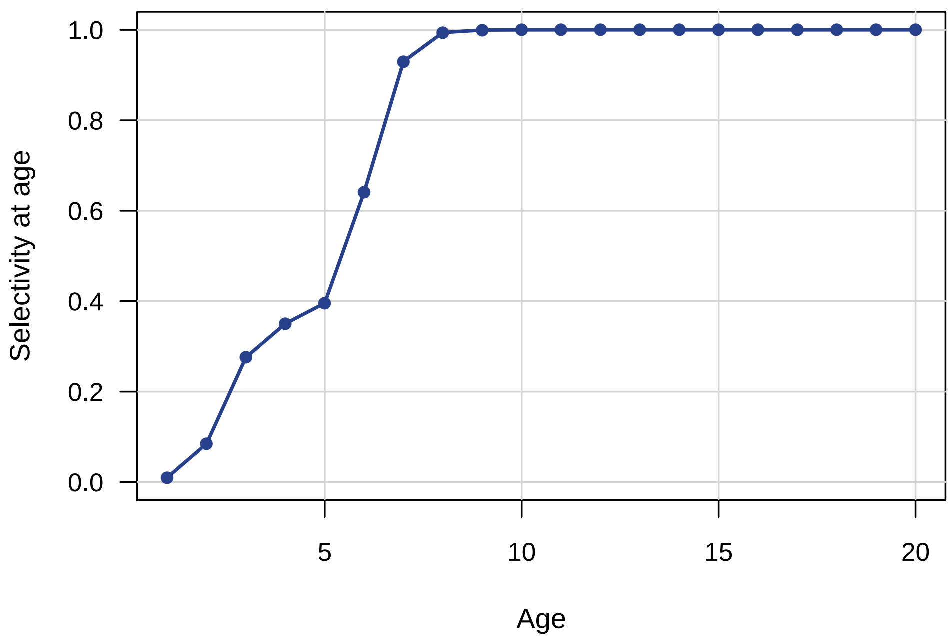


Figure 41. Estimated fully selected fishing mortality rate (per year) by fishery. cH refers to commercial handline, cL to commercial longline, and GR to general recreational; discards included.

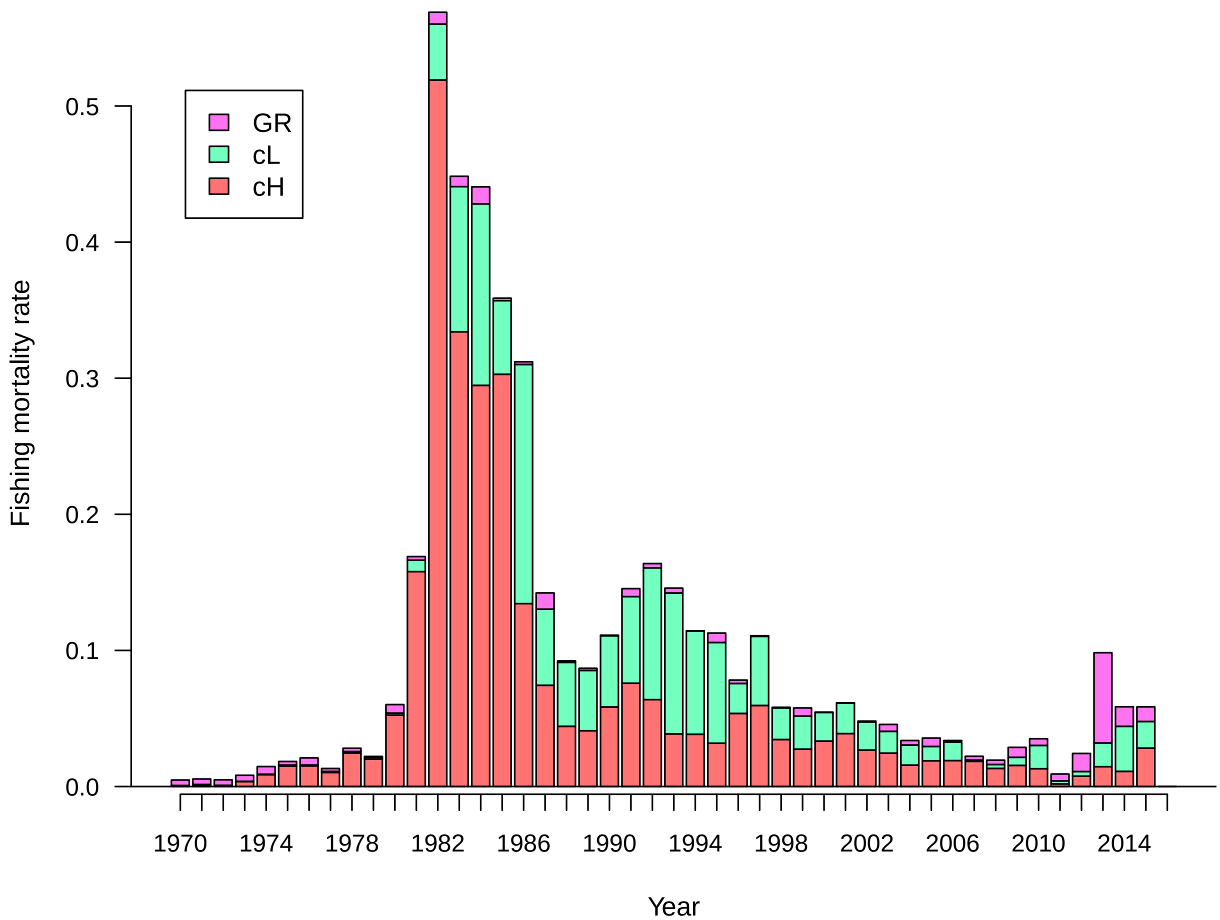


Figure 42. Estimated removals in numbers by fishery from the age-structured production model. cH refers to commercial handline, cL to commercial longline, and GR to general recreational fleet.

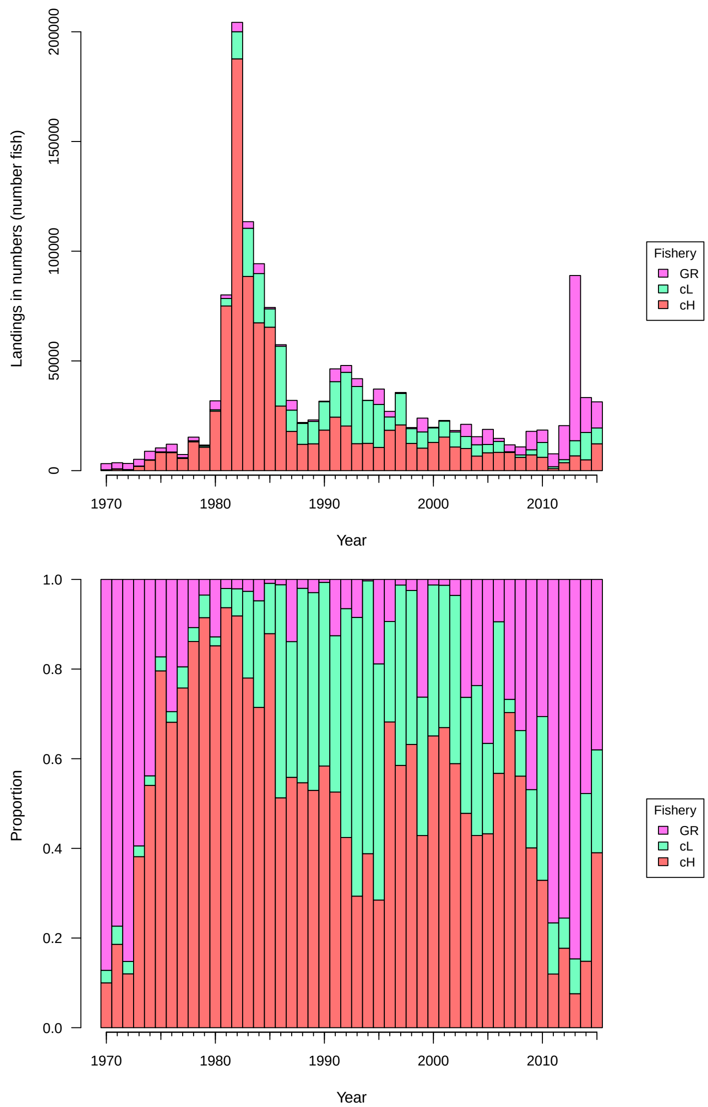


Figure 43. Top panel: Beverton–Holt spawner-recruit curve. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass one year prior.

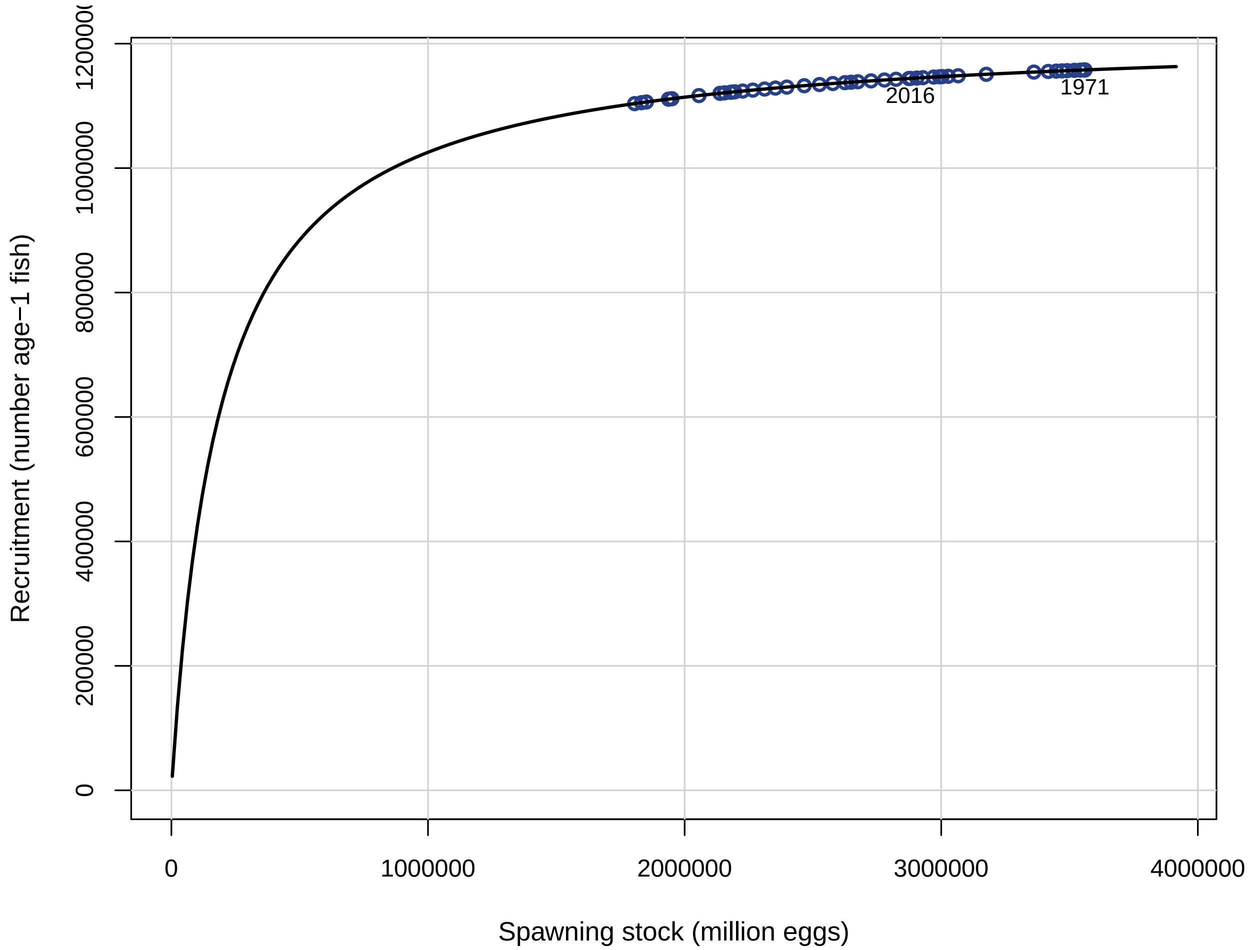


Figure 44. Top panel: yield per recruit. Bottom panel: spawning potential ratio (spawning biomass per recruit relative to that at the unfished level). Both curves are based on average selectivity. $F_{\mathrm{MSY}} = 0.840$. *from the end of the assessment period.*

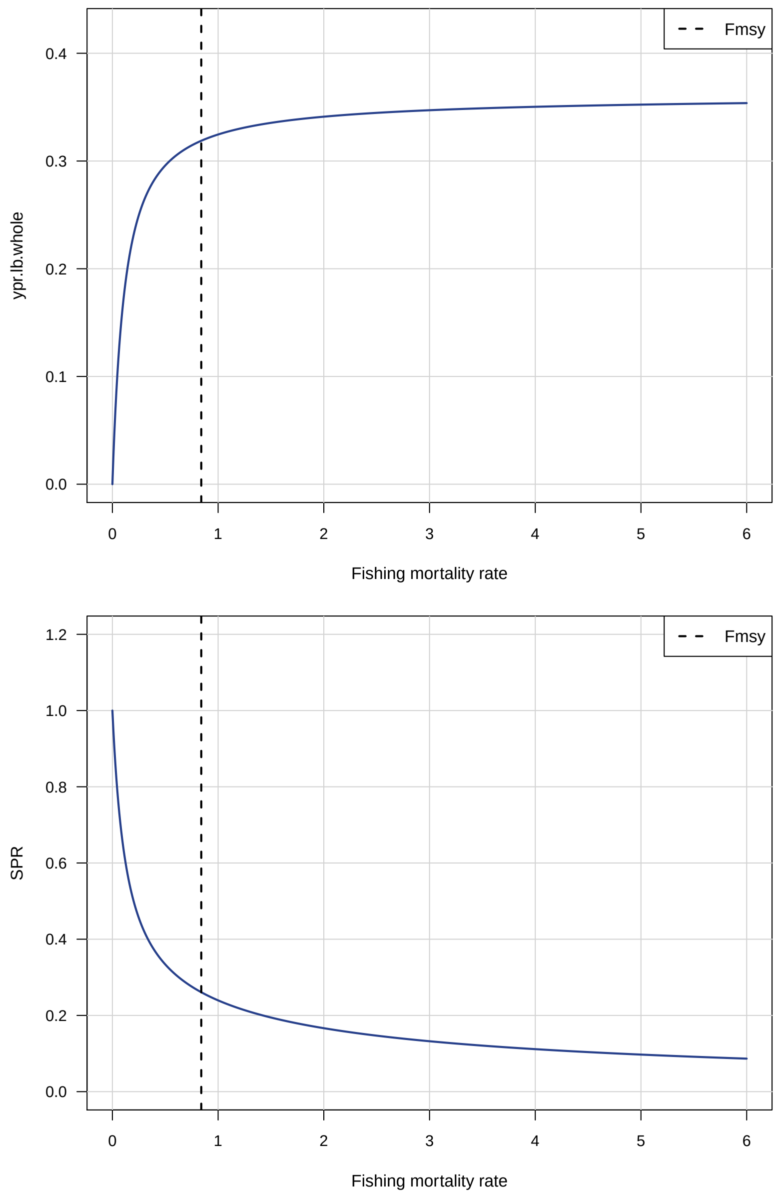


Figure 45. Top panel: equilibrium landings. The peak occurs where fishing rate is $F_{\mathrm{MSY}} = 0.840$ *and equilibrium landings are* MSY = 316 *(1000 lb). Bottom panel: equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.*

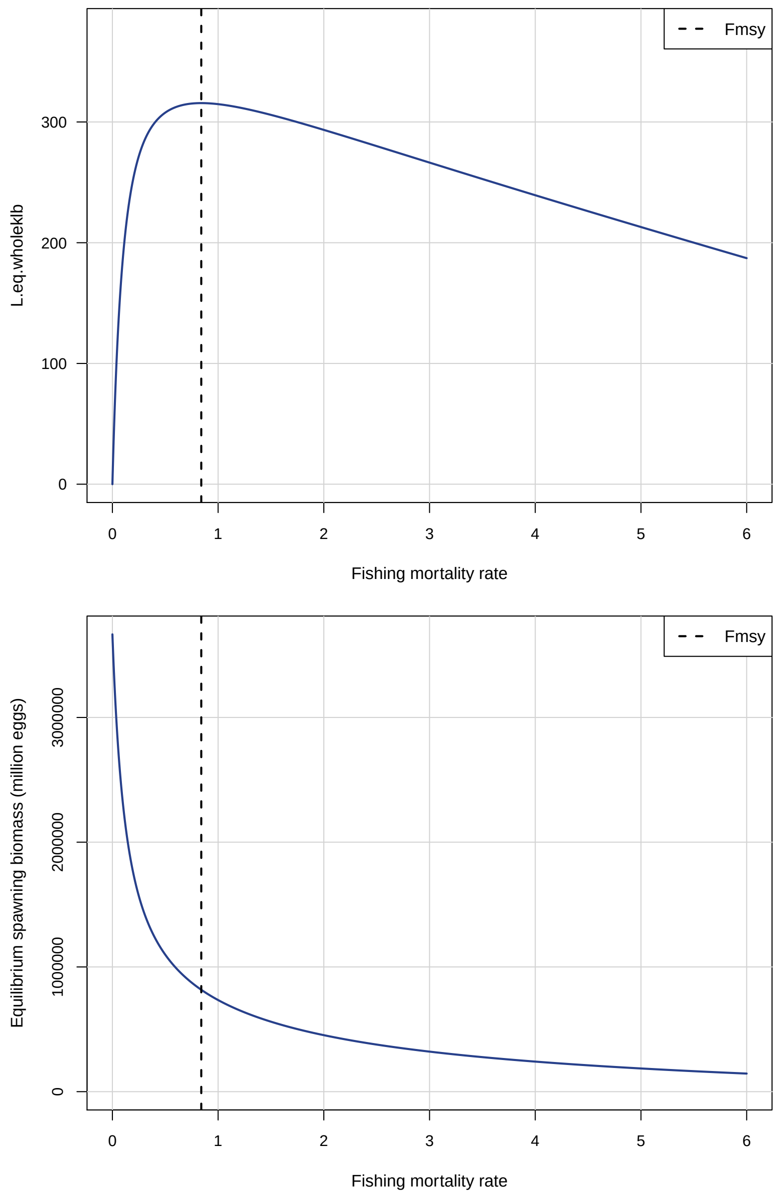


Figure 46. Estimated time series of B, SSB, and F relative to benchmarks. Solid line indicates estimates from main run of the Age-Structured Production Model. Top panel: Total biomass relative to estimated biomass at F_{MSY} (B_{MSY}). Middle panel: spawning biomass relative to SSBmsy. Bottom panel: F relative to F_{MSY}.

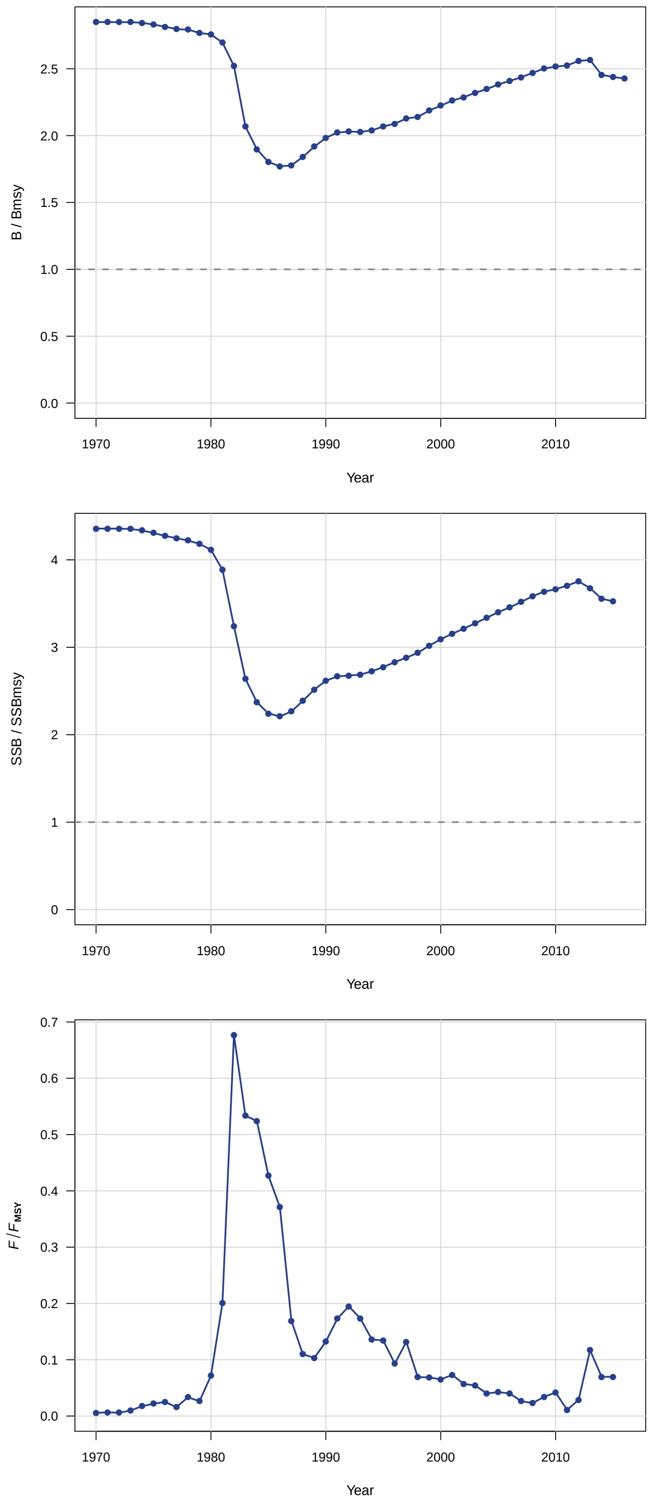


*Figure 47. APSM Sensitivity to age at maturity: ASPM Runs S1-S2. Estimated time series of SSB and F relative to benchmarks. Solid line and open circles indicate estimates from main run of the Age-Structured Production Model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Top panel: Spawning stock biomass (*SSB*) relative to* MSST *(*$0.75\mathrm{SSB}_{\mathrm{MSY}}$*). Bottom panel: F relative to* F_{MSY}.

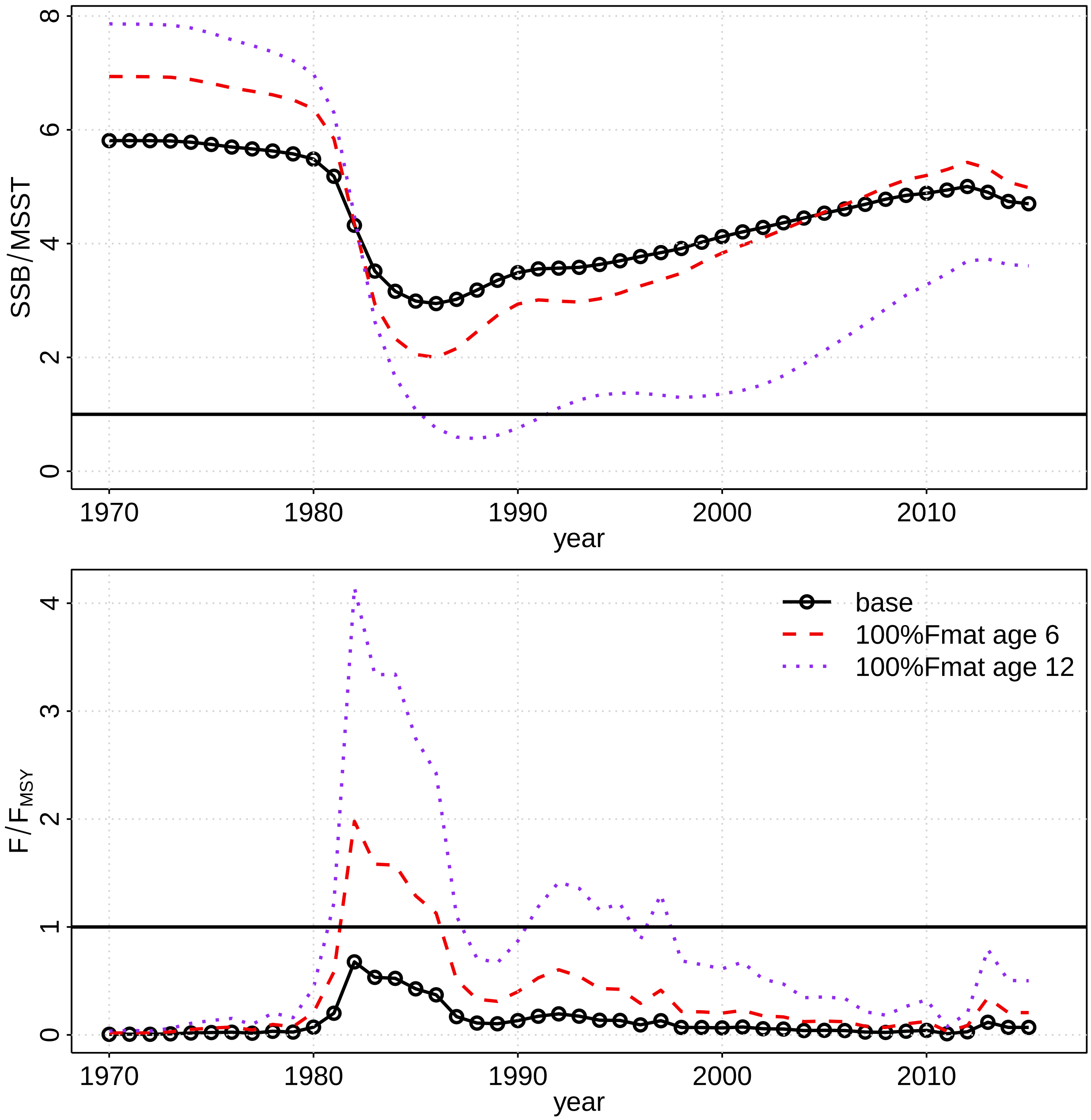


*Figure 48. APSM Sensitivity to natural mortality: ASPM Runs S3-S4. Estimated time series of SSB and F relative to benchmarks. Solid line and open circles indicate estimates from main run of the Age-Structured Production Model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Top panel: Spawning stock biomass (*SSB*) relative to* MSST *(*$0.75\mathrm{SSB}_{\mathrm{MSY}}$*). Bottom panel: F relative to* F_{MSY}.

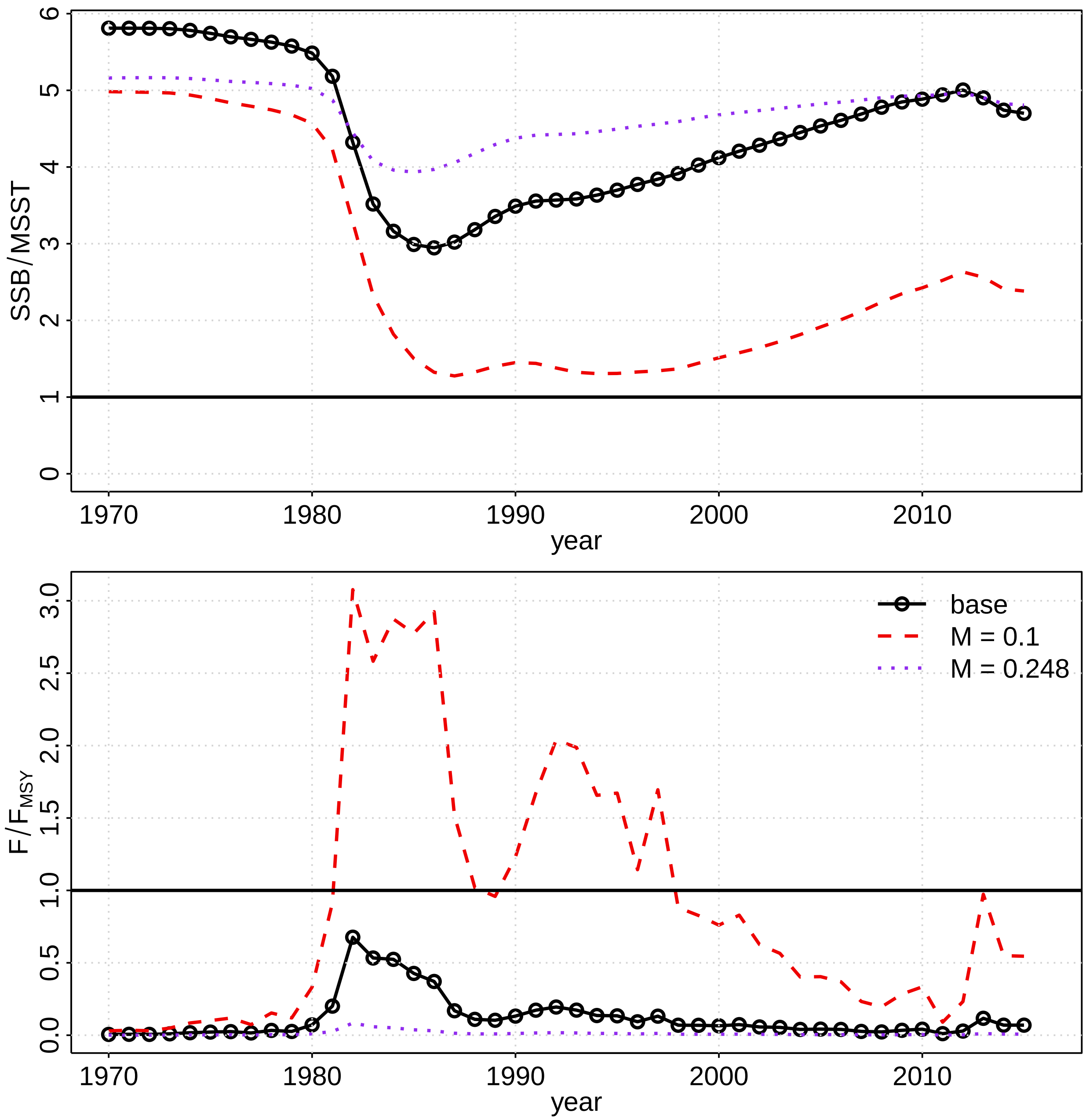


*Figure 49. APSM Sensitivity to age at maturity and natural mortality: ASPM Run S5. Estimated time series of SSB and F relative to benchmarks. Solid line and open circles indicate estimates from main run of the Age-Structured Production Model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Top panel: Spawning stock biomass (*SSB*) relative to* MSST *(*$0.75\mathrm{SSB}_{\mathrm{MSY}}$*). Bottom panel: F relative to* F_{MSY}.

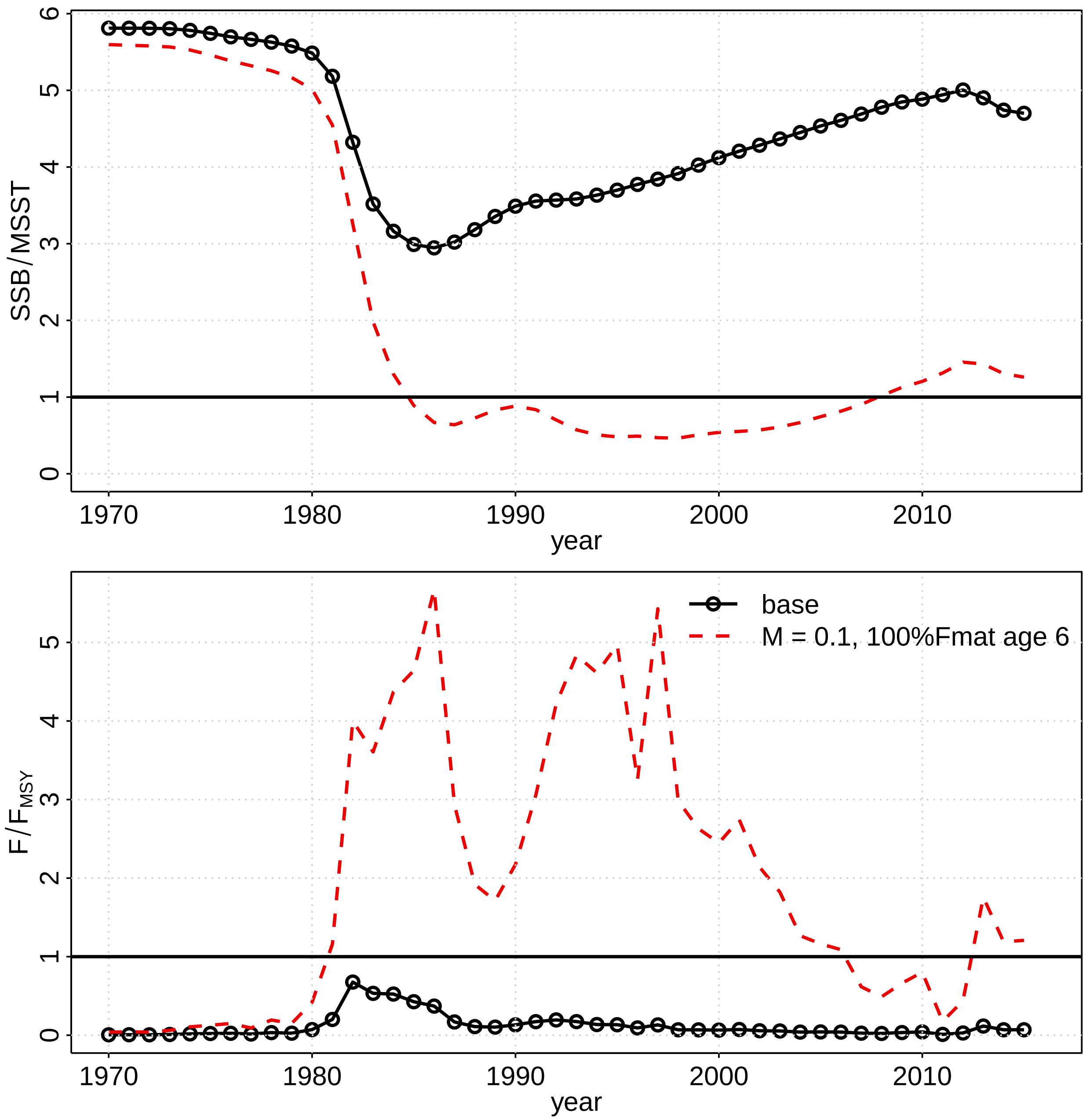


Figure 50. ASPM Sensitivity to Golden Tilefish life history parameters: ASPM Runs S6-S7. Estimated time series of SSB and F relative to benchmarks. Solid line and open circles indicate estimates from main run of the Age-Structured Production Model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Top panel: Spawning stock biomass (SSB) relative to MSST ($0.75\mathrm{SSB}_{\mathrm{MSY}}$). Bottom panel: F relative to F_{MSY}.

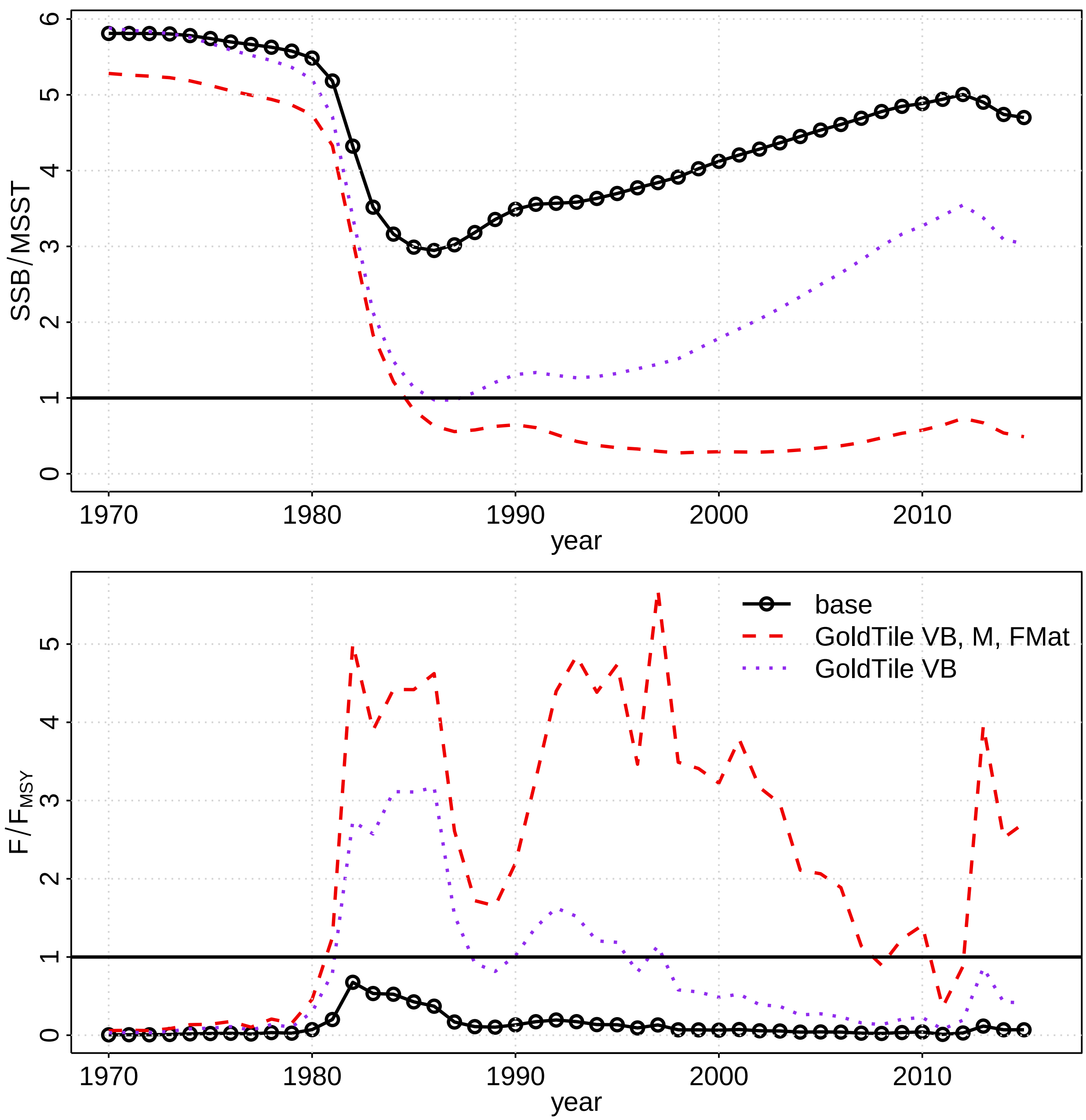


*Figure 51. ASPM Sensitivity to SEDAR 32 Blueline Tilefish settings: ASPM Runs S8-S10. Estimated time series of SSB and F relative to benchmarks. Solid line and open circles indicate estimates from main run of the Age-Structured Production Model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Top panel: Spawning stock biomass (*SSB*) relative to* MSST *(*$0.75\mathrm{SSB}_{\mathrm{MSY}}$*). Bottom panel: F relative to* F_{MSY}.

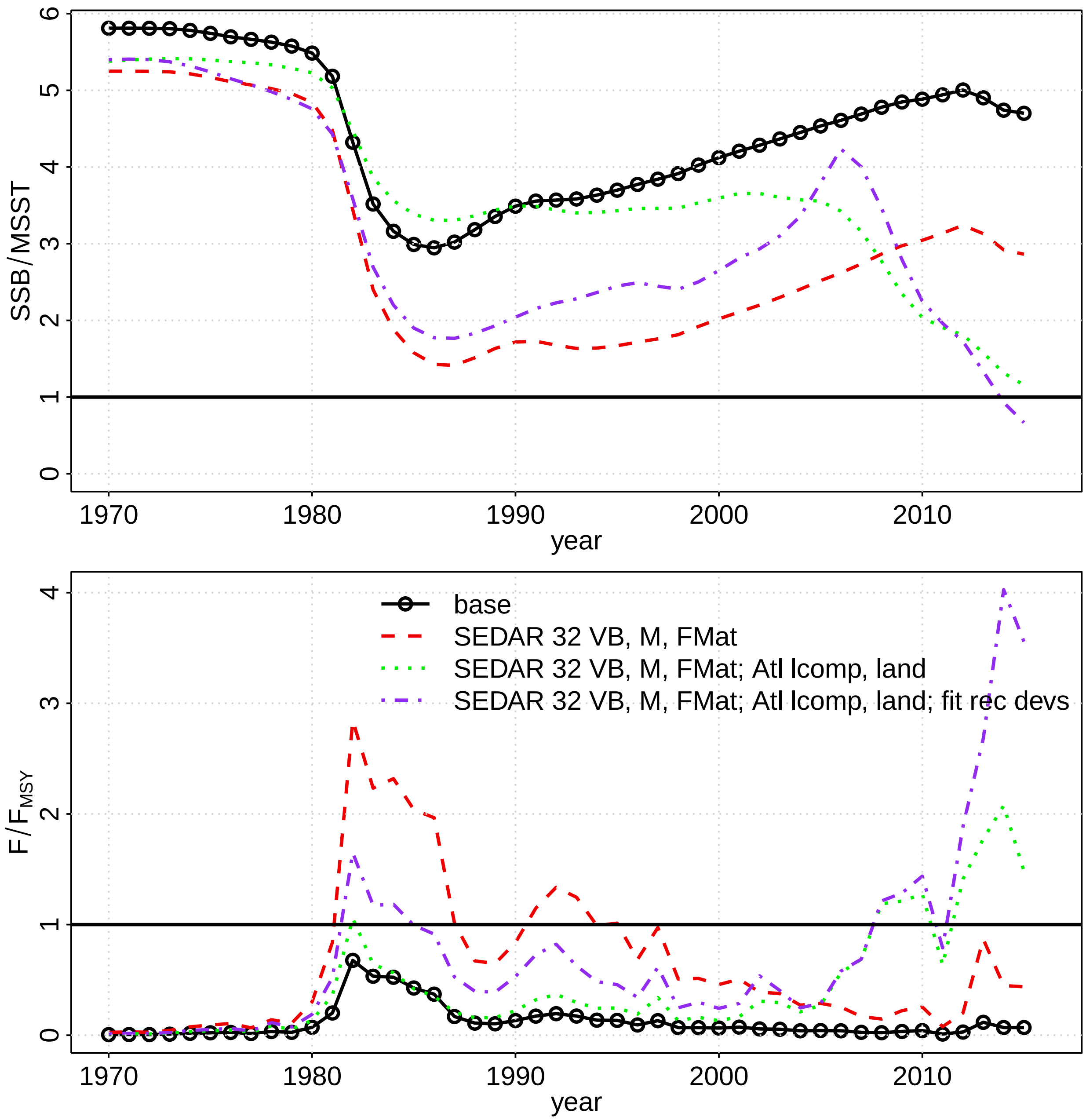


*Figure 52. ASPM Sensitivity to including removals north of Cape Hatteras: ASPM Run S11. Estimated time series of SSB and F relative to benchmarks. Solid line and open circles indicate estimates from main run of the Age-Structured Production Model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Top panel: Spawning stock biomass (*SSB*) relative to* MSST *(*$0.75\mathrm{SSB}_{\mathrm{MSY}}$*). Bottom panel: F relative to* F_{MSY}.

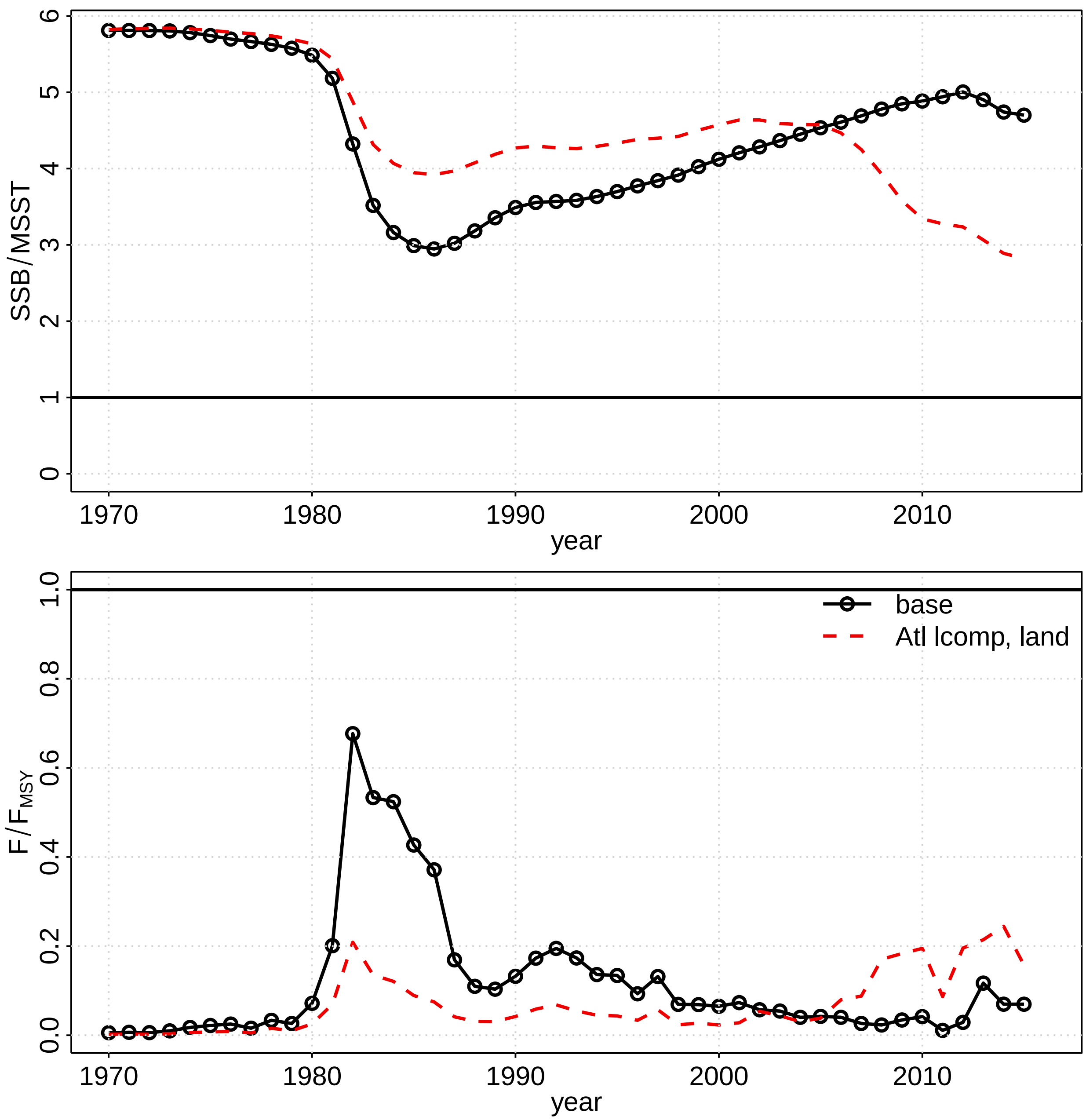


*Figure 53. ASPM Sensitivity to indices: ASPM Runs S12-S15. Estimated time series of SSB and F relative to benchmarks. Solid line and open circles indicate estimates from main run of the Age-Structured Production Model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Top panel: Spawning stock biomass (*SSB*) relative to* MSST *(*$0.75\mathrm{SSB}_{\mathrm{MSY}}$*). Bottom panel: F relative to* F_{MSY}.

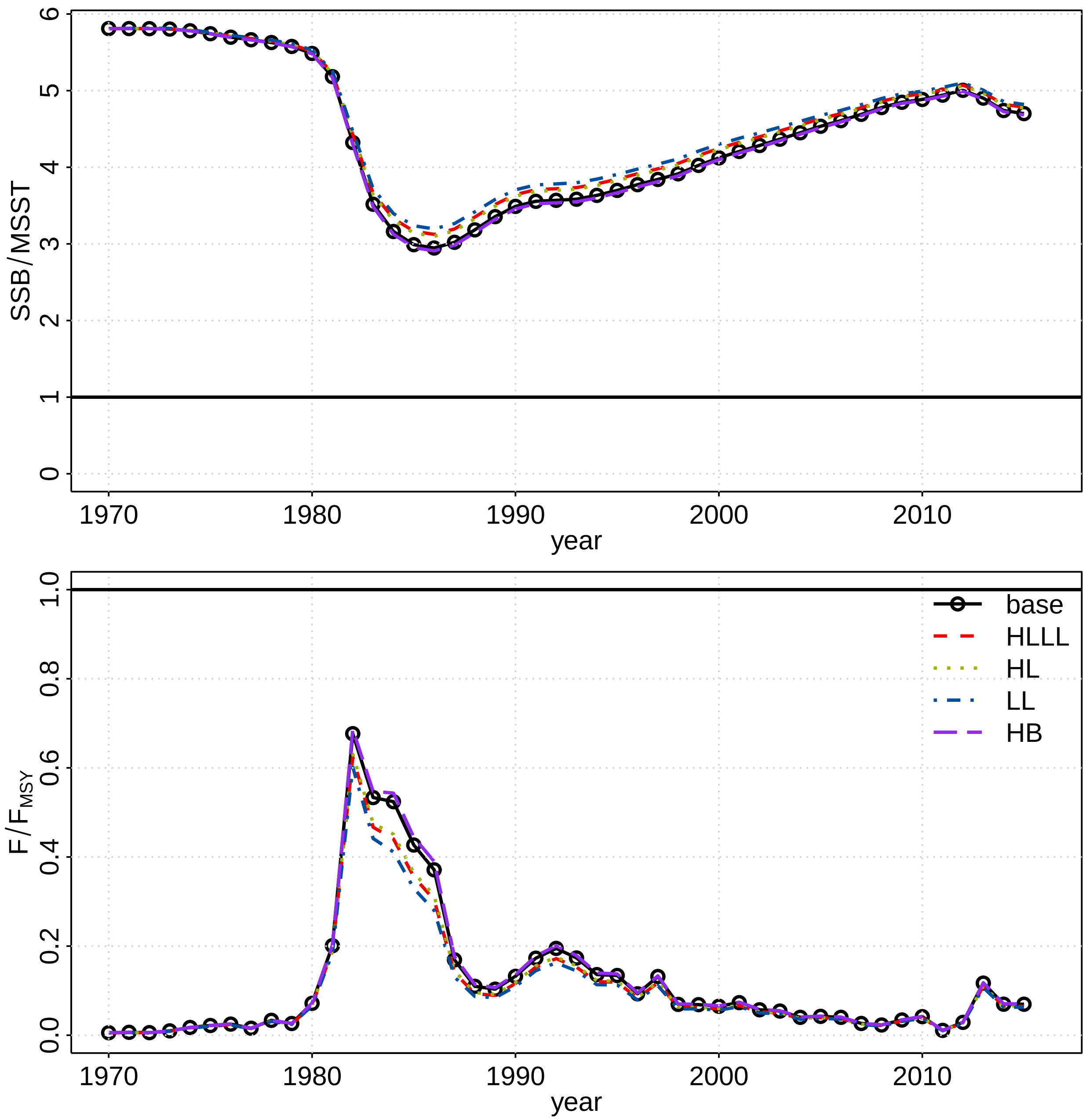


Figure 54. Phase plots of ASPM F and B status estimates for sensitivity runs as well as the base run. Point colors and shapes are indicated in the legend. The number of each sensitivity run is also plotted in black text over each point. The point representing the base run fell within a cluster of points (S12-15) and was therefore labeled with the word "Base" plotted below it, and a red arrow indicating the actual point.

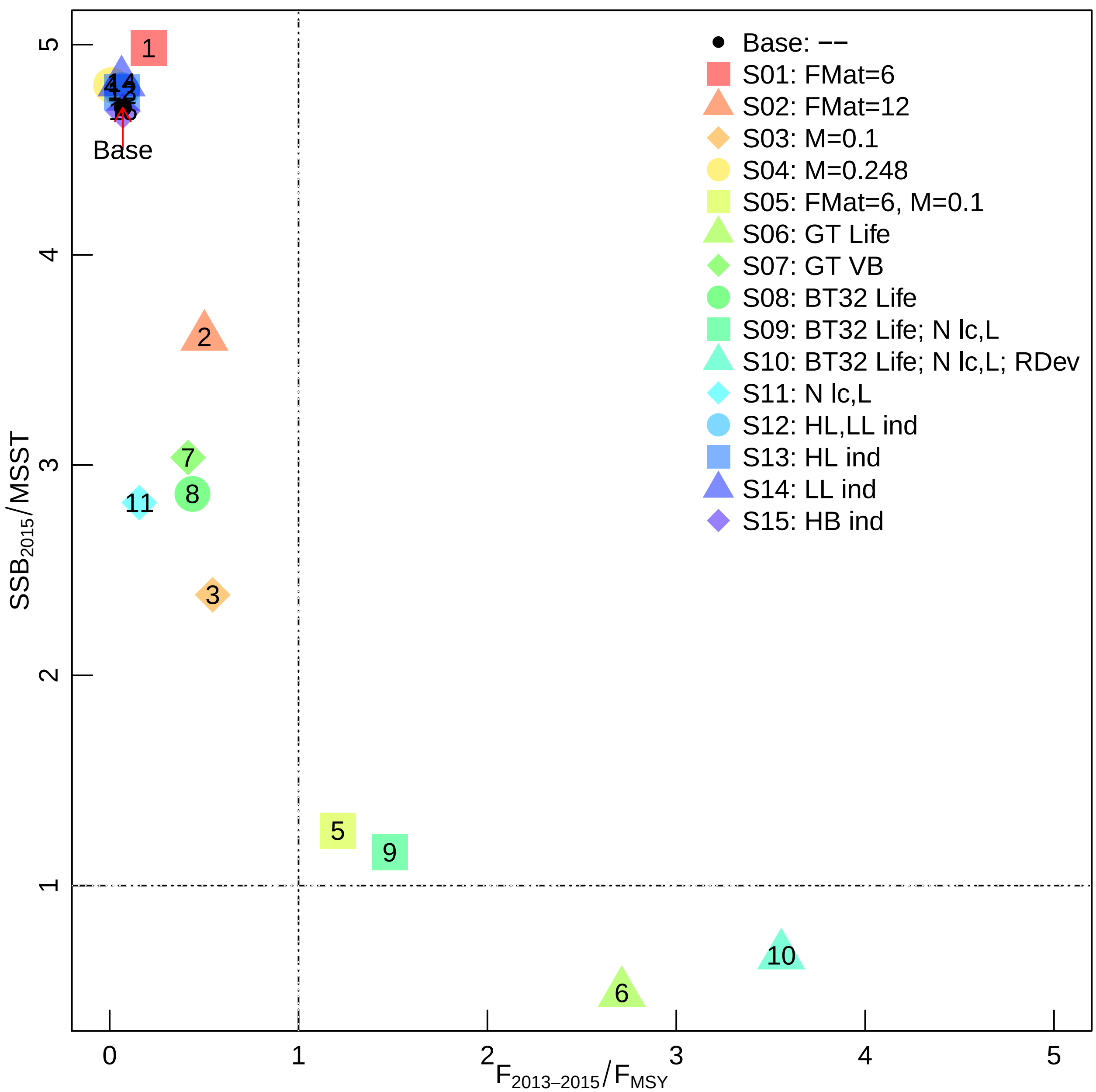


Figure 55. Annual length composition data used in south of Cape Hatteras DLM analysis.

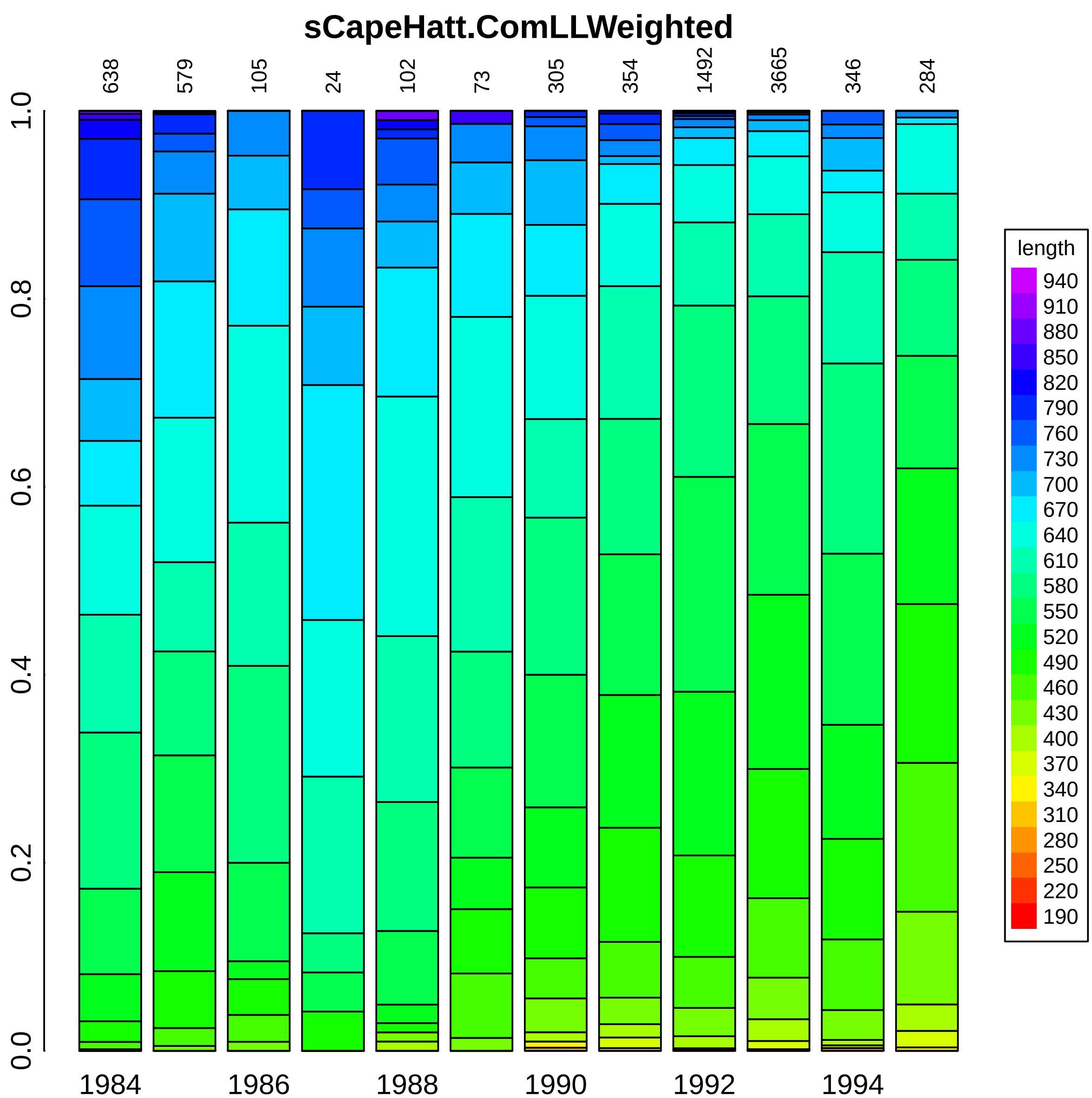


Figure 56. Catch series used in south of Cape Hatteras DLM analysis.

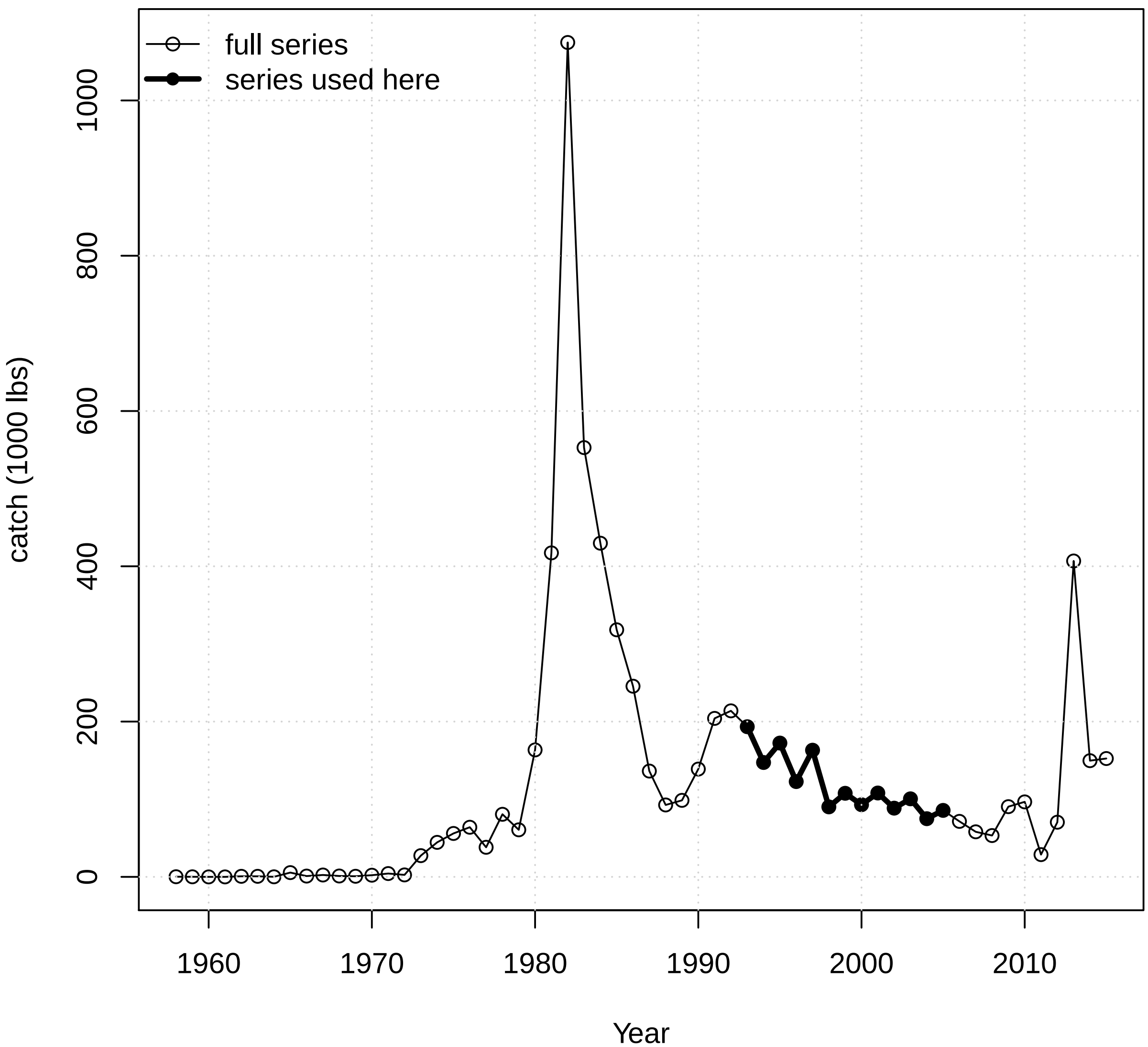


Figure 57. Distributions of TACs from south of Cape Hatteras DLM analysis.

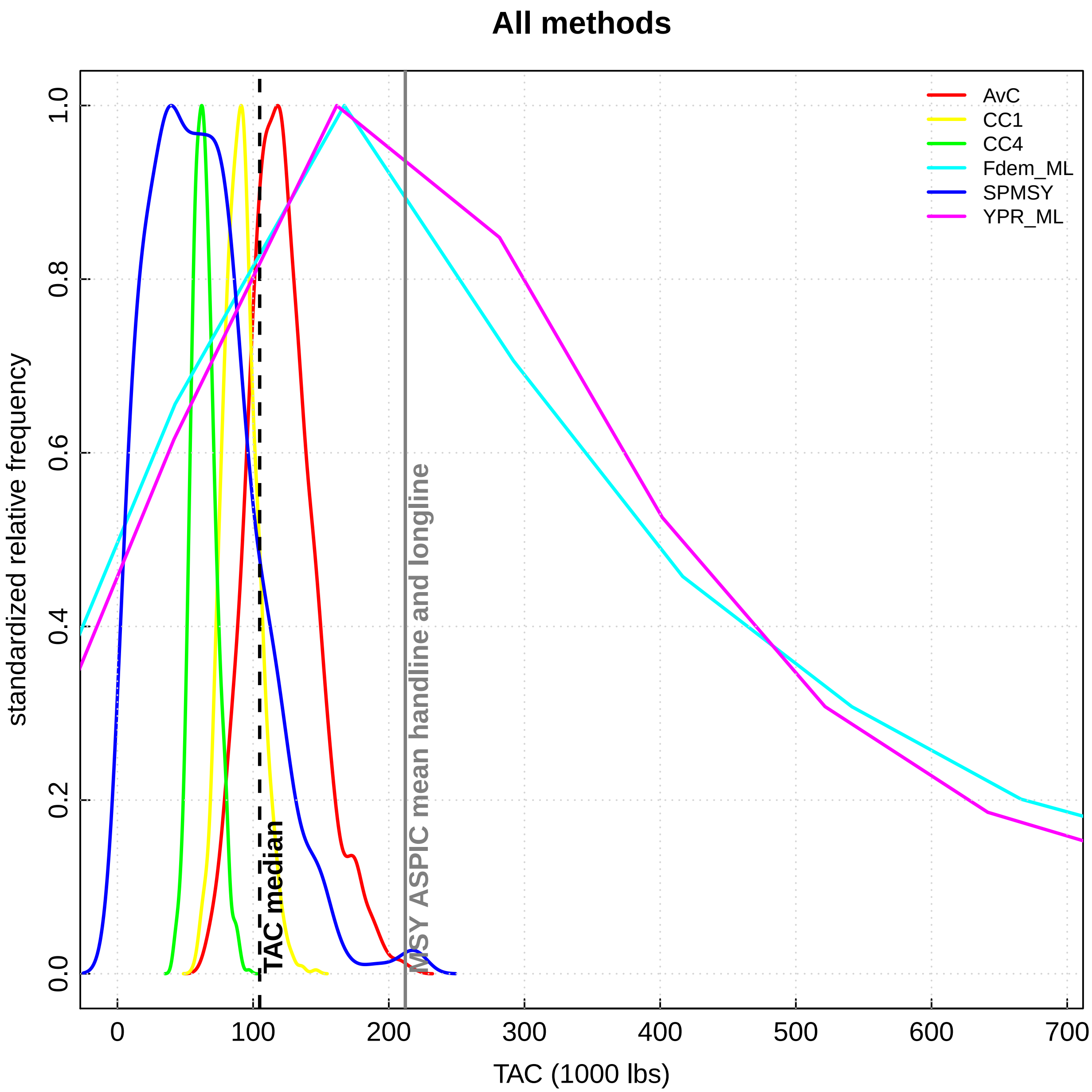


Figure 58. Observed and estimated mean length series for south of Cape Hatteras DLM analysis.

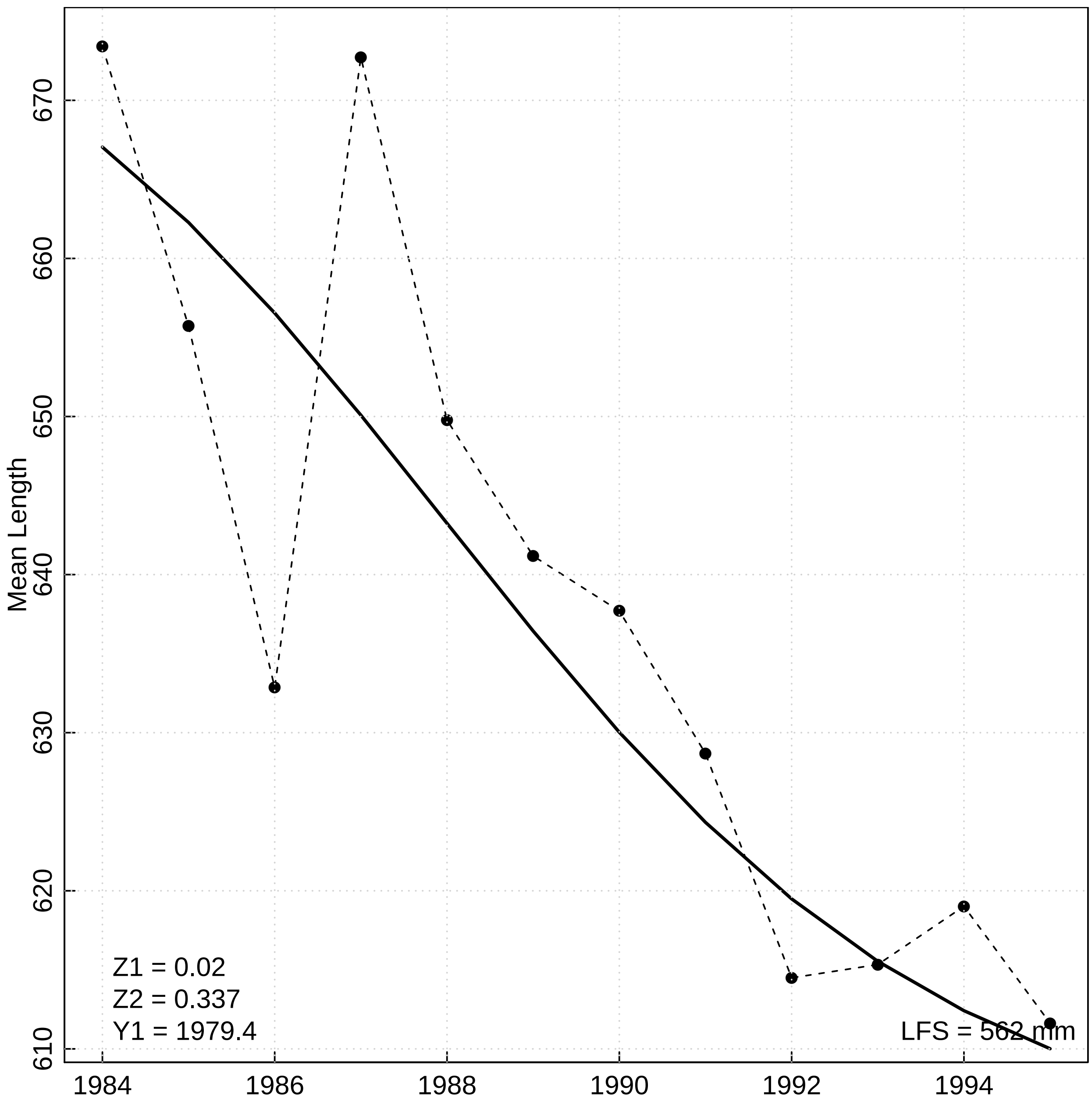


Figure 59. Annual length composition data used in north of Cape Hatteras DLM analysis.

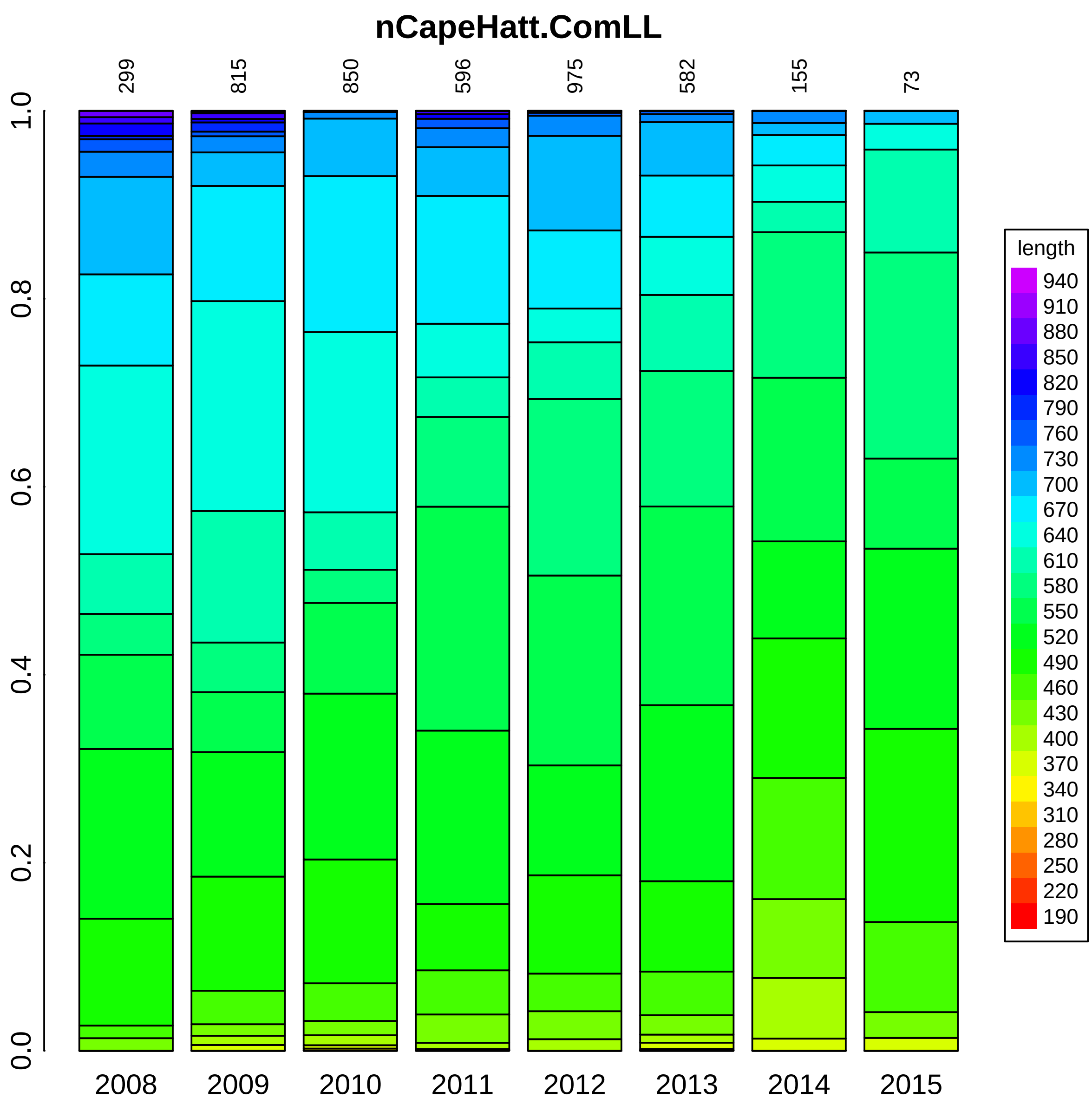


Figure 60. Catch series used in north of Cape Hatteras DLM analysis.

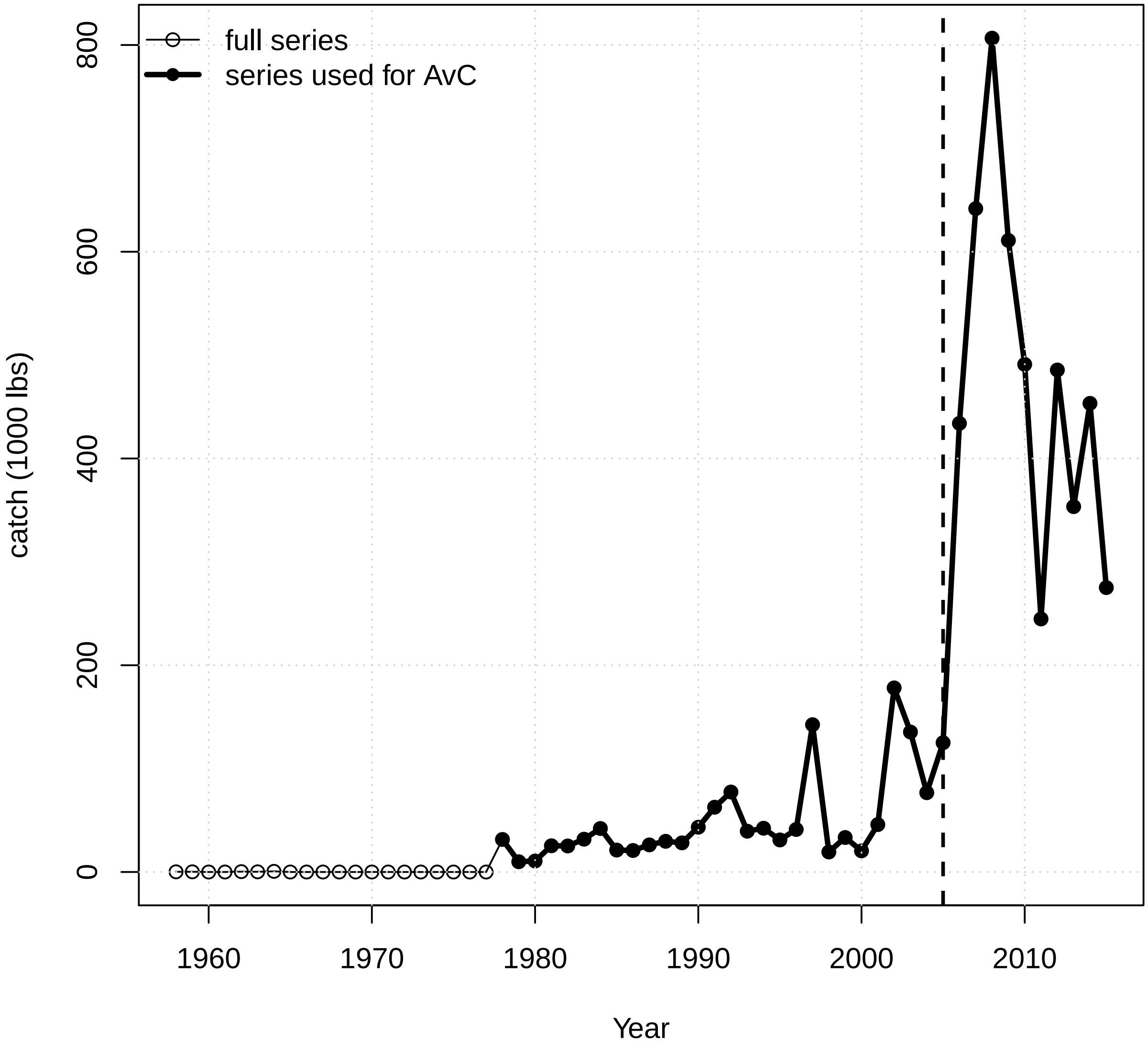


Figure 61. Distributions of TACs from north of Cape Hatteras DLM analysis. Here the AvC method was applied to three different time periods: the time since the fishery in this area effectively began (AvC, 1978-2015); the early part of this time series before the spatial shift in effort (AvC.early, 1978-2005), and during the more recent period after the increase in landings (AvC.late, 2006-2015).

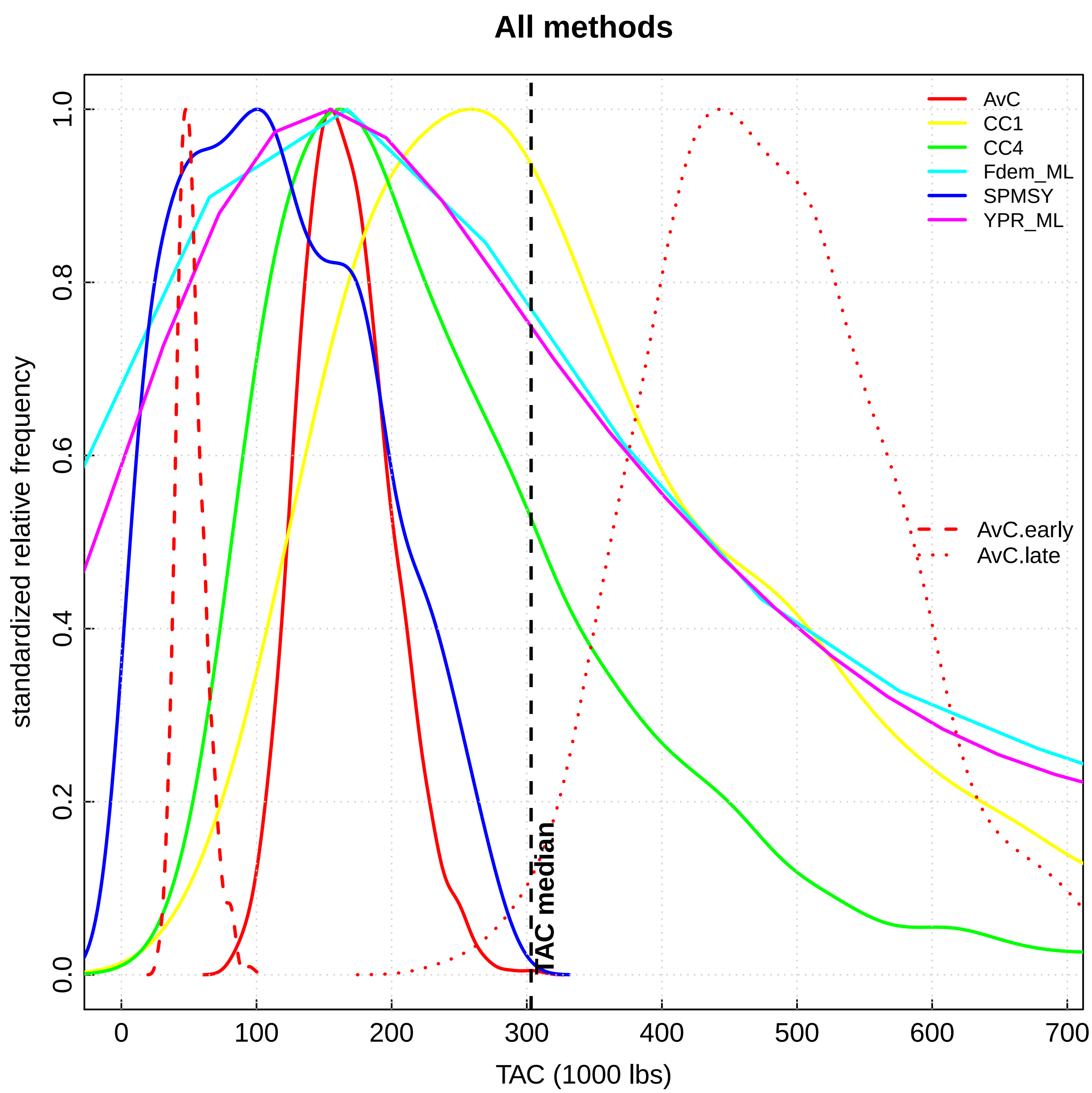


Figure 62. Observed and estimated mean length series for north of Cape Hatteras DLM analysis.

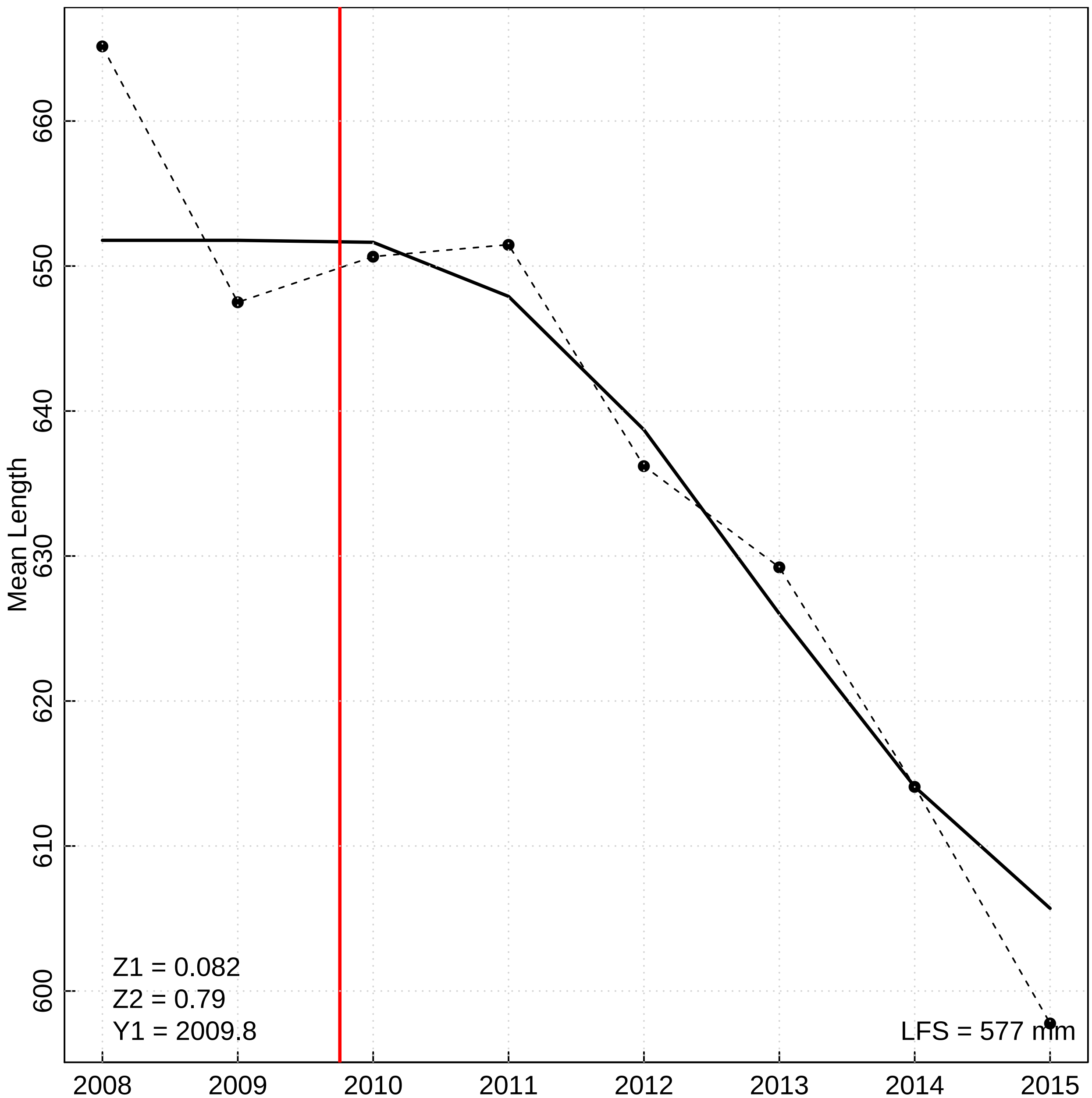


Figure 63. Removals in the Gulf of Mexico, by fleet, supplied to the Gulf of Mexico ASPIC models.

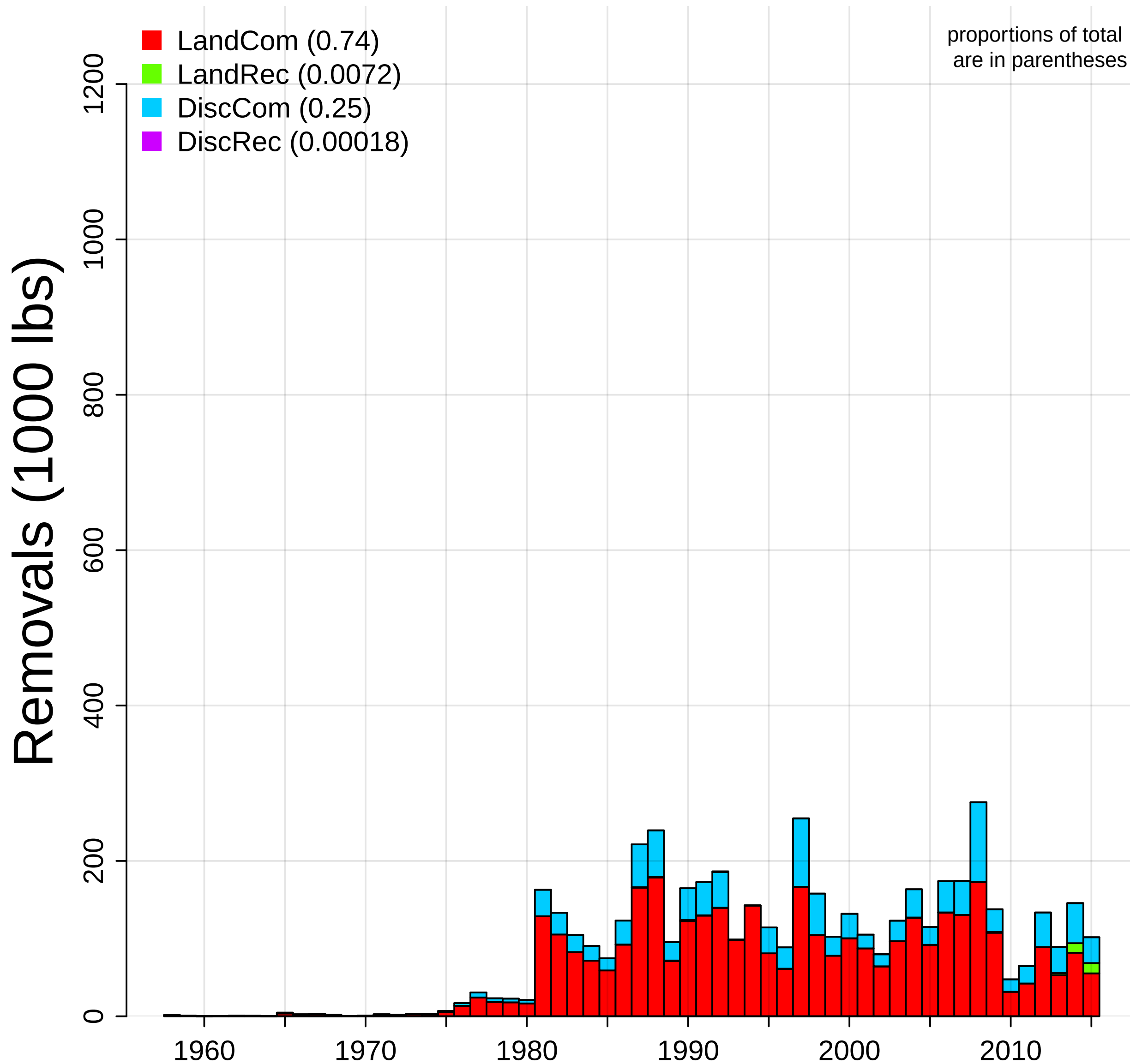


Figure 64. Removals in the Gulf of Mexico, by area, supplied to the Gulf of Mexico ASPIC models. Removals include commercial and recreational landings and dead discards, which were provided at the data workshop in different spatial groupings which overlap in some cases. Here the vast majority of removals were from either Florida waters in the Gulf of Mexico (FLGMex) or other areas of the Gulf of Mexico (GMex), collected by commercial gear.

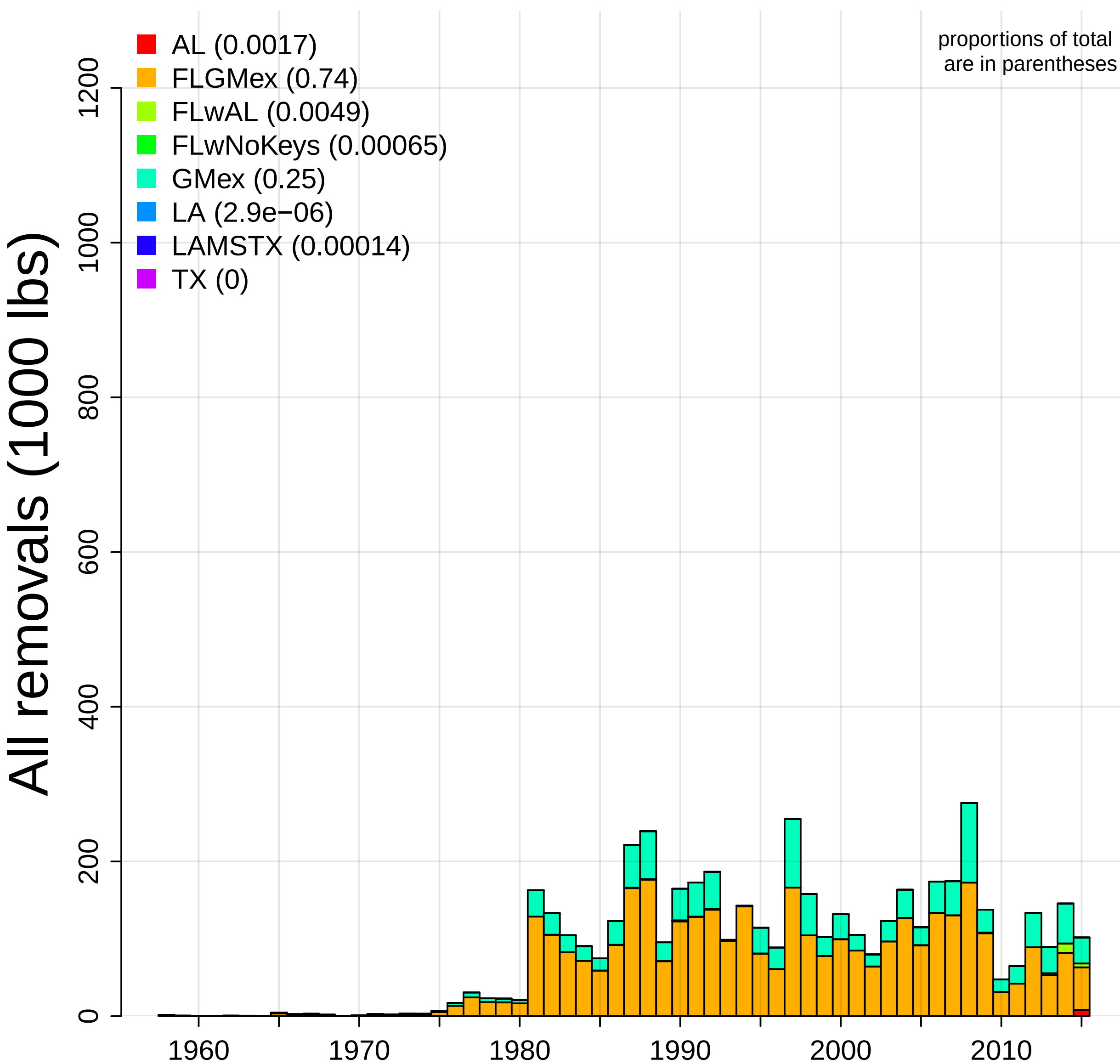


Figure 65. Indices of abundance and error bands used in fitting the Gulf of Mexico assessment model, including the commercial handline index (ComHL), commercial longline index (ComHL), and recreational headboat index (RecHb). Note that error bands were not available for RecHb. Shaded areas represent ±2 standard errors (SE) for each year of each index, calculated from annual CVs.

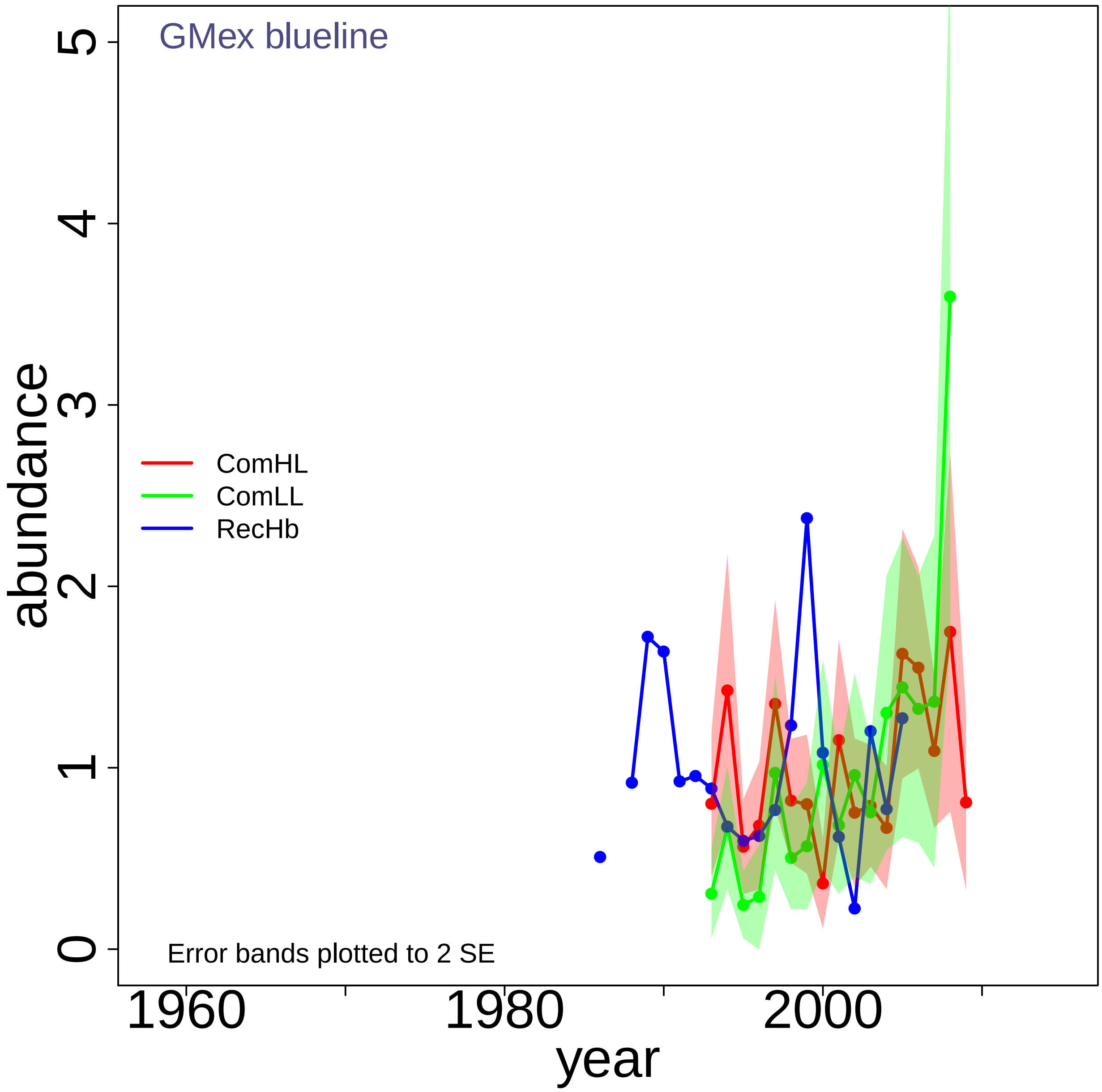
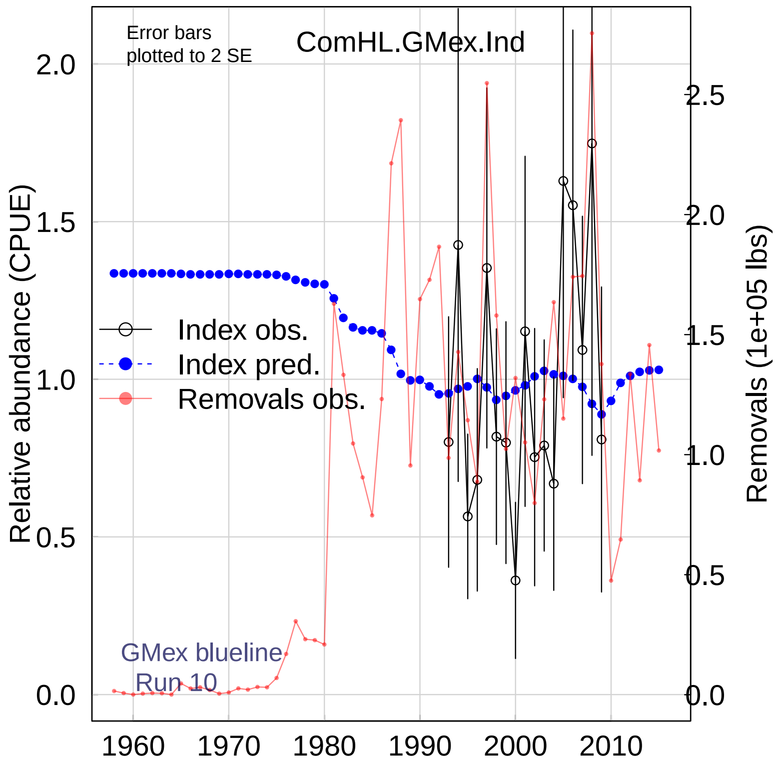


Figure 66. ASPIC fit to the handline model in the Gulf of Mexico. Fits to indices (upper panel) and B and F ratio plots (lower panel). Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015).



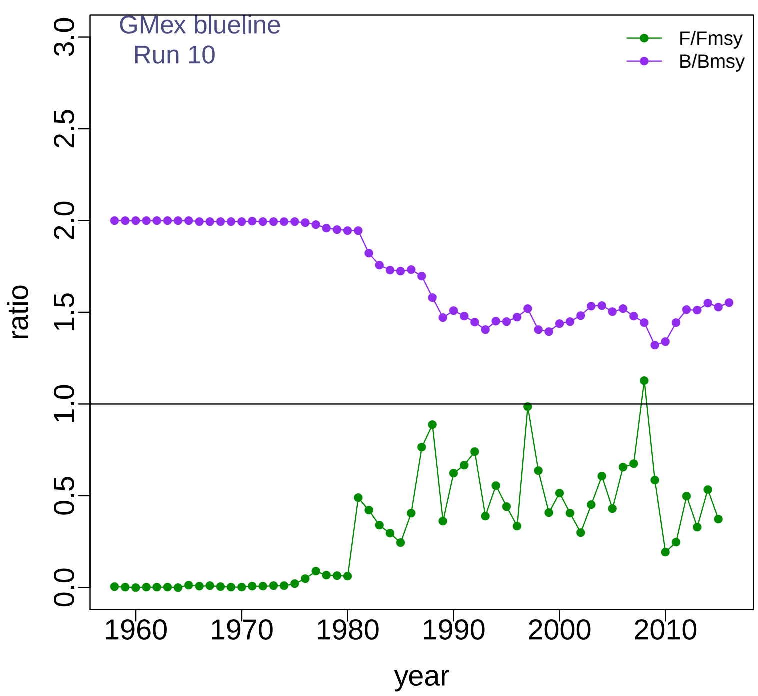


Figure 67. Solid line indicates B series for the Gulf of Mexico ASPIC handline model. The jagged dashed line represents the median B and blue error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials. Horizontal dashed and dotted lines indicate B_{MSY} and MSST.

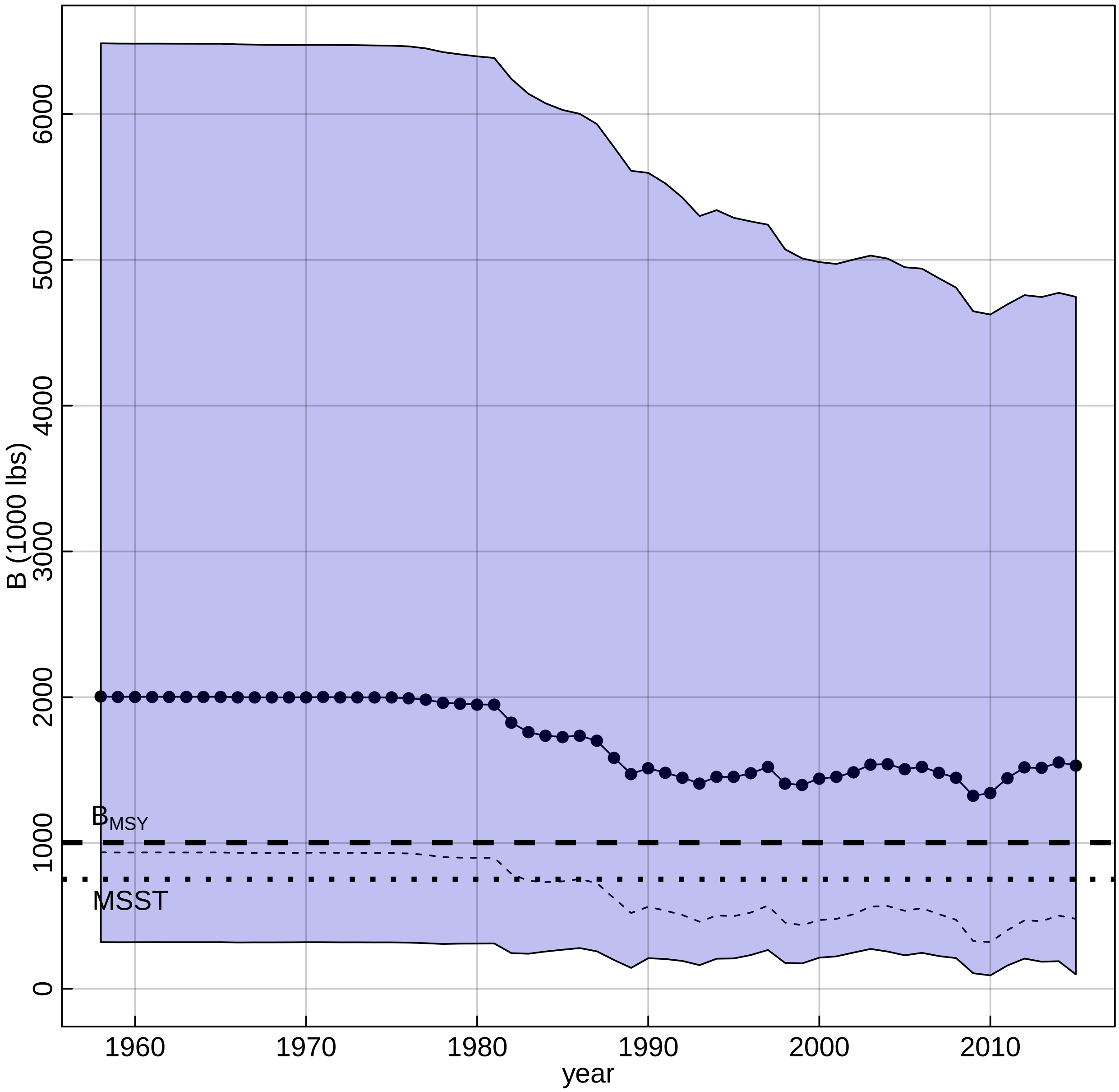


Figure 68. Distribitions of ASPIC parameter estimates for bootstrap runs associated with the Gulf of Mexico ASPIC handline model. The estimates from the handline model are plotted here as thick vertical orange lines. Dotted lines represent 5^{th} *and* 95^{th} *percentiles, dashed line represents the median of the bootstrap runs.*

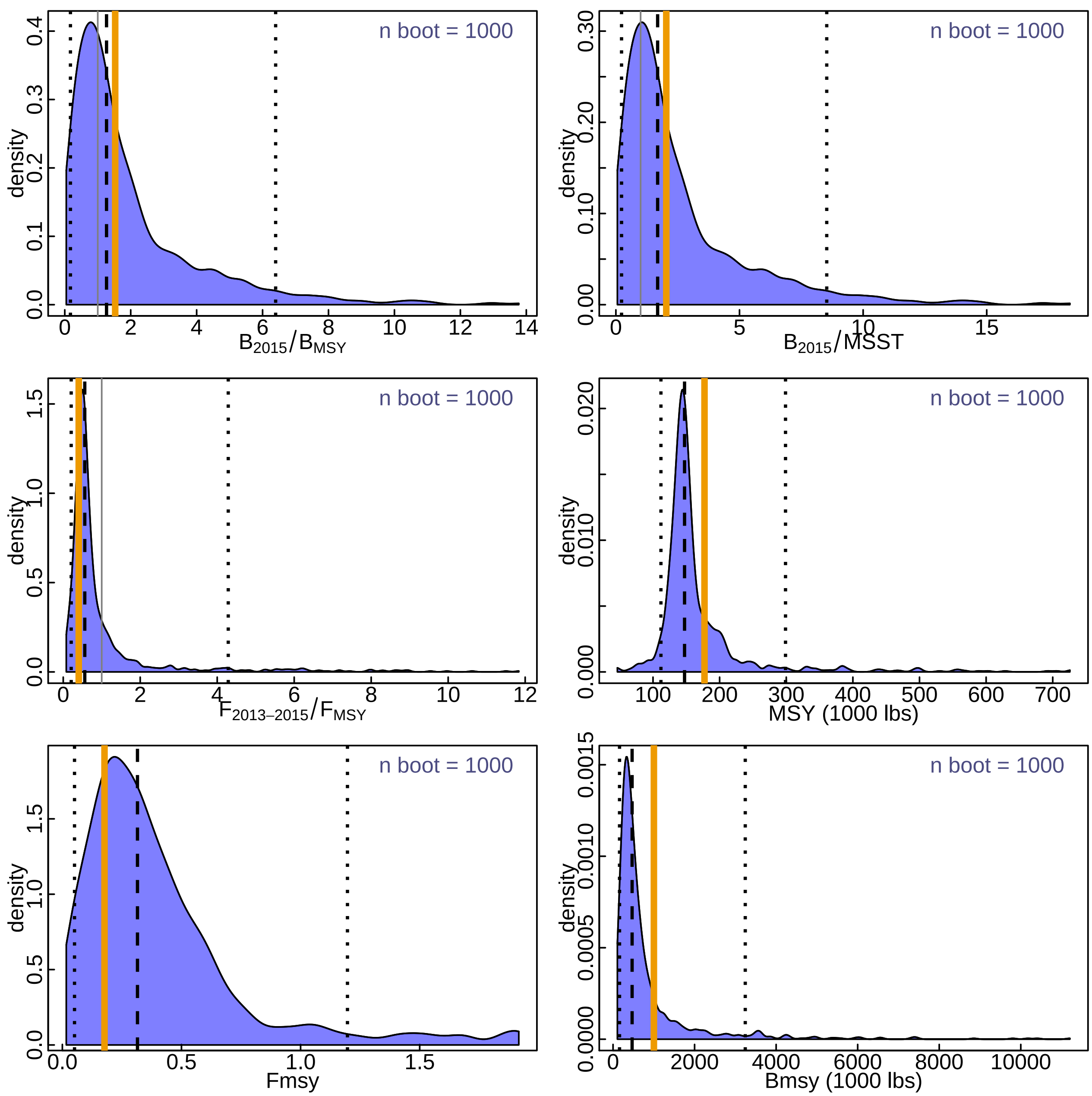


Figure 69. Solid line indicates average B series relative to B_{MSY}, for the Gulf of Mexico ASPIC handline model. The dashed line represents the median B/B_{MSY} and blue error bands indicate 5^{th} and 95^{th} percentiles of the bootstrap trials.

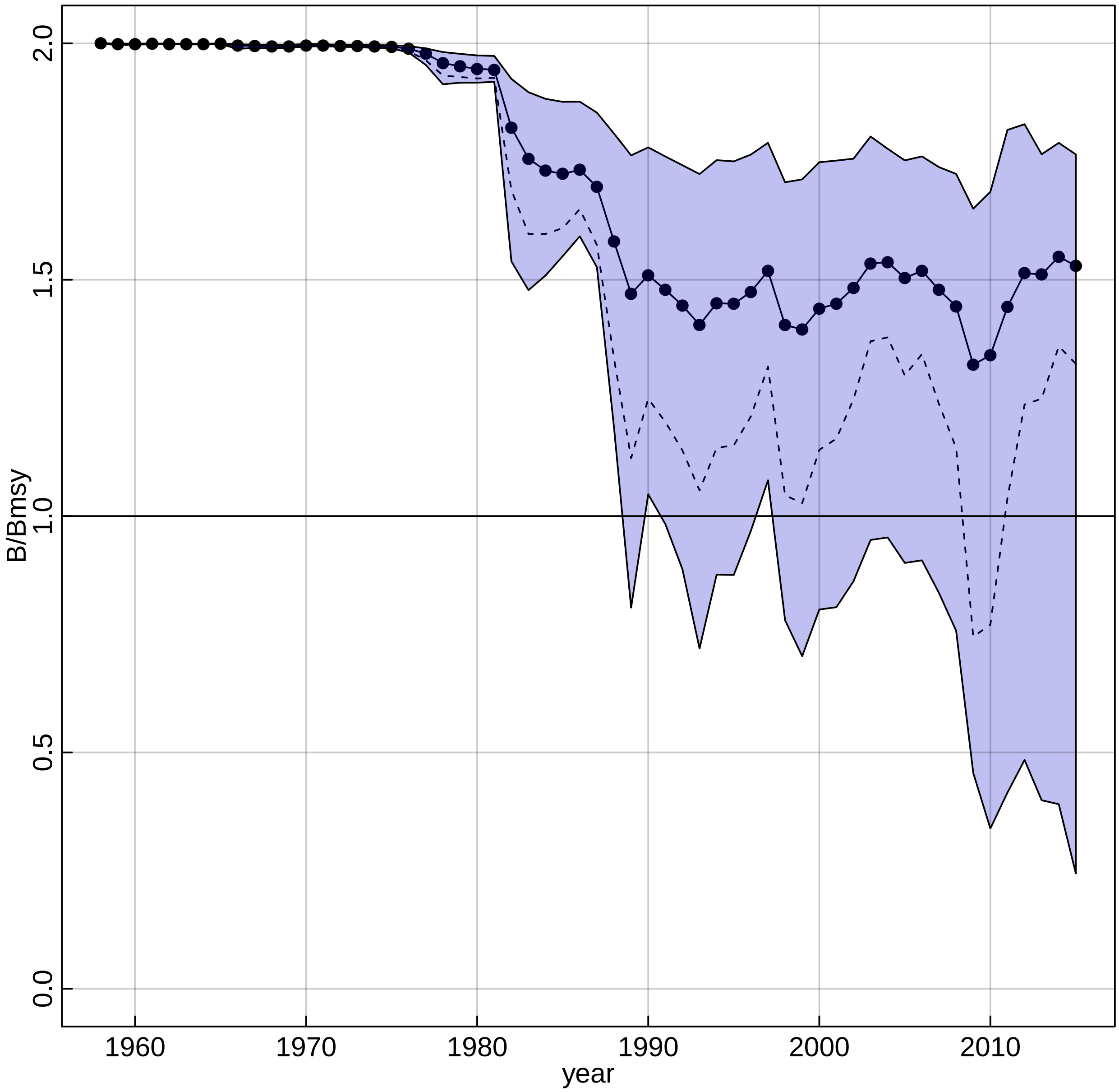


Figure 70. Solid line indicates average F series relative to F_{MSY}, for the Gulf of Mexico ASPIC handline model. The dashed line represents the median F/F_{MSY} and blue error bands indicate 5^{th} and 95^{th} percentiles of the bootstrap trials.

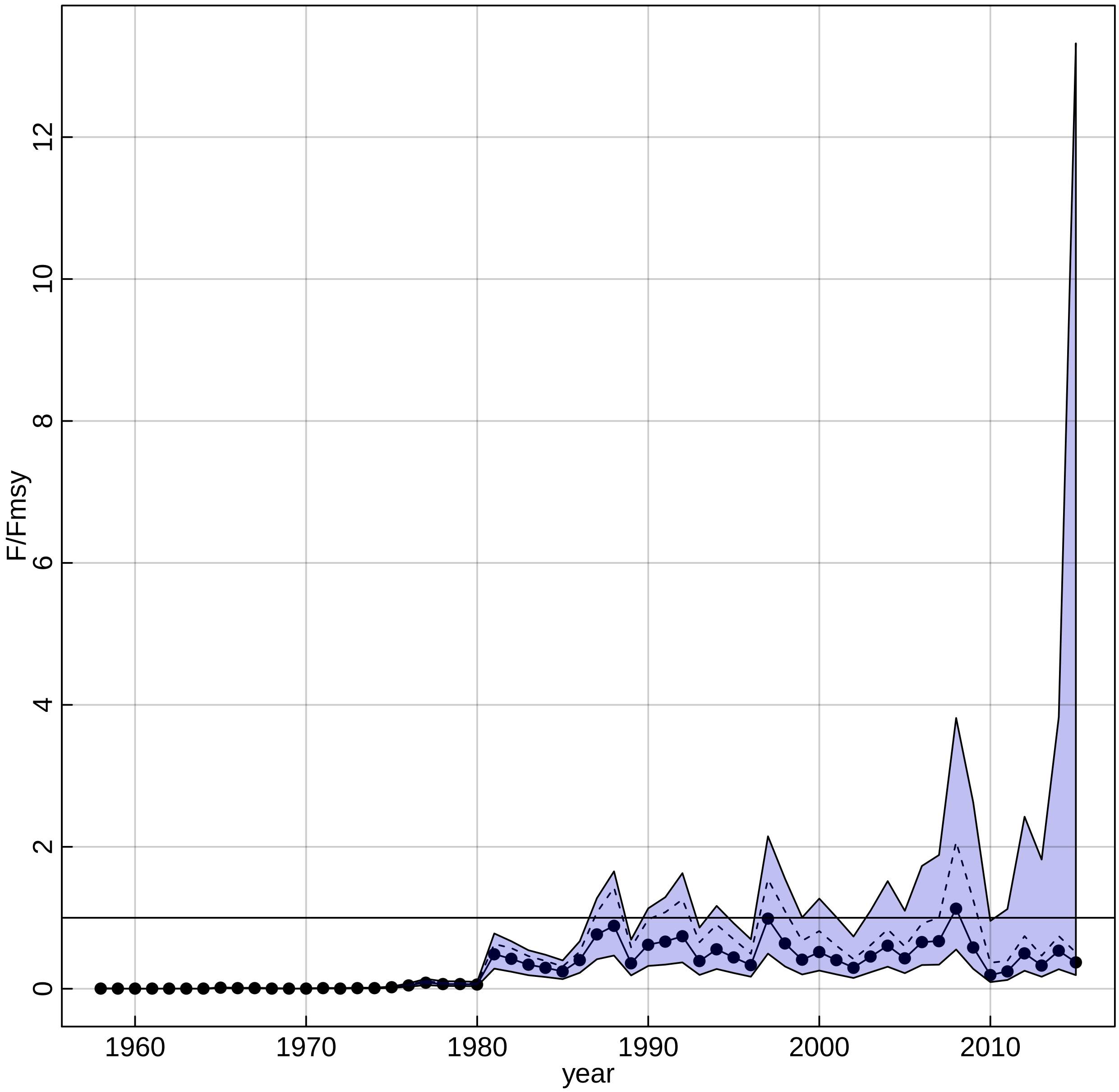


Figure 71. Phase plots of ASPIC F and B status estimates for bootstrap runs associated with the Gulf of Mexico ASPIC handline model. The intersection of crosshairs indicates status estimates from the Gulf of Mexico handline model; lengths of crosshairs defined by 5^{th} and 95^{th} percentiles. Percent of runs falling in each quadrant indicated.

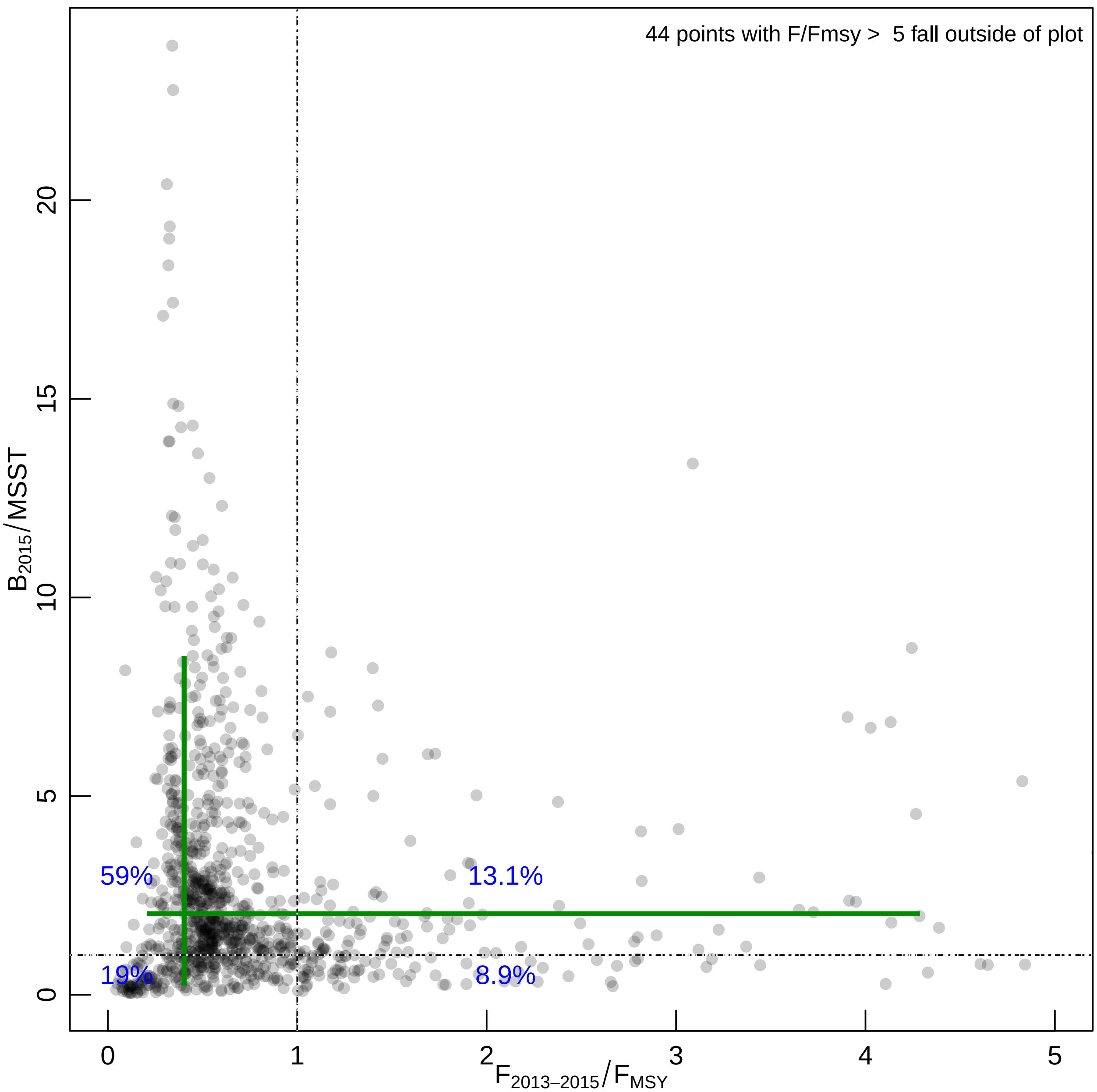


Figure 72. Annual length composition data used in Gulf of Mexico DLM analysis.

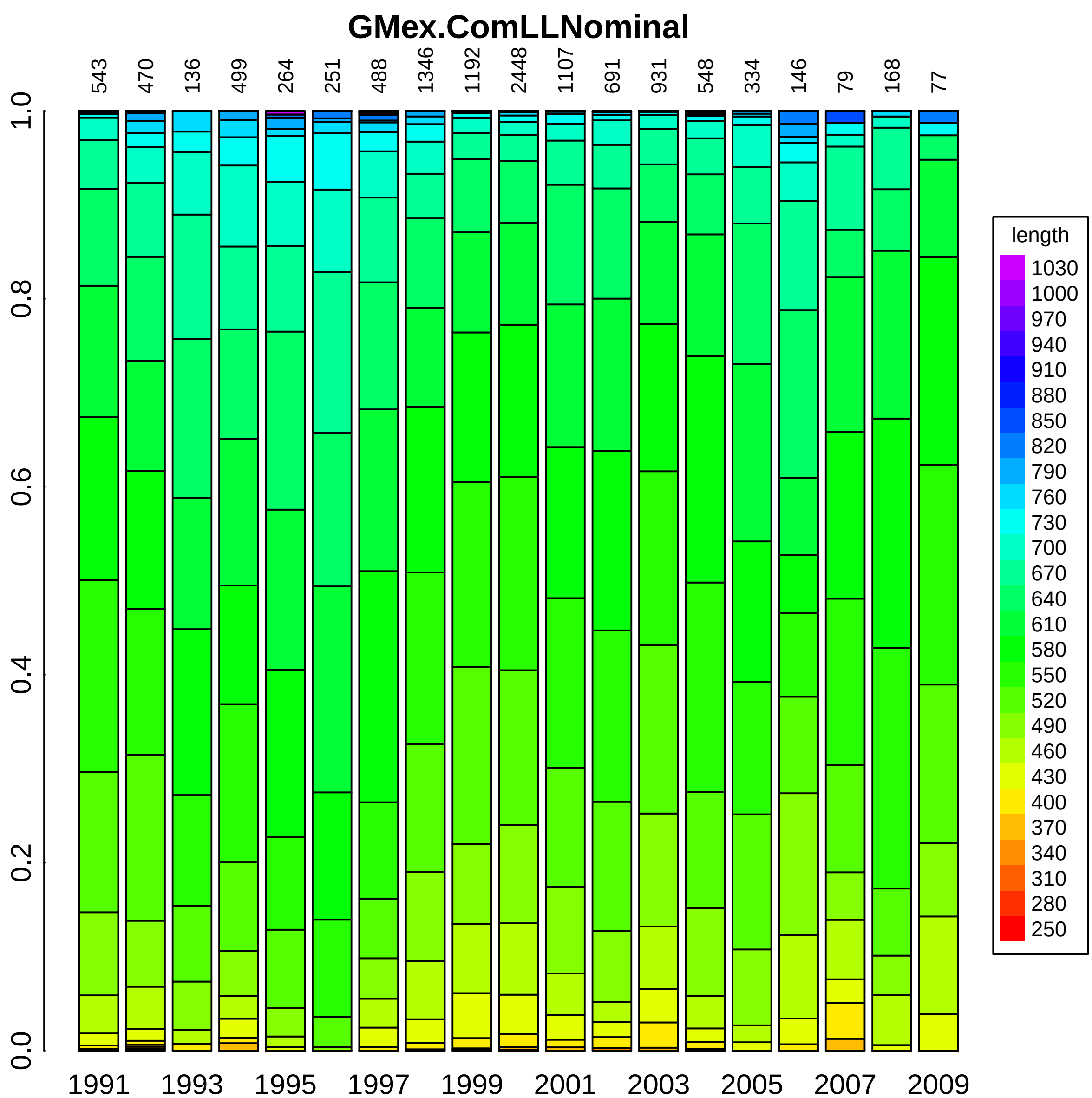


Figure 73. Catch series used in Gulf of Mexico DLM analysis.

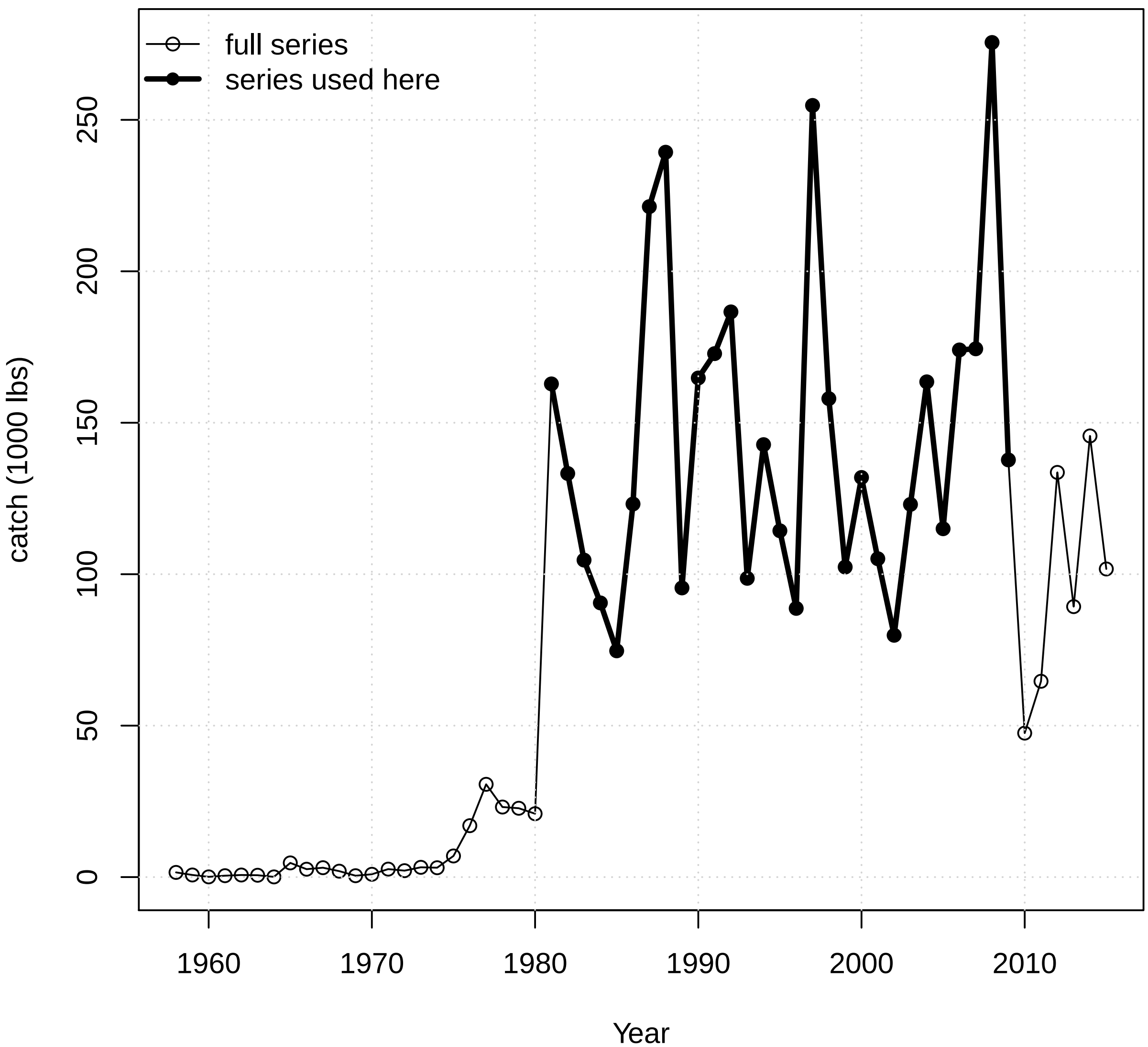


Figure 74. Distributions of TACs from Gulf of Mexico DLM analysis.

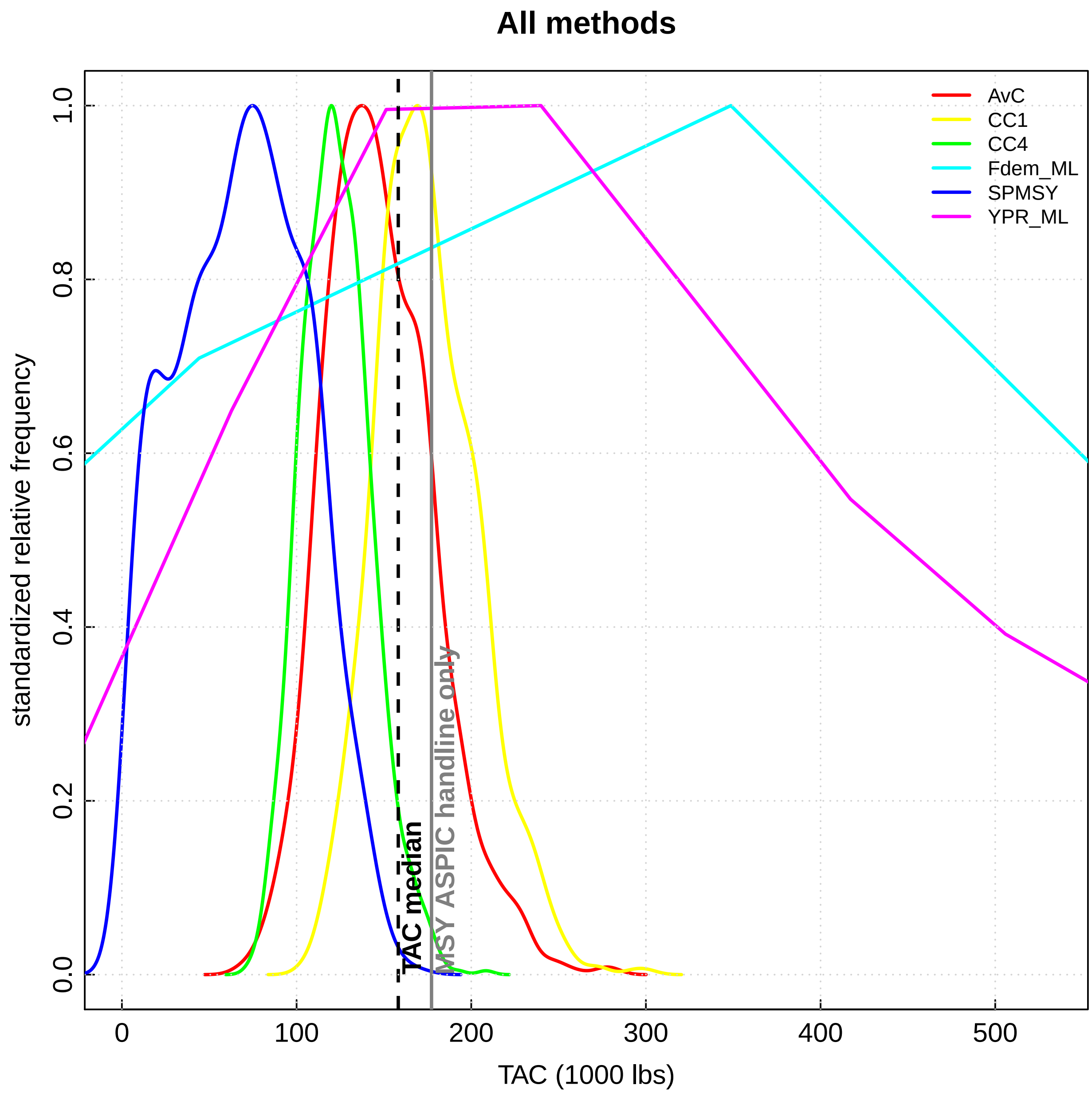
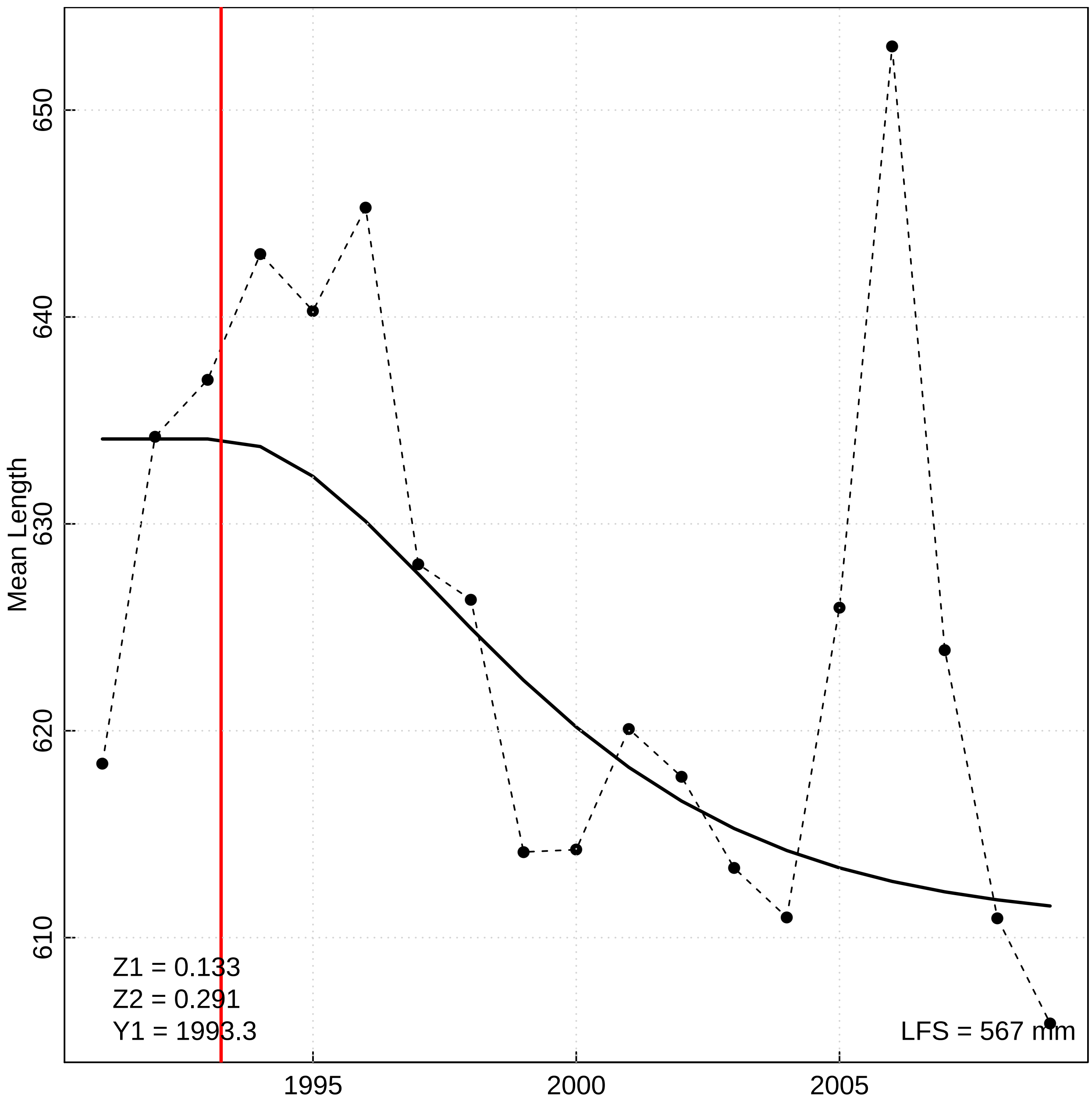


Figure 75. Observed and estimated mean length series for Gulf of Mexico DLM analysis.



Appendix A Abbreviations and symbols

Table 28. Acronyms and abbreviations used in this report

Symbol	Meaning
ABC	Acceptable Biological Catch
AW	Assessment Workshop (here, for blueline tilefish)
ASY	Average Sustainable Yield
B	Total biomass of stock, conventionally on January 1
BAM	Beaufort Assessment Model (a statistical catch-age formulation)
CPUE	Catch per unit effort; used after adjustment as an index of abundance
CV	Coefficient of variation
CVID	SERFS combined chevron trap and video survey
DW	Data Workshop (here, for blueline tilefish)
F	Instantaneous rate of fishing mortality
$F_{30\%}$	Fishing mortality rate at which $F_{30\%}$ can be attained
F_{MSY}	Fishing mortality rate at which MSY can be attained
FL	State of Florida
FHWAR	The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey
GA	State of Georgia
GLM	Generalized linear model
K	Average size of stock when not exploited by man; carrying capacity
kg	Kilogram(s); 1 kg is about 2.2 lb.
klb	Thousand pounds; thousands of pounds
lb	Pound(s); 1 lb is about 0.454 kg
m	Meter(s); 1 m is about 3.28 feet.
M	Instantaneous rate of natural (non-fishing) mortality
MARMAP	Marine Resources Monitoring, Assessment, and Prediction Program, a fishery-independent data collection program of SCDNR
MCB	Monte Carlo/Bootstrap, an approach to quantifying uncertainty in model results
MFMT	Maximum fishing-mortality threshold; a limit reference point used in U.S. fishery management; often based on F_{MSY}
mm	Millimeter(s); 1 inch = 25.4 mm
MRFSS	Marine Recreational Fisheries Statistics Survey, a data-collection program of NMFS, predecessor of MRIP
MRIP	Marine Recreational Information Program, a data-collection program of NMFS, descended from MRFSS
MSST	Minimum stock-size threshold; a limit reference point used in U.S. fishery management. The SAFMC has defined MSST for blueline tilefish as $0.75\mathrm{SSB}_{\mathrm{MSY}}$.
MSY	Maximum sustainable yield (per year)
mt	Metric ton(s). One mt is 1000 kg, or about 2205 lb.
N	Number of fish in a stock, conventionally on January 1
NC	State of North Carolina
NMFS	National Marine Fisheries Service, same as "NOAA Fisheries Service"
NOAA	National Oceanic and Atmospheric Administration; parent agency of NMFS
OY	Optimum yield; SFA specifies that OY $\leq$ MSY.
PSE	Proportional standard error
R	Recruitment
SAFMC	South Atlantic Fishery Management Council (also, Council)
SC	State of South Carolina
SCDNR	Department of Natural Resources of SC
SDNR	Standard deviation of normalized residuals
SEDAR	SouthEast Data Assessment and Review process
SERFS	Southeast Regional Fishery-independent Sampling
SFA	Sustainable Fisheries Act; the Magnuson–Stevens Act, as amended
SL	Standard length (of a fish)
SRHS	Southeast Region Headboat Survey, conducted by NMFS-Beaufort laboratory
SPR	Spawning potential ratio
SSB	Spawning stock biomass; mature biomass of males and females
$\mathrm{SSB}_{\mathrm{MSY}}$	Level of SSB at which MSY can be attained
$\mathrm{SSB}_{\mathrm{F30\%}}$	Level of SSB at which $F_{30\%}$ can be attained
TIP	Trip Interview Program, a fishery-dependent biodata collection program of NMFS
TL	Total length (of a fish), as opposed to FL (fork length) or SL (standard length)
VPA	Virtual population analysis, an age-structured assessment
WW	Whole weight, as opposed to GW (gutted weight)
yr	Year(s)

SEDAR

Southeast Data, Assessment, and Review

SEDAR 50

Atlantic Blueline Tilefish

SECTION IV: Research Recommendations

October 2017

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

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IV. Research Recommendations

1. Stock ID

1.1 Genetics

- Given the results of the genetic work on Blueline Tilefish evaluated here and the limitations identified in the Katz et al. 1983 (SEDAR50-RD18) Golden Tilefish study, patterns in genetic population structure should be revisited for other deep-water species (including Golden Tilefish) using contemporary genetic approaches and analyses.
- To develop a mechanistic understanding of processes facilitating gene flow for Blueline Tilefish, further research should be undertaken to evaluate spawning season duration, pelagic larval stage duration, and adult movements.
- Additional genetic sampling should be conducted in the Gulf of Mexico (Florida Keys to the Texas-Mexico border) to further evaluate the potential for genetic structure across the Gulf of Mexico.

1.2 Life History

- Age reading interpretation of Blueline Tilefish otoliths need to be resolved. Other age validation techniques should be investigated (e.g., Pb\Ra ratio).
- Reproductive biology studies of Blueline Tilefish should be expanded to include the full distributional range of the species, specifically targeting samples from the west and east coasts of Florida and the Mid-Atlantic region. These data are needed to assess possible shifts in spawning season. Sampling of young fish is needed to improve the maturity ogive.
- Better information is needed on the movement or migration of juvenile and adult Blueline Tilefish.
- Studies should be conducted on the identification of Blueline Tilefish larvae and also on the location, duration, and dispersal mechanisms of the egg and larval stages.

1.3 Spatial Distribution

- Further research should be conducted to understand the thermal tolerance of Blueline Tilefish.
- Surveys should be conducted to try to document the distribution of early life stages.
- Further studies are needed on habitat preferences over the whole range of the species.
- Particle modeling to investigate hypotheses about movement of eggs and larvae.
- Research into movement of adults.

1.4 Overall

- A continuous, random, stratified survey should be developed and implemented for Blueline Tilefish throughout its range.

2. Data Workshop

2.1 Life History Working Group

- Collect and take reproductive tissue samples from smaller fish to improve reproductive parameters estimates.
- Investigate movements and locations for post-settlement smaller/juvenile Blueline Tilefish.
- Investigate adult movement through tagging studies (e.g., breakaway tags; see SEDAR50_DW12)
- Design and implement a regional ichthyoplankton survey to investigate larval transport. Note: taxonomic work needs to be done first to describe the eggs and larvae of Blueline Tilefish.
- Mine existing ichthyoplankton collections be assessed for presence of Blueline Tilefish larvae.
- Collect information/data on reproductive and larval behavior for use in modelling larval dispersal.
- Studies to validate the annulus formation and annulus structure of in blueline.
- Further investigate the potential shift in the Radio Bomb Carbon data and reference curve for Blueline Tilefish age validation (Note that this work is ongoing at SCDNR).
- Develop and recommend use of standardized aging methods as recommended by the SEDAR Best Practices Standing Panel Language in the Data Issue Inventory: **Age determination:** develop best practices for age determination to include processing and reading age structures, age calibration, age variability and bias estimates, validation methods, etc.
- Develop and recommend use of methods to provide growth parameter and natural mortality estimates in cases where no reliable age data are available. Focus should be on acceptable approaches for parameter values and error distributions (e.g. meta analyses, use of related species, use of species with comparable life history strategies, etc.).

2.2 Discard Mortality Ad-Hoc Group

- The working group identified limited peer-reviewed literature for deepwater reef fish species and no information for Blueline Tilefish in either the commercial and recreational fisheries. Future research should attempt to provide estimates of discard mortality through tag-recapture, acoustic tagging, or other methods in both sectors. While some information was available to estimate immediate mortality, research is needed to reduced uncertainty in estimates of delayed mortality. Particular interest was expressed into developing mortality estimates when using descender devices to aid recompression, since these devices may have the potential to substantially lower mortality rates. Cooperative research with either sector represents a robust mechanism available to begin obtaining more estimates of mortality and reduce uncertainty in future assessments.

2.3 Commercial Working Group

- Investigate improvements in proportioning unclassified tilefish to species
    - Investigate alternative methods of determining proportions, e.g. relationship to landings of non-tilefish species such as Snowy Grouper
- Increase observer coverage in the South Atlantic
    - Observer data would improve discard estimation and provide estimates of discard sizes and weights
- Implement electronic monitoring of bycatch
    - Such a program should improve discard estimation accuracy and provide size and weight composition of discards

2.4 Recreational Working Group

- Research and implement rare-event data collection procedures.
  E.g. mandatory reporting, logbooks, reef fish stamp to determine universe.
- Fund research efforts to collect discard length and age data from the private sector.
- Additional data collection in the recreational fishery (gear, depth, angler demographics)
- Pre-stratify MRIP Keys, N-S Canaveral, N–S Hatteras.
- At-sea observers collect surface and bottom temperature.

2.5 Index Working Group

- The IWG discussed future research recommendations for Blueline Tilefish. The unanimous consensus was that a coastwide fishery-independent survey is needed for Blueline Tilefish. In the absence of a fishery-independent index, additional information on the targeting behavior of fishermen, in particular the depth or geographic locations fished within a given trip as well as more refined information on fishing effort is needed.

2.6 ToR#7 Ad-hoc Group

ToR #7 *Consider ecosystem and climate issues that could affect population dynamics. Identify and describe available data sources to investigate the effects of abiotic and biotic facto*rs, for *example climate change, predator/prey interactions, etc., on recruitment, growth, geographic distribution, and natural mortality.*

Initiate studies to:

- describe movements/migration of adult Blueline Tilefish,
- investigate possibility of range expansion using recent statistical models and available data,
- determine thermal tolerance of Blueline Tilefish,

- identify Blueline Tilefish larvae,
- investigate larval duration and larval dispersal,
- identify juvenile habitat or movement,
- collect temperature within the water column,
- collect information on location of life stage activities.

3. Assessment Workshop

- Reliable fishery independent indices should be developed, though this would first require a fishery independent survey that samples Blueline Tilefish effectively.
- Aging techniques should continue to be developed for Blueline Tilefish so that future stock assessments may be done using age structured models.
- Genetics samples should be collected from the West Florida Shelf and other areas throughout the Gulf of Mexico to more convincingly determine whether or not Blueline Tilefish in the Gulf of Mexico are part of the same population as Atlantic Blueline Tilefish.
- The search for small blueline tilefish ($< 25cm$), as well as eggs and larvae, should continue. Blueline Tilefish $< 25cm$ are bound to be much more abundant than larger individuals and yet they are rarely encountered by any gear. Eggs and larvae can effectively be identified using genetic techniques, and there are apparently many samples that have been collected but have not yet been genotyped (Lewis et al. 2016). A good place to start would be genotyping more of the available samples. This would also benefit the science on other species.
- Any information on movement of adult Blueline Tilefish, especially movement across Council boundaries would be valuable (e.g. tagging studies). It has been shown that other deepwater tilefish species can be tagged and recaptured (Grimes et al. 1983).
- The possible movement of Blueline Tilefish eggs and larvae between Council regions via ocean currents should be invested further, perhaps with particle tracking models, or more in depth drifter analysis.

4. Review Workshop

• *Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.*

Research recommendations were provided by the Data and Assessments workshops and were reviewed at the Review Workshop. The two main areas where further research would help improve the assessment for both stocks are development of fishery independent indices and resolution of the age determination issues. A third area of research pertains to improving our understanding of biological processes such as reproduction and recruitment dynamics.

NMFS should continue the development of fishery dependent and independent indices for these stocks. The development of a continuous, random, stratified fishery-independent survey implemented for blueline tilefish throughout its range is potentially the single most important recommendation for this stock. The survey could also be used to fill other knowledge gaps (e.g. incorporate a hook selectivity study).

Reliable age reading or growth curve development is also urgently needed for blueline tilefish. If possible, the age reading issues of blueline tilefish otoliths should to be resolved. Other age validation techniques or methods to derive reasonable growth curves should be investigated (e.g., Pb\Ra ratio, or tagging studies). Resolution of the age determination issues would allow considerable past information to be incorporated into the assessment.

Beyond those priorities, further understanding of egg and larval dispersal through biophysical modeling and genetic analysis may be useful. Studies should be conducted on the identification of blueline tilefish larvae and also on the location, duration, and dispersal mechanisms of the egg and larval stages. Eggs and larvae can effectively be identified using genetic techniques, and there are apparently many samples that have been collected but have not yet been genotyped. A good place to start would be genotyping more of the available samples. This would also benefit the science on other species.

Increased observer coverage for both commercial and recreational fisheries in the South Atlantic would improve discard estimation and provide estimates of discard sizes and weights. Implementing electronic monitoring of bycatch would improve discard estimation accuracy and provide size and weight composition of discards. In the absence of a fishery-independent index, additional information on the targeting behavior of fishermen, in particular the depth or geographic locations fished within a given trip as well as more refined information on fishing effort is needed.

Investigation of alternative methods in proportioning unclassified tilefish to golden, blueline, or other species could be explored. For recreational fisheries, research into and implement rare-event data collection procedures (e.g. mandatory reporting, logbooks, reef fish stamp to determine universe.) could also benefit the assessment. ,

An increase in sample size on the catch compositions from both commercial and recreational fisheries would be useful.

Estimates of immediate and delayed discard mortality through tag-recapture, acoustic tagging, or other methods in both commercial and recreational fisheries are needed. Special interest was expressed into developing mortality estimates when using descender devices to aid recompression, since these devices may have the potential to substantially lower mortality rates

Special effort could be put into the data collection in North and South of Cape Hatteras to better understand the spatial distribution of fishing effort, size composition of catch, and catch rate.

Further study on the maturity and reproductive biology would be of value to the assessment. Reproductive biology studies of blueline tilefish should be expanded to include the full distributional range of the species, specifically targeting samples from the west and east coasts of Florida and the Mid-Atlantic region. These data are needed to assess possible shifts in spawning season. Sampling of young fish is needed to improve the maturity ogive to improve reproductive parameters estimates.

Particularly if the age determination issues remain unresolved, development and use of methods to provide growth parameter and natural mortality estimates (may serve as prior elicitation in the future) would benefit the assessment. The focus should be on acceptable approaches for parameter values and error distributions (e.g. meta analyses, use of related species, use of species with comparable life history strategies, etc.)

With respect to assessment models, consideration should be given to developing Bayesian, age-structured models to integrate prior knowledge from the meta-analysis on the life history processes.

• *Provide recommendations on possible ways to improve the SEDAR process.*
The current SEDAR process looks well designed. The process provides for a thorough review and evaluation of the available data, provides thorough consideration and review of analytical approaches and modeling results, provides very good guidance on the information expected to result from the process, and provides very good documentation of the process including decisions made throughout the assessment. The process is highly transparent, particularly because documents produced for review remain unedited after the review. The pre-Review Workshop teleconference is a good component that can help get the Review Workshop meeting to quick start by providing the analytical team advance notice of areas that the RW is likely to question. Distributing presentations in advance of the workshop is useful. As a minor recommendation would be to ensure there is time for at least two rounds of review of the Review Workshop report in the event that there are significant additions to the report or addendum material provided to RW after the meeting is adjourned. This would help to ensure that the RW has the opportunity to reach consensus on all aspects of the report.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 50

Atlantic Blueline Tilefish

SECTION V: Review Workshop Report

October 2017

SEDAR
4055 Faber Place Drive, Suite 201
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1. Introduction

1.1 Workshop Time and Place

The SEDAR 50 Review Workshop for Atlantic Blueline Tilefish was held August 29-31, 2017 in Atlantic Beach, NC.

1.2 Terms of Reference

1. Evaluate the data used in the assessment, addressing the following:
   a) Are data decisions made by the DW and AW sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are data applied appropriately within the assessment model?
   d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   a) Are methods scientifically sound and robust? Do the methods follow accepted scientific practices?
   b) Are assessment models configured appropriately and applied consistent with accepted scientific practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   a) Are population estimates (model output – e.g. abundance, exploitation, biomass) reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   b) Is the stock overfished? What information helps you reach this conclusion?
   c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
   d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
   e) Are the quantitative estimates of the status determination criteria for this stock appropriate for management use? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
   a) Are the methods consistent with accepted practices and available data?
   b) Are the methods appropriate for the assessment model and outputs?
   c) Are the results informative and robust, and useful to support inferences of probable future conditions?
   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
   - Comment on the degree to which methods used to evaluate uncertainty reflect and capture all sources of uncertainty in the population, data sources, and assessment methods
   - Are the implications of uncertainty in technical conclusions clearly stated?
6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.
   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   - Provide recommendations on possible ways to improve the SEDAR process.
7. Provide suggestions on improvements in data or modeling approaches which should be considered when scheduling the next assessment.
8. Prepare a Peer Review Summary of the Panel's evaluation of the stock assessment, addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Peer Review Summary Report in accordance with the project guidelines.

1.3 List of Participants

REVIEW PANEL

Scott Crosson	Review Panel Chair	SAFMC SSC
Churchill Grimes	Reviewer	SAFMC SSC
Yan Jiao	Reviewer	MAFMC SSC
Patrick Cordue	CIE Reviewer	CIE
Jamie Gibson	CIE Reviewer	CIE
Paul Medley	CIE Reviewer	CIE

ANALYTICAL REPRESENTATIVES

Nikolai Klibansky	Lead analyst	SEFSC Beaufort
Kevin Craig	Assessment Team	SEFSC Beaufort
Paul Nitschke*	Assessment team	NEFSC
Kyle Shertzer	Assessment Team	SEFSC Beaufort
Erik Williams	Assessment Team	SEFSC Beaufort

APPOINTED OBSERVERS

Skip Fuller*	For-hire	VA
Jeff Gutman*	For-hire	NJ
Rusty Hudson	Recreational/Commercial	FL / SFA
Andy Piland	For-hire	NC

COUNCIL REPRESENTATIVES

Tony DiLernia*	Council member	MAFMC
Dewey Hemilright	Council member	MAFMC
Anna Beckwith	Council member	SAFMC
Mark Brown*	Council member	SAFMC

COUNCIL AND AGENCY STAFF

Julia Byrd	Coordinator	SEDAR
Kimberly Cole	Admin	SEDAR/SAFMC
Myra Brouwer*	SAFMC lead	SAFMC
John Carmichael*	SAFMC	SAFMC
Jason Didden/Matt Seeley	MAFMC lead	MAFMC
Mike Errigo	Fishery Biologist	SAFMC
Nick Farmer*/Jeff Pulver	Fishery Biologist	SERO

*Did not attend Review Workshop

Review Workshop Attendees

Alan Bianchi
Rob Cheshire
Michelle Duval
Eric Fitzpatrick
Amy Flowers
Jennifer Potts
Mike Schmidtke
Kate Siegfried
Amy Schueller

1.4 List of Background Documents and Review Workshop Working Papers

Atlantic Blueline Tilefish document list.

Document #	Title	Authors
	Documents Prepared for the Data Workshop (DW)	
SEDAR50-DW01	Brief Summary – Habitat and Developing Spatial Species Information for Blueline Tilefish in the South Atlantic Region	Pugliese 2016
SEDAR50-DW02	Summary of the 2015 blueline tilefish cooperative-with-industry data collection project	Kellison 2016

SEDAR50-DW03	A Preliminary Assessment of Reproductive Parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida ****SEE SEDAR50-DW19 FOR FINAL REPRODUCTIVE ANALYSES**	Kolmos et al. 2016
SEDAR50-DW04	Distribution of scientifically collected blueline tilefish (*Caulolatilus microps*) in the Atlantic, and associated habitat	Klibansky 2016
SEDAR50-DW05	Summary of the results of a genetic-based investigation of blueline tilefish (*Caulolatilus microps*)	McDowell 2016
SEDAR50-DW06	Preliminary Genetic Population Structure of Blueline Tilefish *Caulolatilus microps* along the East Coast of the United States	O'Donnell and Darden 2016
SEDAR50-DW07	Description of age and growth for blueline tilefish, *Caulolatilus microps*, caught north and south of Cape Hatteras, NC	Schmidtke and Jones 2016
SEDAR50-DW08	Standard Operative Procedure for Embedding and Sectioning Blueline Tilefish (*Caulolatilus microps*)	Ostrowski 2016
SEDAR50-DW09	Summary of Northeast Fisheries Science Center Blueline Tilefish Survey Data	Nitschke and Miller 2016
SEDAR50-DW10	Summary of Mid-Atlantic Commercial Blueline Tilefish Data	Nitschke and Miller 2016
SEDAR50-DW11	Distribution of blueline tilefish (Caulolatilus microps) in the U.S. EEZ from fishery-dependent and fishery-independent data collections	Farmer and Klibansky 2016
SEDAR50-DW12	**Recommendations from the SEDAR 50 (Blueline Tilefish) Stock ID Work Group Meeting**	**SEDAR 50 Stock ID Work Group 2016**
SEDAR50-DW13	Comparison of Blueline Tilefish Otolith Derived Ages: Comparing Increment Counts Derived by Readers from NMFS SEFSC-Beaufort and SCDNR Age Laboratories	Ballenger 2017
SEDAR50-DW14	TBD	TBD
~~SEDAR50-DW15~~	SEDAR 50 Public Comments – visit the following link to view public comments submitted for SEDAR 50 https://safmc.wufoo.com/reports/sedar-50-public-comments/	

SEDAR 50-DW16	**SEDAR 50 Stock Identification Joint SSC Review Webinar Consensus Statements**	**Joint SSC Sub-Panel 2016 (Includes MAFMC, SAFMC, GMFMC representatives)**
SEDAR 50-DW17	**SEDAR 50 Stock Identification – Management/Science Call Recommendations**	**Council, Science Center, and Regional Office Leadership**
SEDAR50-DW18	Blueline Tilefish Age Workshop II	Potts et al. 2016
SEDAR50-DW19	Reproductive parameters for Blueline Tilefish in Atlantic Waters from Virginia to Florida	Kolmos et al. 2017
SEDAR50-DW20	Virginia Blueline Tilefish Data Collection Summary	Cimino 2017
SEDAR50-DW21	Summary of the Blueline Tilefish meristic conversions using data from the entire US Atlantic and Gulf of Mexico	Ballew and Potts 2016
SEDAR50-DW22	SEDAR 50 Discard Mortality Ad-hoc Group Working Paper	Discard mortality ad-hoc group
SEDAR50-DW23	Estimating dispersal of blueline tilefish (*Caulolatilus microps*) eggs and larvae from drifter data	Klibansky 2017
SEDAR50-DW24	ToR #7 Ad Hoc Work Group Working Paper	ToR #7 Ad-Hoc Work Group
SEDAR50-DW25	Standardized catch rates of blueline tilefish (*Caulolatilus microps*) in the South Atlantic and Gulf of Mexico waters of the U.S. from recreational headboat logbook data	SFB-NMFS 2017
SEDAR50-DW26	Standardized catch rates of blueline tilefish (*Caulolatilus microps*) in the South Atlantic and Gulf of Mexico waters of the U.S. from commercial logbook handline data	SFB-NMFS 2017
SEDAR50-DW27	Standardized catch rates of blueline tilefish (*Caulolatilus microps*) in the South Atlantic and Gulf of Mexico waters of the U.S. from commercial logbook longline data	SFB-NMFS 2017
SEDAR50-DW28	SEDAR 50 additional management actions provided by R. Hudson	Hudson 2017

Documents Prepared for the Assessment Workshop		
SEDAR50-AW01	South Atlantic U.S. Blueline Tilefish (*Caulolatilus microps*) length composition from the recreational fisheries	SFB-NMFS 2017
SEDAR50-AW02	Commercial length composition weighting for U.S. Blueline Tilefish (*Caulolatilus microps*)	SFB-NMFS 2017
SEDAR50-AW03	Additional Commercial Fishery Statistics: Landings in Weight and Number, Mean Weights, Update to Uncertainty, and Catch and Effort Maps	SEDAR 50 Commercial WG
Documents Prepared for the Review Workshop		
SEDAR50-RW01	Information to help interpret results from the data limited toolkit for Atlantic Blueline Tilefish north and south of Cape Hatteras	Ahrens 2017
Final Assessment Reports		
SEDAR50-SAR1	Assessment of Atlantic Blueline Tilefish	To be prepared by SEDAR 50
Reference Documents		
SEDAR50-RD01	SEDAR 32 South Atlantic Blueline Tilefish Stock Assessment Report	SEDAR 32
SEDAR50-RD02	List of documents and working papers for SEDAR 32 (South Atlantic Blueline Tilefish and Gray Triggerfish) – all documents available on the SEDAR website.	SEDAR 32
SEDAR50-RD03	Managing A Marine Stock Portfolio: Stock Identification, Structure, and Management of 25 Fishery Species along the Atlantic Coast of the United States	McBride 2014
SEDAR50-RD04	Workshop to Determine Optimal Approaches for Surveying the Deep-Water Species Complex Off the Southeastern U.S. Atlantic Coast	Carmichael et al. 2015
SEDAR50-RD05	Report to Virginia Marine Resources Commission: Grant F-132-R-2 The Population Dynamics of Blueline and Golden Tilefish, Snowy and Warsaw Grouper and Wreckfish	Schmidtke et al. 2015

SEDAR50-RD06	Estimated Catch of Blueline Tilefish in the Mid-Atlantic Region: Application of the Delphi Survey Process	Allen et al. 2016
SEDAR50-RD07	MAFMC Memo: Blueline Tilefish Catch Series – Feb 23, 2016	Didden 2016
SEDAR50-RD08	Reproductive Biology of the Blueline Tilefish, Caulolatilus microps, off North Carolina and South Carolina	Ross and Merriner 1983
SEDAR50-RD09	Fish species associated with shipwreck and natural hard-bottom habitats from the middle to outer continental shelf of the Middle Atlantic Night near Norfolk Canyon	Ross et al. 2016
SEDAR50-RD10	Systematics and Biology of the Tilefishes (Perciformes: Branchiostegidae and Malacanthidae), with Descriptions of Two New Species	Dooley 1978
SEDAR50-RD11	Integrating DNA barcoding of fish eggs into ichthyoplankton monitoring programs	Lewis et al. 2015
SEDAR50-RD12	Age, growth, and reproductive biology of blueline tilefish along the southeastern coast of the United States, 1982-1999	Harris et al. 2004
SEDAR50-RD13	Description of the Circulation on the Continental Shelf	Bumpus 1973
SEDAR50-RD14	Spawning Locations for Atlantic Reef Fishes off the Southeastern U.S.	Sedberry et al. 2006
SEDAR50-RD15	Observations and a Model of the Mean Circulation over the Middle Atlantic Bight Continental Shelf	Lentz 2008
SEDAR50-RD16	Modeling larval connectivity of the Atlantic surfclams within the Middle Atlantic Bight: Model development, larval dispersal and metapopulation connectivity	Zhang et al. 2015
SEDAR50-RD17	Tilefishes of the Genus *Caulolatilus* Construct Burrows in the Sea Floor	Able et al. 1987
SEDAR50-RD18	Delineation of Tilefish, *Lopholatilus chamaeleonticeps*, Stocks Along the United States East Coast and in the Gulf of Mexico	Katz et al. 1983
SEDAR50-RD19	Chapter 22: Interdisciplinary Evaluation of Spatial Population Structure for Definition of	Cadrin et al. 2014

	Fishery Management Units (excerpt from Stock Identification Methods – Second Edition)	
SEDAR50-RD20	Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey and its partners	Smart et al. 2015
SEDAR50-RD21	Age, Growth, and Mortality of Blueline Tilefish from North Carolina and South Carolina	Ross and Huntsman 1982
SEDAR50-RD22	Radiocarbon from nuclear testing applied to age validation of black drum, *Pogonias cromis*	Campana and Jones 1998
SEDAR50-RD23	A long- lived life history for a tropical, deepwater snapper (*Pristipomoides filamentosus*): bomb radiocarbon and lead-radium dating as extensions of daily increment analyses in otoliths	Andrews et al. 2012
SEDAR50-RD24	Age and growth of bluespine unicornfish (*Naso unicornis*): a half-century life-span for a keystone browser, with a novel approach to bomb radiocarbon dating in the Hawaiian Islands	Andrews et al. 2016
SEDAR50-RD25	Age, growth and reproduction of the barrelfish *Hyperoglyphe perciformis* (Mitchill) in the western North Atlantic	Filer and Sedberry 2008
SEDAR50-RD26	Age, growth, and spawning season of red bream (Beryx decadactylus) off the southeastern United States	Friess and Sedberry 2011
SEDAR50-RD27	Great longevity of speckled hind (*Epinephelus drummondhayi*), a deep-water grouper, with novel use of postbomb radiocarbon dating in the Gulf of Mexico	Andrews et al. 2013
SEDAR50-RD28	Refined bomb radiocarbon dating of two iconic fishes of the Great Barrier Reef	Andrews et al. 2015
SEDAR50-RD29	Age validation of the North Atlantic stock of wreckfish (*Polyprion americanus*), based on bomb radiocarbon (^{14}C), and new estimates of life history parameters	Lytton et al. 2016
SEDAR50-RD30	Stock Complexes for Fisheries Management in the Gulf of Mexico	Farmer et al. 2016
SEDAR50-RD31	Modelling community structure and species co-occurrence using fishery observer data	Pulver et al. 2016
SEDAR50-RD32	Descriptions of the U.S. Gulf of Mexico Reef Fish Bottom Longline and Vertical Line Fisheries Based on Observer Data	Scott-Denton et al. 2011

SEDAR50-RD33	Natural mortality estimators for information-limited fisheries	Kenchington 2014
SEDAR50-RD34	The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural systems and aquaculture	Lorenzen 1996
SEDAR50-RD35	Mortality Rate of Fishes in the Pelagic Ecosystem	Peterson and Wroblewski 1984
SEDAR50-RD36	A Mathematical Model of Some Aspects of Fish Growth, Respiration, and Mortality	Ursin 1967
SEDAR50-RD37	MAFMC Memo: Blueline Tilefish Catch Series – Mar 14, 2016	Didden 2016
SEDAR50-RD38	Mid-Atlantic Fishery Management Council SSC Memo: Proposed BLT Subcommittee Report – March 22, 2016	Miller 2016
SEDAR50-RD39	Hierarchical analysis of multiple noisy abundance indices	Conn 2010
SEDAR50-RD40	Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding	McAllister et al. 2001
SEDAR50-RD41	Evaluating methods for setting catch limits in data-limited fisheries	Carruthers et al. 2014
SEDAR50-RD42	Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act	Restrepo et al. 1998
SEDAR50-RD43	A simple method for estimating MSY from catch and resilience	Martell and Froese 2012
SEDAR50-RD44	Estimating mortality from mean length data in nonequilibrium situations, with application to the assessment of goosefish	Gedamke and Hoenig 2006

2. Review Panel Report

EXECUTIVE SUMMARY

Stock assessment scientists from NOAA's Beaufort lab provided different assessment models and results for the areas south of Cape Hatteras (SOH) and north of Cape Hatteras (NOH). The decisions made by the Data Workshop and Assessment Workshop were generally sound and robust. The RW suggested one significant change to the SOH model, as explained below. The RW did not suggest any significant changes in the NOH model.

The preferred approach of the assessment team for the SOH stock was to use an age-aggregated surplus production model (also known as a Biomass Dynamic Model (BDM)) which was implemented in ASPIC (Prager 1994). A supporting analysis was provided using what the assessment team described as an age-structured production model (ASPM). In contrast, the RW preferred the ASPM over the ASPIC because it has more appropriate population dynamics and it allowed the consequences of uncertainties in the life history parameters to be explored through alternative sensitivity analysis, and hence considered the ASPM the superior base model. The results of the SOH assessment models provide robust evidence that the stock south of Cape Hatteras is not overfished and overfishing is not occurring.

For the stock NOH, only a catch history and some length frequencies were available. Because of this limitation, the R package DLMtool was used to provide TAC range estimates. The DLM analysis of the NOH stock does not provide information about whether the stock is overfished. The medians of the frequency distributions for the three methods that provide catch recommendations based on MSY approximations (Fdem_ML, SPMSY, and YPR_ML) range from 110,000 lbs to 310,000 lbs. In comparison, the average catch for the time period 2006-2015 had a median of 474,000 lbs. Given the high uncertainty in these results, the RW concluded that these results are best interpreted qualitatively, but did agree with the assessment team that the results provide evidence that the recent landings may not be sustainable in the long term. The RW also concluded that the information on potential habitat in the NOH area is insufficient to split the stocks in that area into sustainable landing recommendations along the MAFMC/SAFMC jurisdictional boundary.

The analysts responded quickly to workshop suggestions and made further improvements to the uncertainty analysis during and after the RW meeting by adding alternative sensitivity runs. The RW offered research recommendations and provided guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

2.1. Statements addressing each TOR.

TOR 1. Evaluate the data used in the assessment, addressing the following:

a) Are data decisions made by the DW and AW sound and robust?

In general, the RW agreed that the data decisions made by the DW and AW are sound and robust. Spatial data is limited, including information on stock structure, and this hampers the stock assessment and the determination of status. The conclusion that blueline tilefish are genetically homogeneous in the US Mid-Atlantic bight, South Atlantic Bight, and Gulf of Mexico appears well supported, although samples are not available for all areas. However, assessing blueline tilefish as one large stock encompassing its entire range may not be appropriate because, particularly in the case of recruitment, the biological processes that determine abundance and dynamics may occur at smaller scales. Based on the assumption that eggs and larvae are transported by ocean currents, via an analysis of drifter data, the analysts showed that there could potentially be significant dispersal of eggs and larvae along the coast, and that the exchange could potentially be asymmetrical with rates of movement in one direction that differ from movements in the other direction. This suggestion, coupled with a spatial mismatch between the locations with CPUE indices and the locations of recent removals, led the analysts to model blueline tilefish in the Atlantic as two stocks separate from blueline tilefish in the Gulf of Mexico. One of these stocks occupied the area extending from the SAFMC/GMFMC boundary to Cape Hatteras (the southern stock), and the other extending north from Cape Hatteras (the northern stock). While there is considerable uncertainty about the scale over which blueline tilefish recruitment processes occur, as well as degree to which drifter data may characterize egg and larval dispersal, the RW agreed that the decisions about stock structure were practical and consistent with the available information. However, the extent to which these stocks could be considered closed, an assumption of the models used in this assessment, is not really known.

Because of significant imprecision between aging of otoliths, the aging data was determined to be unsuitable for tracking cohorts in age based stock assessment. The RW hence agreed with the decision not to use the aging data.

Growth model parameter estimates and the Beverton-Holt steepness parameter were derived from a meta-analysis from similar species. The RW suggested estimating the growth parameter values using the age-structured model, which provided estimates consistent with the meta-analysis. The natural mortality rate was estimated based on the relationship between natural mortality and maximum age, using an estimate of maximum age of 40 years. Age at 50% maturity was estimated from empirical data, although, as pointed out in the Data Workshop report, too few immature fish were captured to be sure the estimated value was reliable. The workshop concurred with this but suggested maturity at age be moved from age 2 to 6 given the information from similar species. The RW agreed with the decisions that were made about life history parameter values, but recommended that several sensitivity analyses be undertaken given their high uncertainty. These analyses are discussed later in this report.

The RW expressed concern over the spike in landings in the catch history circa 1980. The ratio of blueline tilefish to other tilefish in the catch history prior to 1985 is unknown, and the ratio from time periods after 1985 were applied to the earlier time period. Commercial fishermen present at the RW stated that many of these landings were likely golden tilefish. The RW suggested that sensitivity analyses be undertaken to address this uncertainty. The recreational catch estimates in recent years are also a concern.

For CPUE, the workshop expressed concerns over the descriptive analysis in the GLM, and the documentation of the inclusion of variables could have been improved.

b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

Data uncertainties were acknowledged. Genetic and drifter study results were presented to aid in assessing the extent of interregional recruitment between the Gulf of Mexico and Atlantic coast zones. The drifter analysis supporting high egg and larval drift and connectivity could be improved by the addition of important biological variables such as pelagic larval duration, egg buoyancy, vertical migration, settlement habitat, etc. As currently presented, the utility of these studies in the stock assessment process is limited and open to interpretation.

As noted above, the aging data from otolith studies could not be adequately calibrated and was not utilized by the AW. The RW agreed with this decision.

c) Are data applied appropriately within the assessment model?

The data were applied appropriately in the SOH and NOH models.

d) Are input data series reliable and sufficient to support the assessment approach and findings?

The input data for the SOH model was sufficient for the two models described below. The NOH model is a data-limited model that by definition utilizes fewer data series. As noted above, the earlier tilefish landings did not sufficiently differentiate between tilefish species, and the RW did express a concern with the accuracy of landings spikes earlier in the time series. Sensitivity analyses suggested by the RW showed that this is a key source of uncertainty in the assessment for the SOH stock.

TOR 2. Evaluate the methods used to assess the stock, taking into account the available data.

South of Cape Hatteras

The assessment team had been expecting to use a statistical catch-age model implemented using the Beaufort Assessment Model (BAM) software (Williams and Shertzer 2015). However, with the absence of age data the preferred approach of the assessment team was to use an age-aggregated surplus production model (also known as a Biomass Dynamics Model (BDM)) which was implemented in ASPIC (Prager 1994). A supporting analysis was provided using what the assessment team described as an age-structured production model (ASPM). The ASPIC model used the catch history and explored combinations of three fishery-dependent CPUE time series, but did not use estimates of life history parameters. Instead an "intrinsic rate of growth" (r) was estimated for the population within the model, together with a carrying capacity (K), with initial depletion (B_1/K) fixed equal to 1. The model was actually parameterized so that the free parameters were F_{MSY} and MSY but this is equivalent.

The ASPM is an age-structured model which used fixed values for the majority of life history parameters which were estimated outside the model in a variety of ways (due to the absence of valid age data). The growth parameters were estimated within the model from the length frequency data and provided estimates consistent with a meta-analysis of growth model parameters for related species. The stock recruitment relationship was assumed to be a Beverton-Holt relationship with the steepness parameter from a prior developed by meta-analysis on related species. The data inputs included the catch history, CPUE indices, and a substantial number of length frequency datasets. Sensitivity runs were performed using alternative life history parameters.

It was not clear to the RW why the assessment team favored the ASPIC over the ASPM. One of the reasons cited by the assessment team was that "the ASPM was very sensitivity to life history assumptions". However, the RW believed this was also a reason for preferring the ASPM. The ASPIC hides the sensitivity of the assessment results to the poorly known life history parameters. The use of the ASPM allows the sensitivity of results to life history parameters and the robustness of conclusions to be more fully explored.

a) *Are methods scientifically sound and robust? Do the methods follow accepted scientific practices?*

The methods used were generally sound and robust. The ASPIC is often used when life history parameters are not well known but removals and biomass indices are available. The use of the ASPIC in this case does come within accepted scientific practice. However, the RW did not consider it the best choice.

The RW preferred the ASPM over the ASPIC because it has more appropriate population dynamics and it allows the consequences of uncertainties in the life history parameters to be fully explored. The ASPIC only has one type of biomass which is particularly inappropriate if vulnerable biomass (that being selected by the fishery) is very different from mature biomass (which drives egg production). The ASPIC has no lag in recruitment which is inappropriate for species which mature or recruit to the fishery later than age 1. Also, in the ASPIC used, B_{MSY} was assumed to occur at 50% *K*. This is a very high value for B_{MSY} compared to any age-structured model using a Beverton-Holt stock recruitment relationship. A ASPIC does not model biological population dynamics properly because it does not model the various separate processes of natural mortality, growth and recruitment. In practice, it can be used successfully to model the past empirical link between catches and abundance. However, this may provide only a poor prediction of future abundance and offers no clear way to explore alternative scenarios or structural uncertainties.

The use of the ASPM as the base model would also have the advantage that the considerable length frequency data available could be used. These data not only allowed the estimation of fishery selectivities but also, in the runs requested by the workshop, allowed the growth parameters to be estimated within the ASPM model. However, a model run with the length frequency data heavily weighted relative to the CPUE indices suggested that it may contain a different signal about changes in mortality rates and abundance than the CPUE indices. This issue was not fully explored at the RW, and if real, the case is not known.

b) *Are assessment models configured appropriately and applied consistent with accepted scientific practices?*

Generally the models were configured appropriately and applied within accepted scientific practices. However, the RW identified a number of issues which needed to be addressed.

The first issue was that the CPUE indices were fitted using only observation error (with CVs as low as 7% in some cases). Abundance indices need to have a component of "process error" which is a consequence of assumptions being violated. In particular, and especially for CPUE, it is likely that the proportionality constant (*q*) for the assumed linear relationship between CPUE and biomass actually varies from year to year. This produces an additional component of variation which is not captured by estimates of observation error. Because the CVs of the CPUE indices were not inflated to allow for process error the handline index (which had the lowest CVs) dominated the longline CPUE index in the model where they were both fitted. This led the assessment team to fit each index separately and then average the results from the two runs.

The averaging of results from two separate runs to provide a final assessment is not the best approach for the type of stock assessments being applied here. If the two runs are telling "very different stories" then they need to be kept in separate runs (one of the runs may be providing the "truth"). If the two runs are not inconsistent then there should just be a single run with all of the data included. The base model recommended by the RW does include both CPUE time series where each time series is given equal weight (CVs = 20%).

The ASPM runs were generally appropriate, but the base ASPM model had full maturity at age 2. This had been calculated using the length at maturity data and the externally estimated growth parameters. However, it was the general feeling of the workshop and indeed the whole meeting that full maturity at age 2 years was very unlikely for this species. A new reference model was proposed by the workshop for exploring results from the ASPM which had full age at maturity at 6 years. This is a conservative value in that the younger the age of maturity the more resilient the stock is to exploitation (according to the estimated fishing selectivities fish are not exploited until about 6 years of age).

c) *Are the methods appropriate for the available data?*

The methods were defensible given the available data. The final base ASPIC model used the handline and longline CPUE indices and excluded the problematic headboat time series. The ASPIC could not use the length frequencies but these were fitted in the ASPM runs. The ASPM runs used all three CPUE time series but the headboat series was split into two periods to account for changes in fishing practice (resulting in a change in selectivity).

<u>North of Cape Hatteras</u>

For the assumed stock to the north of Cape Hatteras only a catch history and some length frequencies were available. The life history estimates were borrowed from those used for south of Cape Hatteras. The R package DLMtool was used to provide TAC range estimates (Carruthers and Hordyk 2016; R Core Team 2016).

a) *Are methods scientifically sound and robust? Do the methods follow accepted scientific practices?*

Various data limited assessment methods exist and the DLMtool provides access to a number of such methods. It must be understood that where there are little data any stock assessment results should be treated cautiously as they are, in reality, very uncertain. With this acknowledged it is reasonable and scientifically defensible to use such a tool to provide some idea of the range of possible TACs. Six methods were used to provide alternative distributions describing possible TACs. Little is known about the relative performance of the individual methods which will be highly case specific.

b) Are assessment models configured appropriately and applied consistent with accepted scientific practices?

Appropriate data and estimated CVs were supplied to the DLMtool.

c) Are the methods appropriate for the available data?

No biomass indices are available so the use of the DLMtool is appropriate. However, two of management procedures use the Gedamke and Hoenig (2006) non-equilibrium mean length method to estimate the instantaneous total mortality rate. An assumption of this method is that all fish larger that the length at which they are fully selected to the fishery experience the same total mortality rate. The RW noted that the method would be less appropriate if the fishery selectivity was dome-shaped, an assumption at times made for gears such as hooks. The effect of violating this assumption would be to over-estimate the mortality rate, but the extent to which would depend in part on the shape of the selectivity curve. Additionally, the extent to which a mean length estimate would change with a change in total mortality would depend upon the shape of the selectivity curve for the gear used to sample the population.

TOR 3. Evaluate the assessment findings with respect to the following:

<u>South of Cape Hatteras</u>

a) Are population estimates (model output – e.g. abundance, exploitation, biomass) reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

When interpreted together with their associated uncertainties, the RW concluded that the estimates of abundance, exploitation and biomass are reliable, consistent with the input data and biological characteristics of the stock, and useful to support status inferences. Uncertainties include those resulting from model selection and configuration, parameter estimation, the dated CPUE abundance indices, and the removals time series. As discussed below, the many sensitivity analyses undertaken by the assessment team indicate that the results appear most sensitive to uncertainty in the removals time series, specifically the very high landings in the early 1980's.

As discussed above (TOR 2), rather than fitting the ASPIC model with the handline and longline indices separately and averaging the results, the RW recommended a base model fitting the ASPIC model with the two indices in the same model but with equal weights. The RW agreed that the ASPM results worked well as a supporting analysis and requested several sensitivity analyses using this model. However, the results of the two models are not directly comparable because biomass is treated differently in the two models. ASPIC models biomass is in terms of what is available to the fishery, whereas the ASPM analyses estimate both total and spawner biomass, neither of which are estimated with the ASPIC model. The RW suggested that depletion ratios (for trend) and projected yields at $F=F_{current}$ (for scale) were quantities produced by both models that might be comparable.

The ASPIC base model run, and the other model runs that do not include the headboat index, all indicate a sharp biomass decline in the early 1980's followed by increasing biomass in the 2000's to about 50% of carrying capacity (Figure 3.1). With the exception of the sensitivity run in which the peak removals in the early 1980's are reduced by 90% (Catch 0.1), biomass trends from the ASPM runs follow a similar pattern (Figure 3.2), although the extent of the biomass decline tends to be less than the ASPIC model runs. With this exception, the ASPM sensitivity runs generally support the trends produced from the ASPIC base model.

The stand out sensitivity is to the magnitude of the catch spike in the 1980s. If the spike is genuine then there must have been sufficient biomass to support the catches, and the subsequent decline in catches coupled with deterministic recruitment means that the stock must have increased to be consistent with the handline and longline indices. However, if the catch spike is removed altogether then a different story emerges. The run shows a different pattern in which biomass is further depleted and has not rebuilt to 50% of carrying capacity by 2015. It may be that the 10% run (which removes the spike completely) is a bit too extreme, but the impact of reducing that catch spike is very apparent in this sensitivity. The ASPM Catch 0.1 sensitivity was undertaken because of the uncertainty in early landings expressed at the RW, and the sensitivity of the model results to this data input confirm that it is a key source of uncertainty to consider when applying the assessment results.

Deterministic yield projections at $F=F_{current}$ from the ASPIC and ASPM reference model runs differ by about 23% (Table 3.1), suggesting that, although the biomass estimates are not directly comparable, the two models are producing estimates on roughly the same scale. Yield projections fishing at F_{MSY} differ markedly, but are not comparable given the differences in assumptions underlying the models (TOR 2).

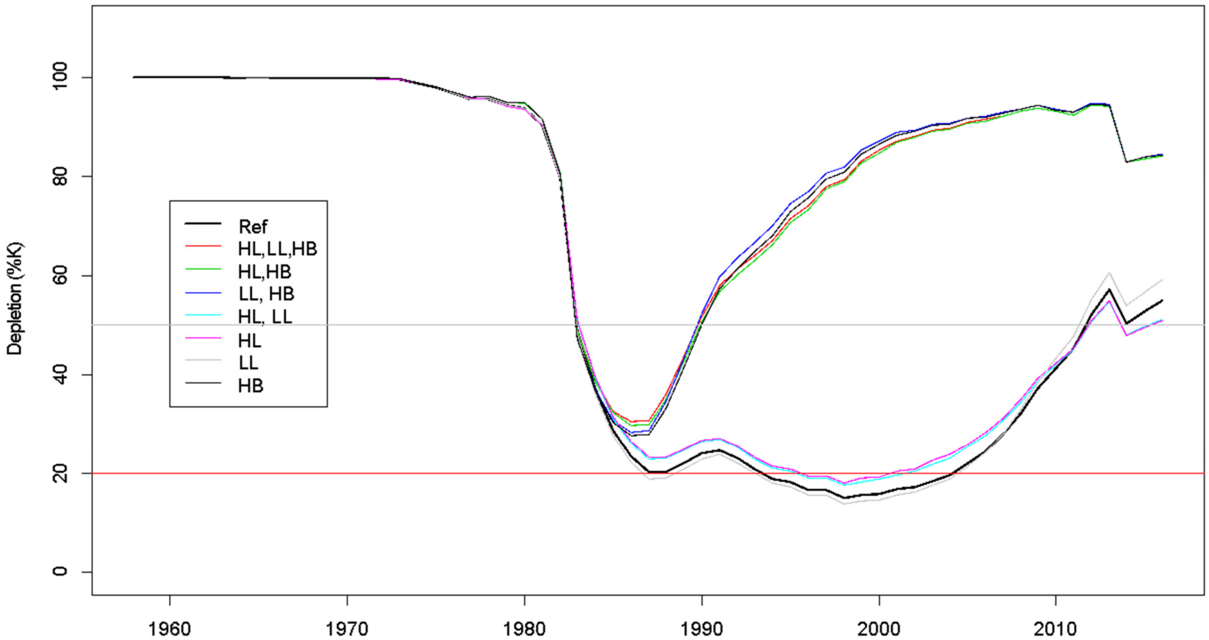

Figure 3.1. Comparison of depletion (% of carrying capacity) for the base ASPIC surplus production model (heavy dark line) and sensitivity analyses undertaken with the model (colored lines) with respect to fitting to various combinations of the handline (HL), longline (LL) and headboat (HB) indices.

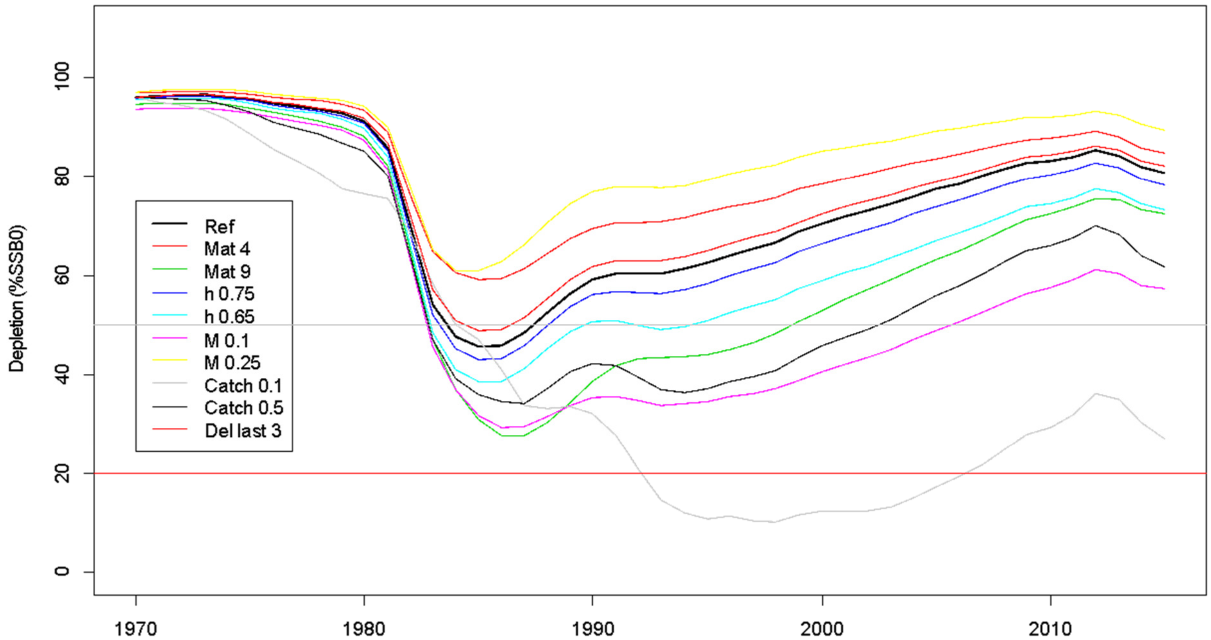

Figure 3.2. Comparison of depletion (% of unfished spawner biomass) for the reference ASPM analysis (heavy dark line) with sensitivity analyses undertaken with the model (colored lines). Sensitivity analyses include: older ages-at-maturity (ages 4 and 9); lower steepness values (0.75, 0.65); different values for the instantaneous natural mortality rate (0.1, 0.25); reducing the peak landings in the early 1980's to 50% and 10% of those used in the reference model; and removing the last three years in the indices.

Table 3.1. Comparison of deterministic yield projections at $F{=}F_{current}$ from the ASPIC and ASPM reference model runs. Adapted from SEDAR 50 Addendum Tables A5 and A23.

Year	Yield (1000 lbs)						
	ASPIC			ASPM			
	$F{=}F_{MSY}$	$F{=}F_{current}$	$F{=}F_{target}$	$F{=}F_{MSY}$	$F{=}F_{current}$	$F{=}F_{30\%}$	$F{=}F_{40\%}$
2017	236	218	180	900	166	795	569
2018	233	218	184	766	165	689	521
2019	231	218	187	674	164	617	484
2020	229	217	190	610	163	564	455

b) Is the stock overfished? What information helps you reach this conclusion?

The results of this assessment provide evidence that the stock south of Cape Hatteras is not overfished. Information in support of this conclusion includes estimated $B/MSST$ ratios above 1.3 from both the ASPIC model for the base model recommended by the RW, and sensitivity analyses pertaining to which CPUE series are included in the model (Table 3.2). Additionally, for the base model, projection results with $F{=}F_{current}$ indicate a probability of $B{>}MSST$ of 0.97 in 2016 (SEDAR 50 Addendum Table A5). Analyses undertaken using the ASPM provide further support for this conclusion: $B/MSST$ ratios from the ASPM sensitivity analyses are above 2.2 (Table 3.3).

This conclusion is subject to some uncertainty resulting from uncertainty in the removals time series (the peak in the early 1980's) and questions about the derivation of the CPUE time series. Additionally, the CPUE series do not provide information on relative abundance since 2007. Recent status determinations are based on productivity as estimated to the end of the CPUE series, projected forward under the assumption that productivity has not changed.

Table 3.2. Estimates of status determination criteria for the South of Cape Hatteras stock from ASPIC for the base model run (bold) and sensitivity analyses undertaken with the model with respect to fitting to various combinations of the commercial handline (HL), longline (LL) and headboat (HB) indices. The numerator in F/F_{MSY} is the geometric mean F from the last three years of the assessment (2013-2015) and B is the biomass in the terminal year of the assessment (2015). Adapted from SEDAR 50 Addendum Table A3.

Run	RunName	F/F_{MSY}	B/B_{MSY}	$B/MSST$
80	**Base (HLLL CV0.2)**	**0.92**	**1.05**	**1.40**
51	HLLLHb	0.41	1.67	2.23
52	HLHb	0.41	1.67	2.23
53	LLHb	0.39	1.68	2.24
54	HLLL	1.06	0.99	1.32
55	HL	1.07	0.99	1.32
56	LL	0.81	1.13	1.51
57	Hb	0.40	1.68	2.23

Table 3.3. Estimates of status determination criteria for the South of Cape Hatteras stock from ASPM for the reference model run and selected sensitivity analyses undertaken with the model. Sensitivity analyses include: older ages-at-maturity (ages 4 and 9); lower steepness values (0.75, 0.65); different values for the instantaneous natural mortality rate (0.1, 0.25); reducing the peak landings in the early 1980's to 50% and 10% of those used in the reference model; and removing the last three years in the indices. Adapted from SEDAR 50 Addendum Table A21.

Description	F/F_{MSY}	B/B_{MSY}	$B/MSST$
Reference	0.12	4.96	6.61
A100is4	0.07	4.87	6.49
A100is9	0.21	4.79	6.39
Steep0.75	0.17	3.76	5.02
Steep0.65	0.26	2.87	3.83
M0.1	0.34	2.82	3.76
M0.25	0.06	6.25	8.34

0.1HLRemo80to85	0.92	1.66	2.21
0.5HLRemo80to85	0.29	3.76	5.02
IndRemLast3yr	0.11	5.06	6.75

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

The results of this assessment provide evidence that the stock south of Cape Hatteras is not undergoing overfishing. Information in support of this conclusion includes the estimated F/F_{MSY} ratios less than one from the base ASPIC model run recommended by the RW (Table 3.2), and from the ASPM analyses (Table 3.3). This conclusion is less certain than the conclusion about whether the stock is in an overfished state. For the ASPIC reference model, bootstrap runs indicate a significant portion of the probability density for F/F_{MSY} that is above one (SEDAR 50 Addendum Figure A5). Additionally, the conclusion is sensitive to decisions about which CPUE indices to include in the model. Two runs including the commercial handline CPUE index provided estimates of F/F_{MSY} ratios slightly greater than one (Table 3.2).

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

Most fisheries models that incorporate population dynamics are based on the assumption that the population is closed, and stocks are often delineated such that this assumption is met. Recruitment dynamics for Atlantic blueline tilefish are poorly understood, and the Assessment Workshop Report discusses, with high uncertainty, how egg and larval drift could result in dispersal among the three putative stocks, resulting in stocks for which recruitment is partially driven by immigration and emigration. In the absence of information about the extent to which immigration and emigration contribute to recruitment processes, the RW concurred that using a stock recruitment relationship (or logistic growth curve for ASPIC) to evaluate productivity and future stock conditions is practical at this time.

ASPIC and ASPM model population dynamics differently; the former using a logistic growth curve that can be used to evaluate productivity. The assumption of the symmetrical shape provides estimates of productivity that differ from what would be expected from an age structured model. The four ASPIC model runs that did not include the headboat index, produced estimates of F_{MSY} that were relatively consistent (SEDAR 50 Addendum Table A3; range: 0.23 to 0.33), implying that that r_{max} is also estimated consistently with these models. Similarly, the estimates of K from the four models were also consistent. The RW accepted that these were useful for evaluating productivity and future stock conditions, noting also that the functional relationships are consistent with those used in the assessment model. However, ASPIC does not discriminate among all types of production including fish growth as well as well as recruitment, so this is not strong evidence of a closed population or simple stock recruitment relationship. Furthermore, BMSY estimates from the ASPM appeared too low to be considered as target reference points, so the RW does not believe a reliable stock recruitment relationship has been demonstrated for this stock. It is likely that the stock structure will need to be modelled more accurately before an accurate stock recruitment relationship could be determined.

e) Are the quantitative estimates of the status determination criteria for this stock appropriate for management use? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

The RW concurred that the quantitative indicators of status determination are appropriate for management use for this stock. The status determinations were robust to many sensitivity analyses undertaken using both ASPIC and ASPM. With respect to current biomass status and projected yields, the base model run from ASPIC provides advice that is lower than some sensitivity model runs and most ASPM model runs, but not all of these are equally plausible.

North of Cape Hatteras

a) Are population estimates (model output – e.g. abundance, exploitation, biomass) reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

The RW accepted that the DLM analyses undertaken for northern blueline tilefish are appropriate given the limited amount of data available for this stock. The assessment team filtered the many methods available in the DLM toolbox to select methods that would provide TAC recommendations. These included three methods that use MSY approximations, and five scenarios based on average catch. Although these analyses do not provide time series of abundance, exploitation, or biomass, they do provide output that can be used to compare average catch management procedures with management procedures based on MSY approximations.

These analyses are consistent with the input data and biological characteristics and subject to uncertainty, provide a basis to support status inferences with respect to whether the stock is undergoing overfishing, but not whether it is in an overfished state.

b) Is the stock overfished? What information helps you reach this conclusion?

The DLM analyses undertaken for the blueline tilefish stock north of Cape Hatteras do not provide information about whether the stock is overfished.

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

The medians of the frequency distributions for the three methods that provide catch recommendations based on MSY approximations, Fdem_ML, SPMSY, and YPR_ML, range from 110,000 lbs to 310,000 lbs. In comparison, the average catch for the late time period (AvC.late: 2006-2015) had a median of 474,000 lbs. although the value would be sensitive to the years used in its calculation. All recommendations are highly uncertain and the frequency distribution for the AvC.late overlaps with the distributions from the methods that use MSY approximations (SEDAR 50 AW Report Figure 61).

Given the high uncertainty in these results, the RW concluded that these results are best interpreted qualitatively, but did agree with the assessment team that the results provide evidence that the recent landings may not be sustainable in the long term.

Analyses of annual removals by habitat area suggest that recent removals per unit area in the area just north of Cape Hatteras are high relative to annual removals per unit area for the southern stock. The implications of this analysis are highly uncertain because relative habitat quality in the two areas is not known, there is subjectivity in the selection of areas for habitat standardization, and the abundance of this stock even further north is not well known. The RW agreed with the assessment team that the analysis appears to suggest that such high removals over such a small area may be cause for concern: specifically that they could lead to localized depletion. However, the effects on the entire stock north of Cape Hatteras are unknown.

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

Given the very limited amount of information available for the stock north of Cape Hatteras, the DLM analysis was not set up to provide an evaluation of productivity and future stock conditions. Although an estimate of the steepness of the stock recruitment relationship was provided to the model, because the estimate was obtained from a meta-analysis of species with similar life-histories, its representativeness for this stock is unknown. Additionally, the unfished equilibrium recruitment is not known. For these reasons, the RW concurred that an informative stock recruitment relationship is not available.

The DLM toolbox does provide methods for projecting future stock conditions, but these methods are intended primarily for the evaluation of management procedures. Given the wide relative frequency distributions for the TAC's provided by the methods that include MSY approximations, the RW agreed with the assessment team's decision not to undertake these analyses at this time.

e) Are the quantitative estimates of the status determination criteria for this stock appropriate for management use? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

Quantitative estimates of status determination criteria for the North of Cape Hatteras stock were not provided by the DLM analyses. The RW concurred that this was appropriate given the limited data available for this stock.

TOR 4. Evaluate the stock projections, addressing the following:

South of Cape Hatteras

a) Are the methods consistent with accepted practices and available data?

Model projections used both maximum likelihood and bootstrap parameter estimates with fixed fishing mortality covering the range of plausible alternatives. The estimated F in 2015 was applied in 2016, and thereafter 2017-2021 the different scenario fishing mortalities were applied. For each projection, information was provided on the stock status and yields for the projection period 2016-2021. The projected yield was clearly compared to current yield, providing suitable information for setting total allowable catches.

The approach used for projections was appropriate for the models and available data and represents good practice. The use of fishing mortality and range of fishing mortalities tested was appropriate and is standard practice. Uncertainties were captured using the bootstrap simulations.

b) Are the methods appropriate for the assessment model and outputs?

The methods applied by the analytical team were appropriate for the models and outputs. The structure of the projection models was the same as that of the respective assessment model.

For the ASPIC model, the projection 2017-2021 was conducted for fixed fishing mortalities: $F = F_{MSY}$, $F=F_{2015}$ and $F=F_{target}$ (75% F_{MSY}). The biomass and yield was reported from the maximum likelihood estimates and the 1000 bootstrap estimates, consisting of the median biomass and the probability that biomass is greater than B_{MSY} and MSST. Similarly, for the ASPM assessment, the projection 2017-2021 of fixed fishing mortalities was applied, but in this case fixed fishing mortalities applied were $F = F_{MSY}$, $F=F_{2015}$, $F=F_{30\%}$ and $F=F_{40\%}$. No ASPM bootstrap estimates were available for the review because this was not the analytical teams preferred model. However it is expected that all suitable indicators will be in the final report, including probability SSB is above the MSY proxy (recommended $F_{40\%}$ level) and the MSST.

c) Are the results informative and robust, and useful to support inferences of probable future conditions?

The projection results are informative and reasonably robust. The results are described in relation to the most important indicators and the analytical team has demonstrated that management advice should be robust to the key uncertainties.

The short term projections are useful for indicating probable future conditions for the fishery, but precision of future estimates will decrease rapidly. The RW agreed with the analytical team that projecting any further than 5 years could be misleading given the limited data and uncertainties.

For the ASPM assessment, the RW recommended not to use the estimated F_{MSY} as a target, as it cannot be estimated reliably and the estimate is not precautionary. $F_{30\%}$ and $F_{40\%}$ are projected as well and it was agreed that these would make more suitable targets for this assessment. These spawner-biomass-per-recruit reference points would also be more robust to over-estimation of the stock's productivity if a significant amount of recruitment originated from larval transport from outside the stock's boundary (they do not depend on a stock recruitment relationship).

d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

The key uncertainties are the structural uncertainties covered by the sensitivity analyses and the observation errors covered by the bootstrap estimates. For the ASPIC model, the bootstrap runs were used for the projections to generate the probability estimates for stock status and supply appropriate confidence intervals for indicators. For ASPM, no bootstrap was carried out for the review meeting, so the RW did not see the ASPM projections with confidence intervals or probability estimates for stock status, only projections based on the maximum likelihood estimates. Bootstrap projections are needed for the ASPM assessment and are expected to be carried out. It was assumed that the median bootstrap estimates would be close to the maximum likelihood estimates for the indicators of interest. The bootstraps should provide adequate estimates of uncertainty caused by the observation error.

Alternative projections have been run with the key sensitivity analyses. The RW identified an alternative catch history with a lower proportion of the tilefish catch 1981-85 allocated to blueline tilefish as the key structural uncertainty. These additional runs, with the bootstraps, should reflect the key uncertainties in the projection results.

The between model uncertainty is very large as the projected yields from the ASPM reference run at $F_{40\%}$ are more than five times higher than those for the sensitivity that removed the 1980s catch spike (Table 4.1). The projected yields for the ASPIC model at F_{targ} are less than half of those from the ASPM reference run (Table 4.1), indicating that results from these models are highly uncertain. If the magnitude of the spike in the 1980s catch is genuine then much higher catches than have recently been removed can be sustainably taken.

Table 4.1: Deterministic projected yields (t) using $F_{current}$ for 2016 and the indicated fishing mortality for 2017–2020. Estimates are given for the ASPIC base model, the ASPM reference run, and the ASPM that removed the spike in the early 1980s catches.

	ASPIC F_{targ}	ASPM ref $F_{40\%}$	ASPM no-spike $F_{40\%}$
2016	219	168	139
2017	180	569	73
2018	184	521	78
2019	187	484	82
2020	190	455	85

North of Cape Hatteras

No projections were run for the fishery North of Cape Hatteras. Given the available data and methods, it was not appropriate to carry out projections for this fishery. The method "DLMtools" implements simulations to test management procedures and does not provide an estimate of stock status. Therefore, it was not appropriate to project the population status forward. Instead, simulations applied fixed catches to various stock models to provide a benchmark for current catches and help determine whether they were sustainable.

TOR 5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

a) Comment on the degree to which methods used to evaluate uncertainty reflect and capture all sources of uncertainty in the population, data sources, and assessment methods

b) Are the implications of uncertainty in technical conclusions clearly stated?

The stock structure is a significant source of uncertainty. Evidence was presented that suggested there were strong linkages through recruitment between the Gulf of Mexico and along the whole Atlantic coast. While the RW understood and supported the decision to assess three areas separately, this source of uncertainty has not been addressed in the stock assessment outputs. An important RW recommendation for future assessments is to develop several models with different spatial links to run at least as alternative sensitivity analyses.

South of Cape Hatteras

Uncertainty was evaluated using two different models, sensitivity analyses and bootstrapping. The implications of the uncertainties are clearly presented and stated in the text and figures. Both the sensitivities and bootstraps were used to report uncertainty in parameter estimates and derived quantities and indicators, so that the consequences of the uncertainty could be evaluated. No bootstrapping was carried out for the ASPM assessment for the RW. The RW recommended this model for management advice, and requested bootstrapping be carried out for the final assessment report. It is expected that the ASPM median bootstrap estimates for important estimated quantities will be close to the maximum likelihood estimate.

Sensitivity analyses considered a wide range of assumptions and model structures. For the ASPIC model, the sensitivities covered which abundance indices were included in the model. The ASPM tested the effect of various life history parameters, including using values from golden tilefish, the previous assessment and setting M and age-at-maturity to alternative plausible values.

Bootstraps are based on sampling theory and simulate alternative data sets using the available data. They are primarily used to assess the effect of observation error. There are many different ways to implement bootstraps. They are a collection of *ad hoc* procedures and many lack a complete underlying theory to support their use, but they are a very flexible tool to characterise uncertainty, particularly when used alongside sensitivity analysis. However, more modern techniques using likelihoods and priors (e.g. MCMC) are generally preferred to cover all sources of uncertainty, including observation and process error.

Additional sensitivity runs were requested by the RW and completed by the stock assessment team. These covered some additional tests for the robustness of the assessment. Notably, reduce the length of the abundance indices, higher, but plausible, age at 100% maturity, lower M, lower SR steepness and an alternative catch history allocating a lower proportion of the tilefish catch 1981-85 to blueline tilefish. The RW identified the alternative catch history as a key structural uncertainty.

The RW believes that the sensitivity analyses capture the most important uncertainties in the assessment and provide important information on the likely plausible range for indicators such as spawning stock biomass and fishing mortality.

North of Cape Hatteras

The DLM tool package is a MSE tool for testing management plans in data poor and hence highly uncertain, fisheries. It simulates population trajectories under different harvest regimes. In each case, key population parameters are drawn from uniform probability distributions covering what is believed to be their possible range. The process gives guidance on setting TACs based on the decision rule and population assumptions, and explicitly addresses the uncertainty. Possible TACs for each rule were presented as densities, but uncertainty over resulting stock status was not evaluated. All consequences for the uncertainty cannot be evaluated and therefore the analytical team was unable to recommend any particular method. Future work could apply the different catch rules to the same population model and data scenarios so that a better comparison might be made on their performance with respect to uncertainty.

TOR 6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.

• *Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.*

Research recommendations were provided by the Data and Assessments workshops and were reviewed at the Review Workshop. The two main areas where further research would help improve the assessment for both stocks are development of fishery independent indices and resolution of the age determination issues. A third area of research pertains to improving our understanding of biological processes such as reproduction and recruitment dynamics.

NMFS should continue the development of fishery dependent and independent indices for these stocks. The development of a continuous, random, stratified fishery-independent survey implemented for blueline tilefish throughout its range is potentially the single most important recommendation for this stock. The survey could also be used to fill other knowledge gaps (e.g. incorporate a hook selectivity study).

Reliable age reading or growth curve development is also urgently needed for blueline tilefish. If possible, the age reading issues of blueline tilefish otoliths should to be resolved. Other age validation techniques or methods to derive reasonable growth curves should be investigated (e.g., Pb\Ra ratio, or tagging studies). Resolution of the age determination issues would allow considerable past information to be incorporated into the assessment.

Beyond those priorities, further understanding of egg and larval dispersal through biophysical modeling and genetic analysis may be useful. Studies should be conducted on the identification of blueline tilefish larvae and also on the location, duration, and dispersal mechanisms of the egg and larval stages. Eggs and larvae can effectively be identified using genetic techniques, and there are apparently many samples that have been collected but have not yet been genotyped. A good place to start would be genotyping more of the available samples. This would also benefit the science on other species.

Increased observer coverage for both commercial and recreational fisheries in the South Atlantic would improve discard estimation and provide estimates of discard sizes and weights. Implementing electronic monitoring of bycatch would improve discard estimation accuracy and provide size and weight composition of discards. In the absence of a fishery-independent index, additional information on the targeting behavior of fishermen, in particular the depth or geographic locations fished within a given trip as well as more refined information on fishing effort is needed.

Investigation of alternative methods in proportioning unclassified tilefish to golden, blueline, or other species could be explored. For recreational fisheries, research into and implement rare-event data collection procedures (e.g. mandatory reporting, logbooks, reef fish stamp to determine universe.) could also benefit the assessment. ,

An increase in sample size on the catch compositions from both commercial and recreational fisheries would be useful.

Estimates of immediate and delayed discard mortality through tag-recapture, acoustic tagging, or other methods in both commercial and recreational fisheries are needed. Special interest was expressed into developing mortality estimates when using descender devices to aid recompression, since these devices may have the potential to substantially lower mortality rates

Special effort could be put into the data collection in North and South of Cape Hatteras to better understand the spatial distribution of fishing effort, size composition of catch, and catch rate.

Further study on the maturity and reproductive biology would be of value to the assessment. Reproductive biology studies of blueline tilefish should be expanded to include the full distributional range of the species, specifically targeting samples from the west and east coasts of Florida and the Mid-Atlantic region. These data are needed to assess possible shifts in spawning season. Sampling of young fish is needed to improve the maturity ogive to improve reproductive parameters estimates.

Particularly if the age determination issues remain unresolved, development and use of methods to provide growth parameter and natural mortality estimates (may serve as prior elicitation in the future) would benefit the assessment. The focus should be on acceptable approaches for parameter values and error distributions (e.g. meta analyses, use of related species, use of species with comparable life history strategies, etc.)

With respect to assessment models, consideration should be given to developing Bayesian, age-structured models to integrate prior knowledge from the meta-analysis on the life history processes.

• *Provide recommendations on possible ways to improve the SEDAR process.*

The current SEDAR process looks well designed. The process provides for a thorough review and evaluation of the available data, provides thorough consideration and review of analytical approaches and modeling results, provides very good guidance on the information expected to result from the process, and provides very good documentation of the process including decisions made throughout the assessment. The process is highly transparent, particularly because documents produced for review remain unedited after the review. The pre-Review Workshop teleconference is a good component that can help get the Review Workshop meeting to quick start by providing the analytical team advance notice of areas that the RW is likely to question. Distributing presentations in advance of the workshop is useful. As a minor recommendation would be to ensure there is time for at least two rounds of review of the Review Workshop report in the event that there are significant additions to the report or addendum material provided to RW after the meeting is adjourned. This would help to ensure that the RW has the opportunity to reach consensus on all aspects of the report.

TOR 7. Provide suggestions on improvements in data or modeling approaches which should be considered when scheduling the next assessment.

A high quality stock assessment requires careful data preparation as well as the use of appropriate modelling tools.

The length frequency data were not carefully analyzed and may not have been appropriately stratified and scaled. An analysis of the variability of fish length within each fishery should be undertaken before the next stock assessment so that appropriately scaled length frequencies can be produced for the years within each fishery where there are adequate data.

The CPUE standardizations were not well documented and more work may have been done than was described. However, there is clearly the need for more detailed analysis. The catch and effort data should be fully investigated and explored before a standardization is attempted. Such a descriptive analysis provides the foundation for a standardization. Explanatory variables need to be carefully chosen and should include effort variables. Hook hours may not be the best unit of effort as bait is not necessarily effective beyond 30 minutes. Also, interactions and/or nested effects need to be considered. For example, seasonal effects may differ by subarea. Area-year interactions especially need to be considered as different trends in different subareas will require an exploration of the effect of different weightings (of the trends across subareas to produce an overall trend).

Hopefully, age data will be available for the next stock assessment and a statistical catch-at-age model can then be used. Should there be a stock for which no age data are available it would still best to use an age-structured model and fit whatever data are available. Any sensitivities to poorly known life history parameters should be explored in an age-structured model rather than hidden by using the ASPIC.

Capturing the uncertainty in stock assessment results using bootstrap procedures is adequate but not ideal. There are many ways to bootstrap any particular problem which means that the approach is necessarily *ad hoc*. It is better to use a formal likelihood approach with asymptotic approximations to confidence/credibility intervals or to adopt a formal Bayesian approach.

2.2. References

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 50

Atlantic Blueline Tilefish

SECTION VI: Addendum

October 11, 2017

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4055 Faber Place Drive, Suite 201
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Document History

August, 2017 Original release of Assessment Report.

October 10, 2017 Original release of Assessment Report Addendum.

October 11, 2017 Minor corrections to Assessment Report Addendum. The ASPM model output file (i.e. rdat file) used to create tables and figures for the ASPM RW Ref model was updated to the most current version, having small effects on some values in tables and figures associated with the ASPM RW Ref model. The correction does not affect ASPM sensitivity runs or projections had already used the most current version of the rdat file. The outdated rdat file was based on the version of the ASPM RW Ref model constructed at the Review Workshop that accidentally used Von Bertalanffy $K = 0.17$ instead of 0.16 to estimate natural mortality at age. The updated version used Von Bertalanffy $K = 0.16$ as was intended. As noted above, this correction results in only minor differences.

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6.0.1 Introduction

This addendum documents relevant changes made to SEDAR 50 models for South Atlantic Blueline Tilefish (south of Cape Hatteras) as requested by the SEDAR 50 Review Workshop (RW) Panel. It has been written to complement the SEDAR 50 Assessment Workshop (AW) Report and avoids restating concepts already expressed in that report. This has been done to avoid redundancy and emphasize differences between models developed with the guidance of the AW Panel, and models developed based on recommendations of the RW Panel. For additional information please see §4 of the SEDAR 50 Assessment Workshop Report above.

6.1 South Atlantic: Age-aggregated Production Model (ASPIC)

6.1.1 Methods

6.1.1.1 Overview

The primary age-aggregated surplus production model (ASPIC) documented in the SEDAR 50 AW Report was the average of two separate ASPIC models (hereafter ASPIC AW Base). One model included only the commercial handline index of abundance and the other included only the commercial longline index. The time series of CVs used for each model were those produced by bootstrapping during index development. These annual CVs ranged from 0.07-0.49. The AW Panel preferred to use an average of the two separate model fits instead of including both indices in a single model to avoid over weighting the index with the lower CVs, since the indices were believed to be equally plausible. The average of the handline and longline ASPIC models was presented in the AW Report.

The RW panel preferred a single ASPIC model including both the handline and longline indices, with all annual CVs set at a constant value of 0.2. The constant CV of 0.2 was preferred to the former approach because it avoids weighting either index more heavily based on lower annual CVs and incorporates a form of process error. The indices themselves did not change from what was presented in the AW Report. The indices and CVs are presented in Table A1 and Figure A1. Using a constant CV of 0.2 had the effect of approximately doubling the CVs on the commercial handline index (AW Base median CV = 0.08), reducing the CVs on the commercial longline (AW median CV = 0.3) and recreational headboat indices (AW Base median CV = 0.27) by approximately one third. The reduction in CVs was largest for the recreational headboat index after 1995 (AW Base median CV = 0.43), which were reduced by more than one half. The removals series and all aspects of the fitting were the same as in the AW Report. The name of this Review Workshop Reference run is hereafter referred to as the ASPIC RW Ref model.

6.1.1.2 Sensitivity analyses

No additional sensitivity analyses were run for the ASPIC model, thus none are presented in this document

6.1.1.3 Uncertainty and Measures of Precision

To evaluate the uncertainty in the model fit and parameter estimates of the ASPIC RW Ref model, 1000 bootstrap runs were conducted.

6.1.1.4 Projections

Projections from the ASPIC RW Ref model were run to predict stock status and yield up to five years after the assessment (2016–2020). These procedures were the same as those presented in §4.

6.1.2 Results

6.1.2.1 Model Fit

For the ASPIC RW Ref model, trends in predicted abundance indices (Figure A2 upper panel) were very similar to those of ASPIC Run 54 (see §4) which included both handline and longline indices but used the observed annual CVs from bootstraps of the indices run by data providers (SEDAR50 DW Report 2017).

6.1.2.2 Estimates of parameters, benchmarks, and status indicators

Estimates of the main ASPIC model parameters, benchmarks, and status indicators from the RW Ref run are presented in Table A2. Estimates for the RW Ref run ($F_{\text{MSY}} = 0.151$, MSY = 217 thousand lb, $F/F_{\text{MSY}} = 0.92$, $B/\text{MSST} = 1.4$) were very similar to those from the AW Base model ($F_{\text{MSY}} = 0.146$, MSY = 212 thousand lb, $F/F_{\text{MSY}} = 0.92$, $B/\text{MSST} = 1.41$).

Bootstrap distributions of these parameters are shown in Figure A5. The mean and median values of the main model parameters estimated by the RW Ref model are similar to the AW Base model. However, the bootstrap distributions for the RW Ref model tended to be unimodal, while those the AW Base model had been bimodal, and the 90% CI tended to be slightly wider for the AW Base model distributions.

6.1.2.3 Time series

Estimated time series of biomass (B) and fishing mortality (F) for the ASPIC RW Ref model (Figures A3 and A4, respectively) were very similar to the corresponding B and F series from the AW Base model. Estimated time series of B/B_{MSY}, B/MSST, and F/F_{MSY} for the ASPIC RW Ref model (Figures A6, A7, and A8, respectively) were also very similar to results from the AW Base model, though the 90% confidence bands tended to be considerably wider for the AW Base model in some years.

6.1.2.4 Status of the Stock and Fishery

Terminal status estimates from the ASPIC RW Ref model indicated that South Atlantic Blueline Tilefish is not overfished or undergoing overfishing ($B/\text{MSST} = 1.4$, $F/F_{\text{MSY}} = 0.92$). Phase plots of terminal status show that 71% of bootstrap estimates resulted in this same status quadrant (Figure A9). Very few bootstrap runs resulted in an overfished stock (3.6%) while a fair proportion resulted in overfishing (25.4%). The proportions within each quadrant were very similar to the AW Base model.

6.1.2.5 Sensitivity

No new sensitivity runs were completed based on the RW Ref model, but a summary of estimates from the models presented in the SEDAR 50 Assessment Report, as well as the RW Ref run, and the AW Base Run are presented in Table A3.

6.1.2.6 Projections

Projections all show the stock to be neither overfished nor undergoing overfishing for years from 2016-2021, whether considering the expected value or the median of the projections (Figures A10, A11, and A12). The probability of $B >$ MSST in 2021 ranged from 0.93 when F was fixed at F_{MSY} to 0.97 when F was fixed at F_{target}, starting in 2017 (Tables A4, A5, and A6). These results are very similar to what was reported in the AW Report.

6.1.3 Discussion

6.1.3.1 Comments on the Assessment

Results from the ASPIC RW Ref model were very similar to the ASPIC AW Base model, so most of the Discussion of the ASPIC results provided in §4 also apply to the RW Ref model. There was very little difference in status indicators, model parameters, or benchmarks between these two models. Differences in estimated F and B time series were almost indiscernible. The most notable differences were in the shape of the bootstrap parameter distributions, which were bimodal in the AW Base model but are unimodal in the RW Ref model, and in the reduced uncertainty in F and B time series in the RW Ref model.

The averaged estimates from the ASPIC handline and longline models indicate that Blueline Tilefish from the SAFMC/GMFMC boundary to Cape Hatteras, NC, is neither overfished nor undergoing overfishing. However, there remains notable uncertainty in overfishing status. Results of uncertainty analysis showed that nearly 35% of bootstrap runs found Blueline Tilefish in this region to be undergoing overfishing (Figure A9).

6.1.3.2 Comments on the Projections

Differences in projections between the ASPIC AW Base and RW Ref models were negligible.

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- In general, projections of fish stocks are highly uncertain, particularly in the long term (e.g., beyond 5–10 years).
- Projections conducted in ASPIC only included uncertainty in indices, based on bootstrapping residuals, and did not include structural (model) uncertainty.
- F_{current} was assumed to be equal to the geometric mean F from the last three years of the assessment period (2013-2015).

6.2 South Atlantic: Age-structured Production Model (ASPM)

6.2.1 Methods

6.2.1.1 Overview

The configuration of the age-structured production model (ASPM) base run developed by the Assessment Panel (ASPM AW Base) was modified at the Review Workshop based on recommendations from the RW Panel. The overall configuration and data structure were the same, but a few important differences were made and are described below to document the ASPM Review Workshop Reference model (ASPM AW Ref).

6.2.1.2 Data Sources and model structure

As in the ASPIC RW Ref model, the same indices of abundance were used in the ASPM with constant CVs of 0.2

In the AW Base model, Von Bertalanffy growth parameters were fixed at values estimated from a meta-analysis. Based on recommendations of the RW Panel, growth parameters L_∞, K, and t_0 were estimated by the assessment model, for the ASPM RW Ref model.

Maturity-at-length data are available for Blueline Tilefish, but of the 1350 fish in this dataset, only four were immature. For the AW Base model, length at 50% maturity (L_{50}) was estimated from these data and combined with the growth curve developed from meta-analysis, to generate a knife-edged maturity-at-age function. This resulted in 100% maturity at age-2. The AW Panel acknowledged that this seemed unrealistic for Blueline Tilefish. But since the estimate of L_{50} was one of the few pieces of empirical life history information available for this species, it was incorporated into the ASPM AW Base model. Still the poor estimate of maturity-at-age was one of several factors that led the AW Panel to focus on the ASPIC model. Acknowledging these issues, the RW Panel recommended assuming an age at 100% maturity of 6 years in the RW Ref model.

6.2.1.3 Sensitivity analyses

Sensitivity runs were intended to demonstrate directionality of results with changes in inputs or simply to explore model behavior, and not all were considered equally plausible. Note that the Assessment Workshop Base Model is the first run in this list. These model runs vary from the RW Ref run as follows:

- ASPM S00: Assessment Workshop Base Model.
- ASPM S01: Assessment Workshop Base Model with fit to growth model parameters.
- ASPM S02: Assessment Workshop Base Model with 100% female maturity at age-6.
- ASPM S03: Assessment Workshop Base Model with CV of abundance indices fixed at 0.2.
- ASPM S04: 100% female maturity at age-4.
- ASPM S05: 100% female maturity at age-9.
- ASPM S06: Constant $M = 0.1$ ($t_{\max} = 40$; use Hoenig 1983 equation).
- ASPM S07: Constant $M = 0.25$ ($t_{\max} = 26$; use Then et al. 2014 equation).
- ASPM S08: Estimate recruitment deviations (1972-2015) with a weight of 10.
- ASPM S09: Estimate recruitment deviations (1972-2015) with a weight of 1.

- ASPM S10: Multiply commercial handline removals from 1980-1985 by 0.1 (i.e. reduce by 90%).
- ASPM S11: Multiply commercial handline removals from 1980-1985 by 0.5 (i.e. reduce by 50%).
- ASPM S12: Reduce weights of all indices to 0.1.
- ASPM S13: Remove last 3 yr from indices.
- ASPM S14: Fix steepness at 0.25
- ASPM S15: Fix steepness at 0.35
- ASPM S16: Fix steepness at 0.45
- ASPM S17: Fix steepness at 0.55
- ASPM S18: Fix steepness at 0.65
- ASPM S19: Fix steepness at 0.75
- ASPM S20: Estimate steepness with uniform prior

Many of these sensitivity runs are typical for SEDAR assessments, such as those involving higher or lower values of 100% female maturity, M, or steepness and those investigating sensitivity to indices of abundance. Runs S01-S03 demonstrate sensitivity to the individual changes made to the ASPM AW Base run to develop the RW Ref run. Sensitivities involving recruitment deviations (S08-S09) are somewhat unique since the ASPM AW Base model, by definition, fixes recruitment deviations at zero (i.e. recruitment follows the stock-recruit curve), while the BAM catch-at-age model fits recruitment deviations. These two runs allowed a time series of recruitment deviations to be estimated with varying levels of flexibility (a lower weight allows more flexibility, and more variation in recruitment deviations). Runs decreasing commercial handline removals between 1980 and 1985 by 90 or 50% (S10-S11) were conducted largely in response to public comments suggesting that a large proportion of the commercial handline landings from these years may actually have been Golden Tilefish misclassified as Blueline Tilefish during data processing of data on unclassified tilefishes reported before 1985. Note however that the issue of unclassified tilefish landings prior to 1985 had been scrutinized by the commercial landings working group at the SEDAR 50 data workshop. Still the landings series they provided are considered the best available data. Their estimates of lower bounds on Atlantic commercial landings of Blueline Tilefish between 1980 and 1985 ranged from 80-90% of the series provided (see Table 3.4 of the SEDAR50 DW Report 2017).

Sensitivities with steepness fixed at 0.65 and 0.75 were run at the SEDAR 50 Review Workshop. Runs with steepness fixed at 0.25, 0.35, 0.45, and 0.55 were run later to examine a wider range of potential values. Upon recognizing that steepness values of 0.45 to 0.55 resulted in lower total likelihoods, an attempt was made to estimate steepness within the model (S20).

6.2.1.4 Uncertainty and Measures of Precision

The ASPM used a mixed Monte Carlo and bootstrap (MCB) approach to characterize uncertainty in results of the RW Ref model. Monte Carlo and bootstrap methods (Efron and Tibshirani 1993; Manly 1997) are often used to characterize uncertainty in ecological studies, and the mixed approach has been applied successfully in stock assessment, including Restrepo et al. (1992), Legault et al. (2001), SEDAR19 (2009), and many South Atlantic SEDAR assessments since SEDAR19 (2009). The approach is among those recommended for use in SEDAR assessments (SEDAR Procedural Guidance 2010).

The MCB approach translates uncertainty in model inputs into uncertainty in model outputs, by fitting the model many times with different values of "observed" data and key input parameters. A chief advantage of the approach is that the results describe a range of possible outcomes, so that uncertainty is characterized more thoroughly than it could be by any single fit or handful of sensitivity runs. A minor disadvantage of the approach is that computational demands are relatively high.

In this assessment, the BAM was successively re-fit in $n = 3100$ trials that differed from the original inputs by bootstrapping on data sources, and by Monte Carlo sampling of several key input parameters. The value of $n = 3100$ was chosen because a minimum of $n = 3000$ runs were desired, and it was anticipated that not all runs would converge or otherwise be valid. Of the $n = 3100$ trials, approximately 1.1% were discarded, based on a 0.5% trim on R_0 or because the model did not properly converge. This left $n = 3067$ MCB trials used to characterize uncertainty, which was sufficient for convergence of standard errors in management quantities.

The MCB analysis should be interpreted as providing an approximation to the uncertainty associated with each output. The results are approximate for two related reasons. First, not all combinations of Monte Carlo parameter inputs are equally likely, as biological parameters might be correlated. Second, all runs are given equal weight in the results, yet some might provide better fits to data than others.

6.2.1.4.1 **Bootstrap of observed data** To include uncertainty in time series of observed indices of abundance, multiplicative lognormal errors were applied through a parametric bootstrap. To implement this approach in the MCB trials, random variables ($x_{s,y}$) were drawn for each year y of time series s from a normal distribution with mean 0 and variance $\sigma^2_{s,y}$ [that is, $x_{s,y} \sim N(0, \sigma^2_{s,y})$]. Annual observations were then perturbed from their original values ($\hat{O}_{s,y}$)

$$O_{s,y} = \hat{O}_{s,y}[\exp(x_{s,y} - \sigma^2_{s,y}/2)] \tag{1}$$

The term $\sigma^2_{s,y}/2$ is a bias correction that centers the multiplicative error on the value of 1.0. Standard deviations in log space were computed from CVs in arithmetic space, $\sigma_{s,y} = \sqrt{\log(1.0 + CV^2_{s,y})}$. The CVs used for generating time series of indices were the annual bootstrap CVs associated with the fitting procedure for each index, provided by the data providers. These CVs are provided in Table 3 of the SEDAR 50 Assessment Workshop Report above. For fitting to indices of abundance in each MCB run constant CVs of 0.2 were used, as in the RW Ref model (Table A1).

Uncertainty in commercial landings was provided at the data workshop as a table of upper and lower bounds, as a proportion of the observed landings, by region and time period. To incorporate this uncertainty into the MCB analysis when generating commercial landings series, values were randomly drawn from uniform distributions between the upper and lower bounds provided for each region and year. Each set of regional time series was then summed as in the RW Ref model to produce a time series of landings for each commercial fleet. Commercial discards were sampled from a lognormal distribution by year and region with a CV of 0.5 (SEDAR50 DW Report 2017).

For recreational landings and discards, CVs were provided by year and region for MRIP only. MRIP landings and discards were sampled from lognormal distributions by year and region using the CVs provided. Headboat landings and discards were sampled from lognormal distributions by year and region using median MRIP CVs for the corresponding region.

When fitting to removals series, CVs of removals were assumed to be 0.05, as in the RW Ref run.

Uncertainty in length compositions was included by drawing new distributions for each year of each data source, following a random sampling process. Lengths of individual fish were drawn at random with replacement using the cell probabilities of the original data. For each year of each data source, the number of fish sampled was the same as in the original data.

6.2.1.4.2 **Monte Carlo sampling** In each successive fit of the model, several parameters were fixed (i.e., not estimated) at values drawn at random from distributions described below.

Natural and discard mortality Point estimates of natural mortality ($M = 0.17$) and discard mortality ($\delta_{com} = 0.95$ and $\delta_{rec} = 0.82$, for commercial and recreational, respectively) were provided by the DW, but with some uncertainty. To carry forward these sources of uncertainty, Monte Carlo sampling was used to generate deviations from the point estimates.

For discard mortality, a new $\delta_{com} = 0.95$ and $\delta_{rec} = 0.82$ values were drawn for each MCB trial from uniform distributions over the ranges suggested by the DW (0.9-1.0 for com. and 0.64-1.0 for rec.). For natural mortality, a new M value was drawn for each MCB trial from a truncated normal distribution (range [0.1, 0.25]) with mean equal to the point estimate ($M = 0.17$) and standard deviation set to provide a lower 95% confidence limit at 0.1 (the boundary nearest the mean). Each realized value of M was used to scale the age-specific Charnov M, as in the base run.

Steepness In each MCB run, a value of steepness was drawn from a beta distribution of steepness values from a meta-analysis by Shertzer and Conn (2012), and then fixed at that value.

6.2.1.5 Projections

Projections were run to predict stock status in years after the assessment, 2016–2021.

The structure and parameters estimates of the projection model were the same as for the ASPM RW Ref. Any time-varying quantities, such as selectivity, were fixed to the most recent values of the assessment period. A single selectivity curve was applied to calculate removals, computed by averaging selectivities across fleets using geometric mean Fs from the last three years of the assessment period, similar to computation of MSY benchmarks.

Expected values of SSB at the time of peak spawning, F, recruits, landings, and discards were represented by deterministic projections using parameter estimates from the base run. These projections were built on the estimated spawner-recruit relationship with bias correction, and were thus consistent with estimated benchmarks in the sense that long-term fishing at F_{MSY} would yield MSY from a stock size at SSB_{MSY}. Uncertainty in future time series was quantified through stochastic projections that extended the Monte Carlo/Bootstrap (MCB) fits of the stock assessment model.

6.2.1.5.3 **Initialization of projections** Although the terminal year of the assessment is 2015, the assessment model computes abundance at age (N_a) at the start of 2016. For projections, those estimates were used to initialize N_a. However, the model has no information to inform the strength of 2016 recruitment, and thus it computes 2016 recruits (N_1) as the expected value, that is, without deviation from the spawner-recruit curve, and corrected to be unbiased in arithmetic space.

In the stochastic projections for SEDAR stock assessments that use the BAM catch-at-age model, lognormal stochasticity is applied to these abundances after adjusting them to be unbiased in log space, with variability based on the estimate of σ_R. However, in the ASPM in the current assessment, recruitment is a deterministic function of the spawner-recruit curve. Thus this source of stochasticity was not applied to abundance in year one of the projections.

Fishing rates that define the projections were assumed to start in 2017. Because the assessment period ended in 2015, the projections required an initialization period (2016). The rate of fishing mortality during this period was assumed equal to the geometric mean F from the last three years of the assessment period (2013-2015; $F_{\text{current}} = 0.042$).

6.2.1.5.4 **Uncertainty of projections** To characterize uncertainty in future stock dynamics, stochasticity was included based on the MCB procedure. Each projection run was essentially a deterministic projection from each MCB model fit. Thus, projections carried forward uncertainties in steepness, natural mortality, and discard mortality, as well as in estimated quantities such as the remaining spawner-recruit parameters, selectivity curves, growth, and in initial (start of 2016) abundance at age.

The procedure was run once for each MCB run ($n = 3067$). Central tendencies were represented by the deterministic projections of the RW Ref run, as well as by medians of the stochastic projections. Precision of projections was represented graphically by the 5^{th} and 95^{th} percentiles of the replicate projections.

6.2.1.5.5 **Projection scenarios** The SEDAR50 TOR described three fixed-F projections scenarios for stocks that are not overfished: $F = F_{\text{current}}$, $F = F_{\text{MSY}}$, and $F = F_{\text{target}}$. For all projection scenarios, F in 2016 is fixed at F_{current}. F_{target} was defined as $75\% F_{\text{MSY}}$ ($F_{\text{MSY}} = 0.319$; $F_{\text{target}} = 0.239$). The Review Workshop Panel also requested projections at $F_{30\%} = 0.218$ and $F_{40\%} = 0.154$.

Thus, this report contains a total of five projections scenarios for the ASPM:

- Scenario 1: $F = F_{\text{MSY}}$ starting in 2017
- Scenario 2: $F = F_{\text{current}}$
- Scenario 3: $F = F_{\text{target}} = 75\% F_{\text{MSY}}$ starting in 2017
- Scenario 4: $F = F_{30\%}$ starting in 2017
- Scenario 5: $F = F_{40\%}$ starting in 2017

6.2.2 Results

6.2.2.1 Measures of Overall Model Fit

The ASPM RW Ref model fit fairly well to the available data. Fits to annual length composition data were reasonable in most years fitted (Figure A13). Fits to removals series are very good because the model was configured with low CVs for fitting the removals (Figures A14, A15, and A16). Apparent differences in fits to annual length comps and removals series between the AW Base and RW Ref models were minimal.

Fits to indices of abundance capture very general trends, but not the short-term fluctuations (Figures A17, A18, and A19). Overall trends in the predicted indices were similar to the AW Base model. However, using a constant CV of 0.2 for all indices tended to increase the standard errors in the commercial handline index, reducing the fit to the two higher values in 2006 and 2007. The decrease in standard errors in the later part of the recreational headboat index also tended to decrease the predicted index slightly.

6.2.2.2 Parameter Estimates

Fitting the Von Bertalanffy growth parameters within the ASPM RW Ref resulted in $L_\infty = 599$ mm FL, $K = 0.3$, and $t_0 = -1.19$ yr. These estimates are different from the fixed values supplied to the AW Base model ($L_\infty = 690$ mm FL, $K = 0.16$, and $t_0 = -1.33$ yr) suggesting that Blueline Tilefish grow more rapidly and reach a smaller maximum size. While maturity-at-age was fixed in the RW Ref model, female reproductive output was dependent on the fitted relationship between length and age. Female reproductive output is a function of fitted length at age, a fixed relationship between fecundity and length, a fixed sex ratio at age, and fixed maturity at age. In the AW Base model, female reproductive output was essentially an increasing linear function of age, while in the RW Ref model, it is zero up to age-5, increases to 3 million eggs at age-6, and then plateaus near 5 million by age-20.

Length, female maturity, and reproductive output at age are shown in Table A7 and Figure A20.

Estimates of management quantities and some key parameters (e.g. stock-recruitment) are reported in sections below.

6.2.2.3 Total and Spawning Biomass

Estimated abundances and biomass-at-age are shown in Tables A8, A9, and A10, and Figures A21 and A22. The general trends are very similar to the AW Base model, but estimated abundance is higher and older fish are more numerous. Estimated biomass is also higher in the RW Ref model.

The estimated recruitment time series is presented in Figure A23. The trend is very similar to the AW Base model, though the number of recruits is slightly higher. The estimated total and spawning stock biomass (eggs) time series are shown in Figure A24.

6.2.2.4 Selectivity

Predicted and average selectivities are plotted in Figures A25 and A26. The average selectivity was shifted about one year younger, compared with the AW Base model.

6.2.2.5 Fishing Mortality

Estimated time series of fully selected fishing mortality rates by fleet are shown in Figure A27. Estimates of F over time are substantially lower than in the AW Base model, and the relative F from 1982-1995 was further reduced.

Estimated removals in numbers by fleet are shown in Figure A28. Estimated total removals and removals at age are presented both in numbers and in weight in Tables A14, A15, A16, and A17.

6.2.2.6 Spawner-Recruitment Parameters

The spawner recruit curve shown in Figure A29. The R_0 parameter was estimated to be 1.36 million fish. Recall that steepness was fixed at 0.84 and recruitment deviations were fixed at zero. The R_0 value was higher than in the AW Base model (AW Base R_0=1.16 million fish) and the spawner recruit curve is shifted to lower values of spawning stock.

6.2.2.7 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio are plotted over a range of F values in Figure A30. Plots of equilibrium removals and spawning stock size at F are presented in Figure A31. Yield as a function of F demonstrated a much sharper peak than in the AW Base model. MSY was estimated at 433 thousand pounds, compared with 316 thousand pounds from the AW Base model and 217 thousand pounds from the ASPIC RW Ref model. F reference points were estimated as $F_{\text{MSY}} = 0.319$, $F_{30\%} = 0.218$, and $F_{40\%} = 0.154$, which were all much lower than in the AW Base model (AW Base $F_{\text{MSY}} = 0.841$, $F_{30\%} = 0.628$, and $F_{40\%} = 0.337$).

6.2.2.8 Benchmarks / Reference Points

Probability densities of MSY-related benchmarks from MCB analysis are presented in Figure A32. MCB analysis was not conducted for the AW Base model. Estimated trends in B, SSB, and F are presented in Figure A33. Estimated trends in stock status are presented in Table A18 and Figure A34. As in the AW Base model, the trends in SSB/MSST suggests that the South Atlantic stock of Blueline Tilefish have never been in an overfished state and that SSB has been more than 5 times MSST in most years. This trend is higher than in the AW Base model. Trends in F/F_{MSY} suggest that slight overfishing occurred in 1982, but not in any other years. The trend in F/F_{MSY} was similar to the AW Base model in pattern and magnitude.

Uncertainty in these trends was very wide. While the lower 90% confidence limit for SSB/MSST dipped only just below one during several years, the upper 90% confidence limit for F/F_{MSY} was well above one for several years from the early 1980s to the early 2000s.

Benchmarks are presented with respect to both F_{MSY} (Table A19) and $F_{30\%}$ (Table A20).

6.2.2.9 Status of the Stock and Fishery

Probability densities of terminal status estimates from MCB analysis of the ASPM are presented in Figure A35. A phase plot of terminal status estimates from MCB analysis is presented in Figure A36. Out of 3067 MCB runs, 90.6% were neither overfished nor undergoing overfishing, 8.6% were not overfished but were undergoing overfishing, 0.8% were overfished and undergoing overfishing, and 0% were overfished but not undergoing overfishing.

6.2.2.10 Sensitivity Analyses

Time series of SSB, B, and F, are plotted to demonstrate sensitivity to diverging from the AW Base model (Figure A37), maturity at age (Figure A38), natural mortality (Figure A39), fitting recruitment deviations (Figure A40), commercial handline removals from 1980-1985 (Figure A41), indices of abundance (Figure A42), and Beverton-Holt steepness (Figure A43).

Increasing the age at 100% maturity from 2 to 6 years caused a large decrease in SSB compared with the AW Base model(compare S00 with S02). After the other modifications were made to the AW Base model to produce the RW Ref model, the resulting change in the SSB time series was not as pronounced. However, changes in B and F time series were larger (compare RW Ref with S00-S03; Figure A37).

For the RW Ref model, status indicators were most sensitive to Beverton-Holt steepness and the large spike in commercial handline removals from 1980-1985 (Table A21 and Figure A44). No sensitivity runs indicated that the stock was in an overfished state, but runs with fixed steepness values lower than 0.55 indicated that overfishing was occurring. A run where steepness was estimated in the model (with a uniform prior) converged without bounding issues, and estimated steepness at 0.52, F/F_{MSY} =1.00 and SSB/MSST =1.364. Runs with steepness between 0.45 and 0.55 showed similar results. Considering the RW Reference run and the steepness sensitivities (S14-S20) the total likelihood for steepness values 0.45-0.55 was at least four likelihood points below runs with steepness values outside that range. This range of steepness values results in rounder stock-recruit curves (i.e. more closely resembling a quarter circle), leading to a greater range in estimated annual recruitment. This increased flexibility in recruitment appears to improve the fit to the abundance indices in these runs (not shown).

6.2.2.11 Projections

Projections at F_{MSY}, for the ASPM RW Ref. model are shown in Table A22 and Figure A45. Projections at F_{current}, for the ASPM RW Ref. model are shown in in Table A23 and Figure A46. Projections at F_{target}, for the ASPM RW Ref. model are shown in Table A24 and Figure A47. Projections at $F_{30\%}$, for the ASPM RW Ref. model are shown in Table A25 and Figure A48. Projections at $F_{40\%}$, for the ASPM RW Ref. model are shown in Table A26 and Figure A49.

Projection scenarios were in agreement that the probability of the stock declining into an overfished status by 2021 was low. The probability of SSB $\geq$ MSST was always $>$ 80%, for all years of all scenarios. Projections at F_{MSY} indicated the greatest risk but highest yield, while projections at F_{current} indicated the least risk but lowest yield. Note that no projections from the ASPM were provided in the SEDAR 50 Stock Assessment Report.

6.2.3 Discussion

6.2.3.1 Comments on Assessment Results

Compared with the AW Base run, the RW Ref run use a fixed CV of 0.2 to fit indices of abundance, Von Bertalanffy growth parameters were estimated internally rather than external to the model, and the age at 100% female maturity at was set to 6 years rather than 2 years. These changes generally had little effect on the shape of estimated SSB and B time series but led to substantial shifts in the entire SSB and B time series. Time series of SSB decreased by $\approx$20-30% while B increased by $\approx$50-80%. Estimates of F decreased by $\approx$25-60% across years, with the largest absolute decreases occurring during the mid 1980s. At the same time the estimate of F_{MSY} decreased by 62% and MSST decreased by 46% from the AW Base model to the RW Ref model. The absolute increase in F/F_{MSY} was relatively small (F/F_{MSY}: AW Base = 0.07; RW Ref = 0.11) though the absolute increase in SSB/MSST was rather large (SSB/MSST: AW Base = 4.70; RW Ref = 6.77).

In estimating the growth model, t_0 differed only slightly from the AW Base value (AW Base = -1.33; RW Ref = -1.19), L_∞ decreased a moderate amount (AW Base = 690 mm FL; RW Ref = 599 mm FL), and K nearly doubled (AW Base = 0.16; RW Ref = 0.3). It's worth noting that these estimated values for L_∞ and K are very similar to values estimated from age data used in SEDAR 32 Blueline Tilefish assessment (L_∞=600 mm FL; K=0.33).

Monte-Carlo bootstrap analysis demonstrated that estimates from the ASPM Ref Model were highly uncertain, though most runs agreed that the stock is not currently overfished or undergoing overfishing.

6.2.3.2 Comments on Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- In general, projections of fish stocks are highly uncertain, particularly in the long term (e.g., beyond 5–10 years).
- Although projections included many major sources of uncertainty, they did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect projection results.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If future recruitment is characterized by runs of large or small year classes, possibly due to environmental or ecological conditions, stock trajectories may be affected.

6.3 Addendum References

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6.4 Tables

Table A1. Observed indices of abundance and with constant CVs of 0.2 from commercial handline (cH), commercial longline (cL), and headboat (HB), used in both the ASPIC and ASPM RW Reference models.

Year	cH	cH_{CV}	cL	cL_{CV}	HB	HB_{CV}
1980	.	.	.	.	1.80	0.2
1981	.	.	.	.	0.50	0.2
1982	.	.	.	.	0.54	0.2
1983	.	.	.	.	0.69	0.2
1984	.	.	.	.	0.16	0.2
1985	.	.	.	.	0.18	0.2
1986	.	.	.	.	0.97	0.2
1987	.	.	.	.	1.00	0.2
1988	.	.	.	.	1.72	0.2
1989	.	.	.	.	0.23	0.2
1990	.	.	.	.	0.11	0.2
1991	.	.	.	.	1.71	0.2
1992	.	.	.	.	0.95	0.2
1993	0.92	0.2	1.39	0.2	1.32	0.2
1994	0.78	0.2	0.67	0.2	1.31	0.2
1995	0.75	0.2	1.35	0.2	1.14	0.2
1996	0.99	0.2	0.51	0.2	1.46	0.2
1997	1.11	0.2	1.06	0.2	1.65	0.2
1998	0.75	0.2	0.60	0.2	0.78	0.2
1999	0.74	0.2	0.80	0.2	0.88	0.2
2000	0.82	0.2	0.46	0.2	2.10	0.2
2001	1.09	0.2	0.57	0.2	0.82	0.2
2002	0.91	0.2	2.47	0.2	1.08	0.2
2003	0.95	0.2	0.90	0.2	1.34	0.2
2004	0.96	0.2	0.66	0.2	0.90	0.2
2005	1.09	0.2	1.43	0.2	0.65	0.2
2006	1.68	0.2	1.13	0.2	.	.
2007	1.46	0.2	.	.	.	.

Table A2. Estimated status indicators, benchmarks, and related quantities for So. Atl. ASPIC Review Workshop reference run (RW Ref.). Also presented are median values and measures of precision (standard errors, SE) from the bootstrap analysis. Rate estimates (F) are in units of y^{-1}*; status indicators are dimensionless; and biomass estimates are in units of 1000 pounds, as indicated.*

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.151	0.154	0.062
$85\% F_{MSY}$	y^{-1}	0.129	0.131	0.052
$75\% F_{MSY}$	y^{-1}	0.114	0.116	0.046
$65\% F_{MSY}$	y^{-1}	0.098	0.100	0.040
B_{MSY}	1000 lb	1433	1424	394
MSST	1000 lb	1075	1068	296
MSY	1000 lb	217	220	45
$F_{2013-2015}/F_{MSY}$	—	0.92	0.84	0.35
B_{2015}/MSST	—	1.40	1.55	0.29
B_{2015}/B_{MSY}	—	1.05	1.16	0.22

Table A3. Parameter estimates from selected So. Atl. ASPIC surplus production model runs. B_{MSY} *and* MSY *are in units of 1000 pounds. Likelihood components (Lik) are presented for each index and as a total* (Lik_{total}). *The numerator in* F/F_{MSY} *is the geometric mean F from the last three years of the assessment (2013-2015) and the numerator in* B/B_{MSY} *and* B/MSST *is biomass in the terminal year of the assessment (2015). Abbreviations in Run Name are as follows: HL = handline index, LL = longline index, Hb = headboat index, Atl. = all Atlantic removals are included, 1974 or 1958 indicates the model start year. The Review Workshop Reference run (RW Ref.) is HLLL.CV0.2. Estimates from the AW Base run (AW.Base; mean of runs 55 and 56) are also shown for comparison.*

Run	RunName	F/F_{MSY}	B/B_{MSY}	B/MSST	B_{MSY}	MSST	MSY	F_{MSY}	Lik_{total}	Lik_{HL}	Lik_{LL}	Lik_{Hb}
51	HLLLHb	0.41	1.67	2.23	1263	947	301	0.238	167.2	23.2	15.7	128.2
52	HLHb	0.41	1.67	2.23	1260	945	299	0.238	151.4	23.2		128.2
53	LLHb	0.39	1.68	2.24	1186	889	316	0.266	143.5		15.7	127.8
54	HLLL	1.06	0.99	1.32	1538	1153	199	0.129	16.9	4.1	12.8	
55	HL	1.07	0.99	1.32	1554	1165	196	0.126	4.1	4.1		
56	LL	0.81	1.13	1.51	1380	1035	228	0.165	12.7		12.7	
57	Hb	0.40	1.68	2.23	1190	892	312	0.262	127.8			127.8
74	Atl.HLLLHb.1974	8.71	0.22	0.30	1769	1327	378	0.214	205.2	46.0	15.1	144.1
75	Atl.HLLLHb.1958	11.27	0.19	0.26	2076	1557	330	0.159	202.3	40.9	15.0	146.5
80	HLLL.CV0.2	0.92	1.05	1.40	1433	1075	217	0.151	17.0	−6.2	23.2	
55, 56	AW.Base	0.92	1.06	1.41	1467	1100	212	0.146				

Table A4. Projection results with fishing mortality fixed at $F = F_{\mathrm{MSY}}$ starting in 2017 for the So. Atl. ASPIC RW Ref. run. For 2016 , $F = F_{\mathrm{current}}$. F = fishing mortality rate (per year), $P(B > B_{\mathrm{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \mathrm{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B_{median} = median biomass (1000 lb) estimate among projections, B = deterministic biomass (1000 lb) estimate, Y = deterministic yield (1000 lb) estimate, Sum Y = cumulative sum of deterministic yield (1000 lb). Yield includes landings and dead discards. Note that observed dead discards were 1, 13 and 40% of total removals from 2013 to 2015 respectively.

Year	F(per yr)	$P(B > B_{\mathrm{MSY}})$	$P(B > \mathrm{MSST})$	B_{median}	B	Y	Sum Y
2016	0.139	0.80	0.97	1684	1572	219	219
2017	0.151	0.79	0.96	1667	1568	236	455
2018	0.151	0.76	0.96	1639	1547	233	688
2019	0.151	0.72	0.95	1617	1530	231	918
2020	0.151	0.69	0.94	1597	1516	229	1147
2021		0.65	0.93	1577	1504		

Table A5. Projection results with fishing mortality fixed at $F = F_{\text{current}}$ starting in 2017 for the So. Atl. ASPIC RW Ref. run. For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B_{median} = median biomass (1000 lb) estimate among projections, B = deterministic biomass (1000 lb) estimate, Y = deterministic yield (1000 lb) estimate, Sum Y = cumulative sum of deterministic yield (1000 lb). Yield includes landings and dead discards. Note that observed dead discards were 1, 13 and 40% of total removals from 2013 to 2015 respectively.

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.139	0.80	0.97	1684	1572	219	219
2017	0.139	0.79	0.96	1667	1568	218	437
2018	0.139	0.78	0.96	1657	1565	218	655
2019	0.139	0.75	0.96	1648	1562	218	872
2020	0.139	0.72	0.95	1640	1560	217	1090
2021		0.70	0.94	1630	1558		

Table A6. Projection results with fishing mortality fixed at $F = F_{\text{target}}$ starting in 2017 for the So. Atl. ASPIC RW Ref. run. For 2016 , $F = F_{\text{current}}$. F = fishing mortality rate (per year), $P(B > B_{\text{MSY}})$ = proportion of stochastic projection replicates exceeding B_{MSY}, $P(B > \text{MSST})$ = proportion of stochastic projection replicates exceeding MSST, B_{median} = median biomass (1000 lb) estimate among projections, B = deterministic biomass (1000 lb) estimate, Y = deterministic yield (1000 lb) estimate, Sum Y = cumulative sum of deterministic yield (1000 lb). Yield includes landings and dead discards. Note that observed dead discards were 1, 13 and 40% of total removals from 2013 to 2015 respectively.

Year	F(per yr)	$P(B > B_{\text{MSY}})$	$P(B > \text{MSST})$	B_{median}	B	Y	Sum Y
2016	0.139	0.80	0.97	1684	1572	219	219
2017	0.114	0.79	0.96	1667	1568	180	399
2018	0.114	0.80	0.97	1695	1602	184	583
2019	0.114	0.82	0.97	1715	1632	187	769
2020	0.114	0.82	0.97	1732	1658	190	959
2021		0.82	0.97	1741	1679		

*Table A7. Life history traits at age used in the ASPM Review Workshop Reference model for the Atlantic south of Cape Hatteras. Length (FL, mm), weight (kg), proportion female (PFemale), proportion of females mature (PMature), Fecundity (millions of eggs), reproductive output, (Reprod=fecundity*PFemale*PMature), and natural mortality (M) at age.*

Age	Length	Weight	PFemale	PMature	Fecundity	Reprod	M
1	328	0.45	0.5	0.0	0.00	0.00	0.71
2	398	0.78	0.5	0.0	0.00	0.00	0.50
3	449	1.12	0.5	0.0	0.00	0.00	0.40
4	488	1.42	0.5	0.0	0.00	0.00	0.33
5	516	1.68	0.5	0.0	0.00	0.00	0.29
6	537	1.89	0.5	1.0	6.08	3.04	0.26
7	553	2.06	0.5	1.0	6.79	3.39	0.24
8	565	2.19	0.5	1.0	7.37	3.68	0.22
9	574	2.29	0.5	1.0	7.84	3.92	0.21
10	580	2.37	0.5	1.0	8.20	4.10	0.20
11	585	2.43	0.5	1.0	8.48	4.24	0.19
12	589	2.47	0.5	1.0	8.70	4.35	0.19
13	591	2.51	0.5	1.0	8.87	4.43	0.18
14	593	2.53	0.5	1.0	8.99	4.50	0.18
15	595	2.55	0.5	1.0	9.08	4.54	0.17
16	596	2.57	0.5	1.0	9.16	4.58	0.17
17	597	2.58	0.5	1.0	9.21	4.60	0.17
18	597	2.58	0.5	1.0	9.25	4.62	0.17
19	598	2.59	0.5	1.0	9.28	4.64	0.16
20	598	2.59	0.5	1.0	9.30	4.65	0.16

Table A8. Estimated total abundance at age (1000 fish) at start of year, for the ASPM Review Workshop Reference model.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1970	1360.71	668.29	403.63	271.35	194.30	145.04	111.40	87.37	69.63	56.21	45.79	37.60	31.07	25.79	21.50	17.98	15.08	12.67	10.67	57.88	3643.95
1971	1360.71	668.30	403.66	271.46	194.52	145.29	111.61	87.54	69.76	56.32	45.88	37.68	31.13	25.84	21.54	18.01	15.11	12.69	10.69	57.99	3645.76
1972	1360.89	668.30	403.67	271.47	194.58	145.40	111.75	87.66	69.86	56.40	45.95	37.73	31.17	25.88	21.58	18.04	15.13	12.71	10.70	58.07	3646.96
1973	1360.99	668.39	403.67	271.48	194.61	145.48	111.88	87.81	69.99	56.51	46.04	37.81	31.23	25.93	21.62	18.07	15.16	12.74	10.72	58.18	3648.30
1974	1361.03	668.44	403.71	271.45	194.48	145.24	111.69	87.70	69.94	56.48	46.02	37.79	31.22	25.92	21.61	18.07	15.15	12.73	10.72	58.16	3647.53
1975	1360.84	668.45	403.72	271.40	194.19	144.63	111.01	87.17	69.55	56.19	45.79	37.60	31.06	25.79	21.50	17.98	15.08	12.67	10.67	57.87	3643.15
1976	1360.39	668.37	403.77	271.51	194.20	144.14	110.24	86.39	68.92	55.71	45.42	37.31	30.82	25.59	21.33	17.84	14.96	12.57	10.58	57.42	3637.46
1977	1359.83	668.14	403.68	271.42	194.07	143.93	109.69	85.65	68.20	55.12	44.96	36.95	30.53	25.35	21.13	17.67	14.82	12.45	10.48	56.88	3630.95
1978	1359.43	667.87	403.59	271.53	194.42	144.47	110.10	85.67	67.97	54.83	44.72	36.77	30.40	25.24	21.04	17.59	14.76	12.40	10.44	56.64	3629.90
1979	1359.01	667.68	403.42	271.39	194.01	143.56	109.40	85.10	67.28	54.08	44.02	36.19	29.93	24.87	20.74	17.34	14.54	12.22	10.29	55.82	3620.88
1980	1358.34	667.48	403.33	271.38	194.21	143.77	109.15	84.90	67.11	53.75	43.59	35.77	29.58	24.59	20.51	17.16	14.39	12.09	10.18	55.24	3616.53
1981	1357.15	667.13	403.11	270.91	192.72	140.95	106.57	82.55	65.24	52.24	42.22	34.52	28.49	23.68	19.77	16.54	13.87	11.66	9.82	53.26	3592.40
1982	1352.65	666.55	402.89	270.44	189.49	132.39	97.30	74.89	58.93	47.18	38.12	31.06	25.54	21.19	17.68	14.80	12.42	10.44	8.79	47.71	3520.48
1983	1336.21	664.29	402.27	268.58	179.29	108.86	72.51	53.84	42.06	33.53	27.09	22.06	18.08	14.95	12.45	10.42	8.75	7.36	6.20	33.62	3322.40
1984	1309.86	656.24	401.06	269.24	184.44	115.16	67.59	45.41	34.22	27.08	21.78	17.74	14.53	11.97	9.93	8.30	6.97	5.86	4.94	26.81	3239.12
1985	1295.13	643.29	396.19	268.54	186.34	121.88	73.98	43.80	29.86	22.79	18.20	14.76	12.09	9.95	8.23	6.85	5.74	4.83	4.07	22.12	3188.64
1986	1289.43	636.09	388.49	265.73	187.11	125.88	81.79	50.39	30.30	20.93	16.12	12.97	10.58	8.71	7.20	5.97	4.99	4.19	3.53	19.19	3169.60
1987	1290.36	633.29	384.19	260.98	187.86	131.62	87.00	57.04	35.66	21.72	15.14	11.75	9.52	7.80	6.45	5.35	4.45	3.72	3.13	17.04	3174.08
1988	1297.19	633.73	382.43	257.94	185.19	135.83	96.20	64.66	43.06	27.27	16.76	11.77	9.20	7.48	6.16	5.11	4.25	3.54	2.97	16.13	3206.87
1989	1307.11	637.11	382.81	257.19	184.19	135.79	101.02	72.80	49.70	33.53	21.43	13.27	9.38	7.36	6.02	4.97	4.13	3.44	2.88	15.55	3249.66
1990	1315.02	641.98	384.85	257.43	183.62	135.03	100.95	76.41	55.93	38.68	26.33	16.96	10.57	7.51	5.92	4.85	4.02	3.35	2.79	15.00	3287.20
1991	1320.05	645.87	387.79	258.78	183.42	133.48	99.10	75.30	57.88	42.92	29.95	20.55	13.32	8.34	5.95	4.70	3.87	3.21	2.68	14.28	3311.44
1992	1322.15	647.68	389.33	260.08	183.51	131.80	96.33	72.60	56.02	43.62	32.64	22.96	15.85	10.32	6.49	4.64	3.68	3.03	2.52	13.37	3318.61
1993	1322.23	648.99	390.76	261.39	184.76	131.92	94.40	69.86	53.44	41.78	32.83	24.76	17.52	12.15	7.95	5.01	3.60	2.86	2.36	12.39	3320.95
1994	1322.21	648.93	391.44	262.34	186.15	133.95	95.35	69.07	51.88	40.21	31.71	25.12	19.06	13.55	9.44	6.19	3.92	2.82	2.24	11.61	3327.18
1995	1323.58	649.39	391.99	263.26	187.25	135.77	98.11	70.85	52.11	39.65	31.01	24.65	19.64	14.98	10.70	7.47	4.92	3.12	2.24	11.07	3341.75
1996	1325.63	649.13	391.12	262.75	187.39	136.44	99.43	72.90	53.45	39.82	30.58	24.10	19.28	15.44	11.82	8.47	5.93	3.91	2.48	10.64	3350.74
1997	1328.04	650.74	391.70	262.70	187.14	136.75	101.30	75.20	56.01	41.61	31.28	24.21	19.20	15.43	12.41	9.53	6.84	4.81	3.17	10.68	3368.77
1998	1330.02	652.21	393.01	263.32	187.05	135.70	99.98	75.25	56.73	42.81	32.08	24.31	18.93	15.09	12.18	9.82	7.56	5.44	3.83	11.08	3376.42
1999	1331.73	653.18	393.92	264.31	188.17	137.63	101.72	76.35	58.38	44.59	33.95	25.65	19.55	15.30	12.24	9.91	8.02	6.19	4.46	12.25	3397.50
2000	1334.52	653.38	393.72	264.32	188.56	138.45	103.18	77.68	59.23	45.88	35.36	27.14	20.63	15.80	12.42	9.97	8.09	6.56	5.07	13.74	3413.70
2001	1336.84	655.42	394.66	264.81	188.89	138.76	103.82	78.83	60.29	46.57	36.40	28.28	21.83	16.68	12.83	10.11	8.14	6.62	5.38	15.46	3430.62
2002	1338.55	656.55	395.88	265.41	189.07	138.58	103.61	78.96	60.91	47.19	36.78	28.98	22.65	17.57	13.48	10.40	8.22	6.63	5.41	17.06	3441.89
2003	1339.98	657.35	396.51	266.23	189.77	139.45	104.21	79.38	61.46	48.03	37.55	29.50	23.38	18.37	14.31	11.01	8.52	6.75	5.45	18.52	3455.72
2004	1341.57	657.43	396.23	266.07	190.00	139.88	104.97	79.96	61.88	48.53	38.27	30.16	23.84	18.99	14.97	11.70	9.03	7.00	5.56	19.80	3465.84
2005	1343.18	658.44	396.57	266.14	190.27	140.75	105.96	81.07	62.73	49.19	38.93	30.94	24.53	19.48	15.58	12.33	9.66	7.47	5.80	21.08	3480.10
2006	1344.81	658.96	396.84	266.09	190.06	140.69	106.52	81.79	63.57	49.84	39.43	31.46	25.15	20.04	15.98	12.82	10.17	7.99	6.19	22.33	3490.73
2007	1346.09	660.33	397.85	266.82	190.39	140.72	106.50	82.21	64.13	50.50	39.95	31.86	25.57	20.55	16.44	13.15	10.58	8.41	6.62	23.69	3502.33
2008	1347.38	660.74	398.41	267.30	190.83	141.23	107.18	82.81	64.95	51.33	40.78	32.52	26.09	21.04	16.98	13.62	10.93	8.81	7.02	25.37	3515.32
2009	1348.82	661.30	398.58	267.63	191.25	141.81	107.76	83.47	65.53	52.07	41.52	33.26	26.68	21.51	17.42	14.10	11.35	9.12	7.37	27.16	3527.68
2010	1349.91	661.43	398.21	267.18	191.01	141.57	107.63	83.45	65.68	52.23	41.88	33.66	27.13	21.87	17.70	14.38	11.67	9.41	7.58	28.78	3532.38
2011	1350.42	662.29	398.68	267.24	190.92	141.40	107.06	82.95	65.34	52.10	41.81	33.79	27.32	22.13	17.91	14.54	11.85	9.64	7.79	30.16	3535.34
2012	1351.20	662.52	399.18	267.59	191.34	142.55	108.57	83.92	66.07	52.72	42.42	34.31	27.90	22.68	18.44	14.97	12.19	9.95	8.11	32.03	3548.66
2013	1352.28	661.69	397.83	266.74	190.58	141.78	108.50	84.35	66.25	52.84	42.55	34.51	28.08	22.95	18.72	15.27	12.43	10.15	8.30	33.57	3549.37
2014	1351.42	654.57	388.04	258.59	184.45	136.42	103.64	80.82	63.83	50.79	40.88	33.18	27.07	22.14	18.16	14.87	12.16	9.92	8.11	33.57	3492.63
2015	1349.27	661.79	393.05	259.27	183.94	135.63	101.94	78.81	62.42	49.94	40.10	32.53	26.56	21.78	17.89	14.72	12.08	9.90	8.10	34.11	3493.83
2016	1348.16	661.22	397.97	263.01	184.35	134.75	101.25	77.53	60.88	48.86	39.44	31.92	26.05	21.38	17.60	14.50	11.97	9.84	8.08	34.55	3493.31

Table A9. Estimated biomass at age (mt) at start of year, for the ASPM Review Workshop Reference model

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1970	605.9	522.3	451.4	386.1	326.8	274.6	229.7	191.6	159.8	133.3	111.3	93.1	77.9	65.3	54.9	46.1	38.8	32.7	27.6	150.1	3979.5
1971	605.9	522.4	451.4	386.2	327.1	275.1	230.1	192.0	160.1	133.6	111.5	93.3	78.1	65.5	55.0	46.2	38.9	32.8	27.7	150.4	3983.3
1972	606.0	522.4	451.4	386.3	327.2	275.3	230.4	192.3	160.3	133.8	111.7	93.4	78.2	65.6	55.1	46.3	39.0	32.8	27.7	150.6	3985.7
1973	606.0	522.4	451.4	386.3	327.3	275.5	230.7	192.6	160.6	134.0	111.9	93.6	78.3	65.7	55.2	46.4	39.0	32.9	27.8	150.9	3988.5
1974	606.1	522.5	451.5	386.2	327.1	275.0	230.3	192.4	160.5	134.0	111.8	93.5	78.3	65.7	55.1	46.3	39.0	32.9	27.8	150.9	3986.7
1975	606.0	522.5	451.5	386.2	326.6	273.8	228.9	191.2	159.6	133.3	111.3	93.1	77.9	65.3	54.9	46.1	38.8	32.7	27.6	150.1	3977.4
1976	605.8	522.4	451.6	386.3	326.6	272.9	227.3	189.5	158.1	132.1	110.4	92.3	77.3	64.8	54.4	45.8	38.5	32.5	27.4	148.9	3965.0
1977	605.5	522.2	451.5	386.2	326.4	272.5	226.2	187.8	156.5	130.7	109.3	91.4	76.6	64.2	53.9	45.3	38.2	32.2	27.1	147.5	3951.3
1978	605.4	522.0	451.4	386.4	327.0	273.5	227.0	187.9	156.0	130.1	108.7	91.0	76.2	63.9	53.7	45.1	38.0	32.0	27.0	146.9	3949.2
1979	605.2	521.9	451.2	386.2	326.3	271.8	225.5	186.6	154.4	128.3	107.0	89.6	75.1	63.0	52.9	44.5	37.5	31.6	26.6	144.8	3929.8
1980	604.9	521.7	451.1	386.1	326.6	272.2	225.0	186.2	154.0	127.5	106.0	88.5	74.2	62.3	52.3	44.0	37.1	31.2	26.4	143.3	3920.7
1981	604.3	521.4	450.8	385.5	324.1	266.9	219.7	181.1	149.7	123.9	102.6	85.4	71.5	60.0	50.4	42.4	35.7	30.1	25.4	138.2	3869.3
1982	602.3	521.0	450.6	384.8	318.7	250.7	200.6	164.3	135.2	111.9	92.7	76.9	64.1	53.7	45.1	38.0	32.0	27.0	22.8	123.8	3715.9
1983	595.0	519.2	449.9	382.2	301.5	206.1	149.5	118.1	96.5	79.5	65.8	54.6	45.4	37.9	31.8	26.7	22.5	19.0	16.0	87.2	3304.5
1984	583.3	512.9	448.5	383.1	310.2	218.0	139.4	99.6	78.5	64.2	52.9	43.9	36.4	30.3	25.3	21.3	17.9	15.1	12.8	69.5	3163.4
1985	576.7	502.8	443.1	382.1	313.4	230.8	152.5	96.1	68.5	54.1	44.2	36.5	30.3	25.2	21.0	17.6	14.8	12.5	10.5	57.4	3090.1
1986	574.2	497.2	434.5	378.1	314.7	238.3	168.6	110.5	69.5	49.6	39.2	32.1	26.5	22.1	18.4	15.3	12.9	10.8	9.1	49.8	3071.5
1987	574.6	495.0	429.7	371.3	315.9	249.2	179.4	125.1	81.8	51.5	36.8	29.1	23.9	19.8	16.5	13.7	11.5	9.6	8.1	44.2	3086.7
1988	577.6	495.3	427.7	367.0	311.5	257.2	198.3	141.8	98.8	64.7	40.7	29.1	23.1	19.0	15.7	13.1	10.9	9.1	7.7	41.8	3150.3
1989	582.1	498.0	428.1	366.0	309.8	257.1	208.3	159.7	114.0	79.5	52.1	32.9	23.5	18.7	15.4	12.7	10.6	8.9	7.4	40.3	3225.0
1990	585.6	501.8	430.4	366.3	308.8	255.7	208.1	167.6	128.3	91.7	64.0	42.0	26.5	19.0	15.1	12.4	10.3	8.6	7.2	38.9	3288.5
1991	587.8	504.8	433.7	368.2	308.5	252.7	204.3	165.2	132.8	101.8	72.8	50.9	33.4	21.1	15.2	12.1	10.0	8.3	6.9	37.0	3327.5
1992	588.8	506.2	435.4	370.1	308.6	249.6	198.6	159.2	128.5	103.5	79.3	56.8	39.8	26.1	16.6	11.9	9.5	7.8	6.5	34.7	3337.5
1993	588.8	507.3	437.0	371.9	310.7	249.8	194.6	153.2	122.6	99.1	79.8	61.3	43.9	30.8	20.3	12.9	9.3	7.4	6.1	32.1	3338.9
1994	588.8	507.2	437.8	373.3	313.1	253.6	196.6	151.5	119.0	95.4	77.1	62.2	47.8	34.3	24.1	15.9	10.1	7.3	5.8	30.1	3350.8
1995	589.4	507.6	438.4	374.6	314.9	257.1	202.3	155.4	119.6	94.1	75.4	61.0	49.3	37.9	27.3	19.2	12.7	8.1	5.8	28.7	3378.5
1996	590.3	507.4	437.4	373.9	315.2	258.3	205.0	159.9	122.7	94.5	74.3	59.7	48.4	39.1	30.2	21.7	15.3	10.1	6.4	27.6	3397.2
1997	591.4	508.6	438.1	373.8	314.7	258.9	208.9	164.9	128.5	98.7	76.0	59.9	48.2	39.1	31.7	24.4	17.6	12.4	8.2	27.7	3431.8
1998	592.3	509.8	439.5	374.7	314.6	256.9	206.1	165.0	130.2	101.5	78.0	60.2	47.5	38.2	31.1	25.2	19.5	14.1	9.9	28.7	3443.0
1999	593.0	510.5	440.5	376.1	316.5	260.6	209.7	167.5	134.0	105.8	82.5	63.5	49.0	38.8	31.2	25.4	20.7	16.0	11.6	31.8	3484.5
2000	594.3	510.7	440.3	376.1	317.1	262.2	212.7	170.4	135.9	108.8	85.9	67.2	51.7	40.0	31.7	25.6	20.8	16.9	13.1	35.6	3517.2
2001	595.3	512.3	441.4	376.8	317.7	262.7	214.1	172.9	138.3	110.5	88.5	70.0	54.8	42.2	32.7	25.9	21.0	17.1	13.9	40.1	3548.1
2002	596.1	513.2	442.7	377.6	318.0	262.4	213.6	173.2	139.8	111.9	89.4	71.7	56.8	44.5	34.4	26.7	21.2	17.1	14.0	44.3	3568.5
2003	596.7	513.8	443.4	378.8	319.2	264.0	214.9	174.1	141.0	113.9	91.3	73.0	58.6	46.5	36.5	28.2	21.9	17.4	14.1	48.1	3595.6
2004	597.4	513.9	443.1	378.6	319.5	264.9	216.4	175.4	142.0	115.1	93.0	74.6	59.8	48.1	38.2	30.0	23.3	18.1	14.4	51.4	3617.1
2005	598.1	514.6	443.5	378.7	320.0	266.5	218.5	177.8	143.9	116.7	94.6	76.6	61.5	49.4	39.8	31.6	24.9	19.3	15.0	54.7	3645.7
2006	598.8	515.0	443.8	378.6	319.6	266.4	219.6	179.4	145.9	118.2	95.8	77.8	63.1	50.8	40.8	32.9	26.2	20.6	16.0	57.9	3667.4
2007	599.4	516.1	444.9	379.6	320.2	266.4	219.6	180.3	147.1	119.8	97.1	78.8	64.1	52.0	41.9	33.7	27.3	21.7	17.1	61.5	3688.9
2008	600.0	516.4	445.6	380.3	320.9	267.4	221.0	181.6	149.0	121.7	99.1	80.5	65.4	53.3	43.3	35.0	28.2	22.8	18.2	65.8	3715.6
2009	600.6	516.9	445.7	380.8	321.7	268.5	222.2	183.1	150.4	123.5	100.9	82.3	66.9	54.5	44.5	36.2	29.2	23.6	19.1	70.4	3740.9
2010	601.1	517.0	445.3	380.2	321.2	268.1	221.9	183.0	150.7	123.9	101.8	83.3	68.0	55.4	45.2	36.9	30.1	24.3	19.6	74.7	3751.7
2011	601.3	517.7	445.9	380.3	321.1	267.7	220.7	181.9	149.9	123.6	101.6	83.6	68.5	56.1	45.7	37.3	30.5	24.9	20.2	78.2	3756.7
2012	601.7	517.8	446.4	380.8	321.8	269.9	223.8	184.1	151.6	125.1	103.1	84.9	70.0	57.4	47.0	38.4	31.4	25.7	21.0	83.1	3785.1
2013	602.2	517.2	444.9	379.5	320.5	268.5	223.7	185.0	152.0	125.3	103.4	85.4	70.4	58.1	47.8	39.2	32.0	26.2	21.5	87.1	3790.0
2014	601.8	511.6	434.0	367.9	310.2	258.3	213.7	177.3	146.5	120.5	99.4	82.1	67.9	56.1	46.4	38.1	31.3	25.6	21.0	87.1	3696.7
2015	600.8	517.3	439.6	368.9	309.4	256.8	210.2	172.8	143.2	118.5	97.5	80.5	66.6	55.2	45.6	37.8	31.1	25.6	21.0	88.5	3686.8
2016	600.3	516.8	445.1	374.2	310.0	255.1	208.8	170.0	139.7	115.9	95.9	79.0	65.3	54.2	44.9	37.2	30.8	25.4	20.9	89.6	3679.3

Table A10. Estimated biomass at age (1000 lb) at start of year, for the ASPM Review Workshop Reference model

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1970	1335.8	1151.5	995.2	851.2	720.5	605.4	506.4	422.4	352.3	293.9	245.4	205.3	171.7	144.0	121.0	101.6	85.5	72.1	60.8	330.9	8773.3
1971	1335.8	1151.7	995.2	851.4	721.1	606.5	507.3	423.3	353.0	294.5	245.8	205.7	172.2	144.4	121.3	101.9	85.8	72.3	61.1	331.6	8781.7
1972	1336.0	1151.7	995.2	851.6	721.4	606.9	507.9	423.9	353.4	295.0	246.3	205.9	172.4	144.6	121.5	102.1	86.0	72.3	61.1	332.0	8787.0
1973	1336.0	1151.7	995.2	851.6	721.6	607.4	508.6	424.6	354.1	295.4	246.7	206.4	172.6	144.8	121.7	102.3	86.0	72.5	61.3	332.7	8793.1
1974	1336.2	1151.9	995.4	851.4	721.1	606.3	507.7	424.2	353.8	295.4	246.5	206.1	172.6	144.8	121.5	102.1	86.0	72.5	61.3	332.7	8789.2
1975	1336.0	1151.9	995.4	851.4	720.0	603.6	504.6	421.5	351.9	293.9	245.4	205.3	171.7	144.0	121.0	101.6	85.5	72.1	60.8	330.9	8768.7
1976	1335.6	1151.7	995.6	851.6	720.0	601.6	501.1	417.8	348.6	291.2	243.4	203.5	170.4	142.9	119.9	101.0	84.9	71.7	60.4	328.3	8741.3
1977	1334.9	1151.3	995.4	851.4	719.6	600.8	498.7	414.0	345.0	288.1	241.0	201.5	168.9	141.5	118.8	99.9	84.2	71.0	59.7	325.2	8711.1
1978	1334.7	1150.8	995.2	851.9	720.9	603.0	500.4	414.2	343.9	286.8	239.6	200.6	168.0	140.9	118.4	99.4	83.8	70.5	59.5	323.9	8706.5
1979	1334.2	1150.6	994.7	851.4	719.4	599.2	497.1	411.4	340.4	282.9	235.9	197.5	165.6	138.9	116.6	98.1	82.7	69.7	58.6	319.2	8663.7
1980	1333.6	1150.2	994.5	851.2	720.0	600.1	496.0	410.5	339.5	281.1	233.7	195.1	163.6	137.3	115.3	97.0	81.8	68.8	58.2	315.9	8643.7
1981	1332.3	1149.5	993.8	849.9	714.5	588.4	484.4	399.3	330.0	273.2	226.2	188.3	157.6	132.3	111.1	93.5	78.7	66.4	56.0	304.7	8530.3
1982	1327.8	1148.6	993.4	848.3	702.6	552.7	442.2	362.2	298.1	246.7	204.4	169.5	141.3	118.4	99.4	83.8	70.5	59.5	50.3	272.9	8192.1
1983	1311.7	1144.6	991.9	842.6	664.7	454.4	329.6	260.4	212.7	175.3	145.1	120.4	100.1	83.6	70.1	58.9	49.6	41.9	35.3	192.2	7285.2
1984	1286.0	1130.7	988.8	844.6	683.9	480.6	307.3	219.6	173.1	141.5	116.6	96.8	80.2	66.8	55.8	47.0	39.5	33.3	28.2	153.2	6974.1
1985	1271.4	1108.5	976.9	842.4	690.9	508.8	336.2	211.9	151.0	119.3	97.4	80.5	66.8	55.6	46.3	38.8	32.6	27.6	23.1	126.5	6812.5
1986	1265.9	1096.1	957.9	833.6	693.8	525.4	371.7	243.6	153.2	109.3	86.4	70.8	58.4	48.7	40.6	33.7	28.4	23.8	20.1	109.8	6771.5
1987	1266.8	1091.3	947.3	818.6	696.4	549.4	395.5	275.8	180.3	113.5	81.1	64.2	52.7	43.7	36.4	30.2	25.4	21.2	17.9	97.4	6805.0
1988	1273.4	1091.9	942.9	809.1	686.7	567.0	437.2	312.6	217.8	142.6	89.7	64.2	50.9	41.9	34.6	28.9	24.0	20.1	17.0	92.2	6945.2
1989	1283.3	1097.9	943.8	806.9	683.0	566.8	459.2	352.1	251.3	175.3	114.9	72.5	51.8	41.2	34.0	28.0	23.4	19.6	16.3	88.8	7109.9
1990	1291.0	1106.3	948.9	807.6	680.8	563.7	458.8	369.5	282.9	202.2	141.1	92.6	58.4	41.9	33.3	27.3	22.7	19.0	15.9	85.8	7249.9
1991	1295.9	1112.9	956.1	811.7	680.1	557.1	450.4	364.2	292.8	224.4	160.5	112.2	73.6	46.5	33.5	26.7	22.0	18.3	15.2	81.6	7335.9
1992	1298.1	1116.0	959.9	815.9	680.3	550.3	437.8	351.0	283.3	228.2	174.8	125.2	87.7	57.5	36.6	26.2	20.9	17.2	14.3	76.5	7357.9
1993	1298.1	1118.4	963.4	819.9	685.0	550.7	429.0	337.7	270.3	218.5	175.9	135.1	96.8	67.9	44.8	28.4	20.5	16.3	13.4	70.8	7361.0
1994	1298.1	1118.2	965.2	823.0	690.3	559.1	433.4	334.0	262.3	210.3	170.0	137.1	105.4	75.6	53.1	35.1	22.3	16.1	12.8	66.4	7387.2
1995	1299.4	1119.1	966.5	825.9	694.2	566.8	446.0	342.6	263.7	207.5	166.2	134.5	108.7	83.6	60.2	42.3	28.0	17.9	12.8	63.3	7448.3
1996	1301.4	1118.6	964.3	824.3	694.9	569.5	451.9	352.5	270.5	208.3	163.8	131.6	106.7	86.2	66.6	47.8	33.7	22.3	14.1	60.8	7489.5
1997	1303.8	1121.3	965.8	824.1	693.8	570.8	460.5	363.5	283.3	217.6	167.6	132.1	106.3	86.2	69.9	53.8	38.8	27.3	18.1	61.1	7565.8
1998	1305.8	1123.9	968.9	826.1	693.6	566.4	454.4	363.8	287.0	223.8	172.0	132.7	104.7	84.2	68.6	55.6	43.0	31.1	21.8	63.3	7590.5
1999	1307.3	1125.5	971.1	829.2	697.8	574.5	462.3	369.3	295.4	233.2	181.9	140.0	108.0	85.5	68.8	56.0	45.6	35.3	25.6	70.1	7682.0
2000	1310.2	1125.9	970.7	829.2	699.1	578.1	468.9	375.7	299.6	239.9	189.4	148.2	114.0	88.2	69.9	56.4	45.9	37.3	28.9	78.5	7754.1
2001	1312.4	1129.4	973.1	830.7	700.4	579.2	472.0	381.2	304.9	243.6	195.1	154.3	120.8	93.0	72.1	57.1	46.3	37.7	30.6	88.4	7822.2
2002	1314.2	1131.4	976.0	832.5	701.1	578.5	470.9	381.8	308.2	246.7	197.1	158.1	125.2	98.1	75.8	58.9	46.7	37.7	30.9	97.7	7867.2
2003	1315.5	1132.7	977.5	835.1	703.7	582.0	473.8	383.8	310.9	251.1	201.3	160.9	129.2	102.5	80.5	62.2	48.3	38.4	31.1	106.0	7926.9
2004	1317.0	1133.0	976.9	834.7	704.4	584.0	477.1	386.7	313.1	253.8	205.0	164.5	131.8	106.0	84.2	66.1	51.4	39.9	31.7	113.3	7974.3
2005	1318.6	1134.5	977.7	834.9	705.5	587.5	481.7	392.0	317.2	257.3	208.6	168.9	135.6	108.9	87.7	69.7	54.9	42.5	33.1	120.6	8037.4
2006	1320.1	1135.4	978.4	834.7	704.6	587.3	484.1	395.5	321.7	260.6	211.2	171.5	139.1	112.0	89.9	72.5	57.8	45.4	35.3	127.6	8085.2
2007	1321.4	1137.8	980.8	836.9	705.9	587.3	484.1	397.5	324.3	264.1	214.1	173.7	141.3	114.6	92.4	74.3	60.2	47.8	37.7	135.6	8132.6
2008	1322.8	1138.5	982.4	838.4	707.5	589.5	487.2	400.4	328.5	268.3	218.5	177.5	144.2	117.5	95.5	77.2	62.2	50.3	40.1	145.1	8191.5
2009	1324.1	1139.6	982.6	839.5	709.2	591.9	489.9	403.7	331.6	272.3	222.4	181.4	147.5	120.2	98.1	79.8	64.4	52.0	42.1	155.2	8247.3
2010	1325.2	1139.8	981.7	838.2	708.1	591.1	489.2	403.4	332.2	273.2	224.4	183.6	149.9	122.1	99.6	81.4	66.4	53.6	43.2	164.7	8271.1
2011	1325.6	1141.3	983.0	838.4	707.9	590.2	486.6	401.0	330.5	272.5	224.0	184.3	151.0	123.7	100.8	82.2	67.2	54.9	44.5	172.4	8282.1
2012	1326.5	1141.6	984.1	839.5	709.4	595.0	493.4	405.9	334.2	275.8	227.3	187.2	154.3	126.5	103.6	84.7	69.2	56.7	46.3	183.2	8344.7
2013	1327.6	1140.2	980.8	836.7	706.6	591.9	493.2	407.9	335.1	276.2	228.0	188.3	155.2	128.1	105.4	86.4	70.5	57.8	47.4	192.0	8355.5
2014	1326.7	1127.9	956.8	811.1	683.9	569.5	471.1	390.9	323.0	265.7	219.1	181.0	149.7	123.7	102.3	84.0	69.0	56.4	46.3	192.0	8149.8
2015	1324.5	1140.4	969.2	813.3	682.1	566.1	463.4	381.0	315.7	261.2	215.0	177.5	146.8	121.7	100.5	83.3	68.6	56.4	46.3	195.1	8128.0
2016	1323.4	1139.3	981.3	825.0	683.4	562.4	460.3	374.8	308.0	255.5	211.4	174.2	144.0	119.5	99.0	82.0	67.9	56.0	46.1	197.5	8111.5

Table A11. Selectivity at age for the ASPM Review Workshop Reference model, for commercial handlines (cH), commercial longline (cL), and two time blocks for the headboat fleet, (HB1: 1980-1990 and HB2: 1991-2005).

Age	cH	cL	HB (1980-1990)	HB (1991-2005)
1	0.000	0.000	0.009	0.009
2	0.002	0.000	0.057	0.057
3	0.025	0.004	0.282	0.282
4	0.234	0.039	0.717	0.717
5	0.783	0.304	0.943	0.943
6	0.977	0.825	0.991	0.991
7	0.998	0.981	0.999	0.999
8	1.000	0.998	1.000	1.000
9	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000

Table A12. Selectivity of removals for the ASPM Review Workshop Reference model, averaged across fleets and time blocks (avg) for landings (L) and total (Tot.).

Age	L.avg	Tot.avg
1	0.125	0.125
2	0.254	0.254
3	0.304	0.304
4	0.385	0.385
5	0.652	0.652
6	0.921	0.921
7	0.991	0.991
8	0.999	0.999
9	1.000	1.000
10	1.000	1.000
11	1.000	1.000
12	1.000	1.000
13	1.000	1.000
14	1.000	1.000
15	1.000	1.000
16	1.000	1.000
17	1.000	1.000
18	1.000	1.000
19	1.000	1.000
20	1.000	1.000

Table A13. Estimated instantaneous fishing mortality rate (per yr) at age, for the ASPM Review Workshop Reference model.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1970	0.000	0.000	0.001	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1971	0.000	0.000	0.001	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1972	0.000	0.000	0.001	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1973	0.000	0.000	0.001	0.003	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
1974	0.000	0.000	0.001	0.004	0.008	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
1975	0.000	0.000	0.001	0.004	0.010	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
1976	0.000	0.000	0.001	0.005	0.012	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
1977	0.000	0.000	0.001	0.003	0.007	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
1978	0.000	0.000	0.001	0.005	0.015	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
1979	0.000	0.000	0.000	0.004	0.012	0.015	0.015	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
1980	0.000	0.000	0.002	0.011	0.033	0.040	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
1981	0.000	0.000	0.003	0.026	0.088	0.112	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115
1982	0.000	0.001	0.010	0.080	0.266	0.343	0.354	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355
1983	0.000	0.001	0.006	0.045	0.155	0.218	0.230	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
1984	0.000	0.001	0.005	0.037	0.126	0.184	0.196	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197
1985	0.000	0.000	0.003	0.030	0.104	0.140	0.146	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
1986	0.000	0.000	0.002	0.016	0.064	0.110	0.122	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124
1987	0.000	0.000	0.002	0.012	0.036	0.055	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
1988	0.000	0.000	0.001	0.006	0.022	0.037	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
1989	0.000	0.000	0.001	0.006	0.022	0.037	0.041	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
1990	0.000	0.000	0.001	0.008	0.031	0.050	0.055	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
1991	0.001	0.002	0.004	0.013	0.043	0.067	0.073	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074
1992	0.001	0.001	0.002	0.011	0.042	0.075	0.083	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084
1993	0.001	0.002	0.002	0.008	0.034	0.066	0.075	0.075	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076
1994	0.000	0.000	0.001	0.006	0.028	0.052	0.059	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
1995	0.001	0.003	0.004	0.009	0.029	0.052	0.059	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
1996	0.001	0.001	0.002	0.008	0.027	0.039	0.041	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
1997	0.000	0.000	0.001	0.009	0.033	0.054	0.059	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
1998	0.000	0.000	0.001	0.005	0.019	0.029	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
1999	0.001	0.002	0.003	0.007	0.019	0.029	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
2000	0.000	0.000	0.001	0.005	0.019	0.029	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
2001	0.000	0.000	0.001	0.006	0.022	0.033	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
2002	0.000	0.000	0.001	0.004	0.016	0.026	0.028	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
2003	0.001	0.002	0.003	0.006	0.017	0.025	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
2004	0.001	0.001	0.002	0.004	0.012	0.019	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
2005	0.001	0.002	0.003	0.006	0.014	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
2006	0.000	0.001	0.001	0.004	0.013	0.019	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
2007	0.001	0.001	0.002	0.004	0.011	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
2008	0.001	0.001	0.002	0.004	0.009	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
2009	0.002	0.003	0.004	0.006	0.013	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
2010	0.001	0.002	0.003	0.005	0.013	0.020	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
2011	0.001	0.002	0.003	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2012	0.003	0.006	0.007	0.008	0.012	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
2013	0.015	0.030	0.035	0.038	0.046	0.054	0.056	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
2014	0.003	0.006	0.007	0.010	0.019	0.032	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
2015	0.002	0.005	0.006	0.010	0.023	0.033	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036

Table A14. Estimated time series of removals (landings and dead discards) in number (1000 fish), for the ASPM Review Workshop Reference model, for commercial handlines (L.cH), commercial longline (L.cL), and recreational (L.GR).

Year	L.cH	L.cL	L.GR	Total
1970	0.36	0.10	2.77	3.23
1971	0.75	0.16	2.78	3.69
1972	0.44	0.10	2.78	3.32
1973	2.21	0.14	3.07	5.42
1974	5.35	0.21	3.87	9.43
1975	9.24	0.37	1.79	11.40
1976	9.19	0.32	3.55	13.07
1977	6.23	0.39	1.43	8.06
1978	14.72	0.53	1.64	16.89
1979	11.92	0.66	0.41	12.98
1980	30.34	0.71	4.08	35.13
1981	84.31	3.83	1.62	89.76
1982	214.10	13.74	4.26	232.11
1983	94.80	23.78	3.02	121.59
1984	68.07	23.25	4.49	95.81
1985	63.52	8.31	0.65	72.47
1986	27.91	26.41	0.68	55.00
1987	16.79	9.25	4.44	30.47
1988	11.34	9.10	0.44	20.88
1989	11.71	9.84	0.68	22.23
1990	17.92	12.67	0.21	30.80
1991	23.94	16.01	4.83	44.78
1992	20.13	24.41	2.81	47.35
1993	12.22	26.10	3.55	41.87
1994	12.39	19.59	0.10	32.09
1995	10.59	19.75	7.00	37.34
1996	18.46	6.14	2.53	27.14
1997	20.85	14.51	0.45	35.81
1998	12.49	6.88	0.41	19.79
1999	10.43	7.58	5.28	23.29
2000	13.17	6.88	0.22	20.27
2001	15.77	7.55	0.30	23.62
2002	11.18	7.18	0.63	18.99
2003	10.54	5.75	5.37	21.66
2004	6.96	5.47	3.64	16.07
2005	8.60	4.03	5.79	18.42
2006	8.85	5.31	1.39	15.55
2007	8.80	0.37	3.10	12.28
2008	6.49	1.18	3.65	11.32
2009	7.71	2.51	8.14	18.36
2010	6.55	7.32	5.66	19.52
2011	0.99	0.95	5.86	7.81
2012	3.94	1.50	15.41	20.85
2013	7.32	7.55	75.06	89.94
2014	5.37	13.64	15.04	34.04
2015	13.31	7.88	11.34	32.54

Table A15. Estimated time series of removals (landings and dead discards) in whole weight (1000 lb), for the ASPM Review Workshop Reference model, for commercial handlines (L.cH), commercial longlines (L.cL), and recreational (L.GR).

Year	L.cH	L.cL	L.GR	Total
1970	1.67	0.49	11.68	13.84
1971	3.50	0.81	11.69	16.00
1972	2.05	0.50	11.71	14.26
1973	10.29	0.68	12.94	23.91
1974	24.90	1.04	16.30	42.24
1975	43.03	1.79	7.53	52.35
1976	42.79	1.58	14.95	59.31
1977	28.99	1.91	6.03	36.93
1978	68.41	2.61	6.89	77.91
1979	55.35	3.22	1.71	60.28
1980	140.74	3.47	17.08	161.29
1981	389.89	18.68	6.74	415.31
1982	979.91	66.75	17.33	1063.99
1983	424.64	114.07	11.85	550.56
1984	299.37	109.85	17.30	426.51
1985	276.15	38.76	2.48	317.38
1986	120.73	122.33	2.59	245.65
1987	72.67	42.71	17.02	132.41
1988	49.39	42.14	1.69	93.21
1989	51.33	45.80	2.66	99.79
1990	79.02	59.28	0.82	139.12
1991	106.02	75.19	13.15	194.36
1992	89.29	114.92	7.65	211.85
1993	54.23	122.98	9.67	186.88
1994	55.04	92.39	0.27	147.70
1995	47.09	93.23	19.18	159.50
1996	82.29	29.01	6.98	118.28
1997	93.15	68.72	1.24	163.11
1998	55.94	32.63	1.15	89.71
1999	46.80	36.04	14.73	97.57
2000	59.27	32.75	0.62	92.64
2001	71.15	36.03	0.84	108.02
2002	50.53	34.33	1.76	86.62
2003	47.73	27.51	15.21	90.45
2004	31.60	26.24	10.33	68.18
2005	39.10	19.36	16.50	74.96
2006	40.31	25.54	3.97	69.82
2007	40.17	1.79	8.90	50.85
2008	29.66	5.71	10.50	45.87
2009	35.30	12.14	23.49	70.93
2010	30.01	35.40	16.35	81.76
2011	4.55	4.61	16.99	26.14
2012	18.10	7.29	44.77	70.16
2013	33.69	36.64	217.87	288.19
2014	24.69	66.20	43.38	134.27
2015	61.20	38.25	32.60	132.04

Table A16. Estimated total removals (landings and dead discards) at age in numbers (1000 fish), for the ASPM Review Workshop Reference model.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1970	0.02	0.07	0.23	0.43	0.45	0.38	0.30	0.24	0.19	0.15	0.13	0.10	0.09	0.07	0.06	0.05	0.04	0.04	0.03	0.16
1971	0.02	0.07	0.24	0.46	0.52	0.44	0.35	0.28	0.22	0.18	0.15	0.12	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.19
1972	0.02	0.07	0.24	0.44	0.47	0.39	0.31	0.24	0.20	0.16	0.13	0.11	0.09	0.07	0.06	0.05	0.04	0.04	0.03	0.17
1973	0.03	0.08	0.28	0.59	0.78	0.68	0.54	0.43	0.34	0.28	0.23	0.19	0.16	0.13	0.11	0.09	0.08	0.06	0.05	0.29
1974	0.03	0.11	0.37	0.90	1.38	1.24	0.98	0.78	0.62	0.51	0.41	0.34	0.28	0.23	0.20	0.16	0.14	0.12	0.10	0.53
1975	0.02	0.06	0.24	0.85	1.69	1.59	1.26	1.00	0.80	0.65	0.53	0.44	0.36	0.30	0.25	0.21	0.18	0.15	0.13	0.68
1976	0.03	0.11	0.39	1.11	1.94	1.77	1.40	1.11	0.89	0.72	0.59	0.49	0.40	0.34	0.28	0.23	0.20	0.17	0.14	0.76
1977	0.01	0.05	0.18	0.61	1.20	1.12	0.89	0.70	0.56	0.46	0.37	0.31	0.26	0.21	0.18	0.15	0.12	0.10	0.09	0.48
1978	0.02	0.06	0.28	1.19	2.56	2.41	1.90	1.49	1.19	0.97	0.79	0.65	0.54	0.45	0.38	0.31	0.26	0.22	0.19	1.02
1979	0.01	0.03	0.15	0.83	1.97	1.89	1.49	1.17	0.93	0.75	0.62	0.51	0.42	0.35	0.29	0.25	0.21	0.17	0.15	0.79
1980	0.04	0.15	0.66	2.59	5.41	5.02	3.94	3.09	2.46	1.98	1.61	1.33	1.10	0.92	0.76	0.64	0.54	0.45	0.38	2.07
1981	0.03	0.17	1.05	6.03	14.06	13.14	10.31	8.06	6.41	5.16	4.18	3.43	2.84	2.36	1.98	1.66	1.39	1.17	0.99	5.35
1982	0.10	0.51	3.15	17.75	38.73	34.11	25.99	20.20	15.99	12.85	10.42	8.52	7.02	5.83	4.88	4.09	3.43	2.89	2.43	13.21
1983	0.06	0.31	1.84	10.03	22.41	18.84	13.32	10.01	7.87	6.30	5.11	4.17	3.43	2.84	2.37	1.99	1.67	1.40	1.18	6.43
1984	0.07	0.33	1.69	8.34	19.07	17.09	10.74	7.31	5.55	4.41	3.56	2.91	2.39	1.97	1.64	1.37	1.15	0.97	0.82	4.44
1985	0.03	0.16	1.11	6.83	16.07	14.05	8.96	5.37	3.68	2.82	2.26	1.84	1.51	1.25	1.03	0.86	0.72	0.61	0.51	2.79
1986	0.02	0.09	0.59	3.54	10.06	11.62	8.40	5.27	3.19	2.21	1.71	1.38	1.13	0.93	0.77	0.64	0.54	0.45	0.38	2.07
1987	0.05	0.20	0.77	2.66	5.82	6.16	4.43	2.95	1.85	1.13	0.79	0.62	0.50	0.41	0.34	0.28	0.24	0.20	0.17	0.91
1988	0.01	0.04	0.23	1.27	3.55	4.36	3.42	2.34	1.57	1.00	0.62	0.43	0.34	0.28	0.23	0.19	0.16	0.13	0.11	0.60
1989	0.01	0.05	0.25	1.30	3.56	4.40	3.63	2.66	1.83	1.24	0.80	0.49	0.35	0.28	0.23	0.19	0.16	0.13	0.11	0.59
1990	0.01	0.04	0.28	1.74	4.86	5.85	4.83	3.71	2.74	1.90	1.30	0.84	0.52	0.37	0.29	0.24	0.20	0.17	0.14	0.75
1991	0.97	1.10	1.12	2.78	6.64	7.65	6.23	4.81	3.73	2.77	1.94	1.34	0.87	0.55	0.39	0.31	0.25	0.21	0.18	0.94
1992	0.57	0.66	0.77	2.41	6.58	8.37	6.86	5.27	4.10	3.20	2.41	1.70	1.17	0.77	0.48	0.35	0.27	0.23	0.19	1.00
1993	0.71	0.81	0.79	1.88	5.31	7.39	6.04	4.56	3.52	2.76	2.18	1.65	1.17	0.81	0.53	0.34	0.24	0.19	0.16	0.83
1994	0.02	0.05	0.22	1.38	4.40	6.02	4.87	3.60	2.72	2.12	1.68	1.33	1.01	0.72	0.50	0.33	0.21	0.15	0.12	0.62
1995	1.39	1.54	1.30	1.99	4.58	6.12	5.01	3.69	2.73	2.09	1.64	1.31	1.04	0.80	0.57	0.40	0.26	0.17	0.12	0.59
1996	0.50	0.58	0.64	1.86	4.35	4.58	3.58	2.66	1.97	1.47	1.13	0.90	0.72	0.58	0.44	0.32	0.22	0.15	0.09	0.40
1997	0.09	0.14	0.36	1.93	5.35	6.36	5.19	3.92	2.94	2.19	1.66	1.28	1.02	0.82	0.66	0.51	0.37	0.26	0.17	0.57
1998	0.08	0.11	0.23	1.13	3.02	3.44	2.77	2.12	1.61	1.22	0.92	0.70	0.54	0.43	0.35	0.28	0.22	0.16	0.11	0.32
1999	1.03	1.14	0.97	1.50	3.05	3.48	2.82	2.15	1.65	1.27	0.97	0.74	0.56	0.44	0.35	0.29	0.23	0.18	0.13	0.35
2000	0.05	0.07	0.20	1.12	3.03	3.47	2.82	2.16	1.66	1.29	1.00	0.77	0.58	0.45	0.35	0.28	0.23	0.19	0.14	0.39
2001	0.06	0.09	0.24	1.32	3.53	3.98	3.24	2.50	1.92	1.49	1.17	0.91	0.71	0.54	0.42	0.33	0.26	0.22	0.18	0.50
2002	0.12	0.15	0.24	1.00	2.67	3.14	2.58	2.00	1.55	1.21	0.94	0.75	0.58	0.45	0.35	0.27	0.21	0.17	0.14	0.44
2003	1.03	1.14	0.96	1.44	2.78	3.04	2.46	1.91	1.49	1.17	0.92	0.72	0.57	0.45	0.35	0.27	0.21	0.17	0.13	0.46
2004	0.69	0.77	0.65	0.98	1.97	2.29	1.89	1.46	1.14	0.90	0.71	0.56	0.44	0.35	0.28	0.22	0.17	0.13	0.10	0.37
2005	1.10	1.21	0.98	1.29	2.28	2.41	1.96	1.52	1.18	0.93	0.74	0.59	0.47	0.37	0.30	0.24	0.19	0.14	0.11	0.41
2006	0.26	0.30	0.32	0.85	2.06	2.39	1.98	1.54	1.21	0.95	0.75	0.60	0.48	0.39	0.31	0.25	0.20	0.15	0.12	0.43
2007	0.58	0.65	0.57	0.95	1.76	1.64	1.28	1.00	0.78	0.62	0.49	0.39	0.32	0.26	0.20	0.16	0.13	0.10	0.08	0.30
2008	0.68	0.76	0.62	0.85	1.47	1.43	1.14	0.89	0.70	0.56	0.44	0.36	0.29	0.23	0.19	0.15	0.12	0.10	0.08	0.28
2009	1.52	1.67	1.31	1.42	2.11	2.08	1.68	1.32	1.04	0.83	0.66	0.53	0.43	0.35	0.28	0.23	0.18	0.15	0.12	0.44
2010	1.05	1.16	0.93	1.15	2.10	2.53	2.13	1.68	1.33	1.06	0.85	0.69	0.56	0.45	0.36	0.30	0.24	0.19	0.16	0.60
2011	1.09	1.19	0.89	0.70	0.69	0.65	0.52	0.41	0.32	0.26	0.21	0.17	0.14	0.11	0.09	0.07	0.06	0.05	0.04	0.15
2012	2.85	3.12	2.34	1.90	1.95	1.74	1.38	1.08	0.86	0.69	0.55	0.45	0.37	0.30	0.24	0.20	0.16	0.13	0.11	0.42
2013	14.01	15.22	11.24	8.46	7.51	6.62	5.31	4.17	3.30	2.64	2.14	1.74	1.42	1.16	0.95	0.77	0.63	0.52	0.42	1.71
2014	2.85	3.09	2.32	2.12	3.08	3.83	3.26	2.59	2.06	1.64	1.33	1.08	0.88	0.73	0.60	0.49	0.40	0.33	0.27	1.11
2015	2.15	2.37	1.87	2.20	3.66	3.92	3.19	2.50	2.00	1.60	1.29	1.05	0.86	0.71	0.58	0.48	0.39	0.32	0.26	1.11

Table A17. Estimated total removals (landings and dead discards) at age in whole weight (1000 lb), for the ASPM Review Workshop Reference model.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1970	0.02	0.13	0.58	1.35	1.68	1.58	1.35	1.14	0.96	0.80	0.67	0.56	0.47	0.40	0.33	0.28	0.24	0.20	0.17	0.92
1971	0.02	0.13	0.59	1.43	1.92	1.85	1.60	1.35	1.13	0.95	0.80	0.67	0.56	0.47	0.40	0.33	0.28	0.24	0.20	1.09
1972	0.02	0.13	0.58	1.37	1.73	1.63	1.40	1.18	0.99	0.83	0.70	0.58	0.49	0.41	0.35	0.29	0.25	0.21	0.18	0.95
1973	0.02	0.15	0.68	1.85	2.89	2.85	2.46	2.07	1.74	1.46	1.22	1.03	0.86	0.72	0.61	0.51	0.43	0.36	0.31	1.67
1974	0.03	0.19	0.92	2.84	5.10	5.16	4.45	3.75	3.15	2.64	2.22	1.86	1.56	1.31	1.10	0.93	0.78	0.66	0.56	3.03
1975	0.02	0.10	0.59	2.66	6.28	6.62	5.73	4.83	4.06	3.41	2.86	2.39	2.01	1.69	1.42	1.20	1.01	0.85	0.72	3.90
1976	0.03	0.19	0.96	3.48	7.20	7.40	6.37	5.36	4.50	3.78	3.17	2.66	2.23	1.87	1.58	1.33	1.12	0.94	0.80	4.33
1977	0.01	0.08	0.45	1.92	4.44	4.69	4.04	3.39	2.84	2.39	2.00	1.68	1.41	1.19	1.00	0.84	0.71	0.60	0.50	2.74
1978	0.02	0.11	0.70	3.73	9.49	10.05	8.64	7.23	6.04	5.06	4.24	3.56	2.99	2.51	2.11	1.78	1.50	1.27	1.07	5.81
1979	0.01	0.05	0.38	2.61	7.30	7.87	6.79	5.68	4.73	3.95	3.30	2.77	2.33	1.96	1.65	1.39	1.17	0.99	0.83	4.53
1980	0.04	0.27	1.62	8.13	20.05	20.94	17.89	14.95	12.44	10.35	8.63	7.23	6.08	5.11	4.30	3.62	3.05	2.58	2.18	11.83
1981	0.03	0.29	2.58	18.90	52.14	54.85	46.84	38.99	32.44	26.97	22.42	18.72	15.69	13.20	11.11	9.36	7.89	6.66	5.63	30.59
1982	0.10	0.88	7.77	55.68	143.61	142.40	118.12	97.66	80.89	67.22	55.86	46.46	38.82	32.58	27.43	23.12	19.50	16.45	13.90	75.56
1983	0.06	0.54	4.53	31.46	83.09	78.64	60.54	48.41	39.83	32.96	27.38	22.77	18.96	15.86	13.32	11.23	9.48	8.00	6.76	36.75
1984	0.07	0.56	4.17	26.16	70.71	71.32	48.82	35.37	28.06	23.06	19.07	15.86	13.20	11.00	9.21	7.75	6.54	5.52	4.67	25.39
1985	0.03	0.28	2.75	21.42	59.59	58.67	40.74	25.95	18.63	14.76	12.13	10.04	8.35	6.96	5.81	4.87	4.10	3.46	2.93	15.93
1986	0.02	0.16	1.45	11.12	37.29	48.50	38.20	25.48	16.14	11.58	9.17	7.54	6.25	5.20	4.34	3.62	3.04	2.56	2.17	11.81
1987	0.05	0.34	1.89	8.35	21.58	25.71	20.11	14.25	9.38	5.93	4.25	3.37	2.77	2.30	1.92	1.60	1.34	1.13	0.95	5.18
1988	0.01	0.07	0.56	3.97	13.15	18.20	15.57	11.32	7.95	5.23	3.30	2.37	1.88	1.55	1.29	1.07	0.90	0.75	0.63	3.44
1989	0.01	0.08	0.62	4.06	13.19	18.36	16.50	12.87	9.26	6.49	4.26	2.70	1.94	1.54	1.27	1.05	0.88	0.74	0.62	3.35
1990	0.01	0.07	0.70	5.44	18.03	24.43	21.94	17.96	13.85	9.95	6.96	4.58	2.90	2.08	1.66	1.37	1.14	0.95	0.80	4.29
1991	0.96	1.90	2.76	8.72	24.62	31.95	28.33	23.27	18.84	14.51	10.41	7.30	4.80	3.04	2.19	1.74	1.44	1.20	1.00	5.37
1992	0.56	1.14	1.90	7.55	24.38	34.96	31.20	25.48	20.72	16.75	12.89	9.26	6.49	4.28	2.72	1.96	1.56	1.29	1.07	5.71
1993	0.70	1.39	1.96	5.90	19.68	30.86	27.46	22.06	17.78	14.43	11.67	8.98	6.46	4.53	2.99	1.90	1.37	1.09	0.90	4.76
1994	0.02	0.09	0.55	4.32	16.33	25.14	22.13	17.39	13.77	11.08	8.99	7.27	5.60	4.03	2.83	1.87	1.19	0.86	0.69	3.56
1995	1.36	2.65	3.20	6.25	16.98	25.55	22.77	17.84	13.83	10.92	8.79	7.13	5.78	4.46	3.21	2.26	1.49	0.95	0.69	3.39
1996	0.49	1.00	1.59	5.82	16.12	19.12	16.28	12.87	9.94	7.69	6.08	4.89	3.97	3.22	2.49	1.79	1.26	0.84	0.53	2.29
1997	0.09	0.23	0.89	6.06	19.84	26.57	23.60	18.95	14.87	11.47	8.87	7.01	5.65	4.59	3.73	2.88	2.08	1.47	0.97	3.28
1998	0.08	0.19	0.57	3.55	11.21	14.37	12.60	10.25	8.14	6.38	4.92	3.81	3.01	2.43	1.98	1.61	1.24	0.90	0.63	1.84
1999	1.01	1.96	2.38	4.71	11.29	14.52	12.81	10.39	8.37	6.64	5.20	4.01	3.11	2.46	1.99	1.62	1.32	1.02	0.74	2.03
2000	0.05	0.12	0.50	3.52	11.25	14.49	12.83	10.44	8.38	6.74	5.35	4.19	3.23	2.51	1.99	1.61	1.31	1.07	0.83	2.25
2001	0.06	0.15	0.60	4.15	13.09	16.63	14.73	12.08	9.73	7.81	6.28	4.98	3.90	3.02	2.34	1.86	1.50	1.23	1.00	2.88
2002	0.12	0.26	0.59	3.14	9.91	13.11	11.72	9.66	7.85	6.31	5.06	4.07	3.23	2.54	1.96	1.53	1.21	0.98	0.80	2.54
2003	1.01	1.96	2.36	4.52	10.32	12.70	11.20	9.21	7.51	6.10	4.90	3.93	3.17	2.52	1.98	1.53	1.19	0.95	0.77	2.62
2004	0.68	1.32	1.59	3.06	7.31	9.55	8.58	7.06	5.76	4.69	3.80	3.06	2.46	1.98	1.58	1.24	0.96	0.75	0.60	2.13
2005	1.08	2.09	2.43	4.05	8.45	10.08	8.89	7.34	5.98	4.87	3.97	3.22	2.59	2.08	1.68	1.34	1.05	0.82	0.64	2.32
2006	0.26	0.52	0.78	2.66	7.64	9.97	8.98	7.46	6.11	4.97	4.04	3.29	2.68	2.16	1.74	1.40	1.12	0.88	0.69	2.48
2007	0.57	1.12	1.39	2.98	6.54	6.83	5.82	4.83	3.97	3.24	2.64	2.15	1.75	1.43	1.15	0.93	0.75	0.60	0.47	1.69
2008	0.67	1.30	1.53	2.67	5.44	5.95	5.17	4.30	3.55	2.91	2.38	1.94	1.58	1.29	1.05	0.85	0.68	0.55	0.44	1.60
2009	1.49	2.88	3.22	4.47	7.84	8.70	7.63	6.36	5.26	4.34	3.56	2.91	2.37	1.94	1.58	1.29	1.04	0.84	0.68	2.52
2010	1.04	2.00	2.30	3.60	7.80	10.54	9.66	8.11	6.73	5.55	4.58	3.76	3.08	2.51	2.05	1.68	1.37	1.11	0.90	3.41
2011	1.07	2.06	2.19	2.19	2.56	2.70	2.36	1.97	1.63	1.35	1.12	0.92	0.76	0.62	0.51	0.41	0.34	0.28	0.22	0.87
2012	2.80	5.38	5.77	5.98	7.21	7.26	6.29	5.23	4.34	3.59	2.97	2.46	2.03	1.67	1.37	1.12	0.92	0.75	0.61	2.43
2013	13.76	26.22	27.71	26.54	27.84	27.64	24.12	20.18	16.69	13.82	11.45	9.48	7.84	6.48	5.34	4.38	3.59	2.94	2.41	9.77
2014	2.80	5.33	5.71	6.64	11.43	15.97	14.80	12.51	10.41	8.60	7.12	5.90	4.89	4.05	3.35	2.76	2.27	1.86	1.53	6.33
2015	2.11	4.09	4.60	6.91	13.59	16.38	14.49	12.10	10.09	8.38	6.92	5.74	4.76	3.95	3.27	2.71	2.24	1.84	1.51	6.37

Table A18. Estimated time series of status indicators, fishing mortality, and biomass, for the ASPM Review Workshop Reference model. Fishing mortality rate is apical F. Total biomass (B, in metric tons, mt, and 1000 lb) is at the start of the year, and spawning biomass (SSB, million eggs) at the time of peak spawning (mid-year). The MSST *is defined by* $\mathrm{MSST} = 0.75\mathrm{SSB}_{\mathrm{MSY}}$.

Year	F	F/F_{MSY}	B (mt)	B (1000 lb)	B/B_{unfished}	SSB	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	SSB/MSST
1970	0.003	0.009	3979	8773	0.982	2636479	6.01	8.01
1971	0.004	0.011	3983	8782	0.983	2643185	6.02	8.03
1972	0.003	0.010	3986	8787	0.984	2647110	6.03	8.04
1973	0.005	0.017	3988	8793	0.985	2648660	6.04	8.05
1974	0.010	0.031	3987	8789	0.984	2641304	6.02	8.02
1975	0.013	0.040	3977	8769	0.982	2624408	5.98	7.97
1976	0.014	0.045	3965	8741	0.979	2603347	5.93	7.91
1977	0.009	0.029	3951	8711	0.976	2588773	5.90	7.86
1978	0.020	0.062	3949	8707	0.975	2573336	5.86	7.82
1979	0.016	0.049	3930	8664	0.970	2549276	5.81	7.74
1980	0.041	0.130	3921	8644	0.968	2507475	5.71	7.62
1981	0.115	0.361	3869	8530	0.955	2360430	5.38	7.17
1982	0.355	1.114	3716	8192	0.917	1939041	4.42	5.89
1983	0.231	0.726	3304	7285	0.816	1496682	3.41	4.55
1984	0.197	0.619	3163	6974	0.781	1322666	3.01	4.02
1985	0.147	0.460	3090	6812	0.763	1264816	2.88	3.84
1986	0.124	0.389	3071	6771	0.758	1273952	2.90	3.87
1987	0.059	0.186	3087	6805	0.762	1344766	3.06	4.09
1988	0.041	0.129	3150	6945	0.778	1461067	3.33	4.44
1989	0.042	0.131	3225	7110	0.796	1567839	3.57	4.76
1990	0.056	0.175	3289	7250	0.812	1643360	3.74	4.99
1991	0.074	0.232	3328	7336	0.822	1677042	3.82	5.10
1992	0.084	0.265	3337	7358	0.824	1678320	3.82	5.10
1993	0.076	0.237	3339	7361	0.824	1677963	3.82	5.10
1994	0.060	0.188	3351	7387	0.827	1700573	3.87	5.17
1995	0.060	0.188	3378	7448	0.834	1735553	3.95	5.27
1996	0.042	0.130	3397	7490	0.839	1778349	4.05	5.40
1997	0.060	0.188	3432	7566	0.847	1814909	4.14	5.51
1998	0.032	0.100	3443	7590	0.850	1847722	4.21	5.61
1999	0.032	0.100	3485	7682	0.860	1903649	4.34	5.78
2000	0.031	0.099	3517	7754	0.868	1952426	4.45	5.93
2001	0.036	0.113	3548	7822	0.876	1990141	4.53	6.05
2002	0.029	0.090	3569	7867	0.881	2022601	4.61	6.14
2003	0.027	0.085	3596	7927	0.888	2059949	4.69	6.26
2004	0.021	0.065	3617	7974	0.893	2099117	4.78	6.38
2005	0.021	0.066	3646	8037	0.900	2140100	4.88	6.50
2006	0.021	0.067	3667	8085	0.905	2173445	4.95	6.60
2007	0.014	0.043	3689	8133	0.911	2207974	5.03	6.71
2008	0.012	0.038	3716	8191	0.917	2247645	5.12	6.83
2009	0.018	0.056	3741	8247	0.924	2278953	5.19	6.92
2010	0.023	0.071	3752	8271	0.926	2293758	5.23	6.97
2011	0.005	0.017	3757	8282	0.927	2316639	5.28	7.04
2012	0.014	0.045	3785	8345	0.934	2349252	5.35	7.14
2013	0.057	0.178	3790	8355	0.936	2323147	5.29	7.06
2014	0.036	0.114	3697	8150	0.913	2260430	5.15	6.87
2015	0.036	0.113	3687	8128	0.910	2229419	5.08	6.77
2016	.	.	3679	8111	0.908	.	.	.

Table A19. Estimated F_{MSY}-based status indicators, benchmarks, and related quantities for the ASPM Review Workshop Reference model, conditional on estimated current selectivities averaged across fleets. Medians and standard errors of values from Monte Carlo/Bootstrap (MCB) analysis are also provided. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured as population fecundity (million eggs)

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.319	0.234	0.290
$85\%F_{\mathrm{MSY}}$	y^{-1}	0.271	0.199	0.246
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.239	0.176	0.217
$65\%F_{\mathrm{MSY}}$	y^{-1}	0.207	0.152	0.188
$F_{30\%}$	y^{-1}	0.218	0.193	0.136
$F_{40\%}$	y^{-1}	0.154	0.137	0.082
B_{MSY}	1000 lb whole	4339	1846	1023
$\mathrm{SSB}_{\mathrm{MSY}}$	million eggs	438871	454964	281925
MSST	million eggs	329153	341223	211444
MSY	1000 lb whole	433	332	274
R_{MSY}	number fish	1084009	934907	897626
$L_{85\%\mathrm{MSY}}$	1000 lb whole	428	328	271
$L_{75\%\mathrm{MSY}}$	1000 lb whole	418	320	265
$L_{65\%\mathrm{MSY}}$	1000 lb whole	402	309	257
$F_{2013-2015}/F_{\mathrm{MSY}}$	—	0.13	0.19	0.40
$\mathrm{SSB}_{2015}/\mathrm{MSST}$	—	6.77	5.24	4.38
$\mathrm{SSB}_{2015}/\mathrm{SSB}_{\mathrm{MSY}}$	—	5.08	3.93	3.28

Table A20. Estimated $F_{30\%}$-based status indicators, benchmarks, and related quantities for the ASPM Review Workshop Reference model, conditional on estimated current selectivities averaged across fleets. Medians and standard errors of values from Monte Carlo/Bootstrap (MCB) analysis are also provided. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured as population fecundity (million eggs)

Quantity	Units	Estimate	Median	SE
$F_{30\%}$	y^{-1}	0.218	0.193	0.136
$85\%F_{30\%}$	y^{-1}	0.185	0.164	0.116
$75\%F_{30\%}$	y^{-1}	0.163	0.145	0.102
$65\%F_{30\%}$	y^{-1}	0.142	0.126	0.089
$F_{30\%}$	y^{-1}	0.218	0.193	0.136
$F_{40\%}$	y^{-1}	0.154	0.137	0.082
$B_{\mathrm{F30\%}}$	1000 lb whole	5878	2338	1492
$\mathrm{SSB}_{\mathrm{F30\%}}$	million eggs	807254	698273	350966
MSST	million eggs	605440	341223	211444
$L_{\mathrm{F30\%}}$	1000 lb whole	454	373	257
$R_{\mathrm{F30\%}}$	number fish	1334975	1127699	1149310
$L_{85\%\mathrm{F30\%}}$	1000 lb whole	387	303	219
$L_{75\%\mathrm{F30\%}}$	1000 lb whole	368	292	207
$L_{65\%\mathrm{F30\%}}$	1000 lb whole	346	278	194
$F_{2013-2015}/F_{30\%}$	—	0.19	0.19	0.40
$\mathrm{SSB}_{2015}/\mathrm{MSST}$	—	3.68	5.24	4.38
$\mathrm{SSB}_{2015}/\mathrm{SSB}_{\mathrm{F30\%}}$	—	2.76	3.93	3.28

Table A21. Estimated status indicators, benchmarks, and related quantities for sensitivity runs for the ASPM Reference Run, south of Cape Hatteras. Rate estimates (F) are in units of y^{-1}*; status indicators are dimensionless; and biomass estimates are in units of 1000 pounds, Beverton-Holt R_0 is in units of 1000 fish. Spawning stock biomass (*SSB*) and minimum stock size threshold (*MSST*) are measured as population fecundity (millions of eggs).* F/F_{MSY} *is based on the geometric mean F for the last three years of the assessment.* $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$ *and* $\mathrm{SSB}/\mathrm{MSST}$ *are based on the terminal year of the assessment. steep = Beverton Holt steepness.* Lik_{total} *= total likelihood for the model. See text for full description of sensitivity runs.*

Run	Description	F_{MSY}	MSST	B_{MSY}	MSY	F/F_{MSY}	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	SSB/MSST	steep	R_0	Lik_{total}
Ref	Reference	0.319	329153	4339	433	0.11	5.08	6.77	0.84	1363	5660
S00	AWBase	0.841	612674	1997	316	0.07	3.53	4.70	0.84	1159	5708
S01	AWBaseFitGrowth	1.162	516000	2193	461	0.05	4.31	5.75	0.84	967	5676
S02	AWBaseA100is6	0.296	349663	2600	246	0.21	3.74	4.98	0.84	1142	5705
S03	AWBaseIndCV0.2	0.815	667576	2174	343	0.06	3.61	4.82	0.84	1262	5701
S04	A100is4	0.558	487082	3886	545	0.06	5.03	6.71	0.84	1411	5661
S05	A100is9	0.193	176225	4500	318	0.21	4.90	6.53	0.84	1264	5659
S06	M0.1	0.186	441170	2026	184	0.32	2.90	3.86	0.84	325	5655
S07	M0.25	0.438	287644	12056	922	0.06	6.38	8.51	0.84	5779	5665
S08	FitRecDevsWgt10	0.322	315212	4134	405	0.12	4.95	6.60	0.84	1304	5446
S09	FitRecDevsWgt1	0.359	148432	1950	182	0.29	3.60	4.80	0.84	614	5589
S10	0.1HLRemo80to85	0.386	105156	1308	118	0.89	1.68	2.24	0.84	380	5628
S11	0.5HLRemo80to85	0.323	174656	2213	214	0.27	3.90	5.20	0.84	686	5652
S12	IndWt0.1	0.315	510161	6794	680	0.07	5.52	7.36	0.84	2155	5485
S13	IndRemLast3yr	0.318	350518	4667	467	0.10	5.20	6.93	0.84	1466	5645
S14	Steep0.25	0.020	1741600	8356	80	1.61	1.12	1.49	0.25	2598	5665
S15	Steep0.35	0.059	806833	4479	115	1.17	1.08	1.44	0.35	1352	5658
S16	Steep0.45	0.097	528570	3364	134	1.02	1.09	1.45	0.45	976	5654
S17	Steep0.55	0.136	379162	2781	148	1.00	1.00	1.34	0.55	775	5653
S18	Steep0.65	0.179	457302	3951	268	0.24	2.93	3.91	0.65	1183	5658
S19	Steep0.75	0.241	402097	4216	351	0.16	3.85	5.13	0.75	1293	5660
S20	SteepFit	0.124	407256	2911	144	1.00	1.02	1.36	0.52	808	5653

Table A22. Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb*).The proportion of 3068 stochastic projection replicates with* SSB ≥ MSST *is also indicated. The subscript* med *indicates median values from the stochastic projections.*

Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB ≥ MSST)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.987
2017	1347	1154	0.319	0.319	1928056	1537127	318	269	1135	982	0.975
2018	1336	1131	0.319	0.319	1475294	1170095	273	232	931	810	0.936
2019	1308	1095	0.319	0.319	1167340	907481	243	206	792	689	0.888
2020	1279	1049	0.319	0.319	954548	736359	223	188	697	606	0.845
2021	1249	1000	0.319	0.319	806244	606675	208	174	631	548	0.813

Table A23. Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{\text{current}}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb*).The proportion of 3068 stochastic projection replicates with* SSB $\geq$ MSST *is also indicated. The subscript* med *indicates median values from the stochastic projections.*

Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB $\geq$ MSST)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.987
2017	1347	1154	0.042	0.042	2161901	1720181	46	39	166	144	0.991
2018	1346	1152	0.042	0.042	2136905	1710806	45	39	165	143	0.997
2019	1345	1155	0.042	0.042	2118573	1692481	45	38	164	143	0.999
2020	1344	1159	0.042	0.042	2101179	1682592	45	38	163	142	0.999
2021	1343	1162	0.042	0.042	2085621	1673572	45	38	162	142	1.000

Table A24. Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{\text{target}}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb*).The proportion of 3068 stochastic projection replicates with* SSB ≥ MSST *is also indicated. The subscript* med *indicates median values from the stochastic projections.*

Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	P(SSB ≥ MSST)
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.987
2017	1347	1154	0.239	0.239	1992681	1588173	244	207	876	759	0.981
2018	1339	1136	0.239	0.239	1641164	1303360	218	186	758	658	0.963
2019	1320	1113	0.239	0.239	1384330	1088796	200	170	672	585	0.938
2020	1301	1085	0.239	0.239	1193797	929781	187	158	609	530	0.908
2021	1282	1056	0.239	0.239	1052151	814673	177	149	563	489	0.882

Table A25. Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{30\%}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb*).The proportion of 3068 stochastic projection replicates with* $\mathrm{SSB} \geq \mathrm{MSST}_{\mathrm{F30\%}}$ *is also indicated. The subscript* med *indicates median values from the stochastic projections.*

Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	$P(SSB \geq MSST_{F30\%})$
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	1.000
2017	1347	1154	0.218	0.218	2010203	1602341	224	190	805	697	1.000
2018	1339	1137	0.218	0.218	1688297	1342502	202	172	706	613	0.999
2019	1323	1116	0.218	0.218	1448677	1141989	187	159	633	552	0.999
2020	1306	1096	0.218	0.218	1267478	986531	175	149	579	504	0.997
2021	1290	1069	0.218	0.218	1130395	877573	167	141	539	469	0.995

Table A26. Projection results for the ASPM south of Cape Hatteras with fishing mortality rate fixed at $F = F_{40\%}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), SSB = spawning stock (million eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb*).The proportion of 3068 stochastic projection replicates with* $\mathrm{SSB} \geq \mathrm{MSST}_{\mathrm{F40\%}}$ *is also indicated. The subscript* med *indicates median values from the stochastic projections.*

Year	R	R_{med}	F	F_{med}	SSB	SSB_{med}	L (n)	L_{med} (n)	L (w)	L_{med} (w)	$P(SSB \geq MSST_{F40\%})$
2016	1348	1159	0.042	0.048	2196126	1745084	46	44	168	162	0.997
2017	1347	1154	0.154	0.154	2063827	1645585	162	137	584	506	0.996
2018	1342	1143	0.154	0.154	1838443	1465053	151	128	535	464	0.997
2019	1331	1126	0.154	0.154	1661428	1316731	143	122	497	434	0.996
2020	1321	1116	0.154	0.154	1519467	1201382	137	117	467	408	0.995
2021	1312	1103	0.154	0.154	1406161	1103169	132	112	444	387	0.993

6.5 Figures

Figure A1. Indices of abundance and error bands used in both the ASPIC and ASPM RW Reference models for the So. Atl., including the commercial handline index (ComHL), commercial longline index (ComHL), and recreational headboat index (RecHb). Note that the RecHb index was not used in the ASPIC RW Reference model. Shaded areas represent ±2 standard errors (SE) for each year of each index, calculated from a constant CV of 0.2.

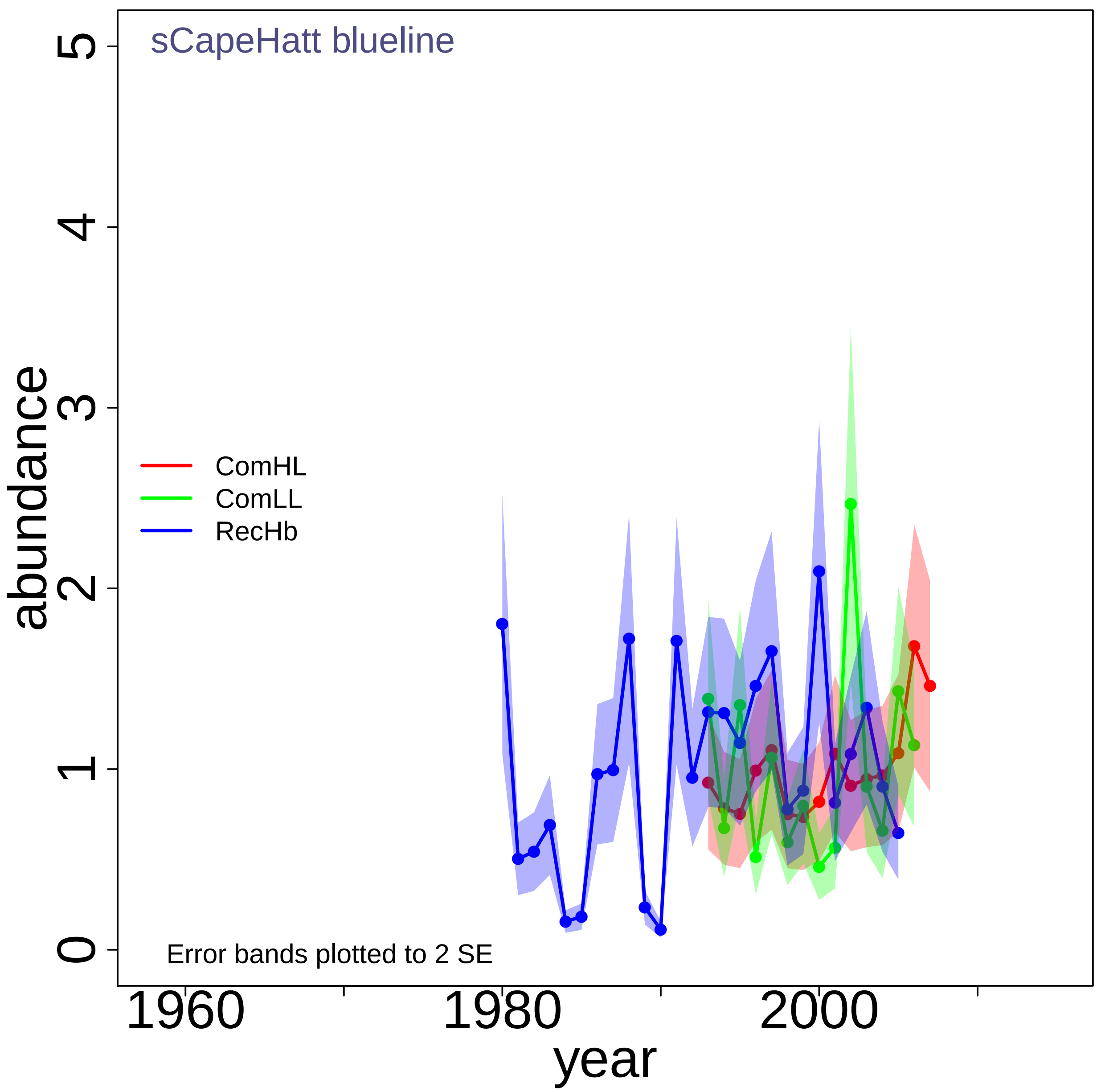
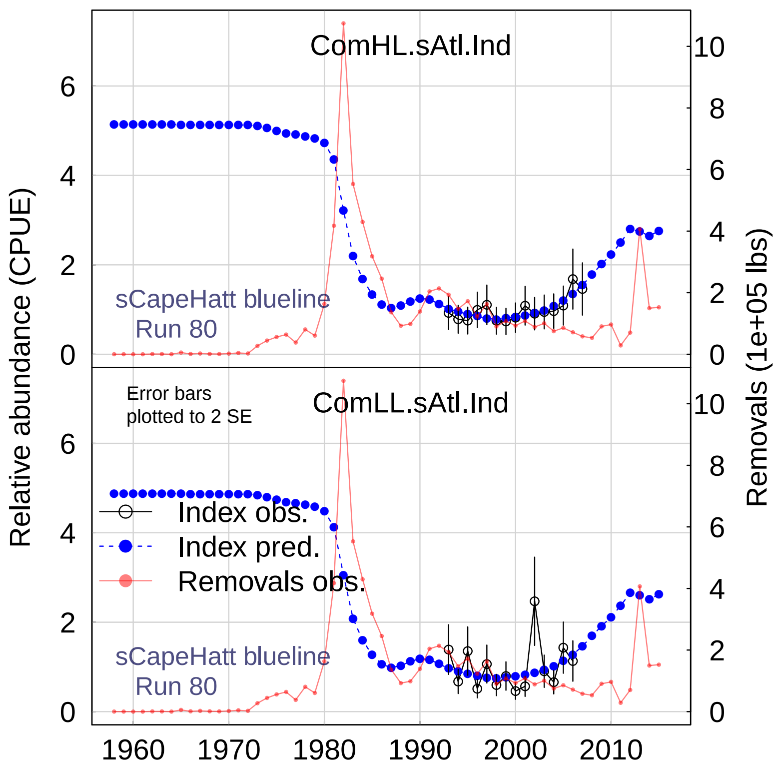


Figure A2. ASPIC RW Reference model for the South Atlantic. Fits to indices (upper panel) and B and F ratio plots (lower panel). Note that the last year plotted in the B/B_{MSY} series is a one year projection (2016) while the last year of the F/F_{MSY} series is the terminal year of the assessment (2015). The B and F trends plotted here were not used directly to make status determinations, but are shown to enable comparisons with the sensitivity runs.



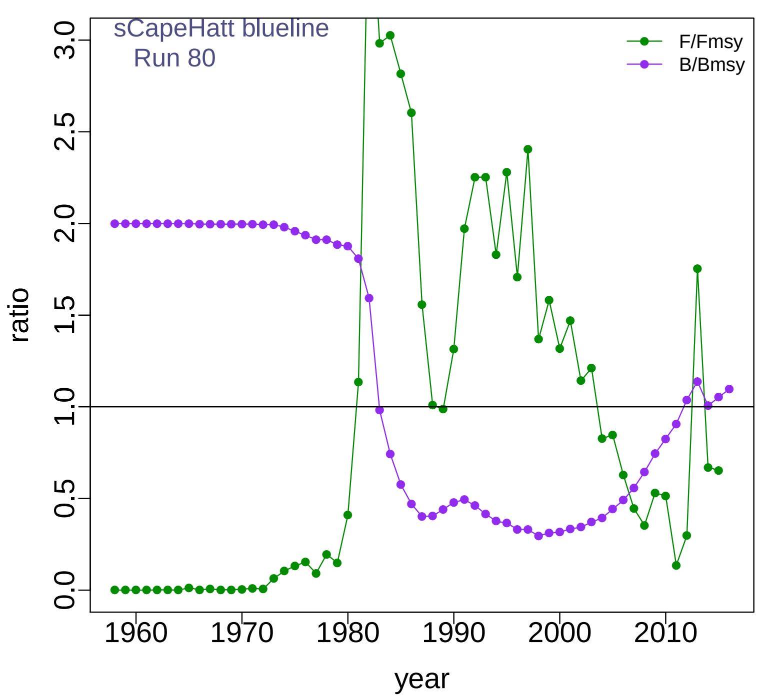


Figure A3. Estimated biomass series (B) from the ASPIC RW Reference model for the South Atlantic. Solid line indicates estimated B series. The jagged dashed line represents the median B and blue error bands indicate 5^{th} and 95^{th} percentiles of the bootstrap trials. Horizontal dashed and dotted lines indicate B_{MSY} and MSST.

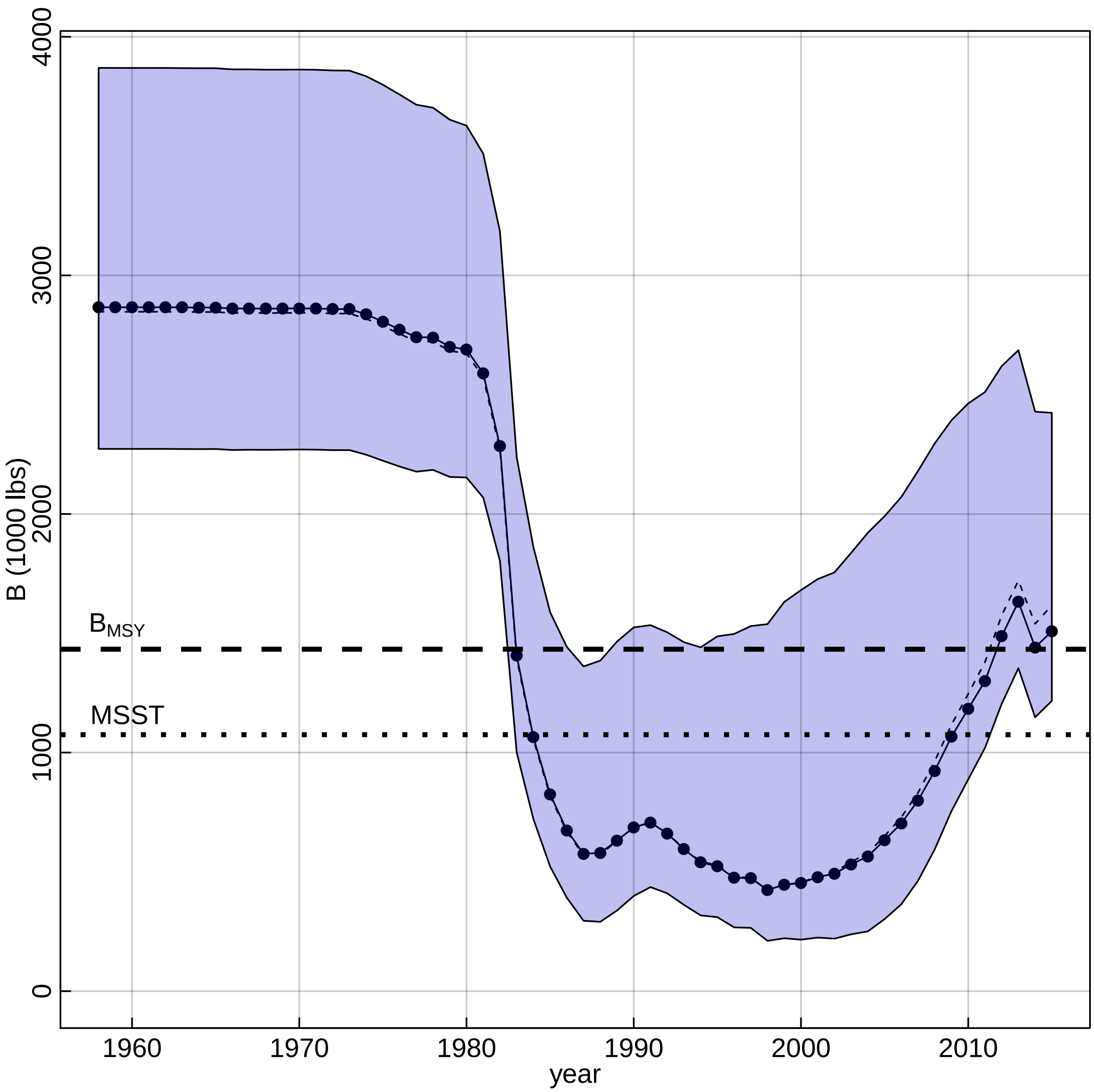


Figure A4. Estimated fishing mortality series (F) from the ASPIC RW Reference model for the South Atlantic. Solid line indicates estimated F series. The jagged dashed line represents the median F and blue error bands indicate 5^{th} and 95^{th} percentiles of the bootstrap trials. Horizontal dashed and dotted lines indicate F_{MSY} and $F_{2013-2015}$ (F_{current}; geometric mean F from 2013-2015).

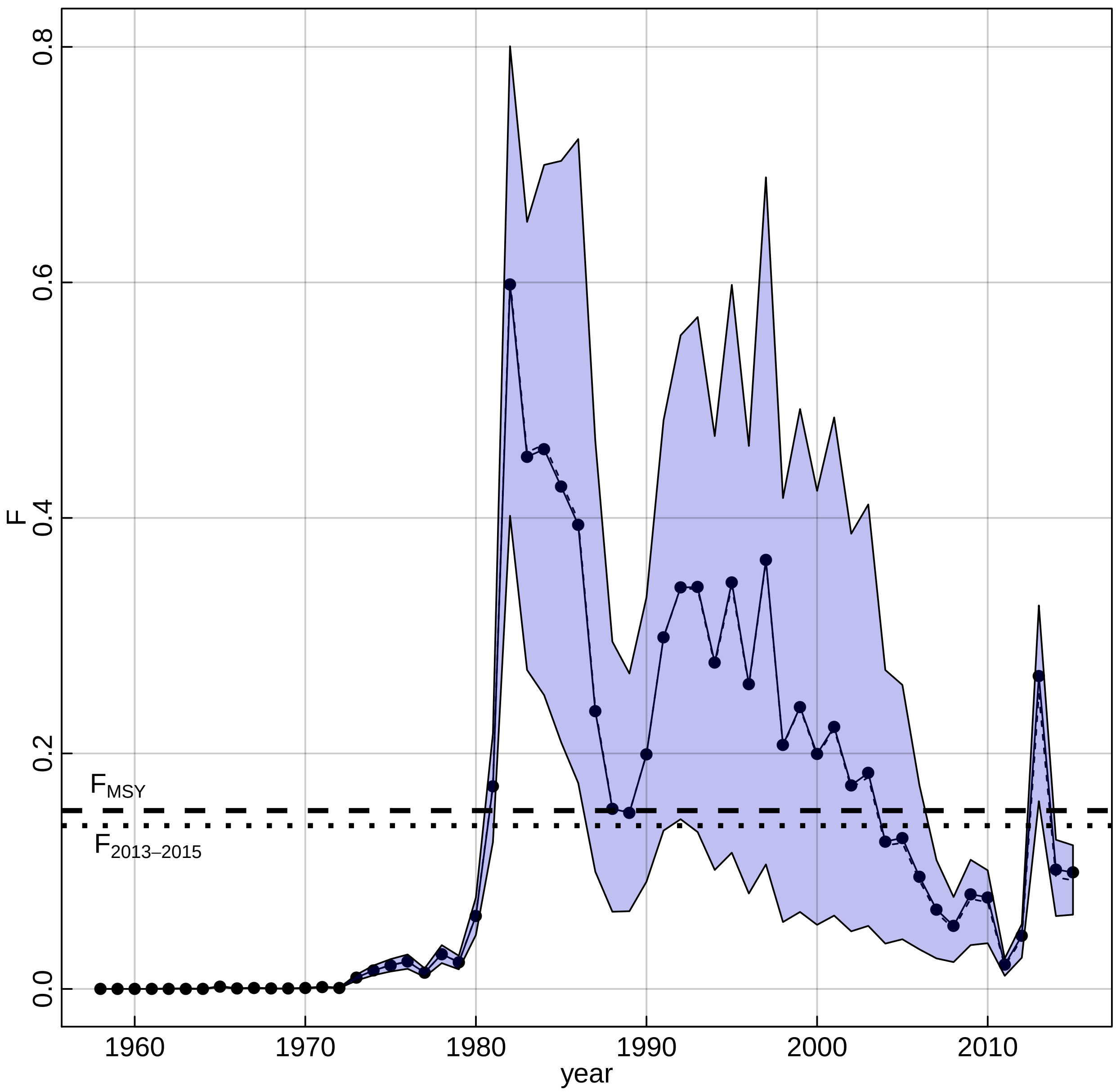


Figure A5. Distribitions of ASPIC parameter estimates from the ASPIC RW Reference model for the South Atlantic. Dotted lines represent 5^{th} and 95^{th} percentiles, dashed line represents the median of the bootstrap runs. Thick solid orange lines represent estimates from the RW Reference model.

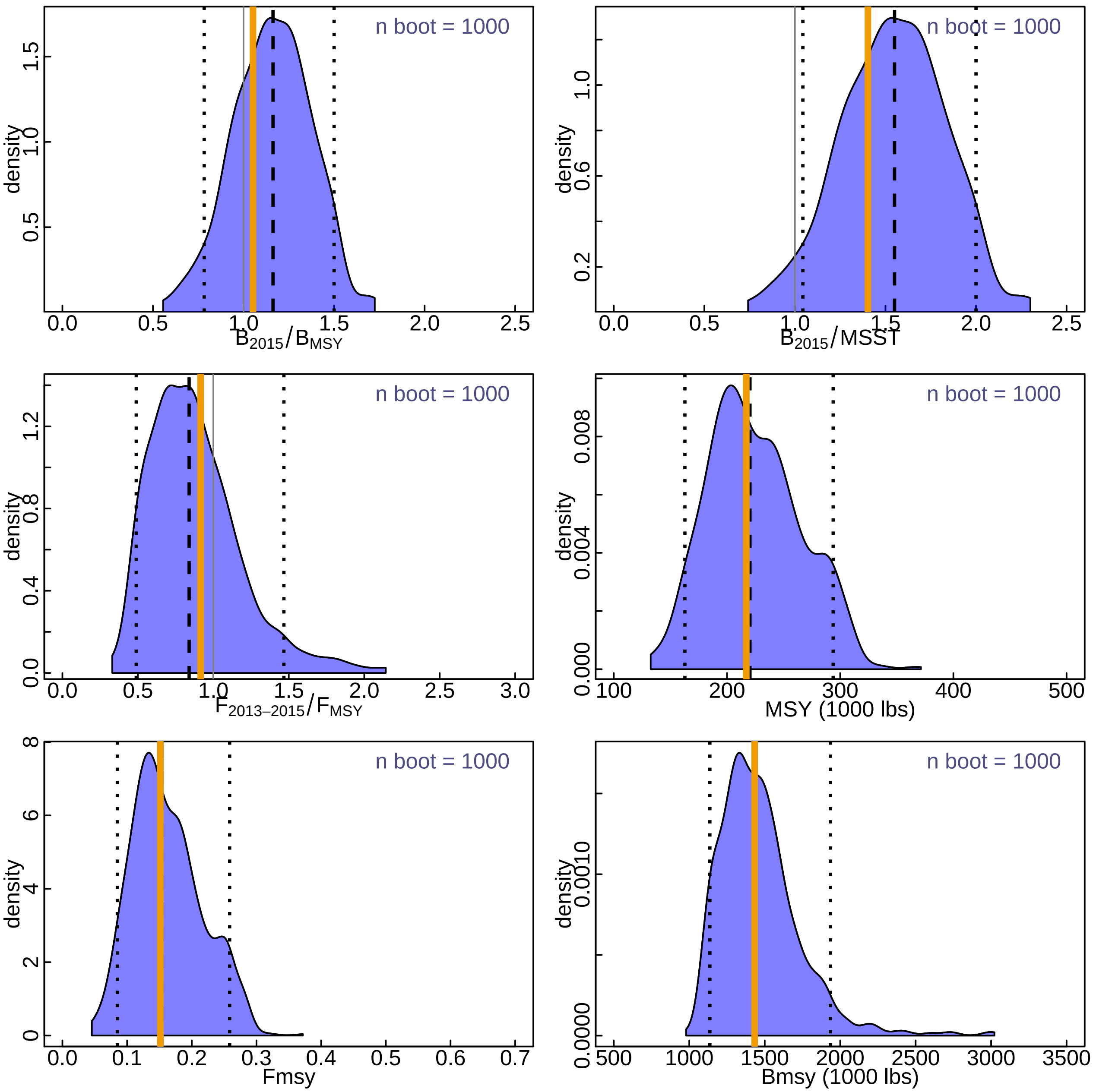


Figure A6. Estimated biomass series (B) relative to B_{MSY} from the ASPIC RW Reference model for the South Atlantic. Solid line indicates average B series relative to B_{MSY}. The dashed line represents the median B/B_{MSY} and blue error bands indicate 5^{th} and 95^{th} percentiles of the bootstrap trials.

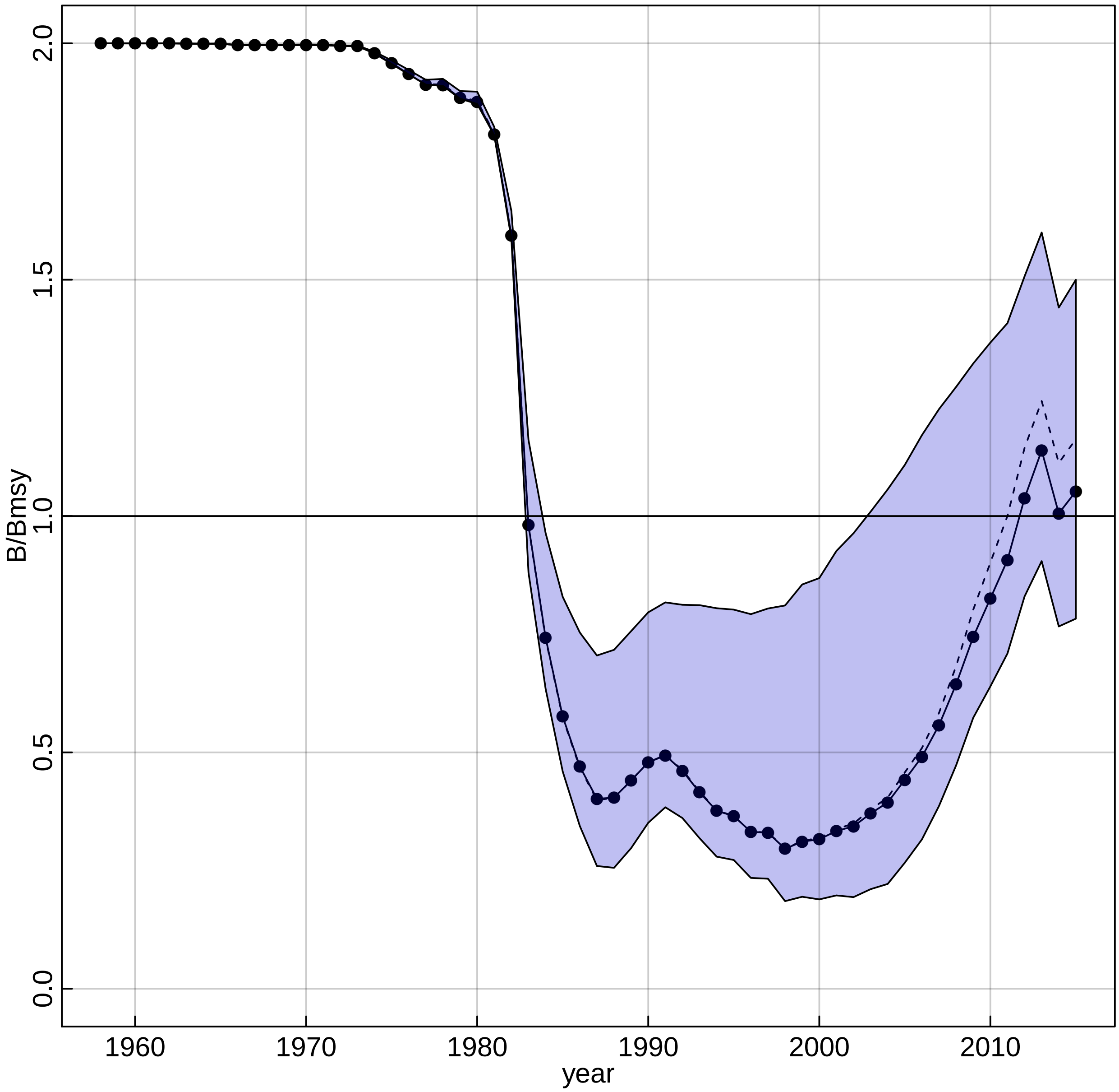


Figure A7. Estimated biomass series (B) relative to MSST *from the ASPIC RW Reference model for the South Atlantic. Solid line indicates B series relative to* MSST *(*$0.75B_{\mathrm{MSY}}$*). The dashed line represents the median* B/MSST *and blue error bands indicate* 5^{th} *and* 95^{th} *percentiles of the bootstrap trials.*

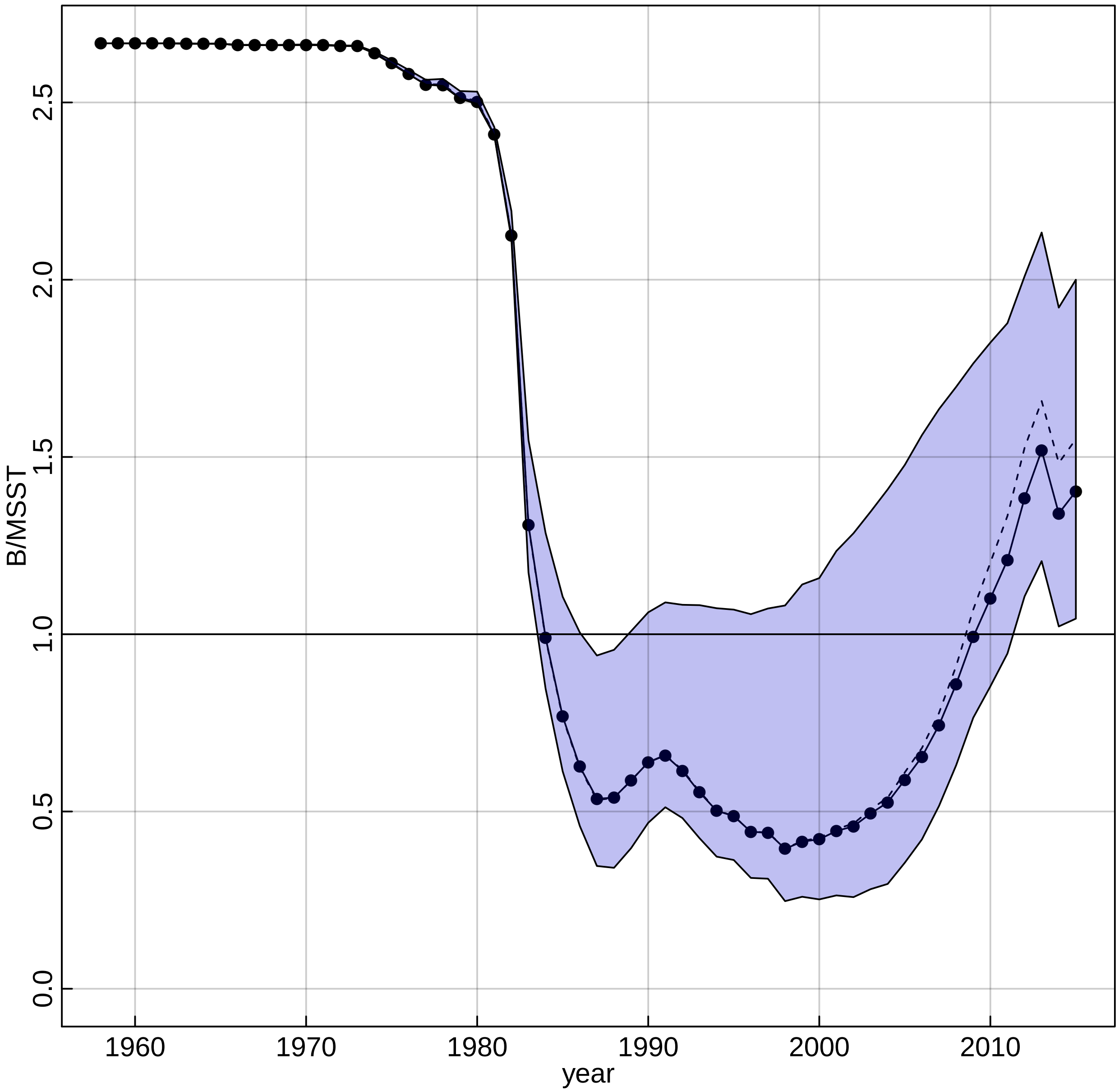


Figure A8. Estimated fishing mortality series (F) relative to F_{MSY} from the ASPIC RW Reference model for the South Atlantic. Solid line indicates F series relative to F_{MSY}. The dashed line represents the median F/F_{MSY} and blue error bands indicate 5^{th} and 95^{th} percentiles of the bootstrap trials.

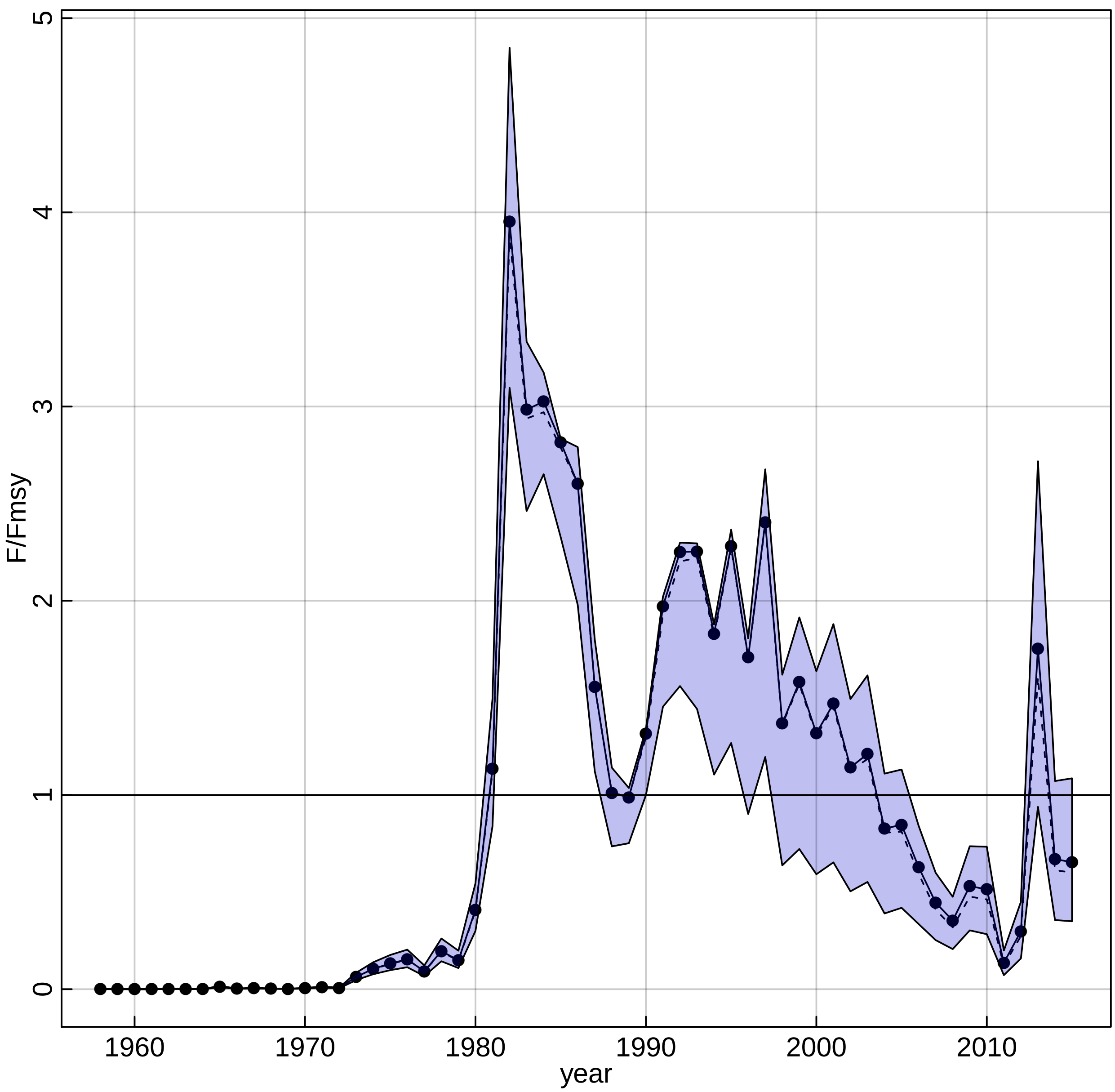


Figure A9. Phase plots of ASPIC F and B terminal status estimates for bootstrap runs from the ASPIC RW Reference model for the South Atlantic. The intersection of crosshairs indicates estimate from the RW Ref. model; lengths of crosshairs defined by 5^{th} and 95^{th} percentiles. Percent of runs falling in each quadrant indicated.

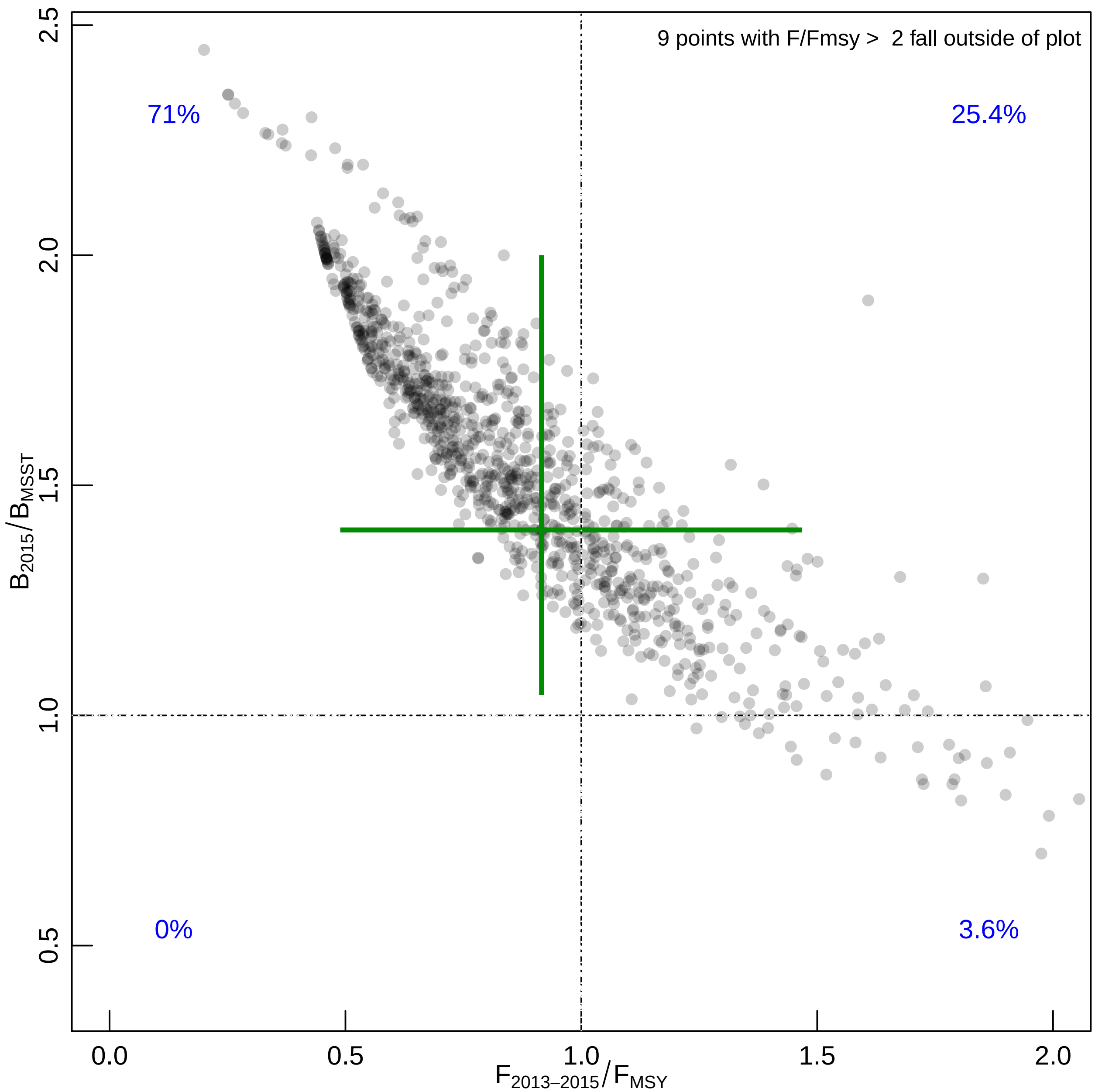


Figure A10. Plots of F, F/F_{MSY}, B, B/B_{MSY}, Y, and B/MSST for five year projections from ASPIC for the South Atlantic region with F set at F_{MSY} beginning the year after the terminal year of the assessment. Solid circles represent values projected by the assessment model while open circles represent values produced by the projection code. The solid and dashed lines are the deterministic estimates and medians of the bootstrap projections, respectively. The blue error bands indicate 10^{th} and 90^{th} percentiles of the bootstrap trials.

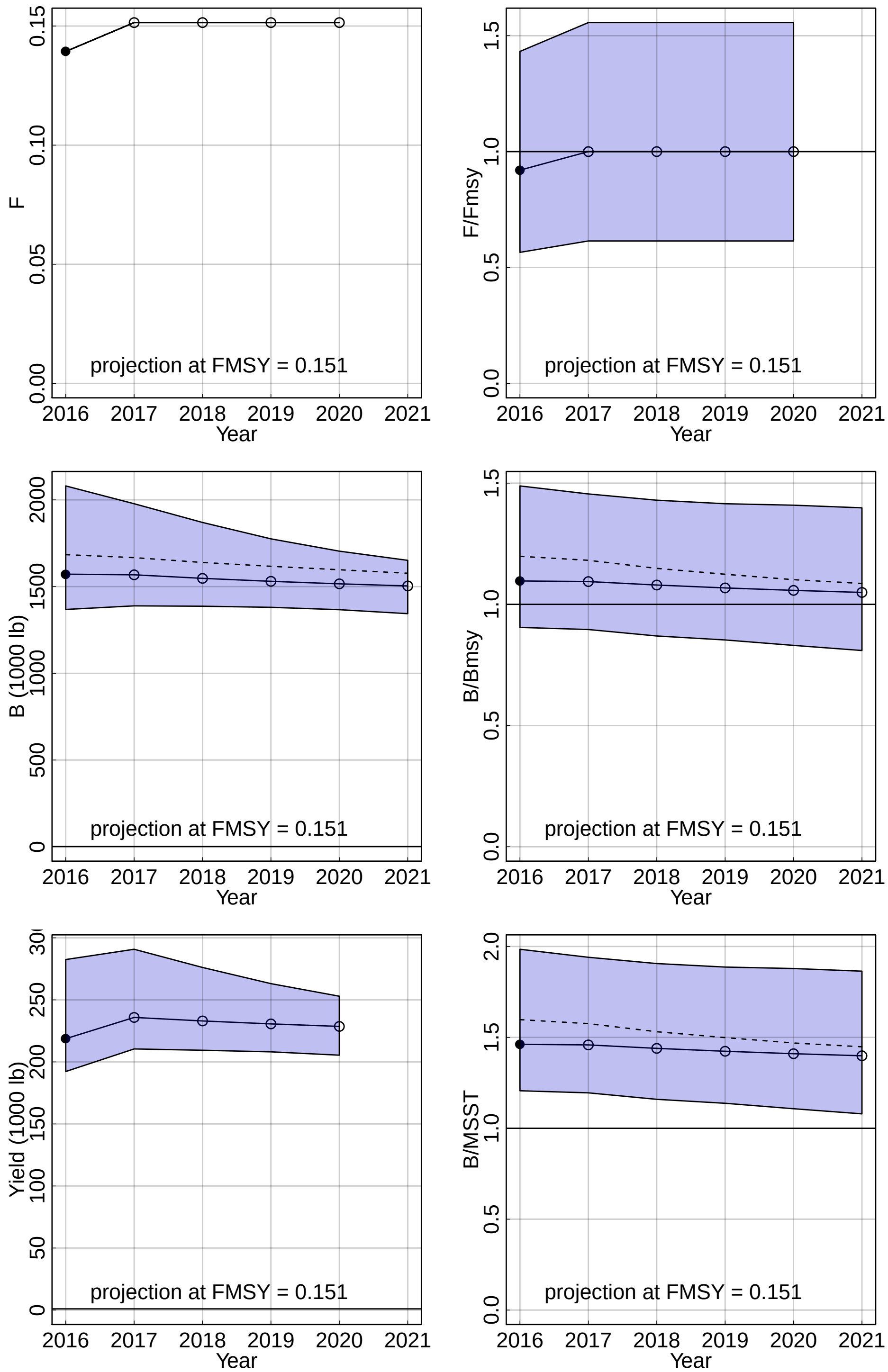


Figure A11. Plots of F, F/F_{MSY}, B, B/B_{MSY}, Y, and B/MSST for five year projections from ASPIC for the South Atlantic region with F set at F_{current} beginning the year after the terminal year of the assessment. Solid circles represent values projected by the assessment model while open circles represent values produced by the projection code. The solid and dashed lines are the deterministic estimates and medians of the bootstrap projections, respectively. The blue error bands indicate 10^{th} and 90^{th} percentiles of the bootstrap trials.

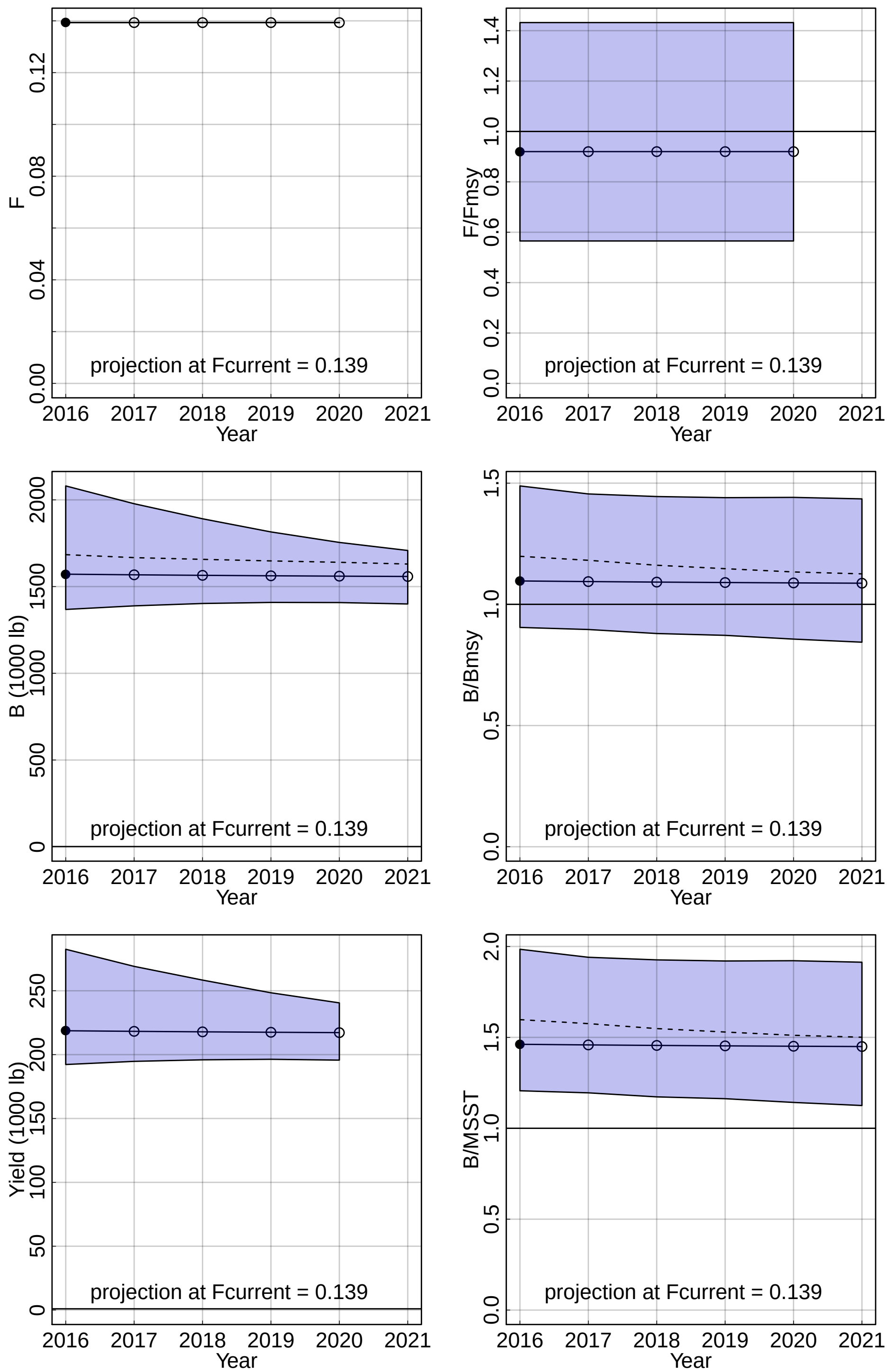


Figure A12. Plots of F, F/F_{MSY}, B, B/B_{MSY}, Y, and B/MSST for five year projections from ASPIC for the South Atlantic region with F set at F_{target} beginning the year after the terminal year of the assessment. Solid circles represent values projected by the assessment model while open circles represent values produced by the projection code. The solid and dashed lines are the deterministic estimates and medians of the bootstrap projections, respectively. The blue error bands indicate 10^{th} and 90^{th} percentiles of the bootstrap trials.

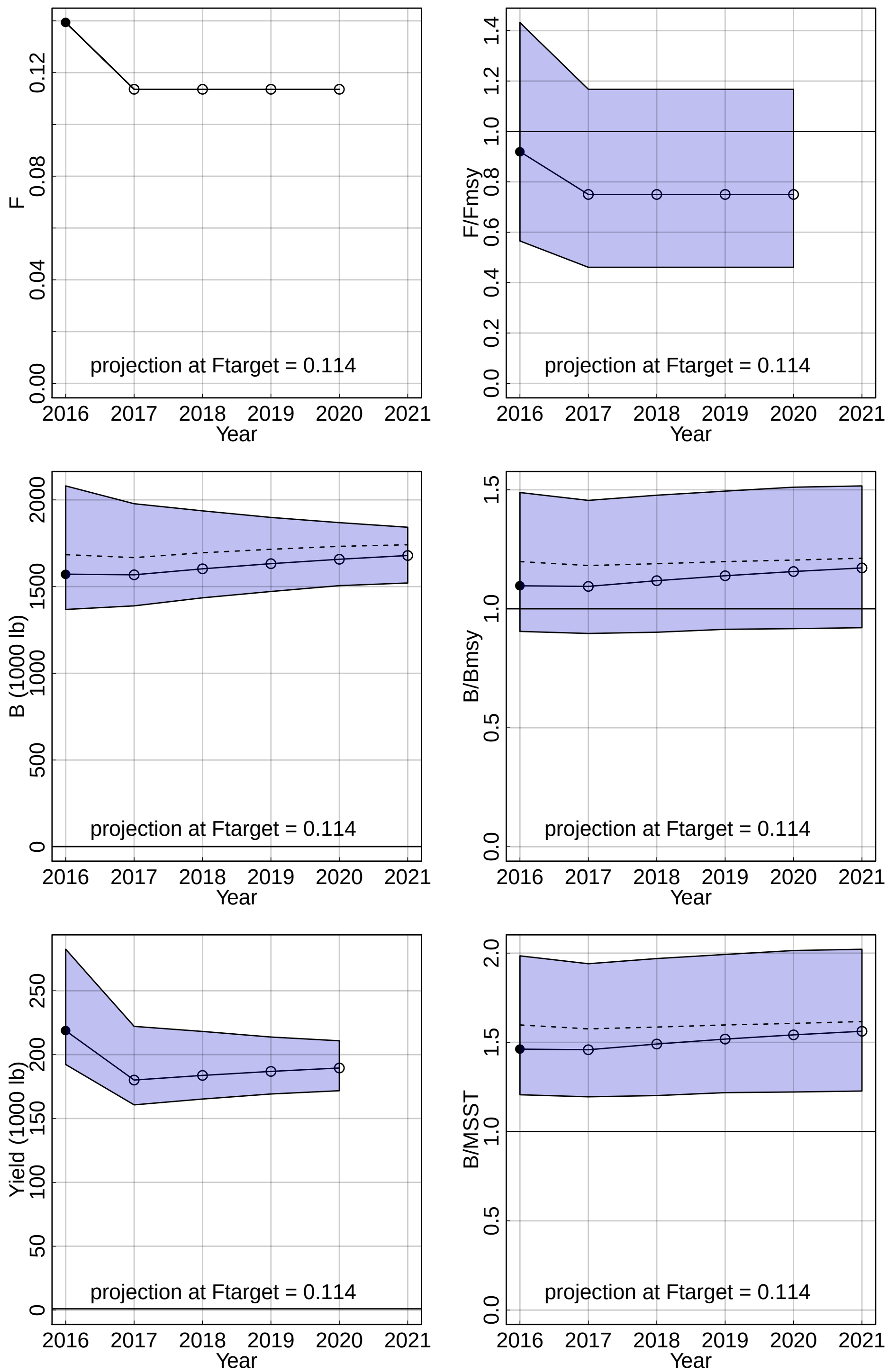


Figure A13. Observed (open circles) and estimated (solid line) annual length compositions by fleet, for the ASPM Review Workshop Reference model for the South Atlantic. In panels indicating the data set: lcomp = length compositions, cH = commercial handline, cL = commercial longline, GR = general recreational, including MRIP and headboat samples. N indicates the number of trips from which individual fish samples were taken. Four digit number in upper right corner of each panel indicates year of sampling (e.g. 1983, 1984).

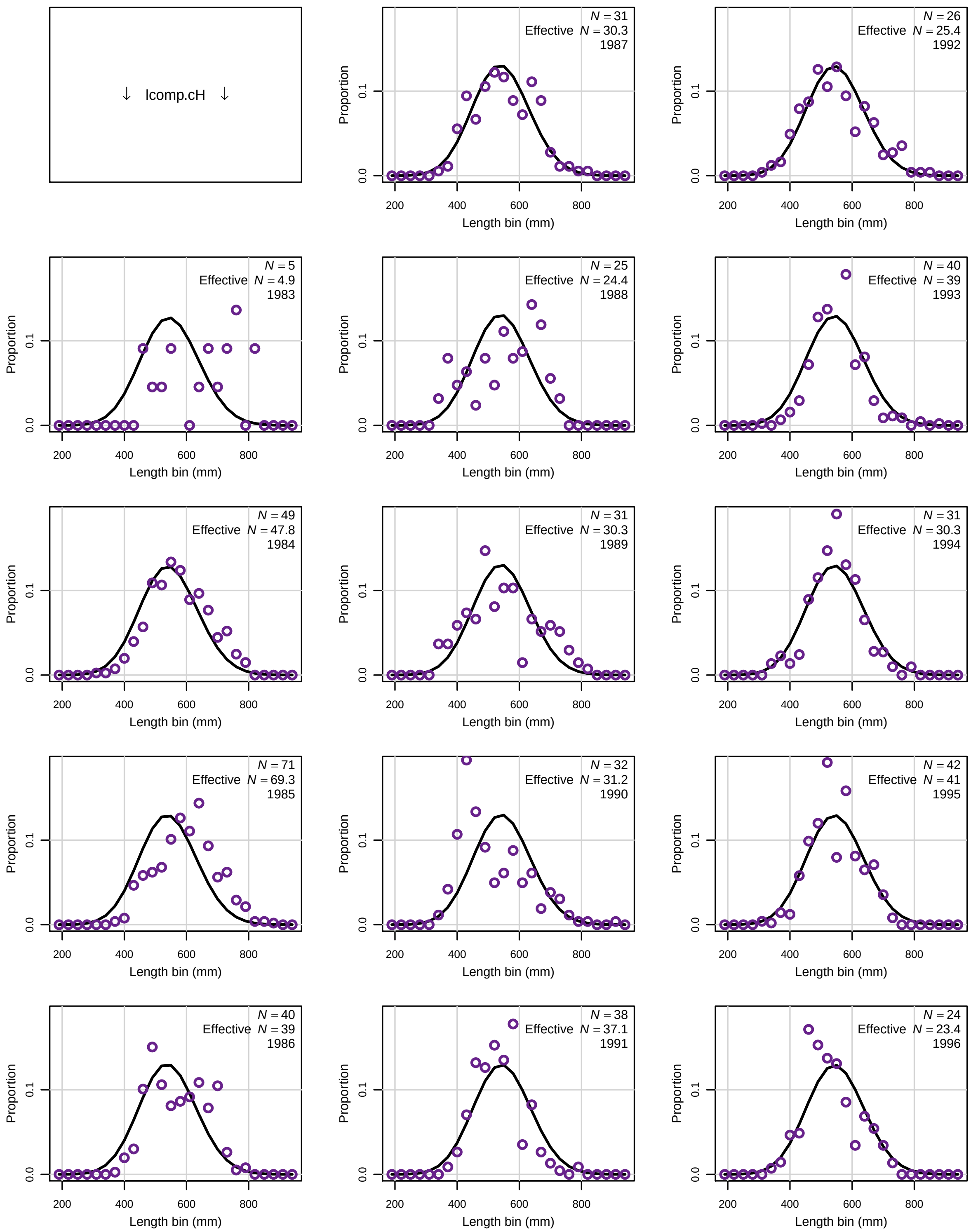


Figure A13. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet, for the ASPM Review Workshop Reference model for the South Atlantic.

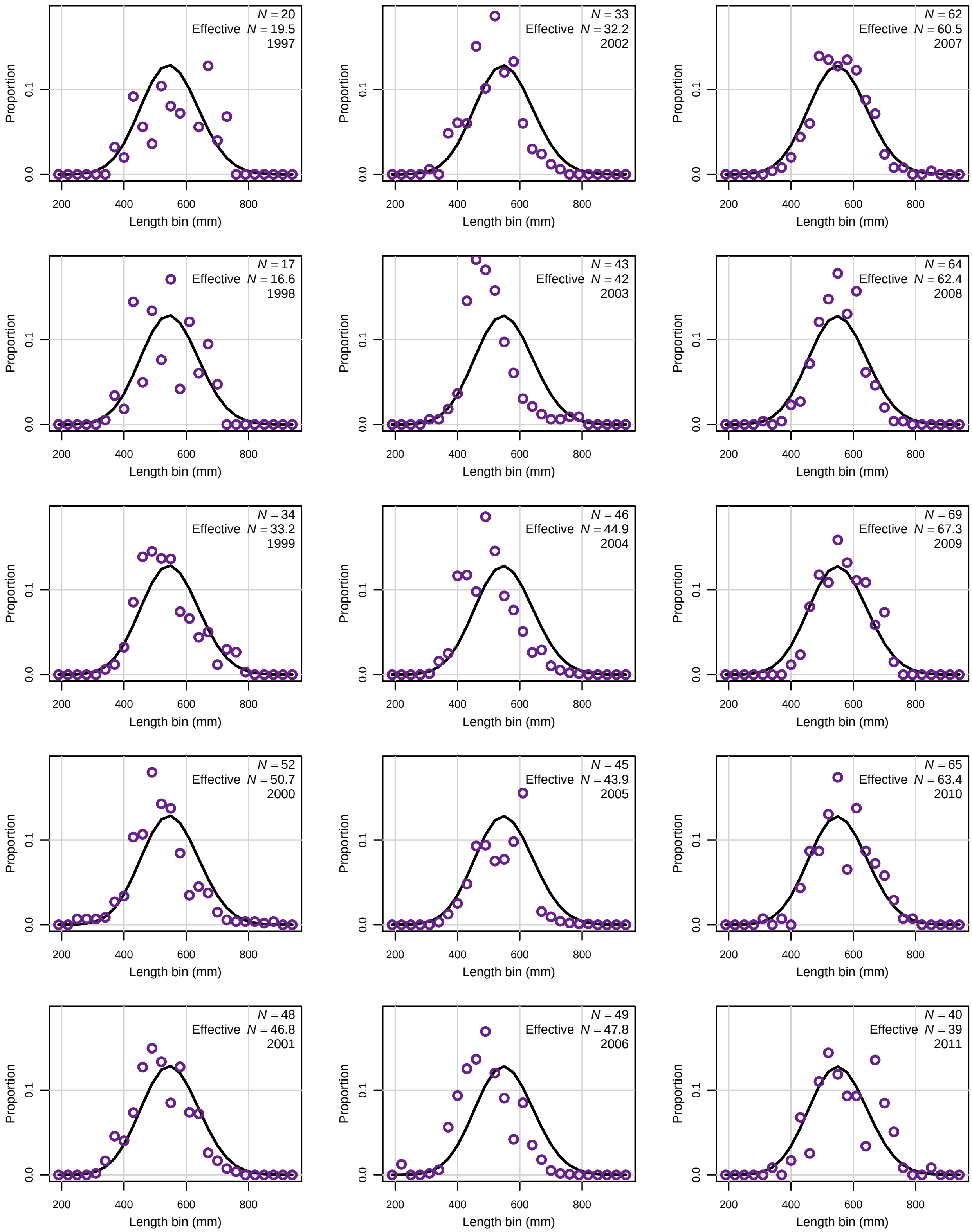


Figure A13. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet, for the ASPM Review Workshop Reference model for the South Atlantic.

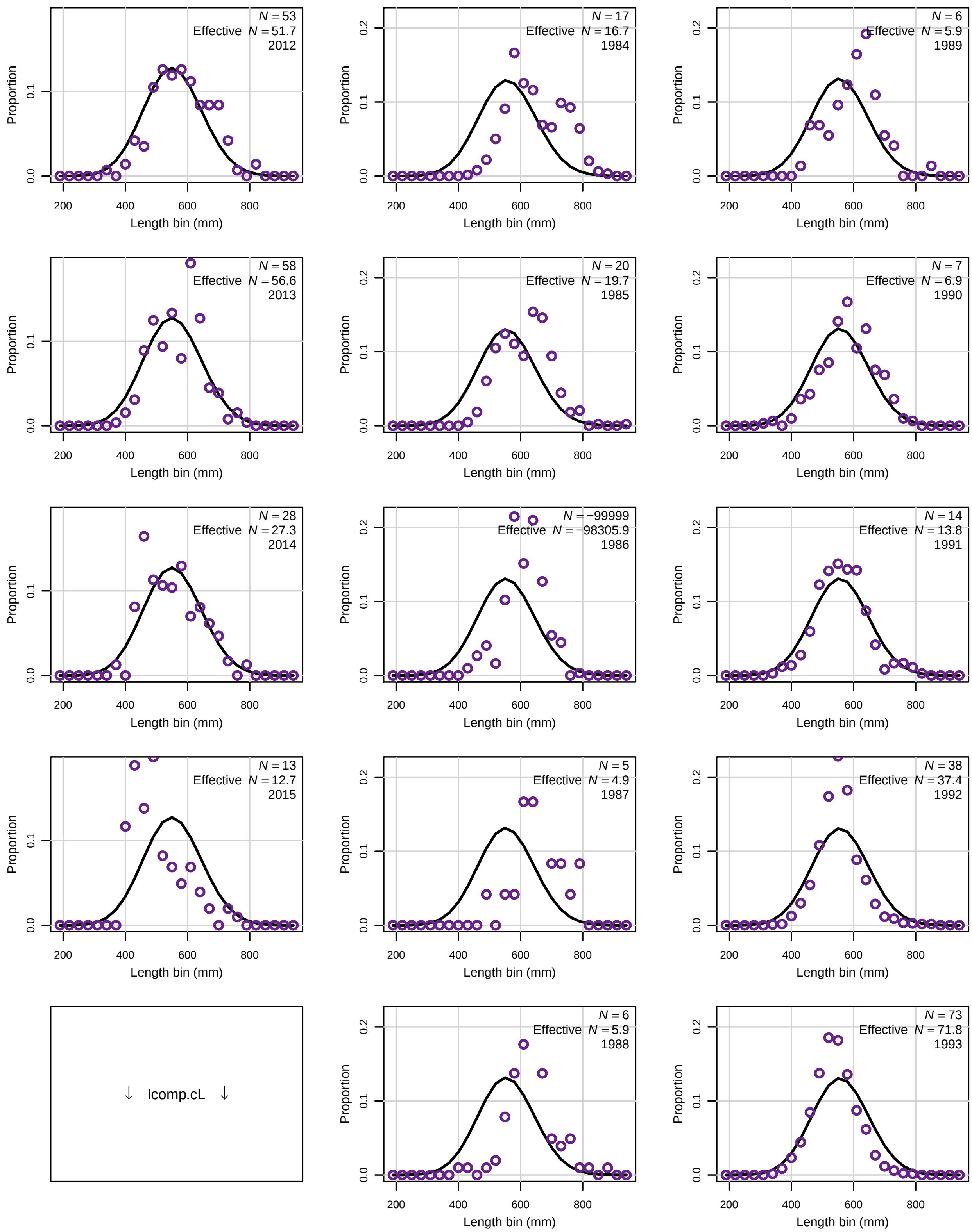


Figure A13. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet, for the ASPM Review Workshop Reference model for the South Atlantic.

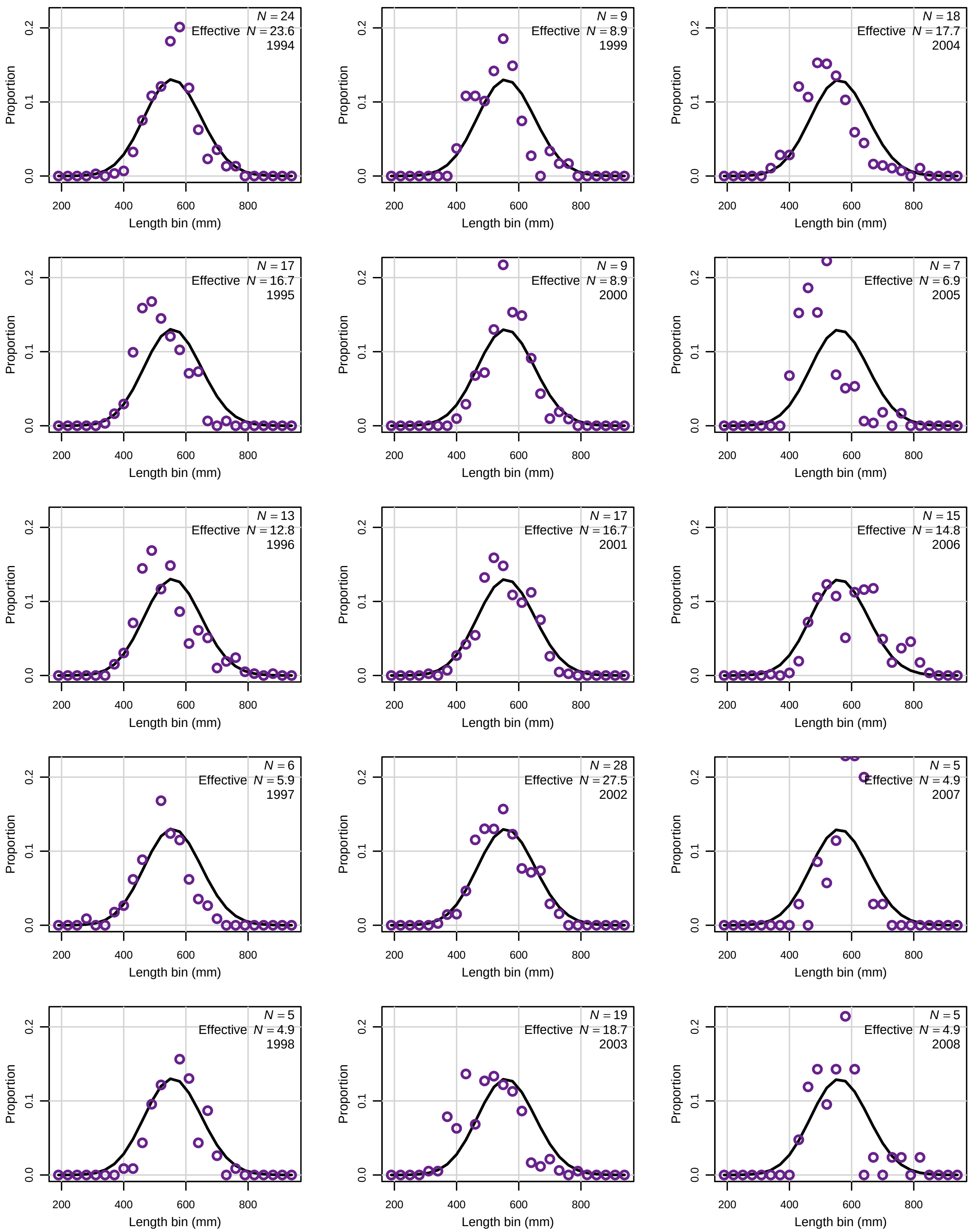


Figure A13. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet, for the ASPM Review Workshop Reference model for the South Atlantic.

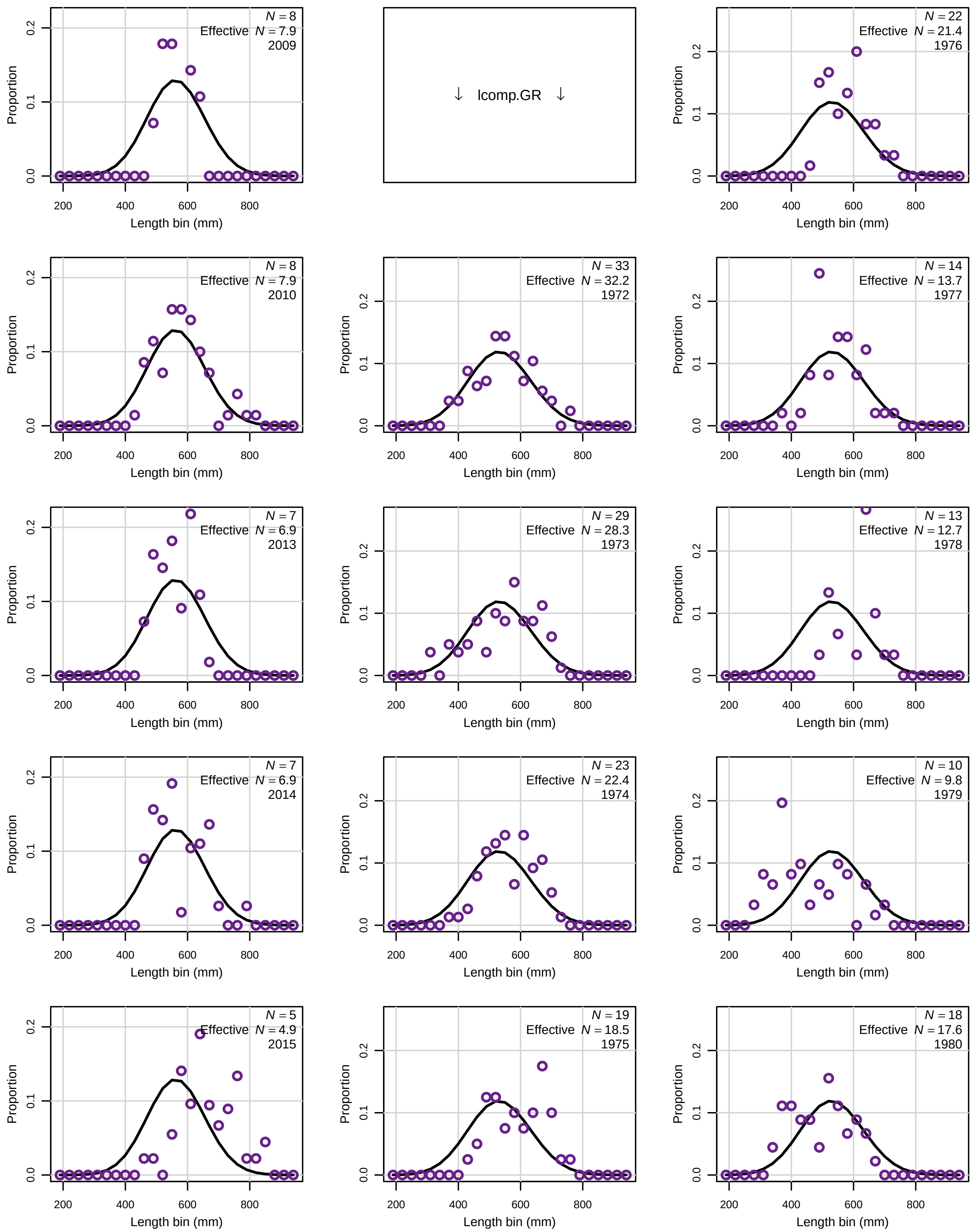


Figure A13. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet, for the ASPM Review Workshop Reference model for the South Atlantic.

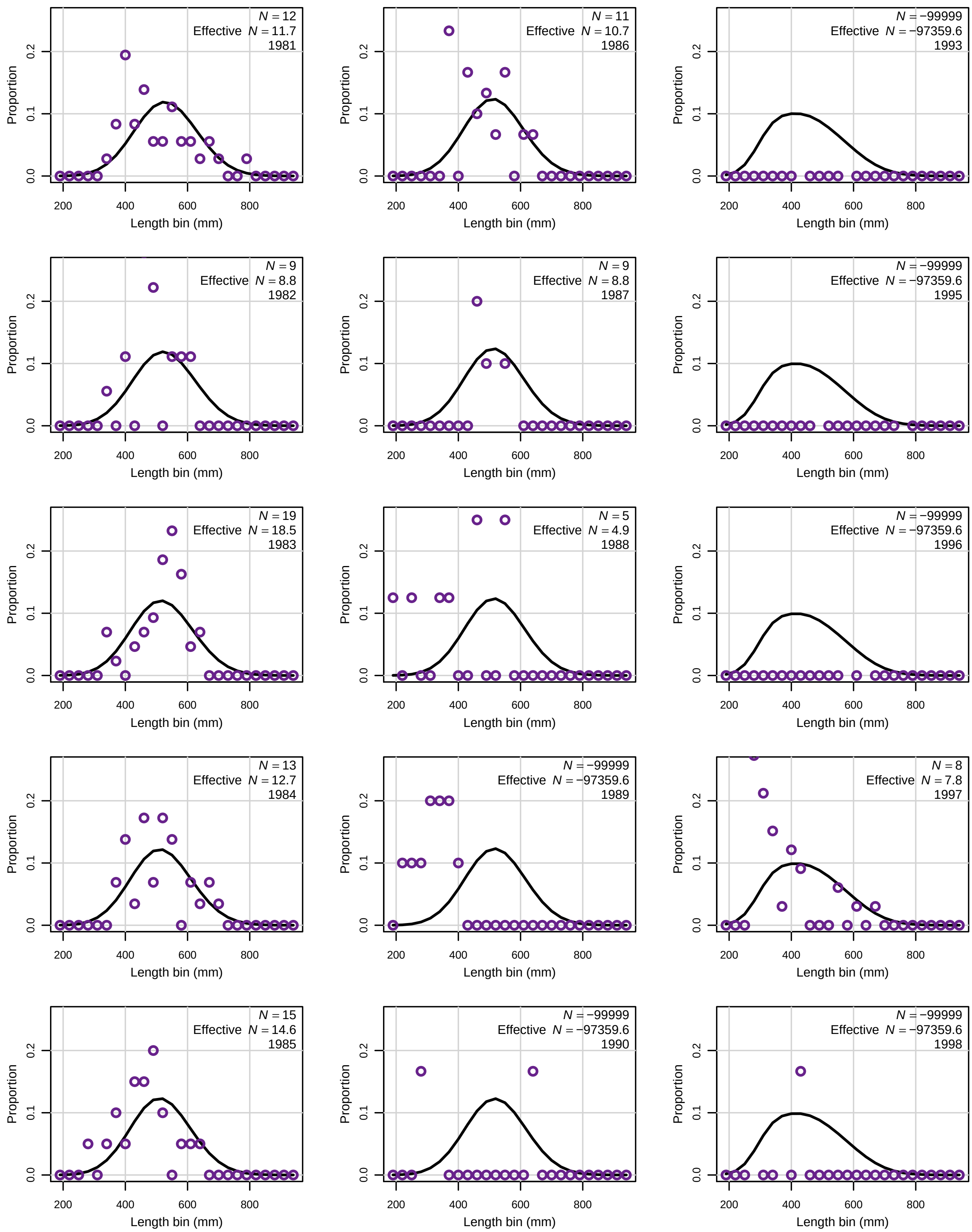


Figure A13. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet, for the ASPM Review Workshop Reference model for the South Atlantic.

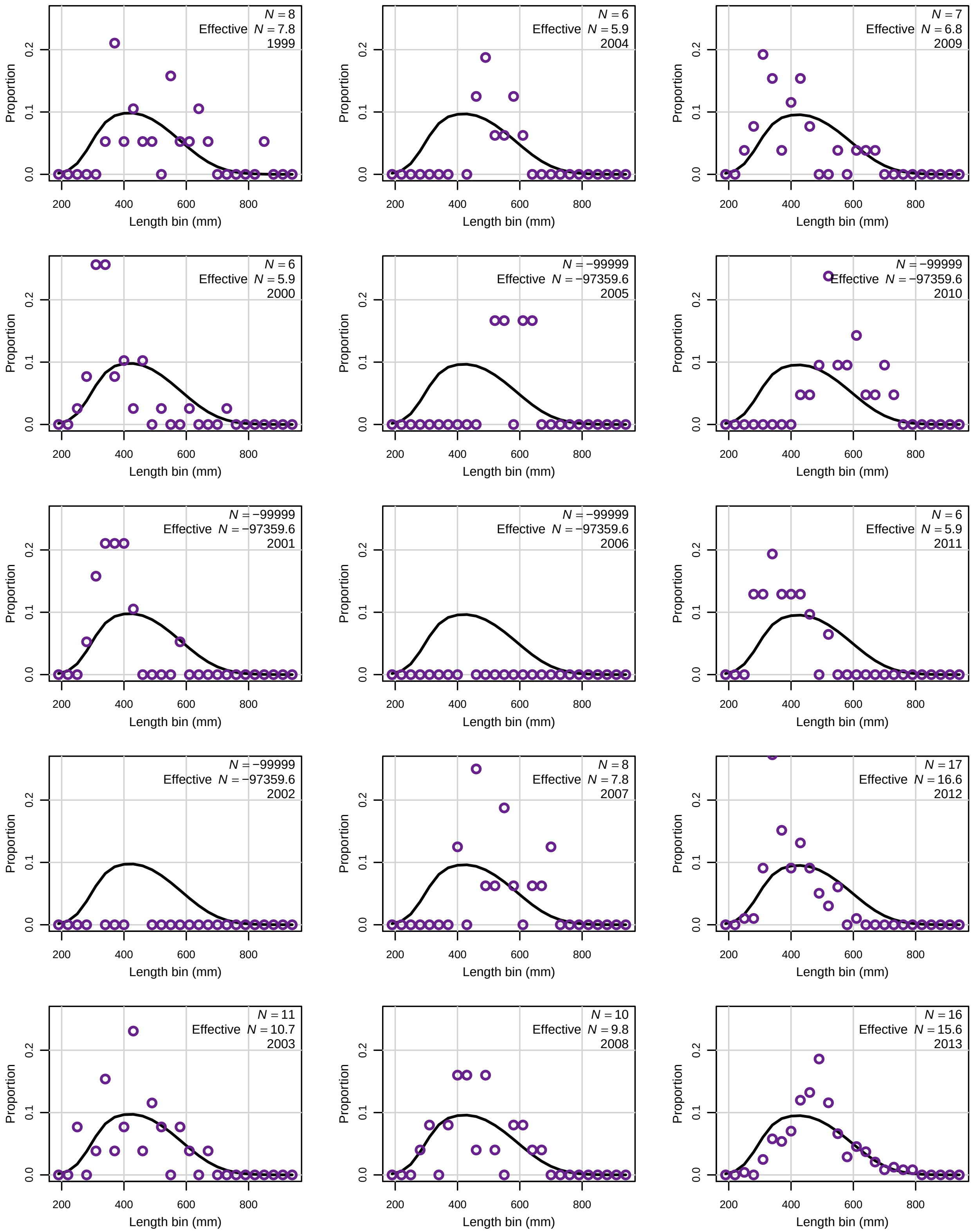


Figure A13. (cont.) Observed (open circles) and estimated (solid line) annual length compositions by fleet, for the ASPM Review Workshop Reference model for the South Atlantic.

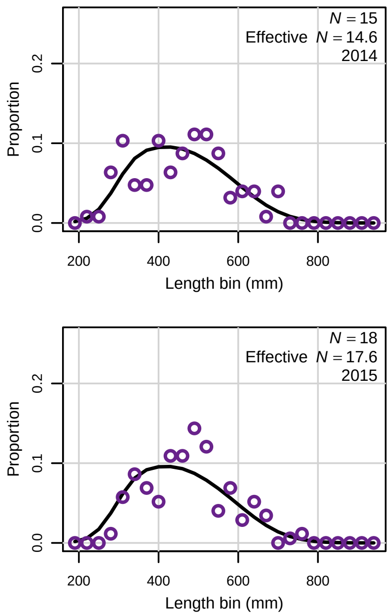


Figure A14. Observed (open circles) and estimated (line, solid circles) combined commercial handline and commercial 'other' landings and discards (1000 lb whole weight), for the ASPM Review Workshop Reference model for the South Atlantic.

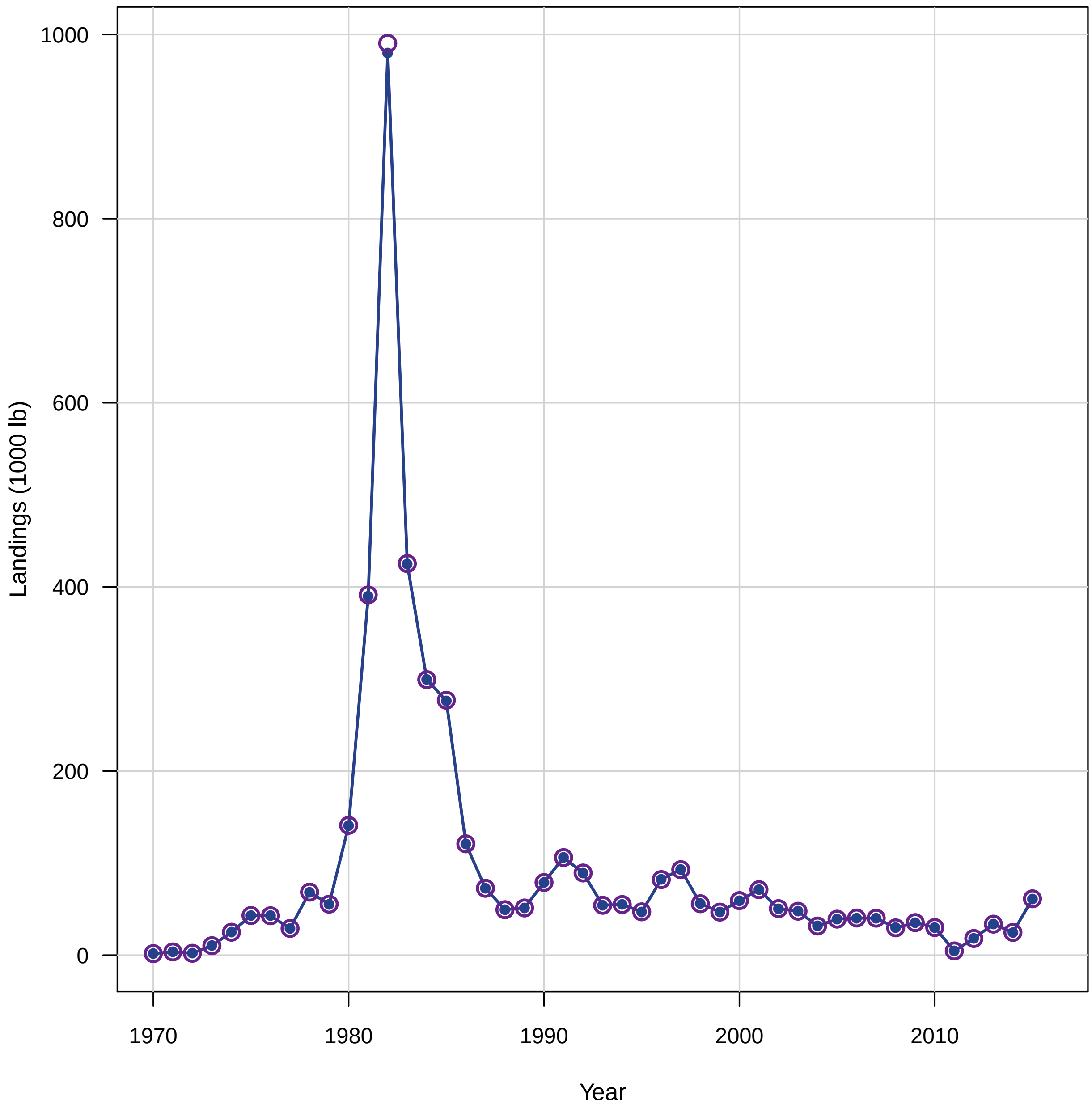


Figure A15. Observed (open circles) and estimated (line, solid circles) commercial longline landings and discards (1000 lb whole weight), for the ASPM Review Workshop Reference model for the South Atlantic.

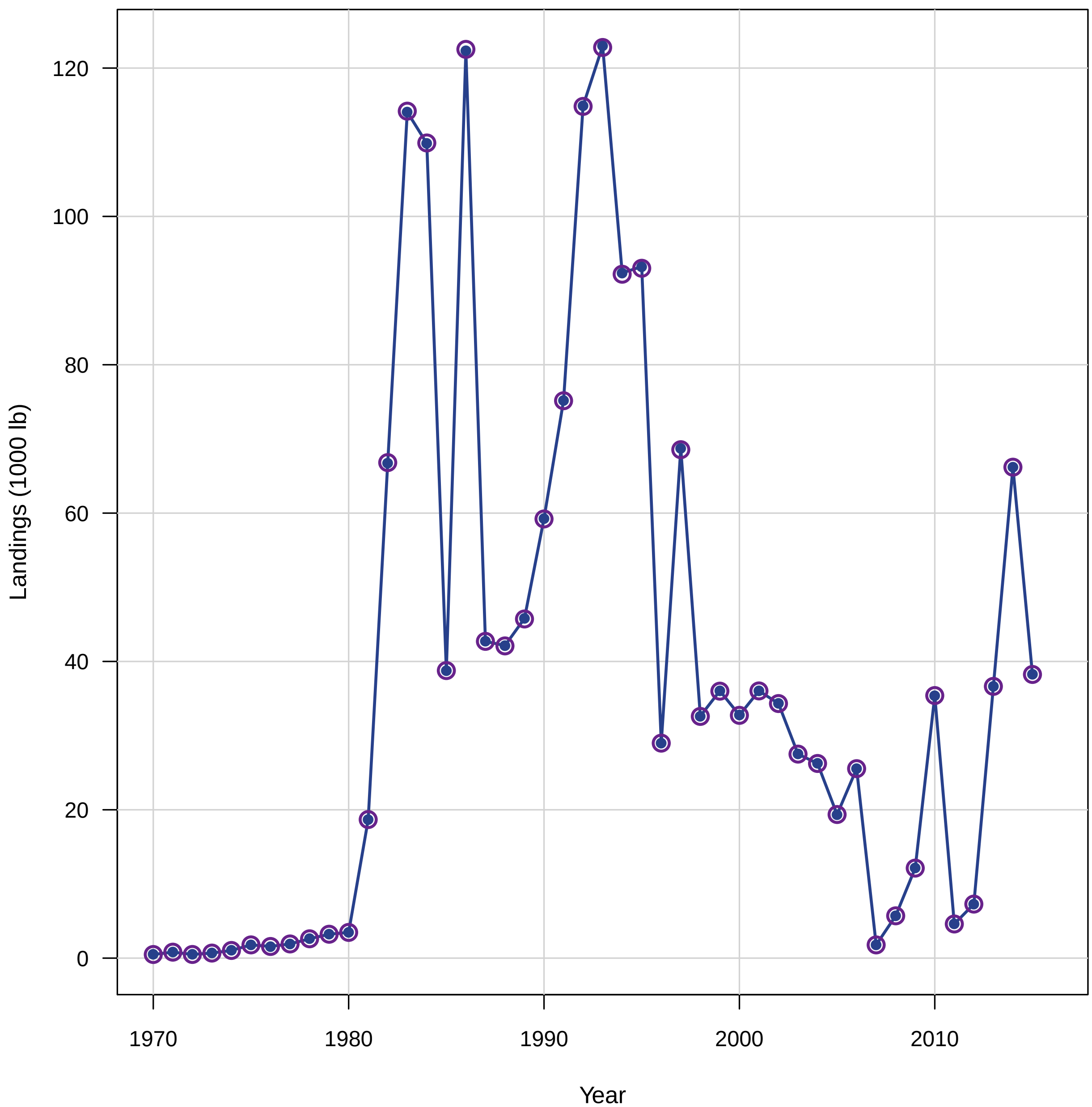


Figure A16. Observed (open circles) and estimated (line, solid circles) combined general recreational (headboat and MRIP) landings and discards (1000 fish), for the ASPM Review Workshop Reference model for the South Atlantic.

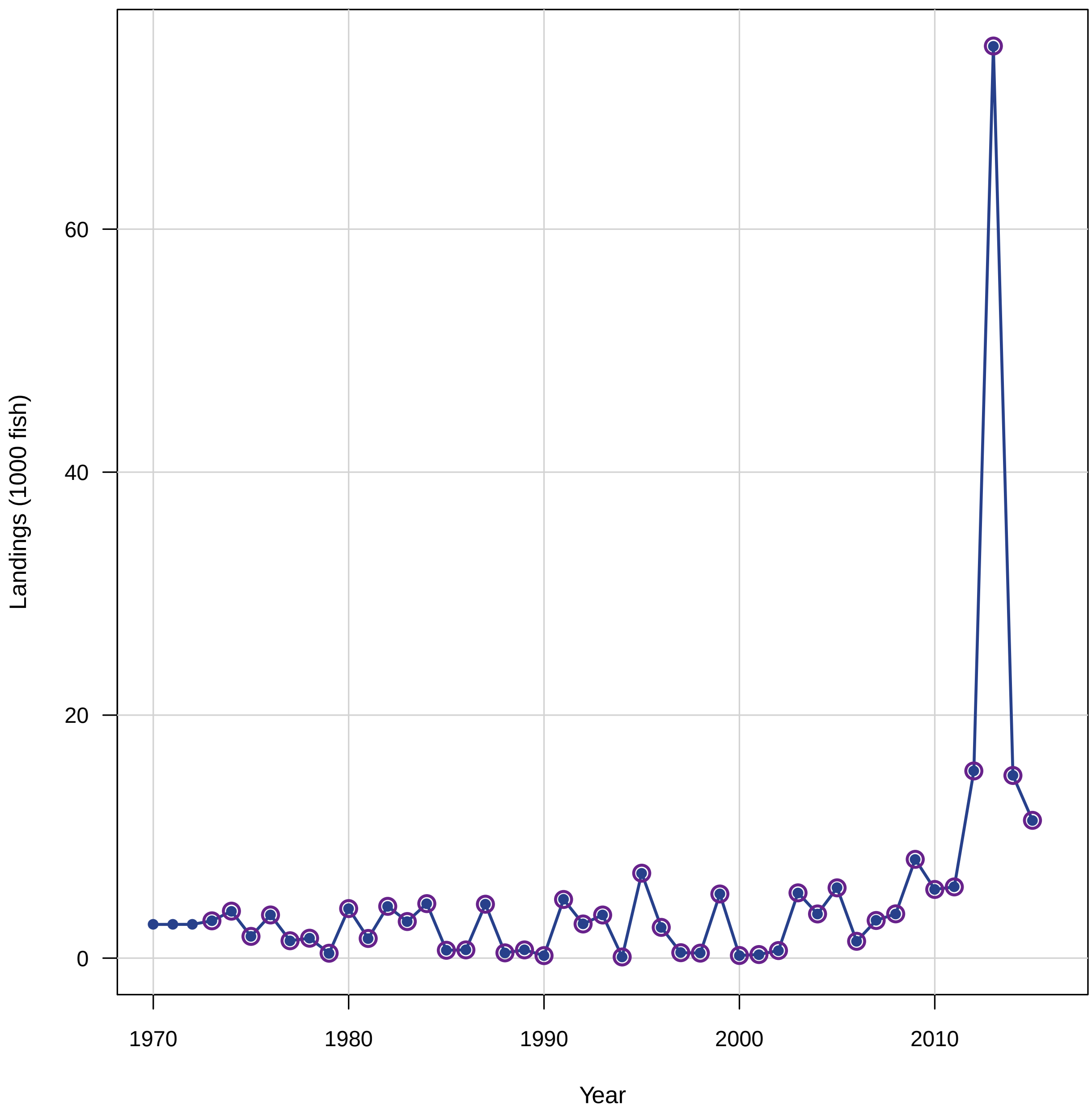


Figure A17. Observed (open circles) and estimated (line, solid circles) commercial handline abundance index, for the ASPM Review Workshop Reference model for the South Atlantic.

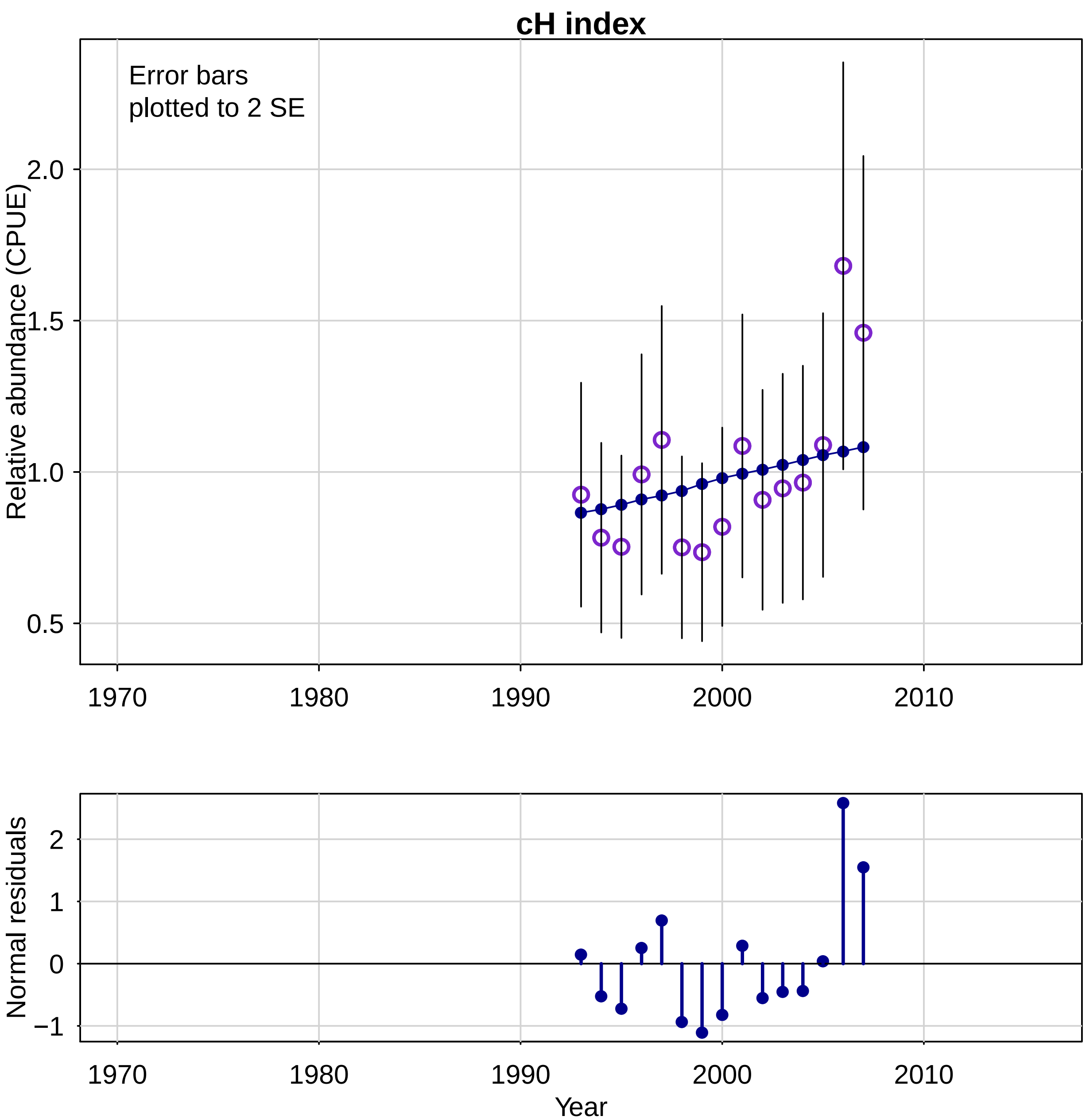


Figure A18. Observed (open circles) and estimated (line, solid circles) commercial longline abundance index, for the ASPM Review Workshop Reference model for the South Atlantic.

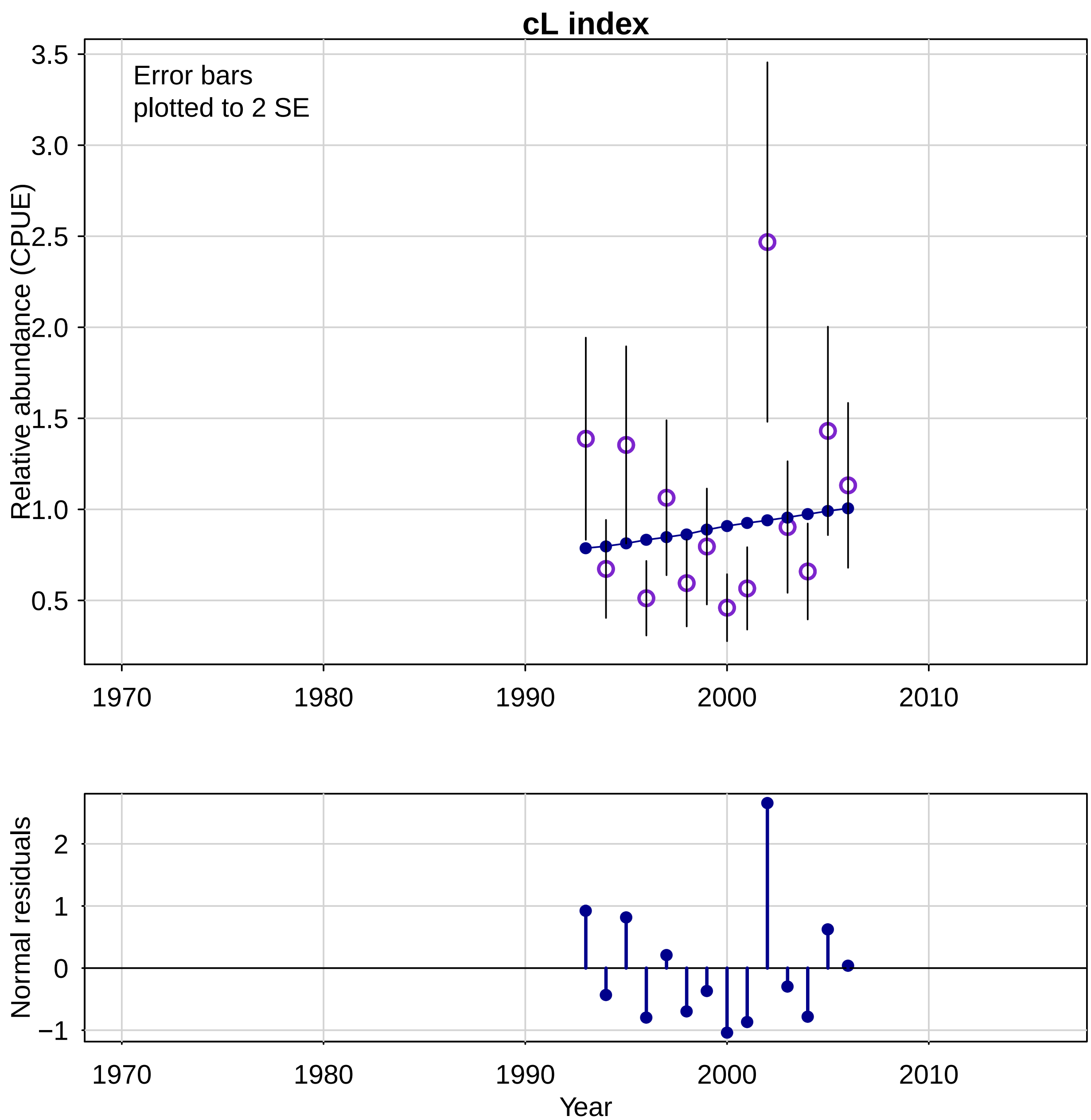


Figure A19. Observed (open circles) and estimated (line, solid circles) recreational headboat abundance index, for the ASPM Review Workshop Reference model for the South Atlantic.

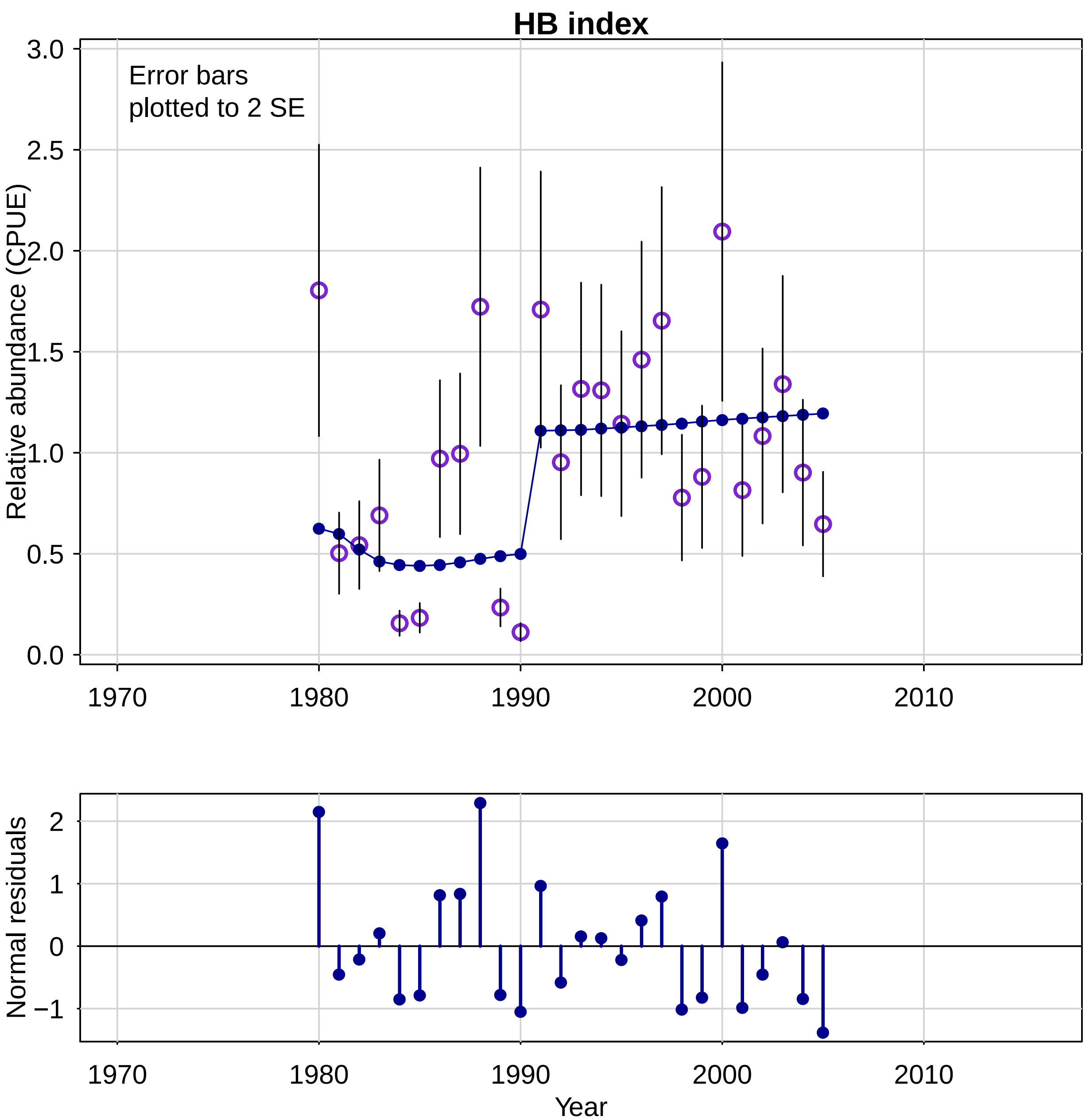


Figure A20. Length, female maturity, and reproductive output at age, for the ASPM Review Workshop Reference model for the South Atlantic. Female maturity at age was fixed in this model, but length and reproductive output at age were dependent on fitted parameters. Top panel: Mean length at age (mm) and estimated 95% confidence interval of the population. Middle panel: Female maturity by age. Bottom panel: Reproductive output by age (million eggs).

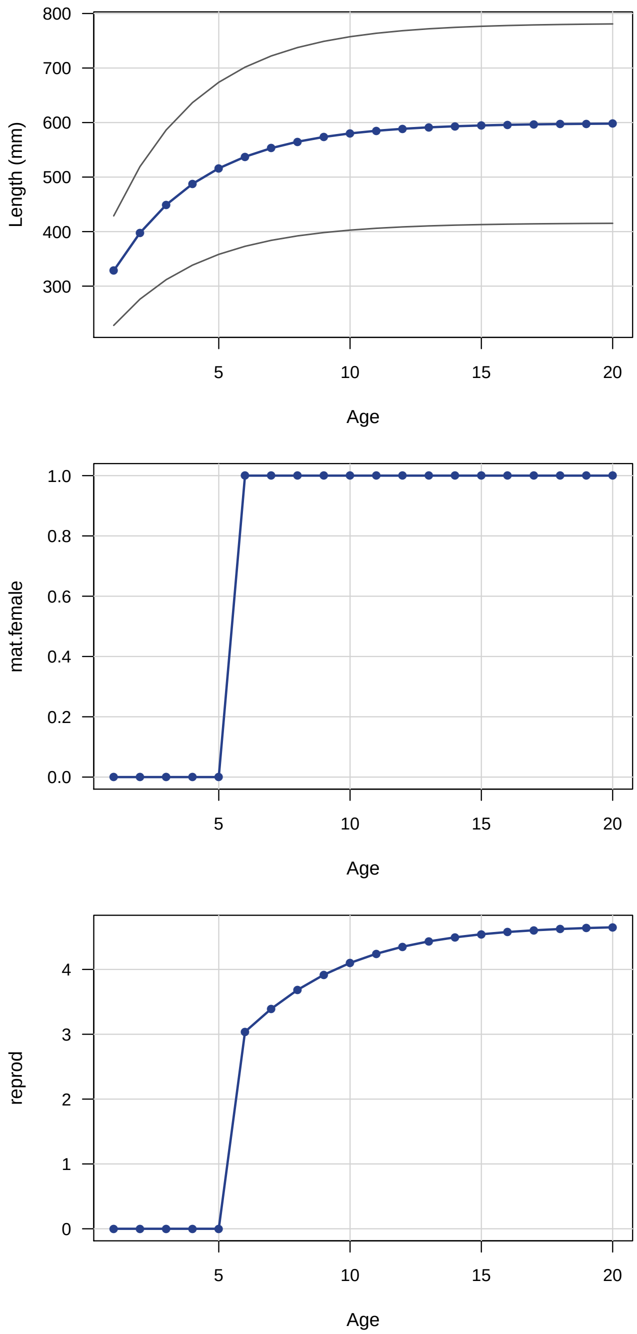


Figure A21. Estimated abundance at age at start of year, for the ASPM Review Workshop Reference model for the South Atlantic.

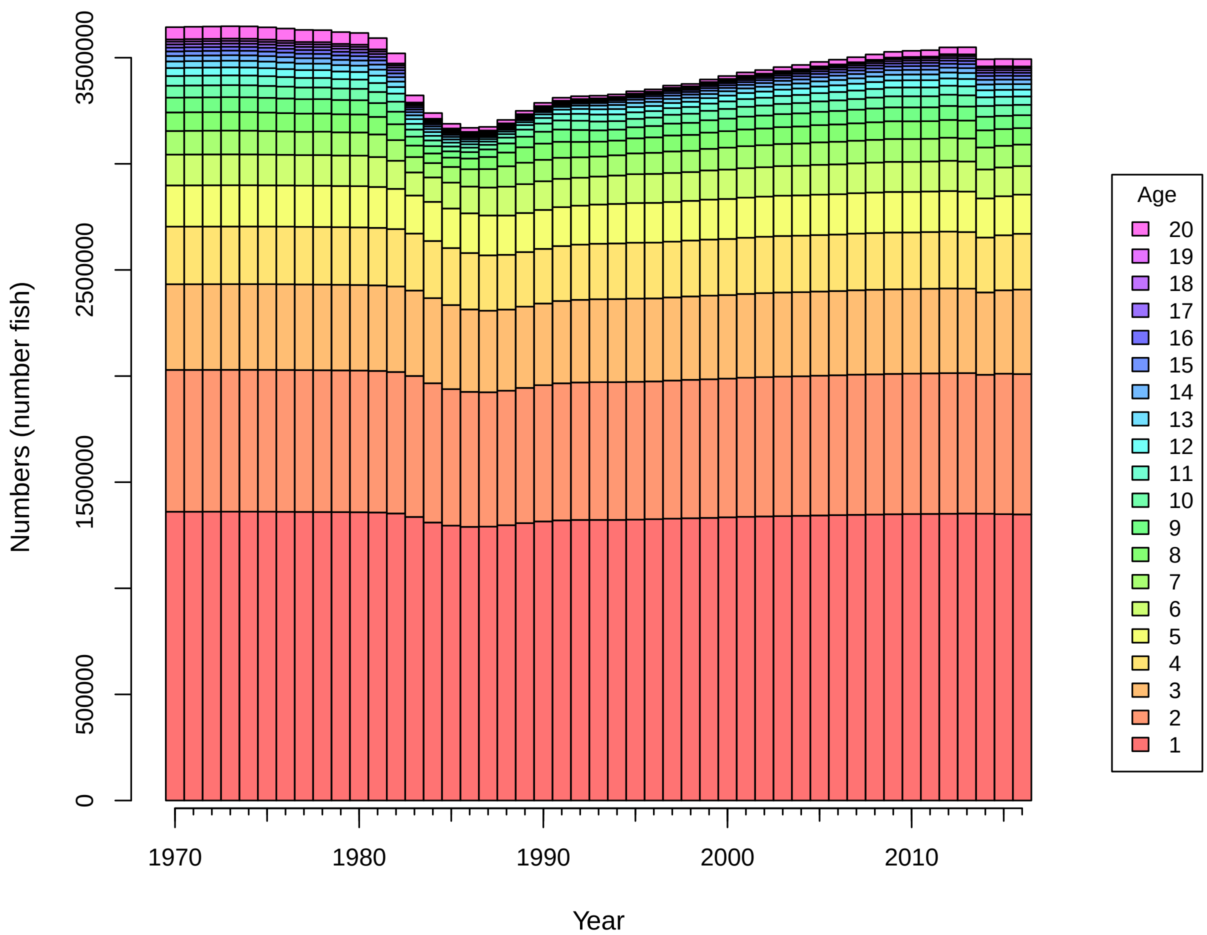


Figure A22. Estimated biomass at age at start of year, for the ASPM Review Workshop Reference model for the South Atlantic.

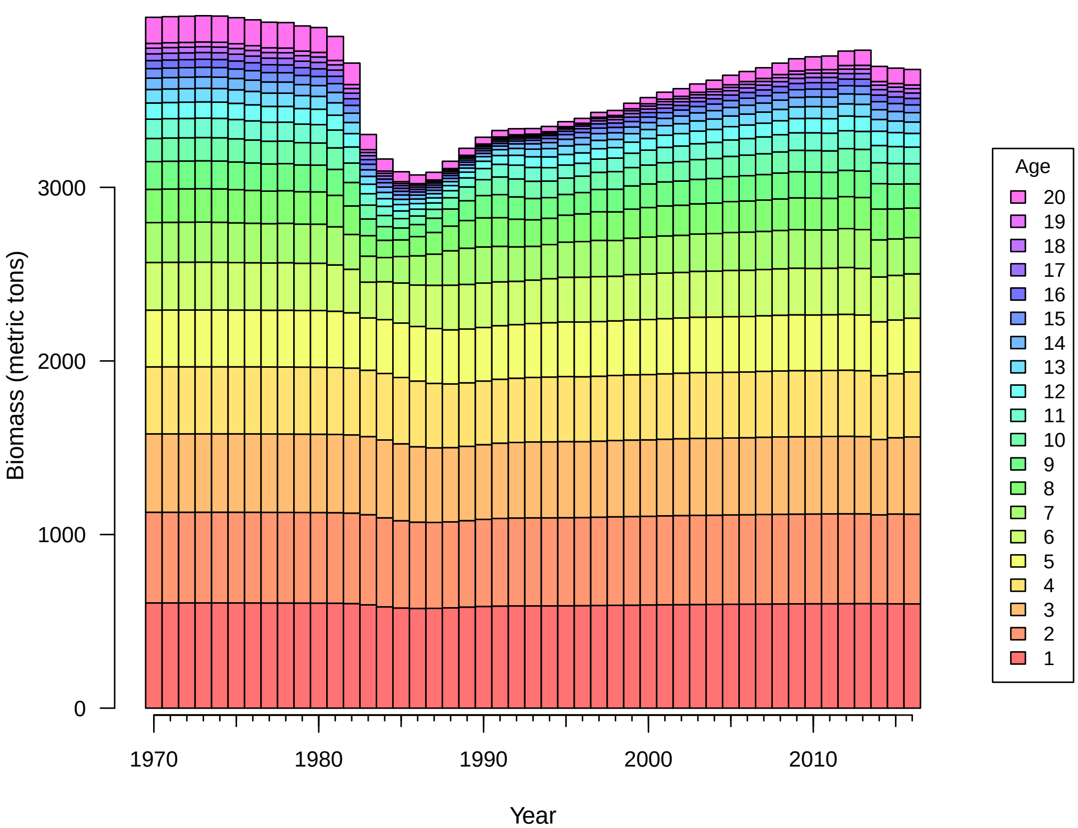


Figure A23. Estimated recruitment time series, for the ASPM Review Workshop Reference model for the South Atlantic. Top panel: Estimated recruitment of age-1 fish. Horizontal dashed line indicates R_{MSY}. Bottom panel: log recruitment residuals.

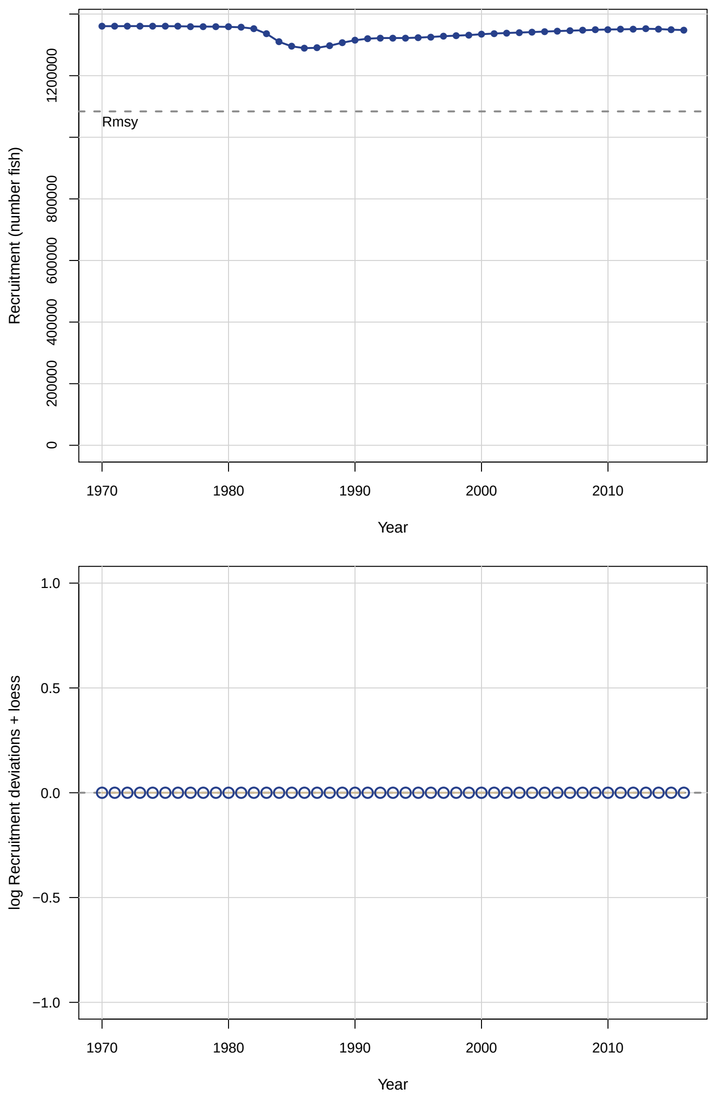


Figure A24. Estimated total biomass and spawning stock time series, for the ASPM Review Workshop Reference model for the South Atlantic. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates B_{MSY}. Bottom panel: Estimated spawning stock (million eggs) at time of peak spawning.

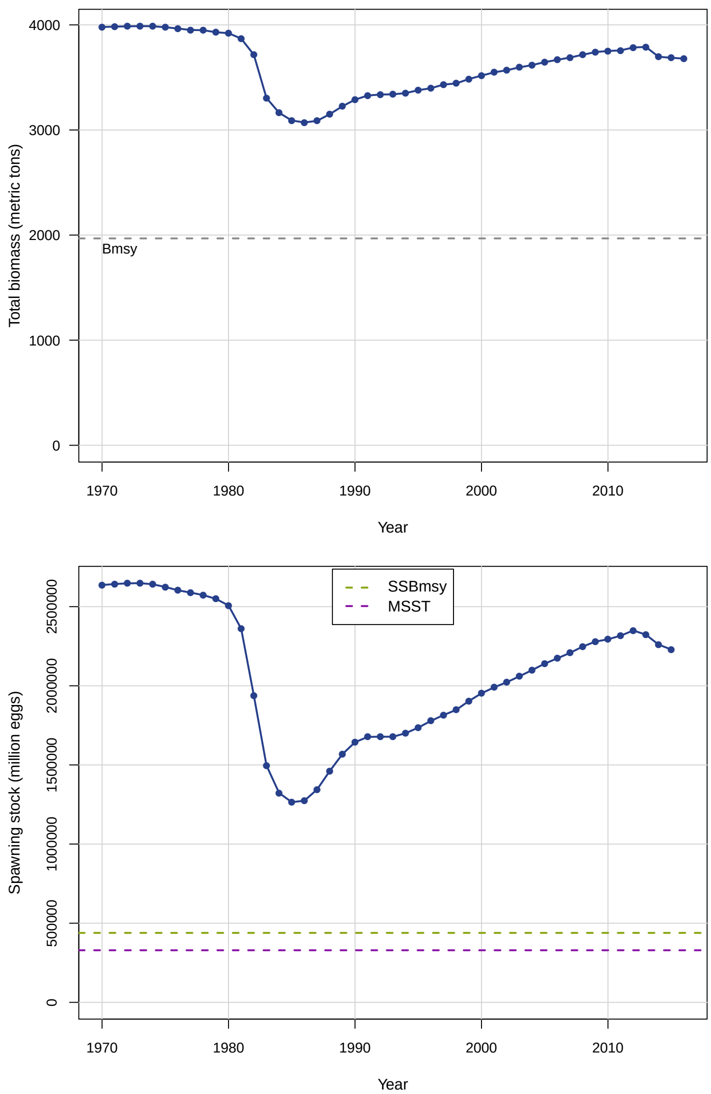


Figure A25. Selectivities of fleets 1970–2015, for the ASPM Review Workshop Reference model for the South Atlantic. Top panel: commercial handline and commercial other, including landings and discards. Middle panel: commercial longline including landings and discards. Bottom panel: general recreational (headboat and MRIP) including landings and discards.

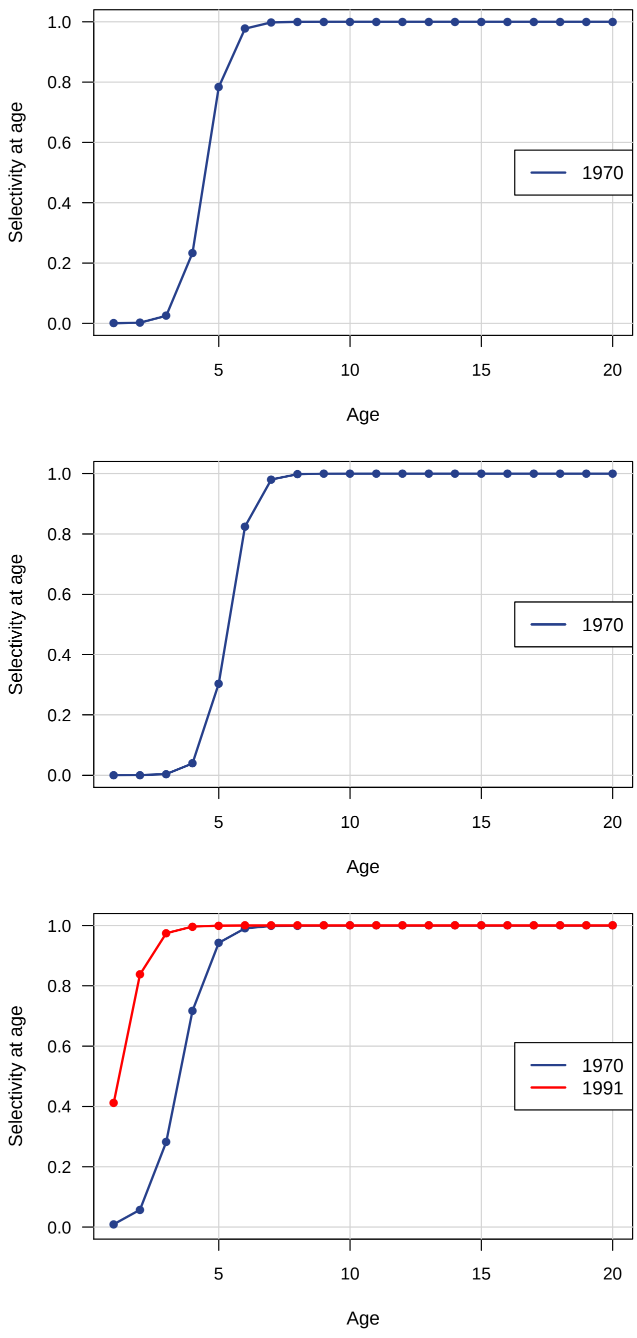


Figure A26. Average selectivity from the terminal assessment year weighted by geometric mean Fs from the last three assessment years, and used in computation of benchmarks and central-tendency projections. Corresponds to the ASPM Review Workshop Reference model for the South Atlantic.

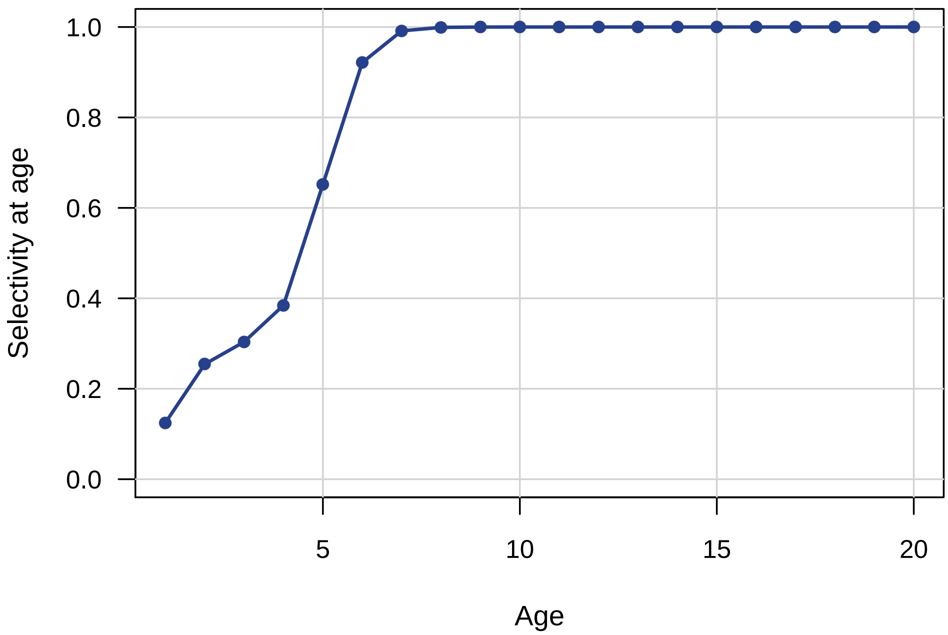


Figure A27. Estimated fully selected fishing mortality rate (per year) by fishery, for the ASPM Review Workshop Reference model for the South Atlantic. cH refers to commercial handline, cL to commercial longline, and GR to general recreational; discards included.

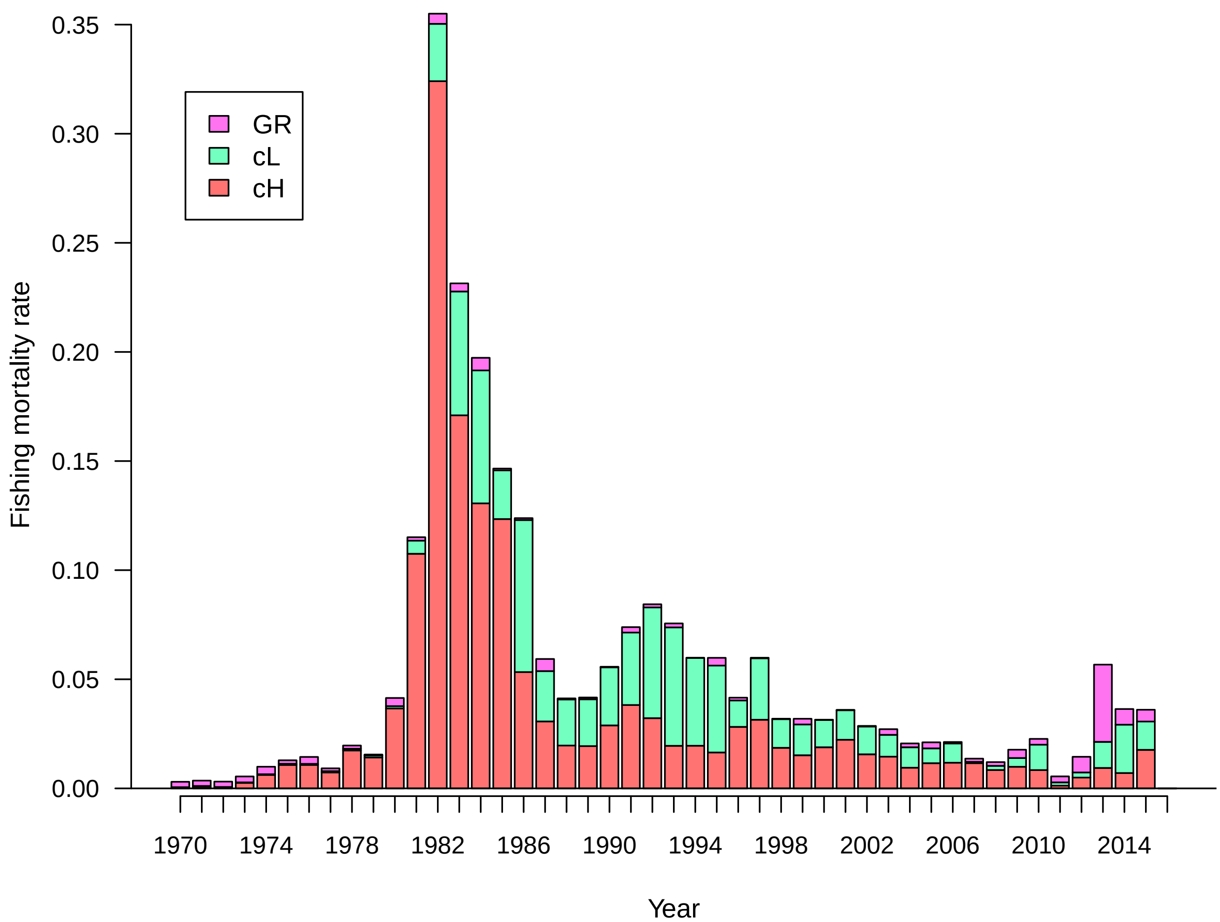


Figure A28. Estimated removals in numbers by fishery, for the ASPM Review Workshop Reference model for the South Atlantic. cH refers to commercial handline, cL to commercial longline, and GR to general recreational fleet.

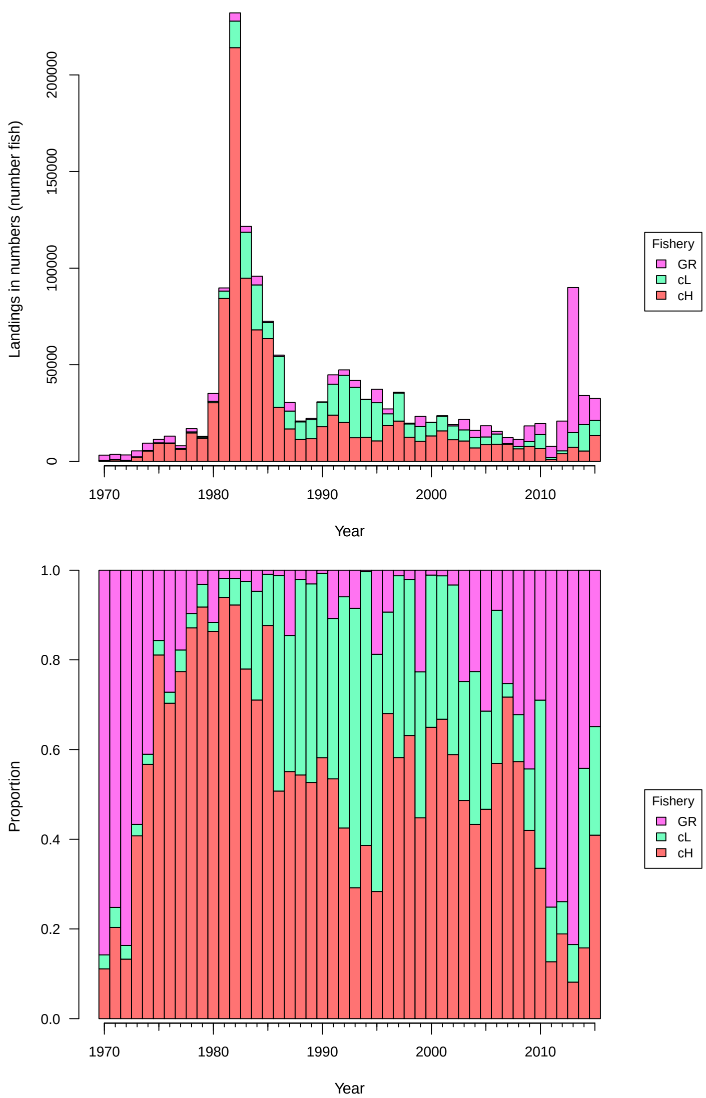


Figure A29. Beverton–Holt spawner-recruit curve for the ASPM Review Workshop Reference model for the South Atlantic. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass one year prior.

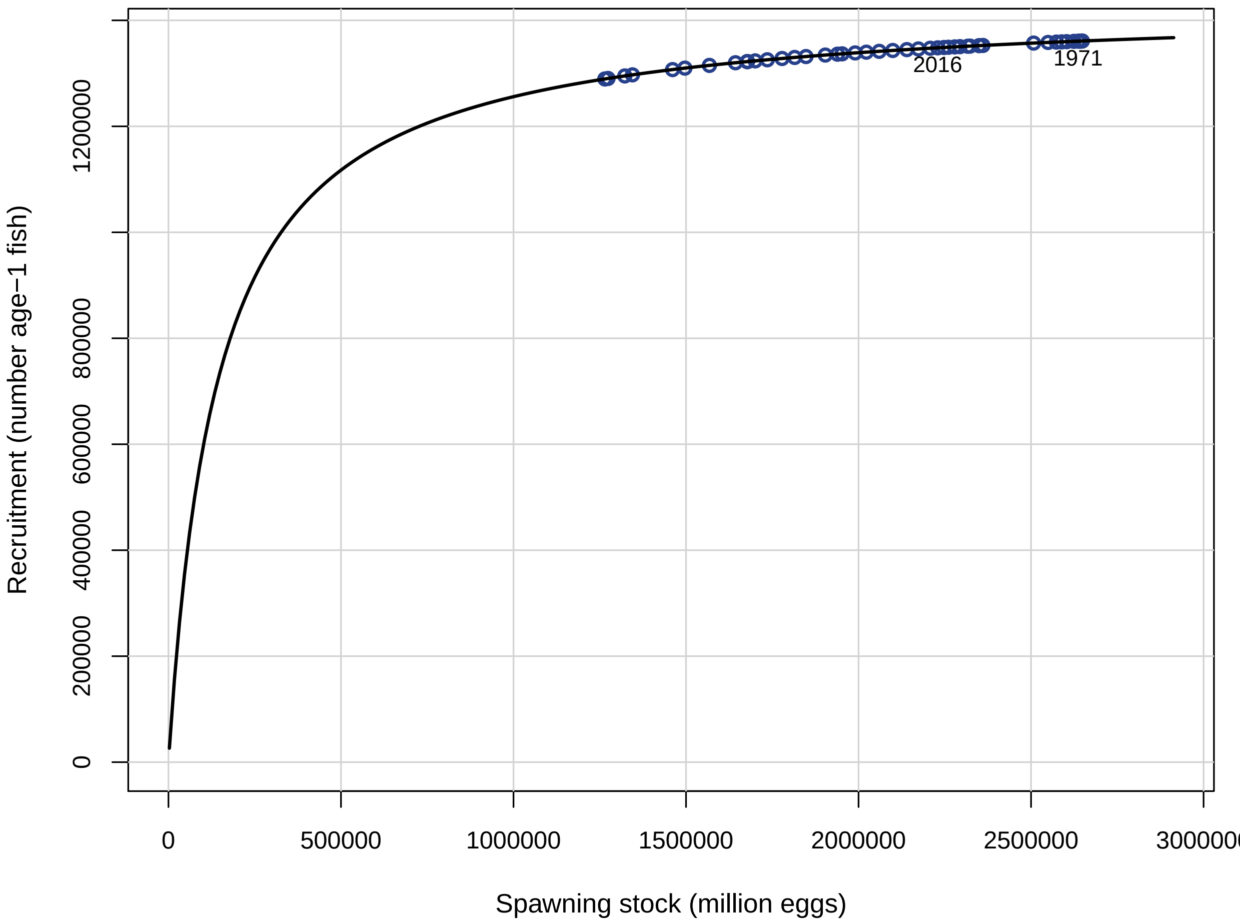


Figure A30. Yield per recruit and spawning potential ratio at F, for the ASPM Review Workshop Reference model for the South Atlantic. Top panel: yield per recruit. Bottom panel: spawning potential ratio (spawning biomass per recruit relative to that at the unfished level). Both curves are based on average selectivity. $F_{\mathrm{MSY}} = 0.319$. *from the end of the assessment period.*

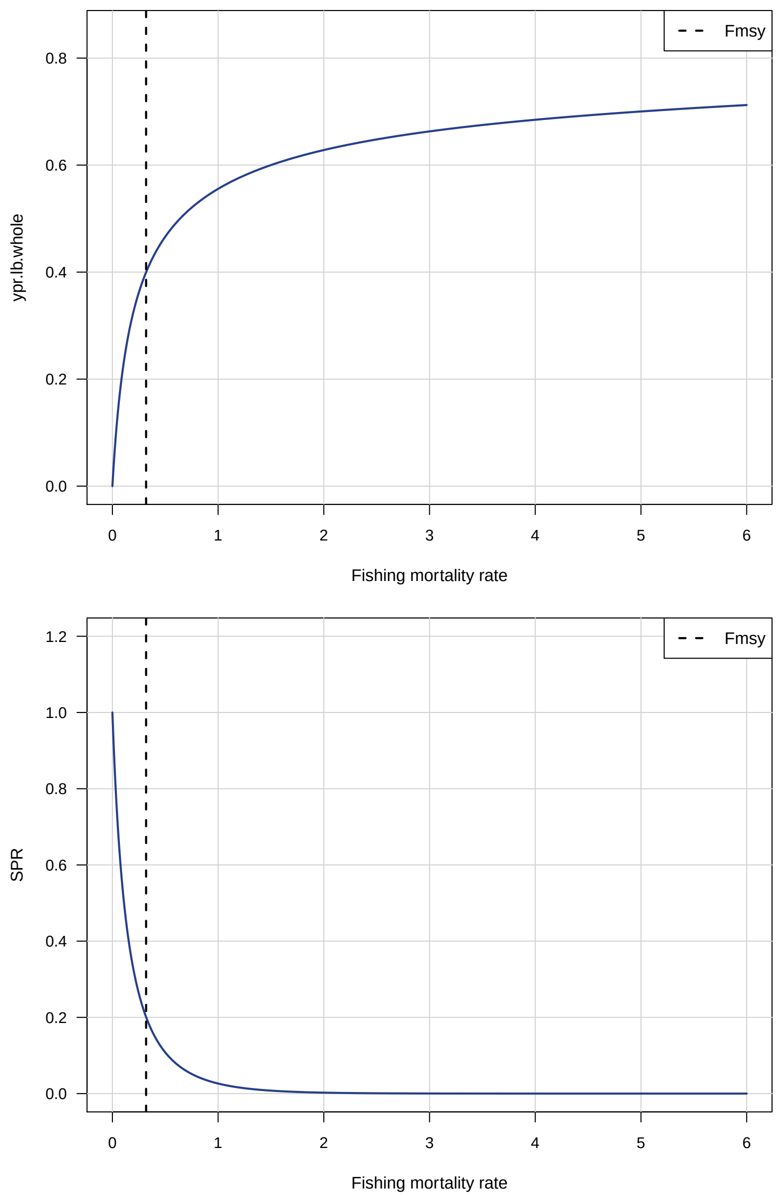


Figure A31. Equilibrium removals and spawning stock at F, for the ASPM Review Workshop Reference model for the South Atlantic. Top panel: equilibrium landings. The peak occurs where fishing rate is $F_{\mathrm{MSY}} = 0.319$ and equilibrium landings are $\mathrm{MSY} = 433$ (1000 lb). Bottom panel: equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.

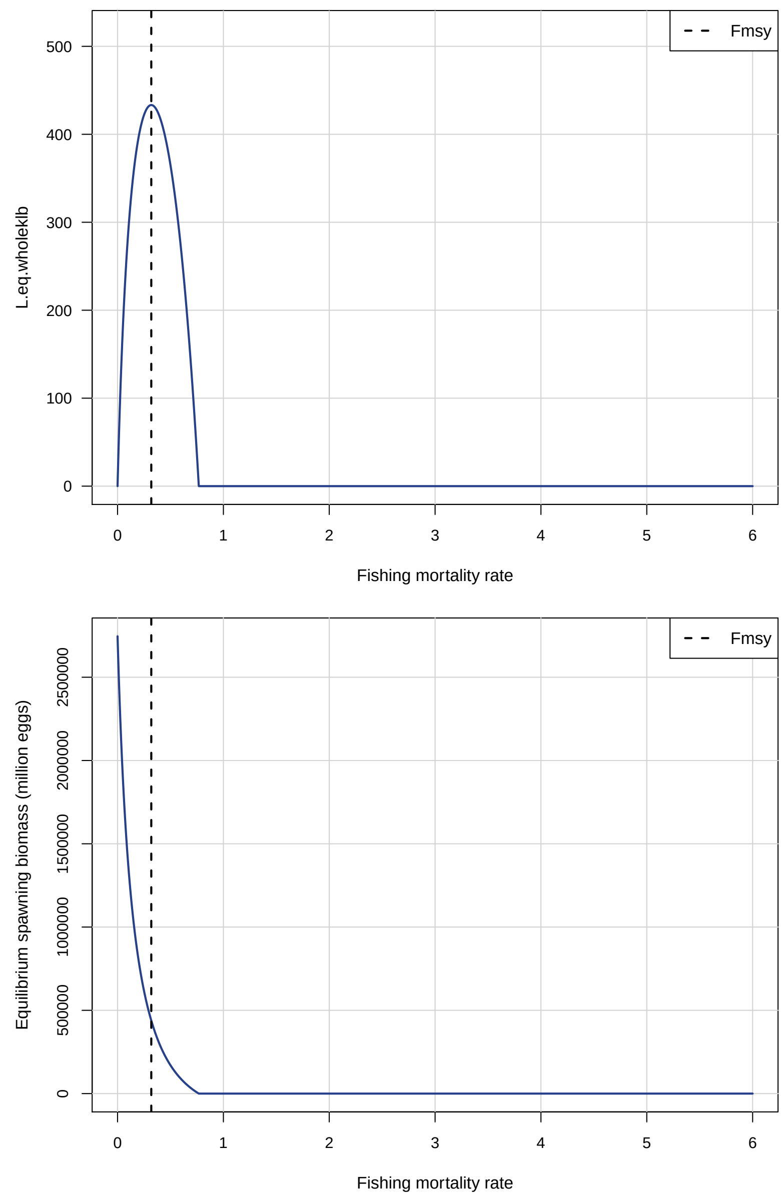


Figure A32. Probability densities of MSY*-related benchmarks from MCB analysis of the ASPM. Dotted lines represent* 5^{th} *and* 95^{th} *percentiles, dashed line represents the median of the MCB runs. Thick solid orange lines represent estimates from the RW Reference model.*

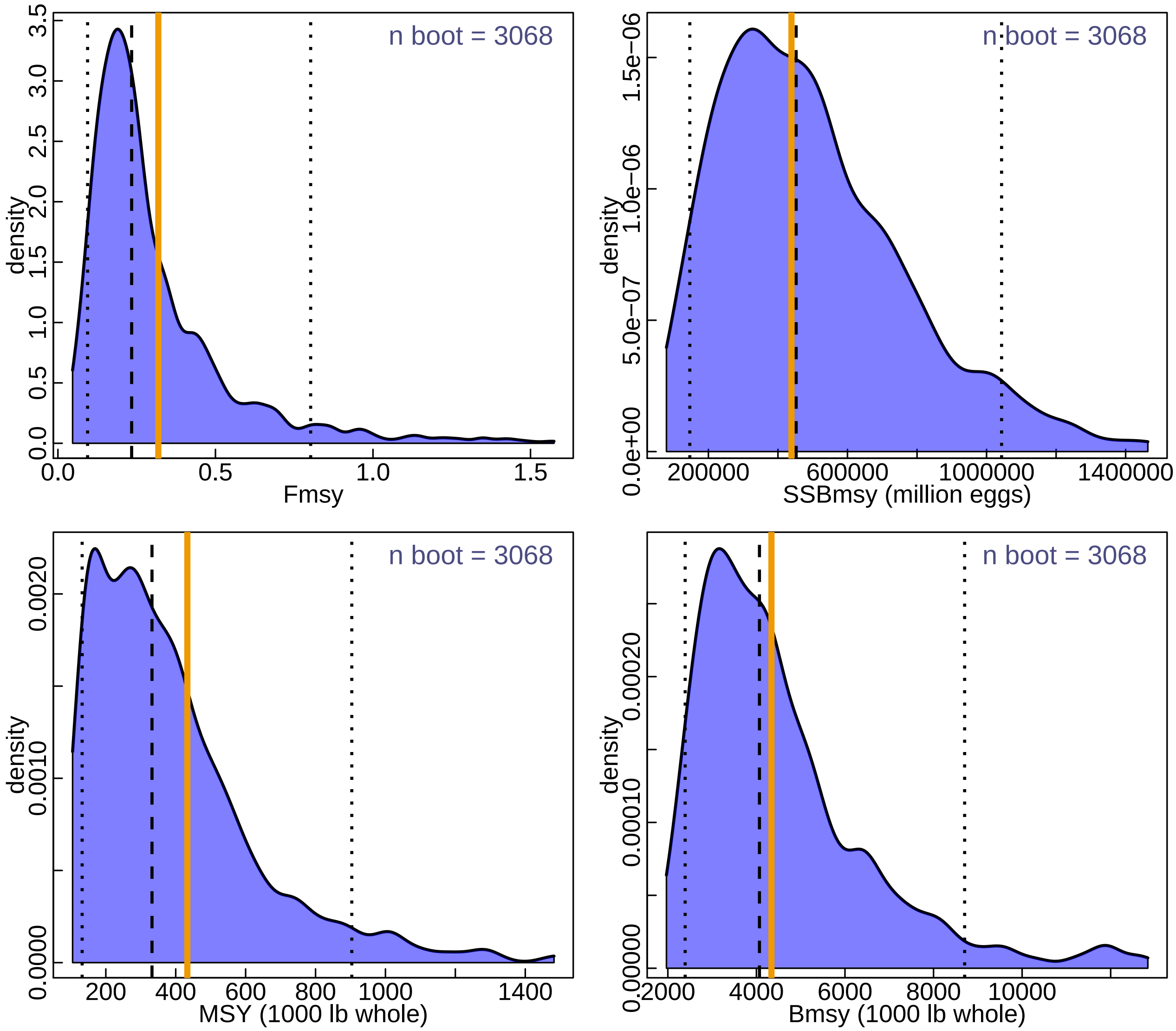


Figure A33. Estimated time series of B, SSB, and F for the ASPM Review Workshop Reference model for the South Atlantic. Solid lines indicate estimates from the ASPM RW Ref. model. Dashed lines indicate median of MCB runs. Error bands indicate 5^{th} *and* 95^{th} *percentiles of the MCB trials. Top panel: Total biomass. Middle panel: spawning biomass. Bottom panel: F.*

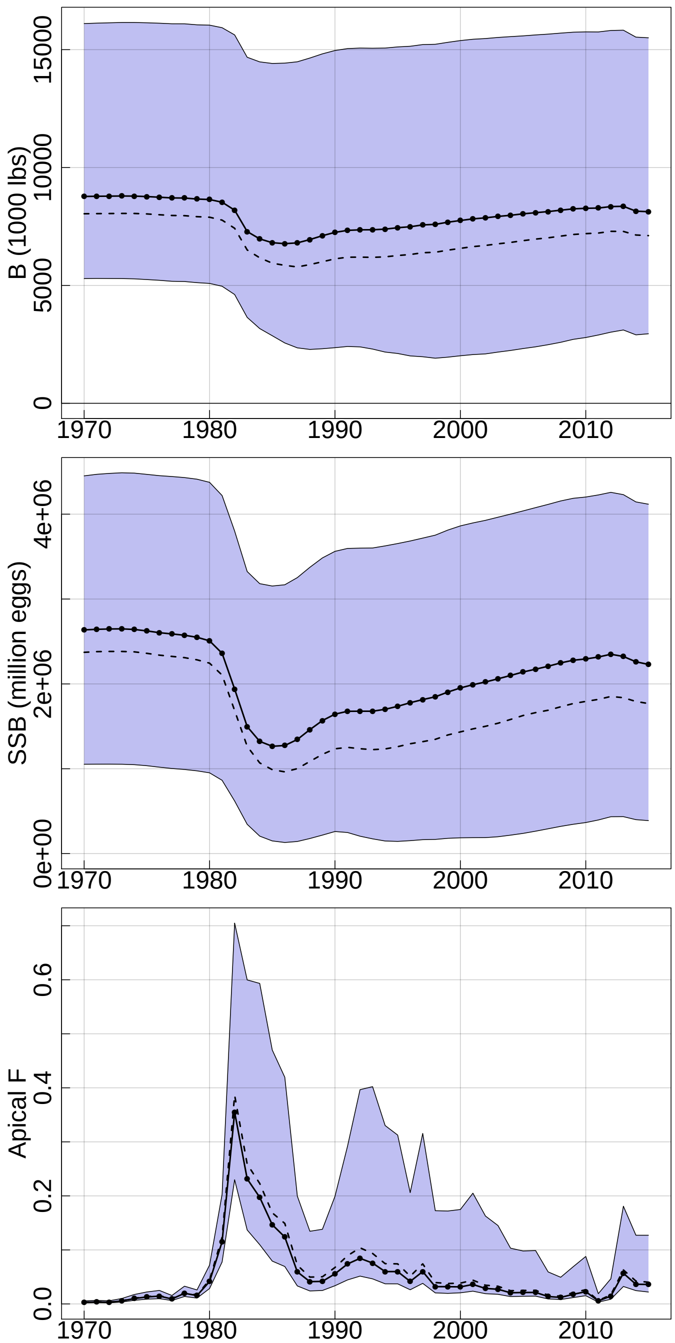


Figure A34. Estimated time series of B, SSB, and F relative to benchmarks, for the ASPM Review Workshop Reference model for the South Atlantic. Solid lines indicate estimates from the ASPM RW Ref. model. Dashed lines indicate median of MCB runs. Error bands indicate 5^{th} *and* 95^{th} *percentiles of the MCB trials. Top panel: Total biomass relative to estimated biomass at* F_{MSY} *(*B_{MSY}*). Middle panel: spawning biomass relative to* MSST *(75%* $\mathrm{SSB}_{\mathrm{MSY}}$*). Bottom panel: F relative to* F_{MSY}*.*

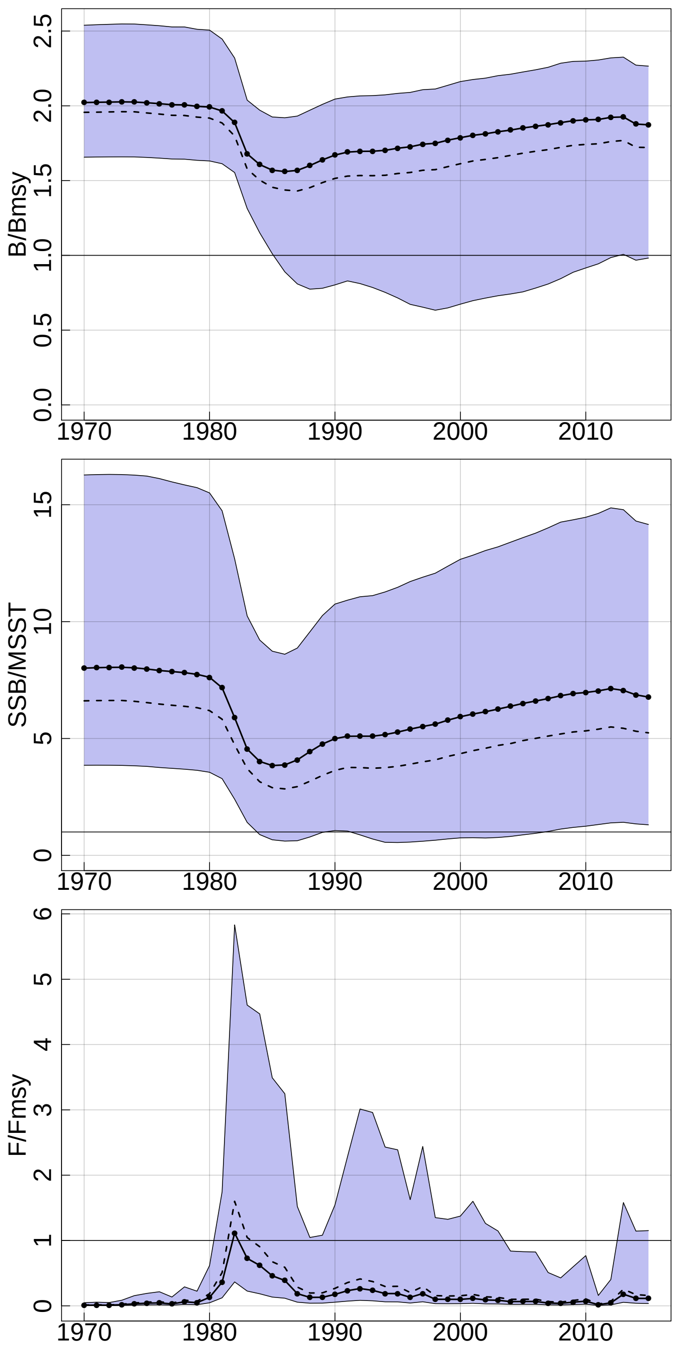
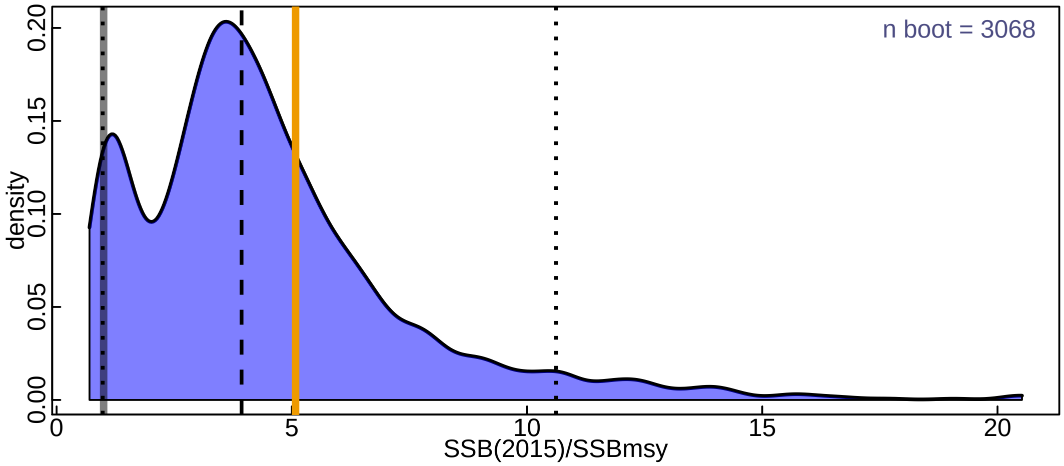
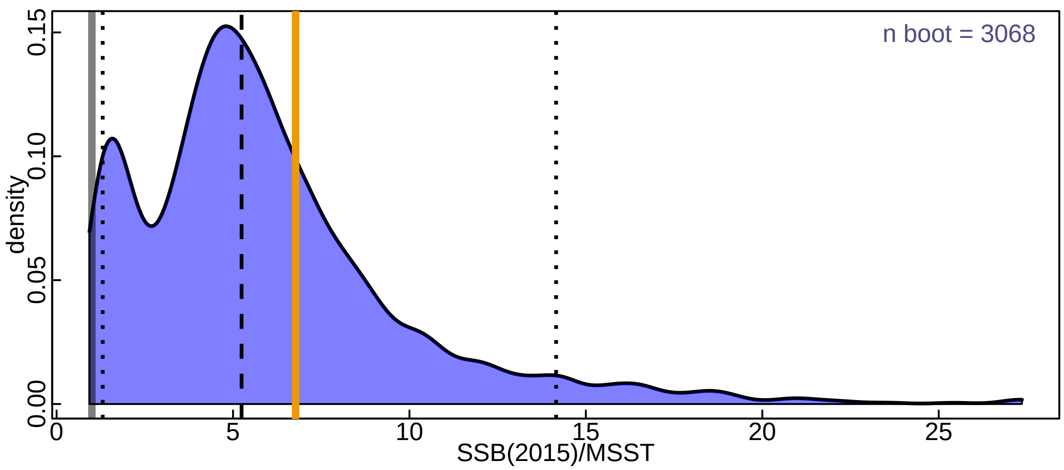


Figure A35. Probability densities of terminal status estimates from MCB analysis of the ASPM. Dotted lines represent 5^{th} and 95^{th} percentiles, dashed line represents the median of the MCB runs. Thick solid orange lines represent estimates from the RW Reference model. Translucent, black, vertical lines are plotted at x=1.





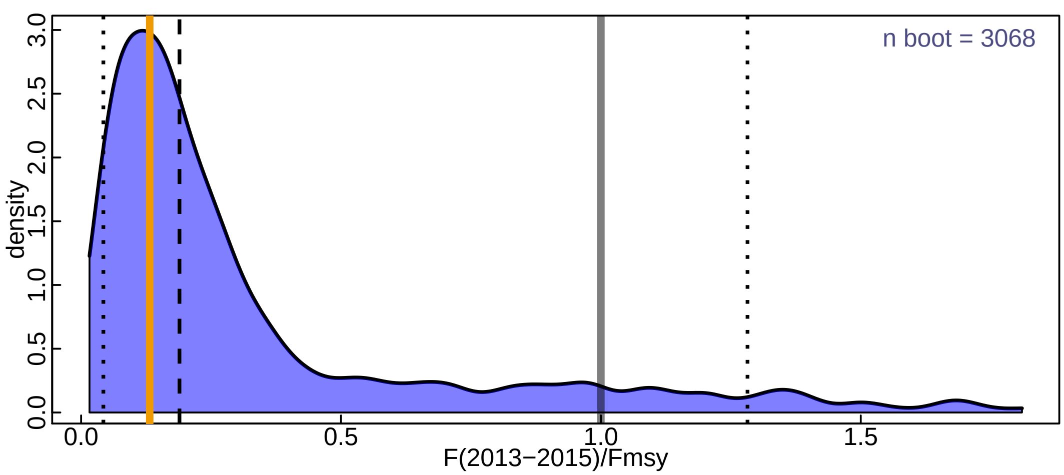


Figure A36. Phase plot of terminal status estimates from MCB analysis of the ASPM. The intersection of crosshairs indicates estimate from the RW Ref. model; lengths of crosshairs defined by 5^{th} and 95^{th} percentiles. Percent of runs falling in each quadrant indicated.

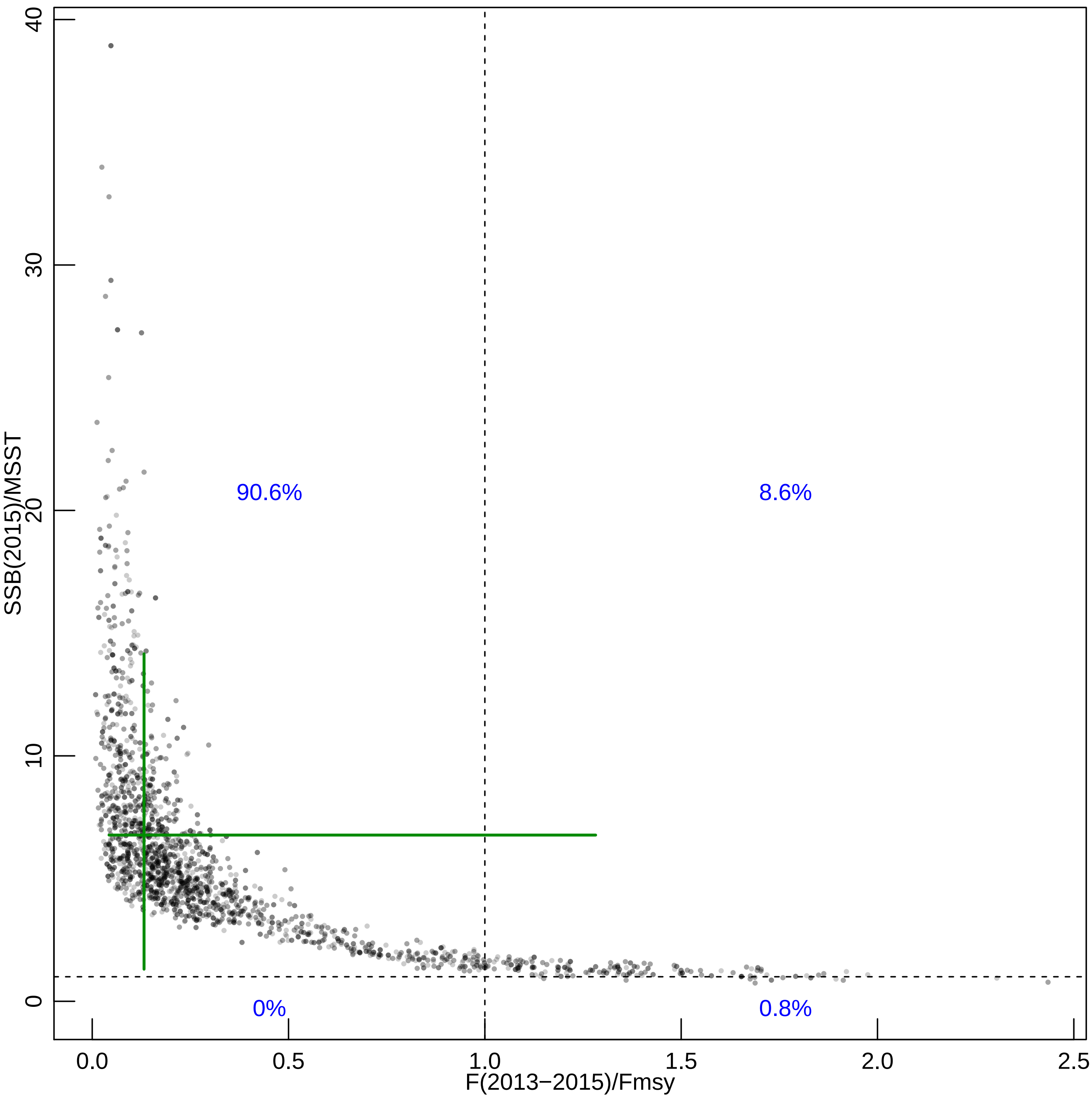


Figure A37. Sensitivity of the ASPM RW Ref. model to changes made to the Assessment Workshop Base model resulting in the Review Workshop Reference model: ASPM Runs S00-S03. Estimated time series of SSB, B, and F. Solid line and open circles indicate estimates from the ASPM RW Reference model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Horizontal lines indicate MSY*-based reference points from the RW Reference model:* $\mathrm{SSB}_{\mathrm{MSY}}$, MSST *(*$0.75\mathrm{SSB}_{\mathrm{MSY}}$*),* B_{MSY}*, and* F_{MSY}*. Top panel: Spawning stock biomass. Middle panel: Biomass. Bottom panel: Fishing mortality*

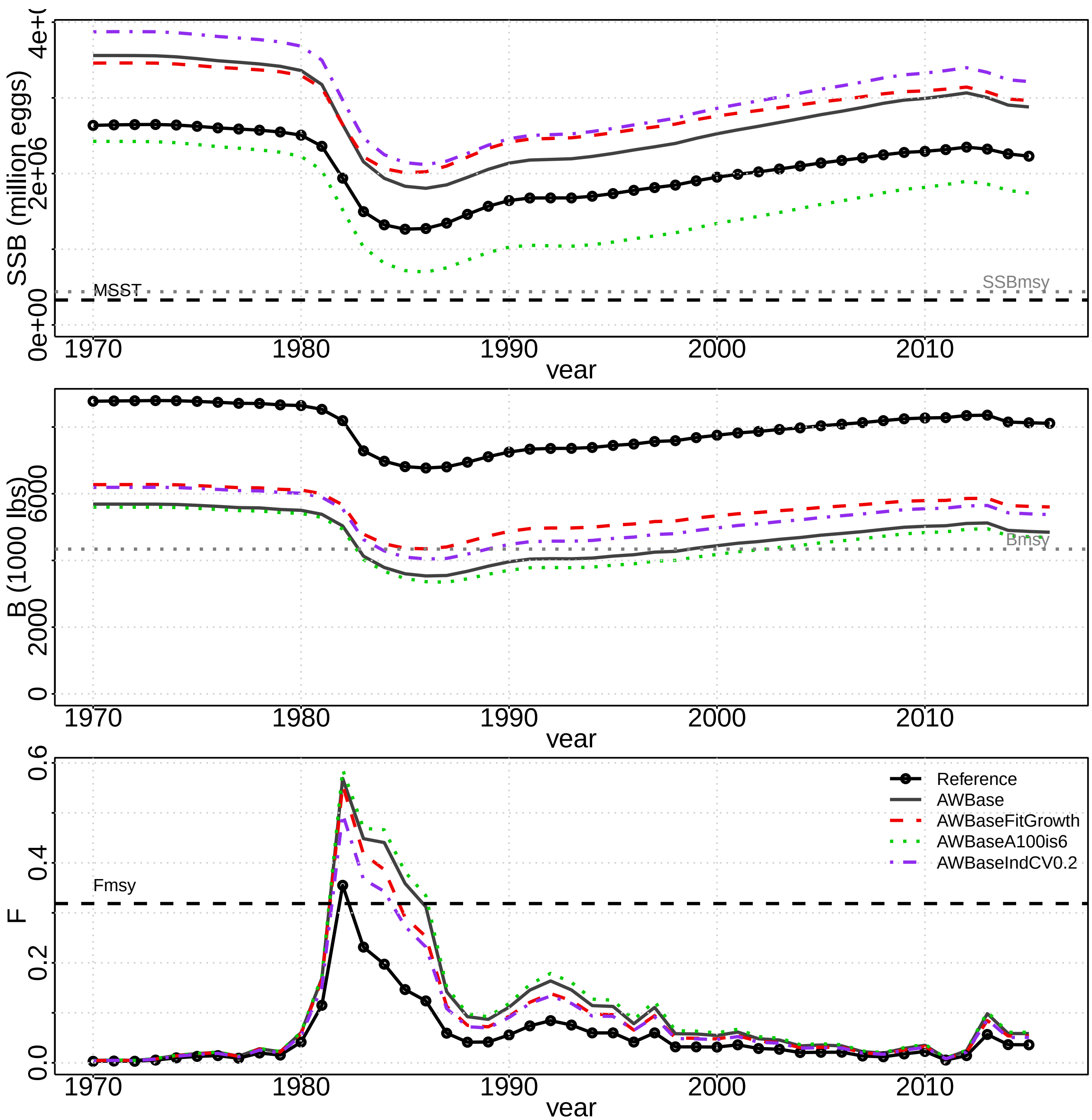


Figure A38. Sensitivity of the ASPM RW Ref. model to age at maturity: ASPM Runs S04-S05. Estimated time series of SSB, B, and F. Solid line and open circles indicate estimates from the ASPM RW Reference model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Horizontal lines indicate MSY*-based reference points from the RW Reference model:* $\mathrm{SSB}_{\mathrm{MSY}}$, MSST *(*$0.75\mathrm{SSB}_{\mathrm{MSY}}$*),* B_{MSY}*, and* F_{MSY}*. Top panel: Spawning stock biomass. Middle panel: Biomass. Bottom panel: Fishing mortality*

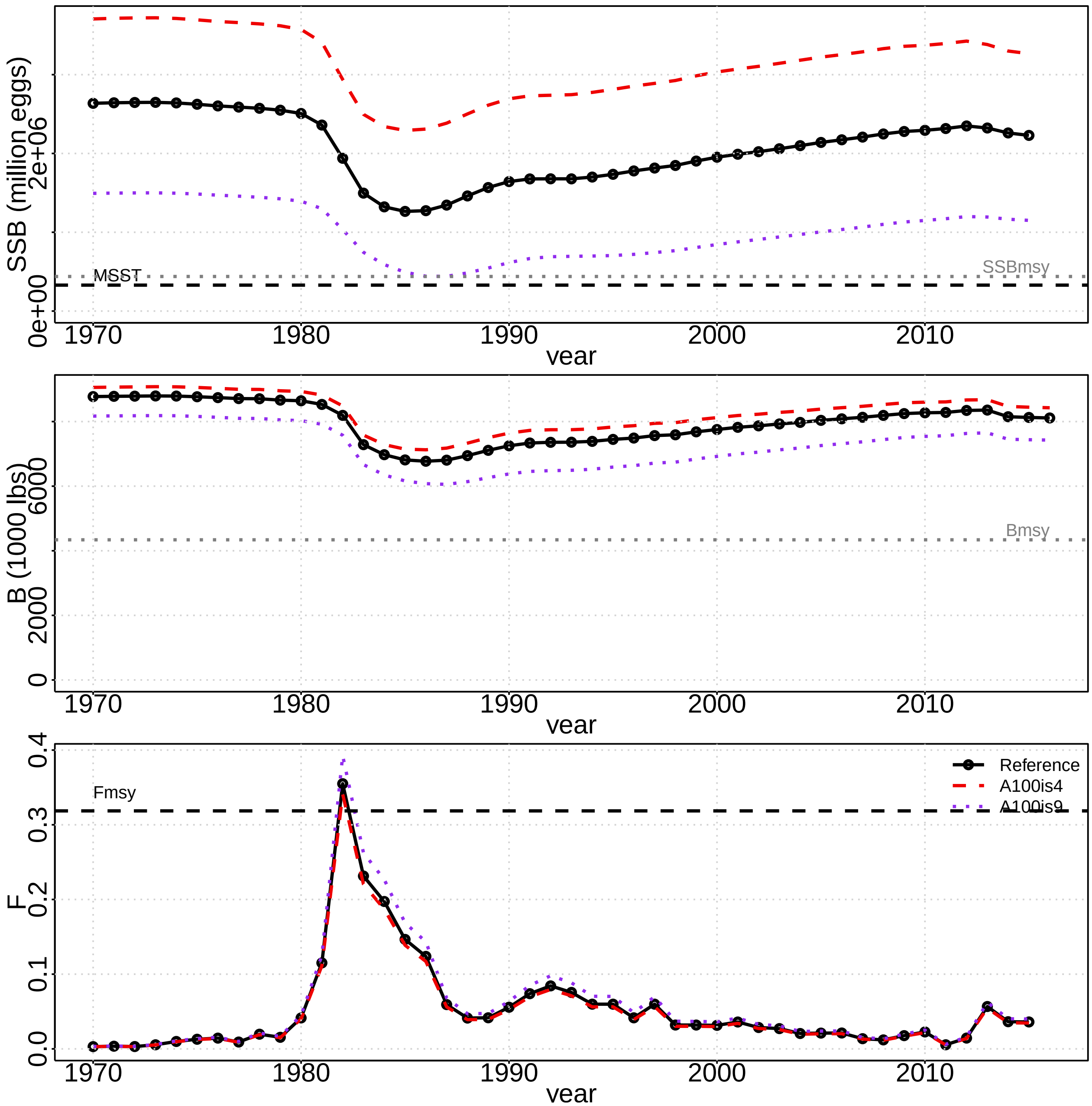


Figure A39. Sensitivity of the ASPM RW Ref. model to natural mortality: ASPM Runs S06-S07. Estimated time series of SSB, B, and F. Solid line and open circles indicate estimates from the ASPM RW Reference model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Horizontal lines indicate MSY*-based reference points from the RW Reference model:* $\mathrm{SSB_{MSY}}$, MSST *(*$0.75\mathrm{SSB_{MSY}}$*),* B_{MSY}*, and* F_{MSY}*. Top panel: Spawning stock biomass. Middle panel: Biomass. Bottom panel: Fishing mortality*

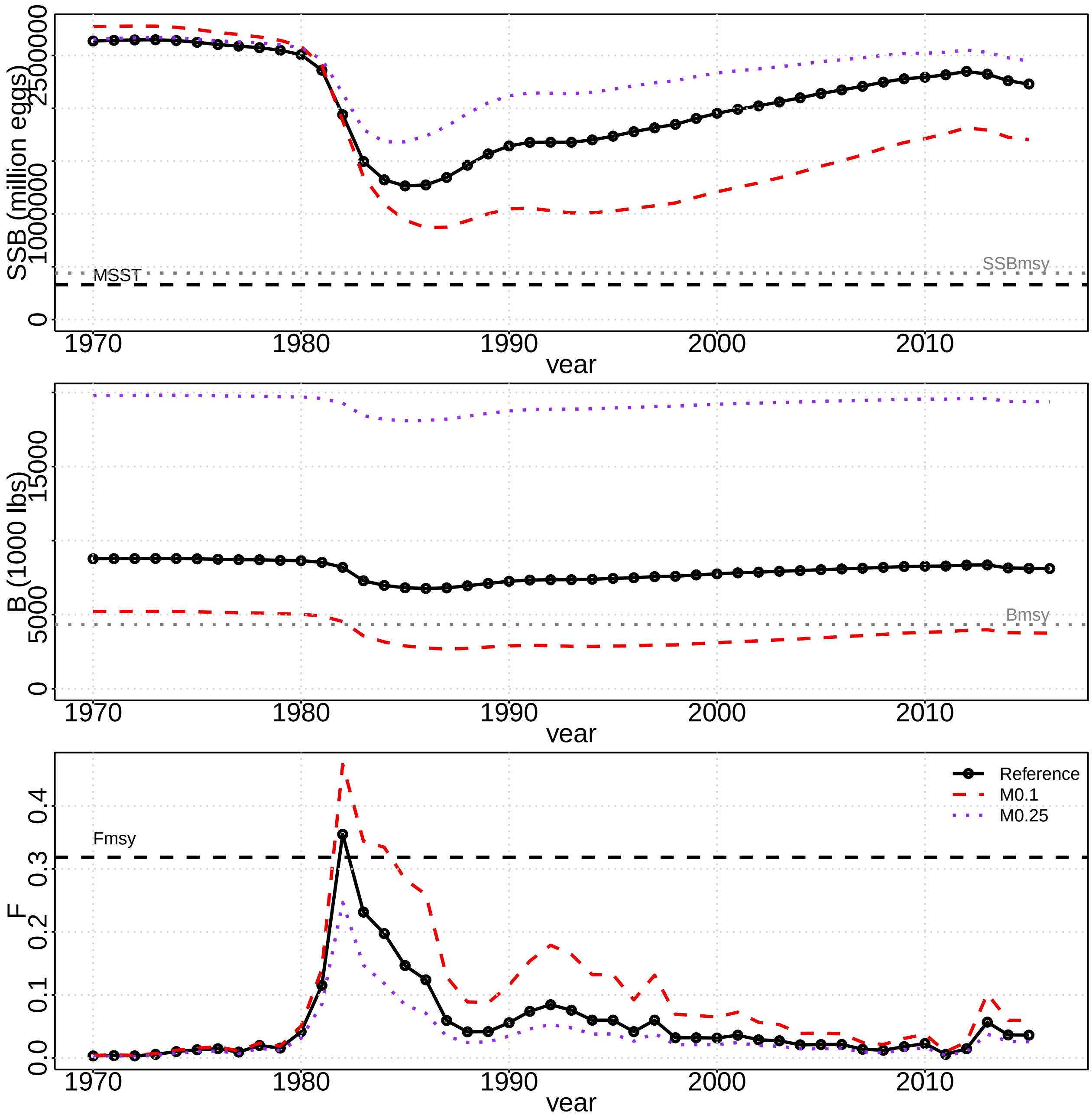


Figure A40. Sensitivity of the ASPM RW Ref. model to fitting recruitment deviations: ASPM Runs S08-S09. Estimated time series of SSB, B, and F. Solid line and open circles indicate estimates from the ASPM RW Reference model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Horizontal lines indicate MSY*-based reference points from the RW Reference model:* SSB_{MSY}, MSST *(0.75*SSB_{MSY}*),* B_{MSY}*, and* F_{MSY}*. Top panel: Spawning stock biomass. Middle panel: Biomass. Bottom panel: Fishing mortality*

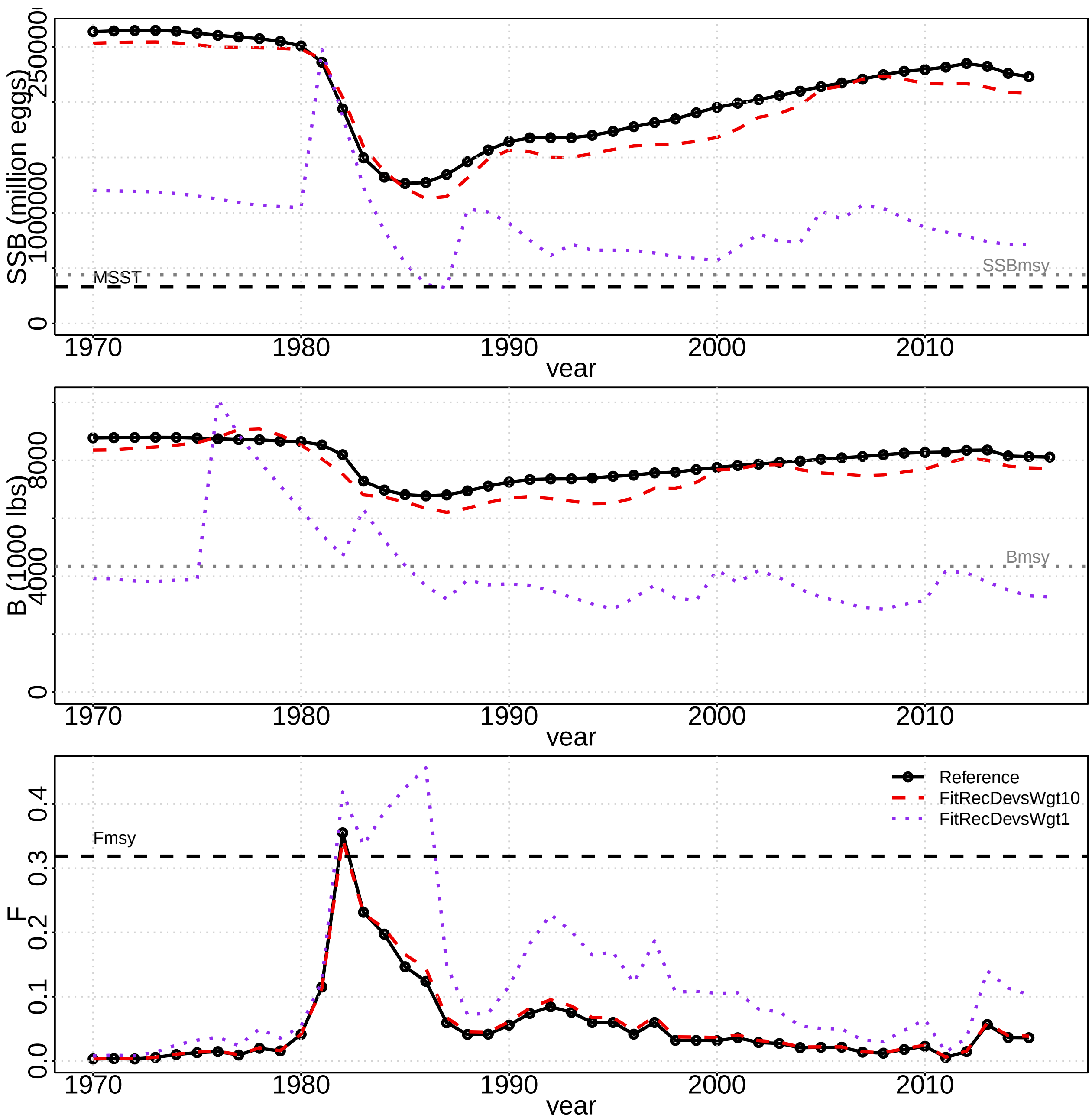


Figure A41. Sensitivity of the ASPM RW Ref. model to 1980-1985 handline removals: ASPM Runs S10-S11. Estimated time series of SSB, B, and F. Solid line and open circles indicate estimates from the ASPM RW Reference model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Horizontal lines indicate MSY*-based reference points from the RW Reference model:* $\mathrm{SSB_{MSY}}$, MSST *(*$0.75\mathrm{SSB_{MSY}}$*),* B_{MSY}*, and* F_{MSY}*. Top panel: Spawning stock biomass. Middle panel: Biomass. Bottom panel: Fishing mortality*

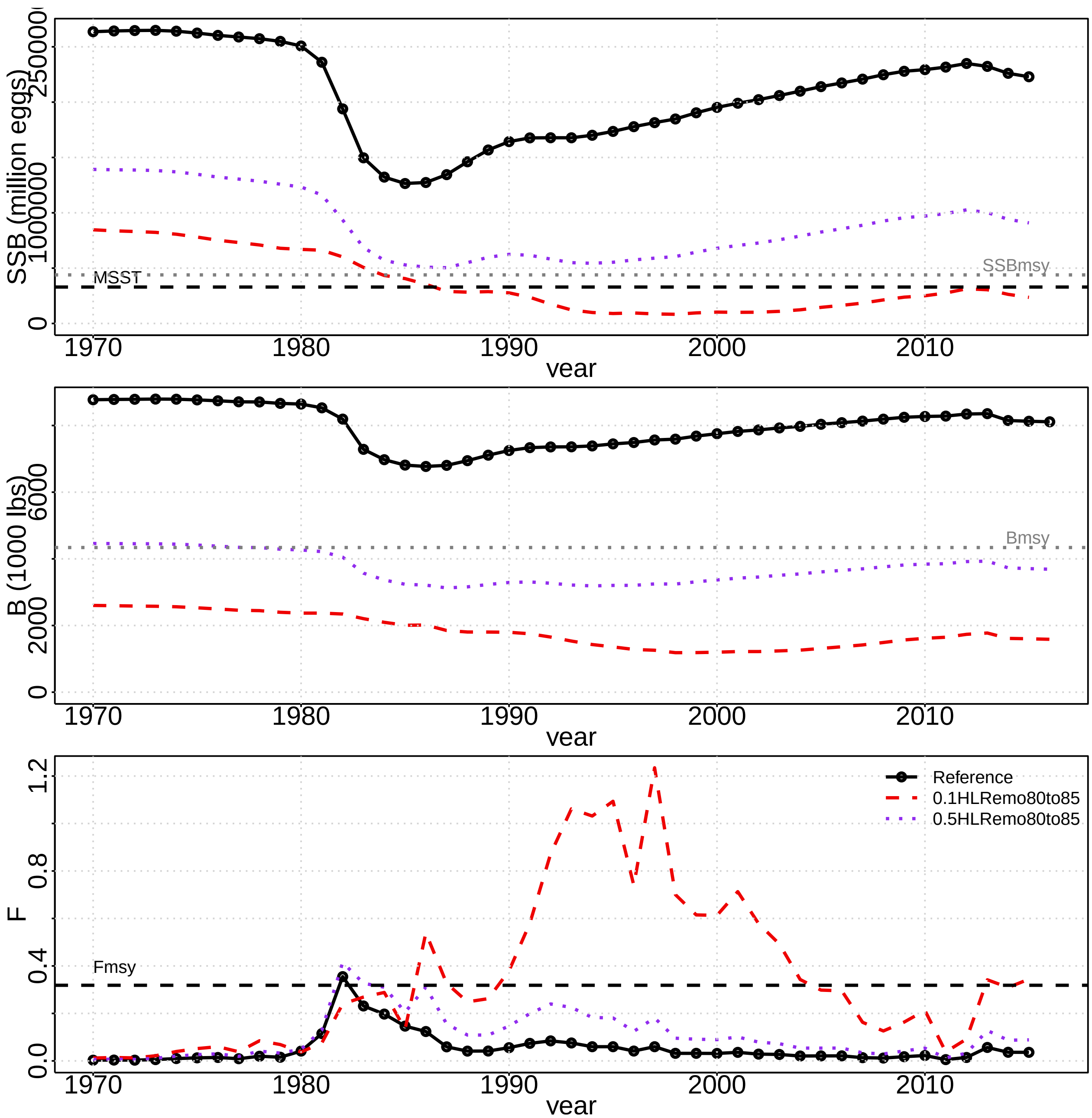


Figure A42. Sensitivity of the ASPM RW Ref. model to modifications to indices of abundance: ASPM Runs S12-S13. Estimated time series of SSB, B, and F. Solid line and open circles indicate estimates from the ASPM RW Reference model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Horizontal lines indicate MSY*-based reference points from the RW Reference model:* $\mathrm{SSB}_{\mathrm{MSY}}$*,* MSST *(0.75*$\mathrm{SSB}_{\mathrm{MSY}}$*),* B_{MSY}*, and* F_{MSY}*. Top panel: Spawning stock biomass. Middle panel: Biomass. Bottom panel: Fishing mortality*

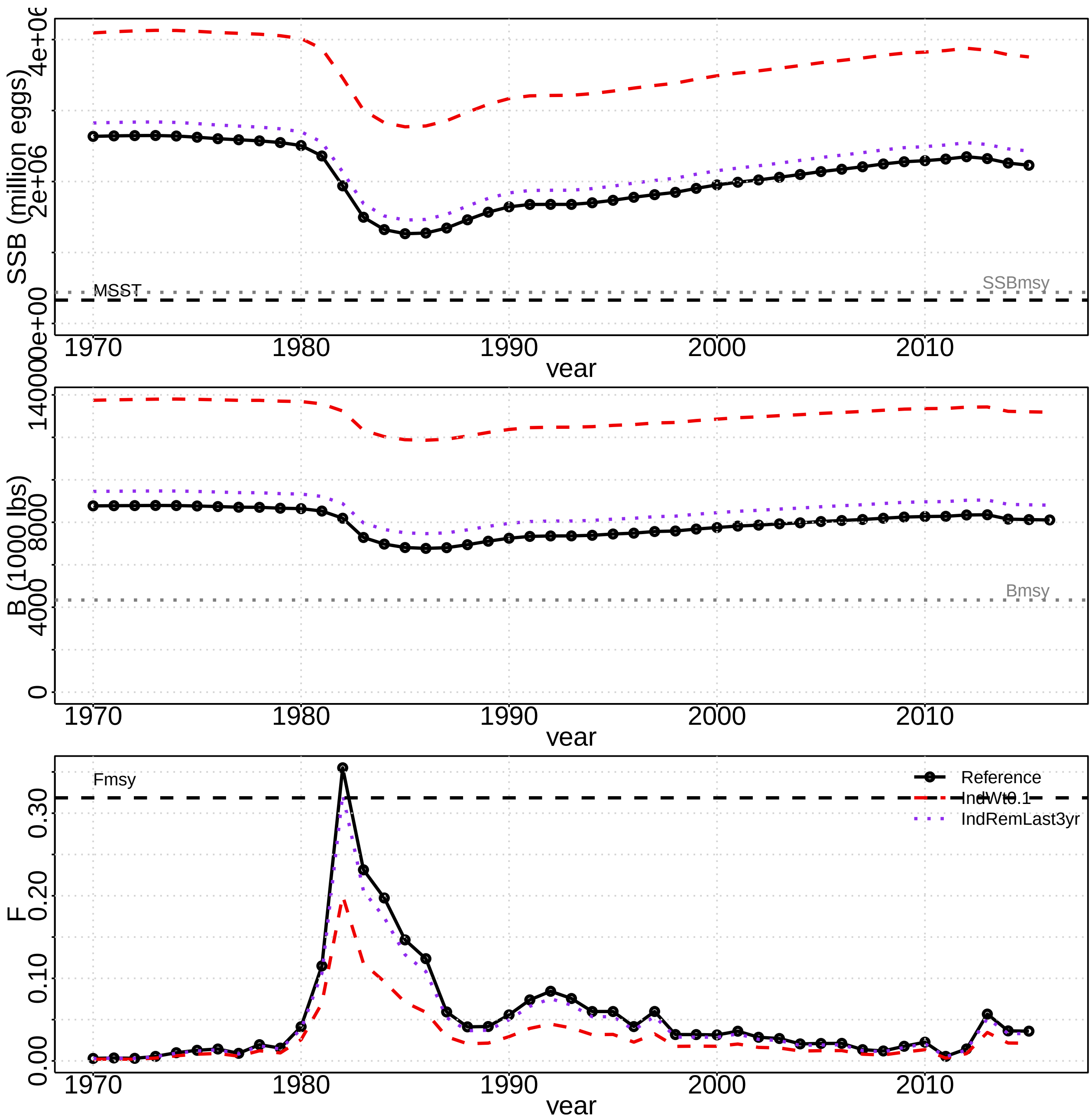


Figure A43. Sensitivity of the ASPM RW Ref. model to steepness: ASPM Runs S14-S20. Estimated time series of SSB, B, and F. Solid line and open circles indicate estimates from the ASPM RW Reference model. Sensitivity runs are indicated by colored broken lines, represented in the legend. Horizontal lines indicate MSY*-based reference points from the RW Reference model:* $\mathrm{SSB}_{\mathrm{MSY}}$, MSST *(*$0.75\mathrm{SSB}_{\mathrm{MSY}}$*),* B_{MSY}*, and* F_{MSY}*. Top panel: Spawning stock biomass. Middle panel: Biomass. Bottom panel: Fishing mortality*

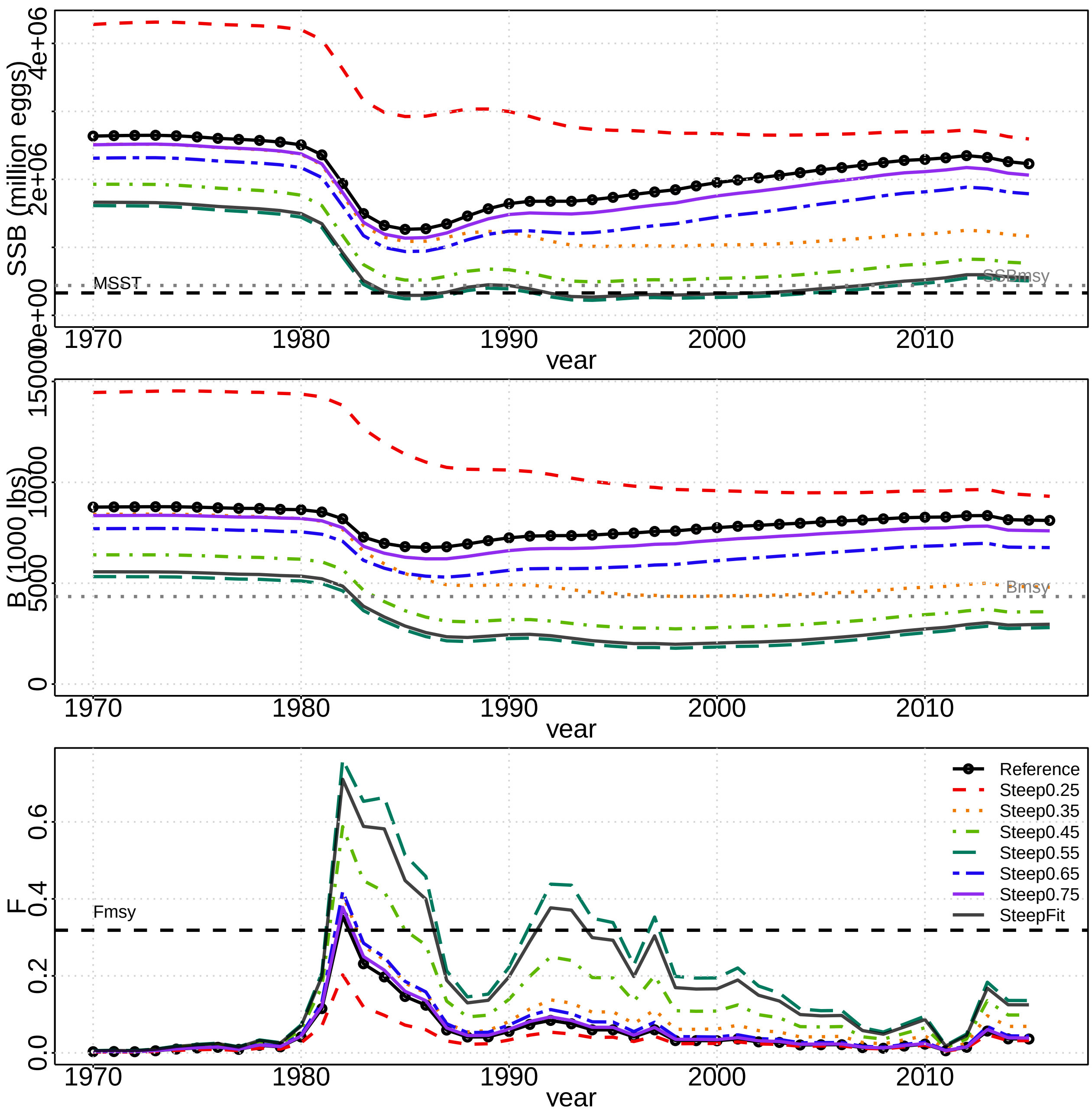


Figure A44. Phase plot of terminal F, B, and SSB status estimates from ASPM sensitivity runs, as well as the ASPM RW Reference model. Point colors and shapes are indicated in the legend. The number of each sensitivity run is also plotted in black text over each point.

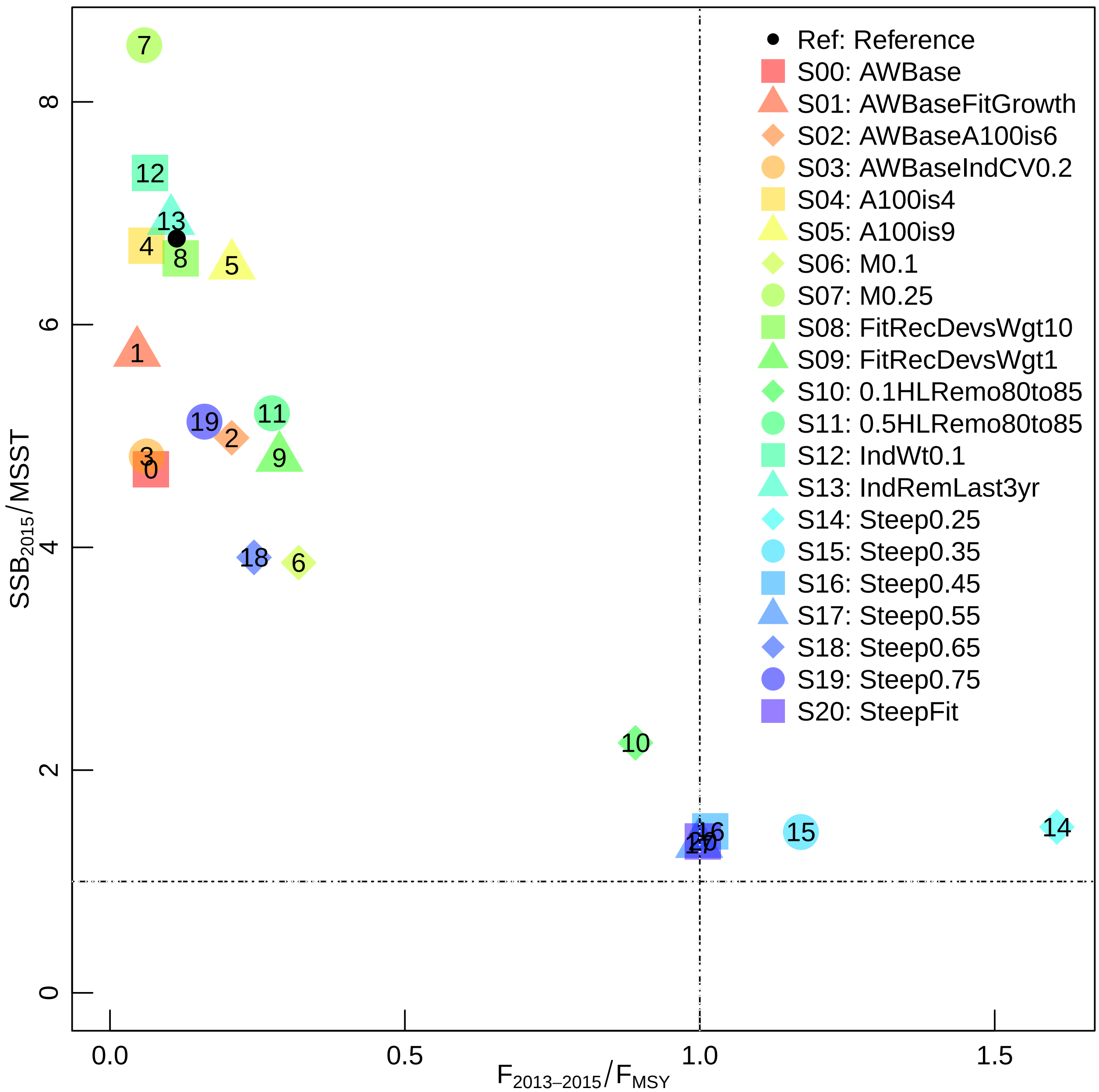


Figure A45. Projections at F_{MSY}, from the ASPM RW Ref. model. Plots of fishing mortality (F), spawning stock biomass (SSB; million eggs), total biomass (B), recruits, landings, and probability that SSB is greater than the appropriate SSB reference point. Projections are based on the ASPM Review Workshop Reference model for the South Atlantic region with F set at F_{MSY} beginning the year after the terminal year of the assessment. The solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively. The error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials. In the upper left panel, blue solid, dashed, and dotted horizontal reference lines correspond to F_{MSY} from the RW Reference model, median F_{MSY} from the MCB runs, and F_{current}, respectively. In other panels, these lines correspond to the appropriate F_{MSY}-based references.

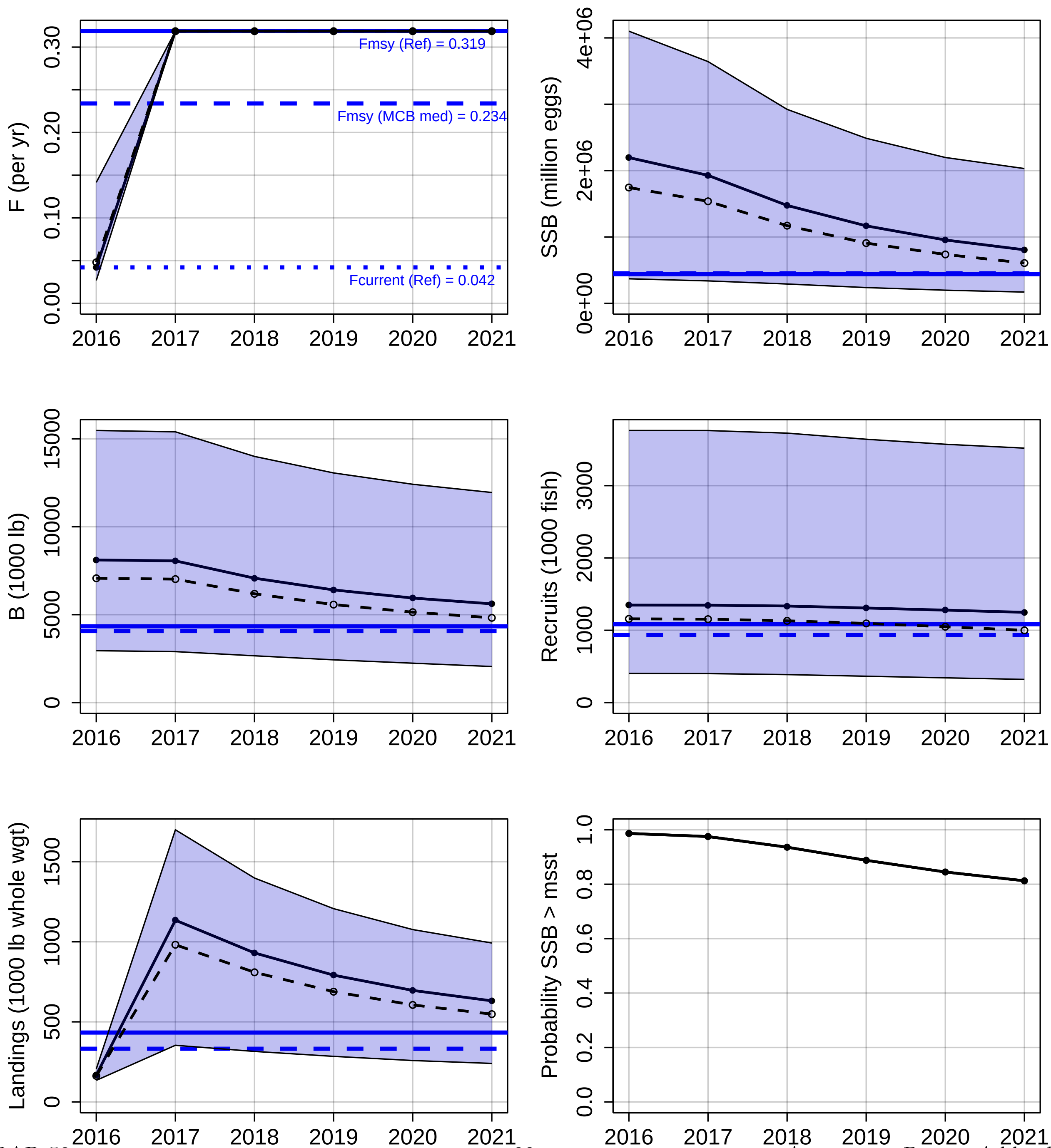


*Figure A46. Projections at F_{current}, from the ASPM RW Ref. model. Plots of fishing mortality (F), spawning stock biomass (*SSB*; million eggs), total biomass (B), recruits, landings, and probability that* SSB *is greater than the appropriate* SSB *reference point. Projections are based on the ASPM Review Workshop Reference model for the South Atlantic region with F set at F_{current} beginning the year after the terminal year of the assessment.The solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively. The error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials. In the upper left panel, blue solid, dashed, and dotted horizontal reference lines correspond to F_{MSY} from the RW Reference model, median F_{MSY} from the MCB runs, and F_{current}, respectively. In other panels, these lines correspond to the appropriate F_{MSY}-based references.*

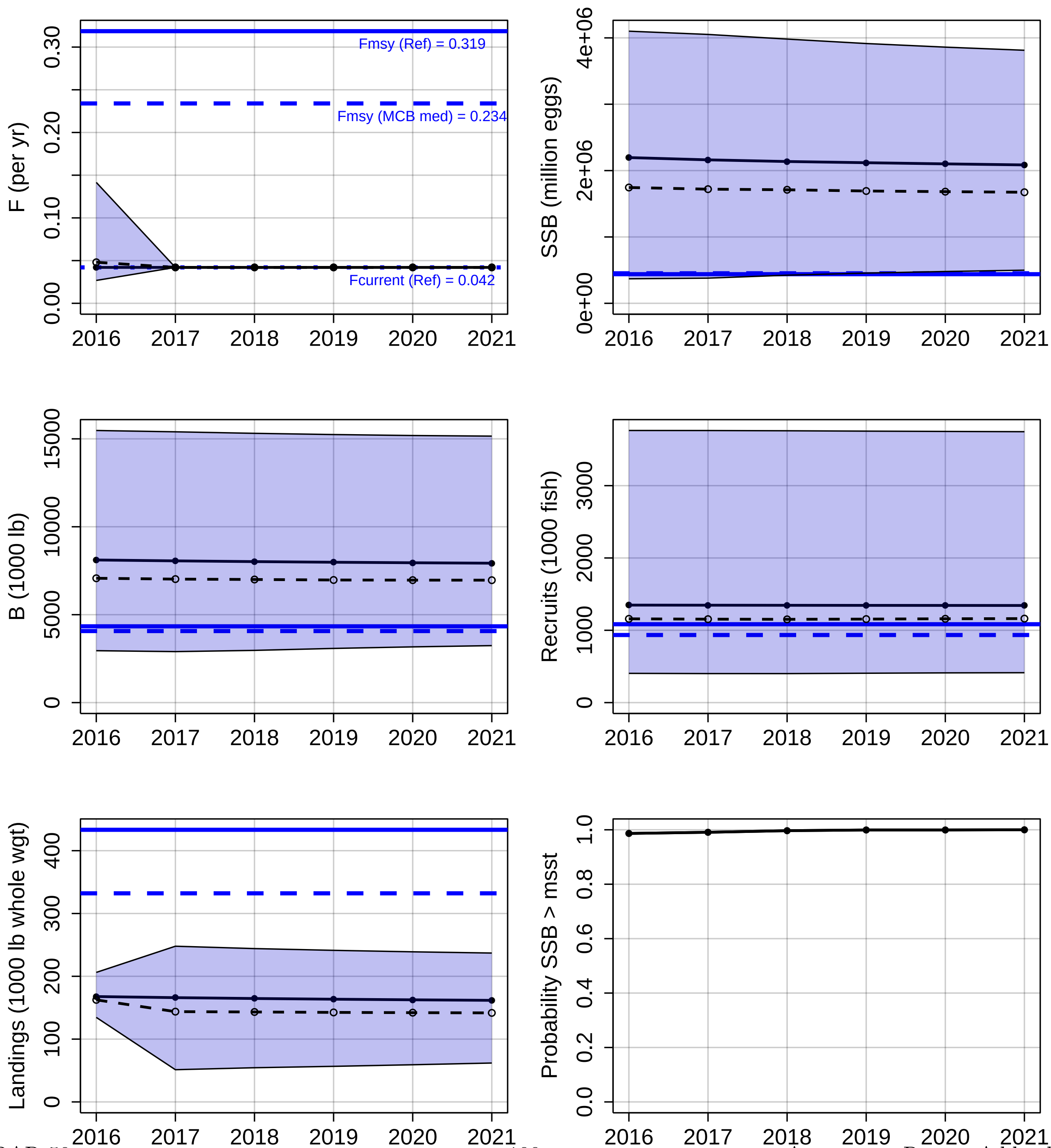


Figure A47. Projections at F_{target}, from the ASPM RW Ref. model. Plots of fishing mortality (F), spawning stock biomass (SSB; million eggs), total biomass (B), recruits, landings, and probability that SSB is greater than the appropriate SSB reference point. Projections are based on the ASPM Review Workshop Reference model for the South Atlantic region with F set at F_{target} beginning the year after the terminal year of the assessment. The solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively. The error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials. In the upper left panel, blue solid, dashed, and dotted horizontal reference lines correspond to F_{MSY} from the RW Reference model, median F_{MSY} from the MCB runs, and F_{current}, respectively. In other panels, these lines correspond to the appropriate F_{MSY}-based references.

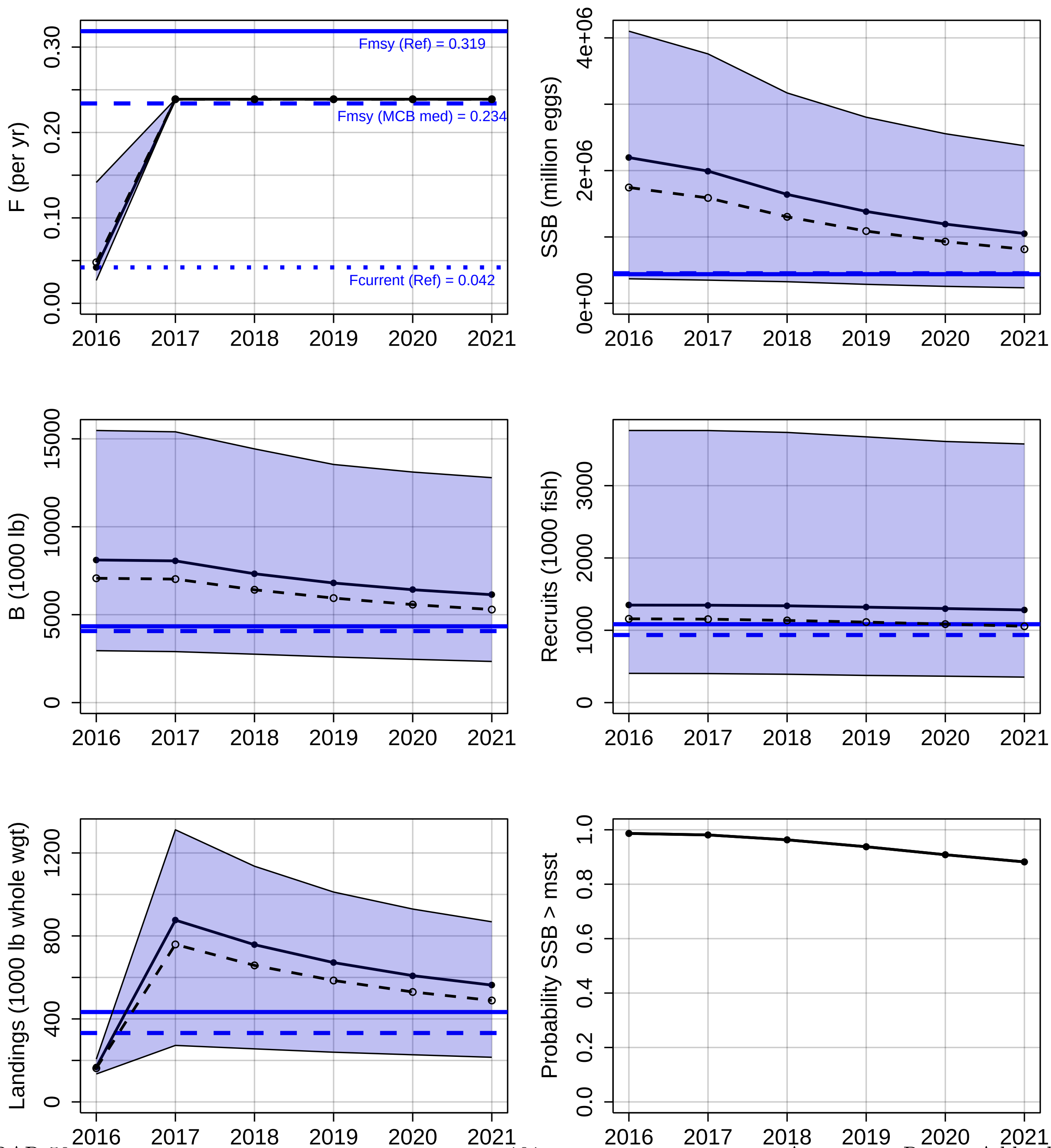


Figure A48. Projections at $F_{30\%}$, from the ASPM RW Ref. model. Plots of fishing mortality (F), spawning stock biomass (SSB; million eggs), total biomass (B), recruits, landings, and probability that SSB is greater than the appropriate SSB reference point. Projections are based on the ASPM Review Workshop Reference model for the South Atlantic region with F set at $F_{30\%}$ beginning the year after the terminal year of the assessment.The solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively. The error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials. In the upper left panel, blue solid, dashed, and dotted horizontal reference lines correspond to $F_{30\%}$ from the RW Reference model, median $F_{30\%}$ from the MCB runs, and F_{current}, respectively. In other panels, these lines correspond to the appropriate $F_{30\%}$-based references.

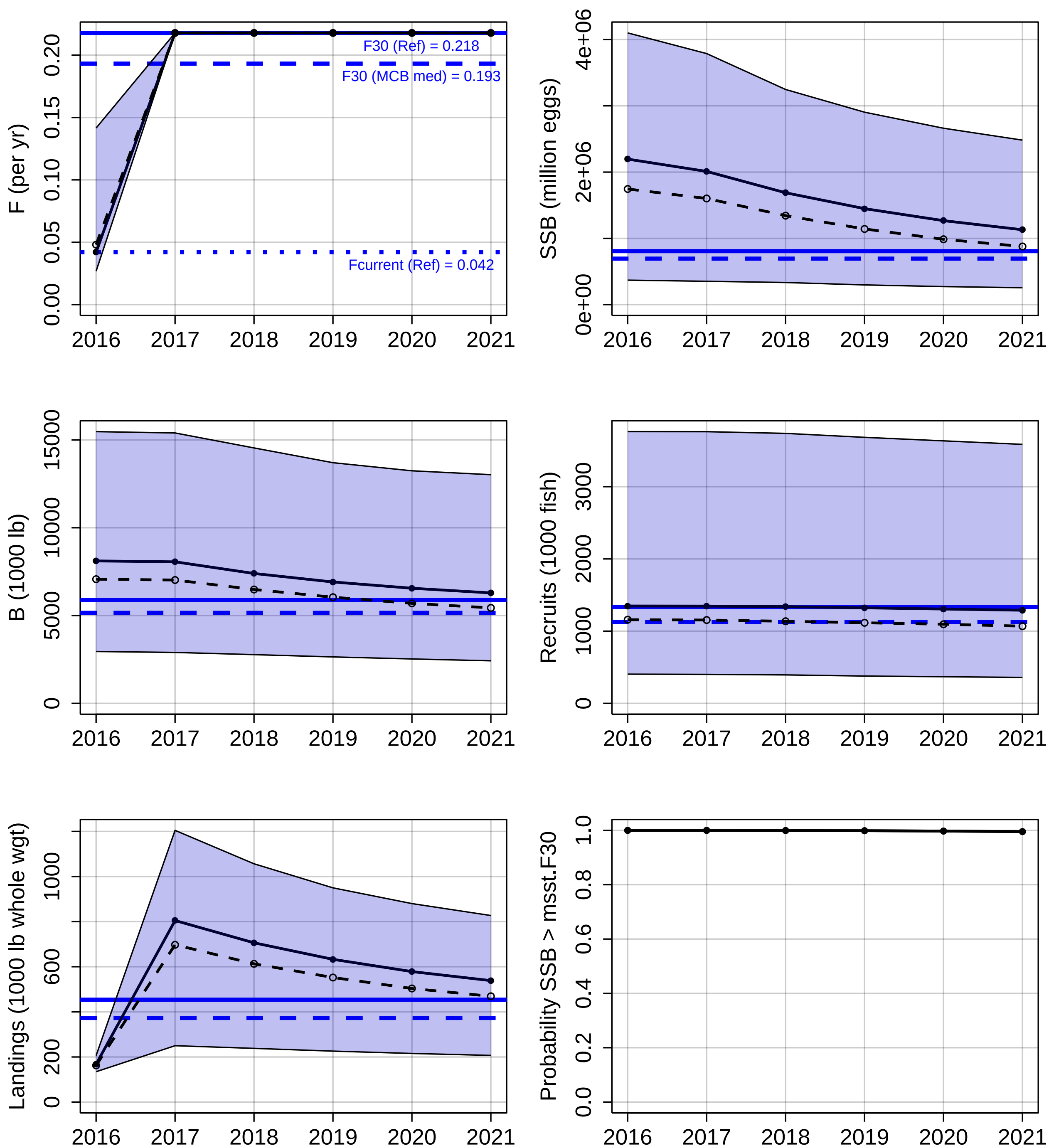


Figure A49. Projections at $F_{40\%}$, from the ASPM RW Ref. model. Plots of fishing mortality (F), spawning stock biomass (SSB; million eggs), total biomass (B), recruits, landings, and probability that SSB is greater than the appropriate SSB reference point. Projections are based on the ASPM Review Workshop Reference model for the South Atlantic region with F set at $F_{40\%}$ beginning the year after the terminal year of the assessment.The solid and dashed black lines are the deterministic estimates and medians of the MCB projections, respectively. The error bands indicate 5^{th} and 95^{th} percentiles of the combined bootstrap trials. In the upper left panel, blue solid, dashed, and dotted horizontal reference lines correspond to $F_{40\%}$ from the RW Reference model, median $F_{40\%}$ from the MCB runs, and F_{current}, respectively. In other panels, these lines correspond to the appropriate $F_{40\%}$-based references.