SEDAR
Southeast Data, Assessment, and Review

SEDAR 79
Stock Assessment Report

Southeastern US Mutton Snapper

September 2024

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

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SECTION I: Introduction

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Introduction

SEDAR 79 addressed the stock assessment for Southeastern US Mutton Snapper. The process consisted of an in-person Data Workshop, a series of assessment webinars, and an in-person Review Workshop.

The Stock Assessment Report is organized into 6 sections. Section I – Introduction 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. The Data Workshop Report can be found in Section II. It documents the discussions and data recommendations from the Data Workshop Panel. Section III is the Assessment Process 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 stages of the process can be found in Section IV for easy reference. Section V documents the discussions and findings of the Review Workshop (RW). Finally, Section VI – Addenda and Post-Review Workshop Documentation 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 Southeastern US mutton snapper was disseminated to the public in October 2024. The Gulf of Mexico and South Atlantic Fishery Management Councils' Scientific and Statistical Committee (SSC) will review the SAR. The SSC is tasked with recommending whether the assessments represent Best Available Science, whether the results presented in the SARs are useful for providing management advice and developing fishing level recommendations for the Council. An SSC 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). A review of the assessment will be conducted by the Gulf of Mexico and South Atlantic Fishery Management Councils' SSCs in February 2025, followed by the Councils receiving that information at in Spring 2024.

1 SEDAR PROCESS DESCRIPTION

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

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

South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; 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 normally organized around two workshops and a series of webinars. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. The second stage is the Assessment Process, which is conducted via a workshop and/or a series of webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. The final step 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 stages and all supporting documentation, is then forwarded to the Council SSC for certification as 'appropriate for management' and development of specific management recommendations.

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

2 SOUTHEASTERN US MUTTON SNAPPER MANAGEMENT OVERVIEW

2.1. Fishery Management Plan and Amendments

The Florida Fish and Wildlife Conservation Commission (FWC) is responsible for managing fish and wildlife resources for the people of the State of Florida. There are multiple federal and state agencies which also management fish and wildlife resources with overlapping responsibilities and jurisdictions, and the FWC works cooperatively with the regional fishery management councils (South Atlantic Fishery Management Council and Gulf of Mexico Fishery Management Council) and the National Marine Fisheries Service to effectively manage saltwater fisheries in Florida. The FWC Fish and Wildlife Institute is responsible for providing information and research on fish and wildlife resources in the state, including assessments of the status of fish populations such as mutton snapper.

The following summary describes only those management actions in the southeastern U.S. in the jurisdictions of the South Atlantic Fishery Management Council (SAFMC), the Gulf of Mexico Fishery Management Council (GMFMC), and the Florida Fish and Wildlife Conservation Commission (FWC) that were likely to affect mutton snapper 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 fishery conservation zone (FCZ) under the area of authority of the South Atlantic Fishery Management Council (SAFMC) and the territorial seas of the states, extending from the North Carolina/Virginia border through the Atlantic side of the Florida Keys to 83° W longitude. In the case of the sea basses, the management regime applies only to south of Cape Hatteras, North Carolina. Regulations apply only to federal waters.

SAFMC FMP Amendments affecting mutton snapper

Description of Action	FMP/Amendment	Effective Date
4" trawl mesh size; Gear limitations – poisons, explosives, fish traps, trawls; Designated modified habitats or artificial reefs as Special Management Zones (SMZs).	Snapper Grouper FMP	08/31/1983
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 lb Snapper Grouper on board; Established rebuttable assumption that vessel with Snapper Grouper on board had harvested such fish in the exclusive economic zone (EEZ).	Amendment 1 (1988)	01/12/1989
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; Defined overfishing/overfished and established rebuilding timeframe: less than or equal to 10 years; Required permits (commercial & for-hire) and specified data collection regulations; Permit, gear, and vessel id requirements specified for black sea bass traps; No retention of snapper grouper species caught in other fisheries with gear prohibited in snapper grouper fishery if captured snapper grouper had no bag limit or harvest was prohibited. If a bag limit in effect, could retain only the bag limit; 12-inch total length minimum size limit; Aggregate snapper bag limit – 10/person/day, excluding vermilion snapper and allowing no more than 2 red snappers;	Amendment 4 (1991)	01/01/1992

Description of Action	FMP/Amendment	Effective Date
Spawning season closure – commercial harvest mutton snapper greater than aggregate snapper bag limit prohibited during May and June; Charter/headboats and excursion boat possession limits extended.		
Creation of the Oculina Experimental Closed Area.	Amendment 6 (1993)	06/27/1994
16-inch total length minimum size limit; 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 NC; Adjusted bag limit and crew specs. for charter and head boats.	Amendment 7 (1994)	01/23/1995
Limited entry program: transferable permits and 225-lb non-transferable permits.	Amendment 8 (1997)	12/1998
MSY proxy for mutton snapper is 30% static SPR; OY proxy is 40% static SPR. MSST = (1-M)*B_{MSY}. MFMT=F_{MSY}.	Amendment 11B (1998)	12/02/1999
Extended for an indefinite period the regulation prohibiting fishing for and possessing snapper grouper species within the *Oculina* Experimental Closed Area.	Amendment 13A (2003)	4/26/2004
Established eight deepwater Type II marine protected areas to protect a portion of the population and habitat of long-lived deepwater snapper grouper species.	Amendment 14 (2007)	02/12/2009
Prohibited the sale of snapper-grouper harvested or possessed in the EEZ under the bag limits and prohibited the sale of snapper-grouper harvested or possessed under the bag limits by vessels with a Federal charter vessel/headboat permit for South Atlantic snapper-grouper regardless of where harvested; Required a vessel that fished in the EEZ, if selected by NMFS, to carry an observer and install electronic logbook and/or video monitoring equipment provided by NMFS.	Amendment 15B (2008)	12/16/09, except for the amendments to § 622.18(c) was effective 11/16/2009; the amendment to § 622.10(c) was effective 2/16/2010; and §§ 622.5, 622.8, and 622.18(b)(1)(ii) required OMB approval.
Required use by commercial and recreational fishermen of dehooking devices for releasing reef fish	Amendment 16 (2009)	07/29/2009

Description of Action	FMP/Amendment	Effective Date
Use of non-stainless steel circle hooks in the snapper -grouper fishery not required south of 28°N	Amendment 17A (2010)	03/02/2011
Limited harvest of snapper grouper species in SC SMZs to the bag limit.	Amendment 23 (2011)	1/30/2012
Established acceptable biological catch (ABC) control rules, ABCs, annual catch limits (ACLs), and accountability measures (AMs) for species not undergoing overfishing; Specified allocations between commercial and recreational sectors for species not undergoing overfishing; Limited the total mortality for federally managed species in the South Atlantic to the ACLs.	Amendment 25 (2011; Comprehensive ACL Amendment)	04/16/2012
Modified the crew member limit on dual-permitted snapper grouper vessels; Modified the restriction on retention of bag limit quantities of some snapper grouper species by captain and crew of for-hire vessels.	Amendment 27 (2013)	1/27/2014
Required electronic reporting for headboat vessels at weekly intervals.	Amendment 31 (2013; Joint South Atlantic and Gulf of Mexico Generic Headboat Reporting Amendment)	1/27/2014
Modified accountability measures.	Amendment 34 (2015)	2/22/2016
Established SMZs to enhance protection for snapper-grouper species in spawning condition.	Amendment 36 (2016)	7/31/2017
Updated the MSY, ABC, ACL, OY, and MSST for mutton snapper; Designated spawning months of April through June for regulatory purposes; Revised management measures for mutton snapper including the minimum size limit (18 inches total length), recreational bag limit (five mutton snapper per person per day within the ten-snapper aggregate), and commercial trip limit (500 pounds whole weight during January through March and July through December; and during the April through June spawning season, of five mutton snapper per person per day, or five mutton snapper per person per trip, whichever is more restrictive).	Amendment 41 (2017)	2/10/2018

SAFMC FMP Regulatory Amendments

Regulatory Amendment 1 (March 1987)
Prohibited fishing in Special Management Zones (SMZ) except with hand-held hook-and-line and spearfishing gear.

Regulatory Amendment 2 (March 1989)
Established 2 artificial reefs off Ft. Pierce, FL as SMZs.

Regulatory Amendment 3 (November 1990)
Established artificial reef at Key Biscayne, FL as SMZ.

Regulatory Amendment 5 (July 1993)
Established 8 SMZs off South Carolina, where only hand-held hook-and-line gear and spearfishing (excluding powerheads) were allowed.

Regulatory Amendment 7 (January 1999)
Established 10 SMZs at artificial reefs off South Carolina.

Regulatory Amendment 8 (November 2000)
Established 12 SMZs at artificial reefs off Georgia; revised boundaries of 7 existing SMZs off Georgia; restricted fishing in new and revised SMZs.

Regulatory Amendment 10 (May 2011)
Eliminated closed area for snapper grouper species approved in Amendment 17A.

Regulatory Amendment 29 (July 2020)
Modified gear requirements for South Atlantic snapper-grouper species, including modifications to requirements for circle hooks and powerheads. Required possession of descending devices.

Regulatory Amendment 34 (May 2021)
30 SMZs off North Carolina and 4 off South Carolina were established at artificial reef sites.

ORIGINAL GMFMC FMP

The Fishery Management Plan (FMP) for the reef fish fishery of the Gulf of Mexico was implemented on November 8, 1984. This plan is for the management of reef fish resources under the authority of the Gulf of Mexico Fishery Management Council. The plan considers reef fish resources throughout its range from Florida through Texas. The areas which will be regulated by the federal government under this plan is confined to the waters of the fishery conservation zone (FCZ). The estimated area of the FCZ is 6.82 x 10^5 km^2 (263,525 square miles) and of that 12.4% of it is estimated as part of the continental shelf that is encompassed within the FCZ. Yellowtail snapper is one of the many species included in the fishery management unit. The four objectives of the FMP were: (1) to rebuild the declining reef fish stocks wherever they occur within the fishery; (2) establish a fishery reporting system for monitoring the reef fish fishery; (3) conserve reef fish habitats and increase reef fish habitats in appropriate areas and to provide protection for juveniles while protecting existing new habitats; (4) to minimize conflicts between user groups of the resource and conflicts for space.

Measures in the original FMP that would have affected the harvest of yellowtail snapper are maximum sustainable yield (MSY and optimum yield (OY) estimates for all grouper and snapper species in aggregate, permits and gear specifications for fish traps along with a limit on the number of fish traps allowed per vessel, establishment of a stressed area within which the use of fish traps, roller trawls, and powerheads for the taking of reef fish was prohibited, and a prohibition on the use of poison or explosives for taking reef fish.

GMFMC FMP Amendments affecting mutton snapper

Description of Action	FMP/Amendment	Effective Date
MSY and OY estimates for all groupers and snappers in aggregate, permits and gear specifications for fish traps and limits on the number of fish traps allowed per vessel, establishment of a stressed area within which the use of fish traps, roller trawls, and powerheads for reef fish harvest was prohibited, explosives and poisons for taking reef fish prohibited.	Reef Fish FMP	[Submitted 8/1981] 11/08/1984
The stressed area was expanded, and a longline/buoy gear boundary was established. The number of fish traps allowed per vessel was reduced from 200 to 100. Reef fish permits were required for commercial reef fish vessels. Commercial harvest of reef fish using trawls or entangling nets was prohibited. Reporting requirements established for commercial and for-hire recreational vessels, 12” TL minimum size limit for mutton snapper adopted, 10 fish aggregate recreational bag limit for snappers (including mutton snapper) implemented, prohibited use of entangling gear for direct harvest, reef fish vessel permit established with an income qualification. MSY and OY were set to 20% SSBR (spawning stock biomass per recruit) and overfishing was defined as the fishing mortality that exceeds 20% transitional SPR.	Amendment 1	[Submitted 8/1989] 02/21/1990
Moratorium on new reef fish permits which was extended at various times and was in effect through 2005.	Amendment 4	05/1992
Among other actions, this amendment closed Riley’s Hump to all fishing during May and June	Amendment 5	1994

Description of Action	FMP/Amendment	Effective Date
to protect Mutton Snapper aggregations. All harvest of Mutton Snapper during May and June reduced to the 10-fish aggregate bag limit for snappers with specified bag limits.		
Established a 10-year phase-out of fish traps.	Amendment 14	03-04/1997
Prohibited harvest of reef fish from traps other than permitted reef fish traps, stone crab traps, or spiny lobster traps.	Amendment 15	01/1998
Implemented regulations compatible with Florida rules on mutton snapper size limits of 16" TL and size limits of several other reef fish, including other snappers (cubera, mahogany, schoolmaster), scamp, triggerfish, and hogfish.	Amendment 16B	11/1999
Prohibited retention of reef fish exhibiting "trap rash" on vessels with a reef fish permit that is fishing spiny lobster or stone crab traps except for vessels possessing a valid fish trap endorsement.	Amendment 16A	01/2000
Generic amendment addressing the establishment of the Tortugas Marine Reserves – establishes two marine reserves and prohibits fishing for any species and anchoring by fishing vessels inside the two marine reserves.	Amendment 19	08/19/2002
Commercial and recreational fishermen fishing for reef fish required to use non-stainless steel circle hooks when using natural baits, and to use dehooking and venting tools for releasing reef fish.	Amendment 27	02/2008
Established regulations for ACTs, ACLs, and other Sustainable Fishery Act requirements such as setting the minimum stock size threshold (MSST), maximum fishing mortality rate (MFMT), and other associated parameters for reef fish species for which these have not been defined.	Generic Sustainable Fisheries Act Amendment	12/2011

GMFMC FMP Regulatory Amendments

Framework Action to Modify Mutton Snapper and Gag Management Measures (July 2018)

Removed the annual catch target (ACT) for mutton snapper and decreased the annual catch limit (ACL) to 134,424 pounds whole weight (lbs ww) for 2018 and 139,392 lbs ww for 2019 and subsequent years. Set the recreational mutton snapper bag limit at 5-snapper per day within the

10-snapper aggregate bag limit and increased the commercial and recreational minimum size limit to 18 inches total length.

Generic Framework Action: Modification of For-Hire Multi-day Trip Possession Limits (March 2021)
Modified the possession limit on-board vessels with Federal Reef Fish or Coastal Migratory Pelagic Charter/Headboat Permits. Anglers fishing from such vessels may possess two-daily bag limits on trips greater than 30-hours and may retain their second daily bag limit at any time during the trip. All other requirements to retain the recreational possession limit are unchanged.

ORIGINAL FWC REGULATIONS

Florida's management of reef fish fisheries, prior to the establishment of the Marine Fisheries Commission (MFC) in 1983, began with the implementation of size limits in 1979 (Florida Statutes in chapter 370.11) for several groupers (red, Nassau, gag, black, and goliath). In July of 1985, the Florida MFC implemented rules in the Florida Administrative Code (F.A.C.) to establish minimum 12" TL size limits for red, mutton, and yellowtail snapper. Later rules sought to achieve a higher level of conformance between state and federal (Council) regulations to reduce potential conflicts between state and federal management. After the merger of the Florida Department of Environmental Protection and the Florida Game and Freshwater Fish Commission by the Florida Legislature on July 1, 1999, the management functions of the MFC became part of the Florida Fish and Wildlife Conservation Commission (FWC).

While much of the fishery for Mutton Snapper occurs in federal waters, juveniles of this species utilize estuarine and nearshore habitats, particularly seagrass, during their first year after hatching.

FWC REGULATIONS AFFECTING MUTTON SNAPPER

Description of Action	Rule chapter	Effective Date
Established 12" TL minimum size for mutton snapper from state waters.	F.A.C. Chap. 68-14	07/1985
Established a 10 fish aggregate bag limit for snappers (included mutton snapper, excluded lane, vermilion, and yelloweye [= silk] snappers). Stab nets (anchored, bottom gill nets) for the harvest of reef fish prohibited in Atlantic waters of Monroe County. Use of long line gear in state waters to harvest snapper prohibited.	F.A.C. Chap. 68-14	12/1986
Required the appropriate federal permit to exceed the recreational bag limit in state waters and to purchase or sell snapper on the state's Gulf coast. All harvest of mutton snapper in May and June is restricted to the bag limit.	F.A.C. Chap. 68-14	12/1992

Description of Action	Rule chapter	Effective Date
Temporarily allowed fishermen to land reef fish in the Florida Keys if they possessed either South Atlantic snapper grouper permits or Gulf reef fish permits, with subsequent extensions of these provisions in July 1995 and January 1996.	F.A.C. Chap. 68-14	10/1993
Established 16” TL minimum size for mutton snapper from state waters.	F.A.C. Chap. 68-14	03/1994
Rule changes for mutton snapper, red porgy, and amberjack to be compatible with federal regulations on commercial trips.	F.A.C. Chap. 68-14	01/2003
Prohibited commercial fishermen from harvesting or possessing the recreational bag limit of reef fish species on commercial trips.	F.A.C. Chap. 68-14	07/2007
Required commercial and recreational anglers fishing for any Gulf reef fish species to use circle hooks, de-hooking devices, and venting tools.	F.A.C. Chap. 68-14	06/2008
Required dehooking tools to be aboard commercial and recreational vessels for anglers to use as needed to remove hooks from Atlantic reef fish.	F.A.C. Chap. 68-14	01/2010
Eliminated the requirement to possess and use venting tools when fishing for reef fish in the Gulf of Mexico.	F.A.C. Chap. 68-14	01/2014
Increased the recreational, commercial, importation, and sale minimum size limits to 18 inches. Reduced the recreational bag limit to 5 fish per person within the 10-fish snapper aggregate bag limit. Replaced the May – June commercial trip limit in all state waters with a 5 fish per person/day limit from April – June in Atlantic state waters. Established a 500-pound commercial vessel limit for the remainder of the year (July – March) in Atlantic state waters	F.A.C. Chap. 68-14	01/2017
Created a State Reef Fish Survey for private recreational reef fish anglers to improve data collection.	F.A.C. Chap. 68-14	07/2020
Required the use of non-stainless-steel, non-offset circle hooks north of 28°N. latitude and non-stainless-steel hooks south of 28°N. latitude when fishing for reef fish with hook-and-line with natural baits on board a vessel in Atlantic state waters.	Florida Statutes, sect. 120.54(6)	01/2021
Prohibited fishing at Western Dry Rocks, a multi-species spawning aggregation site, from April – July.	F.A.C. Chap. 68B-6.004	04/2021

2.2. Emergency and Interim Rules

SAFMC: **Emergency Rule (12/3/2010)** – Delayed the effective date of the area closure for snapper grouper species implemented through Amendment 17A.

GMFMC: None

2.3. Secretarial Amendments

SAFMC: None
GMFMC: None

2.4. Control Date Notices

SAFMC: **Notice of Control Date (3/8/2007)** – Considered measures to limit participation in the snapper grouper for-hire sector.

Notice of Control Date (1/31/2011) – Anyone entering the federal South Atlantic snapper grouper fishery after 09/17/10 was not assured of future access if a limited entry program was developed.

Notice of Control Date (6/15/2016) – Anyone entering the federal South Atlantic snapper grouper fishery after 6/15/2016 will not be assured of future access should a management regime that limits participation in the sector be prepared and implemented.

GMFMC: None

2.5. Management Program Specifications

Table 2.5.1. General Management Information

South Atlantic

Species	Mutton Snapper (*Lutjanus analis*)
Management Unit	Southeastern U.S.
Management Unit Definition	All waters within the South Atlantic Fishery Management Council boundaries. Defined as the economic zone (EEZ), 200 miles from state boundary line.
Management Entity	South Atlantic Fishery Management Council
Management Contacts SERO/Council	Rick DeVictor/Mike Schmidtke
Stock exploitation status (as of SEDAR 15A Update, 2015)	Not undergoing overfishing
Stock biomass status as of SEDAR 15A Update, 2012)	Not overfished

Gulf of Mexico

Species	Mutton Snapper (*Lutjanus analis*)
Management Unit	U. S. Gulf of Mexico
Management Unit Definition	All waters within the Gulf of Mexico Fishery Management Council's jurisdictional boundary. Defined as the economic zone (EEZ), 200 miles from state boundary line.
Management Entity	Gulf of Mexico Fishery Management Council
Management Contacts SERO/Council	Peter Hood/Ryan Rindone
Stock exploitation status (as of SEDAR 15A Update, 2015)	Not undergoing overfishing
Stock biomass status as of SEDAR 15A Update, 2015)	Not overfished

Table 2.5.2. Specific Management Criteria

South Atlantic and Gulf of Mexico*				
Criteria	Current (SEDAR 15A, 2015; Snapper Grouper Amendment 41, 2017)		Results from SEDAR 79	
	Definition	Value**	Definition	Value
MSST	75% of SSB_{MSY}	3,486,900 lbs ww	75% of SSB_{MSY}	TBD
MFMT	$F_{30\%SPR}$	0.18	$F_{30\%SPR}$	TBD
MSY	Yield at $F_{30\%SPR}$ (MSY proxy)*	912,500 lbs ww	Yield at $F_{30\%SPR}$	TBD
F_{MSY}	$F_{30\%SPR}$	0.18	$F_{30\% SPR}$	TBD
SSB_{MSY}	$SSB_{30\%SPR}$ (SSB_{MSY} proxy)	2,094 mt	SSB_{MSY}	TBD
OY	Yield at F_{OY} ($F_{30\%SPR}$)*	172,700 fish	Yield at F_{OY}	TBD
F Target (i.e. F_{OY})	$F_{30\%SPR}$	0.18	$F_{30\%SPR}$	TBD
Yield at F_{TARGET} (equilibrium)	Landings and discards, lbs and numbers*	172,700 fish	Landings and discards, lbs and numbers	TBD
M	Natural mortality rate, Age-Specific	0.17	Age-Specific	TBD
Terminal F	Exploitation ($F_{2011-2013}$)	0.12	Exploitation ($F_{2018-2020}$)	TBD
Terminal Biomass	SSB_{2013}	2,354 mt	SSB_{2020}	TBD
Exploitation Status	$F_{2011-2013}/F_{30\%SPR}$	0.65	$F_{2018-2020}/F_{30\%SPR}$	TBD
Biomass Status (SSB)	SSB_{2013}/MSST	1.50	SSB_{2020}/MSST	TBD
	$SSB_{2013}/SSB_{30\%SPR}$	1.12	$SSB_{2020}/SSB_{30\%SPR}$	TBD
Generation Time				
$T_{REBUILD}$ (if appropriate)		-		

* Note: Catch limits from SEDAR 15U were projected based on an F_{MSY} proxy of $F_{30\%SPR}$ based on a probability distribution function using a P* value of 0.5 for the overfishing limit, and a P* value of 0.3 for the acceptable biological catch.

Table 2.5.3. Stock Rebuilding Information
Mutton snapper is not under a rebuilding plan.

Table 2.5.4. Stock projection information.

First Year of Management	2023
Interim basis	2022
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 2.5.5. 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 2.5.6. 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.

Basis	Value	Years to project	P* applies to
P*	50%	Interim + 5	Probability of overfishing
P*	30%	Interim + 5	Probability of overfishing
Exploitation at MSY	F_{MSY}	Interim + 5	NA
Exploitation at OY	Fp*30 for $_{30\%SPR}$	Interim + 5	NA

Table 2.5.7. Quota Calculation Details

SAFMC Catch Limits	Commercial	Recreational	Total Annual Catch Limit
Current ACL Value	111,354 lbs ww	127,115 fish	141,614 fish
Next Scheduled Quota Change	-	-	-
Annual or averaged quota?	Annual	Annual	Annual
If averaged, number of years to average	-	-	-
Does the quota account for bycatch/discard?	NO	NO	NO

GMFMC Catch Limits	Total Annual Catch Limit
Current ACL Value (2021)	143,694 lbs ww
Next Scheduled Quota Change	2022
Annual or averaged quota?	Annual
If averaged, number of years to average	-
Does the quota account for bycatch/discard?	NO

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

- Sector ACLs are used in the South Atlantic, but not in the Gulf.

2.6. Management and Regulatory Timeline

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

Federal Harvest Restrictions – Trip Limits*
*Trip limits do not apply during closures (if season is closed, then trip limit is 0)

First Yr In Effect	Effective Date	End Date	Fishery	Bag Limit Per Person/Day	Trip Limit Per Boat/Day	Region Affected	FR Reference	Amendment Number or Rule Type
1984	1/1/84	Present	Comm	-	None	Gulf of Mexico	55 FR 2086	Amendment 1
1984	1/1/84	7/22/18	Rec	10 snapper aggregate in the 20 reef fish aggregate	None	Gulf of Mexico	55 FR 2086	Amendment 1
1992	1/1/92	Ongoing	Rec	Recreational aggregate bag limit - 10 snapper/person/day, excluding vermilion snapper and allowing no more than 2 red snappers		South Atlantic	56 FR 56016	Snapper Grouper Amendment 4
2018	7/23/18	Present	Rec	5 fish within the 10 snapper aggregate	None	Gulf of Mexico	83 FR 29041	2018 Framework Action
2018	2/10/18	Ongoing	Both	5 (recreational; included in 10-snapper aggregate)	500 pounds whole weight (commercial) during January-March and July-December; 5 fish per person per day or 5 fish per person per trip, whichever is more restrictive, during April-June	South Atlantic	83 FR 1305	Snapper Grouper Amendment 41

Federal Harvest Restrictions – Size Limits*
*Size limits do not apply during closures

First Yr In Effect	Effective Date	End Date	Fishery	Size Limit	Length Type	Region Affected	FR Reference	Amendment Number or Rule Type
1990	2/21/90	11/23/99	Both	12"	TL	Gulf of Mexico	55 FR 2086	Amendment 1
1992	1/1/92	1/22/95	Comm and Rec	12"	TL	South Atlantic	56 FR 56016	Snapper Grouper Amendment 4
1995	1/23/95	2/9/18	Comm and Rec	16"	TL	South Atlantic	59 FR 66270	Snapper Grouper Amendment 7
1999	11/24/99	7/22/18	Both	16"	TL	Gulf of Mexico	64 FR 57404	Amendment 16B
2018	7/23/18	Present	Both	18"	TL	Gulf of Mexico	83 FR 29041	2018 Framework Action
2018	2/10/18	Ongoing	Comm and Rec	18"	TL	South Atlantic	83 FR 1305	Snapper Grouper Amendment 41

Federal Harvest Restrictions – Fishery Closures*
*Area specific regulations are documented under spatial restrictions

First Yr In Effect	Effective Date	End Date	Fishery	Closure Type	First Day Closed	Last Day Closed	Region Affected	FR Reference	Amendment Number or Rule Type
1992	1/1/92	2/9/18	Comm	Spawning Season; harvest may occur under recreational regulations	1-May	30-Jun	South Atlantic	56 FR 56016	Snapper Grouper Amendment 4
2018	2/10/18	Ongoing	Comm	Spawning Season; harvest may occur under recreational regulations	1-Apr	30-Jun	South Atlantic	83 FR 1305	Snapper Grouper Amendment 41

** No Fishery Closures have occurred in the Gulf of Mexico

Federal Harvest Restrictions – Spatial Restrictions – Gulf of Mexico

Area	First Yr In Effect	Effective Date	End Date	Fishery	First Day Closed	Last Day Closed	Restriction in Area	FR Reference	Amendment Number or Rule Type
Gulf of Mexico Stressed Areas	1984	11/8/84	Ongoing	Both	Year round		Prohibited powerheads for Reef FMP	49 FR 39548	Original Reef Fish FMP
	1984	11/8/84	Ongoing	Both	Year round		Prohibited pots and traps for Reef FMP	49 FR 39548	Original Reef Fish FMP
EEZ, inside 50 fathoms west of Cape San Blas, FL	1990	2/21/90	Ongoing	Both	Year round		Prohibited longline and buoy gear for Reef FMP	55 FR 2078	Reef Fish Amendment 1
EEZ, inside 20 fathoms east of Cape San Blas, FL	1990	2/21/90	4/17/09	Both	Year round		Prohibited longline and buoy gear for Reef FMP	55 FR 2078	Reef Fish Amendment 1
Alabama Special Management Zones	1994	2/7/94	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	Reef Fish Amendment 5
EEZ, inside 50 fathoms east of Cape San Blas, FL	2009	5/18/09	10/15/09	Both	18-May	28-Oct	Prohibited bottom longline for Reef FMP	74 FR 20229	Emergency Rule
EEZ, inside 35 fathoms east of Cape San Blas, FL	2009	10/16/09	4/25/10	Both	Year round		Prohibited bottom longline for Reef FMP	74 FR 53889	Sea Turtle ESA Rule
	2010	4/26/10	Ongoing	Rec	Year round		Prohibited bottom longline for Reef FMP	75 FR 21512	Reef Fish Amendment 31
	2010	4/26/10	Ongoing	Com	1-Jun	31-Aug	Prohibited bottom longline for Reef FMP	75 FR 21512	Reef Fish Amendment 31
Madison-Swanson	2000	6/19/00	6/2/04	Both	Year round		Fishing prohibited except HMS[1]	65 FR 31827	Reef Fish Regulatory Amendment
	2004	6/3/04	Ongoing	Both	1-May	31-Oct	Fishing prohibited except surface trolling	70 FR 24532 74 FR 17603	Reef Fish Amendment 21 Reef Fish Amendment 30B
	2004	6/3/04	Ongoing	Both	1-Nov	30-Apr	Fishing prohibited	70 FR 24532 74 FR 17603	Reef Fish Amendment 21 Reef Fish Amendment 30B
Steamboat Lumps	2000	6/19/00	6/2/04	Both	Year round		Fishing prohibited except HMS[1]	65 FR 31827	Reef Fish Regulatory Amendment
	2004	6/3/04	Ongoing	Both	1-May	31-Oct	Fishing prohibited except surface trolling	70 FR 24532 74 FR 17603	Reef Fish Amendment 21 Reef Fish Amendment 30B
	2004	6/3/04	Ongoing	Both	1-Nov	30-Apr	Fishing prohibited	70 FR 24532 74 FR 17603	Reef Fish Amendment 21 Reef Fish Amendment 30B

The Edges	2010	7/24/09	Ongoing	Both	1-Jan	30-Apr	Fishing prohibited	74 FR 30001	Reef Fish Amendment 30B Supplement
20 Fathom Break	2014	7/5/13	Ongoing	Rec	1-Feb	31-Mar	Fishing for SWG prohibited[2]	78 FR 33259	Reef Fish Framework Action
Flower Garden	1992	1/17/92	Ongoing	Both	Year round		Fishing with bottom gears prohibited[3]	56 FR 63634	Sanctuary Designation
Riley's Hump	1994	2/7/94	8/18/02	Both	1-May	30-Jun	Fishing prohibited	59 FR 966	Reef Fish Amendment 5
Tortugas Reserves	2002	8/19/02	Ongoing	Both	Year round		Fishing prohibited	67 FR 47467	Tortugas Amendment
Pulley Ridge	2006	1/23/06	Ongoing	Both	Year round		Fishing with bottom gears prohibited[3]	70 FR 76216	Essential Fish Habitat (EFH) Amendment 3
DWH Oil Spill closure	2010	5/2/10	11/15/10	Both			All fishing prohibited in designated areas	75 FR 24822	

[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

Federal Harvest Restrictions – Spatial Restrictions – South Atlantic

There are no spatial restrictions for mutton snapper in the South Atlantic

Federal Harvest Restrictions – Gear – Gulf of Mexico

*Area specific gear restrictions are documented under spatial restrictions

Gear Type	First Yr In Effect	Effective Date	End Date	Gear/Harvesting Restrictions	Region Affected	FR Reference	Amendment Number or Rule Type
Poison	1984	11/8/84	Ongoing	Prohibited for Reef FMP	Gulf of Mexico EEZ	49 FR 39548	Original Reef Fish FMP
Explosives	1984	11/8/84	Ongoing	Prohibited for Reef FMP	Gulf of Mexico EEZ	49 FR 39548	Original Reef Fish FMP
Pots and Traps	1984	11/23/84	2/3/94	Established fish trap permit	Gulf of Mexico EEZ	50 FR 39548	Original Reef Fish FMP
	1984	11/23/84	2/20/90	Set max number of traps fish by a vessel at 200	Gulf of Mexico EEZ	50 FR 39548	Original Reef Fish FMP
	1990	2/21/90	2/3/94	Set max number of traps fish by a vessel at 100	Gulf of Mexico EEZ	55 FR 2078	Reef Fish Amendment 1
	1994	2/4/94	2/7/97	Moratorium on additional commercial trap permits	Gulf of Mexico EEZ	59 FR 966	Reef Fish Amendment 5
	1997	3/25/97	2/6/07	Phase out of fish traps begins	Gulf of Mexico EEZ	62 FR 13983	Reef Fish Amendment 14
	1997	12/30/97	2/6/07	Prohibited harvest of reef fish from traps other than permitted reef fish, stone crab, or spiny lobster traps.	Gulf of Mexico EEZ	62 FR 67714	Reef Fish Amendment 15
	2007	2/7/07	Ongoing	Traps prohibited	Gulf of Mexico EEZ	62 FR 13983	Reef Fish Amendment 14
All	1992	4/8/92	12/31/95	Moratorium on commercial permits for Reef FMP	Gulf of Mexico EEZ	68 FR 11914 59 FR 39301	Reef Fish Amendment 4 Reef Fish Amendment 9
	1994	2/7/94	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	Reef Fish Amendment 9
	1996	6/1/96	12/31/05	Moratorium on commercial permits for Gulf reef fish.	Gulf of Mexico EEZ	61 FR 34930 65 FR 41016	Interim Rule Reef Fish Amendment 17
	2006	9/8/06	Ongoing	Use of Gulf reef fish as bait prohibited.[1]	Gulf of Mexico EEZ	71 FR 45428	Reef Fish Amendment 18A
Vertical Line	2008	6/1/08	Ongoing	Requires non-stainless steel circle hooks and dehooking devices	Gulf of Mexico EEZ	74 FR 5117	Reef Fish Amendment 27
	2008	6/1/08	9/3/13	Requires venting tools	Gulf of Mexico EEZ	74 FR 5117 78 FR 46820	Reef Fish Amendment 27 Framework Action
Longline	2009	10/16/09		750 hooks fishing	Gulf of Mexico EEZ		Endangered Species Act and regulatory action

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

Federal Harvest Restrictions – Gear - South Atlantic
*Area specific gear restrictions are documented under spatial restrictions

Gear Type	First Yr In Effect	Effective Date	End Date	Gear/Harvesting Restrictions	Region Affected	FR Reference	Amendment Number or Rule Type
Poison	1983	8/31/83	ongoing	Prohibited	South Atlantic EEZ	48 FR 39463	SG FMP
Explosives	1983	8/31/83	ongoing	Prohibited	South Atlantic EEZ	48 FR 39463	SG FMP
Fish traps	1983	8/31/83	12/31/91	Prohibited shoreward of the 100 ft contour, south of Fowey Rocks Light (Miami). Restriction on pulling traps from one hour before sunset to one hour before sunrise south of Cape Canaveral. Gear specs (degradaable panel, degradable door fasteners, mesh size).	South Atlantic EEZ	48 FR 39463	SG FMP
Hand-held hook and line and spearfishing	1987	3/27/87	ongoing	Only gear allowed in Special Management Zones	SMZs within the South Atlantic EEZ	52 FR 9864	Regulatory Amendment 1
Trawl	1989	1/12/89	ongoing	Prohibited south of Cape Hatteras, NC and north of Cape Canaveral, FL	specified area within the South Atlantic EEZ	54 FR 1720	Amendment 1
Fish traps	1992	1/1/92	ongoing	Prohibited fish traps (except black sea bass pots) north of Cape Canaveral, FL	specified area within the South Atlantic EEZ	56 FR 56016	Amendment 4
Entanglement nets	1992	1/1/92	ongoing	Prohibited	South Atlantic EEZ	56 FR 56016	Amendment 4
Longline	1992	1/1/92	ongoing	Prohibited inside of 50 fathoms	specified area within the South Atlantic EEZ	56 FR 56016	Amendment 4
Powerheads and bangsticks	1992	1/1/92	ongoing	Prohibited in SMZs off South Carolina	specific areas off SC	56 FR 56016	Amendment 4
Allowable gear	1995	1/23/95	ongoing	Specified allowable gear in the SG fishery	South Atlantic EEZ	59 FR 66270	Amendment 7

Non-stainless steel circle hooks	2011	3/3/11	ongoing	Required to fish for SG species with natural baits north of 28 degrees N Lat.	specified area within the South Atlantic EEZ	75 FR 76874	Amendment 17A

Federal Quota History

First Yr In Effect	ctive Date	End Date	Quota or ACL	Region Affected	FR Reference	Amendment Number or Rule Type
2012	1/1/12	12/31/12	203,000 lbs ww	Gulf of Mexico (Stock)		
2013	1/1/13	12/31/13	203,000 lbs ww	Gulf of Mexico (Stock)		
2014	1/1/14	12/31/14	203,000 lbs ww	Gulf of Mexico (Stock)		
2015	1/1/15	12/31/15	203,000 lbs ww	Gulf of Mexico (Stock)		
2016	1/1/16	12/31/16	203,000 lbs ww	Gulf of Mexico (Stock)		
2017	1/1/17	12/31/17	203,000 lbs ww	Gulf of Mexico (Stock)		
2018	1/1/18	12/31/18	134,424 lbs ww	Gulf of Mexico (Stock)		
2019	1/1/19	12/31/19	139,392 lbs ww	Gulf of Mexico (Stock)		
2020	1/1/20	12/31/20	143,694 lbs ww	Gulf of Mexico (Stock)		
2021	1/1/21	12/31/21	143,694 lbs ww	Gulf of Mexico (Stock)		
2012	4/16/12	2/9/18	768,893 lbs ww	South Atlantic - Rec	77 FR 15916	Snapper Grouper Amendment 25
2018	2/10/18	12/31/18	121,318 fish	South Atlantic - Rec	83 FR 1305	Snapper Grouper Amendment 41
2019	1/1/19	12/31/19	124,766 fish	South Atlantic - Rec	83 FR 1305	Snapper Grouper Amendment 41
2020	1/1/20	Ongoing	127,115 fish	South Atlantic - Rec	83 FR 1305	Snapper Grouper Amendment 41
2012	4/16/12	2/9/18	157,707 lbs ww	South Atlantic - Comm	77 FR 15916	Snapper Grouper Amendment 25
2018	2/10/18	12/31/18	104,231 lbs ww	South Atlantic - Comm	83 FR 1305	Snapper Grouper Amendment 41
2019	1/1/19	12/31/19	107,981 lbs ww	South Atlantic - Comm	83 FR 1305	Snapper Grouper Amendment 41
2020	1/1/20	Ongoing	111,354 lbs ww	South Atlantic - Comm	83 FR 1305	Snapper Grouper Amendment 41

Table 7. State Regulatory History

Florida Harvest Restrictions – Trip Limits*

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

First Yr In Effect	Effective Date	End Date	Fishery	Bag Limit Per Person/Day	Region Affected	Reference
1986	12/11/86	Ongoing	Both	10 snapper aggregate per day the 20 snapper possession	Statewide	Ch. 46-14, F.A.C
1992	12/31/92	6/30/95		Requires the appropriate federal permit in order to exceed snapper/grouper bag limits and to purchase or sell snapper/grouper on the state's Gulf coast	Gulf of Mexico waters	CH 46-14, F.A.C.
1992	12/31/92	1/1/17	Both	Restricts all harvest of Mutton Snapper in May and June to the bag limit for this species	Statewide	Ch. 46-14, F.A.C
1993	10/18/93	6/30/95	Comm	Allows persons who possess either a Gulf of Mexico or South Atlantic federal reef fish permit to commercially harvest snappers and groupers (except red snapper) in all state waters, until July 1, 1995 and January 1, 1996.	Statewide	CH 46-14, F.A.C.
1994	3/1/94	Ongoing	Rec	Allows a two-day possession limit for reef fish statewide for persons aboard charter and headboats on trips exceeding 24 hours provided that the vessel is equipped with a permanent berth for each passenger aboard, and each passenger has a receipt verifying the trip length	Statewide	Ch. 46-14, F.A.C
2007	7/1/07	Ongoing	Both	Prohibits commercial fishermen from harvesting or possessing the recreational bag limit of reef fish species on commercial trips	State waters	CH 46-14, F.A.C.
2017	1/1/17	Ongoing	Rec	Reduces the recreational bag limit to five fish per person within the 10-fish snapper aggregate bag limit	Statewide	Ch. 46-14, F.A.C
2017	1/1/17	Ongoing	Comm	Replaces the May – June commercial trip limit in all state waters with a five fish per person/day limit from April – June in Atlantic state waters. Establish a 500-pound commercial vessel limit for the remainder of the year (July – March) in Atlantic state waters	Atlantic state waters	Ch. 46-14, F.A.C

2021	8/25/21	Ongoing	Rec	Under limited circumstances that are consistent with those in adjacent federal waters, passengers on for-hire trips in state waters that span more than 24 hours may possess and land double the bag limit of reef fish	Statewide	Ch. 46-14, F.A.C

Florida Harvest Restrictions – Size Limits*
*Size limits do not apply during closures

First Yr In Effect	Effective Date	End Date	Fishery	Size Limit	Length Type	Region Affected	Reference
1985	7/29/85	2/28/94	Both	12"	TL	Statewide	CH 46-14, F.A.C.
	3/1/94	12/31/16	Both	16"	TL	Statewide	CH 46-14, F.A.C.
2017	1/1/17	Ongoing	Both	18"	TL	Statewide	CH 46-14, F.A.C.

Florida Harvest Restrictions – Fishery Closures*
*Area specific regulations are documented under spatial restrictions

First Yr In Effect	Effective Date	End Date	Fishery	Closure Type	First Day Closed	Last Day Closed	Region Affected	Reference
2021	4/1/21	3/31/28	Both		1-Apr	31-Jul	Western Dry Rocks in Monroe County waters	CH. 64B.004

Florida Harvest Restrictions – Spatial Restrictions

Area	First Yr In Effect	Effective Date	End Date	Fishery	First Day Closed	Last Day Closed	Restriction in Area	Reference
Western Dry Rocks in Monroe County waters	2021	4/1/21	3/31/28	Both	1-Apr	31-Jul	Fishing and possession of fish are prohibited within Western Dry Rocks, described in subsection (1), from April 1 through July 31.	CH. 64B.004

Florida Harvest Restrictions – Gear

*Area specific gear restrictions are documented under spatial restrictions

Gear Type	First Yr In Effect	Effective Date	End Date	Gear/Harvesting Restrictions	Region Affected	Reference
All	1990	2/1/90	Ongoing	All commercial harvest of any species of snapper, grouper, and sea bass is prohibited in state waters whenever harvest of that species is prohibited in adjacent federal waters. Allowable gear: Hook and line, black sea bass trap, spear, gig, or lance (except powerheads, bangsticks, or explosive devices) for snapper and grouper. Snapper and grouper must be landed in whole condition.	State waters	CH. 64-14, F.A.C.
	1994	2/7/94	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)	State waters	CH. 64-14, F.A.C.
	2008	6/1/08	1/23/14	Requires all commercial and recreational anglers fishing for any Gulf reef fish species to use circle hooks, dehooking devices and venting tools, beginning June 1, 2008	Gulf state waters	CH. 64-14, F.A.C.
	2010	1/19/10	Ongoing	Requires dehooking tools to be aboard commercial and recreational vessels for anglers to use as needed to remove hooks from Atlantic reef fish	Atlantic state waters	CH. 64-14, F.A.C.
	2014	1/24/14	Ongoing	Eliminated the requirement to possess and use venting tools when fishing for reef fish in the Gulf of Mexico	Gulf state waters	CH. 64-14, F.A.C.
	2021	1/1/21	Ongoing	Required the use of non-stainless-steel, non-offset circle hooks north of 28°N. latitude and non-stainless-steel hooks south of 28°N. latitude when fishing for reef fish with hook-and-line with natural baits on board a vessel in Atlantic state waters.	Atlantic state waters	Florida Statutes, sect. 120.54(6)
Longline	1986	12/11/86	6/30/95	Use of longline gear by commercial fishermen prohibited; bycatch allowance of 5% is permitted harvesters of other species using this gear.	Atlantic waters Monroe County waters	CH. 64-14, F.A.C.
Stab nets	1986	12/11/86	Ongoing	Use of stab nets (or sink nets) to take snapper or grouper is prohibited in Atlantic waters of Monroe County.	Monroe County waters	CH. 64-14, F.A.C.

Other Florida State Regulations

First Yr In Effect	Effective Date	End Date	Harvesting Restrictions	Region Affected	Reference
1990	2/1/90	**Ongoing**	Designates all snapper and grouper as "restricted species"	State waters	CH 46-14, F.A.C.
1995	7/1/95	12/31/95	Continues the allowance of persons to possess either the proper South Atlantic or Gulf permit to harvest reef fish for commercial purposes	State waters	CH 46-14, F.A.C.
1996	1/1/96	12/31/96	Continues the allowance of persons to possess either the proper South Atlantic or Gulf permit to harvest reef fish for commercial purposes	State waters	CH 46-14, F.A.C.
1997	11/27/96	12/31/97	Continues the allowance of persons to possess either the proper South Atlantic or Gulf permit to harvest reef fish for commercial purposes	State waters	CH 46-14, F.A.C.
1998	12/31/98	Ongoing	Requires that all reef fish species managed in Florida be landed in a whole condition, and designate all such species as "restricted species". Changes rule language regarding possession of mutton snapper, red porgy and amberjack during commercial trips to correspond with federal regulations	State waters	CH 46-14, F.A.C.
2000	1/1/00	Ongoing	Restores the documentation requirement for reef fish species possessed during a closure period	State waters	CH 46-14, F.A.C.
2003	1/1/03	Ongoing	Changes rule language regarding possession of mutton snapper, red porgy and amberjack during commercial trips to correspond with federal regulations. Deletes a provision pertaining to closure notices for state waters when adjacent federal waters close	State waters	CH 46-14, F.A.C.
2006	7/1/06	Ongoing	Provides that, for purposes of determining the legal size of reef fish species, "total length" means the straight line distance from the most forward point of the head with the mouth closed, to the farthest tip of the tail with the tail compressed or squeezed, while the fish is lying on its side	State waters	CH 46-14, F.A.C.

2010	1/19/10	Ongoing	Requires dehooking tools to be aboard commercial and recreational vessels for anglers to use as needed to remove hooks from Atlantic reef fish	State waters	CH 46-14, F.A.C.
2014	8/26/14	Ongoing	Create a Gulf Reef Fish Data Reporting System for private recreational reef fish anglers to improve data collection	State waters	CH 46-14, F.A.C.
2016	7/1/16	Ongoing	Requires a valid transferable commercial permit or a trip-limited commercial permit for South Atlantic snapper-grouper shall not apply to the harvest of black snapper, dog snapper, mahogany snapper, schoolmaster, or wenchman for commercial purposes in the Atlantic Ocean.	Atlantic State waters	CH 46-14, F.A.C.
2020	7/2020	Ongoing	Created a State Reef Fish Survey for private recreational reef fish anglers to improve data collection.	State waters	CH 46-14, F.A.C.

3 ASSESSMENT HISTORY AND REVIEW

The first SEDAR assessment of Mutton Snapper, SEDAR 15A, was completed in 2008 (SEDAR 15A 2008) and had a terminal year of 2006. SEDAR 15A considered a suite of analytical models with varying assumptions including catch curves, non-equilibrium surplus production (ASPIC), surplus production (modified DeLury), untuned virtual population analysis (VPA), stochastic stock reduction (SRA), and a forward projecting statistical catch-at-age (ASAP, generic SCAM). The assessment workshop panel recommended the Age-Structured Assessment Program (ASAP, version 1A, 1998) as the primary model for determining the condition of the stock, and to use the other models for supporting analyses. The ASAP model was configured with five fleets, with discards being considered separately but linked to their appropriate fleet, and 11 indices, six of which were fishery- independent indices and five were fishery-dependent. Two of the fishery-independent indices were associated with recruitment.

In SEDAR 15A, spawning stock biomass was defined as both male and female mature biomass. The estimated total spawning stock biomass reached a low in 1995 and increased to 7,140 metric tons in 2006. The total spawning stock biomass associated with 30%SPR was estimated to be 6,296 metric tons and therefore the population was not considered to be overfished, however sensitivity runs indicate that there was a moderate probability that the stock could be overfished. Recruitment was variable, but the low was 462,000 fish in 1985, and the high was 2.40 million fish in 2005. Estimated fishing mortality rates ranged from 0.05 y^{-1} in 1985 to approximately 0.40 y^{-1} in 1995 and declined to 0.18 y^{-1} in 2006. $F_{30\%SPR}$ was estimated to be 0.34 y^{-1}, thus overfishing was not occurring.

The update assessment, SEDAR 15AU, completed in 2015 (SEDAR 15AU 2015) with a terminal year of 2013, used an updated version of ASAP (ASAP3, version 3.0.17) as the modelling platform. The updated ASAP version allowed for age- and year-specific values for natural mortality rates and multiple weights by age and year such as average spawning weights, catch weights by fleet and partition (i.e., retained or released), and average stock weight at the beginning of the year. Further, it accommodated multiple fleets with one or more selectivity blocks within the fleets, incomplete age-composition to accommodate fisheries that are not sampled every year, and indices of abundance in either numbers or biomass that are offset by month. The original version of ASAP only allowed for selectivity by specific ages while ASAP3 had selectivity options for single logistic or double logistic curves (2- or 4-parameters, respectively), generally reducing the number of parameters in the model compared to age-specific parameters.

The recreational fleet structure remained unchanged from SEDAR 15A (i.e., headboat and other fishing modes [MRFSS]), but the commercial fleet structure was simplified from three to two primary gears: hook-and-line (including miscellaneous gears such as traps, trawls, etc.) and longlines.

Several indices of abundance that were included in SEDAR 15A were either removed or modified in SEDAR 15AU. First, the FWC Visual Survey was absorbed into the NMFS-UM Reef Visual Census (RVC) in 2008. Instead of estimating selectivity by age for the RVC, a dome-shaped, double logistic curve, for ages one to seven years was estimated. The NMFS Riley's Hump index was updated through its last year, 2011, and applied to ages 5-15 based on limited length estimates. The SEAMAP video survey index was dropped because so few Mutton Snapper were observed and the index had relatively high uncertainty (CV range 0.32-3.08) with a corresponding poor fit [see Fig. 2.2.3.3 of SEDAR 15A (2008)]. Also, the headboat index in SEDAR 15A that was representative of 1981-1991 (a period of lower minimum size limits and limited survey spatial coverage; SEDAR 15A-DW-11-12) was removed. Lastly, the lengths of specimens represented by the FIM Age-1+ index in SEDAR 15A were reexamined and the majority (over 89%) of specimens collected by the 183-m seines in Indian River and Loxahatchee River estuaries were estimated to be age-0. Because this index was an estimate of the abundance late-age-0 fish rather than ages 1+, the index value for the sampled year was advanced to the following January 1 and the model was configured to use the observed values as an index of expected age-1 fish on January 1.

Life history parameters were also updated in SEDAR 15AU. First, the von Bertalanffy growth equation was revised and used to develop a stochastic age-length key. The von Bertalanffy growth curve used in SEDAR 15A (2008) was $L_t = 874(1-e^{(-0.164(t+1.32))}$ (n = 7,172 fish, r^2=0.839) where L_t is the average length at age, t, while the growth curve estimated for SEDAR 15AU was $L_t = 861(1-e^{(-0.165(t+1.23))}$($n$ = 13,052 fish, r^2=0.803).

The maximum observed age of 40 years remained the same as that specified in SEDAR 15A, therefore both previous assessments assumed the same average natural mortality rates for ages 3-40 of 0.11 per year (Hoenig 1983, Hewitt and Hoenig 2005). However, in SEDAR 15AU, the revised von Bertalanffy growth curve parameters were used to update the Lorenzen, age-specific, natural mortality rates according to Lorenzen (2005).

The sex ratio in Mutton Snapper was examined in SEDAR 15AU and the probability of fish being female at any age was estimated to be 50%. Consequently, spawning stock biomass in SEDAR 15AU was specified as female spawning stock biomass rather than total spawning stock bioomass as was previously specified in SEDAR 15A.

Another notable difference between the SEDAR 15AU update assessment and SEDAR 15A benchmark assessment was a change in the maturity curves. The age at 50% maturity was reduced from 3.71 years to 2.85 years. Note, however, that the maturity at age presented in Table 2.2.1 in the SEDAR 15AU stock assessment report was evaluated at a fractional age with peak spawning occurring on May 1 (e.g., 1.33, 2.33, 3.33; see table below) prior to multiplying by the proportion female (0.50); whereas the maturity at age specified in the ASAP base model was based on a peak spawning occurring on July 1 (e.g., 1.5, 2.5, 3.5; see table below) prior to multiplying by the proportion female (0.50).

Calendar Age	ASAP Base Model (Peak Spawn - July 1)	Feb 2015 Report (Peak Spawn -May 1)
1	0.01	0
2	0.23	0.14
3	0.904	0.84
4	0.996	1
5	1	1
6+	1	1

The SEDAR 15AU update assessment estimated $F_{30\%SPR}$ (MFMT) to be 0.18 y^{-1} and $F_{current}$ (the geometric mean of age-3 fishing mortality rates from 2011-2013) to be 0.12 y^{-1}; therefore, the resulting F-ratio of 0.65 indicated that Mutton Snapper was not undergoing overfishing. The estimated female spawning biomass in 2013 was 2,387 metric tons, while the equilibrium female spawning biomass at $F_{30\%SPR}$ was 2,109 metric tons, leading to a biomass ratio of 1.13 indicating that Mutton Snapper was not overfished (SEDAR 15AU Supplement 2015).

SEDAR 15A. 2008. Stock assessment report, SEDAR 15A South Atlantic and Gulf of Mexico Mutton Snapper, 410 pp. Available at: https://sedarweb.org/assessments/sedar-15a/

SEDAR 15AU. 2015. SEDAR 15A Update. South Atlantic and Gulf of Mexico Mutton Snapper. South Atlantic Fishery Management Council. Charleston, SC. 144 pp. Available at: https://sedarweb.org/assessments/sedar-15a-update-south-atlantic-and-gulf-of-mexico-mutton-snapper/

SEDAR 15AU Supplement. 2015. Supplement and Corrigenda to SEDAR 15A Mutton Snapper Update Assessment South Atlantic and Gulf of Mexico Mutton Snapper. South Atlantic Fishery Management Council. Charleston, SC. 16 pp. Available at: https://sedarweb.org/assessments/sedar-15a-update-south-atlantic-and-gulf-of-mexico-mutton-snapper/

4 REGIONAL MAPS

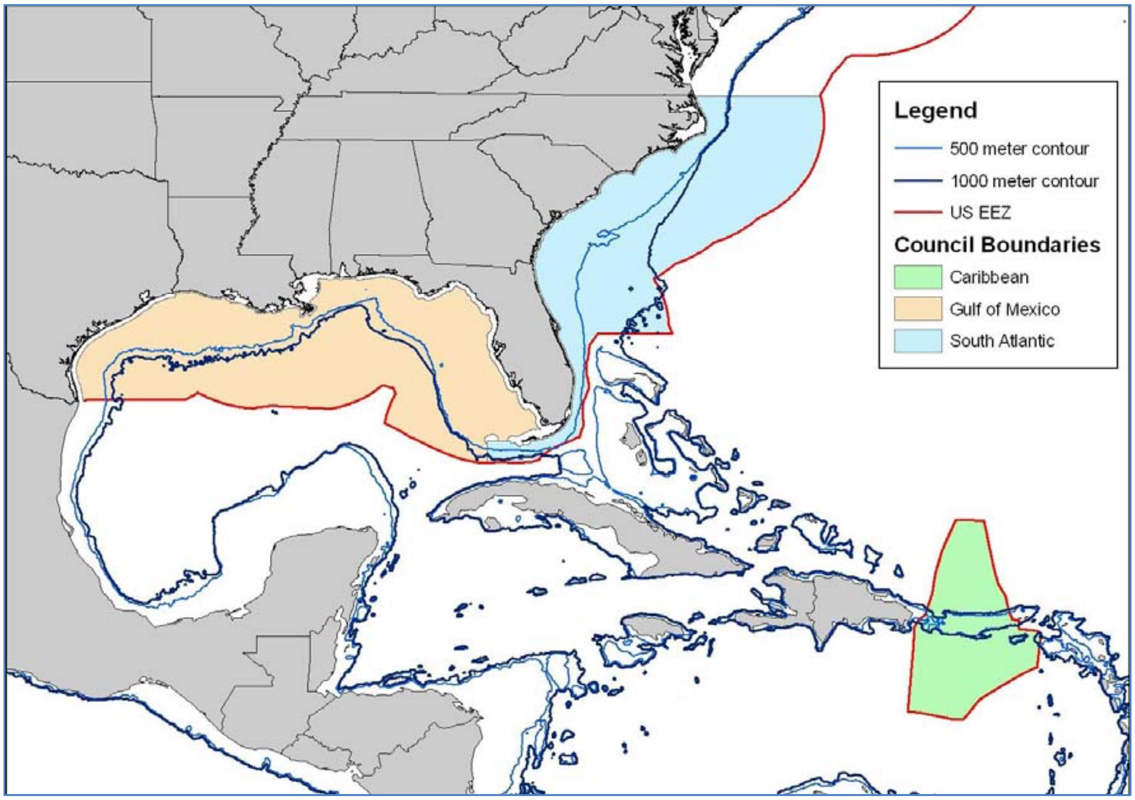

Figure 4.1 Southeast Region including Council and EEZ Boundaries.

5 SEDAR ABBREVIATIONS

ABC	Acceptable 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
APAIS	Access Point Angler Intercept Survey
ASMFC	Atlantic States Marine Fisheries Commission
B	Biomass (stock) level
BAM	Beaufort Assessment Model
B_{msy}	B capable of producing MSY on a continuing basis
BSIA	Best Scientific Information Available
CHTS	Coastal Household Telephone Survey
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	Catch Per Unit Effort
EEZ	Exclusive Economic Zone

F	Fishing mortality (instantaneous)
FES	Fishing Effort Survey
FIN	Fisheries Information Network
F_{MSY}	F to produce MSY under equilibrium conditions
F_{OY}	F rate to produce OY under equilibrium
$F_{XX\%\ SPR}$	F rate resulting in retaining XX% of the maximum spawning production under equilibrium conditions
F_{max}	F maximizing the average weight yield per fish recruited to the fishery
F_o	F close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	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)
MARFIN	Marine Fisheries Initiative
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MDMR	Mississippi Department of Marine Resources
MFMT	Maximum Fishing Mortality Threshold: 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
MSA	Magnuson Stevens Act
MSST	Minimum Stock Size Threshold: 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
OST	Office of Science and Technology, NOAA
OY	Optimum Yield
SAFMC	South Atlantic Fishery Management Council
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	Southeast Fisheries Science Center, NMFS
SERFS	Southeast Reef Fish Survey
SERO	Southeast Regional Office, NMFS
SRFS	State Reef Fish Survey (Florida)
SRHS	Southeast Region Headboat Survey
SPR	Spawning Potential Ratio: B relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SS	Stock Synthesis
SSC	Scientific and Statistical Committee
TIP	Trip Incident Program: biological data collection program of the SEFSC and Southeast States
TPWD	Texas Parks and Wildlife Department
Z	total mortality (M+F)

SEDAR

Southeast Data, Assessment, and Review

SEDAR 79

Southeastern US Mutton Snapper

SECTION II: Data Workshop Report

November 2023

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

This information is distributed solely for the purpose of peer review. It does not represent and should not be construed to represent any agency determination or policy.

Table of Contents

1 INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 79 Data Workshop was held August 21-25, 2025, in Saint Petersburg, Florida. In addition to the in-person workshop, a series for webinars were held before (April and June 2023) and after (September 2023) the meeting.

1.2 TERMS OF REFERNCE

1. Review stock structure and unit stock definitions and consider whether changes are required.
2. Review, discuss, and tabulate available life history information.
   - Evaluate age, growth, natural mortality, and reproductive characteristics
   - Provide appropriate models to describe population growth, maturation, and fecundity by age, sex, and/or length by appropriate strata as feasible.
   - Evaluate the adequacy of available life history information for conducting stock assessments and recommend life history information for use in population modeling.
   - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. 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 mutton snapper as well as similar species from the southeastern United States 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 using a terminal year of 2020.
   - Consider species identification issues between mutton snapper and other species, and correct for these instances as appropriate
   - 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 adequately and reliably represent population abundance for use in assessment modeling
- Provide appropriate measures of uncertainty for the abundance indices to be used in stock assessment models
- Rank the available indices with regard to their reliability and suitability for use in assessment modeling

5. Provide commercial catch statistics through 2020, 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 fishery sector or gear
   - Provide length and age distributions for both landings and discards if feasible
   - Provide maps of fishery effort and harvest and fishery sector or gear
   - Provide estimates of uncertainty around each set of landings and discard estimates
6. Provide recreational catch statistics through 2020, 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
     - Specifically explore the transition from MRIP-CHTS to MRIP-FES
     - Specifically explore the State Reef Fish Survey data from the State of Florida
     - Explore whether the recreational fleet structure can be realigned into individual fleets as appropriate
   - Provide length and age distributions for both landings and discards if feasible
   - Provide maps of fishery effort and harvest and fishery sector or gear
   - Provide estimates of uncertainty around each set of landings and discard estimates
7. Identify and describe ecosystem, climate, species interactions, habitat considerations, and/or episodic events that would be reasonably expected to affect population dynamics.
8. Incorporate socioeconomic information that affect stock status and related fishing effort and catch levels as practicable.
9. 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.
10. Review, evaluate, and report on the status and progress of all research recommendations listed in the last assessment, peer review reports, and SSC report concerning this stock.
11. 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 Participants

Shanae Allen (Lead Analyst) .... FWC/FWRI
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Jessica Keller .... FWC/FWRI
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Dominique Lazarre .... NOAA/SERO
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Workshop Observers

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Tom Sminkey ....

Data Process Webinar Observers

Alejandro Acosta ....FWC
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Nate Bacheler...SEFSC
Samantha Binion-Rock ....SEFSC
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Ken Brennan ....SEFSC
Matt Campbell ....SEFSC
Andrew Cathey ....SEFSC
Scott Crosson ....SEFSC
Gary Decossas..SEFSC
Eric Fitzpatrick...SEFSC
Doug Gregory ....GMFMC SSC
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Kelcie LaRoche...FWC
Justin Lewis ....FWC
Rich Malinowski..NMFS
Gil McRae..FWC
Hayden Menendez ....FWC
Carole Neidig .... Mote Marine Lab
Jack Olsen ....FWC
Chloe Ramsay ....FWC
Jeff Renchen..FWC
Skyler Sagarese..NMFS
Jesse Second..FWC
Mike Schmidtke .... SAFMC Staff
George Sedberry .... SAFMC SSC
Julie Vecchio.. SCDNR

1.4 LIST OF DATA WORKSHOP WORKING PAPERS & REFERNCE DOCUMENTS

Document #	Title	Authors	Date Submitted
Documents Prepared for the Data Workshop			
SEDAR79-DW-01	Mutton Snapper Fishery Performance Report	SAFMC Snapper Grouper Advisory Panel	April 2021
SEDAR79-DW-02	General Recreational Survey Data for Mutton Snapper in the Southeast	Matt A. Nuttall and Samantha Binion-Rock	10 May 2023 Updated: 22 September 2023
SEDAR79-DW-03	Size and age information for Mutton Snapper, *Lutjanus analis*, collected in association with fishery-dependent monitoring along Florida's coast	Julie Vecchio, Jessica Carroll, Dominque Lazarre, Beverly Sauls Updated by: Ellie Corbettt and Bridget Cermark	25 January 2022 Updated: 11 August 2023
SEDAR79-DW-04	Descriptions of Florida's Mutton Snapper recreational fishery assessed using fishery-dependent survey data	Julie Vecchio, Dominique Lazarre, Beverly Sauls Updated By: Maria Kappos	25 January 2022 Updated: 16 August 2023
SEDAR79-DW-05	Electronic Monitoring Documentation of Mutton Snapper (*Lutjanus analis*) in the Eastern Gulf of Mexico Bottom Longline Fishery	Max Lee, Katie Harrington, Carole Neidig, and Ryan Schloesser	25 February 2022 Updated: 2 August 2023
SEDAR79-DW-06	Headboat Data for Mutton Snapper in the Southeast U.S. Atlantic and Gulf of Mexico	Robin T. Cheshire, Kenneth Brennan, and Matthew E. Green	2 August 2023 Updated: 24 August 2023
SEDAR79-DW-07	*Estimated discards of Southeastern Mutton Snapper (Lutjanus analis) from vertical line commercial fishing vessels*	Sarina Atkinson	2 June 2023
SEDAR79-DW-08	Preliminary standardized catch rates of mutton snapper from the United	Sustainable Fisheries Branch	13 June 2023

	States Gulf of Mexico and South Atlantic commercial handline and longline fisheries, 1993-2022		Updated: 31 August 2023
SEDAR79-DW-09	Fisherman Feedback: Mutton Snapper Response Summary	GMFMC Staff	13 June 2023
SEDAR79-DW-10	Standardized video counts of southeast US Atlantic mutton snapper (*Lutjanus analis*) from the Southeast Reef Fish Survey	Nathan Bacheler, Rob Cheshire, and Kyle Shertzer	20 July 2023
SEDAR79-DW-11	Abundance and Distribution of Juvenile Mutton Snapper in Nearshore Seagrass Habitat in the Middle Florida Keys	Jessica Keller, Jack Olson, Ariel Tobin, Alejandro Acosta	31 July 2023
SEDAR79-DW-12	Mutton Snapper Reproduction	Susan Lowerre-Barbieri and Claudia Friess	2 August 2023
SEDAR79-DW-13	Standardized Catch Rates of Mutton Snapper (*Lutjanus analis*) from the Marine Recreational Information Program (MRIP) in Southeast Florida and the Florida Keys, 1981-2022	Shanae Allen	2 August 2023
SEDAR79-DW-14	A Summary of Mutton Snapper Discard Length Data Collected from At-Sea Observers in Recreational Fishery Surveys in Florida	Ellie Corbett	16 August 2023
SEDAR79-DW-15	Biscayne National Park Creel Survey index, 1978-2022	Robert Muller	18 August 2023
SEDAR79-DW-16	Riley's Hump Visual Census Survey, Tortugas South Ecological Reserve 2002-2015	Robert Muller	18 August 2023
SEDAR79-DW-17	Standardized visual indices for Mutton Snapper, *Lutjanus analis*, for the Florida Keys (1997 – 2022), Dry Tortugas (1999-2021), and Southeast Florida (2013-2022)	Robert G. Muller and Shanae D. Allen	18 August 2023
SEDAR79-DW-18	Age-0 Mutton Snapper Abundance Index from Inshore Surveys of Indian River Lagoon on Florida's Atlantic Coast	Brian Klimek, Heather Christiansen, Shanae Allen and Theodore Switzer	17 August 2023 Updated: 25 September 2023

SEDAR79-DW-19	Historical Commercial Fishery Landings of Mutton Snapper in the Southeastern U.S.	Chris Bradshaw	25 September 2023
SEDAR79-DW-20	Length frequency distributions for Mutton Snapper collected by TIP in the Southeast from 1983 to 2022	Chris Bradshaw	25 September 2023
SEDAR79-DW-21	Indices of abundance for Mutton Snapper (*Lutjanus analis*) using combined data from two fishery independent video surveys	Heather M. Christiansen, Kevin A. Thompson, Theodore S. Switzer, Sean F. Keenan, Christopher Gardner, Katherine E. Overly, Matt Campbell	23 August 2023
SEDAR79-DW-22	Descriptions of age, growth, and natural mortality of Mutton Snapper, *Lutjanus analis*, collected from fisheries-independent and -dependent sources in the southeastern United States from 1977 – 2022	Christopher E. Swanson, Shanae D. Allen, and Jessica L. Carroll	31 August 2023

Reference Documents

SEDAR79-RD01	Population structure, long-term connectivity, and effective size of mutton snapper (*Lutjanus analis*) in the Caribbean Sea and Florida Keys	Evan W. Carson, Eric Saillant, Mark A. Renshaw, Nancie J. Cummings, John R. Gold
SEDAR79-RD02	A potential larval recruitment pathway originating from a Florida marine protected area	Michael L. Domeier
SEDAR79-RD03	Larval transport pathways from Cuban snapper (Lutjanidae) spawning aggregations based on biophysical modeling	Claire B. Paris, Robert K. Cowen, Rodolfo Claro, Kenyon C. Lindeman
SEDAR79-RD04	Population connectivity among Dry Tortugas, Florida, and Caribbean populations of mutton snapper (*Lutjanus analis*), inferred from multiple microsatellite loci	Shulzitski, Kathryn; McCartney, Michael A.; Burton, Michael L.

SEDAR79-RD05	Evaluating Measurement Error in the MRIP Fishing Effort Survey	NOAA Fisheries Service, Office of Science and Technology
SEDAR79-RD06	S74-AP-01: A meta-analysis of red snapper (*Lutjanus campechanus*) discard mortality in the Gulf of Mexico	Chloe Ramsay, Julie Vecchio, Dominque Lazarre, Beverly Sauls
SEDAR79-RD07	S74-AP-02: Final Report of the SEDAR 74 Ad-hoc Discard Mortality Working Group for Gulf of Mexico Red Snapper (*Lutjanus campechanus*)	Beverly Sauls (Working Group Chair)
SEDAR79-RD08	S73-WP-15: Utility and Usage of Descender Devices in the Red Snapper Recreational Fishery in the South Atlantic	Julie Vecchio, Dominique Lazarre, Beverly Sauls

2 LIFE HISTORY

2.1 OVERVIEW

The Life History Workgroup (LHW) reviewed and discussed available data for Mutton Snapper and offered recommendations. Information was examined on stock definition, habitat, movements and migrations, age, growth, natural mortality, reproduction, and morphometric equations and conversions. A summary of the data presented, discussed, and recommendations made is presented below.

1.1.1. Life History Workgroup Participants

Chris Swanson (lead)	FWRI, St. Petersburg, FL
Jessica Carroll	FWRI, St. Petersburg, FL
Bridget Cermak	FWRI, St. Petersburg, FL
Kristin Cook	FWRI, St. Petersburg, FL
Kiley Gray	FWRI, St. Petersburg, FL
Jessica Keller	FWRI, Marathon, FL
Sue Lowerre-Barbieri	UF/FWRI, St. Petersburg, FL
Ariel Poholek	NMFS, Tavernier, FL
Marcel Reichert	SSC, SAFMC
Jim Tolan	SSC, GMFMC

1.1.2. Life History Terms of Reference

DW TOR #1. Review stock structure and unit stock definitions and consider whether changes are required.

DW TOR #2 Review, discuss, and tabulate available life history information.

- Evaluate age, growth, natural mortality, and reproductive characteristics
- Provide appropriate models to describe population growth, maturation, and fecundity by age, sex, and/or length by appropriate strata as feasible.
- Evaluate the adequacy of available life history information for conducting stock assessments and recommend life history information for use in population modeling.
- Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide estimates or ranges of uncertainty for all life history information.

DW TOR #3. Recommend discard mortality rates.

- Review available research and published literature
- Consider research directed at mutton snapper as well as similar species from the southeastern United States 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

DW TOR #7. Identify and describe ecosystem, climate, species interactions, habitat considerations, and/or episodic events that would be reasonably expected to affect population dynamics.

2.2 REVIEW OF WORKING PAPERS

Three working papers were submitted for review to the LHW:

SEDAR79-DW-11: Abundance and Distribution of Juvenile Mutton Snapper in Nearshore Seagrass Habitat in the Middle Florida Keys.

SEDAR79-DW-12: Mutton Snapper Reproduction.

SEDAR79-DW-22: Descriptions of age, growth, and natural mortality of Mutton Snapper, *Lutjanus analis*, collected from fisheries-independent and -dependent sources in the southeastern United States from 1977 – 2022.

Discussion of working papers and other literature reviewed is listed below by topic.

2.3 STOCK DEFINITION AND DESCRIPTION

2.3.1. Classification and Identification Issues

Online summaries of the taxonomy and biology of Mutton Snapper available from Murray and Bester (2007) and Froese and Pauly (2023) are as follows:

Kingdom: Animalia (animals)

Phylum: Chordata (organisms with a notochord)

Subphylum: Vertebrata (animals with a backbone)

Class: Actinopterygii (ray-finned fishes)

Order: Perciformes

Family: Lutjanidae

Genus: *Lutjanus*

Species: *analis* (Cuvier 1828)

Lutjanus analis were first described by Georges Cuvier in 1828 from a Hispanolan specimen, and is synonymous with Mesoprion sobra (Cuvier 1828), Mesoprion isodon (Valenciennes 1829) and Mesoprion rosaceus (Poey 1870). English common names include mutton snapper, mutton fish, king snapper, virgin snapper, snapper, and in Spanish include pargo, pargo cebado, pargo cebal, pargo colorado, pargo criollo (Cuba), pargo mulato, and sama.

This species is recognizable from other reef-dwelling snapper (Family *Lutjanidae*) by its black spot on the upper back just above the lateral line and below the anterior dorsal fin rays, blue stripes on the snout-cheek region partially continuing up beyond the eye, reddish-orange tinge on lower sides and belly, and angulated (i.e., pointed instead of rounded) anal fin (Figure 2.14.1).

2.3.2. Population Genetics

Analysis of mitochondrial and microsatellite DNA of Mutton Snapper collected from locations within the southeastern U.S. (i.e., Dry Tortugas, Marathon, FL, and Jupiter, FL) found no evidence of genetic heterogeneity with samples collected from Caribbean populations in Puerto Rico, St. Thomas, St. Croix, Belize, and Honduras (Shulzitski et al. 2009, Carson et al. 2011, Portnoy and Gold 2013). Average long-term effective population sizes estimated between the Florida Keys and northern Caribbean Sea populations were found to differ three-fold where the Florida Keys population was estimated highest (Carson et al. 2011). While the effective population size does not need to be the same across localities with homogenous allele frequencies (Saillant and Gold 2006), it could signal a reduced capability to respond to over-exploitation or habitat degradation (Frankham 1995).

No further genetic studies on the population structure of Mutton Snapper within the southeastern U.S. have been conducted or updated since the previous update assessment (SEDAR 15AU 2015) and no genetic information is available for parts of the unit stock inhabiting the West Florida Shelf (and west) or northeastern Florida (and further north).

2.3.3. Larval Transport/Connectivity

Lutjanids have a pelagic egg/larval stage that lasts for several weeks (approximately 30 days for Mutton Snapper), during which time they are highly vulnerable to starvation, predation, and advection away from suitable juvenile habitat, and survival rates may be near zero (Houde 1987; D'Alessandro et al. 2010). In the Straits of Florida (SOF) from the east Florida shelf (off Biscayne Bay) to the Great Bahama Bank, D'Alessandro et al. (2010) reported that eight snapper species including Mutton Snapper had significant spatiotemporal larval distribution patterns. Mutton Snapper larvae occurrence was even across stations but were more abundant and twice as concentrated in the eastern portion of the SOF. They occurred most of the year with higher abundances from June to November when water temperatures were warmest and were more abundant in depths of 0 – 25 meters.

In the Dry Tortugas, Domeier (2004) released drifter vials during times of Mutton Snapper spawning (i.e., full moon in months of May and June) at known spawning sites in Riley's Hump and showed indirect evidence of a larval delivery pathway; significant vial recovery occurred throughout the Florida Keys and as far north as the Palm Coast. Despite the occurrence of seagrass beds in nearby Fort Jefferson Park (24 km east of Riley's Hump), no vials were recovered there and the closest region with significant vial recovery to Riley's Hump was greater than 200 km away in the Middle Keys. Support for the Middle Keys as an area of Mutton Snapper settlement also comes from fishery-independent sampling of Mutton Snapper in the nearshore seagrass beds located there (Keller et al. 2023); unfortunately, sampling of this survey is restricted to the Middle Keys and was unable to corroborate settlement rates to seagrass beds further east. Lastly, models of larval dispersal from Cuban waters revealed that larval emigration from Cuba (particularly from western and northwestern regions) to southeastern Florida may occur (Lindeman et al. 2001, Paris et al. 2005, Kough et al. 2016). However, contribution in terms of total number of advected larvae over the planktonic larval duration is low. Thus, oceanographic barriers may be influencing low levels of connectivity between the south Florida and Caribbean Sea populations.

2.3.4. Stock Definition and Description

Mutton Snapper are reportedly distributed within the Western Atlantic from Massachusetts, U.S.A. to southeastern Brazil with concentrations primarily in the Caribbean Sea and off southern Florida (Froese and Pauly 2023). The Mutton Snapper fishery is managed in the U.S. by the South Atlantic Fishery Management Council (SAFMC) and the Gulf of Mexico Fishery Management Council (GMFMC) as separate stock units with the boundary being U.S. Highway 1 in the Florida Keys west to the Dry Tortugas (Figure 2.14.2). The State of Florida also participates in the management of this species in state waters. Given the information available on Mutton Snapper genetics and stock connectivity, the LHW considers the unit stock of Mutton Snapper at the functional population level and is defined as the total number of individuals that use waters within the jurisdiction of the SAFMC and the GMFMC. The assumption of a closed population in the SAFMC and GMFMC jurisdictions for the purpose of the stock assessment and management was found reasonable by the LHW and is consistent with previous assessments.

2.4. MORPHOMETRICS AND CONVERSION FACTORS

Morphometrics characterize the size and shape of an organism and reduce the idea of physical form to a series of measured variables (Ihssen et al. 1981). These include multiple types of length (standard [SL], fork [FL], and total [TL]) or weight (total [TW] or gutted [GW]) measurements. Morphometric data for Mutton Snapper are collected by various fishery-dependent and -independent data collection programs (e.g., Trip Interview Program [TIP], Marine Recreational Information Program [MRIP], Southeast Region Headboat Survey [SRHS], and FWRI's Fisheries Dependent Monitoring [FWRI-FDM] program) and help facilitate comparisons between the length and weight measurement data from other studies.

Ideally, the length type used within a stock assessment is consistent with the management regulations of that species. For Mutton Snapper, the current management regulations on minimum legal size specifies an 18” maximum total length (“max”) where the fish is measured by compressing the tail to its maximum length. However, methods of measuring total length were found to differ between data sources which necessitated a conversion to maximum TL. For example, the SRHS measures Mutton Snapper using a natural TL (“relaxed”) where the fish is measured with the tail flat in its normal shape instead of compressed to its maximum length. Therefore, included here is the relationship between natural TL and maximum TL as was also provided by the two prior stock assessments for this species (SEDAR 15A 2008, SEDAR 15AU 2015).

Morphometric data from fishery-dependent and -independent sources were combined to estimate morphometric equations and conversion factors. Linear (for length-length conversion) and non-linear (for length-weight conversion) regressions were conducted in R (R Core Team 2020) and outliers were removed if they fell outside of the 99.9th percentile prediction interval. Linear regressions are in the form $Y = a + bX$ and non-linear regressions are in the form $W = aL^b$. Non-linear length-weight models in real space demonstrated less prediction error compared to linear length-weight models in lognormal space.

Updated length-length (linear regression) and length-weight (non-linear regression) equations were developed for southeastern U.S. Mutton Snapper and are presented in Table 2.13.1. Reported here is also the gutted weight to total (whole) weight conversion of 1.11 (SEDAR 15A 2008).

2.5. AGE AND GROWTH

2.5.1. Available Age Data

Age data available for Mutton Snapper in the southeastern U.S. were primarily supplied by the National Marine Fisheries Service’s Southeast Fisheries Science Center (NMFS-SEFSC) laboratories (Miami, Panama City, and Beaufort), FWRI, and the Gulf States Marine Fisheries Commission (GSMFC). Data were collected by federal and state biologists involved in fishery-dependent (e.g., TIP, SRHS, and MRIP) and fishery-independent (e.g., FWRI’s Fisheries Independent Monitoring and Fish Biology) biological data collection programs from 1977 – 2022 on both Atlantic and Gulf of Mexico coasts.

Data were spatially delineated into 5 regions within Florida waters and based on where the sampled fish was landed: Northeast Florida (Nassau County south to Brevard County), Southeast Florida (Indian River County south to Miami-Dade County), Florida Keys (Monroe County), Southwest Florida (Levy County south to Collier County), and Northwest Florida (Escambia County south to Dixie County). Areas outside of Florida are defined as either “West of Florida” for states west of Florida through Texas along the Gulf of Mexico or “North of Florida” for states north of Florida through North Carolina along the southeastern US Atlantic. The Dry Tortugas region (Monroe County west of longitude -82.7 and south of latitude 25) is also described here because it was an area sampled by both fishery-dependent and -independent sources. However, only fishery-independent data were regular in reporting Mutton Snapper sampled there. Fishery-dependent sources were inconsistent in their reporting of coordinates from the Dry Tortugas region as an area fished; therefore, spatial delineation for the purposes of these analyses was defined by where Mutton Snapper were landed. The gears defined here are grouped into hook and line (encompassing hook and line, bandit rigs, and electric or hydraulic reels), long line, other (comprised largely of spear, seine, as well as pots and traps), and unknown.

A total of 25,586 otoliths were assigned ages for Mutton Snapper from years 1977 – 2022 (Table 2.13.2). The majority of otoliths were found to be ages 3 to 5 (53.2%) and ages 2 – 9 comprised 86.1% of the data (Table 2.13.2).

Ages sampled from the recreational fishery (n = 12,549 otoliths, Table 2.13.3, Figure 2.14.3a) constituted a total of 49.0%, predominantly from the headboat survey (n = 10,106 otoliths, Table 4, Figure 2.14.3b), while ages sampled from the commercial fishery (n = 11,827 otoliths, Tables 2.13.3 and 2.13.4, Figure 2.14.3a) made up 46.2%. Age data from fishery-independent sources totaled 1,210 otoliths (4.7%) from Mutton Snapper (Tables 2.13.3 and 2.13.4, Figure 2.14.3a). The total number of ages sampled annually from fishery-dependent and -independent sources was very low throughout the 1980s and otoliths during this time were only sampled from the headboat fishery (Figure 2.14.3b). Beginning in 1992, otoliths started to be sampled from multiple fishery modes and the number of samples continually increased until a peak in 2010 (n = 1,926 otolith samples, Figure 2.14.3a). Afterwards, the total number of age samples began decreasing to an annual average ~1,000 samples through 2022 (Figure 2.14.3a). Sampling during years 2019 – 2021 were below average and were likely impacted by COVID-19 during years 2020 – 2021. Hook and line gear contained 75.3% of samples (n = 19,258 otoliths, Table 2.13.5) followed by long line gear (n = 4,346 otoliths, Table 2.13.5, Figure 2.14.4).

Age data for Mutton Snapper are predominantly (97.4%) from the state of Florida (n = 24,890 otoliths). Within Florida, 40.3% (n = 10,303 otoliths) of samples came from the southeast Florida region (Indian River County south to Miami-Dade County and 32.4% (n = 8,293 otoliths) came from the Florida Keys region (Monroe County, Table 2.13.6, Figure 2.14.5). The number of samples from the southwest Florida region totaled 4,463 otoliths (17.4%,) and was lowest west of Florida (n = 11 otoliths, Table 2.13.6, Figure 2.14.5).

The distribution of ages among fishery-dependent sources was generally similar with modes occurring at ages 3 and 4 (Figure 2.14.6); however, samples from the commercial fishery contained a higher proportion of older fish (Figure 2.14.6) and were primarily from the long line gear (Figure 2.14.7). Samples of older Mutton Snapper (i.e., > 8 years) were sparse from fishery-independent surveys (Figure 2.14.6). In the southeast region, the distribution of Mutton Snapper ages was noticeably younger (mean = 3.87 years, median = 4 years) compared to the Florida Keys region (mean = 6.78 years, median = 6 years) and all the other regions (Figure 2.14.8). The southwest region contained the highest proportions of older ages (mean = 9.11 years, median = 7 years, Figure 2.14.8) within Florida waters and is where the long line commercial fishery for

Mutton Snapper is concentrated. Outside of Florida waters where fishing pressure for Mutton Snapper significantly decreases, sampled ages were oldest north of Florida (mean = 11.87 years, median = 8 years, Figure 2.14.8). Figure 2.14.9 shows the age distribution by year with evidence of strong year classes in 2008, 2014, and 2017. Another stronger year classes may also have occurred in 1984, however, samples sizes during this earlier period were very low.

2.5.2. Otolith Processing and Age Determination

Sectioned otoliths are the preferred structures for ageing Mutton Snapper (Mason and Manooch 1985, Burton 2002) and the left sagittal otolith was processed for age determination. Otoliths were attached directly to cardstock using hot glue, then cut using a Buehler Isomet low-speed saw with a multiblade configuration to create three thin transverse sections (VanderKooy et al. 2020). Sections were then adhered to glass slides using a clear mounting medium. Otoliths were examined using stereo microscopes with objectives ranging from 0.63X–2.0X magnification and either transmitted or reflected light. Each otolith was read at least twice, either by an individual reader two times, or by two different readers. A third read was conducted to resolve any discrepancies between the two age estimates. All ages were determined without reader knowledge of fish length or sex (VanderKooy et al. 2020, Carroll and Lowerre-Barbieri 2019).

Marginal increment analyses (Burton 2002) have indirectly validated that Mutton Snapper form an opaque annulus in the spring (typically March – May) and deposition is assumed to be completed by July 1. Calendar ages were calculated using annulus count (number of opaque zones), degree of marginal completion, average date of otolith increment deposition, and date of capture. Using these criteria, age was assigned by readers to advance by one year if a large translucent zone (more than 2/3 translucence) was visible on the margin and the capture date was between January 1 and June 30. For fish collected after June 30, age was typically assigned to be annulus count. Calendar ages were converted to biological (i.e., fractional) ages based on a June 1 hatch date and month of capture for fitting growth curves.

2.5.3. Precision Calculations

Precision measurements are valuable for evaluating the structure's ease of age determination, the reproducibility of an individual's age, and the skill level of each reader in a laboratory (Campana 2001). Average percent error (APE) and coefficient of variation (CV) are the two most widely used precision calculations (Campana 2001) and are considered "age independent" methods for determining precision (Kimura & Lyons 1991). APE is calculated as:

$$APE_j = 100\% \times \frac{1}{R}\sum_{i=1}^{R}\frac{\left|x_{ij} - x_j\right|}{X_j}$$

for otoliths with multiple age determinations (R), Xij is the ith age estimate for the jth fish. Disagreement by one year between readers on a 2-year-old fish is weighted more heavily than a one year discrepancy of a 20-year-old fish (Kimura and Anderl 2005). When individual errors are averaged across all samples, the outcome is the average percent error for the data set (Beamish and Fournier 1981, Campana 2001).

CV is the ratio of standard deviation over the mean (Chang 1982) and is written as:

$$CV_j = 100\% \times \frac{\sqrt{\sum_{i=1}^{R} \frac{(X_{ij} - X_j)^2}{R-1}}}{X_j}$$

Precision estimates between readers were calculated using a random subsample from recreational and commercial collections. This quality control subsample of 240 fish included samples from 2018–2020 that were aged by the three primary Mutton Snapper readers. Standard protocol for quality control ageing typically calls for a larger subsample. However, Mutton Snapper ageing was conducted primarily during the COVID pandemic so overlapping ageing reads (especially resolution of disagreements) were difficult to ascertain. APE and CV precision estimates were calculated on the entire age dataset (from individual first and second reads of all fish), as well as the quality control subsample. Age bias plots assessing reader precision of the quality control subsample were generated using FSA: fisheries stock analysis R Package (Ogle 2020).

Campana (2001) suggests an APE of 5% or less as an acceptable benchmark for precision, which corresponds to approximately a 7.6% CV calculation. The APE and CV of the Mutton Snapper age dataset at the time of this precision evaluation (n=24,738 otoliths) was 1.2% and 1.7%, while the quality control subsample (n=240) was 1.7% and 2.2%, respectively. These values are well below the benchmark for acceptable precision standards indicating that Mutton Snapper reads were highly precise. Age bias plots of the quality control subsample of the primary FWRI readers reveals overall high precision and low bias (Figure 2.14.10). The quality control subsample consisted of fish ages 2–30, which is representative of the larger fishery-dependent life history dataset. No single age class was determined to be significantly different from the consensus age for any readers. Ageing precision was highest amongst the youngest and most numerous age classes. Variability was generally higher for older age classes, which is to be expected, but differing reads were consistently within one year of the consensus age.

2.5.4. Maximum Age

The current maximum observed age of Mutton Snapper based on sectional otoliths is 42 years; the fish (n = 1 otolith) was collected in the Florida Keys in 2015 and represents the maximum age for the entire southeastern U.S. stock. This is an update to the previous assessment (SEDAR 15AU 2015) which had a terminal year of 2013 and an observed maximum age at 40 years from samples (n = 6 otoliths) collected in Florida, South Carolina, and North Carolina.

2.5.5. Growth

Length-at-age data were filtered to eliminate observations that included a known size or effort bias or if lengths were collected using a known non-random sampling method or were selected by quota sampling. Data were further restricted to records containing complete information on year, month, and state (or were assigned a state based on area fished or sample location if the area fished was unknown or unassigned). Finally, total length observations were grouped by calendar age and iteratively Z-scored; outliers were removed using threshold values of ±8 in the first iteration and values of ±4 in the second iteration.

Length-at-age data based on biological (i.e., fractional) ages and maximum total length data were modeled using a size-truncated von Bertalanffy growth model (Diaz et al. 2004) executed in ADMB (Auto Differentiate Model Builder). This growth model accounts for minimum size restrictions (using a truncated normal distribution) which influence non-random sampling across ages (e.g., smaller fish not available to sample); however, it does not account for dome-shaped selectivity (e.g., larger fish not available to sample). It also allows for the exploration of alternative variance structures. Model options for variance structure used here were constant standard deviation (sigma) with age, constant CV with age, CV increasing linearly with age, and CV increasing linearly with size at age. Growth models were applied to both unweighted data and data weighted by using the inverse (1/n) of the count of each calendar age (Burton et al. 2015). Size truncation for the fishery-dependent data was set using the minimum size limits of 12" TL first implemented by the SAFMC Snapper-Grouper FMP amendment on 1/1/92, then 16" TL implemented on 1/23/95, and 18" TL implemented on 2/10/18. Model selection criteria was based on model convergence (maximum gradient < 0.0001), model objective function (minimized negative loglikelihood), Akaike Information Criteria (AIC), and model standardized-residual diagnostic plots.

Mutton Snapper length-at-age displayed a size truncated profile (Figure 2.14.11a) and the number of sampled lengths was highest between 400 – 500 mm TL (Figure 2.14.11b). The truncated pattern due to the enacted minimum size limits was seen in the commercial and recreational length-at-age data which contained similar profiles (Figure 2.14.12). Analogous to the pattern seen in the age data, the commercial fishery contained a higher proportion of larger fish (>~800 mm TL) sampled largely from the long line gear (Figure 2.14.13). The fishery-independent length-at-age data contained smaller and younger fish not present in fishery-dependent data, but also showed a paucity of older and larger individuals (Figure 2.14.12). Lack of larger and older individuals will likely result in poor model estimation of L_∞; therefore, the fishery-independent data was not isolated for use in modeling growth. Length-at-age by region is shown in Figure 2.14.14 and profiles display patterns similar to those described in the age data above.

From the available age data, a total of 24,234 length-at-age observations were retained (94.7%) for size-truncated modeling of growth. The fit statistics for the size-truncated von Bertalanffy growth models indicated that models fit to the inverse-weighted data were significantly better than those fit to the unweighted data (Table 2.13.7). The model whose variance was estimated with CV was a linear function of age contained the lowest AIC value (Table 2.13.7, Figure 2.14.15) with equation:

$$L_t = 847\ (1 - e^{(-0.163\ (t + 1.115))})$$

The residuals for this model indicate overall goodness of fit (Figure 2.14.16a – b) and by fishery (Figure 2.14.16c), by region (Figure 2.14.16d), and by calendar age (Figure 2.14.16e). Residuals by year indicate some inconsistency in fitting to the earlier and data-poorer period before year 1991 (Figure 2.14.16f). This model estimated the average asymptotic maximum length to be 14 mm smaller than when previously assessed (L_∞ = 861 mm, SEDAR 15AU 2015; which was smaller still compared to the initial assessment where L_∞ = 874 mm, SEDAR 15A 2008). Therefore, the LHW recommended this model for use within stock assessment.

The models whose variances were estimated with a constant sigma or with CV as a linear function of size at age had nearly the same AIC values and differed from the best fit model by less than 2 AIC units. These models estimated smaller L_∞ parameters (837.6 mm and 841.7 mm, respectively) and similar K parameters (0.175 and 0.164, respectively, Table 2.13.7).

2.6. NATURAL MORTALITY

Natural mortality, M, characterizes all causes of natural (i.e, non-fishing) mortality such as predation, starvation, disease, and senescence (Gulland 1983, Hilborn and Walters 1992) but may also include some forms of human-induced mortality not due to fishing (Maunder et al. 2023). While it is one of the most influential parameters within fisheries stock assessment, it is rarely observed or measured in fish populations; consequently, it is difficult to estimate and remains a large source of uncertainty within most stock assessment models (Vetter 1988, Hampton 2000, Maunder et al. 2023). M is commonly treated as a constant within stock assessment processes and textbooks (e.g., Hilborn and Walters 1992, Quinn and Deriso 1999, Haddon 2011), but application as a size-dependent or equivalent age-dependent function using a stock-specific growth function with constant M scaled to a fully selected age or range of ages (e.g., the 'Lorenzen *M'* model) is becoming more commonly practiced in stock assessments conducted in the southeastern United States (Lorenzen 2022, Lorenzen et al. 2022).

Constant as well as size- and age-dependent estimates of natural mortality of Mutton Snapper were explored using the approaches and recommendations presented in the recent review of natural mortality estimation methods by Maunder et al. (2023) and the 'generalized length-inverse mortality (GLIM)' paradigm presented by Lorenzen (2022). Where relevant, all natural mortality models assumed von Bertalanffy growth. Constant M estimates were calculated based on the longevity and empirical K models updated by Hamel and Cope (2022) and the revised Pauly$_{\text{nls-T}}$ model described in Then et al (2015). These estimates of constant M were then converted to mortality-at-length and -age by applying the survival equations described in Lorenzen (2000, 2005) and using age-3 as the reference age for the constant M estimate. A similar method was performed in SEDAR 15AU (2015), but the cumulative mortality rate was predicted for ages 3 and greater and scaled so that it agreed with the constant M estimate based on the Hoenig (1983) model. Therefore, this was also explored by applying that scaling to all three constant M estimates presented here.

In addition, allometric scaling models for mortality at length or weight were explored using the mortality-weight model described in Lorenzen (1996), the length-inverse model described in Lorenzen (2022; see equation 1a therein), and the empirically based length-inverse model described in Lorenzen (2022; see Table 1 therein). For the length-inverse model, the Hamel and Cope (2022) longevity-based estimate of constant M was used as the mortality at reference length scale parameter and the length associated with age-3 as the reference length. Scaling the cumulative mortality rate predicted for ages 3 and greater so that it agreed with the constant M estimate was also explored. In the empirically based length-inverse model, the mortality at asymptotic length parameter, $M_{L\infty}$, was calculated using the parameters described by the best fit regression (model 6) located in Table 3 of Lorenzen et al. (2022) where a = 0.42, c = 0.93, and K is the von Bertalanffy growth coefficient. The $M_{L\infty}$ parameter is described by Lorenzen et al. (2022) as "closely related to constant adult M traditionally used in fisheries assessments". Longevity estimates were based on the observed maximum age for Mutton Snapper and the mortality-weight model utilized the parameters of the non-linear length-weight model converting maximum total length (mm) to total weight (g).

The estimation methods of natural mortality along with their respective equations are presented in Table 2.13.8. Longevity estimates were based on the observed maximum age for Mutton Snapper (t_{max} = 42 years) and the von Bertalanffy growth parameter values were based on the final growth model above (L_{inf} = 847 mm, K = 0.163, $t0$ = -1.115). Length-weight model parameters of Mutton Snapper used within the mortality-weight model were obtained from the non-linear length-weight model converting maximum total length (mm) to total weight (g) where a = 4.59E-6 and b = 3.160.

Constant mortality estimates based on the longevity and empirical K models were found to be M = 0.129 yr^{-1} and 0.253 yr^{-1}, respectively. The revised Pauly$_{\text{nls-T}}$ model also estimated M = 0.253 yr^{-1}. The mortality at asymptotic length parameter was estimated to be $M_{L\infty}$ = 0.282. Thus, estimates of constant M correlated with growth were nearly double those based on longevity and maximum age would need to be about half (~age 21 years) for the longevity model to equal the empirical K model estimates of M.

Converted mortality-at-age estimates ranged from 0.302 – 0.068 yr^{-1} for the longevity model, from 0.514 – 0.116 yr^{-1} for the longevity (scaled) model, from 0.593 – 0.133 yr^{-1} for the empirical K model, and from 0.594 – 0.134 yr^{-1} for the revised Pauly$_{\text{nls-T}}$ model (Table 2.13.9, Figure 2.14.17). Cumulative survival to the oldest age class for these models is 2.7%, 0.2%, 0.1%, and 0.1%, respectively. Estimates of mortality-at-age for empirical K (scaled) and Pauly$_{\text{nls-T}}$ (scaled) models are not reported here because cumulative survival to the oldest age class in both models was less than 0.001%.

Estimated mortality-at-age from the mortality-weight model ranged from 1.146 – 0.224 yr^{-1}, from 0.378 – 0.063 yr^{-1} for the length-inverse model, from 0.691 – 0.115 yr^{-1} for the length-inverse (scaled) model, and from 1.695 – 0.282 yr^{-1} for the length-inverse (empirical) model (Table 2.13.10, Figure 2.14.17). Both the mortality-weight and the length-inverse (empirical) models estimated high natural mortality-at-age where cumulative survival to the oldest age class was also less than 0.001%. For the length-inverse and length-inverse (scaled) models, cumulative survival to the oldest age class for these models is 2.9% and 0.2%, respectively.

The LHW recommended estimates of natural mortality be size- or age-dependent and recommended the Lorenzen (2022) length-inverse (scaled) model be used for the mortality-at-age vector for the stock assessment model(s).

In SEDAR 15AU (2015), constant natural mortality was calculated using methods from Hoenig (1983) and Hewitt and Hoenig (2005) where M = 0.11 yr^{-1} for a maximum age of 40 years and scaled across ages 3 – 40. Mortality-at-age was estimated to range from 0.406 – 0.099 yr^{-1}. During that update assessment, Then et al. (2015) was published and the $Hoenig_{nls}$ equation, which calculated M = 0.17 yr^{-1}, was also used and explored as a sensitivity run. While these methods may no longer be recommended (e.g., older data or lack of adequate transformation; see Maunder et al. 2023), the estimates are similar in magnitude to the more recent longevity-based estimates provided here.

2.6.1. Catch Curve Analysis

A catch curve analysis to estimate total mortality (Z) was performed on commercial long line catch data from years 1992 – 2022. This gear was considered to exhibit flat-topped selectivity whereas other catch data from the commercial and recreational sectors likely exhibited dome-shaped selectivity. There were 4,266 observations of Mutton Snapper in the long line data ranging from ages 2 – 40. The logarithmically transformed catch-at-age data showed peak abundances at age-6 and individuals were considered fully selected by this gear for ages 6 – 40 (Figure 2.14.18).

Two methods were used to calculate Z, a weighted regression (Maceina and Bettoli 1998) and the Chapman-Robson estimate of the annual survival rate (Chapman and Robson 1960, Robson and Chapman 1961). The weighted regression estimated Z = 0.166 (LCI = 0.155, UCI = 0.177) and the Chapman-Robson method estimated Z = 0.190 (LCI = 0.172, UCI = 0.207).

There are several assumptions within a catch curve analysis (e.g., the population is closed to emigration and immigration, recruitment is constant, total mortality and selectivity is constant across ages and years on the descending limb, and sampling isn't biased on any specific age group), but it's useful in providing context when comparing estimates of M. Estimates of Z between both methods were higher than the Hamel and Cope (2022) longevity-based estimate (M = 0.129) but was much lower than the estimate correlated with growth (e.g., Empirical K, M = 0.253).

2.6.2. Sensitivity Analyses

Sensitivity analyses on natural mortality are recommended by the SEDAR Best Practices (2016) given the uncertainty surrounding this life history component and its impact within the assessment model. Therefore, the LHW recommended a sensitivity analysis where the Lorenzen (1996) mortality-weight model (see above) be used for the mortality-at-age vector for the stock assessment model. This model gives similar results to the other scaled mortality-at-age models based on growth (e.g., the empirical *K* [scaled] and $\text{Pauly}_{\text{nls-T}}$ [scaled] models) that were presented here.

Maunder et al. (2023) also recommends allowing *M* to be estimated within an integrated assessment model where estimation of a greater range of sampling processes (e.g., selectivity, effective sample size) may reduce bias and result in improved precision of estimated quantities. Internal estimation will also allow for data conflicts to be evaluated through processes such as likelihood component profiling on *M*. The LHW, therefore, recommends exploring the estimation of *M* internally using the Lorenzen method option within Stock Synthesis using the Hamel and Cope (2022) longevity-based constant *M* estimate as the initial value for the single input *M* parameter along with the recommended corresponding lognormal prior (sd = 0.31) for uncertainty, and age 3 as the reference age (unless a different fully selected age is determined).

2.6.3. Episodic Mortality Events

No attempt was made to investigate episodic types of natural mortality (red tides, cold kills, oil spills, etc.) because there were no data on which to base such modifications to the *M* parameter. Red tide blooms are more commonly seen on Florida's Gulf Coast and usually occur well north of the Florida Keys and away from the center of the distribution of Mutton Snapper. Cold stuns and kills from water temperatures of perhaps 15ºC or lower (see discussion in Gilmore et al. 1978), while infrequent, may occur once or twice a decade in Florida. An extreme cold event in January of 2010 caused massive mortality of patch reefs in the Florida Keys (Colella et al. 2012) which most likely impacted Mutton Snapper habitat, but no specific reports on Mutton Snapper mortalities were reported (Hallac et al. 2010).

The impact of algal blooms and decreased water quality on the mortality of young Mutton Snapper within the Indian River Lagoon system is also difficult to define. Submerged aquatic vegetation, which is important for age-0 Mutton Snapper abundance in this system (Klimek et al. 2023), has been in decline there for the past decade but the low abundances observed in 2016 and 2019 may be a combination of these factors plus hurricane activity (Matthew in 2016 and Dorian in 2019).

2.7. RELEASE MORTALITY

An ad-hoc workgroup comprised of all workshop panelists convened during the in-person Data Workshop to discuss discard or release mortality. Beverly Sauls and Maria Kappos (FWRI) presented relevant data and analyses.

2.7.1. Review of Working Papers

One working paper was submitted for review to the Discard Mortality ad-hoc Workgroup:

SEDAR79-DW-04: Descriptions of Florida's Mutton Snapper Recreational Fishery Assessed Using Fishery-Dependent Survey Data.

2.7.2. Summary of Past Assessments

Release mortality estimates for SEDAR 15A (SEDAR 2008) were based on a literature review and SEDAR 7 (Gulf of Mexico Red Snapper, section 6.0) since limited data were available on *Lutjanus analis* release condition. Articles were deemed relevant if they focused on a species with similar body size to Mutton Snapper (< 1 m total length), with similar life history strategies (adults reside on marine reefs), collected with similar gear types (hook and line). Two groups of data could be easily discerned from the data - those collected in less than 30 m depth, and those collected at greater depths. Immediate release mortality rates averaged 15% in shallow water of less than 30 m and averaged 66% in deeper waters. The shallow depth group of 15% was considered to be a proxy for fishes collected nearshore and available to recreational anglers and the commercial handline fleet. There were no discards for the commercial longline fleet. A sensitivity run was performed with a 5% release mortality rate for the inshore recreational fisheries. The update assessment (SEDAR 15AU; SEDAR 2015) continued to apply the 15% immediate release mortality to recreational and commercial handline discards and performed sensitivity runs with 5% and 20% release mortality rates.

2.7.3. New Information Available for SEDAR 79

Data on release condition of *Lutjanus analis* include long-term monitoring data collected by at-sea observers (At-Sea: 2009-2022) aboard randomly selected for-hire fishing vessels (charter boats and larger headboats). Approximately 44% of fish were released in good condition without being vented, 26% were vented but swam down strongly, and 1% of fish were descended in the for-hire fishery during the decade of sampling presented in this analysis. Approximately 19% of fish were impaired upon release, 9% of fish were deep-hooked, and 1% were released dead or eaten by a predator (Table 5 in the Kappos 2023).

These data suggest release mortality could be as high as 29% if no fish released alive with an impairment survive. This assumption is likely an overestimate, but also does not account for any additional mortality suffered by unimpaired fish (from predation, for example). A recent meta-analysis of Red Snapper (*Lutjanus campechanus*) discard mortality in the Gulf of Mexico included both immediate and delayed mortality measures (Ramsay et al. 2022). This meta-analysis combined 11 studies, with 84 distinct estimates from 34 years of research and included only studies that assessed both immediate and delayed mortality. The study considered whether depth, season, release method, or region could significantly predict discard mortality. While discard mortality was higher in the western Gulf during summer months, season was not a significant predictor in the eastern Gulf. Depth was a significant factor across all regions.

Red Snapper exhibit similar body size to Mutton Snapper (< 100 cm total length), similar life history strategies (adults reside on marine reefs), and are collected with similar gear types (hook and line). Due to these similarities and the dearth of data informing Mutton Snapper release mortality, release mortality of Red Snapper from Ramsay et al. (2022) was used a proxy for Mutton Snapper.

Data collected by at-sea observers aboard for-hire fishing vessels suggest that in the Florida Keys, Mutton Snapper are caught in shallow water (77% were caught in < 10-meter depth), while in southeast Florida, 92% of Mutton Snapper were caught in 20–39-meter depth (Table 3 and Figure 2 in Kappos 2023). Median depths fished for the commercial handline fleet (including all gears other than longline) from TIP data range from approximately 45-meters in southwest Florida, 20-meters in the Florida Keys and Dry Tortugas, and 30-meters in northeast and southeast Florida. The majority of landings from the commercial handline fleet occur in the Dry Tortugas and Florida Keys, as well as southeast Florida. Thus, the Workgroup considered the primary capture depth range of Mutton Snapper to be in shallow waters of 30 meters or less.

2.7.4. Workgroup Recommendations

The Workgroup referred to Figure 4B in Ramsay et al. (2022) to determine a release mortality at 30-meter depth to be approximately 30%. The Workgroup then decided on a 15% lower bound for a sensitivity run applied to both commercial handline and recreational fisheries to be consistent with the previous assessment and an upper bound of 45% for symmetry.

2.8. REPRODUCTION

There were no additional reproductive data for Mutton Snapper submitted for the SEDAR 79 benchmark assessment. The available data discussed below are the same as were available and used during the update assessment (SEDAR 15AU 2015) but reanalyzed using an updated methodology (Lowerre-Barbieri et al. 2022).

2.8.1. Standardizing the Reproductive Data

Reproductive potential plays an important role in stock assessments and biological reference points and is commonly measured as either spawning stock biomass (SSB) or total egg production (TEP). Both measures need an estimate of the sex ratio. Estimates of size- and age-at maturity are needed for SSB, whereas for TEP there is also the need to estimate annual fecundity-at-age.

There is little published on Mutton Snapper reproduction, but they have been reported to form large spawning aggregations at specific spawning sites (Claro et al. 2009), typically at the time of the full moon in March through July (Heyman and Kjerfve 2008; Feeley et al. 2018;

Heidmann et al. 2021). However, peak spawning activity can vary even within a country, as in Cuba where peaks can occur between May and August depending on the location (SCRFA https://www.scrfa.org/aggregations/aggregating-species/mutton-snapper/). Fish which form spawning aggregations at consistent locations and times are vulnerable to overfishing. Known spawning aggregation sites within the U.S. include Riley's Hump within the Dry Tortugas (Feeley et al. 2018).

For SEDAR 79, there were 3,673 fish with a sex assigned as female that could potentially be used to estimate size and age at maturity. There were no fecundity estimates. Because maturity (and other reproductive parameters) are not invariant over space and time and 99.8% of the data came from samples collected in two general locations and time periods, we first censored records outside the spatio-temporal range. We then selected for females with multiple ovarian development indicators: a macroscopic or histological reproductive phase (or both) and gonadosomatic index (GSI), calculated as:

$$GSI = \frac{gonad\ weight}{(total\ weight - gonad\ weight)} * 100$$

The resulting data set included: 876 fish sampled in the Florida Keys (1998 – 2004, n = 171; 2007 – 2011, n = 705) and 2,155 fish sampled in Southeast Florida (1998 – 2004, n = 159; 2007 – 2011, n = 1996). Samples from the first period were from fishery independent sampling and capture methods included Chevron traps, hook and line, and spearfishing. This dataset was first described by Barbieri and Colvocoresses (2003), with 28 additional fish sampled in the Florida Keys in 2004.

A lack of standardized methods and criteria to categorize development and terminology makes it difficult to conduct reproductive analyses on databases from multiple studies, as needed in stock assessments. In addition, although histological analysis is considered the most accurate method to assess gonadal development, with reproductive phase assigned based on the most advanced gamete stage (MAG) and/or post-ovulatory follicles and atresia (Table 2.13.11) for many fish reproductive phases are still assigned macroscopically. In the Mutton Snapper dataset, there were 3,653 females with a macroscopic reproductive phase and only 652 with a reproductive phase based on histology. Macroscopic analysis cannot identify immature fish or accurately distinguish between regenerating, developing, and regressing, and these phases are assigned as mature, undeveloped (MU). Because fully yolked oocytes are typically pale yellow and ~0.50 mm, they can be identified macroscopically and used as a phase indicator (YO – yolked oocytes). Ovaries assigned as YO can also have fresh POFs which would not be macroscopically visible. Also hydrated oocytes are typically ~1.0 mm and are easily identifiable macroscopically both before and after they are ovulated, making it possible to identify active spawners (AS).

Several webinars were held in 2022 to build on standardization presented in Lowerre-Barbieri et al. (2011) and Brown-Peterson et al. (2011) to develop a SEDAR reproductive data template. As many of the scientists were involved in that effort, we used SEDAR 74 as a means to build on these efforts and develop best practices for standardization in reproductive analyses for stock assessment (Lowerre-Barbieri et al. 2022). For this data set extensive QCing was needed to develop a data set with standardized reproductive phases that could be used to estimate size and age at maturity.

2.8.2. Spawning Season

Spawning seasonality was based on ovarian development, with the macroscopic phases "YO" and "AS", and histologic phases "spawning capable" and "actively spawning" indicative of the spawning season. Typically, peak spawning is based on months with a high percentage (~75%) of spawning capable females (Lowerre-Barbieri et al. 2009).

Macroscopic phase data was used to evaluate spawning seasonality, given the large sample sizes (and very small histological sample sizes) and the high accuracy of macroscopic staging for yolked and active spawners. Females with yolked oocytes (YO macroscopic phase) occurred throughout the year in the Florida Keys and in most months in SE Florida, although in much lower numbers (Figure 2.14.19). Active spawners first occurred in April (n = 2) and were last sampled in September (n = 1, none were sampled in August; Figure 2.14.20). Based on elevated GSIs and proportion of spawning capable females (YO and AS), we consider April through July to be the core spawning season (Figure 2.14.19).

The data set has a low frequency of spawning indicators, especially in SE Florida. Most females macroscopically staged were "UN" (undeveloped, 89%), 10% were YO (yolked oocytes) and only 1% were active spawners (AS). Histological analysis confirmed very low proportions of active and spawning capable females, as well as an extended time period over which developing, regressing, and regenerating females occurred (Figure 2.14.21). The peak proportion of spawning capable females (YO and AS) occurred in the Florida Keys in May and June (Figure 2.14.20), but even in these months it was only ~60% in the Keys and never surpassed 10% in SE Florida. Mutton Snapper are reported to aggregate to spawn, at least at Riley's Hump, where fish were present from April to August for ~one week at a time. Some fish returned 2 – 3 times within a spawning season (Feeley et al., 2018). Typically, when a species moves to a location specifically to spawn the proportion of active spawners is much higher. For example, at a spotted seatrout aggregation site, the proportion of females that were actively spawning was 91% (Lowerre-Barbieri et al. 2009). However, like Spotted Seatrout, Mutton Snapper may not all exhibit the same reproductive strategy in terms of spawning site selection.

Additional research is needed to better understand Mutton Snapper reproduction in the US. It is important to note that all reproductive data used here were more than 10 years old. Because reproductive timing in spring and summer-spawning fish is tightly coupled to temperature (Lowerre-Barbieri et al, 2011) spawning seasonality may have changed with climate change. In addition, the data are suggestive of potential migration through SE Florida to Keys spawning grounds and possibly even a second spawning season. Understanding these processes will be critical to estimating annual fecundity in this species.

2.8.3. Age/Size and Maturity

Fitting a logistic curve to sex-specific maturity data distributed by size or age is the traditional method of estimating size and age at 50% sexual maturity. However, the accuracy of the resulting estimate will be affected by the spatial distribution of sampling relative to that of nursery and adult habitat, the time period over which samples are collected, and the method used to categorize fish as mature or immature (Hunter and Macewicz 2003; Lowerre-Barbieri et al. 2011). Here we use binomial generalized linear models (GLMs) to model maturity at age and length, with different link functions (logit, probit, cloglog and cauchit) specified, and the best model chosen via corrected Akaike Information Criterion (AICc). Models were fitted in R and model comparison was performed using the R package ‘MuMIn’. Estimated parameters were the intercept and slope. For the logit link function, the binomial GLM model parameters, intercept and slope, can readily be translated to fit the logistic function of the form:

$$\mathrm{y} = \frac{1}{\left(1 + \left(e^{\left(-a*(x-b)\right)}\right)\right)}$$

where *y* is the proportion mature, *a* is the model slope, *x* is equal to either length or age, and *b* is the inflection point (age or length at 50% maturity) calculated by dividing the negative value of the model intercept by the slope. The standard error for *b* was calculated using the propagation of errors formula:

$$\mathrm{SE} = |b| * \sqrt{\left(\frac{SE(intercept)}{intercept}\right)^2 + \left(\frac{SE(slope)}{slope}\right)^2}$$

Several approaches were explored for time period selection and maturity indicators. The traditional approach is to use histologically assigned reproductive phases and filter for dates within the core spawning season to decrease the number of regenerating females that might be misidentified as immature (Hunter and Macewicz 2003). However, this approach appears to work best for fishes with constricted spawning seasons. In contrast Mutton Snapper, like Red Snapper, have extended spawning seasons and regenerating females occur within the spawning season and even peak spawning months. To increase sample sizes for species with these patterns we developed a method that rather than censoring months of the year censors reproductive phases (Lowerre-Barbieri et al. 2022). With this method only fish assigned as immature histologically are used and mature fish are represented by those either confirmed as mature because they are active spawners or if the sample size is too small also including those which have yolked oocytes and are spawning capable. Here we used histologically assigned immature (IM), macroscopically and histologically assigned ovaries with yolked oocytes (YO and spawning capable) and active spawners.

Accurately estimating maturity in marine fish is difficult, even with histology as MAGS do not differ between immature and mature regenerating females and additional histological indicators such as ovarian wall thickness and muscle bundles must be used. In some species, GSI can improve the classification of immature females and it has the potential to then be applied to females evaluated macroscopically. However, in Mutton Snapper there was significant overlap between GSI of immature and mature, non-spawning females, as assigned via histology (Figure 2.14.22). We therefore only included immature individuals assigned via histology, and mature fish designated as spawning or spawning capable either using histology or macroscopic staging in the maturity analysis. We note that, of the 11 individuals assigned as immature using histology, ten were assigned as regenerating and only one as immature based on macroscopic staging.

An additional difficulty in accurately estimating size and age at maturity for stock assessments is that minimum size limits are typically developed to select for only mature fish, resulting in the inability to collect immature samples in fishery dependent sampling. Of the fish histologically assigned as immature in the Mutton data set, all came from fishery-independent sampling and from period 1 (sampled prior to 2003; Figure 2.14.23). Samples to accurately estimate size and age at maturity need to fall above and below the maturation window, with relatively large samples within the window (Lowerre-Barbieri et al. 2022). The maturation window is defined as the smallest, youngest spawning fish to the largest, oldest immature fish. The smallest mature female Mutton Snapper (YO, SC or AS reproductive phases) was 405 mm natural total length (TL) and the largest immature female observed via histological staging was 425 mm TL (Tables 2.13.12 and 2.13.13; Figure 2.14.24). The youngest mature female Mutton Snapper was 3 years old, and the oldest immature female observed via histological staging was 4 years (Tables 2.13.12 and 2.13.14, Figure 2.14.25). The logit model was within 2 delta AICc values of the best model for all model runs, and thus we report model parameters for the logit model here. Length and age at 50% maturity were estimated as 422 mm TL and 3.5 years, respectively, when only spawning capable and actively spawning females were included as mature and no temporal filter was applied. When we included all non-regenerating females with histological data and sampled during the spawning season, we obtained smaller estimates of size and age at maturity, 387 mm TL and 2.4 years, respectively.

2.8.4. Comparison to Previous Maturity Estimates

The estimates of size and age at maturity presented here are similar to those from the first benchmark assessment (L50 = 402 mm TL, A50 = 3.71 years; SEDAR 15A 2008), but larger than those from the update assessment (L50 = 398 mm TL, A50 = 2.85 years; SEDAR 15AU 2015). In SEDAR 15A (2008), female reproductive phases were assigned via histology (n=310) from 999 fishery independent samples (Barbieri and Colvocoresses 2003). After filtering for core spawning months (April through June) and removing regenerating females only 39 samples were left for estimating maturity parameters. For the update assessment completed in 2015 (SEDAR 15AU 2015), additional maturity data included fishery dependent data collected as part of a cooperative research study (Cody and Poholek 2011). Available data had reproductive phases assigned via macroscopic evaluation. Filtering for core spawning months and removing regenerating females resulted in 192 samples to update the maturity-at-age relationship and 221 samples to update the maturity-at-length relationship. However, only 38 were based on histological analysis. Because immature fish cannot be accurately assigned with macroscopic staging, this presumably affected the L50 and A50 estimates. By applying the newly developed method to censor phases rather than sampling months (Lowerre-Barbieri et al. 2022), we were able to increase sample size to 274.

2.8.5. Sex-ratio

Sex ratios are commonly used to indicate the numerical relationship between the sexes and is conventionally expressed as a proportion where the number of males is divided by the total number of individuals (Wilson and Hardy 2002). Within the total Mutton Snapper dataset there were 9,058 males and 7,586 females identified. Sex ratios were first calculated by obtaining the proportions for each sex; the male proportion was 0.544 and the female proportion was 0.456. The overall male:female sex ratio was then calculated to be 1.19:1.00 where slight bias was toward the number of males.

Within the Florida Keys, the male:female sex ratio was found to be 1.11:1.00 (number of males = 3,259; number of females = 2,928) and in southeast Florida it was 1.21:1.00 (number of males = 5,340; number of females = 4,406). Similar results are reported from Belize (Graham et al. 2008) where the male:female sex ratio was 1.23:1.00 (number of males = 4,096; number of females = 3,323). In northern Brazil, a study conducted by Teixeira et al. (2010) with comparatively smaller sample sizes report the male:female sex ratio slightly biased towards females at 1.00:1.21 (number of males = 61; number of females = 74).

2.9. MOVEMENTS AND MIGRATIONS

Mutton Snapper exhibit spatial separation of adult and juvenile members of the local population and therefore constitute a nursery species as defined by Beck et al. (2001). After a pelagic larval period of ca. 31 days, Mutton Snapper settle onto a suite of available habitats such as nearshore seagrass beds < 10 m deep (Lindeman et al. 2000). While data are limited, it is reasonable that Mutton Snapper undergo ontogenetic shifts in habitat use from shallow vegetated habitats to alternative structure (e.g., the reef tract) in response to changing exposure to predation caused by increasing body size (e.g., Dahlgren and Eggleston 2000). Stable isotope work focusing on trophic niches and ontogeny of juvenile mutton snapper in Brazil resulted in high variability, indicating individuals foraged in mangrove, estuarine, seagrass, and reef habitats (Bastos et al. 2022). However, Bastos et al. (2022) did support a shift toward macroalgae and marine particulate organic matter in mutton snapper between 230 mm and 240 mm TL. In the Netherland Antilles, Mutton Snapper densities were greatest in seagrass beds, then mangroves, then coral reef habitat (Nagelkerken et al. 2000). However, more work is needed to determine the full extent of habitat use and ontogenetic shifts of *Lutjanus analis* in southeastern U.S. waters.

Movement studies on acoustically tagged Mutton Snapper have produced varied results, with mean home range sizes estimated at 0.103 km^2 in the United States Virgin Islands (Heidmann et al. 2021) and between 2.5 km^2 (Feeley et al. 2018) and 7.64 km^2 (Farmer and Ault 2011) in the Dry Tortugas, FL. However, long distance movements to and from spawning aggregations have been recorded in the range of 23 – 40 km (Pittman et al. 2014, Feeley et al. 2018). New tracking data from the Florida Keys revealed individual Mutton Snapper tagged at Western Dry Rocks, a multispecies spawning aggregation location off Key West, moved to the Dry Tortugas and up to Biscayne Bay (Figure 2.14.26; J. Keller, FWC, unpublished data). These movements were linked to the lunar phase and only occurred in peak spawning months (April – July), indicating Mutton Snapper were migrating up to 225 km to get to a spawning aggregation.

Mark-recapture data between 2010 – 2023 in South Florida also indicates longer-range movements, with five Mutton Snapper recaptured more than 15 nautical miles (nmi) away from their tagging location (Table 2.13.15; B. Cermak, J. Cortes, S. Wilms, FWC, unpublished data). However, the average distance for the 82 recaptured fish with location information was 5.65 nmi, indicating that Mutton Snapper may have relatively high site fidelity, but larger movements (46 – 105 km) do occur. Most of the tagging occurred in southeast Florida and the Florida Keys with a 5.4% average recapture rate. All five of the longest distances occurred in southeast Florida and the Florida Keys (Figure 2.14.27), but the temporal component of the mark-recapture data is too coarse to link these movements to potential spawning migrations from the acoustic telemetry data. The long-distance migrations recently discovered are the largest reported for this species and further work is needed to elucidate movement patterns, spawning behavior, and source and sink dynamics of this species in south Florida and throughout their range.

2.10. COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES

2.10.1. Stock Definition

Genetic analyses available for Mutton Snapper supported a single genetically homogenous stock in the southeastern U.S. and Gulf of Mexico regions. However, since the prior assessment no additional analyses have been conducted in other parts of the defined unit stock (e.g., northeastern Florida, the West Florida Shelf, or off the Carolinas). Despite this, the assumption of it being a closed population in the SAMFC and GMFMC jurisdictions for the purpose of this stock assessment and management is considered reasonable and consistent with previous assessments; but the uncertainty associated with this assumption is unknown and therefore difficult to define or estimate.

2.10.2. Morphometrics and Conversion Factors

Programs from both fishery-dependent and fishery-independent sources provided adequate quantities of differing length and weight measurement types to create adequate length-length and length-weight equations and conversion factors.

A large component of the length measurements available for Mutton Snapper come from the headboat fishery which measures Mutton Snapper using a ‘natural’ total length. Typically, measurement units within an assessment model follow the regulations to better align with the management advice coming from the assessment model. For Mutton, the LHW noted some concern with the mismatch between the large number of observations of ‘natural’ total length and the much smaller number of ‘maximum’ total length observations (i.e., the regulation definition for total length). This means the lengths within the model will largely be converted values. Regardless, the length-length relationships appear well-defined and the use of ‘maximum’ total length within the assessment model is consistent with the prior assessments for this species.

2.10.3. Age and Growth

The age data appeared to be ample and representative of the landings with the assigned ages supported by the precision analyses conducted. The LHW characterized the data represented as the best available and recommended its use for stock assessment purposes. Through continued efforts of fishery-dependent and -independent sampling, the known maximum age of Mutton Snapper in southeastern U.S. and Gulf of Mexico jurisdictions has been lengthened slightly to 42 years from 40 years in SEDAR 15AU (2015).

The size-truncated von Bertalanffy growth model fit to the inverse-weighted data whose variance was estimated as the CV increasing linearly with age was recommended by the LHW to be used in modeling length-at-age for stock assessment purposes. The estimated von Bertalanffy parameter values should be considered for use in the development of age-length keys (e.g., for an ASAP model) and should be considered as initial values for internal estimation of growth within a Stock Synthesis model. Length-at-age data came primarily from fishery-dependent sources with active minimum size limits and necessitated the use of a size-truncated growth model. However, expanded biological samples from fishery-independent efforts, primarily for younger (ages 0 – 2) and older (ages greater than 8) may address these gaps and preclude the need for this type of growth model in the future.

2.10.4. Natural Mortality

Direct methods of estimating mortality (e.g., mark-capture, acoustic telemetry tagging) for Mutton Snapper were unavailable or insufficient; however, the empirical methods provided here represent ‘good practices’ and were based on the most recent research available and recommended for use within stock assessment models. Longevity-based estimators of M are considered the most informative (Then et al. 2015, Cope and Hamel 2022), are recommended by the SEDAR Best Practices (2016), and should be accompanied by measures of uncertainty (e.g., see the Natural Mortality Tool developed by Cope and Hamel [2022] and the standard deviations in lognormal space developed by Hamel and Cope [2022]). While the estimates of constant M

correlated with growth were nearly double those based on longevity, they are at least as likely to be correct as the longevity-based ones (Kai Lorenzen, pers. comm.) and should be explored via model sensitivity analyses.

2.10.5. Release Mortality

In the absence of any substantive empirical data, the Workgroup panel considered the approach presented here to be a reasonable approximation for a release mortality rate for this species. However, an important assumption is that the relationship between mortality and depth for *Lutjanus campechanus* can be applied to *Lutjanus analis*.

2.10.6. Reproduction

While the reproductive data utilized here were the same as what was available for the previous update assessment (and is now largely more than 10 years old), the recently developed best practices permitted a re-analysis of that data yielding more robust results. Therefore, the LHW found the information on size- and age-at-maturity and spawning seasonality sufficient for use, but also stressed the need for more recent reproductive data.

2.10.7. Movements and Migrations

Recent acoustic telemetry data has documented migrations in the order of 140 nautical miles in south Florida waters, which is more than six times longer than previously documented migrations for this species. Previous studies have documented fairly small home ranges for Mutton Snapper, but this new data indicates that adult fish may travel further than previously believed to reach a spawning aggregation. Thus, individual fish may travel between regions of Florida in order to reproduce.

2.11. RESEARCH RECOMMENDATIONS

2.11.1. Stock Definition

The LHW recommended expanding genetic sampling to other areas parts of the defined unit stock (e.g., northeastern Florida or on the West Florida Shelf) to either reinforce or challenge current hypothesized boundaries of the Mutton Snapper stock within southeastern U.S. waters. In addition, the presence of Mutton Snapper larvae sampled at stations across the Straits of Florida between the east Florida shelf (e.g., off Biscayne Bay) and the Great Bahama Bank (D'Alessandro et al. 2010) suggests possible connectivity between the two regions. There is no genetic data published from Mutton Snapper in the Bahamas (Carson et al. [2011] comments about it being a less well-documented aggregation area) and investigating this could provide insight into any connection with southeastern Florida as well as any potential source and sink dynamics. While genetic analyses for Mutton Snapper have been conducted from elsewhere in the Caribbean (e.g., Puerto Rico, St. Croix, St. Thomas, Cuba, Belize) and support a homogenous stock, there is no genetic information available from populations observed off the Yucatan peninsula in the southwest Gulf of Mexico.

2.11.2. Morphometrics and Conversion Factors

The LHW recommends additional length measurements in 'maximum' total length be taken across both fishery-dependent and fishery-independent programs to better align with current management regulations and the length units used within the assessment model(s).

2.11.3. Age and Growth

The number of otoliths sampled and available for this assessment had significantly increased from the number available in the previous update assessment and was adequate for use in developing models for growth and tracking strong year classes through time (albeit once they've entered the fishery, about age-3). Yet, the LHW noted a paucity of fishery-independent age data particularly for pre-fishery individuals aged 0 – 2 years and also greater than age ~8 years. Of the ongoing fishery-independent surveys which track young Mutton Snapper throughout the Florida Keys and southeast Florida regions, otolith-derived age information was largely collected from the Indian River Lagoon system.

The LHW, therefore, expressed an interest in the need to increase fishery-independent age sampling of these younger and older parts of the population. Such information could help further our understanding of ontogeny and recruitment throughout the Florida Keys and allow for earlier detection of strong year classes, rather than waiting for them to be sampled from the fishery. Information of older fish also makes possible fishery-independent estimates of L_∞, which is currently not feasible. The LHW also understands that implicit in this is the probable expansion of fishery-independent surveys targeting these parts of the Mutton Snapper population and may be considered a 'heavy lift'.

2.11.4. Natural Mortality

The field of natural mortality is not yet in a position to establish 'best practices' (Maunder et al. 2023) and suggested 'good practices' are often trade-offs between reliability and availability of the data. More direct methods of estimating mortality, such as mark-recapture or acoustic telemetry tagging, are generally recommended over empirical methods but are largely unavailable for Mutton Snapper. Therefore, tagging studies for this species are recommended for the purposes of estimating mortality. Effort into acoustic telemetry tagging requires a large enough array of detectors to minimize incomplete detections and the candidacy of Mutton Snapper may need to be evaluated if movement out of the array area is for extended periods (i.e., are the change in numbers due to mortality or migration). But acoustic telemetry will also help alleviate the human reporting issues within conventional tagging.

2.11.5. Release Mortality

Future research is recommended to obtain a more accurate estimate of Mutton Snapper discard mortality, which could include similar work conducted by Forrestal et al. (2017) on the development of physiological parameters or acoustic tagging of Mutton Snapper releases at a series of depths to evaluate post release mortality. In addition, studies that quantify Mutton Snapper immediate and delayed mortality of discards caught from commercial fishing gears are needed to validate the assumption that discard mortalities are comparable among fisheries.

Depredation (the removal of fish from fishing gear by non-target species) of Mutton Snapper is a concern among commercial, charter, and headboat captains primarily in the Gulf of Mexico in recent years (GMFMC Staff 2023 and Workgroup discussions). However, depredation is currently not explicitly incorporated in estimates of discard mortality. Attempts should be made to measure depredation rates from either existing or new surveys and provide recommendations on how to incorporate this information in a stock assessment model.

2.11.6. Reproduction

The LHW emphasized that additional research is needed to better understand Mutton Snapper reproduction in the southeastern U.S., and it is important to note that all reproductive data used here were largely more than 10 years old. A common problem sampling for maturity is that truly immature fish are often smaller than legal size and/or are located in habitat differing from adult habitat. Histological data from the Florida Keys, especially from fishery-independent sources on immature fish, is needed and should be collected throughout the year given the recent best practices developed and conducted here for determining size- and age-at-maturity and spawning seasonality. Furthermore, because reproductive timing in spring and summer-spawning fish is tightly coupled to temperature (Lowerre-Barbieri et al. 2011) spawning seasonality may have changed with climate change. Data are also suggestive of potential migration through SE Florida to Keys spawning grounds and possibly even a second spawning season. Therefore, understanding all these processes will be critical to estimating annual fecundity in this species.

2.11.7. Movement and Migration

The movement data presented here for Mutton Snapper is recent and unpublished but is already challenging previous understandings for this species. The LHW, therefore, recommended continual investigation of the movement and migration rates between the Florida Keys, southeast Florida, and southwest Florida (e.g., through increased tagging) as well as to continue examining migration distances and catchment areas of Mutton Snapper traveling to known spawning aggregations. The LHW also recommended further investigation into ontogenetic shifting of juveniles from nearshore areas to reef habitat as this is not well documented within south Florida waters.

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2.13. TABLES

Table 2.13.1. Length-length and length-weight relationships developed for southeastern U.S. Mutton Snapper. Linear length-length regressions are in the form Y = *a* + *b*X and non-linear length-weight regressions are in the form $W = aL^b$. SL: standard length; FL: fork length; TL: total length; TW: total weight.

LENGTH- LENGTH

Y (mm)	a	b	X (mm)	n	Min X (mm)	Max X (mm)	Avg. X (mm)	MSE	Adj. r2
FL	17.5033	1.1301	SL	2,019	196	723	410.3	79.109	0.994
$TL_{relaxed*}$	18.5711	1.2244	SL	2,462	75	723	370.4	173.197	0.990
TL_{max**}	35.6926	1.2057	SL	1,855	121	723	408.2	122.244	0.991
TL_{max}	15.5177	1.0710	FL	2,886	195	819	491.4	35.412	0.998
FL	-9.8710	0.9282	$TL_{relaxed}$	16,967	125	882	509.5	53.741	0.994
TL_{max}	10.3668	1.0057	$TL_{relaxed}$	1,407	261	863	500.7	45.505	0.996

LENGTH-WEIGHT

Y (g)	a	b	X (mm)	n	Min X (mm)	Max X (mm)	Avg. X (mm)	MSE	Adj. r2
TW	4.05E-05	2.9425	SL	1,764	75	723	370.9	66724.564	0.995
TW	1.31E-05	3.0490	FL	22,880	118	850	466.3	48012.329	0.985
TW	7.11E-06	3.1004	$TL_{relaxed}$	28,395	99	895	507.7	50856.330	0.980
TW	3.99E-06	3.1904	TL_{max}	1,370	156	885	540.2	56813.658	0.989
TW	4.59E-06	3.1601	$TL_{max\_final***}$	36,369	110	926	521	61558.950	0.979

LENGTH-WEIGHT

Y (kg)	a	b	X (cm)	n	Min X (cm)	Max X (cm)	Avg. X (cm)	MSE	Adj. r2
TW	6.63E-06	3.1601	$TL_{max\_final***}$	36,369	11.0	92.6	52.1	61558.950	0.979

$TL_{relaxed*}$ - Tail flat, in its natural state

TL_{max**} - Tail compressed to its maximum length

$TL_{max\_final***}$ - Contains both observed and converted length measurements

Table 2.13.2. Number of ages of Mutton Snapper sampled by year from the southeastern U.S. from 1977 – 2022.

	Age (years)																																										
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	Total
1977	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1979	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1980	0	0	7	8	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
1981	0	0	11	84	29	4	6	3	5	1	2	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	149
1982	0	0	2	27	72	20	4	15	6	9	3	4	0	0	0	0	2	1	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	169
1983	0	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
1984	0	0	17	5	0	2	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
1985	0	0	6	41	21	1	6	10	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88
1986	0	0	3	3	21	2	0	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33
1987	0	2	3	2	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
1988	0	0	8	12	8	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33
1990	0	0	0	1	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
1991	0	0	1	3	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
1992	0	2	6	15	16	3	3	3	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52
1993	0	0	15	24	16	16	10	10	1	4	2	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101
1994	0	0	2	24	33	8	11	6	3	0	0	1	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92
1995	0	0	12	58	48	27	7	3	5	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	162
1996	0	0	11	30	58	34	17	6	5	4	1	2	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170
1997	0	2	25	29	48	39	44	28	15	6	2	3	2	0	1	0	1	0	0	0	1	0	0	2	1	2	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	253
1998	56	13	38	132	60	50	25	22	10	1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	412
1999	19	22	54	125	70	50	18	15	13	5	1	1	2	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	399
2000	21	12	107	169	101	28	22	6	5	5	5	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	484
2001	12	9	59	225	108	66	20	15	5	9	3	3	0	2	6	5	2	2	2	0	2	2	0	0	1	0	1	1	0	0	0	2	0	2	0	0	0	0	0	1	0	0	565
2002	0	3	36	173	176	113	49	24	10	6	3	8	4	3	4	3	5	1	2	1	3	1	2	1	0	0	1	2	2	1	2	0	1	1	2	1	0	0	0	0	0	0	644
2003	0	4	43	172	251	86	43	20	13	8	3	17	10	5	7	6	5	5	3	6	7	4	5	0	4	2	1	2	1	0	0	3	1	0	1	1	1	1	1	0	1	0	743
2004	1	1	46	101	123	106	54	32	27	13	8	6	5	2	5	2	1	6	7	3	1	1	4	1	2	3	2	1	2	3	1	1	0	2	1	0	0	1	0	1	1	0	577
2005	0	2	56	331	152	92	54	55	26	17	5	3	5	5	5	3	2	6	2	6	4	4	1	0	1	0	3	3	2	1	0	0	0	1	1	1	0	0	0	0	0	0	849
2006	0	0	20	211	113	76	98	92	62	20	23	21	16	15	6	11	14	5	7	4	5	7	3	1	3	4	3	1	1	1	0	2	3	1	3	0	2	0	0	0	1	0	855
2007	0	3	95	222	280	91	61	37	43	24	12	18	7	11	7	3	6	7	4	6	8	4	2	2	4	2	1	0	2	4	1	0	1	2	0	3	0	0	0	0	0	0	973
2008	0	0	79	477	149	224	120	78	61	53	33	24	18	7	5	2	3	6	4	7	3	3	9	7	5	0	1	0	1	2	1	0	2	0	0	0	0	0	0	0	0	0	1,384
2009	0	0	43	267	526	97	227	86	64	43	40	27	16	16	8	5	5	7	6	6	2	4	2	1	3	2	1	0	0	4	3	1	0	1	1	0	0	0	0	0	0	0	1,514
2010	0	0	24	298	485	491	113	201	79	49	40	29	15	19	19	9	10	5	2	3	3	5	7	6	5	3	0	1	1	0	1	2	0	0	0	0	0	0	0	0	1	0	1,926
2011	0	0	10	114	343	321	330	68	135	37	24	18	19	13	11	11	4	5	3	9	8	0	2	4	1	5	3	2	0	0	2	0	2	2	0	0	1	0	0	0	1	0	1,508
2012	0	0	33	18	114	192	165	216	73	131	56	31	30	28	14	20	18	14	9	6	6	7	2	3	4	5	2	3	4	1	2	1	1	0	0	1	1	1	0	0	1	0	1,213
2013	1	1	45	128	33	104	137	159	151	48	44	30	22	12	8	13	10	10	7	4	4	4	5	1	3	2	1	2	0	1	1	0	0	2	0	0	0	0	0	0	0	0	993
2014	0	4	78	360	111	22	75	106	116	115	42	26	10	9	15	12	6	6	9	8	7	6	5	5	3	0	4	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1,163
2015	1	3	74	212	244	96	15	59	65	79	48	12	13	13	8	9	12	7	5	6	2	4	3	4	6	2	2	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1,008
2016	1	2	52	246	250	326	78	15	33	49	72	59	21	19	11	9	8	13	2	6	2	6	2	3	1	3	2	1	1	0	1	0	0	1	1	0	0	0	0	0	0	0	1,296
2017	0	1	19	172	214	165	207	44	7	27	32	38	42	24	9	10	3	8	8	8	11	3	5	5	5	1	1	2	2	1	0	0	0	1	0	0	0	0	0	0	0	0	1,075
2018	1	1	9	113	238	227	178	190	44	9	16	42	49	50	11	21	10	9	9	6	8	7	9	3	3	3	3	1	4	4	1	2	0	0	0	0	0	0	1	0	0	0	1,282
2019	2	1	7	62	253	167	96	85	53	13	7	6	16	16	20	6	7	5	3	3	5	4	5	2	1	3	1	0	3	0	2	1	1	0	0	0	0	0	0	0	0	0	856
2020	0	1	3	14	56	148	92	64	51	48	1	6	8	16	22	10	7	5	13	7	6	3	2	4	1	0	2	3	1	1	1	3	1	1	1	0	0	0	0	0	0	0	602
2021	0	0	2	42	82	88	243	98	42	37	28	3	1	5	11	13	10	9	1	2	2	3	6	4	1	2	0	1	0	2	3	1	1	0	1	1	0	0	0	0	0	0	745
2022	1	1	13	62	122	172	151	303	134	33	20	25	3	3	4	7	17	13	8	4	1	5	2	7	4	8	1	1	0	2	1	0	0	0	0	2	1	0	0	0	0	0	1,131
Total Number	116	90	1,175	4,812	5,034	3,769	2,792	2,176	1,366	906	579	466	339	296	222	191	169	157	118	114	102	88	84	68	62	53	36	29	29	29	23	20	15	17	12	10	7	3	3	2	6	1	25,586
Percent	0.453	0.352	4.592	18.807	19.675	14.731	10.912	8.505	5.339	3.541	2.263	1.821	1.325	1.157	0.868	0.747	0.661	0.614	0.461	0.446	0.399	0.344	0.328	0.266	0.242	0.207	0.141	0.113	0.113	0.113	0.090	0.078	0.059	0.066	0.047	0.039	0.027	0.012	0.012	0.008	0.023	0.004	

Table 2.13.3. Number of Mutton Snapper age samples by commercial (COM), recreational (REC), and fishery independent (FI) sectors collected from the southeastern U.S. from 1977 – 2022.

Year	COM	REC	FI	Total
1977	0	2	0	2
1979	0	1	0	1
1980	0	17	0	17
1981	0	149	0	149
1982	0	169	0	169
1983	0	4	0	4
1984	0	32	0	32
1985	0	88	0	88
1986	0	33	0	33
1987	0	14	0	14
1988	0	33	0	33
1990	0	6	0	6
1991	0	11	0	11
1992	47	5	0	52
1993	47	54	0	101
1994	63	29	0	92
1995	36	126	0	162
1996	146	24	0	170
1997	233	20	0	253
1998	208	0	204	412
1999	236	0	163	399
2000	215	4	265	484
2001	310	41	214	565
2002	415	120	109	644
2003	407	336	0	743
2004	314	263	0	577
2005	344	505	0	849
2006	537	318	0	855
2007	293	676	4	973
2008	573	804	7	1,384
2009	414	1,094	6	1,514
2010	881	1,039	6	1,926
2011	770	735	3	1,508
2012	571	633	9	1,213
2013	515	474	4	993
2014	540	620	3	1,163
2015	335	670	3	1,008
2016	286	999	11	1,296
2017	366	703	6	1,075
2018	543	720	19	1,282

2019	434	402	20	856
2020	537	50	15	602
2021	505	180	60	745
2022	706	346	79	1,131
Total	11,827	12,549	1,210	25,586

Table 2.13.4. Number of Mutton Snapper age samples by Commercial (Com), Headboat (HB), Charter, Private, fishery independent scientific surveys (SS), and tournament (Tour) fishing modes collected from the southeastern U.S. from 1977 – 2022.

Year	Com	HB	Charter	Private	SS	Tour	Total
1977	0	2	0	0	0	0	2
1979	0	1	0	0	0	0	1
1980	0	17	0	0	0	0	17
1981	0	149	0	0	0	0	149
1982	0	169	0	0	0	0	169
1983	0	4	0	0	0	0	4
1984	0	32	0	0	0	0	32
1985	0	88	0	0	0	0	88
1986	0	33	0	0	0	0	33
1987	0	14	0	0	0	0	14
1988	0	33	0	0	0	0	33
1990	0	6	0	0	0	0	6
1991	0	11	0	0	0	0	11
1992	47	5	0	0	0	0	52
1993	47	53	0	0	0	1	101
1994	63	29	0	0	0	0	92
1995	36	126	0	0	0	0	162
1996	146	24	0	0	0	0	170
1997	233	20	0	0	0	0	253
1998	208	0	0	0	204	0	412
1999	236	0	0	0	163	0	399
2000	215	3	1	0	265	0	484
2001	310	12	20	7	214	2	565
2002	415	2	113	4	109	1	644
2003	407	118	208	7	0	3	743
2004	314	137	122	4	0	0	577
2005	344	241	261	3	0	0	849
2006	537	234	74	3	0	7	855
2007	293	580	81	15	4	0	973
2008	573	742	54	8	7	0	1,384
2009	414	993	83	18	6	0	1,514
2010	881	945	75	19	6	0	1,926
2011	770	533	192	10	3	0	1,508
2012	571	587	46	0	9	0	1,213
2013	515	431	43	0	4	0	993
2014	540	539	77	4	3	0	1,163
2015	335	587	83	0	3	0	1,008
2016	286	954	45	0	11	0	1,296
2017	366	549	137	17	6	0	1,075
2018	543	485	215	20	19	0	1,282
2019	434	293	89	19	20	1	856
2020	537	15	30	5	15	0	602
2021	505	70	50	60	60	0	745

2022	706	240	30	76	79	0	1,131
Total	11,827	10,106	2,129	299	1,210	15	25,586

Table 2.13.5. Number of Mutton Snapper age samples by hook and line (H&L), long line (LL), other, and unknown fishing gears collected from the southeastern U.S. from 1977 – 2022.

Year	H&L	LL	OTHER	UNK	Total
1977	2	0	0	0	2
1979	1	0	0	0	1
1980	17	0	0	0	17
1981	149	0	0	0	149
1982	169	0	0	0	169
1983	4	0	0	0	4
1984	32	0	0	0	32
1985	88	0	0	0	88
1986	33	0	0	0	33
1987	14	0	0	0	14
1988	33	0	0	0	33
1990	6	0	0	0	6
1991	11	0	0	0	11
1992	42	1	0	9	52
1993	55	11	0	35	101
1994	50	5	0	37	92
1995	127	3	0	32	162
1996	132	0	0	38	170
1997	226	24	3	0	253
1998	342	3	67	0	412
1999	335	5	59	0	399
2000	266	9	177	32	484
2001	342	52	171	0	565
2002	476	94	73	1	644
2003	592	147	4	0	743
2004	286	147	3	141	577
2005	560	166	0	123	849
2006	390	402	20	43	855
2007	649	232	2	90	973
2008	1,168	208	6	2	1,384
2009	1,349	136	24	5	1,514
2010	1,526	365	34	1	1,926
2011	1,261	229	18	0	1,508
2012	897	246	24	46	1,213
2013	632	255	45	61	993
2014	792	287	70	14	1,163
2015	779	162	49	18	1,008
2016	1,133	121	36	6	1,296
2017	790	236	49	0	1,075
2018	893	338	49	2	1,282
2019	676	89	85	6	856
2020	528	32	42	0	602
2021	577	70	76	22	745
2022	828	271	31	1	1,131
Total	19,258	4,346	1,217	765	25,586

Table 2.13.6. Number of Mutton Snapper age samples collected by region within the southeastern U.S. from 1977 – 2022. Regions are defined as North of Florida (North of FL), Northeast Florida (NE FL), Southeast Florida (SE FL), the Florida Keys (FL Keys), the Dry Tortugas (Dry Tortugas), Southwest Florida (SW FL), Northwest Florida (NW FL), and West of Florida (West of FL).

Year	North of FL	NE FL	SE FL	FL Keys	Dry Tortugas	SW FL	NW FL	West of FL	Total
1977	0	2	0	0	0	0	0	0	2
1979	0	0	1	0	0	0	0	0	1
1980	0	0	16	1	0	0	0	0	17
1981	0	6	80	63	0	0	0	0	149
1982	0	0	65	104	0	0	0	0	169
1983	0	0	4	0	0	0	0	0	4
1984	0	0	32	0	0	0	0	0	32
1985	0	6	81	1	0	0	0	0	88
1986	0	8	25	0	0	0	0	0	33
1987	0	4	10	0	0	0	0	0	14
1988	0	8	25	0	0	0	0	0	33
1990	0	6	0	0	0	0	0	0	6
1991	0	7	0	4	0	0	0	0	11
1992	0	5	46	0	0	1	0	0	52
1993	0	5	52	32	0	12	0	0	101
1994	0	7	61	19	0	5	0	0	92
1995	0	22	117	22	0	1	0	0	162
1996	4	2	150	14	0	0	0	0	170
1997	7	1	189	32	0	24	0	0	253
1998	0	5	388	16	0	3	0	0	412
1999	0	1	359	31	1	7	0	0	399
2000	0	4	328	142	0	10	0	0	484
2001	0	10	342	154	0	58	1	0	565
2002	0	37	420	83	0	104	0	0	644
2003	2	28	550	11	0	152	0	0	743
2004	10	10	369	29	0	157	2	0	577
2005	25	12	578	58	0	173	2	1	849
2006	37	8	276	89	0	445	0	0	855
2007	30	16	603	95	0	228	1	0	973
2008	28	13	671	458	7	207	0	0	1,384
2009	22	33	685	631	6	137	0	0	1,514
2010	17	26	948	549	6	379	0	1	1,926
2011	37	35	661	530	1	242	0	2	1,508
2012	42	7	196	794	1	173	0	0	1,213
2013	7	27	148	536	1	259	15	0	993
2014	7	26	353	479	0	262	36	0	1,163
2015	6	9	303	508	0	182	0	0	1,008
2016	12	89	328	718	0	140	9	0	1,296
2017	18	55	174	568	3	253	4	0	1,075
2018	27	49	200	646	0	313	40	7	1,282

2019	34	155	143	352	0	170	2	0	856
2020	8	386	25	132	0	51	0	0	602
2021	102	281	111	176	2	52	21	0	745
2022	81	381	190	216	0	263	0	0	1,131
Total	563	1,792	10,303	8,293	28	4,463	133	11	25,586

Table 2.13.7. Parameter estimates from the size-truncated von Bertalanffy growth models used to predict length (‘maximum total length mm)-at-age (fractional, yr) for southeastern U.S. Mutton Snapper. Variance parameter(s) were modeled with constant standard deviation (sigma) with age, constant coefficient of variation (CV) with age, CV increasing linearly with age, and CV increasing linearly with size at age. Growth models were applied to both unweighted (--) data and data weighted by using the inverse (1/*n*) of the count of each calendar age. The final model selected was the size-truncated model applied to the inverse-weighted data where CV was a linear function of age.

Variance Parameter	Parameters	Weighting	N	NegLL	AIC	L_∞	K	t_0	Varpar[1]	Varpar[2]	Gradient
Constant sigma	4	--	24,234	129,945	259,898	823.8	0.2042	-0.294	62.8212	--	4.98E-05
Constant CV	4	--	24,234	129,867	259,741	839.0	0.1771	-0.945	0.1094	--	1.05E-04
CV as linear function of age	5	--	24,234	129,637	259,283	838.5	0.1779	-0.899	0.1250	0.0297	1.59E-03
CV as linear function of size at age	5	--	24,234	129,693	259,395	839.5	0.1793	-0.846	0.1479	0.0874	3.39E-05
Constant sigma	4	Inverse	24,234	227.548	463.097	837.6	0.1747	-0.975	56.6350	--	1.42E-07
Constant CV	4	Inverse	24,234	233.331	474.662	831.7	0.1821	-0.993	0.0915	--	2.16E-08
CV as linear function of age	5	Inverse	24,234	225.684	461.369	847.3	0.1633	-1.115	0.1391	0.0279	7.13E-07
CV as linear function of size at age	5	Inverse	24,234	226.590	463.180	841.7	0.1643	-1.046	0.2567	0.0578	3.88E-07

Table 2.13.8. Constant and size- or age-dependent natural mortality models (assuming von Bertalanffy growth where relevant). L_∞ is the von Bertalanffy asymptotic length; K is the von Bertalanffy growth coefficient; $M(w)$ is the natural mortality rate at weight W; $M(a)$ and $M(L)$ is the natural mortality rate-at-age and -length, respectively; t_{max} is the observed maximum age; $M_{L\infty}$ is the natural mortality rate at asymptotic length L_∞; c is the allometric scaling with body length (c = -1).

Approach	Equation	Reference	Notes
Constant			
Longevity	$M = 5.4/t_{max}$	Hamel and Cope (2022)	Standard deviation in log space = 0.31
Empirical K	$M = 1.55\ K$	Hamel and Cope (2022)	Standard deviation in log space = 0.85
$\text{Pauly}_{\text{nls-T}}$ revised	$M = 4.118\ K^{0.73}\ L_\infty^{-0.33}$	Then et al. (2015)	L_∞ in units of cm
Allometric			
Weight	$M(w) = 3\ W^{-0.288}$	Lorenzen (1996)	Uses the non-linear model converting maximum total length (mm) to weight (g)
Length-inverse	$M(L) = M_{Lr}(L/L_r)^c$	Lorenzen (2022)	A constant M estimate used as M_{Lr}; length associated with age-3 as reference length (L_r)
Length-inverse (empirical)	$M(a) = M_{L\infty}\ (1 - e^{-K(a - a0)})^c$	Lorenzen (2022), Lorenzen et al. (2022)	$ln(M_{L\infty}) = 0.42 + 0.93\ ln(K)$; see Model 6, Table 3 in Lorenzen et al. (2022)

Table 2.13.9. Natural mortality-at-age, *M(a)*, or -weight, *M(w)*, of Mutton Snapper with an observed maximum age of 42 years. 'Longevity', 'Empirical *K'*, and the 'Pauly$_{nls\text{-}T}$ revised' estimates of *M(a)* are derived following Lorenzen (2000, 2005) using their respective constant *M* estimates (0.129, 0.253, 0.253) as the reference *M* scaled to age 3 and the von Bertalanffy growth model parameters (L_{inf} = 847; *K* = 0.163; *t0* = -1.115). The 'Longevity (scaled)' model scaled the cumulative mortality rate predicted for ages 3 – 42 to the longevity-based constant *M* estimate.

			Longevity	Longevity (scaled)	Empirical *K*	Pauly$_{nls\text{-}T}$ revised
Age (yr)	Length (mm)	Weight (g)	M(a)	M(a)	M(a)	M(a)
0	141	28.3	0.302	0.514	0.593	0.594
1	247	167.0	0.197	0.336	0.388	0.388
2	337	446.8	0.153	0.261	0.301	0.301
3	414	853.7	0.129	0.219	0.253	0.253
4	479	1354.9	0.113	0.193	0.223	0.223
5	534	1914.0	0.103	0.175	0.202	0.203
6	581	2498.5	0.095	0.163	0.188	0.188
7	621	3082.2	0.090	0.153	0.177	0.177
8	655	3646.3	0.086	0.146	0.168	0.169
9	684	4177.8	0.082	0.141	0.162	0.162
10	709	4669.1	0.080	0.136	0.157	0.157
11	729	5116.4	0.078	0.133	0.153	0.153
12	747	5518.6	0.076	0.130	0.149	0.150
13	762	5877.0	0.075	0.127	0.147	0.147
14	775	6193.6	0.074	0.125	0.145	0.145
15	786	6471.7	0.073	0.124	0.143	0.143
16	795	6714.5	0.072	0.123	0.141	0.141
17	803	6925.6	0.071	0.121	0.140	0.140
18	809	7108.6	0.071	0.121	0.139	0.139
19	815	7266.5	0.070	0.120	0.138	0.138
20	820	7402.6	0.070	0.119	0.137	0.138
21	824	7519.6	0.070	0.119	0.137	0.137
22	827	7619.9	0.069	0.118	0.136	0.136

23	830	7705.9	0.069	0.118	0.136	0.136
24	833	7779.5	0.069	0.117	0.135	0.136
25	835	7842.4	0.069	0.117	0.135	0.135
26	837	7896.1	0.069	0.117	0.135	0.135
27	838	7941.9	0.068	0.117	0.134	0.135
28	840	7981.0	0.068	0.117	0.134	0.135
29	841	8014.3	0.068	0.116	0.134	0.134
30	842	8042.6	0.068	0.116	0.134	0.134
31	842	8066.8	0.068	0.116	0.134	0.134
32	843	8087.3	0.068	0.116	0.134	0.134
33	844	8104.8	0.068	0.116	0.134	0.134
34	844	8119.7	0.068	0.116	0.134	0.134
35	845	8132.4	0.068	0.116	0.134	0.134
36	845	8143.1	0.068	0.116	0.133	0.134
37	845	8152.3	0.068	0.116	0.133	0.134
38	846	8160.1	0.068	0.116	0.133	0.134
39	846	8166.7	0.068	0.116	0.133	0.134
40	846	8172.3	0.068	0.116	0.133	0.134
41	846	8177.1	0.068	0.116	0.133	0.134
42	846	8181.1	0.068	0.116	0.133	0.134

Table 2.13.10. Natural mortality-at-age, *M(a)*, or -weight, *M(w)*, of Mutton Snapper with an observed maximum age of 42 years. The 'Mortality-weight' model followed Lorenzen (1996) and used length-weight parameters a = 4.59E-6 and b = 3.160. The 'Length-inverse' and 'Length-inverse (scaled)' estimates of *M(a)* follow Lorenzen (2022) using the Hamel and Cope (2022) constant *M* estimate (0.129) as the mortality at reference length scale parameter, the von Bertalanffy growth model parameters (L_{inf} = 847; K = 0.163; $t0$ = -1.115), and the exponent c = -1. The 'Length-inverse (scaled)' model scaled the cumulative mortality rate predicted for ages 3 – 42 to the longevity-based constant *M* estimate. The 'Length-inverse (empirical)' model used $M_{L\infty}$ (0.282), the von Bertalanffy growth coefficient, and the exponent c = -1.

Age (yr)	Length (mm)	Weight (g)	Mortality-weight M(w)	Length-inverse M(a)	Length-inverse (scaled) M(a)	Length-inverse (empirical) M(a)
0	141	28.3	1.146	0.378	0.691	1.695
1	247	167.0	0.687	0.215	0.394	0.966
2	337	446.8	0.517	0.158	0.288	0.707
3	414	853.7	0.429	0.129	0.235	0.576
4	479	1354.9	0.376	0.111	0.203	0.498
5	534	1914.0	0.340	0.100	0.182	0.446
6	581	2498.5	0.315	0.092	0.167	0.410
7	621	3082.2	0.297	0.086	0.157	0.384
8	655	3646.3	0.283	0.081	0.148	0.364
9	684	4177.8	0.272	0.078	0.142	0.349
10	709	4669.1	0.263	0.075	0.137	0.337
11	729	5116.4	0.256	0.073	0.133	0.327
12	747	5518.6	0.251	0.071	0.130	0.319
13	762	5877.0	0.246	0.070	0.128	0.313
14	775	6193.6	0.243	0.069	0.126	0.308
15	786	6471.7	0.240	0.068	0.124	0.304
16	795	6714.5	0.237	0.067	0.122	0.300
17	803	6925.6	0.235	0.066	0.121	0.297
18	809	7108.6	0.233	0.066	0.120	0.295

19	815	7266.5	0.232	0.065	0.119	0.293
20	820	7402.6	0.231	0.065	0.119	0.291
21	824	7519.6	0.229	0.065	0.118	0.290
22	827	7619.9	0.229	0.064	0.118	0.288
23	830	7705.9	0.228	0.064	0.117	0.287
24	833	7779.5	0.227	0.064	0.117	0.286
25	835	7842.4	0.227	0.064	0.116	0.286
26	837	7896.1	0.226	0.064	0.116	0.285
27	838	7941.9	0.226	0.063	0.116	0.285
28	840	7981.0	0.226	0.063	0.116	0.284
29	841	8014.3	0.225	0.063	0.116	0.284
30	842	8042.6	0.225	0.063	0.116	0.283
31	842	8066.8	0.225	0.063	0.115	0.283
32	843	8087.3	0.225	0.063	0.115	0.283
33	844	8104.8	0.225	0.063	0.115	0.283
34	844	8119.7	0.224	0.063	0.115	0.283
35	845	8132.4	0.224	0.063	0.115	0.282
36	845	8143.1	0.224	0.063	0.115	0.282
37	845	8152.3	0.224	0.063	0.115	0.282
38	846	8160.1	0.224	0.063	0.115	0.282
39	846	8166.7	0.224	0.063	0.115	0.282
40	846	8172.3	0.224	0.063	0.115	0.282
41	846	8177.1	0.224	0.063	0.115	0.282
42	846	8181.1	0.224	0.063	0.115	0.282

Table 2.13.11. Ovarian classification and terms based on histological analysis (modified from Lowerre-Barbieri et al., 2009).

Reproductive State	Phase	Histological Indicators	Significance
Non-spawning	Immature	Only oogonia and primary growth oocytes, including chromatin nucleolar and perinucleolar oocytes. Usually no atresia.	Virgin that has not yet recruited to the spawning population.
Non-spawning	Developing	Cortical alveolar and sometimes early yolked oocytes. No evidence of POFs. Some atresia may be present.	Mature or maturing. Environmental signals have triggered the maturation process, but fish are not yet developed enough to spawn.
Spawning	Spawning-capable	Yolked oocytes. May have some early OM and/or some atresia; fish which have spawned within the past 48 h may have remnant POFs.	Part of the spawning population. Fish developed enough to spawn.
Spawning	Sub-phase: Actively Spawning	Late OM (completed GVM or GVBD with yolk coalescence and partial to full hydration); ovulation; or newly-collapsed POFs.	Part of the spawning population. Fish sampled in close proximity to the time of spawning and thus useful for assessing spawning sites.
Non-spawning	Regressing	A high percentage of yolked oocytes undergoing atresia (alpha and beta).	Mature fish at the end of the spawning season, resorbing left over developed oocytes.

Non-spawning	Regenerating	Only primary growth oocytes present, including chromatin nucleolar and perinucleolar. Muscle bundles, enlarged blood vessels, thick and/ or convoluted ovarian wall, and gamma or delta atresia may be present.	Sexually mature, reproductively inactive. Most common outside of the spawning season.

Table 2.13.12. Sample sizes, minimum and maximum observed lengths and ages of immature and mature females for the different methods of data subsetting considered. Immature were always histo only samples. No estimates could be produced for the "Spawning season, Histo & Macro SC & AS" method, as the lengths and ages of mature and immature individuals did not overlap. RN = Regenerating, SC = Spawning capable, AS = Actively spawning.

Response	Season	Maturity Phases	Maturity	N	Min Obs	Max Obs
TL	All Year	Histo & Macro SC & AS	Immature	58	227	425
			Mature	216	405	863
	Spawning Season	Histo & Macro SC & AS	Immature	11	325	396
			Mature	197	405	850
	Spawning Season	Only Histo except Regenerating	Immature	11	325	396
			Mature	63	375	815
Age	All Year	Histo & Macro SC & AS	Immature	55	1	4
			Mature	185	3	29
	Spawning Season	Histo & Macro SC & AS	Immature	10	2	4
			Mature	167	3	29
	Spawning Season	Only Histo except Regenerating	Immature	10	2	4
			Mature	58	2	17

Table 2.13.13. Predicted and observed maturity at natural total length from binomial model fit with logit link for the model that included all sampling months and spawning capable or actively spawning females assigned through histology and macroscopic staging in the mature group. Total N_{obs} = 274.

Length bin midpoint	N	N_{mat}	Observed Prop Mature	Predicted Prop Mature
225	1	0	0.0000	0.0000
275	1	0	0.0000	0.0000
325	17	0	0.0000	0.0000
375	30	0	0.0000	0.0028
425	19	10	0.5263	0.6046
475	13	13	1.0000	0.9988
525	12	12	1.0000	1.0000
575	10	10	1.0000	1.0000
625	29	29	1.0000	1.0000
675	36	36	1.0000	1.0000
725	51	51	1.0000	1.0000
775	38	38	1.0000	1.0000
825	16	16	1.0000	1.0000
875	1	1	1.0000	1.0000

Table 2.13.14. Predicted and observed age at maturity from binomial model fit with logit link for the model that included all sampling months and spawning capable or actively spawning females assigned through histology and macroscopic staging in the mature group. Total N_{obs} = 240.

Age	N	N_{mat}	Observed Prop Mature	Predicted Prop Mature
1	3	0	0.0000	0.0001
2	28	0	0.0000	0.0039
3	26	4	0.1538	0.1426
4	14	12	0.8571	0.8752
5	20	20	1.0000	0.9966
6	34	34	1.0000	0.9999
7	17	17	1.0000	1.0000
8	25	25	1.0000	1.0000
9	14	14	1.0000	1.0000
10-29	59	59	1.0000	1.0000

Table 2.13.15. Mark-recapture information for southeastern U.S. Mutton Snapper that were recaptured more than 15 nautical miles from their tagging location between 2010 and 2023.

Fish Number	Date Tagged	Date Recaptured	Total length at Tagging (mm)	Total length at Recapture (mm)	Nautical Miles	Kilometers
38	2/17/2014	7/4/2015	334	457	26.18	48.48536
51	3/20/2018	10/13/2018	290	NA	44.53	82.46956
63	7/5/2021	1/9/2023	316	330	24.9	46.1148
76	12/10/2022	1/8/2023	245	305	56.85	105.2862
77	6/13/2022	1/8/2023	352	NA	32.51	60.20852

2.14. FIGURES

Figure 2.14.1. A Mutton Snapper on live hard bottom reef habitat.

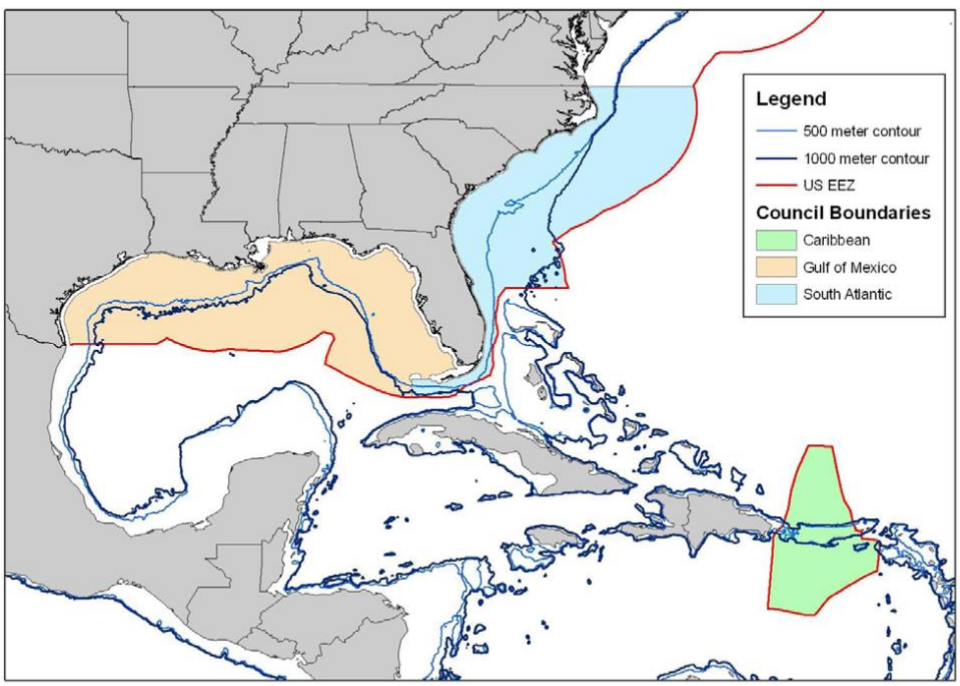

Figure 2.14.2. Jurisdictional boundaries in the Southeast Region for the South Atlantic Fishery Management Council, the Gulf of Mexico Fishery Management Council, and the Caribbean Fishery Management Council.

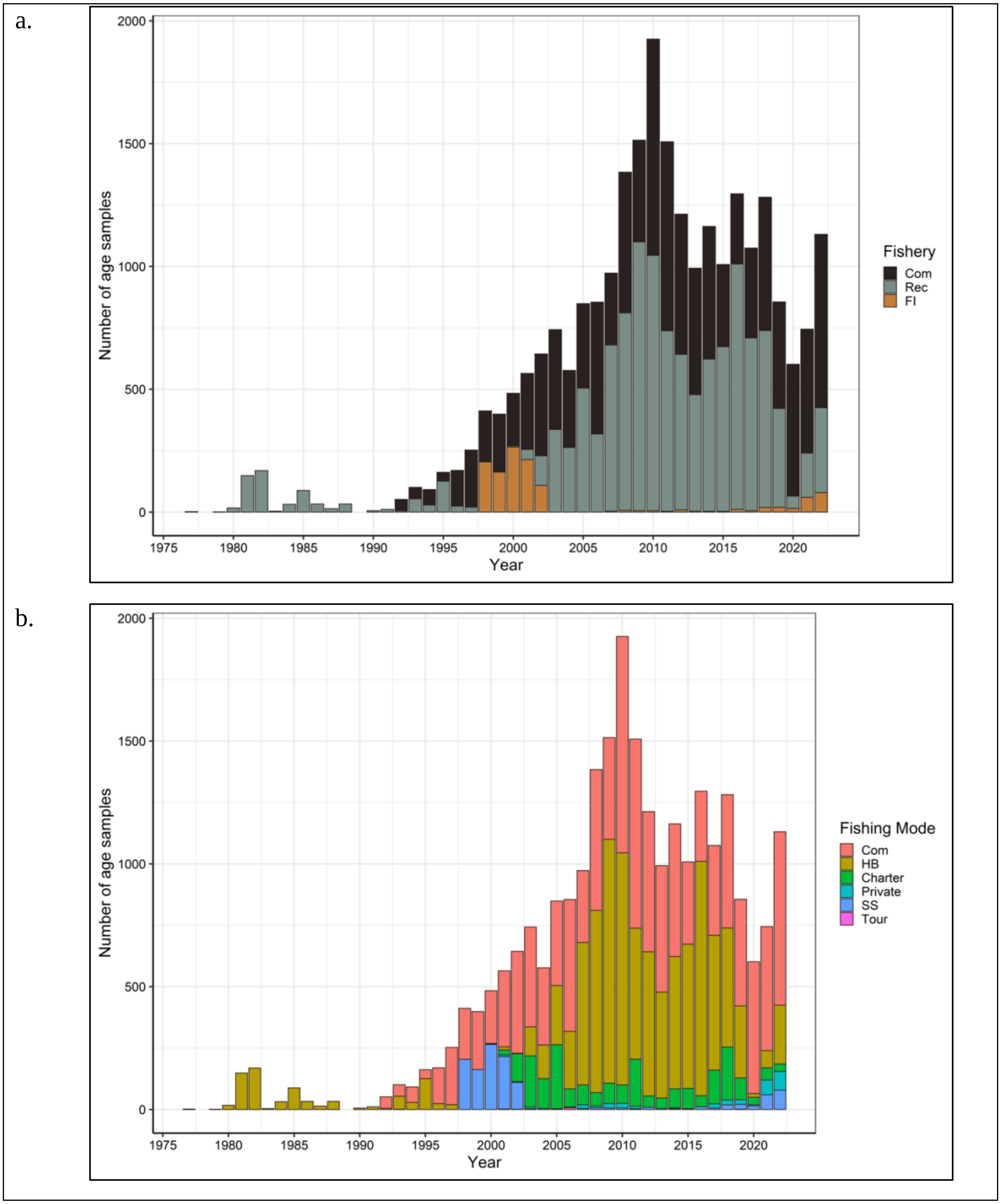

Figure 2.14.3. Number of Mutton Snapper age samples collected per year from the southeastern U.S. from 1977 – 2022. **(a)** Bar plots by commercial (Com), recreational (Rec), and fishery independent (FI) sectors and **(b)** by commercial (Com), recreational (Headboat [HB], Charter, Private, tournament [Tour]), and fishery-independent (scientific surveys [SS]) fishing modes.

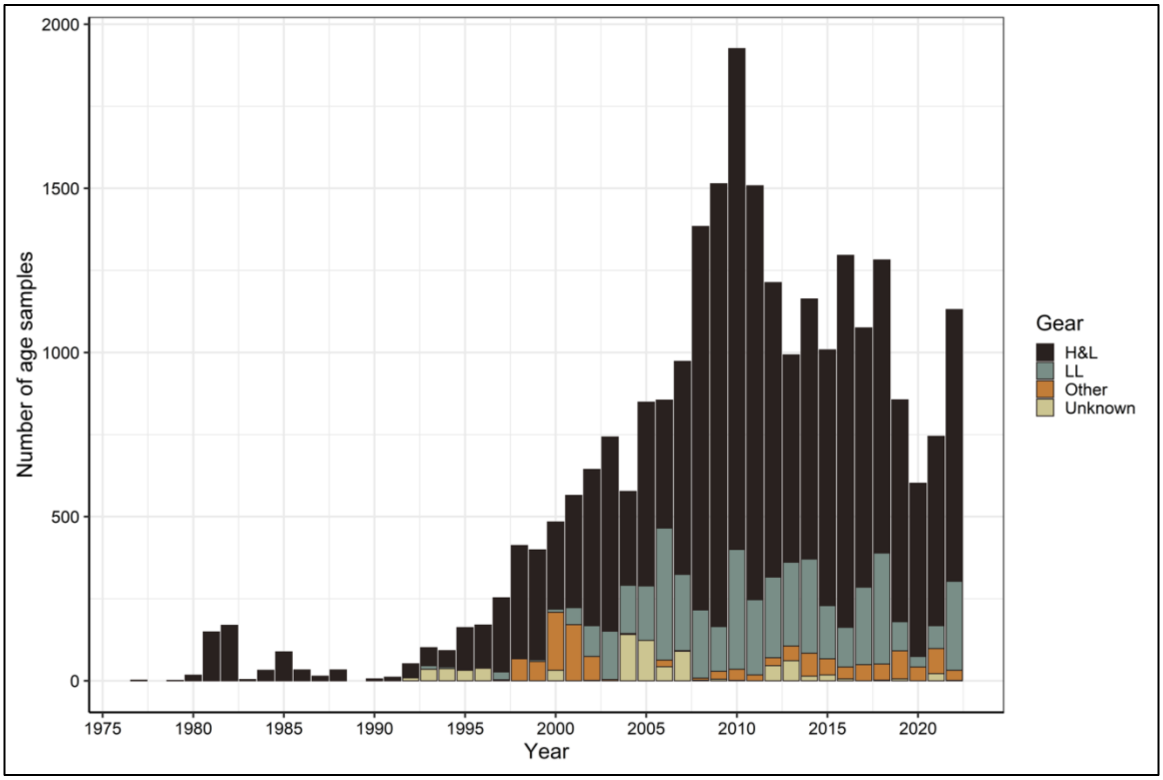

Figure 2.14.4. Number of Mutton Snapper age samples by hook and line (H&L), long line (LL), other, and unknown fishing gears collected from the southeastern U.S. from 1977 – 2022.

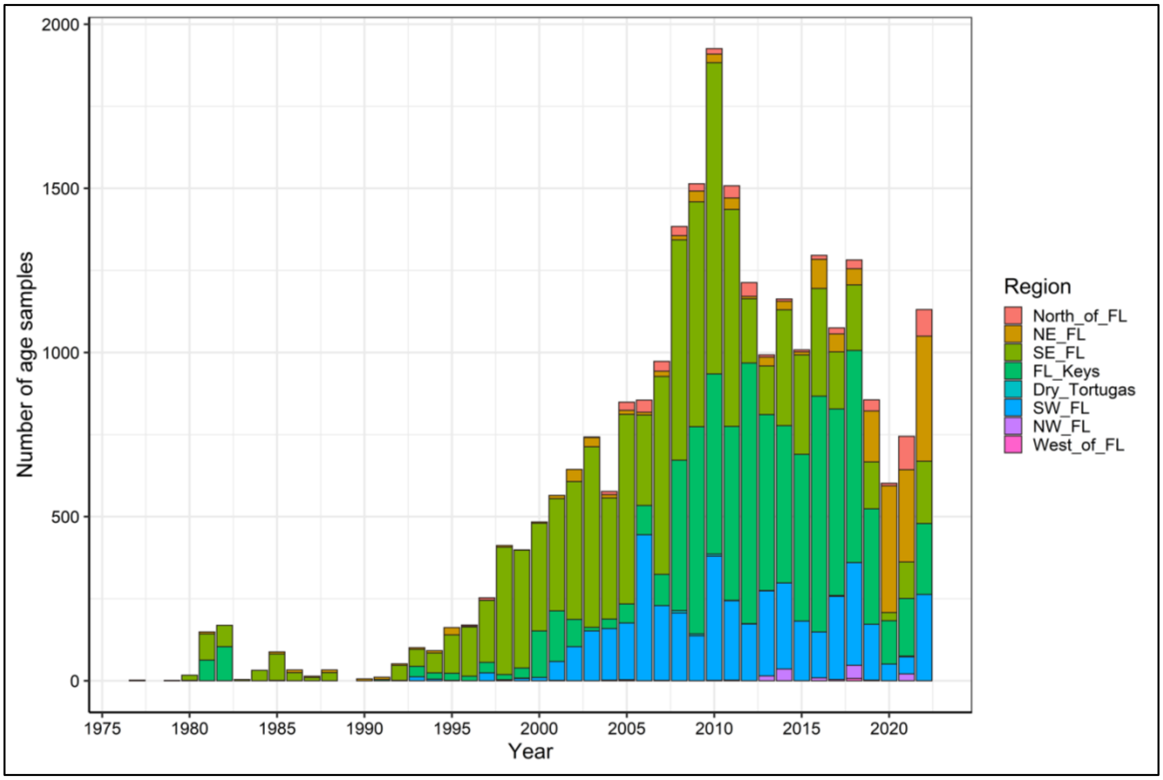

Figure 2.14.5. Number of Mutton Snapper age samples collected by region within the southeastern U.S. from 1977 – 2022.Regions are defined as North of Florida (North of FL), Northeast Florida (NE FL), Southeast Florida (SE FL), the Florida Keys (FL Keys), the Dry Tortugas (Dry Tortugas), Southwest Florida (SW FL), Northwest Florida (NW FL), and West of Florida (West of FL).

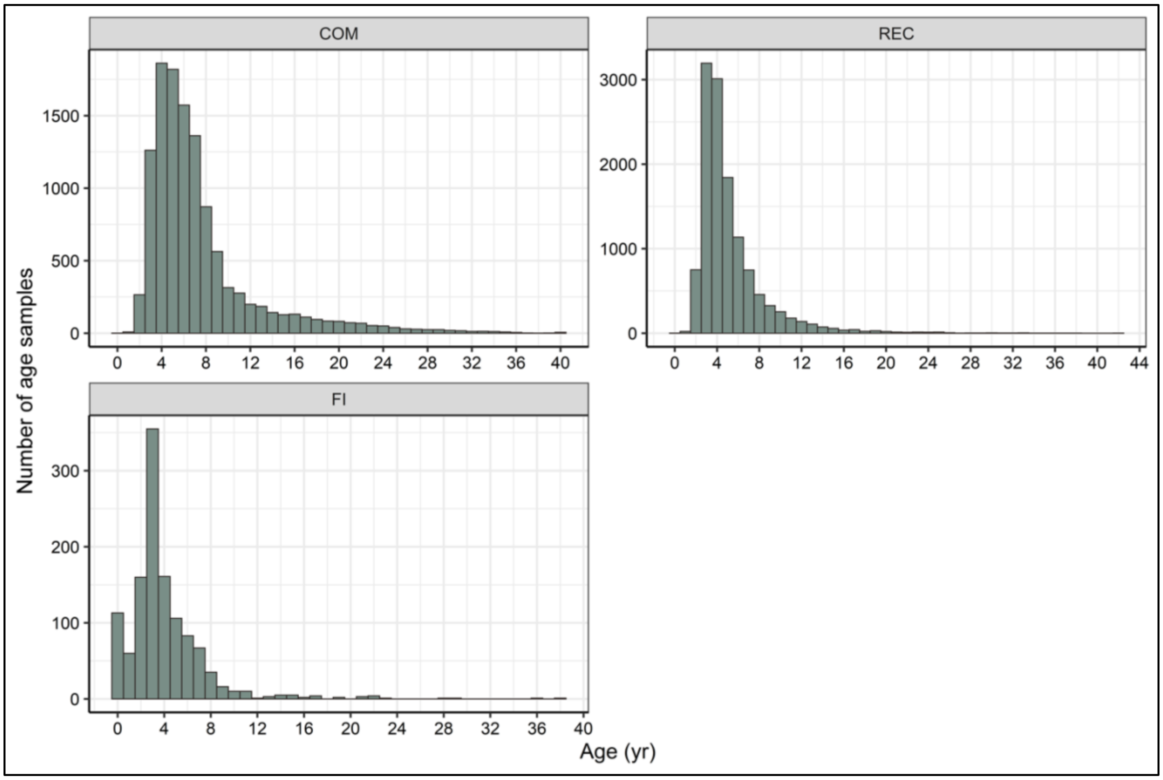

Figure 2.14.6. Histograms of Mutton Snapper age samples collected by commercial (COM), recreational (REC), and fishery independent (FI) sectors within the southeastern U.S. Bin increments are equal to 1 year.

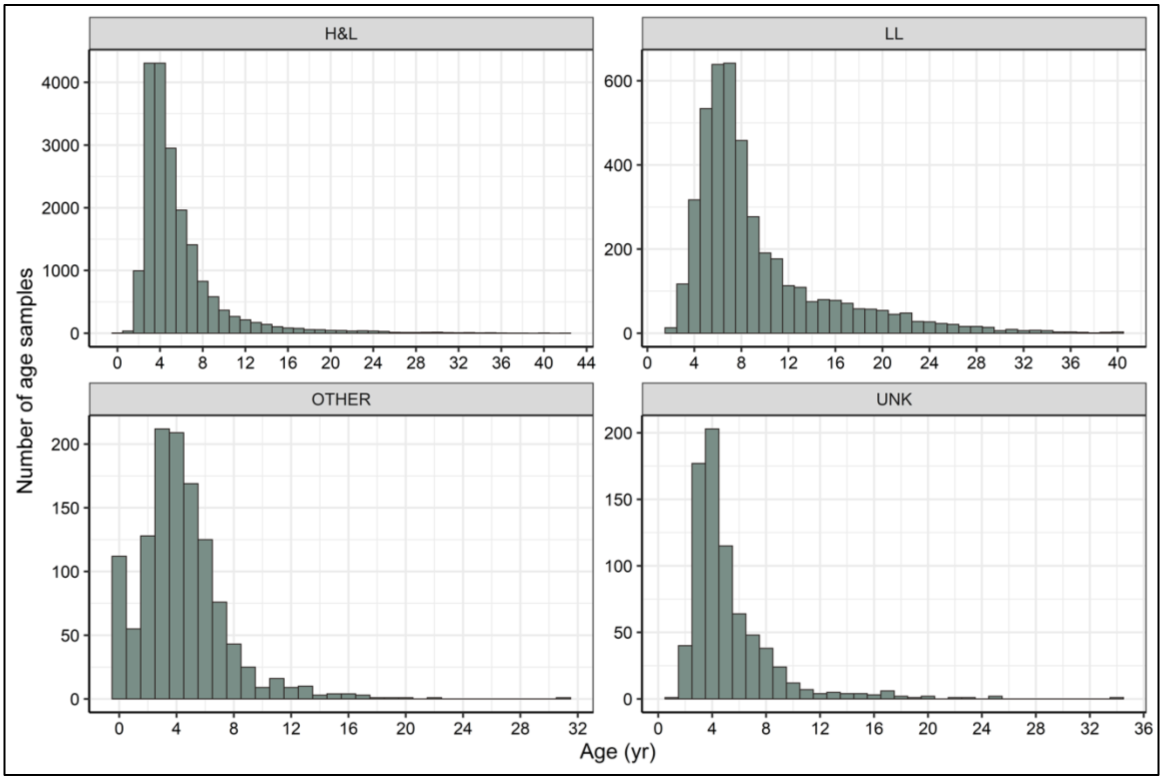

Figure 2.16.7. Histograms of southeastern U.S. Mutton Snapper age samples collected by gear from fishery-dependent and -independent data sources between 1977 – 2022. Bin increments are equal to 1 year.

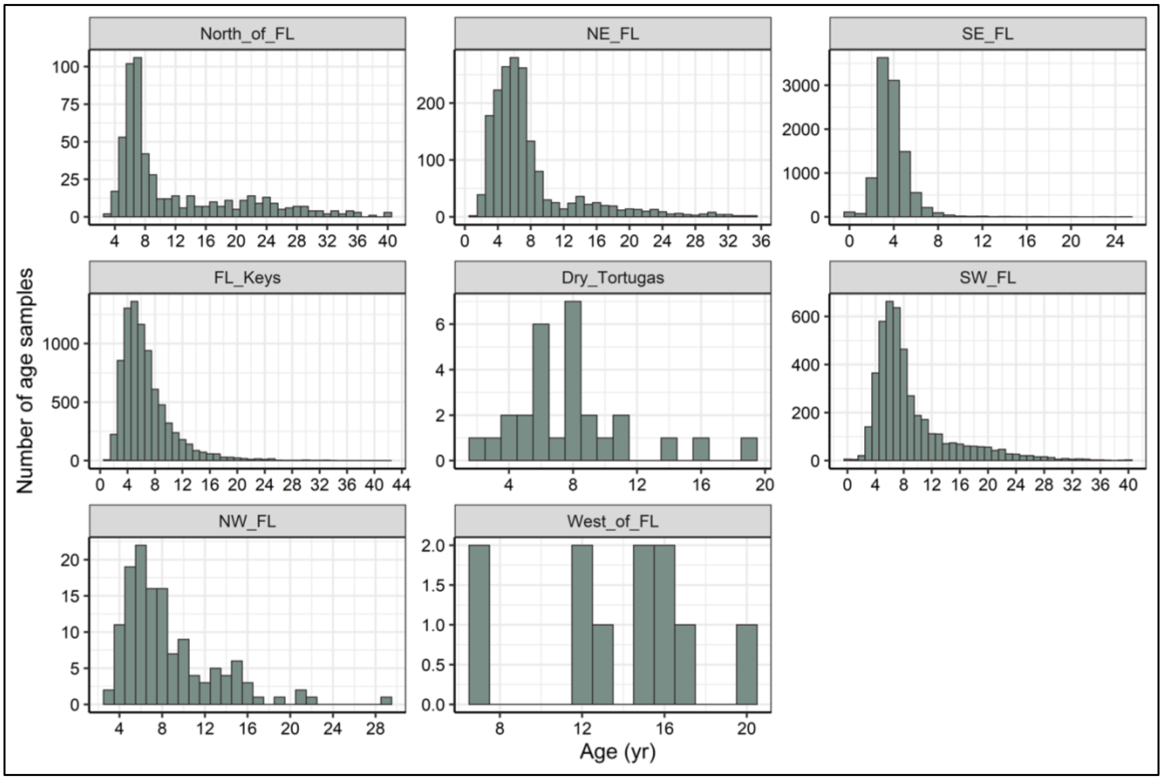

Figure 2.14.8. Histograms of Mutton Snapper age samples collected by region within the southeastern U.S. Regions are defined as North of Florida (North of FL), Northeast Florida (NE FL), Southeast Florida (SE FL), the Florida Keys (FL Keys), the Dry Tortugas (Dry Tortugas), Southwest Florida (SW FL), Northwest Florida (NW FL), and West of Florida (West of FL). Bin increments are equal to 1 year.

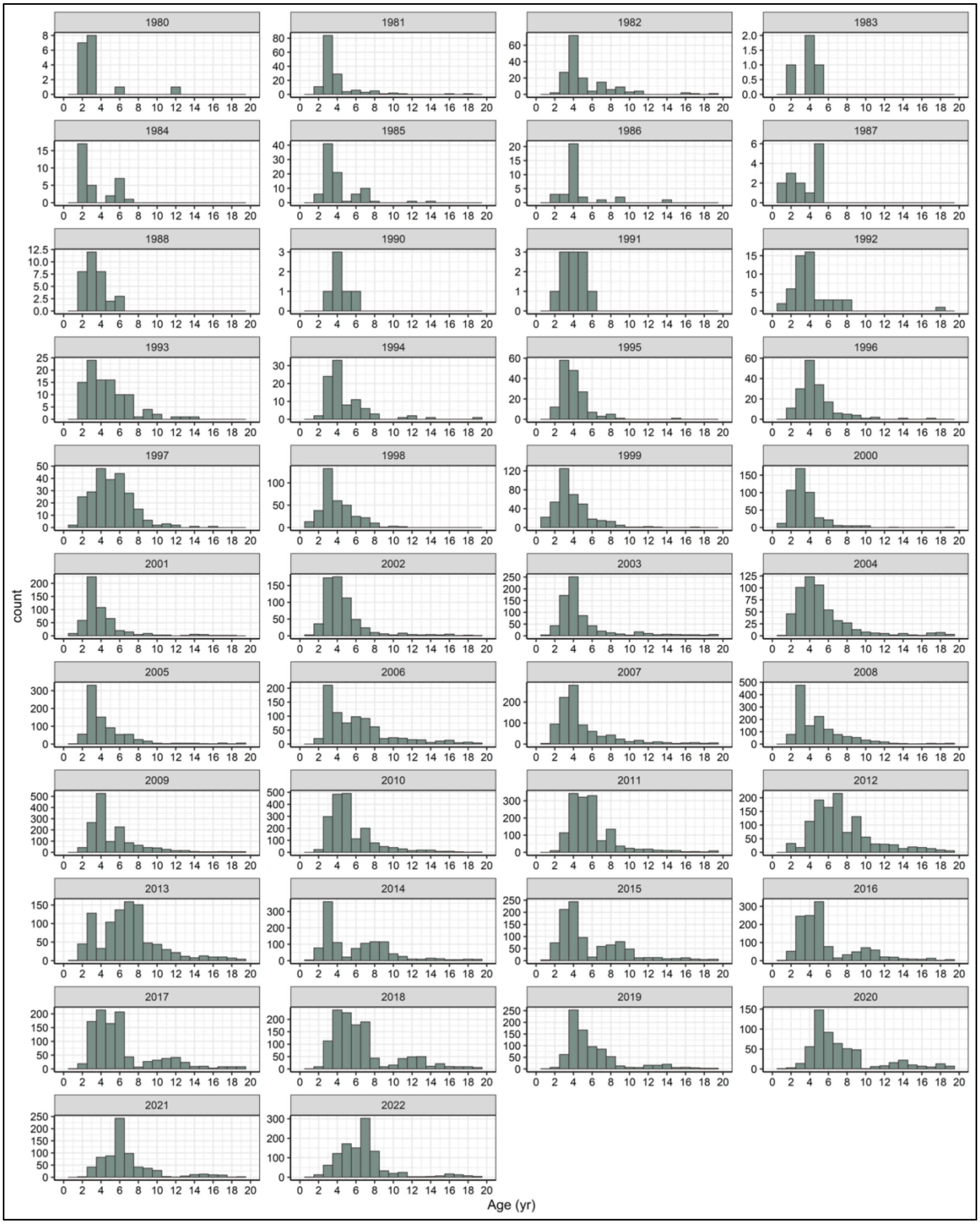

Figure 2.14.9. Histograms of Mutton Snapper age samples by calendar age (curtailed to ages 0 to 20 years) collected from the southeastern U.S. from 1980 – 2022. Bin increments are equal to 1 year.

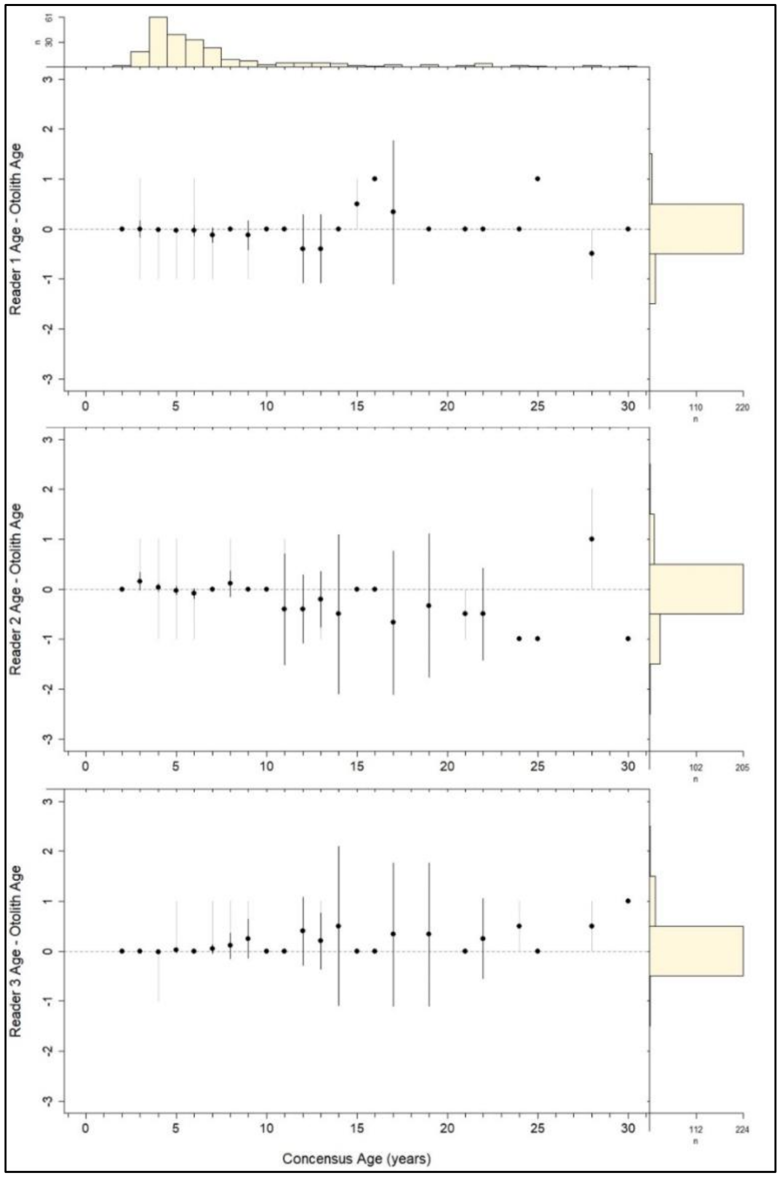

Figure 2.14.10. Age bias plots for the three primary FWRI ageing staff from quality control subsample (n=240). X-axis is consensus age, y-axis is agreement between reader and consensus age. The gray vertical lines of each point demonstrate the age estimation range by each reader, and the black vertical lines indicate the confidence interval of the individual age classes. Open points indicate that a significant difference was detected between the individual reader and the consensus age. The histogram to the right denotes distribution of age agreement for each reader and the upper histogram illustrates the age distribution of the entire sample.

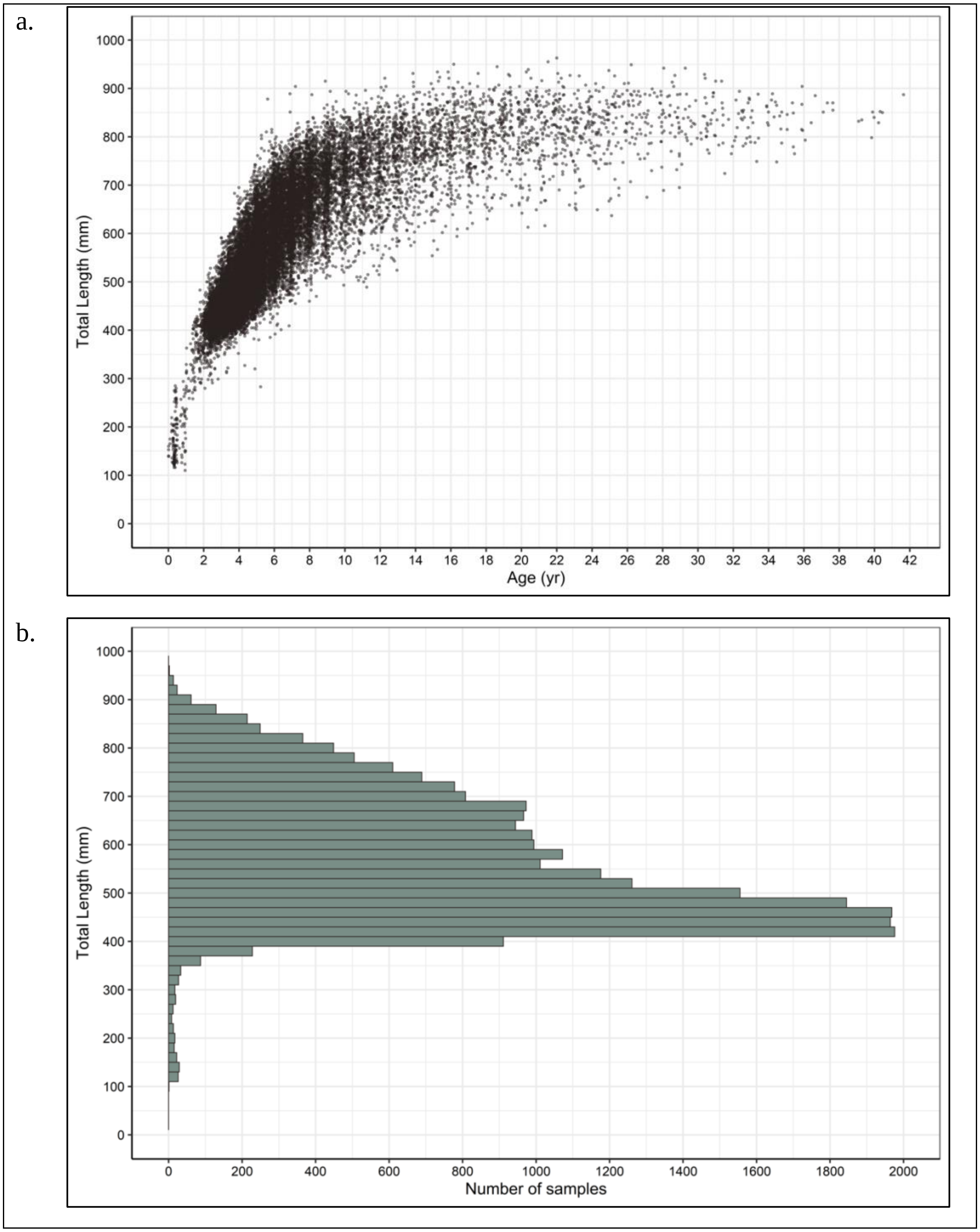

Figure 2.14.11. Southeastern U.S. Mutton Snapper collected from fishery-dependent and -independent data sources between 1977 – 2022. (**a**) Scatterplot of the length ('maximum' total length mm)-at-age (fractional, yr) and (**b**) histogram of the number of length samples in 20 mm bin increments.

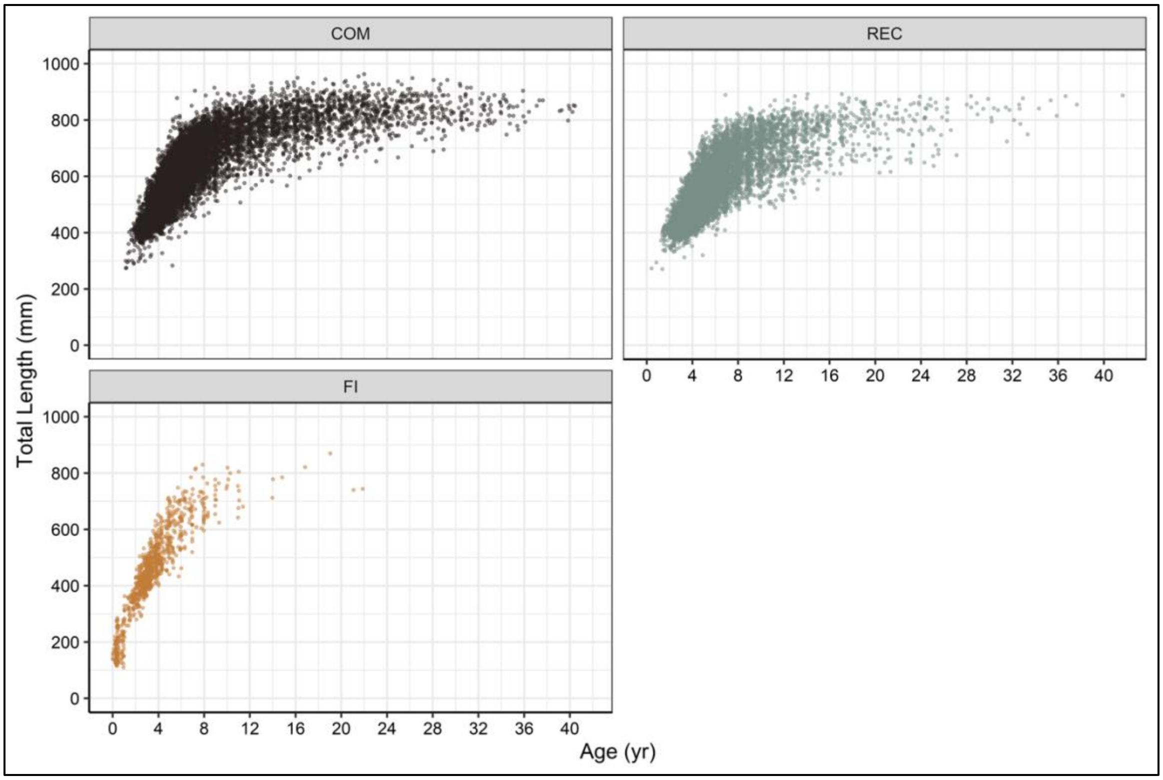

Figure 2.14.12. Southeastern U.S. Mutton Snapper length (‘maximum’ total length mm)-at-age (fractional, yr) by commercial (COM), recreational (REC), and fishery independent (FI) sectors between 1977 – 2022.

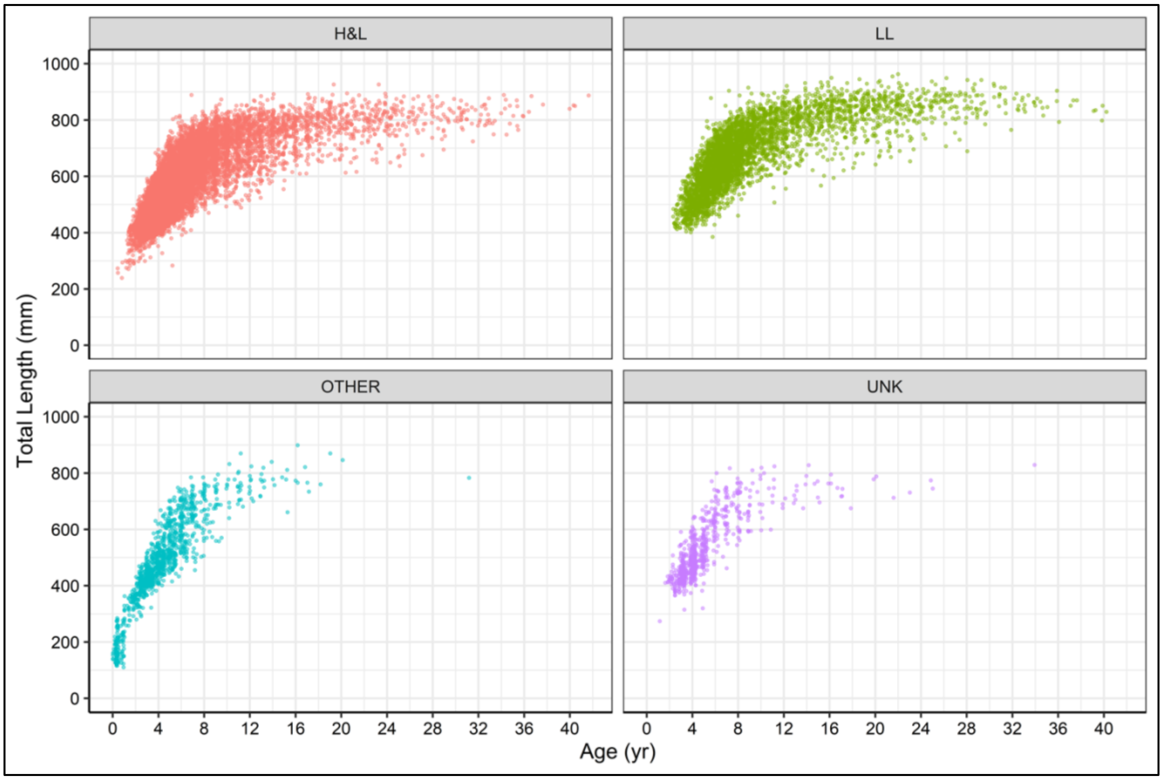

Figure 2.14.13. Southeastern U.S. Mutton Snapper length ('maximum' total length mm)-at-age (fractional, yr) by gear from fishery-dependent and -independent data sources between 1977 – 2022.

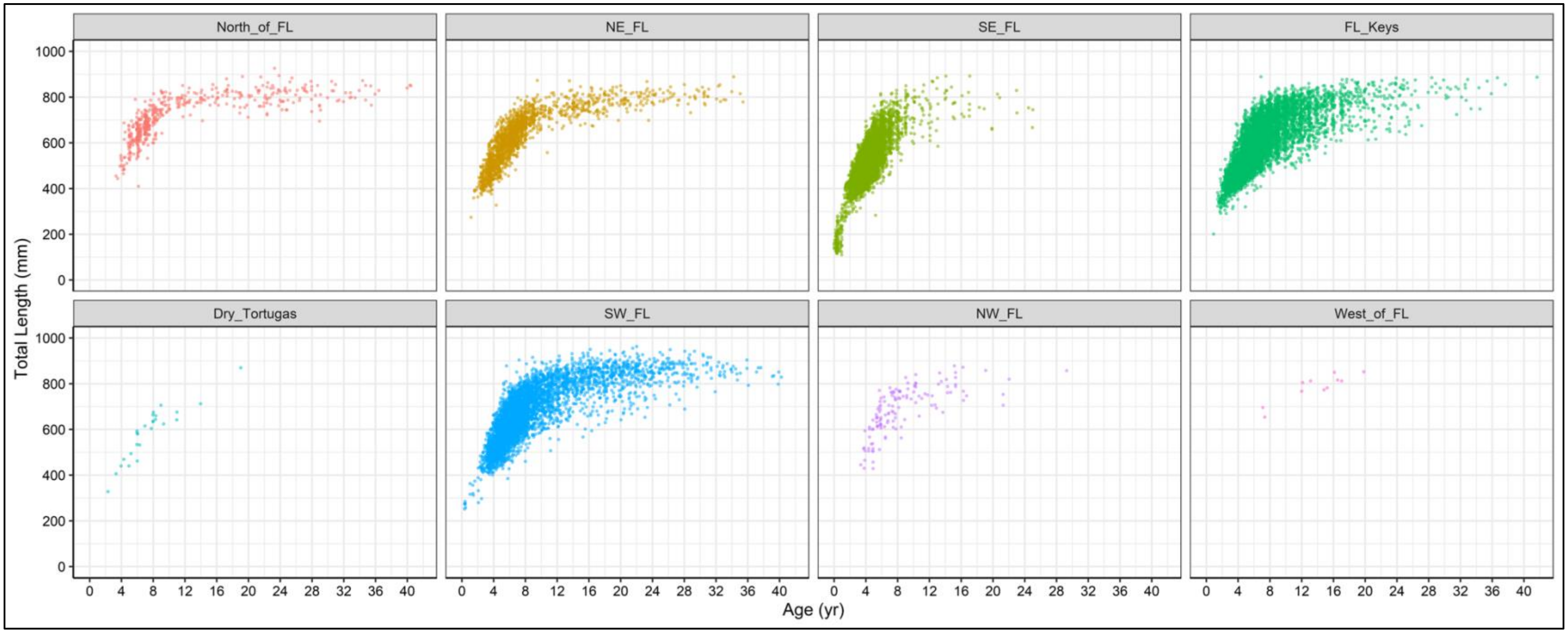

Figure 2.14.14. Southeastern U.S. Mutton Snapper length ('maximum' total length mm)-at-age (fractional, yr) by region between 1977 – 2022. Regions are defined as North of Florida (North of FL), Northeast Florida (NE FL), Southeast Florida (SE FL), the Florida Keys (FL Keys), the Dry Tortugas (Dry Tortugas), Southwest Florida (SW FL), Northwest Florida (NW FL), and West of Florida (West of FL).

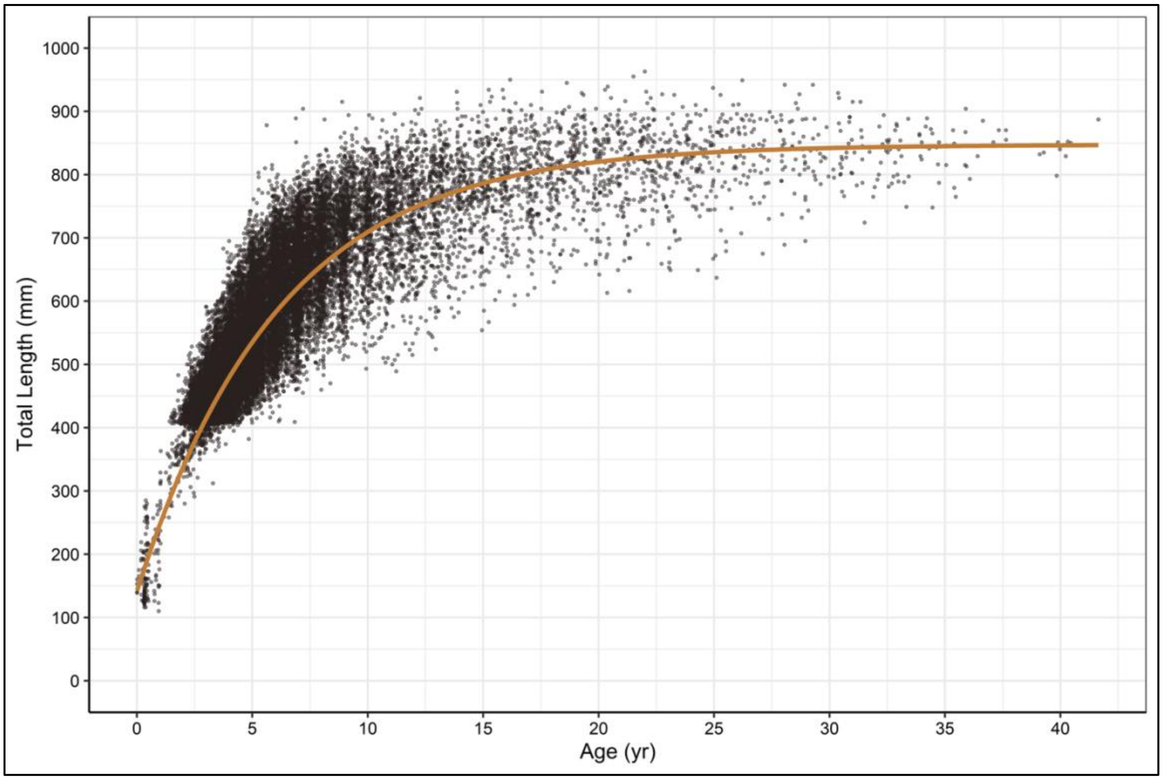

Figure 2.14.15. Size-truncated southeastern U.S. Mutton Snapper length ('maximum' total length mm)-at-age (fractional, yr) collected from fishery-dependent and -independent data sources between 1977 – 2022 (n = 24,234 otoliths). The dark orange line is the predicted length-at-age from the best fit size-truncated von Bertalanffy growth model applied to inverse-weighted data where CV was a linear function of age.

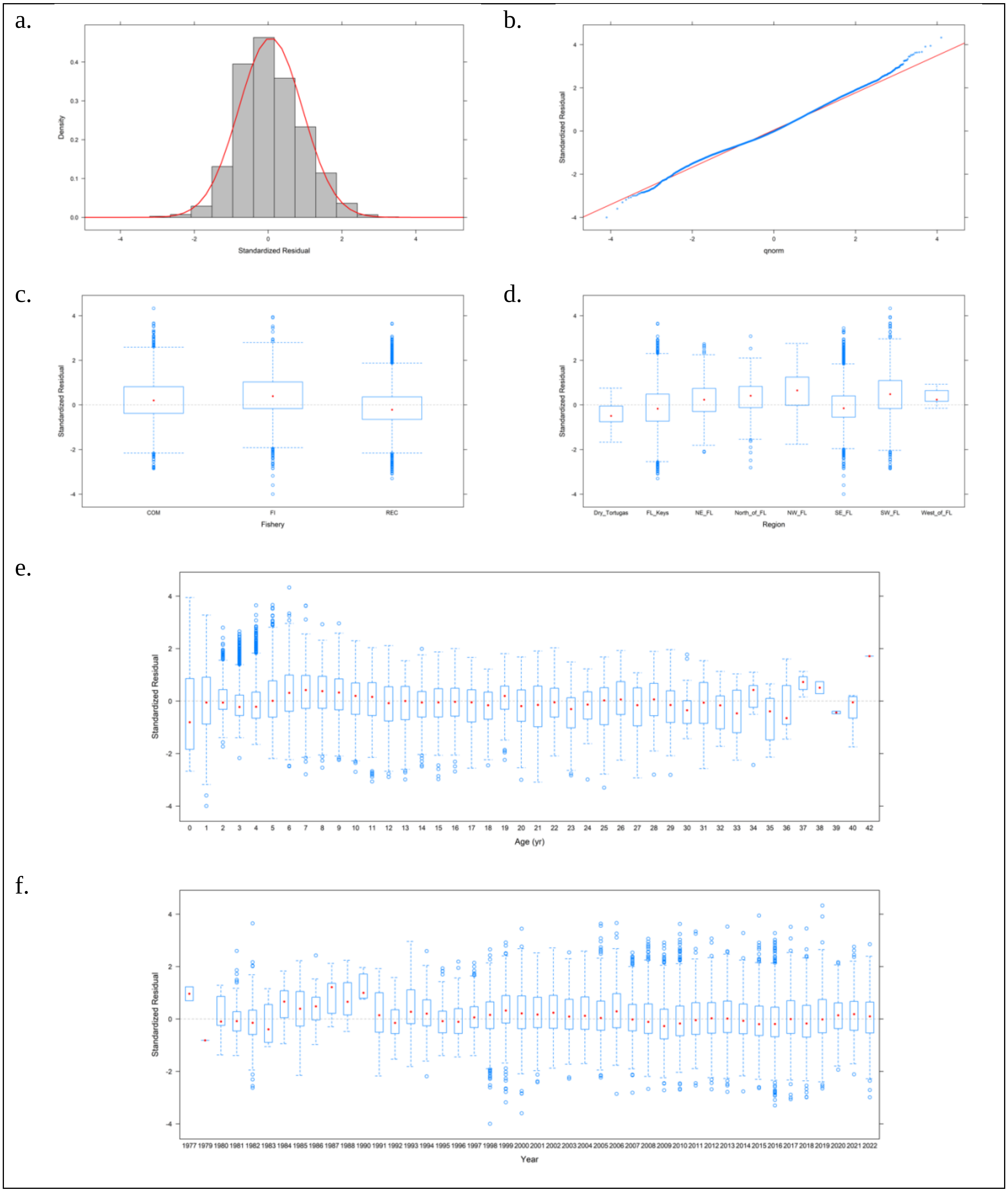

Figure 2.14.16. Standardized residual diagnostic plots for the size-truncated von Bertalanffy growth model applied to inverse-weighted data where CV was a linear function of age: a) density distribution, b) normal probability plot (quantiles vs standardized residuals), c) standardized residuals by fishery, d) standardized residuals by region, e) standardized residuals by age, and f)

standardized residuals by year. Boxplots include the median, upper and lower quartiles, and outliers (open circles).

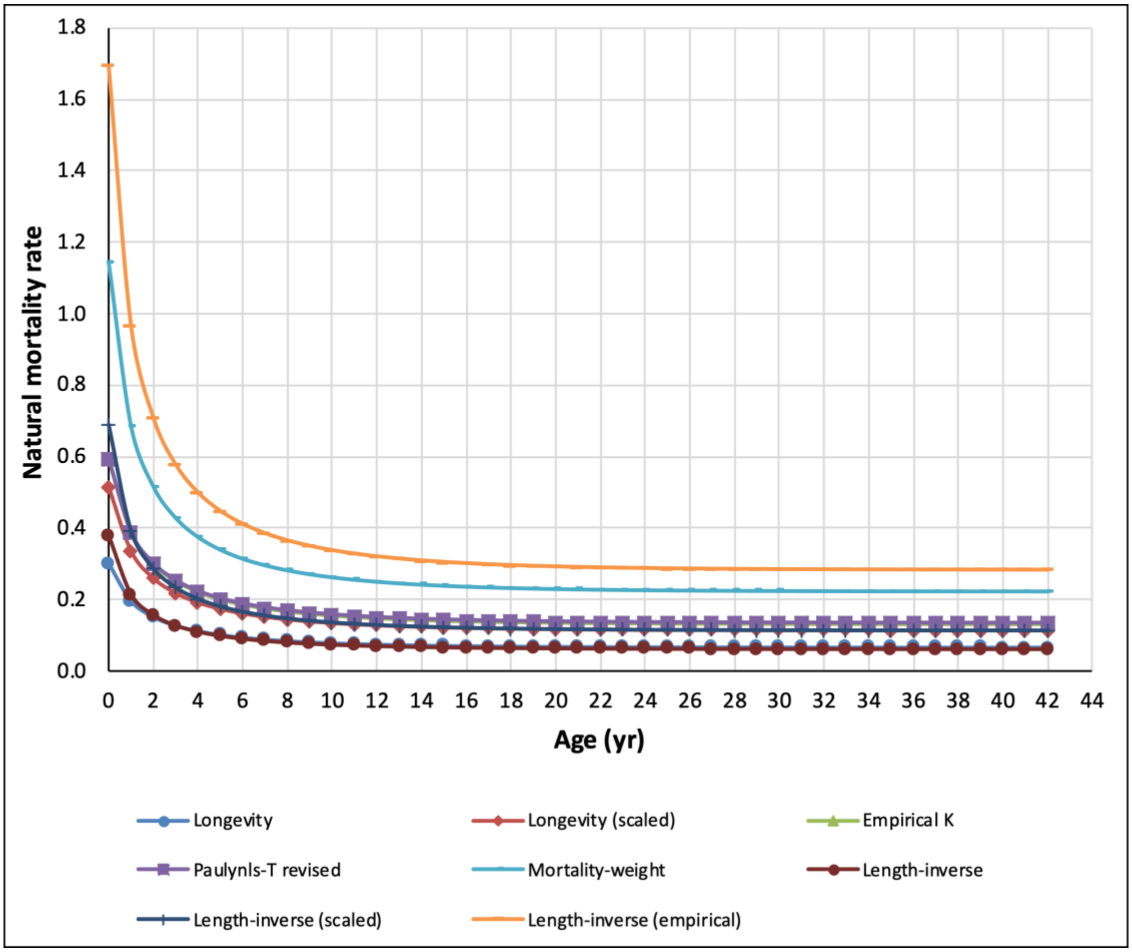

Figure 2.14.17. Natural mortality-at-age, *M(a)*, of Mutton Snapper with an observed maximum age of 42 years. 'Longevity', 'Empirical K', and the 'Pauly$_{\text{nls-T}}$ revised' estimates of *M(a)* are derived following Lorenzen (2000, 2005) using their respective constant *M* estimates (0.129, 0.253, 0.253) as the reference *M* scaled to age 3 and the von Bertalanffy growth model parameters (L_{inf} = 847; *K* = 0.163; *t0* = -1.115). The 'Longevity (scaled)' model scaled the cumulative mortality rate predicted for ages 3 – 42 to the longevity-based constant *M* estimate. The 'Mortality-weight' model followed Lorenzen (1996) and used length-weight parameters *a* = 4.59E-6 and *b* = 3.160. The 'Length-inverse' and 'Length-inverse (scaled)' estimates of *M(a)* follow Lorenzen (2022) using the longevity-based constant *M* estimate as the mortality at reference length scale parameter, the von Bertalanffy growth model parameters, and the exponent c = -1. The 'Length-inverse (scaled)' model scaled the cumulative mortality rate predicted for ages 3 – 42 to the longevity-based constant *M* estimate. The 'Length-inverse (empirical)' model used $M_{L\infty}$ (0.282) , the von Bertalanffy growth coefficient, and the exponent c = -1.

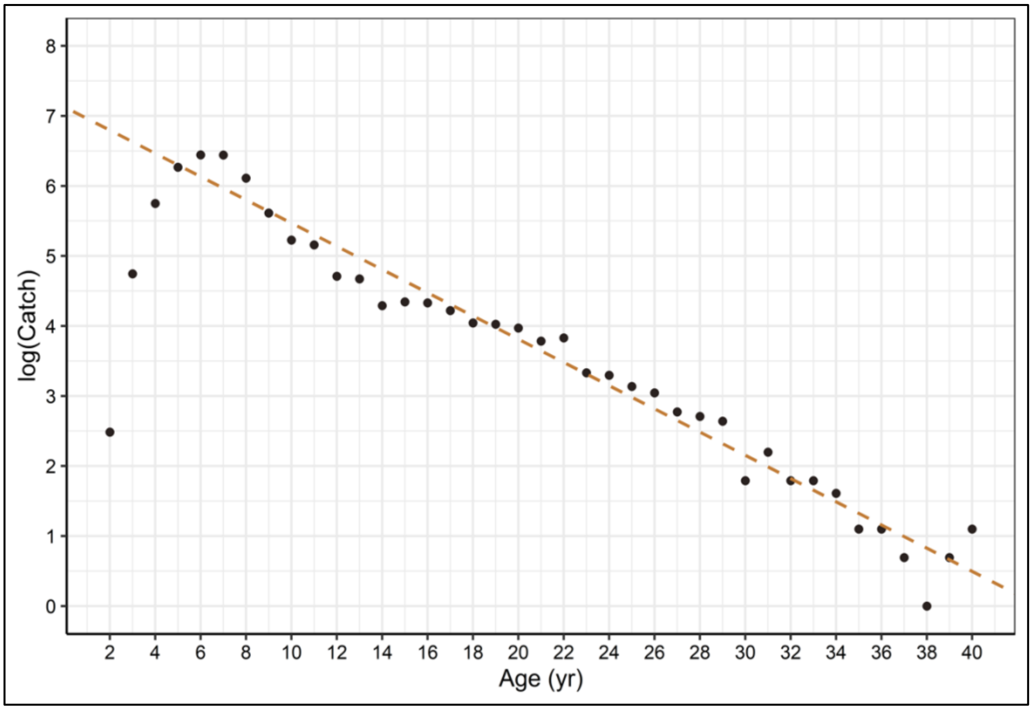

Figure 2.14.18. Commercial long line catch-at-age data (log transformed) of southeastern U.S. Mutton Snapper from 1992 – 2022 for catch curve analysis. The dashed line is the weighted linear regression fit to ages 6 – 40 whom are considered fully selected.

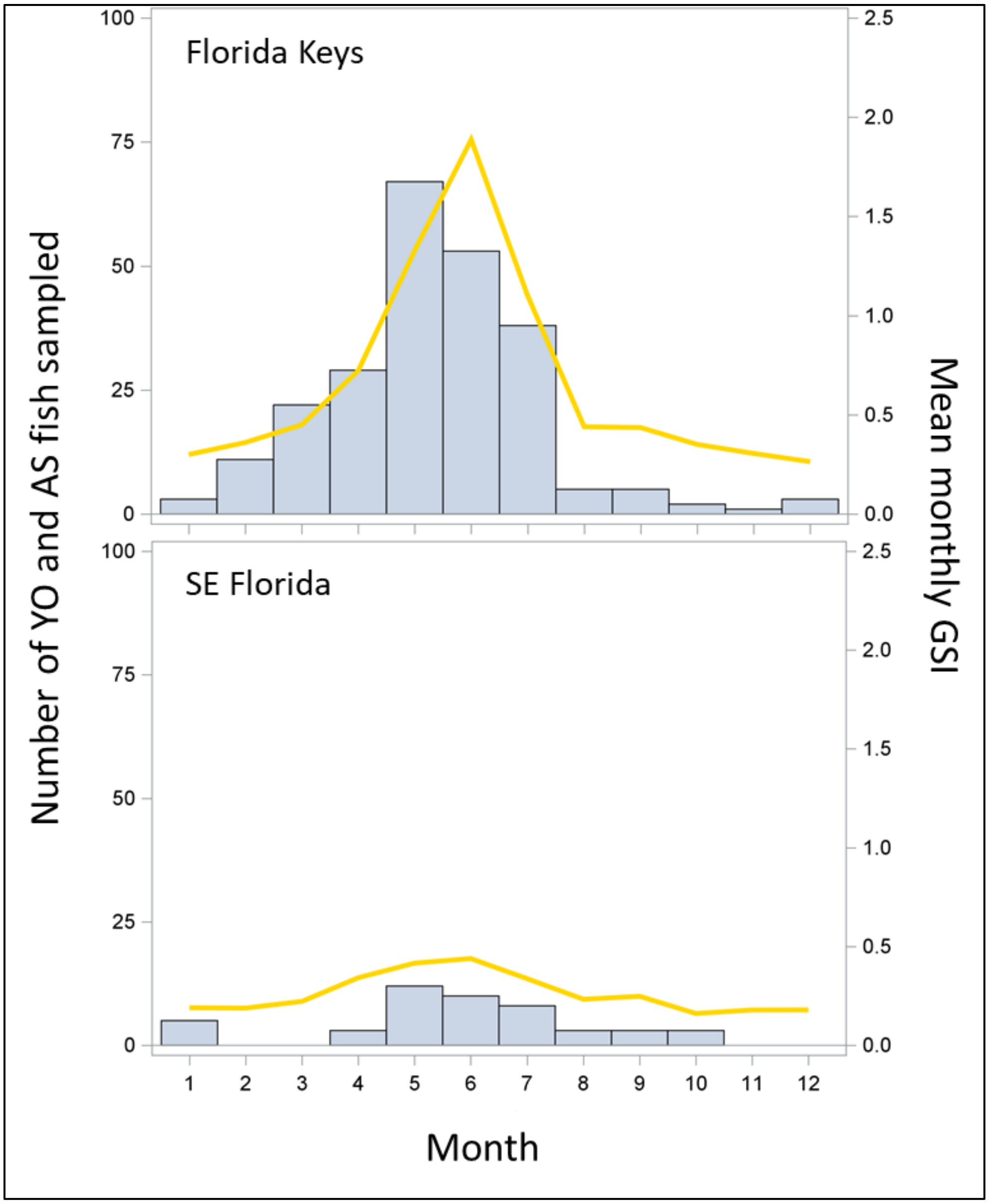

Figure 2.14.19. Female Mutton Snapper macroscopically staged as having yolked oocytes (macroscopic reproductive phase “YO”) occurred in all months in the Florida Keys and most months in southeast (SE) Florida. The number of YO females peaked in May, with GSI of all females peaking in June. GSI and number of YO females was quite low in SE Florida throughout the year.

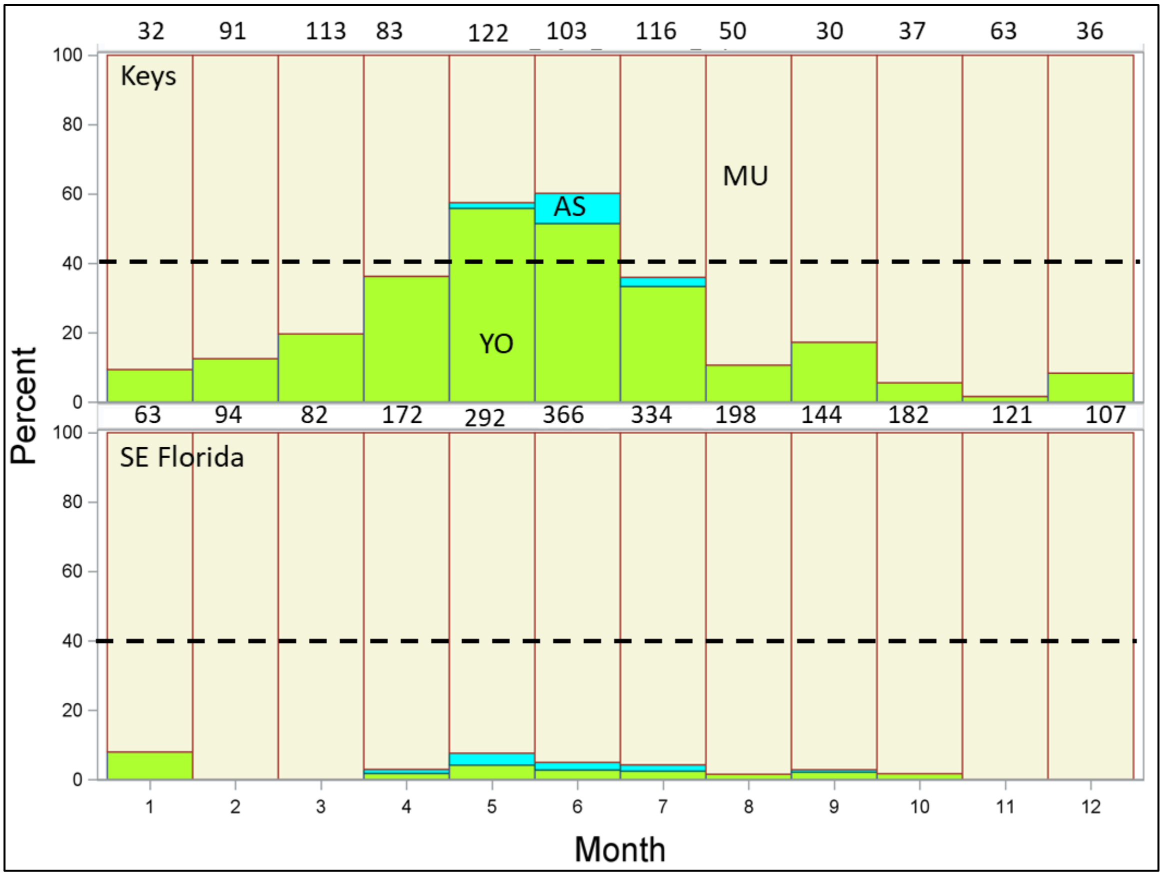

Figure 2.14.20. Monthly proportion of macroscopic phases (YO = yolked, AS = active spawner, MU = mature undeveloped) of Mutton Snapper. Peak spawning occurred in May and June when the proportion of spawning capable females (YO and AS) was > 40% (dashed reference line).

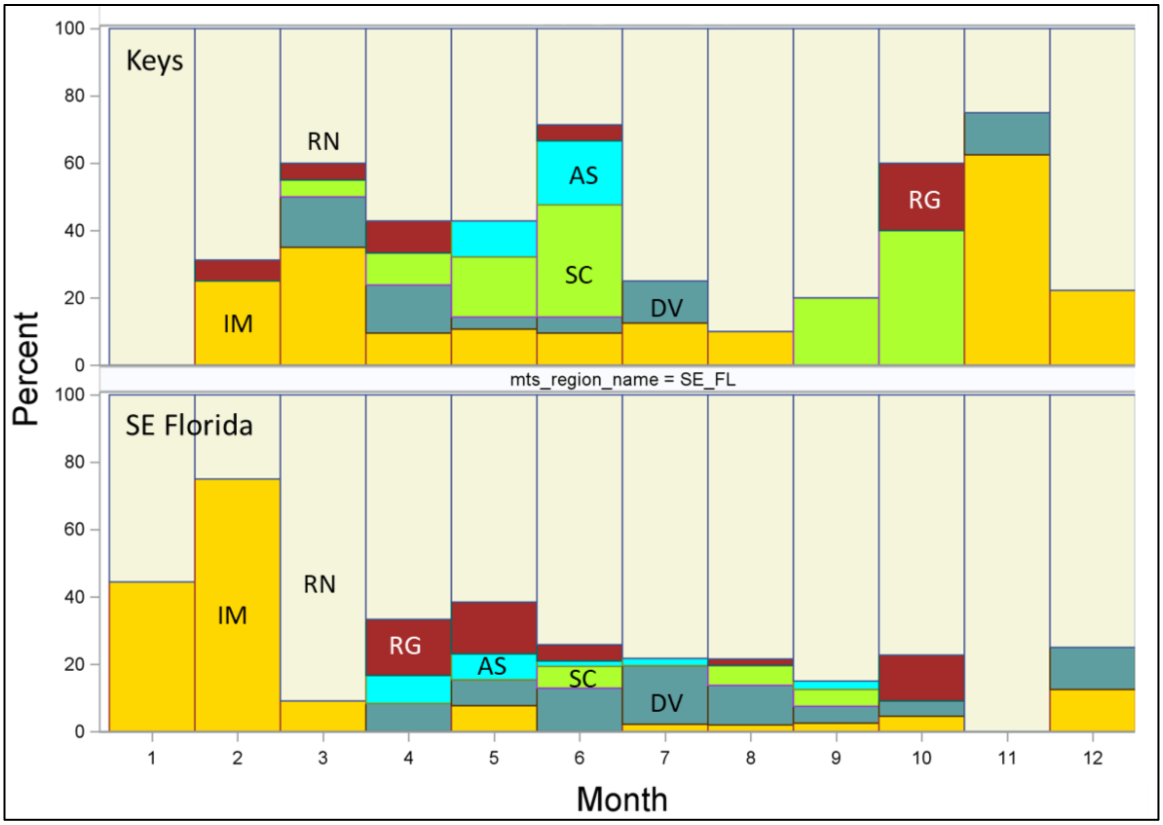

Figure 2.14.21. Frequency plot of monthly histological reproductive phases of Mutton Snapper by study area (Florida Keys (Keys): n = 156; southeast (SE) Florida, n = 294). IM = Immature, DV = Developing, SC = Spawning capable, AS = Active Spawner RG = Regressing, RN=regenerating.

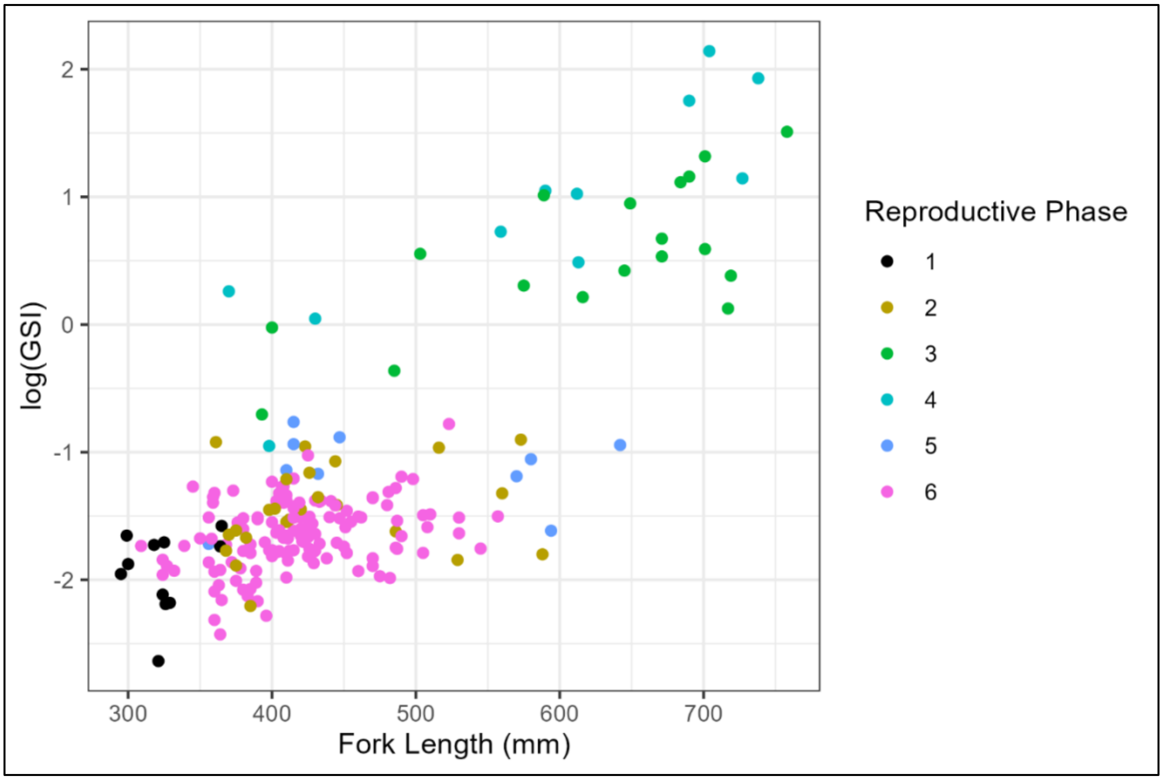

Figure 2.14.22. GSI in log space as a function of fork length for Mutton Snapper samples assessed via histology (n = 213), showing GSI cannot be used to distinguish immature (Reproductive Phase 1) individuals from mature, non-spawning individuals.

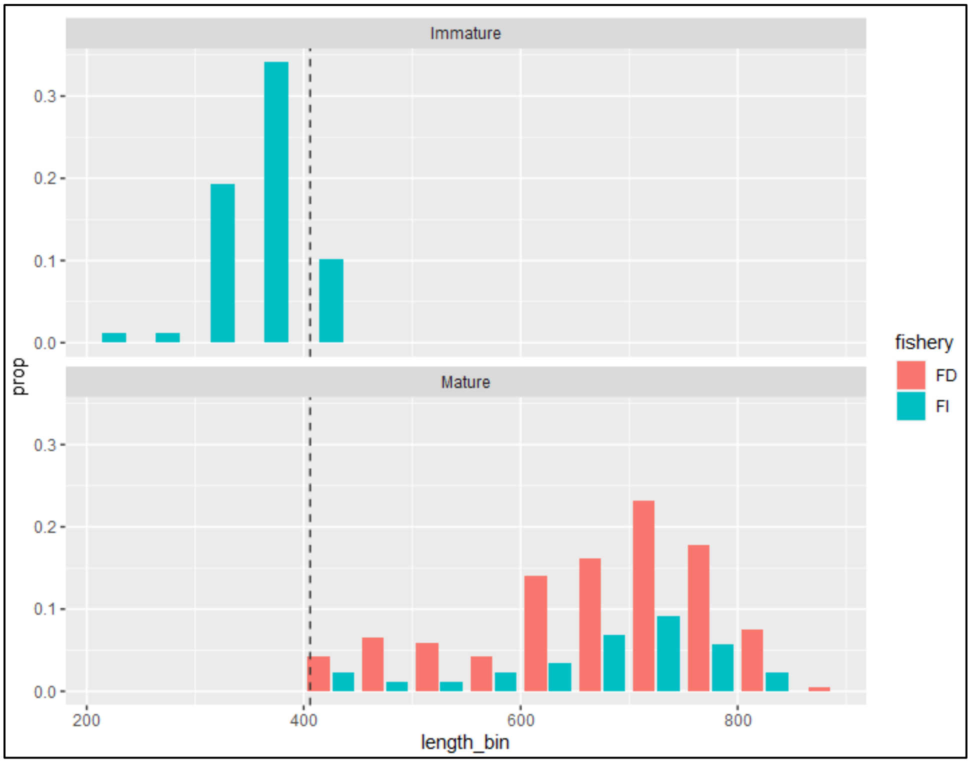

Figure 2.14.23. Length distribution (shown as proportions by fishery; FI = fishery-independent, FD = fishery-dependent) for the 274 female Mutton Snapper used in the recommended maturity-at-length model (All year, Histo and Macro spawning capable and actively spawning) for natural total length. All immature individuals came from FI sampling, and most of the FI samples were immature. The dotted grey line is the minimum size limit of 16 inches total length.

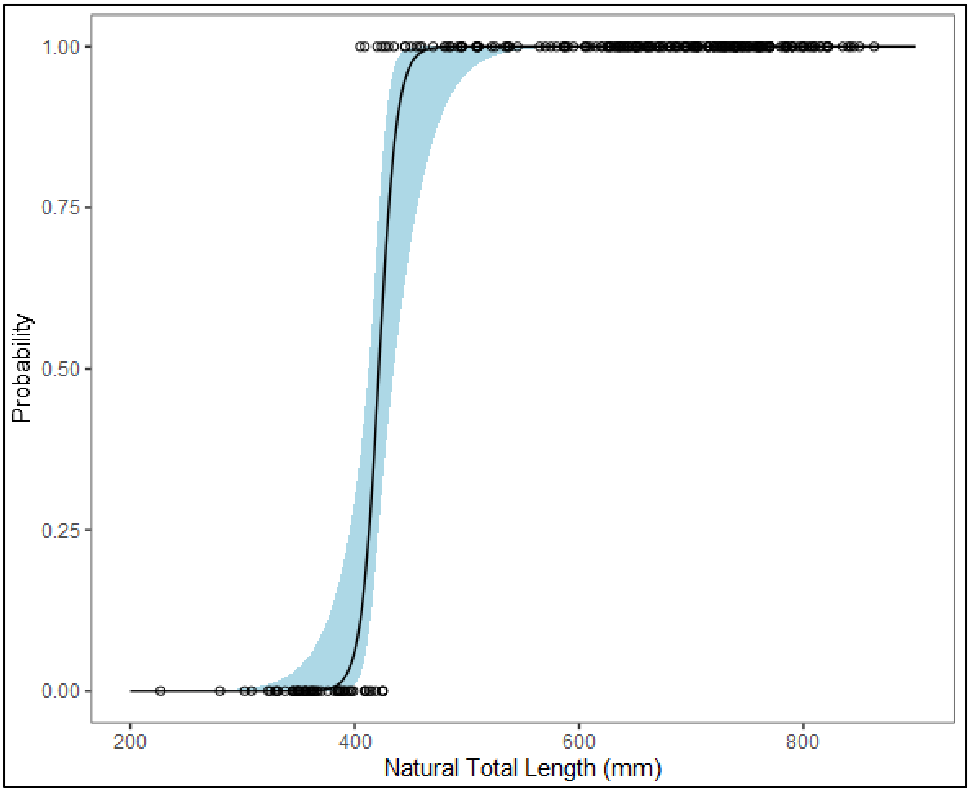

Figure 2.14.24. Observed (n = 274) and predicated fork length-at-maturity for Mutton Snapper with 95% confidence intervals for the model that included all sampling months and spawning capable or actively spawning females assigned through histology and macroscopic staging in the mature group. The estimated size at 50% maturity for this model was 422 mm natural total length.

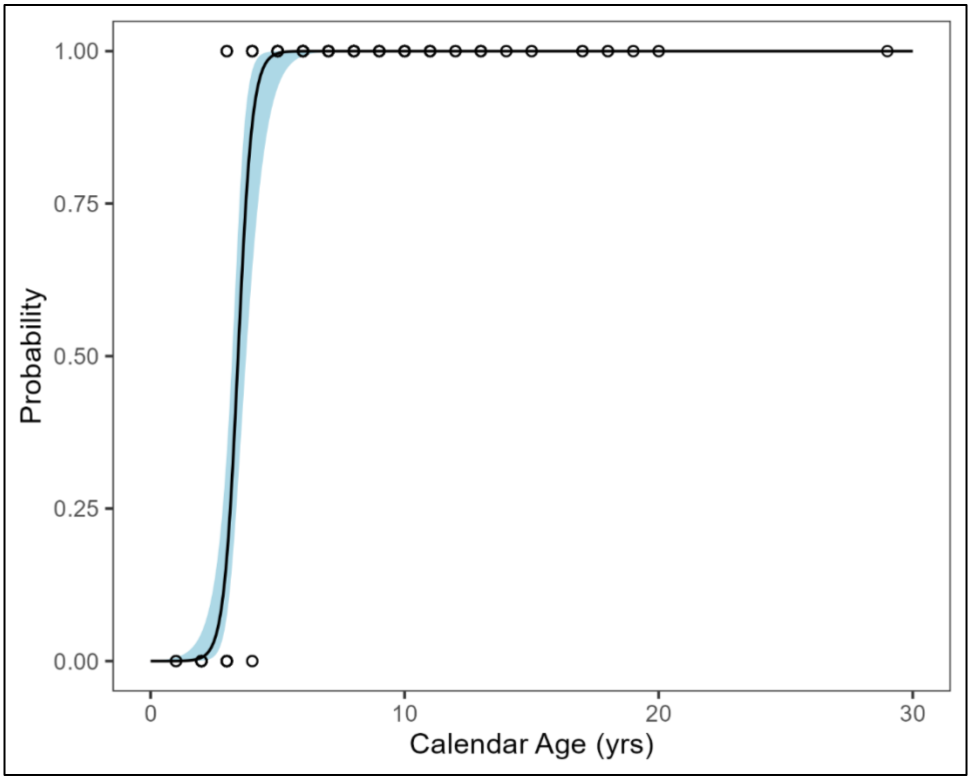

Figure 2.14.25. Observed (n = 240) and predicated age-at-maturity for Mutton Snapper with 95% confidence intervals for the model that included all sampling months and spawning capable or actively spawning females assigned through histology and macroscopic staging in the mature group. The estimated age at 50% maturity for this model was 3.5 years.

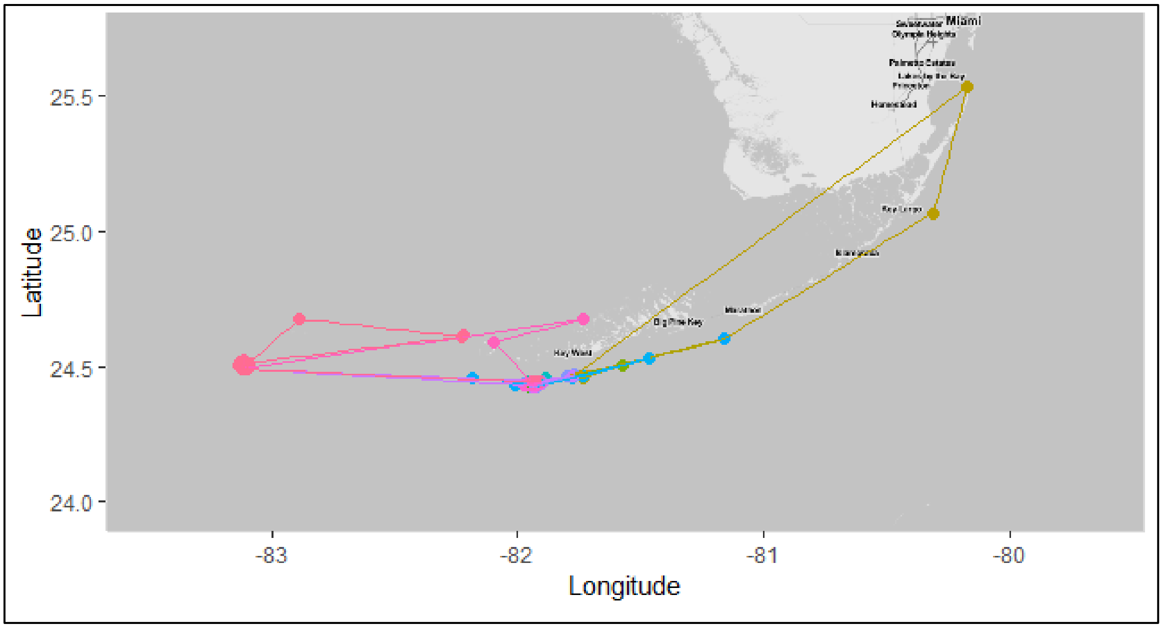

Figure 2.14.26. Total movement paths (April 2021 – May 2023) of Mutton Snapper tagged at Western Dry Rocks off Key West, FL. Colors represent different individuals, circles represent detections at acoustic receivers, and lines represent movement between detections.

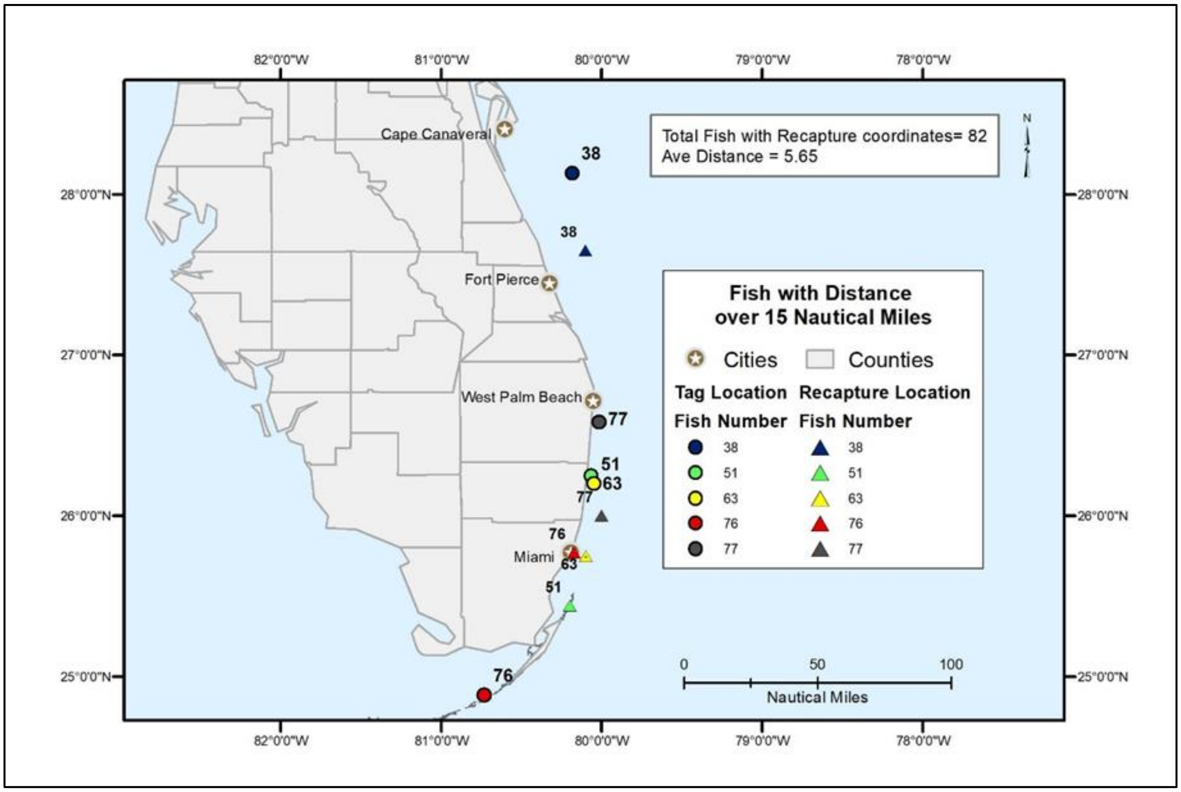

Figure 2.14.27. Mark-recapture locations of southeastern U.S. Mutton Snapper whose tagging and subsequent recapture locations were with more than 15 nautical miles.

3. COMMERCIAL FISHERY STATISTICS

3.1. OVERVIEW

Commercial landings for the SE US Mutton snapper stock were developed by gear (trap, diving, hook and line, longline, and other) and fishing area in whole weight pounds for the period 1981-2022 based on federal and state database. Corresponding landings in numbers were based on mean weights estimated from the Trip Interview Program (TIP) aggregated by region of fishing.

Commercial discards were calculated from vessels fishing in the SE US using data from the SE Discard Logbook and the Coastal Fisheries Logbook Program (CFLP) from 1993-2022.

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

3.1.1. Commercial Workgroup Participants

Chris Bradshaw	Workgroup leader	FL FWC
Michael Rinaldi	Rapporteur/Data	ACCSP
Vivian Matter	Data Provider	SEFSC
Sarina Atkinson	Data provider	SEFSC
Abby Carrigan	Data provider	FL FWC
Kristin Foss	Data provider	FL FWC
David Johnson	Commercial	FL
Charlie Renier	Commercial	FL
Max Lee	Data Provider	MOTE
Alan Lowther*	Data Provider	SEFSC
Larry Beerkircher*	Data provider	SEFSC

*Did not attend workshop

3.1.2. Commercial Terms of Reference

DW ToR #5: Provide commercial catch statistics through 2022, including both landings and discards in both pounds and numbers.

- Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by fishery sector or gear
- Provide length and age distributions for both landings and discards if feasible
- Provide maps of fishery effort and harvest and fishery sector or gear
- Provide estimates of uncertainty around each set of landings and discard estimates

3.1.3. Issues Discussed at the Data Workshop

Issues discussed included start and end years for landings and discards, spatial aggregations by area fished vs county landed, data sources, uncertainty estimates, proportioning landings with unknown gears, and discard mortality. There are no known species identification issues with

Mutton snapper in the commercial sector, both historically and present day. Methodologies used were consistent with recent SEDARs (e.g., SEDAR 64) for discard estimation, and best practices for data compilation and generation of uncertainty estimates.

The group received invaluable feedback from multiple industry members. The information provided by industry experts was used to guide discussion and workgroup decisions and helped cross validate signals and trends in commercial data.

The discard estimation method from SEDAR 32 & 41 was used over the method from SEDAR 15A (McCarthy 2013, 2014). The newer method utilizes data filtering and discard rate calculation with established best practices. The newer method provides a more consistent trend. The 12-inch size limit went into effect in 1990. Due to an absence of complete logbook data from 1990-1992, discards could not be estimated until 1993. In addition, discard estimates from 1993-1994 in the South Atlantic and from 1993-1999 in the Gulf of Mexico) may be an overestimate due to an absence of discard rate data during the time periods when the 12-inch size limit was in effect. Instead, the discard rate from the period when the 16-inch time limit was in effect was used to calculate discards, which may lead to overestimate in discards.

Commercial landings, while available through the 1960s, were provided from 1981-2022. The decisions were based after expert discussion on commercial uncertainty, available recreational data, and the SEDAR 15A decision. The main driver in selecting 1981, even though the uncertainty was the same throughout the 1978 to 1985 block, was matching the recreational data start, a preference of the assessment staff.

South Atlantic landings have increased substantially in recent years, in both volume and proportion of coastal landings. The work group included Mutton snapper caught and landed north of Florida.

3.2. REVIEW OF WORKING PAPERS

SEDAR 79-DW-05: Electronic Monitoring Documentation of Mutton Snapper (*Lutjanus analis*) in the Eastern Gulf of Mexico Bottom Longline Fishery: This report detailed data from 2016-2022 from EM devices on vessels in the bottom longline fishery. The report confirmed trends and practices provided by industry and data representatives. High level conclusions were retention rates are high (>99%), nominal discards are due to damaged catch, majority of individuals are large, and the core of the Mutton snapper fishery occurs south of the 26 latitude line. The report asserts that core areas indicative for the health of the stock include Pulley Ridge and the Dry Tortugas.

SEDAR 79-DW-07: Estimated discards of Southeastern Mutton Snapper (*Lutjanus analis*) from vertical line commercial fishing vessels: This report provided the method and data for SEDAR 79 commercial discards. Longline trips were very limited (n=2), and observer trips were limited for FL Keys. The mean discard rate was calculated by management regime (size limits) measured with total effort stratified by region (NW FL, SW FL, FL Keys, SE FL, and NW FL).

SEDAR 79-DW-08: Preliminary standardized catch rates of mutton snapper from the United States Gulf of Mexico and South Atlantic commercial handline and longline fisheries, 1993-2022: The report uses procedures to find which trips were likely to occur over snapper-grouper habitat. Subsets of the data were then used in a model to judge whether Mutton snapper were likely to be caught on that trip, based on parameters such as crew size, days at sea, region and year. CPUE was based on whether the trip was positive. The report showed some concurrence between fishery-independent and fishery-dependent data. However, independent data might be showing increased abundance as a trend, whereas dependent might show changes in effort vs. actual abundance.

3.3. COMMERCIAL LANDINGS

Commercial landings of Mutton snapper were compiled from 1981 through 2022 for the SE US. Sources for landings included the Florida Fish and Wildlife Conservation Commission trip ticket program (FWC), Southeast Fisheries Science Center (SEFSC), South Carolina Department of Natural Resources (SCDNR), North Carolina Division of Marine Fisheries (NCDMF), and the Atlantic Coastal Cooperative Statistics Program (ACCSP).

Comparisons were made between Florida's commercial trip ticket data (1986-2022) to both the NMFS ALS (1962-2022) and logbook data (1993-2022). The Accumulative Landings System (ALS) data, received shortly before the data workshop, contained monthly aggregated landings of Mutton snapper for the Southeast. The ALS data are of a longer time series than Florida trip ticket, but both datasets appear identical when comparing statewide landings from 1986-2022 (Figure 3.11.1). The NMFS logbook data are of a shorter time series but do have agreement with Florida trip ticket and ALS data for years that they overlap (Figure 3.11.1). Additional comparisons also show that Florida trip ticket and ALS show similar landings by region, particularly for the Florida Keys, Southwest, and Southeast Florida where the majority of Mutton Snapper are landed (Figure 3.11.2). However, there is slight variation in landings by region across data sources because of differences in fisher report versus dealer reported data. The workgroup decided to combine landings from Florida trip ticket (1986-2022), NMFS ALS (1981-1986) for all states, and NMFS ALS (1981-2022) for non-Florida states to establish final commercial landings by region and gear.

3.3.1. Commercial Gears Considered

The workgroup investigated reported gears landing Mutton snapper from various data sources (FWC, CFLP, ACCSP, NCDMF, SCDNR, GADNR) and determined that the predominant gears were hook and line and long lines (~90%). However, other gears were consistently reported. It was the work group's recommendation to then categorize landings into the following groups: hook and line, long line, trap, diving, other gears.

Commercial landings data collected by NMFS before the FL trip ticket program's inception often contain unknown gear information. ALS data had the unknown gears corrected with data from the Annual General Canvass Statistics survey. This process is known and often used to assign gears to ALS data without gear information. For unknown gears in Florida trip ticket data the group decided to use 1986-2000 trip ticket data with known gear, to create proportions by year, region, and gear and apply the proportions to unknown gear landings A total of 4.41% of all landings were proportioned with annual values of proportioned landings percentage between 0.65% and 24.71% occurring. The largest annual landings proportioning percentage being the first 3 years of Florida Trip Tickets. The same methods were used, but sourced from ALS data, for landings West of Florida (7.3% of total landings, 840 pounds).

The group reviewed South Atlantic landings (North of Florida) with unknown gears. Because of the low frequency of unknowns (0.37%), and low poundage (692 pounds) associated with those records, the group decided to combine unknown landing gears into the hook and line fleet.

A list of gears included in each category can be found in Table 3.10.1.

Decision 1: The work group recommended five gear groupings to characterize the Mutton snapper fishery: hook and line, long line, trap, diving, and other.

The decision was approved by the plenary

3.3.2. Commercial Regions

Since most Mutton Snapper landings occur in Florida, the stock assessment group asked that the landings be separated by region using the Marine Recreational Information Program (MRIP) for-hire regions in Florida (Figure 3.11.3). Landings were separated into seven different for-hire survey (FHS) regions based first on area fished, and then county landed, if area fished was not present. Any landings reported west of Florida in the Gulf of Mexico were categorized as West of Florida (region 0), and any landings reported north of Florida on the Atlantic coast were placed in the North of Florida category (region 6). The five FHS regions within Florida were defined as: Northwest=1, Southwest=2, Florida Keys=3, Southeast=4, and Northeast=5. The Florida Keys region was later subdivided into the Tortugas and Florida Keys (excluding the Tortugas) at the request of assessment staff.

The Workgroup recommended that, when available, fishing area rather than county landed be the primary method for region assignment. By using county landed as a primary method, signals would be lost for the FL Keys and Dry Tortugas, as the FL Keys and Dry Tortugas are not identifiable in Monroe County landings.

3.3.3. Misidentification of Mutton Snapper

The workgroup discussed the potential for misidentification of Mutton Snapper in the commercial sector. The opinion of the industry representatives and the workgroup that misidentifications were unlikely based on the distinctive shape and coloration of Mutton Snapper. The recreational group was worried about the misidentification of Mutton Snapper as Lane snapper, but this is not a concern in the commercial sector because of the size of Mutton Snapper encountered by industry.

Decision 4: The Workgroup does not feel there is a likelihood of misidentification of Mutton Snapper in the commercial sector and no modifications are needed to commercial landings.

This decision was approved by the plenary.

3.3.4. Commercial Landings by Gear and State

Table 3.10.2 shows annual Mutton Snapper landings in whole weight pounds by region and gear. Though landings will be provided by the defined region and gear for the assessment, Table 3.10.2 shows landings by more general regions and for only FL gears to address confidentiality issues. Most landings of Mutton Snapper were reported in gutted weight and converted to whole weight using a conversion of 1.11 where:

$$\text{Whole weight} = 1.11 * \text{gutted weight}$$

<u>Confidentiality Issues</u>

Landings of Mutton Snapper were aggregated among states (except for Florida) to meet the rule of 3 and ensure confidential landings were not presented in this report. Any cell of data still deemed confidential was masked by an '*'. These landings account for less than 0.1% of the annual totals. Landings by year, month, region, and gear will be provided to assessment staff for use in the assessment.

<u>Uncertainty</u>

After consultation with assessment biologists, the commercial workgroup estimated uncertainty in commercial fishery landings by using a similar methodology and modifying the uncertainty estimates used in SEDAR 64 (Yellowtail Snapper) and SEDAR 82 (South Atlantic Grey Triggerfish). These estimates of uncertainty are not coefficients of variation but are estimates of possible reporting error such that they represent the range in actual commercial landings relative to the reported landings.

Because of its unique appearance and that misidentification would be unlikely, a single assumption was used in establishing uncertainty estimates for commercial landings of Mutton Snapper:

Landings may be underreported during all years; but underreporting was likely highest during early years of the time series and landings were more accurate in recent years. 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 the Florida trip ticket program, were assumed to be the most reliable and inclusive of all commercial landings. Based on this information Table 3.10.3 shows estimated uncertainties by multi-year blocks for Mutton Snapper. Uncertainty estimates were adjusted from 1986 to 2000 for Florida landings from 0.5 to 0.1 to account for the large volume of landings (~25%) with missing gear information.

3.3.5. Converting Landings in Weight to Landings in Numbers

Commercial landings in whole weight pounds were converted to landings in numbers based on mean weights from the TIP data pooled across all years and FHS region (Table 3.10.4). TIP weights were taken in kilograms and then converted into whole weights in pounds. Few samples were available for FHS regions and gear, so the data were aggregated solely to the FHS region. Mean weights were higher at the edges of the species distribution similar to Yellowtail Snapper in SEDAR 64. Noticeable was the low mean weights in Southeast Florida, an area described by industry and recreational representatives as having fish harvested as soon as they reach minimum size. Table 3.10.5 shows annual Mutton Snapper landings in whole fish (i.e., numbers) by region and gear.

3.4. COMMERCIAL DISCARDS

3.4.1. Directed Fishery Discards

Methods used to calculate commercial discards are described in document SEDAR 79-DW-07. Mutton Snapper discards were calculated using self-reported discard logbook data from the vertical line (handline and electric/hydraulic “bandit” gear) commercial fishery. Discards were calculated for fish reported as discarded alive or discarded dead. Reported discards from any other gear were minimal and lacked sufficient data to calculate a discard rate.

Due to limited available discard data, the methods of SEDAR32 were followed with discard rates calculated as the mean nominal discard rate among all trips that reported to the discard logbook program over the period 2002-2022 by minimum size limit. Minimum size limits changed over time with slight differences between the Gulf of Mexico and South Atlantic regions. Discard logbook data were available for only the 16” and 18” total length size limit. Those discard rates were then multiplied by the yearly fishing effort (total hook-hours fished) reported to the coastal logbook program by region (Gulf of Mexico FL Keys, Southwest FL, South Atlantic FL Keys, Southeast FL, and Northeast FL). Effort data were available for the period 1993-2022. While the coastal logbook program was implemented in 1990, the first few years did not cover the entire Southeast and 20% of the permit holders in Florida were only required to report. It was not until 1993 that logbooks were expanded to all permit holders in both the Gulf of Mexico and South

Atlantic. Therefore, from 1990 to 1992, discards could not be estimated. When a 12" total length size limit was in effect, the discard rate for the 16" size limit was used indicating a possible overestimation of discards for this management regime.

Calculated discards (in number) by year and region are provided in Tables 3.10.6. Discards ranged from 7,500 fish in 1995 to 3,000 fish in 2008. This accounted from anywhere between 5 – 20% of the total catch of Mutton Snapper. A single mean weight of 1.42 pounds using limited commercial observer data were used to convert discards in number to discards in weight.

The discard calculations rely on self-reported discard and effort data. Perhaps the most important source of error in the commercial discard calculations was misreporting and non- reporting of discards, both of Mutton Snapper and other species. An effort was made to minimize that potential error by removing data from vertical line vessels that never reported discards of any species during a year. In addition, data from vertical line vessels that reported more than 6 trips in the Gulf of Mexico and 28 trips in the South Atlantic without reporting discards of any species (the mean number of reported trips prior to the first trip with reported discard plus two standard deviations of that mean) were excluded. Although such clear instances of discard non-reporting were identified and excluded, other cases of non-reporting and misreporting have not been quantified. The degree to which continued non or misreporting may have affected the discard calculations is unknown. The conclusion of the commercial working group was that given the very limited observer data, fisher reported discard data represent the best available information on commercial Mutton Snapper discards.

Decision 10: The Workgroup accepts the discard estimates of Mutton Snapper for 1993-2022 as developed in working paper SEDAR 79-DW-07.

This decision was approved by the plenary.

3.4.2. Eastern Gulf Bottom Longline Discards Recorded Through Electronic Monitoring

The Center for Fisheries Electronic Monitoring at Mote (CFEMM) has collaborated with 15 bottom longline vessels located on Florida's west coast since 2016. These vessels voluntarily carry EM systems to record catch and discards (methods are detailed in SEDAR 79-DW-05). Data collected through the review of 2,136 hauls from 392 trips yielded 819 mutton snapper catch events. Mutton snapper were observed across the West Florida Shelf from The Edges to the Dry Tortugas, with the core area of harvest south of 26 degrees latitude. Overall, discarding of mutton snapper was rare, with 0.98% recorded as discarded (n=8). Depredation was the primary driver of discards rather than sublegal individuals.

3.5. COMMERCIAL EFFORT

The distribution of commercial effort in trips by gear and year was compiled from the Florida Trip Ticket database for 1986-2022. The years were combined into 1986-1994, 1995-2003, 2004-2012, and 2013-2022 to protect confidential data. Only the H&L and Longline gear/year combinations possess enough data to not be confidential, therefore all other maps are not presented in this document. Effort aggregates are supplied for information purposes. These data are presented in Figure 3.11.4 (A. H&L and B. Longline). The distribution of harvest by statistical grid, as reported, is displayed in Figure 3.11.5 (A. H&L and B. Longline).

3.6. BIOLOGICAL SAMPLING

Commercial length data were available from the SEFSC Trip Interview Program for 1983-2022. TIP data were supplied by SEFSC staff. TIP data were pulled from the SEFSC TIPONLINE.TIP_MV table, which is a master view table that collapses the one-to many relational tables in the main TIP database tables. The TIP_MV table is audited weekly to ensure that the contents agree with the master data tables.

Data were assigned as FL regional samples via a hierarchal procedure. If area fished was in the interview's effort information (e.g. usually derived from captain) this was used. If this information was not available, but area fished was provided in the interview's landings information (e.g. derived from the dealer's records), then the landings information was used. If area fished was in neither the effort nor the landings information, then the state and county of landing were used to make a region assignment. Where a single trip used multiple gears, the primary gear was assigned to each record with an assumption that the first gear recorded entered by a sampler was the primary gear type used during the trip.

The group reviewed TIP catch length compositions, aggregated across all years and by region (NE FL, NW FL, SE FL, SW FL, Keys, Tortugas, W of FL, N of FL). Low sample sizes in certain year and regions required aggregations across all available years.

Data were flagged for later exclusion where the following were indicated: disabled trips, non-commercial trips, trips for which a bias was indicated, and observations for which the sample was indicated as non-random. The latter filtering should be interpreted as applying to fish selection within a sample, rather than trip selection itself. A lower length filter of 200 mm was applied and an upper filter for length values was set at 1000 mm; this resulted in the exclusion of 5 observations.

3.6.1. Length/Age distributions

<u>Landings</u>

All Mutton snapper lengths were converted to mm, but kept within measured length types (fork length, total length). Length and landings data were divided into FHS region based on the area fished. Length compositions by length type, FHS region, and year, will be provided for the SEDAR 79 Assessment Workshop.

Trends seen in length frequencies were validated by other work groups and industry representatives. SE FL exhibits younger, smaller fish. The group noted that separating FL into 8 regions might provide the best fit for the model but would be sub-optimal in a management context.

All mutton snapper lengths were grouped by their length type measured in the field. Lengths in the data delivery were not converted using formulas from the SEDAR 79 Life History Group as assessment staff had indicated that they would prefer to do all conversions themselves. All mutton snapper lengths were binned into one-centimeter groups. The length data and landings data were divided into the same gear groupings. Annual length compositions of mutton snapper have been provided for the SEDAR 79 Assessment Workshop. Length was also not converted to weight (whole weight in pounds) using conversions provided by the SEDAR 79 Life History Group as the Assessment staff also wished to perform these conversions themselves.

<u>Discards</u>

Observer reported length data of discarded Mutton Snapper from the vertical line and bottom longline fishery were provided. In the South Atlantic, available observer data was collected by the Gulf & South Atlantic Fisheries Foundation (GSAFF 2008) and the SEFSC South Atlantic Reef Fish Observer Program (Decossass & Mathers 2023). In the Gulf of Mexico, discarded length data of Mutton Snapper were provided by the Reef Fish Observer Program (Scott-Denton 2014, Atkinson et al. 2021). There was very limited discard length data from the bottom longline fishery and does not warrant enough information to provide a composition. Raw data were provided to allow the Assessment staff to perform the compositions themselves since the decisions of aggregating years and regions would need to be decided.

3.6.2. Adequacy for characterizing catch

Length sampling is inadequate for region/gear combinations in some years and aggregation will be needed. Sample sizes need to be paid particular attention to when using the length compositions. The number of samples for some of the less frequent gears may indicate that length compositions for these gear categories should be supplemented with H&L and Longline length compositions to obtain a reasonable sample size.

3.7. COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES

The workgroup asserts that the landings data are adequate for the assessment analyses. There is a clear landings history for the available time series. Commercial landings were relatively unsubstantial prior to the 1980's, and consistent with previous SEDARs, the group asserts that the time series ought to start at 1981. There were no documented issues with species identification, nor any irregular or noticeably inaccurate reporting to state and federal agencies. Additional commercial data sources such as the Coastal Fisheries Logbook Program (CFLP) and Discard Logbook Program were included.

Commercial landings data were available north of Florida and were included in data sets provided to assessment staff. These data were sourced from state trip ticket programs of North Carolina DMF, South Carolina DNR, and Georgia DNR. Historically, landings from these areas make up <1% of landings for each year. However, the amount and percentage of Mutton snapper caught and landed in NC-GA have increased in the past 10 years. Trends in the data were cross-validated by fishing industry representatives and staff at NCDMF.

Discard data were deemed to be adequate, although they are subject to the typical concerns of self-reported discard data. Newer methods of discard calculation have created greater confidence in these estimates. Biological sampling data were also deemed to be adequate. However, as mentioned, low sample sizes in certain year and regions required aggregations across all available years.

3.8. RESEARCH RECOMMENDATIONS

Biological Sampling

- Increased observer and EM coverage in the Gulf and South Atlantic fisheries
- Recommend the observer program investigate the allocation of some observer coverage for focused trips to aid in future SEDARs as a subset of existing strata
    - For Mutton Snapper, this may include allocating addition effort to increase the probability of Mutton encounters in areas of higher population density (SE FL, FL Keys)
- Allocating funding to support research on predator depredation and effect on landings and discards

3.9. LITERATURE CITED

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SEDAR15A-SAR3. 2008. Stock assessment report, SEDAR 15A South Atlantic and Gulf of Mexico Mutton Snapper, 410 pp.

3.10. TABLES

Table 3.10.1 Specific gears in each gear category for Mutton Snapper commercial landings.

Aggregated Gear	Gear Code	Gear
DIVE	660	SPEARS
DIVE	661	SPEARS, DIVING
DIVE	750	BY HAND, DIVING GEAR
DIVE	760	BY HAND, NO DIVING GEAR
H&L	300	HOOK AND LINE
H&L	301	HOOK AND LINE, MANUAL
H&L	302	HOOK AND LINE, ELECTRIC
H&L	303	ELECTRIC/HYDRAULIC, BANDIT REELS
H&L	320	TROLL LINES
H&L	321	TROLL LINE, MANUAL
H&L	322	TROLL LINE, ELECTRIC
H&L	408	BUOY GEAR
H&L	700	HAND LINE
LONGLINE	400	LONG LINES
LONGLINE	403	LONG LINES, BOTTOM
LONGLINE	404	LONG LINES, SURFACE, MIDWATER
OTHER	10	HAUL SEINES
OTHER	40	LAMPARA/RING NETS
OTHER	92	OTTER TRAWL BOTTOM, FISH
OTHER	95	OTTER TRAWL BOTTOM, SHRIMP
OTHER	110	OTHER TRAWLS
OTHER	118	BUTTERFLY NETS
OTHER	200	GILL NETS
OTHER	204	GILL NETS, SINK ANCHOR
OTHER	210	TRAMMEL NETS
OTHER	551	CAST NETS
OTHER	552	BULLY NETS
OTHER	671	SPONGE HOOKS
OTHER	800	OTHER GEARS
TRAP	130	POTS AND TRAPS
TRAP	132	POTS AND TRAPS, BLUE CRAB
TRAP	139	POTS AND TRAPS, FISH
TRAP	140	POTS AND TRAPS, SPINY LOBSTER
TRAP	145	POTS AND TRAPS, STONE CRAB

Table 3.10.2 Florida Mutton Snapper landings, in whole weight pounds by aggregate region and aggregate gear groups. Due to confidentiality, landings West of FL and North of FL are excluded

Year	FL Gulf of Mexico			Keys			FL South Atlantic		
	H&L	LONGLINE	OTHER	H&L	LONGLINE	OTHER	H&L	LONGLINE	OTHER
1986	18,512	37,754	9,182	80,835	52,609	43,290	114,721	29,398	22,220
1987	23,806	57,925	7,717	140,681	106,492	26,194	116,818	20,808	49,196
1988	24,814	56,797	8,637	109,101	45,544	30,166	89,455	12,109	75,072
1989	24,105	44,513	6,375	145,805	102,949	27,117	69,857	22,057	105,192
1990	25,066	41,676	10,419	148,302	64,789	13,259	62,459	24,877	63,614
1991	28,545	46,134	2,658	147,098	82,088	34,563	64,070	17,421	58,373
1992	29,487	30,349	1,409	179,747	40,436	41,474	65,816	3,035	6,246
1993	21,756	47,037	1,793	147,384	25,665	78,648	103,221	2,390	13,354
1994	19,311	30,648	1,381	160,053	13,535	48,207	65,029	5,632	10,578
1995	12,765	28,679	1,260	118,393	13,630	29,624	58,267	3,366	14,975
1996	13,490	40,821	514	115,631	9,292	39,085	64,985	623	4,224
1997	9,582	46,824	480	131,002	9,845	24,235	61,330	1,918	3,590
1998	12,242	58,984	164	124,411	14,815	63,310	65,804	5,602	5,741
1999	10,186	53,050	570	63,803	19,260	40,603	53,368	1,407	5,018
2000	8,266	52,916	1,605	60,253	18,710	24,025	30,009	2,032	2,469
2001	9,077	76,931	723	68,355	14,409	12,347	40,323	900	5,947
2002	7,891	64,210	778	74,006	14,551	19,825	41,664	492	5,453
2003	5,317	90,625	381	87,406	20,086	16,170	34,928	493	5,069
2004	9,770	122,040	652	94,035	74,523	10,467	26,190	422	2,641
2005	7,653	61,375	626	60,802	59,120	7,679	26,782	*	2,936
2006	11,887	107,897	247	49,926	85,593	5,427	15,788	549	1,977
2007	3,809	78,192	197	57,845	50,967	7,780	12,977	*	1,868
2008	2,395	46,845	251	59,512	27,083	4,411	12,352		663
2009	3,370	22,040	363	56,152	10,370	4,449	18,158	*	2,398
2010	4,736	35,746	447	52,599	168	5,397	24,784	*	1,121
2011	18,131	54,578	336	41,683	*	18,510	19,708	*	1,869
2012	15,612	53,180	*	49,911	*	14,936	25,455	*	3,265
2013	10,793	85,007	940	36,615	475	10,482	27,908		2,965
2014	10,221	124,381	4,710	42,885		11,742	28,361		2,619
2015	18,840	111,610	1,901	35,052		11,567	40,371		2,627
2016	11,862	56,989	1,915	40,391	687	9,145	25,448		2,345
2017	13,420	92,164	915	44,439	3,441	13,395	18,483		2,603
2018	9,151	109,161	10,195	50,075	4,471	11,825	20,799		1,788
2019	5,370	44,581	2,175	33,132	1,289	14,181	25,329	*	2,092
2020	7,339	45,818	1,712	36,306	4,013	8,032	21,834		2,920
2021	4,483	46,032	2,353	29,809	2,302	6,611	17,333	*	2,739
2022	5,530	44,380	2,719	26,357	11,609	8,438	20,378		2,343

Table 3.10.3 Estimated CVs for landings by year and state.

Year Range	TX-AL	FL	GA-NC
1950-1961	0.25	0.25	0.25
1962-1977	0.2	0.2	0.2
1978-1985	0.2	0.1	0.1
1986-2000	0.1	0.1	0.1
2001-2003	0.1	0.05	0.1
2004-2022	0.05	0.05	0.05

Table 3.10.4 Mean and Median weights of fish from TIP (kilograms and pounds).

Kilogram	W_OF_FL	NW_FL	SW_FL	TORTUGAS	KEYS	SE_FL	NE_FL	N_OF_FL
Mean Weight	6.097	5.531	4.953	4.334	3.010	2.159	4.251	5.335
Median Weight	6.149	5.480	4.675	4.172	2.695	1.756	4.165	5.351

Pounds	W_OF_FL	NW_FL	SW_FL	TORTUGAS	KEYS	SE_FL	NE_FL	N_OF_FL
Mean Weight	13.441	12.193	10.919	9.555	6.635	4.759	9.371	11.761
Median Weight	13.557	12.081	10.307	9.198	5.941	3.871	9.183	11.796

Table 3.10.5 Florida Mutton Snapper landings, in whole fish (i.e., numbers) by aggregate region and aggregate gear groups. Due to confidentiality, some landings are replaced with a *.

Year	FL Gulf of Mexico			Keys			FL South Atlantic		
	H&L	LONGLINE	OTHER	H&L	LONGLINE	OTHER	H&L	LONGLINE	OTHER
1981	3,328	559	103	12,463	8,515	4,408	19,101		3,286
1982	3,271	481	143	19,019	13,553	4,924	10,302		1,227
1983	3,542	2,423	10	18,516	9,509	4,171	7,480		2,029
1984	1,615	1,761	67	18,428	4,823	2,265	10,480		1,374
1985	1,490	2,276	130	16,900	4,665	2,010	13,045		716
1986	1,685	3,455	839	13,333	7,920	6,681	14,543	5,207	3,624
1987	2,243	4,769	704	21,474	16,751	3,911	17,513	3,268	8,555
1988	2,277	5,003	785	16,443	7,387	4,512	13,614	1,750	13,275
1989	2,204	4,071	536	22,456	16,454	4,136	11,600	2,780	21,501
1990	2,267	3,381	949	22,075	11,074	2,000	11,786	2,829	13,138
1991	2,543	4,202	242	22,170	12,577	5,457	12,867	2,900	10,940
1992	2,715	2,776	128	27,091	6,094	5,787	12,284	582	1,053
1993	2,054	4,304	162	22,213	3,865	10,827	21,271	482	1,740
1994	1,606	2,801	123	24,948	2,125	7,432	11,106	1,060	1,304
1995	1,059	2,421	46	18,049	1,956	4,950	8,755	538	1,399
1996	1,900	3,729	40	15,920	1,275	4,842	12,915	66	670
1997	813	4,285	42	19,076	1,313	3,532	12,093	205	623
1998	1,051	4,572	13	18,830	3,125	7,320	13,071	345	1,133
1999	726	4,833	45	9,801	2,564	4,758	9,741	162	982
2000	757	4,839	147	8,121	2,030	2,841	6,373	239	503
2001	899	6,436	66	9,192	2,501	1,665	8,206	106	1,181
2002	715	5,252	71	10,952	2,346	2,309	8,188	73	1,049
2003	518	5,900	35	12,067	5,216	2,208	7,241	89	1,017
2004	899	8,792	60	12,155	11,258	1,561	5,386	89	532
2005	691	5,616	58	8,960	7,138	1,135	5,584	*	567
2006	813	8,978	23	7,194	9,984	710	3,471	115	407
2007	345	7,031	18	8,502	5,473	1,155	2,807	*	367
2008	218	4,437	23	9,052	2,984	637	2,613		128
2009	191	706	33	8,243	3,038	639	3,572	*	451
2010	433	2,844	41	7,496	508	813	4,975	*	221
2011	1,660	4,347	31	4,992	750	2,716	3,693	*	272
2012	1,427	4,731	*	7,522	136	2,190	4,225	*	492
2013	894	5,352	63	5,626	2,852	1,588	4,495		444
2014	843	3,348	426	5,906	9,803	1,728	4,155		344
2015	1,574	7,088	164	4,574	3,849	1,718	5,364		404
2016	1,086	2,528	174	6,001	3,129	1,370	3,770		395
2017	1,229	8,435	83	6,499	409	2,004	2,867		363
2018	840	9,392	934	7,465	1,135	1,700	3,126		307
2019	492	2,986	199	4,598	1,856	1,843	3,768		352
2020	669	4,199	157	5,229	510	1,205	3,554		631
2021	418	3,523	216	4,518	1,046	974	3,163		489
2022	506	3,883	249	3,367	1,431	1,259	3,249		377

Table 3.10.6 Annual Muton Snapper discards (in number) from the vertical line commercial fishery from 1993-2022. Discards calculated separately for Gulf of Mexico FL Keys, Southwest (SW) FL, South Atlantic FL Keys, Southeast (SE) FL, and Northeast (NE) FL.

	Gulf of Mexico				South Atlantic					
	FL Keys		SW FL		FL Keys		SE FL		NE FL	
Year	Number	SE	Number	SE	Number	SE	Number	SE	Number	SE
1993	742	129	2,649	460	778	61	344	27	1,141	90
1994	832	144	2,736	475	852	67	507	40	1,701	134
1995	992	172	3,088	536	1,112	88	530	42	1,858	146
1996	665	115	2,883	500	1,240	98	458	36	1,555	123
1997	646	112	2,715	471	1,576	124	576	45	1,478	116
1998	489	85	2,712	470	1,091	86	506	40	908	72
1999	649	113	2,911	505	1,114	88	416	33	725	57
2000	806	140	2,887	501	1,084	85	448	35	697	55
2001	390	68	2,310	401	925	73	428	34	660	52
2002	716	124	2,128	369	908	72	429	34	740	58
2003	336	58	2,091	363	843	66	429	34	623	49
2004	253	44	2,157	374	737	58	424	33	586	46
2005	214	37	1,819	316	630	50	374	29	463	36
2006	239	41	1,976	343	575	45	376	30	447	35
2007	175	30	1,671	290	509	40	393	31	757	60
2008	169	29	1,380	239	477	38	411	32	690	54
2009	233	40	2,276	395	618	49	470	37	782	62
2010	187	33	2,349	407	483	38	474	37	482	38
2011	236	41	1,394	242	537	42	522	41	621	49
2012	306	53	1,742	302	555	44	445	35	507	40
2013	349	61	2,307	400	551	43	385	30	612	48
2014	260	45	3,640	632	566	45	525	41	803	63
2015	180	31	4,563	792	750	59	413	33	825	65
2016	173	30	2,976	516	679	54	449	35	657	52
2017	103	18	2,077	360	651	51	385	30	647	51
2018	221	54	3,209	770	904	126	632	89	866	121
2019	350	100	3,620	1,035	789	114	657	95	923	133
2020	202	58	3,799	1,086	727	105	515	74	951	137
2021	199	57	3,829	1,094	737	106	409	59	675	97
2022	205	59	2,310	660	610	88	612	88	735	106

3.11. FIGURES

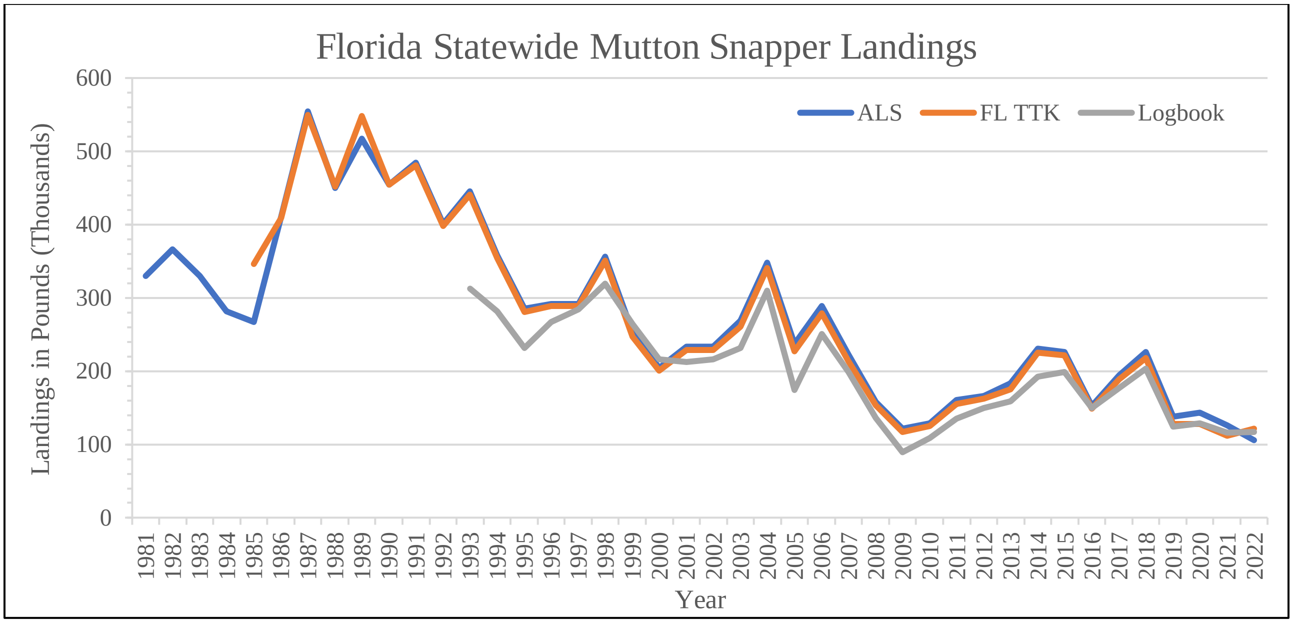


Figure 3.11.1 Comparison of total mutton snapper landings for Florida between the Accumulative Landings System (ALS), Florida Trip Ticket Program (FL TTK), and the Coastal Logbook Program (Logbook).

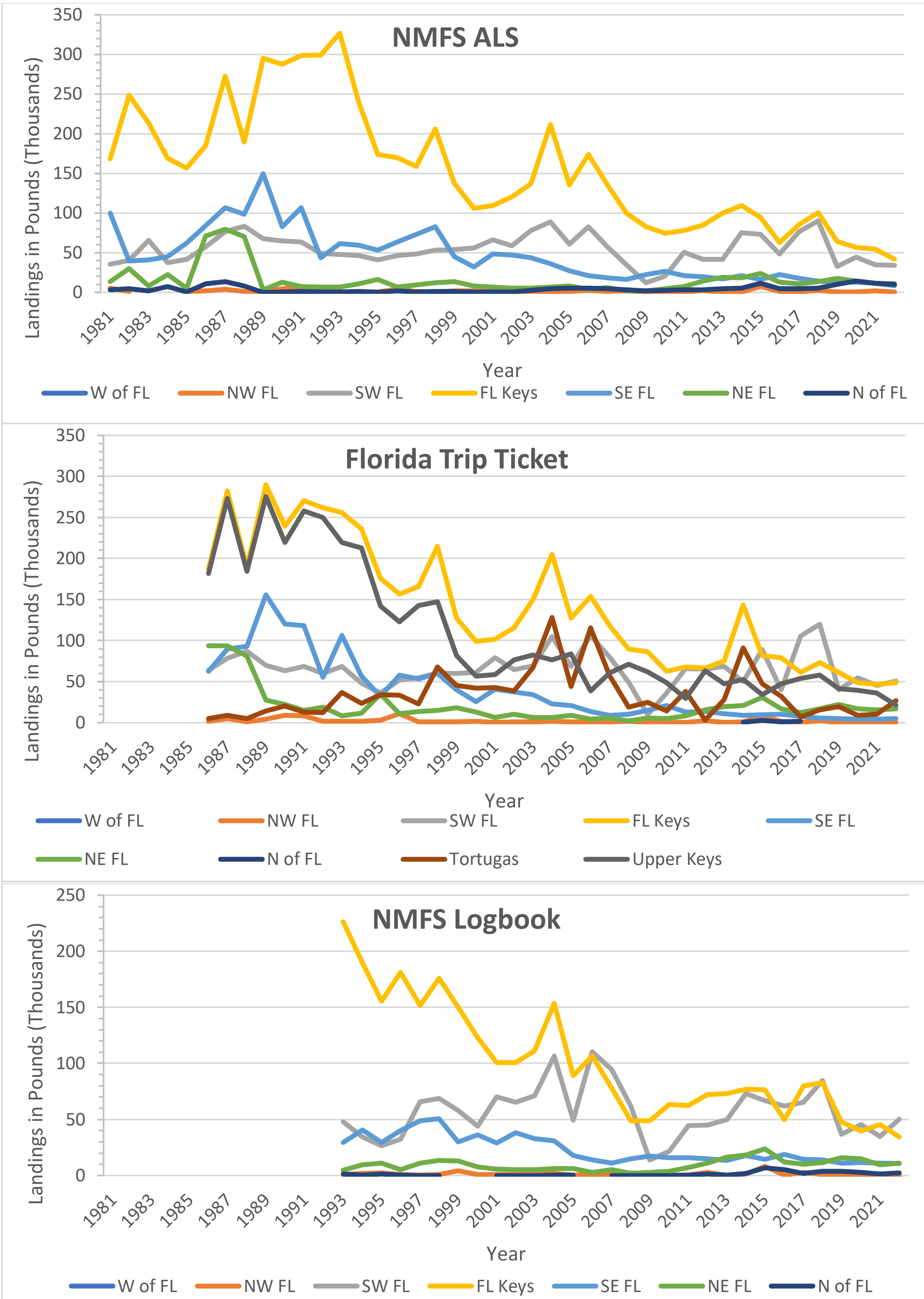
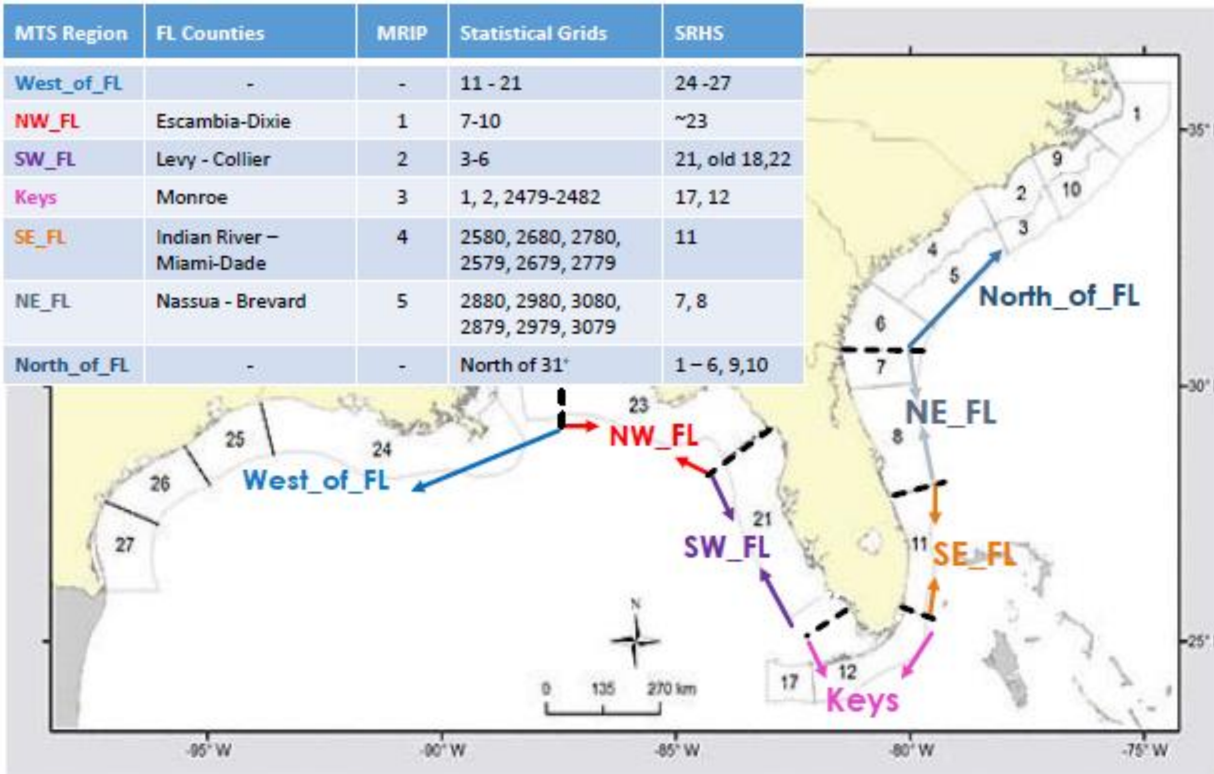
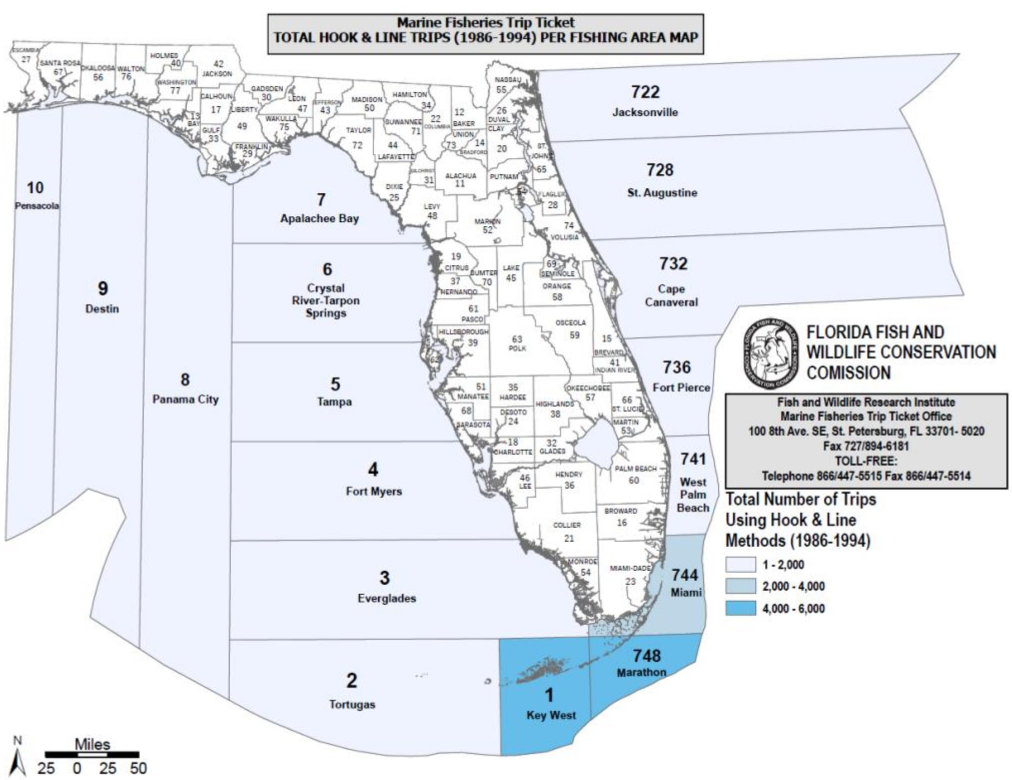


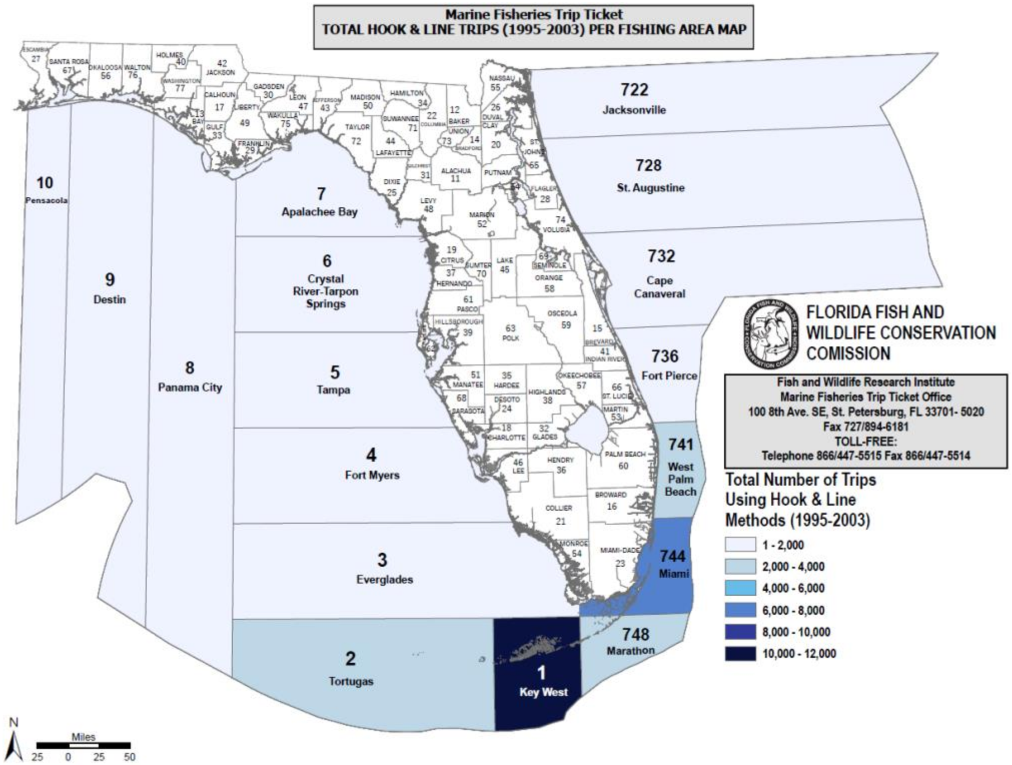
Figure 3.11.2 Mutton Snapper landings by region (West of FL, NW FL, SW FL, FL Keys, Tortugas*, SE FL, NW FL, and North of FL) for each source (ALS, FL TTK, and Logbook). *Tortugas was included in Florida data at the request of assessment staff.



MTS Region	FL Counties	MRIP	Statistical Grids	SRHS
West_of_FL	-	-	11 - 21	24 -27
NW_FL	Escambia-Dixie	1	7-10	~23
SW_FL	Levy - Collier	2	3-6	21, old 18,22
Keys	Monroe	3	1, 2, 2479-2482	17, 12
SE_FL	Indian River – Miami-Dade	4	2580, 2680, 2780, 2579, 2679, 2779	11
NE_FL	Nassua - Brevard	5	2880, 2980, 3080, 2879, 2979, 3079	7, 8
North_of_FL	-	-	North of 31°	1 – 6, 9,10

Figure 3.11.3 Mutton Snapper data delivery regions.




Marine Fisheries Trip Ticket
TOTAL HOOK & LINE TRIPS (1995-2003) PER FISHING AREA MAP
722 Jacksonville
728 St. Augustine
732 Cape Canaveral
736 Fort Pierce
741 West Palm Beach
744 Miami
748 Marathon
1 Key West
2 Tortugas
3 Everglades
4 Fort Myers
5 Tampa
6 Crystal River-Tarpon Springs
7 Apalachee Bay
8 Panama City
9 Destin
10 Pensacola
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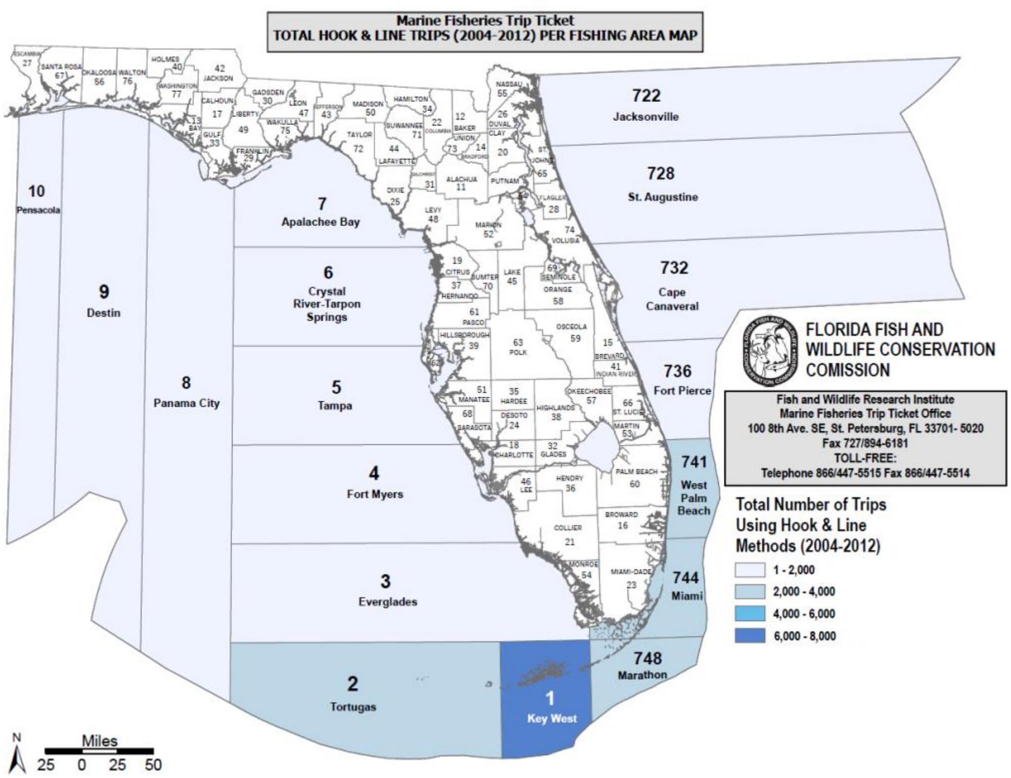
Fish and Wildlife Research Institute
Marine Fisheries Trip Ticket Office
100 8th Ave. SE, St. Petersburg, FL 33701- 5020
Fax 727/894-6181
TOLL-FREE:
Telephone 866/447-5515 Fax 866/447-5514
Total Number of Trips Using Hook & Line Methods (1995-2003)
1 - 2,000
2,000 - 4,000
4,000 - 6,000
6,000 - 8,000
8,000 - 10,000
10,000 - 12,000
Miles
25 0 25 50


Marine Fisheries Trip Ticket
TOTAL HOOK & LINE TRIPS (2004-2012) PER FISHING AREA MAP
722 Jacksonville
728 St. Augustine
732 Cape Canaveral
736 Fort Pierce
741 West Palm Beach
744 Miami
748 Marathon
1 Key West
2 Tortugas
3 Everglades
4 Fort Myers
5 Tampa
6 Crystal River-Tarpon Springs
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10 Pensacola
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Total Number of Trips Using Hook & Line Methods (2004-2012)
1 - 2,000
2,000 - 4,000
4,000 - 6,000
6,000 - 8,000
Miles
25 0 25 50

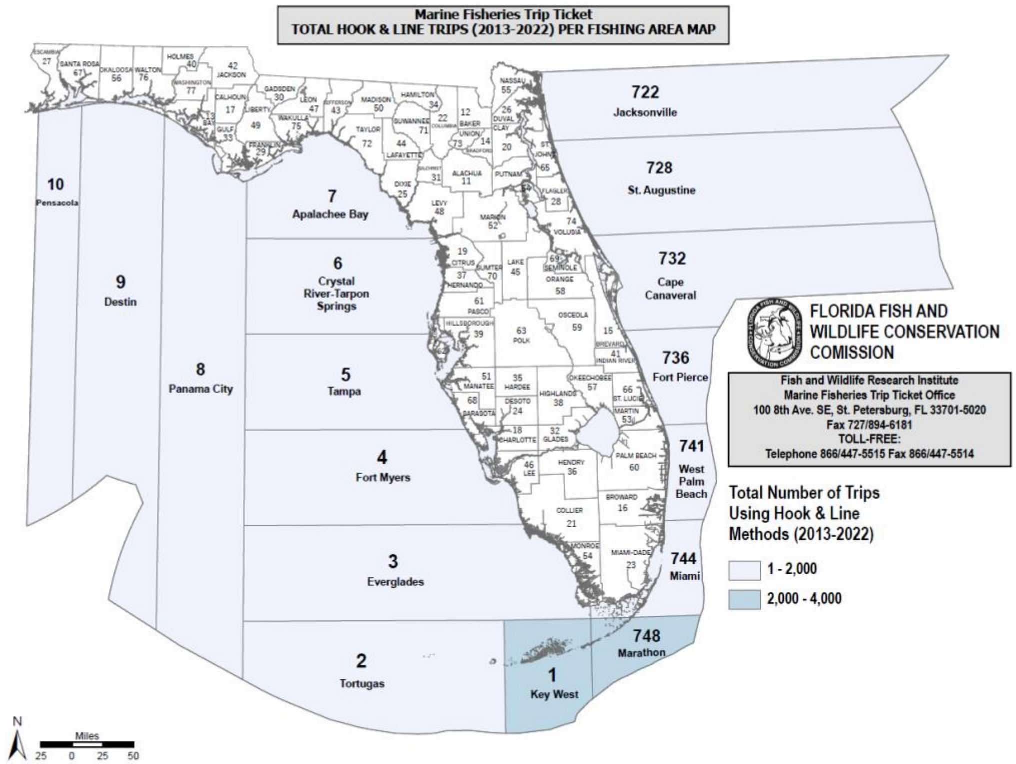
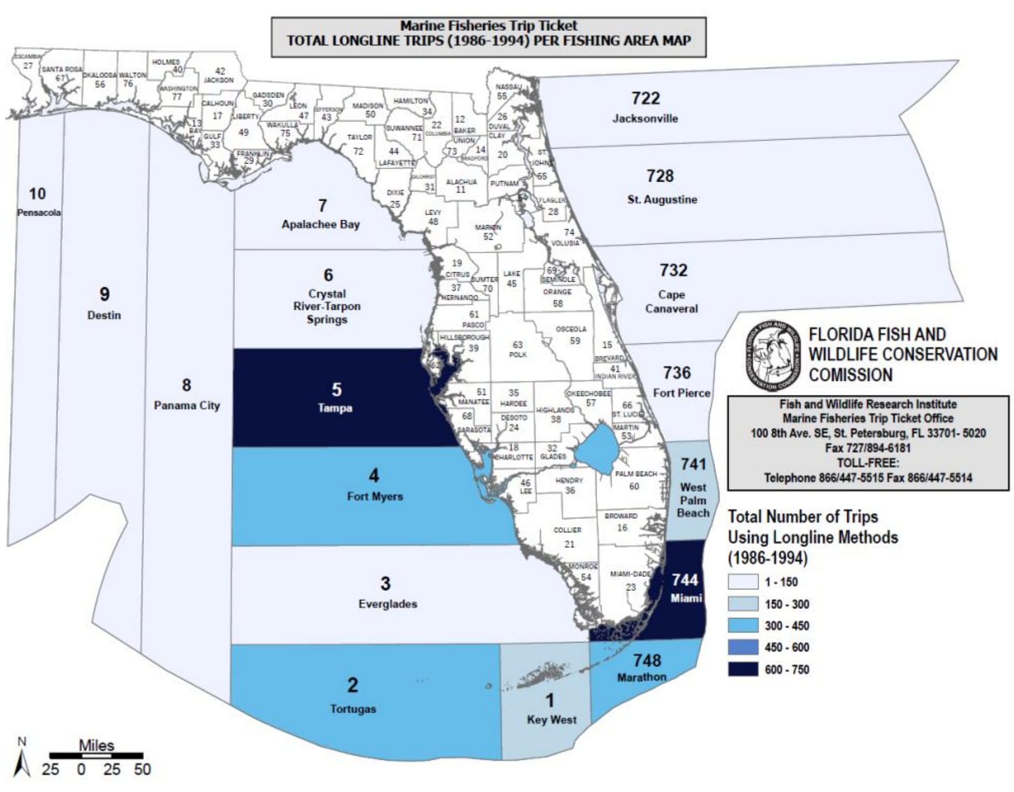
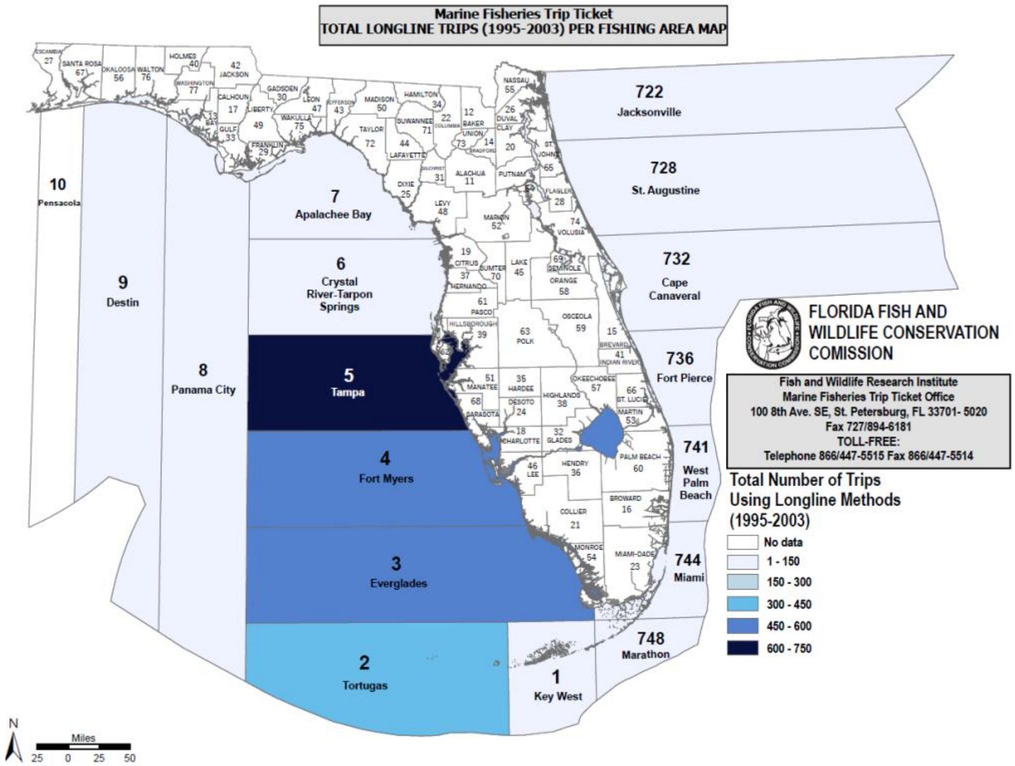


Figure 3.11.1A Total number of H&L trips landing Mutton Snapper, by statistical grid and year group (1986-1994, 1995-2003, 2004-2012, and 2013-2022), in Florida Trip Tickets.




Marine Fisheries Trip Ticket
TOTAL LONGLINE TRIPS (1995-2003) PER FISHING AREA MAP
722 Jacksonville
728 St. Augustine
732 Cape Canaveral
736 Fort Pierce
741 West Palm Beach
744 Miami
748 Marathon
1 Key West
2 Tortugas
3 Everglades
4 Fort Myers
5 Tampa
6 Crystal River-Tarpon Springs
7 Apalachee Bay
8 Panama City
9 Destin
10 Pensacola
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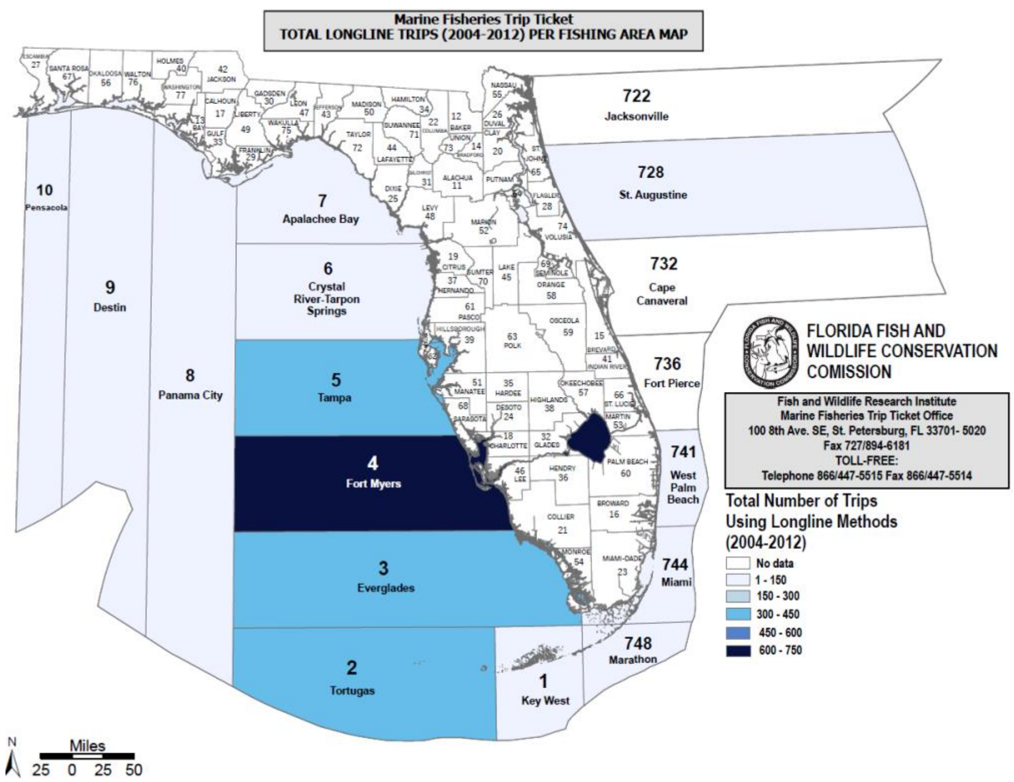
TOLL-FREE:
Telephone 866/447-5515 Fax 866/447-5514
Total Number of Trips Using Longline Methods (1995-2003)
No data
1 - 150
150 - 300
300 - 450
450 - 600
600 - 750
Miles
25 0 25 50


Marine Fisheries Trip Ticket
TOTAL LONGLINE TRIPS (2004-2012) PER FISHING AREA MAP
722 Jacksonville
728 St. Augustine
732 Cape Canaveral
736 Fort Pierce
741 West Palm Beach
744 Miami
748 Marathon
1 Key West
2 Tortugas
3 Everglades
4 Fort Myers
5 Tampa
6 Crystal River-Tarpon Springs
7 Apalachee Bay
8 Panama City
9 Destin
10 Pensacola
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Telephone 866/447-5515 Fax 866/447-5514
Total Number of Trips Using Longline Methods (2004-2012)
No data
1 - 150
150 - 300
300 - 450
450 - 600
600 - 750
Miles
25 0 25 50

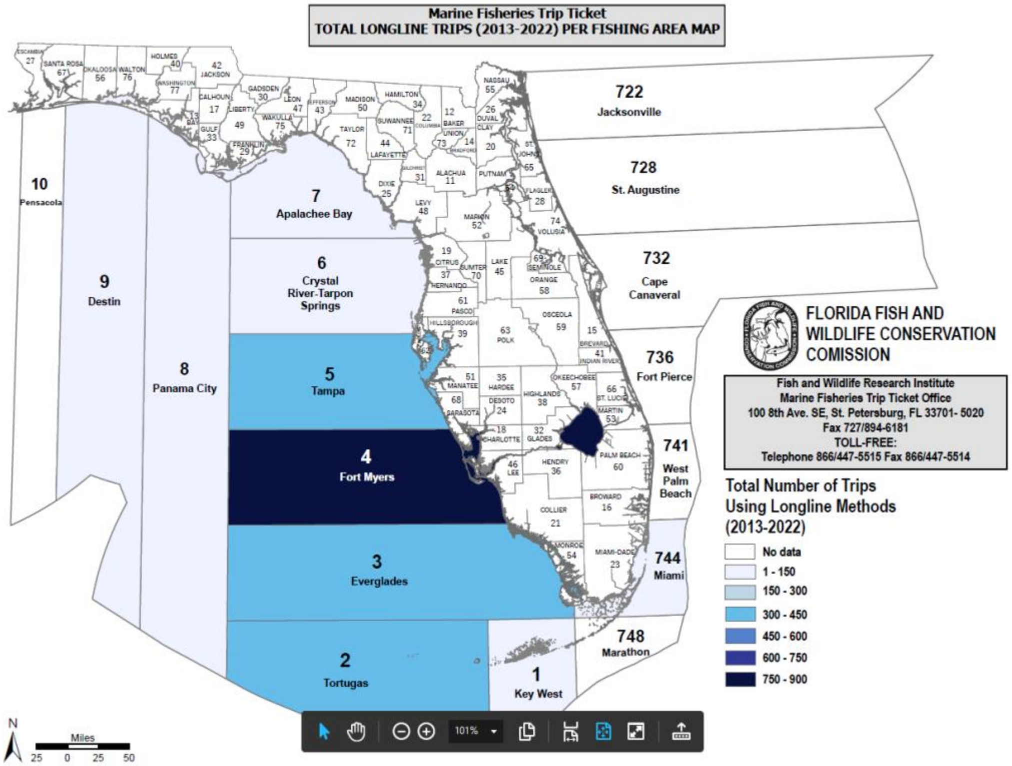
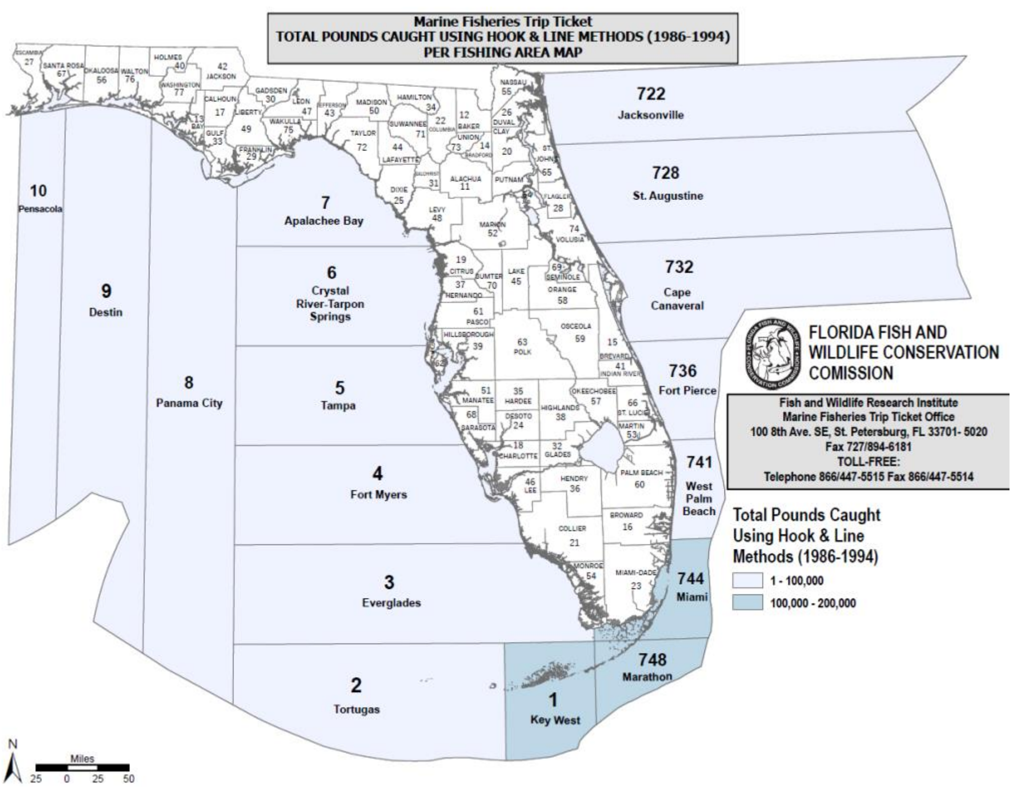
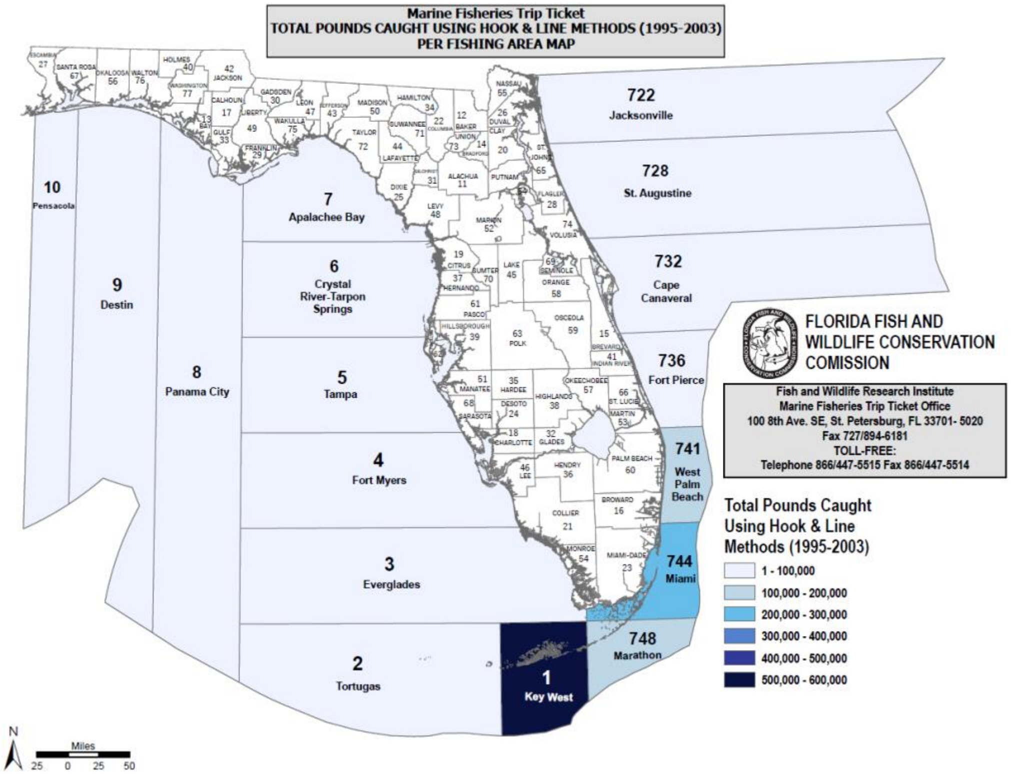


Figure 3.11.2B Total number of Longline trips landing Mutton Snapper, by statistical grid and year group (1986-1994, 1995-2003, 2004-2012, and 2013-2022), in Florida Trip Tickets.




Marine Fisheries Trip Ticket
TOTAL POUNDS CAUGHT USING HOOK & LINE METHODS (1995-2003)
PER FISHING AREA MAP
722 Jacksonville
728 St. Augustine
732 Cape Canaveral
736 Fort Pierce
741 West Palm Beach
744 Miami
748 Marathon
1 Key West
2 Tortugas
3 Everglades
4 Fort Myers
5 Tampa
6 Crystal River-Tarpon Springs
7 Apalachee Bay
8 Panama City
9 Destin
10 Pensacola
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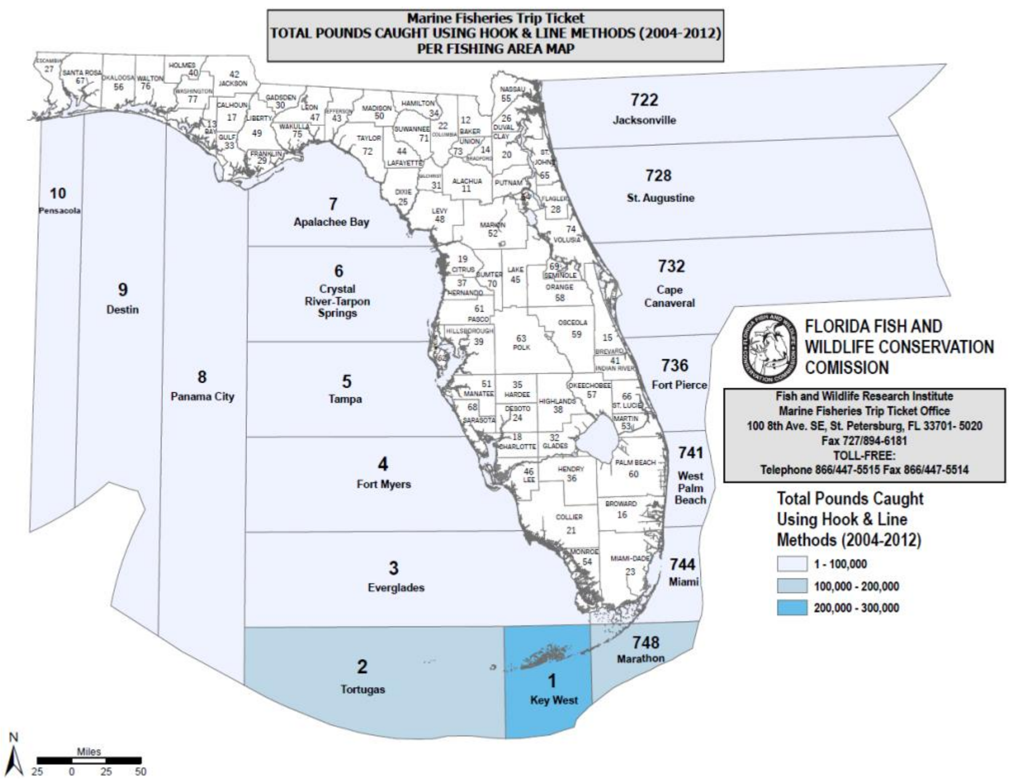
Fax 727/894-6181
TOLL-FREE:
Telephone 866/447-5515 Fax 866/447-5514
Total Pounds Caught Using Hook & Line Methods (1995-2003)
1 - 100,000
100,000 - 200,000
200,000 - 300,000
300,000 - 400,000
400,000 - 500,000
500,000 - 600,000
Miles
25 0 25 50


Marine Fisheries Trip Ticket
TOTAL POUNDS CAUGHT USING HOOK & LINE METHODS (2004-2012)
PER FISHING AREA MAP
722 Jacksonville
728 St. Augustine
732 Cape Canaveral
736 Fort Pierce
741 West Palm Beach
744 Miami
748 Marathon
1 Key West
2 Tortugas
3 Everglades
4 Fort Myers
5 Tampa
6 Crystal River-Tarpon Springs
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8 Panama City
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Total Pounds Caught Using Hook & Line Methods (2004-2012)
1 - 100,000
100,000 - 200,000
200,000 - 300,000
Miles
25 0 25 50

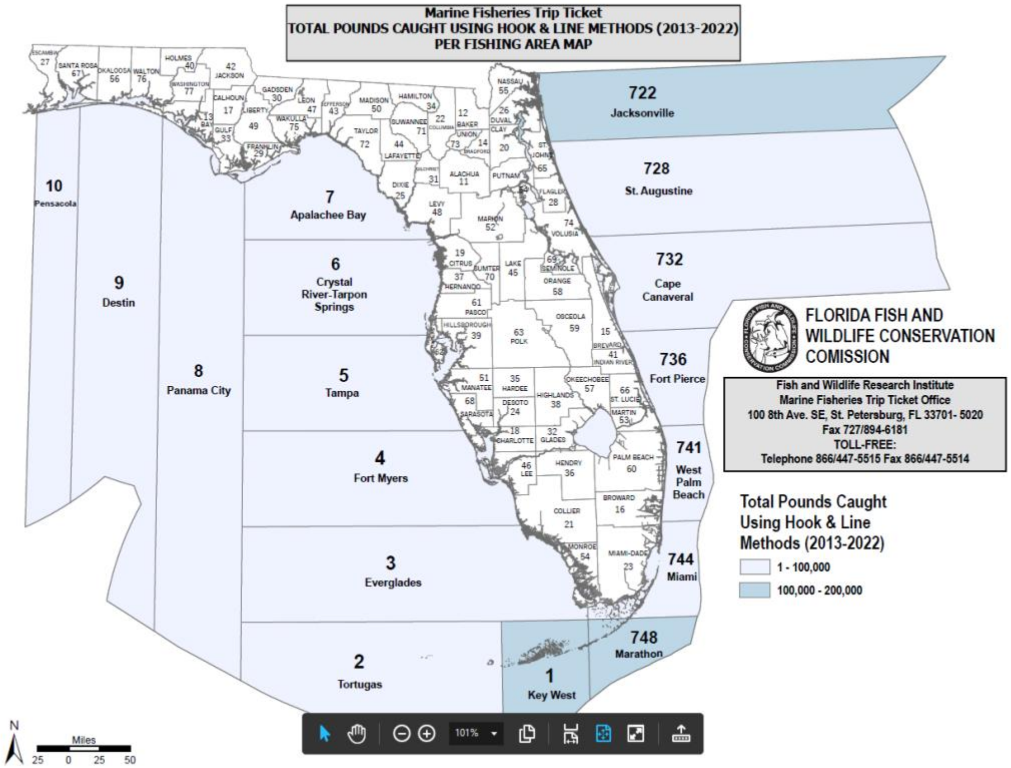
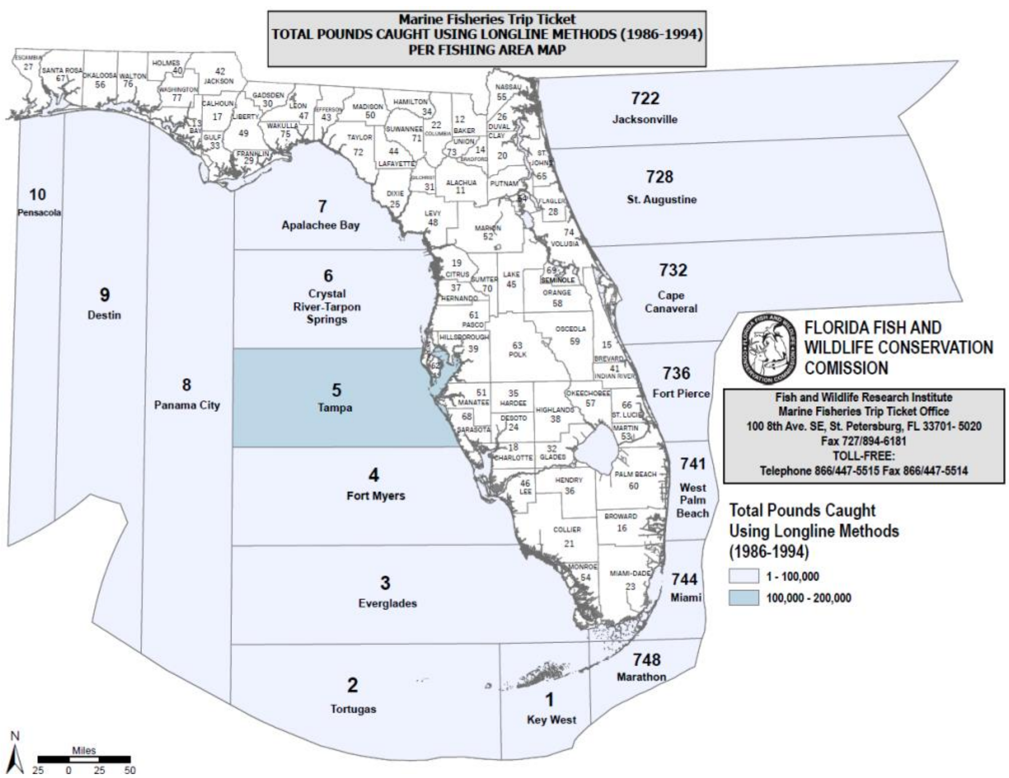
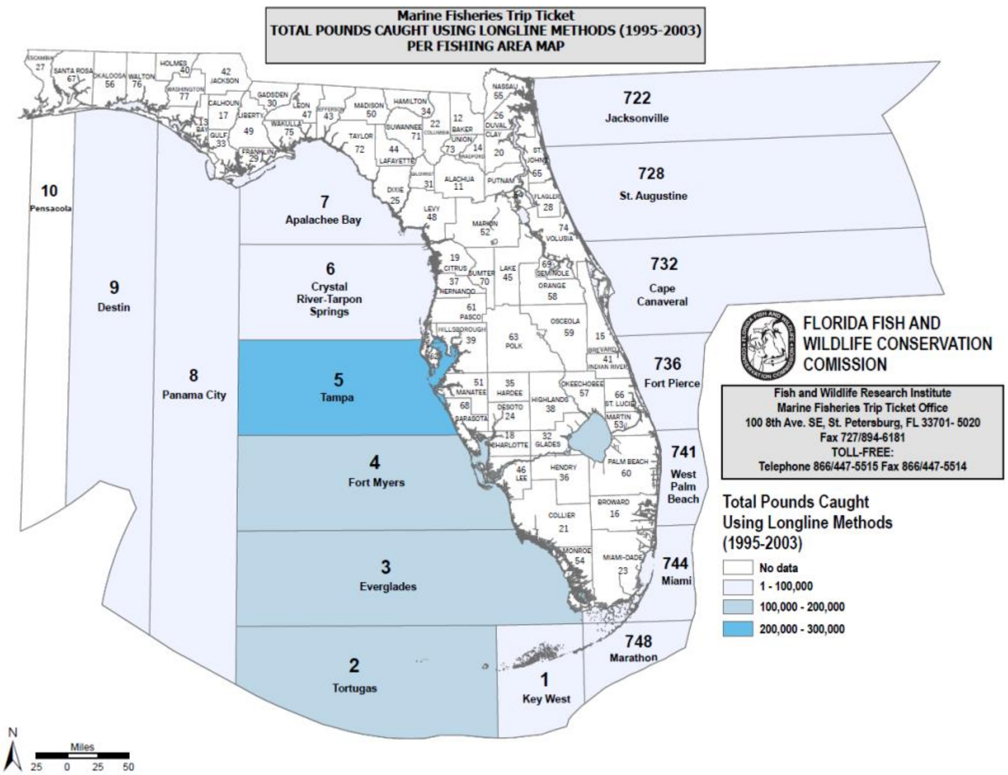


Figure 3.11.5A Total harvest of Mutton Snapper from H&L trips, by statistical grid and year group (1986-1994, 1995-2003, 2004-2012, and 2013-2022), in Florida Trip Tickets.




Marine Fisheries Trip Ticket
TOTAL POUNDS CAUGHT USING LONGLINE METHODS (1995-2003)
PER FISHING AREA MAP
10
Pensacola
9
Destin
8
Panama City
7
Apalachee Bay
6
Crystal River-Tarpon Springs
5
Tampa
4
Fort Myers
3
Everglades
2
Tortugas
1
Key West
748
Marathon
744
Miami
741
West Palm Beach
736
Fort Pierce
732
Cape Canaveral
728
St. Augustine
722
Jacksonville
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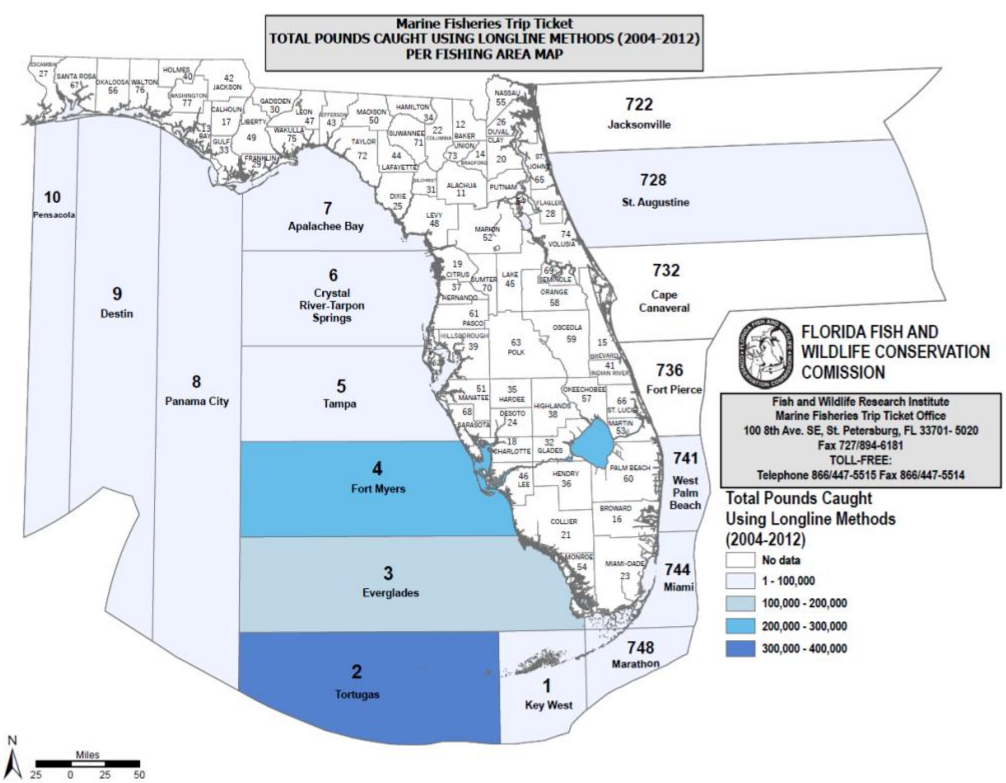
Fax 727/894-6181
TOLL-FREE:
Telephone 866/447-5515 Fax 866/447-5514
Total Pounds Caught Using Longline Methods (1995-2003)
No data
1 - 100,000
100,000 - 200,000
200,000 - 300,000
N
Miles
25 0 25 50


Marine Fisheries Trip Ticket
TOTAL POUNDS CAUGHT USING LONGLINE METHODS (2004-2012)
PER FISHING AREA MAP
10
Pensacola
9
Destin
8
Panama City
7
Apalachee Bay
6
Crystal River-Tarpon Springs
5
Tampa
4
Fort Myers
3
Everglades
2
Tortugas
1
Key West
748
Marathon
744
Miami
741
West Palm Beach
736
Fort Pierce
732
Cape Canaveral
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St. Augustine
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Total Pounds Caught Using Longline Methods (2004-2012)
No data
1 - 100,000
100,000 - 200,000
200,000 - 300,000
300,000 - 400,000
N
Miles
25 0 25 50

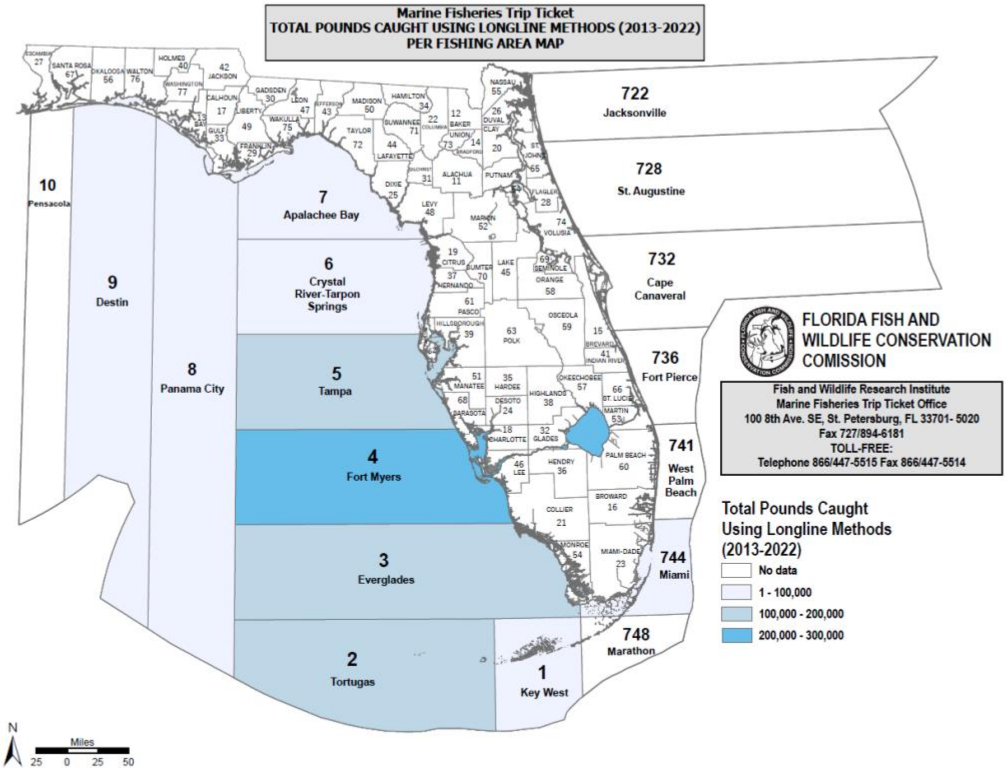


Figure 3.11.5B Total harvest of Mutton Snapper from Longline trips, by statistical grid and year group (1986-1994, 1995-2003, 2004-2012, and 2013-2022), in Florida Trip Tickets.

4. RECREATIONAL FISHERY STATISTICS

4.1. OVERVIEW

4.1.1. Recreational Workgroup (RWG) Members

FWCC: Halie OFarrell (RWG Lead), Dustin Addis, Beverly Sauls, Maria Kappos, Ellie Corbett, Craig Lavine, Juan Cortes, Sean Wilms, Shanae Allen

NOAA: Matthew Nuttall (SEFSC), Dominique Lazarre (SERO), Robin Cheshire (SEFSC)

Gulf Council: C.J. Sweetman, Ryan Rindone

Anglers: Eric Schmidt (Headboat Industry Representative, FL), Richard Gomez (For Hire Key West), David Moss (Recreational)

4.1.2. Recreational Terms of Reference

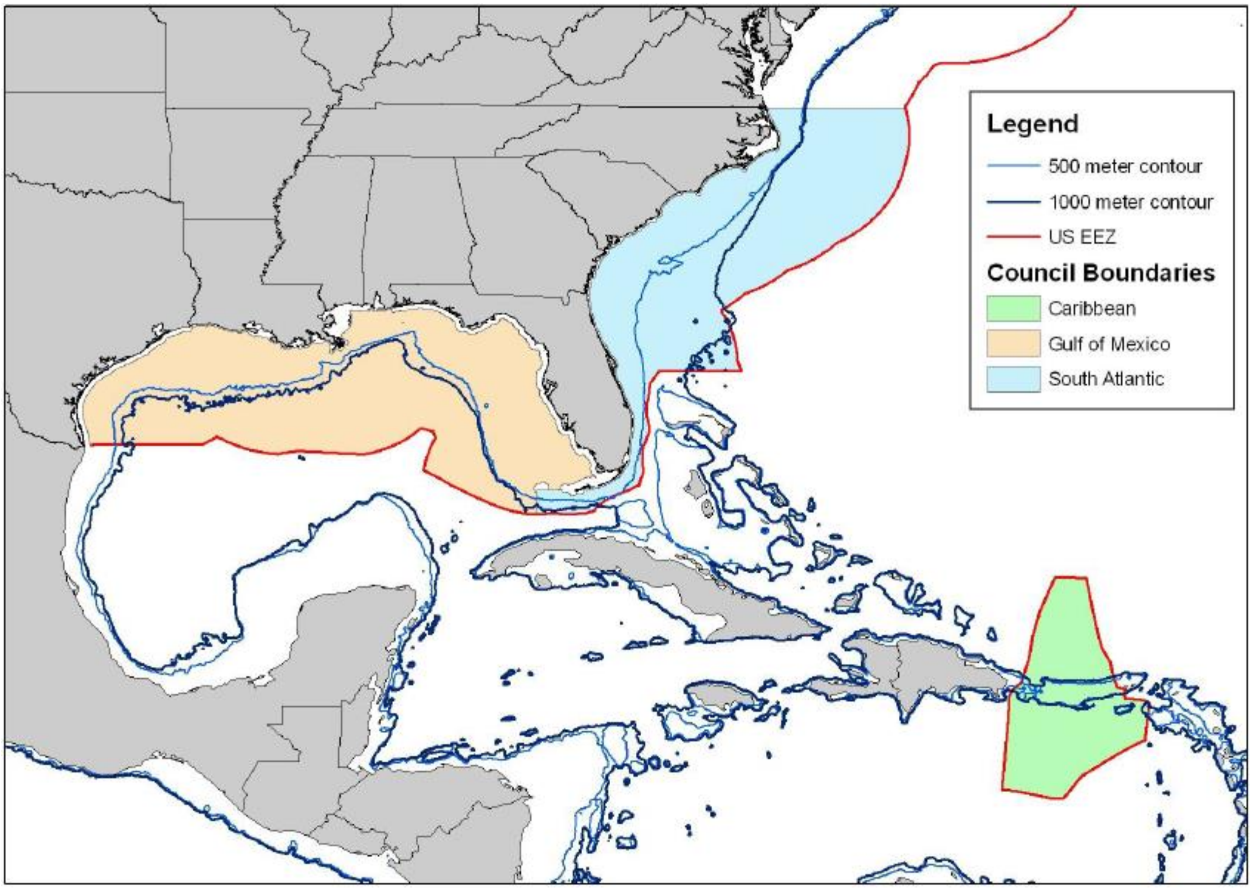
Provide recreational catch statistics through 2022, including both landings and discards in both pounds and number.

- Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear
  - Specifically explore the transition from MRIP-CHTS to MRIP-FES
  - Specifically explore the State Reef Fish Survey data from the State of Florida
  - Explore whether the recreational fleet structure can be realigned into individual fleets as appropriate
- Provide length and age distributions for both landings and discards if feasible
- Provide maps of fishery effort and harvest and fishery sector or gear
- Provide estimates of uncertainty around each set of landings and discard estimates

4.1.3. Issues Discussed at the Data Workshop

1) Document and compile angler observations about the recreational fishery in general and regarding the TORs.
2) Identification of appropriate spatial and modal mode resolutions for recreational data products, as informed by (for example) distributions of landings by strata and associated length/age compositions.
3) Investigation of relatively high/low MRIP landings and discard estimates, as compared to adjacent time periods.
4) Evaluation of the State Reef Fish Survey (SRFS) as an appropriate data source for recreational angling activities of southeastern mutton snapper.
5) Exploration of the MRIP transition from CHTS to FES and discuss the implications of Andrews 2022 MRIP FES pilot study.
6) Evaluation of headboat discard estimates from the Southeast Region Headboat Survey (SRHS) between 2004-2022 and back-calculation of discard estimates prior to 2007.

4.1.4. Gulf of Mexico and South Atlantic Fishery Management Council Jurisdictional Boundaries



4.2. REVIEW OF WORKING PAPERS

SEDAR 79-DW-02: General Recreational Survey Data for Mutton Snapper in the Southeast. Matthew A. Nuttall and Samantha Binion-Rock.

General recreational survey data for Mutton Snapper from the Marine Recreational Information Program (MRIP), Texas Parks and Wildlife Department (TPWD), and Louisiana Creel Survey (LA Creel) are summarized from 1981 to 2022 for Gulf of Mexico and Atlantic states from Texas to Maine. Charter, Headboat, Private, and Shore fishing modes are presented. These fully calibrated MRIP estimates consider the change in the Fishing Effort Survey, the redesigned Access Point Angler Intercept Survey, and the For Hire Survey. Tables and figures presented include calibration comparisons, landing and discard estimates, associated CVs, sample sizes, fish sizes, and effort estimates.

SEDAR 79-DW-03: Size and age information for Mutton Snapper, *Lutjanus analis*, collected in association with fishery-dependent monitoring along Florida’s coast. Julie Vecchio, Jessica Carroll, Dominque Lazarre, Beverly Sauls; Updated By: Ellie Corbett and Bridget Cermark.

This report summarizes the several unique recreational angler surveys conducted by the state of Florida Fishery Dependent Monitoring Program that allow for the collection of supplemental biological data.

SEDAR 79-DW-04: Descriptions of Florida's Mutton Snapper recreational fishery assessed using fishery-dependent survey data. Julie Vecchio, Jessica Carroll, Dominque Lazarre, Beverly Sauls. Updated By: Maria Kappos

This report characterizes the interactions between the for-hire /private recreational fishing fleets and Mutton Snapper in Florida waters. The data summaries presented include numbers of landed and released fish, typical fishing depth, size distribution (fork lengths in mm) of harvested and discarded fish, and release conditions of discarded fish in each region of the state.

SEDAR 79-DW-06: Headboat Data for Mutton Snapper in the Southeast U.S. Atlantic and Gulf of Mexico. Robin T. Cheshire, Kenneth Brennan, and Matthew E. Green.

This report documents the Southeast Region Headboat Survey (SRHS) which estimates landings and effort for headboats operating in the southeast U.S. Atlantic and Gulf of Mexico based on electronic logbook reporting.

SEDAR 79-DW-14: A Summary of Mutton Snapper Discard Length Data Collected from At-Sea Observers in Recreational Fishery Surveys in Florida. Ellie Corbett.

This report details the at-sea for-hire observer surveys conducted by the state of Florida Fishery Dependent Monitoring Program that allow for the collection of supplemental discard biological data.

4.3. RECREATIONAL LANDINGS

Recreational landings of Mutton Snapper were compiled from 1981 through 2022 for the U.S. Atlantic and Gulf of Mexico. Sources for landings include the Southeast Region Headboat Survey (SRHS), Marine Recreational Information Program (MRIP), Texas Parks and Wildlife Department (TPWD), and Louisiana Creel survey program (LA Creel). Recreational landings are primarily from private and shore modes and recreational landings outside of Florida comprise less than 0.2% of the total recreational landings.

Further discussion of how landings were compiled from the SRHS can be found in the working paper (SEDAR 79-DW-06) in the Methods section and associated tables and figures are presented in the Results section. Tables 3 and 5 present landings in numbers and pounds, respectively by region. Figures 3 and 4 present overall SRHS landings by region in numbers and pounds respectively.

Tables 1 and 2 in the SEDAR 79-DW-02 working paper present landings from MRIP, TPWD, and LACreel by region and fishing mode, respectively. Tables 3 and 6 present coefficients of variance (CVs) associated with landings-in-number and landings-in-pounds. Figures 3a and 3b illustrate the number of fish landed and discarded by region, while Figures 4a and 4b show the contribution by mode per year. These figures show that the vast majority of landings originate from the private and shore modes and from Florida (Figure 4.11.1).

Time series of estimated landings (in pounds and numbers) by region after combining all data sources and modes are described in Table 4.10.1 and Figure 4.11.2. A map of average landings from 1981-2022 is presented in Figure 4.11.3.

Issue:
Compare MRIP calibrations.

Recommendation:
To maintain a consistent time series, charter estimates were calibrated on the Gulf coast prior to 2000 and the Atlantic coast prior to 2004 (SEDAR64-RD-12). CHTS and calibrated FHS charter catch estimates for Mutton Snapper from 1981 to 2003 are shown in Figure 1 of SEDAR 79-DW-02. Calibrated APAIS and FES estimates for Mutton Snapper from 1981 to 2017 are shown in Figure 2 of SEDAR 79-DW-02.

Issue:
The MRIP FES CV values are relatively high when split by mode, particular for the shore mode. The length compositions indicate that all modes have similar selectivities and can all catch similarly sized fish (Figures 4.11.1 and 4.11.2). Length distributions appear to differ more starkly by region with eastern areas catching smaller fish than western Florida. Size compositions of landed fish in the Florida Keys were determined to be more similar to western Florida than the Atlantic coast.

Recommendation:
All modes should be combined into a single “recreational” fleet, but with separate with regions defined for the East (Southeast Florida, Northeast Florida, and North of Florida) and West (Florida Keys, Southwest Florida, Northwest Florida, and West of Florida).

Issue:
The working group investigated the time series to identify relatively high/low estimates of recreational landings, as compared to adjacent time periods. The group investigated the high landings estimate for the East region in 2008, the majority of which comes from a single stratum: ~64% of the annual landings estimate is from the eastern Florida shore mode in wave4 and ocean <= 3 miles (S79-DW-02). The estimate for this stratum was informed by intercepts from 36 angler trips, and not the result of one or two intercepts reporting relatively high landings. The group further found that this estimate coincides with strong tropical storm activity (Fay) and a strong recruitment class in 2007 (as supported by the Indian River YOY Index and age comps from the commercial and recreational sectors). Anglers report more encounters of Mutton Snapper closer to shore immediately following tropical storm activity. The group also investigated the relatively low landings in 2010-2011, which coincided with the 2010 Deepwater Horizon Oil Spill (reduced effort and potentially biological effects) and unseasonably cold temperatures experienced throughout the state of Florida in January 2010 that resulted in widespread fish kills.

Recommendation:
The RWG did not find reason to further manipulate these estimates, which were supported by multiple information sources including fishery dependent data, fishery independent data, and firsthand knowledge of the environmental conditions in those years.

Issue:
Catch estimates from the early years of the MRIP survey (e.g., 1981-1985) are highly variable and tend to result in higher CVs than those estimated in subsequent years. Coupled with the relatively large landings estimates for Eastern Florida mutton snapper caught by the shore mode, the RWG discussed a potential recommendation to start the assessment model in 1986, as has been done in other SEDAR stock assessments. The group has no particular concerns with retaining and using the recreational data in these early years as inputs into the assessment model but recognizes that the above reasons could be used for justification of removal.

Recommendation:
The RWG concluded that both options are valid and supported and recommends this decision be made during the assessment process based on other aspects of data availability and modeling needs.

Issue:
Is the SRFS data available, 2021-2022 full years, appropriate for use?

Recommendation:
We considered SRFS as a possible data source of recreational landings & discards for Florida mutton snapper, but this species wasn’t added to the survey until 2020 and so didn’t provide an adequate time-series for use in this assessment.

4.4. RECREATIONAL DISCARDS

Recreational discards of Mutton Snapper were compiled from 1981 through 2022 for the U.S. Atlantic and Gulf of Mexico. Sources for discards include the Southeast Region Headboat Survey (SRHS) and Marine Recreational Information Program (MRIP). Discard data from Texas Parks and Wildlife Department (TPWD) and Louisiana Creel survey program (LA Creel) are not available and are assumed to be negligible.

Discards from MRIP are summarized in the working paper SEDAR 79-DW-02. A comparison of landings and discards estimates from 1981 to 2017 under the MRIP base, Access Point Angler Intercept Survey (APAIS) calibrated, and fully calibrated APAIS and Fishing Effort Survey (FES) is shown in Figures 1 and 2. Tables 1 and 2 in the SEDAR 79-DW-02 working paper present discard estimates from 1981-2022 by region and fishing mode, respectively. Tables 3 and 6 present coefficients of variance (CVs) associated with discards-in-numbers and discards-in-pounds. Figures 3a and 3b illustrate the number of fish landed and discarded by region, while Figures 4a and 4b show the contribution by mode per year.

Headboat discards (SRHS) were estimated according to methods in the Discards section from the working paper (SEDAR 79-DW-06). Observers with the headboat at-sea program collect catch and discard information from a subset of anglers. Annual catch rates from the observer data can be compared to catch rates reported on logbooks to evaluate the validity of logbook discard data for 2004 to 2007. The Results and Appendix sections present annual discards-in-numbers by region in Tables A1 and Figure A3.

The summaries of MRIP and headboat working paper show that the vast majority of discards originate from the private and shore modes operating in Florida. Time series of estimated discards combining all data sources and modes by region are described in Table 4.10.1 and Figure 4.11.2. A map of average discards from 2004-2022 is presented in Figure 4.11.4.

Issue:
The working group investigated the time series to identify relatively high/low estimates of recreational discards, as compared to adjacent time periods. The group investigated the relatively high discard estimates in the East region in 2008 and 2016-2017. The group found that these estimates coincided with strong tropical storm activity in these years (2008 Tropical Storm Fay, 2016 Hurricane Matthew, 2017 Hurricane Irma). Anglers report more encounters of Mutton closer to shore immediately following tropical storm activity. For the 2008 estimate, a strong recruitment signal in 2007 (Indian River YOY Index) and strong year classes observed in the age comps (commercial and recreation) support the increase in discards (Table 4.10.2). For 2016 and 2017, multiple strata showed evidence of relatively high discards in these years, some of which were consistent with estimates from surrounding years (e.g., private mode). Additionally, state regulations for mutton snapper harvest changed in January 2017 to increase the minimum size limit to 18”. The group also investigated the relatively low discards in 2010-2011, which coincided with the 2010 Deepwater Horizon Oil Spill (reduced effort and potentially biological effects) and unseasonably cold temperatures experienced throughout the state of Florida in January 2010 that resulted in widespread fish kills.

Recommendation:
The RWG did not find reason to further manipulate these estimates, which were supported by multiple information sources including fishery dependent data, fishery independent data, and firsthand knowledge of the environmental conditions in those years.

Issue:
The group discussed the appropriateness of those discards estimated from SRHS logbook data (2004-2022; Table 6 in S79-DW-06). The RWG identified high variability in discard estimates from the early years in the East, specifically from SE Florida, and some indication from the headboat at-sea observer data that discard rates from the SRHS logbook data were being under-reported in these years for the Florida Keys (Figures A1). The group explored a corrective scaling to account for the under-reporting in the Keys.

Recommendation:
The panel decided to exclude logbook discard estimates in 2004 - 2007 and concluded that logbook discard estimates should be used from 2008 – 2022. Also, the proxy method presented in the working paper (SEDAR 79-DW-06) was considered appropriate for estimation of headboat discards in years prior when valid estimates from SRHS logbooks could be calculated.

4.5. BIOLOGICAL SAMPLING

4.5.1. Sampling Intensity Length/Age/Weight

Biological samples of Mutton Snapper were compiled from 1981 through 2022 for the U.S. South Atlantic and Gulf of Mexico. Recreational sources for length, weight, and age data were collected by the biological sampling programs of the Southeast Region Headboat Survey (SRHS), MRIP, TPWD, the Florida At-Sea Observer Programs, and other data collection programs (FWRI Representative Biological Sampling Program, SRFS, MARFIN, GulfFIN). For all data sources, the data comes primarily from Southeast Florida and the Florida Keys.

The FWC-FWRI Fishery Dependent Monitoring (FDM) At-sea observers have collected length and discard information from reef fish species caught by the for-hire fleet in Florida from 2005-2022. Survey design and data related to Mutton Snapper are described in detail in the working papers (SEDAR 79-DW-03, SEDAR 79-DW-04, SEDAR 79-DW-14). At-sea observer spatial coverage is presented in Table 1 of SEDAR 79-DW-03 and Table 2 presents the number of trips by region, year and trip duration for the charter recreational fleets. Tables 4 and 5 contain the number of discarded and harvested fish observed on headboat and charterboat trips, respectively, by region and year. A total of 6,818 age samples were collected from the recreational sector, including 259 samples from private boat trips, 1,718 from charter trips, and 4,841 from headboats. The depth of capture, release condition and hook location for released fish are also summarized in Tables 3 and 5 within SEDAR 79-DW04. Most of the fish encountered were not legal to keep, making depredation, release condition, and post-release predation important factors to understand. Approximately 44% of fish were released in good condition without being vented, 26% were vented but swam down strongly, and 1% of fish were descended in the for-hire fishery during the decade of sampling presented in this analysis.

Other FWC-FWRI FDM survey programs, including State Reef Fish Survey dockside intercept survey, GulfFIN funded opportunistic sampling, and Representative Biological Sampling (RepBio), have collected length, weight, and age information from reef fish species caught by the private boat fleet in Florida from 2000-2022. Survey designs and data relating to Mutton Snapper are described in detail in the working papers (SEDAR 79-DW-03, SEDAR-79 DW-04). Private fleet (all modes) sampling spatial coverage is presented in Table 1 of SEDAR 79-DW-03 and Table 5 presents the number of trips sampled by region and year. The depth of capture and percentage of released fish is presented in Table 4 of SEDAR 79-DW-04.

SRHS biological sampling effort by region is presented in SEDAR79 DW-06. Annual numbers of Mutton Snapper measured for lengths in the headboat fleet by state and region are given in Tables 24-25. The number of trips from which Mutton Snapper were measured are summarized in Tables 26-27. Mean total lengths (mm) and weight (g) and associated CVs for the headboat fishery are tabulated by state and region in Tables 28–35. Patterns in length and weight by year and region are shown in Figures 8 and 9.

4.5.2. Length – Age distributions

Summary statistics for MRIP intercepted Mutton Snapper fork lengths (mm) by region and year are presented in Table 8 in the working paper (SEDAR 79-DW-02). Similarly, Table 9 presents summary statistics for weights. Sample sizes in these tables include imputed (i.e., predicted) lengths and weights. Summary statistics for TPWD intercepted Mutton Snapper total lengths (mm) by mode and year are presented in Table 13 in the working paper (SEDAR 79-DW-02).

Summaries of length and age information (number, minimum, mean, and maximum lengths; fork length) were provided in working papers for each data source by year and region. Tables 1,2,4,5 in SEDAR 79-DW-03 presents this information for charter, headboat, and private boat sector sampling from Fishery Dependent Monitoring programs. Age-length distributions were similar across sectors with fish representing a wide age range in the length range of 700-850 mm fork length. The youngest and smallest fish were collected from the private fleet with very few larger fish represented, whereas the charter boat and headboat fleets have larger and older fish. All fish collected concentrated mostly in the Age 2–10-year range, with commercially caught fish being the oldest and longest (SEDAR 79-DW-03 Figure 5).

Length frequencies of harvested and released Mutton Snapper measured by at-sea observers on charter and headboat sectors in SE FL and the FL Keys for 2012-2022 (years with discards) are presented in Figures 1 and 2 in SEDAR 79-DW-14. Discards are primarily undersized fish for both charter and headboats. Most harvested fish are around and just above the legal size, with very few beneath legal size, and some representation of larger fish. Tables 28 and 32 and Figure 8 in SEDAR 79-DW-06 shows length information for the SRHS There is a pattern of smaller fish in southeast Florida which are also seen in the East region. Only southeast Florida and the Florida Keys met the SEDAR best practice minimum sample sizes for compositions development (30 fish and 10 trips). All other recreational lengths are presented in Table 10 in SEDAR 79-DW-2.

Timeseries of the number of Mutton Snapper sampled per calendar age for all recreational modes and data sources combined are shown in Table 4.10.2 for the East region (Southeast Florida, Northeast Florida, and North of Florida) and Table 4.10.3 for the West region (Florida Keys, Southwest Florida, Northwest Florida, and West of Florida).

4.6. RECREATIONAL EFFORT

4.6.1. MRIP Effort

Total effort estimates by state and mode from the MRIP, TPWD, and LACreel survey programs are provided in the working paper (SEDAR 79-DW-02) in Tables 16 and 17, respectively. Total effort estimates are measured in the number of angler trips and are not specific to Mutton Snapper. MRIP effort averaged over all years (1981-2022) by region is shown in Figure 4.11.5.

4.6.2. SRHS Effort

Details on total effort estimation and tables and figures of non-directed effort (in angler days) are presented in the SEDAR 79-DW-06 working paper (total Table 18 and by region Table 20). State surveys continue to collect biological data through at-sea observer trips and dockside intercept surveys. SRHS effort by region, as measured by the average number of angler days from 1986 through 2022, is presented in Figure 4.11.6.

4.7. COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES

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

- The recreational landings and discard estimates represented in this report appear to be adequate for southeastern Mutton Snapper for the time period covered, although the RWG did identify some relatively high estimates in some years, particularly for the shore mode.
- While the RWG acknowledges recent concerns regarding the MRIP FES estimates, in the absence of alternative data sources, MRIP FES is recommended for use in this assessment at this time.
- The RWG recommends additional analyses to explore the effect of different scales of recreational catch on model behavior and outputs. As an example, perform a sensitivity analysis using the estimated difference in catch from the MRIP pilot study (Andrews 2022) to scale recreational catches.
- The SRFS time series for Mutton Snapper is currently too short to develop a robust calibration from which a complete SRFS time series (1981-2022) may be calculated from historic MRIP estimates. A 3-year benchmarking period will be available in 2024, using MRIP:SRFS overlap between 2021-2023, after which the RWG recommends additional consideration of SRFS data if made available before the end of the SEDAR 79 assessment process, acknowledging concerns with MRIP FES (Andrews 2022).

4.8. RESEARCH RECOMMENDATIONS

- Study effect of hurricanes on mutton movement
- Continuation of FES pilot study
- Continued evaluation of appropriate SRFS/FES calibration
- Improve precision of MRIP estimates for the shore mode
- Study rates of depredation on recreational fishing

4.9. LITERATURE CITED

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4.10. TABLES

Table 4.10.1. Mutton Snapper landings (AB1) and discards (B2), in numbers of fish (n), with associated coefficients of variation (CV; Dettloff et al. 2020), as well as Mutton Snapper landings (AB1) in pounds (lbs) by region and year for all modes combined (MRIP, LACreel 2014+, TPWD, SRHS).

	EAST						WEST					
Year	**AB1 (lbs)**	**CV (lbs)**	**AB1 (n)**	**CV (n)**	**B2 (n)**	**CV (n)**	**AB1 (lbs)**	**CV (lbs)**	**AB1 (n)**	**CV (n)**	**B2 (n)**	**CV (n)**
1981	958,958	0.56	405,393	0.53	0	0.00	1,253,374	0.47	604,133	0.57	2,318	1.00
1982	313,123	0.33	457,850	0.53	7,594	1.00	2,255,114	0.52	321,168	0.50	3,925	1.00
1983	1,277,681	0.73	467,252	0.66	21,758	1.00	1,288,995	0.56	136,541	0.52	0	0.00
1984	627,797	0.50	232,164	0.49	11,959	0.64	2,623,718	0.58	490,150	0.56	234,463	0.72
1985	243,434	0.64	75,393	0.63	120,106	0.79	332,380	0.51	61,845	0.54	21,195	1.00
1986	237,213	0.27	83,078	0.26	86,742	0.66	1,900,605	0.53	341,129	0.52	5,774	0.68
1987	573,444	0.61	203,125	0.49	202,822	0.82	958,342	0.38	408,848	0.43	86,035	0.71
1988	312,758	0.31	97,484	0.29	33,764	0.57	2,051,509	0.7	338,094	0.68	195,281	0.60
1989	467,026	0.33	143,641	0.33	27,034	0.51	780,457	0.59	258,544	0.59	9,144	1.00
1990	310,267	0.26	103,242	0.25	4,497	0.78	562,542	0.4	196,786	0.40	52,163	0.79
1991	432,482	0.30	123,288	0.28	21,791	0.38	1,313,272	0.4	266,478	0.37	586,706	0.54
1992	569,221	0.45	215,679	0.44	138,336	0.35	947,195	0.45	226,968	0.46	146,030	0.44
1993	589,742	0.18	305,225	0.17	180,967	0.28	817,812	0.3	296,068	0.30	673,141	0.64
1994	393,928	0.22	143,339	0.21	138,893	0.32	324,684	0.19	94,813	0.19	144,734	0.44
1995	369,392	0.28	76,220	0.25	146,166	0.60	844,567	0.48	156,481	0.46	187,032	0.61
1996	305,370	0.28	63,741	0.27	62,483	0.31	402,587	0.37	87,006	0.37	164,620	0.44
1997	268,533	0.22	59,730	0.21	115,562	0.27	351,280	0.43	54,542	0.41	374,889	0.47
1998	408,067	0.25	102,399	0.24	189,729	0.28	492,526	0.43	79,463	0.42	415,659	0.49
1999	396,292	0.23	104,654	0.21	107,451	0.23	812,860	0.44	120,914	0.44	81,711	0.42
2000	576,241	0.21	136,307	0.20	193,457	0.28	158,592	0.52	21,104	0.50	23,964	0.77
2001	425,246	0.23	114,407	0.22	90,384	0.24	130,025	0.4	16,487	0.37	13,559	0.66
2002	605,286	0.14	191,445	0.13	271,508	0.23	336,735	0.41	81,168	0.44	19,696	0.42
2003	532,495	0.18	136,190	0.15	140,899	0.18	440,927	0.33	101,488	0.30	105,949	0.45
2004	526,019	0.26	152,773	0.26	173,350	0.26	159,833	0.27	25,167	0.26	38,854	0.40
2005	542,965	0.17	184,021	0.16	229,727	0.24	77,547	0.36	14,580	0.35	524,129	0.85

Year	EAST						WEST					
	AB1 (lbs)	CV (lbs)	AB1 (n)	CV (n)	B2 (n)	CV (n)	AB1 (lbs)	CV (lbs)	AB1 (n)	CV (n)	B2 (n)	CV (n)
2006	646,162	0.17	206,481	0.17	399,516	0.21	1,081,111	0.57	254,039	0.59	176,896	0.67
2007	908,235	0.14	240,970	0.13	421,893	0.16	822,064	0.44	181,041	0.45	321,859	0.39
2008	1,543,864	0.59	719,486	0.62	1,745,908	0.46	1,024,751	0.43	182,026	0.42	208,852	0.27
2009	530,220	0.17	206,905	0.17	335,141	0.16	349,885	0.4	55,544	0.37	191,365	0.54
2010	625,147	0.15	188,368	0.14	120,415	0.21	297,954	0.52	57,210	0.48	17,322	0.53
2011	217,129	0.19	63,688	0.19	39,395	0.30	171,606	0.32	29,689	0.31	25,725	0.55
2012	367,622	0.20	88,293	0.20	321,280	0.37	986,783	0.49	124,028	0.47	113,577	0.56
2013	566,121	0.25	166,472	0.24	316,752	0.32	905,801	0.3	128,812	0.28	338,568	0.38
2014	779,101	0.28	289,848	0.28	619,150	0.28	533,195	0.31	121,204	0.29	466,058	0.56
2015	802,636	0.25	256,242	0.23	759,817	0.20	617,700	0.32	130,829	0.33	168,497	0.48
2016	1,013,292	0.29	287,528	0.28	1,351,713	0.32	688,776	0.29	129,137	0.24	385,945	0.41
2017	690,634	0.31	168,003	0.29	1,700,224	0.34	411,962	0.4	55,405	0.36	383,601	0.40
2018	631,491	0.37	148,489	0.35	754,325	0.25	339,709	0.24	71,395	0.23	246,667	0.35
2019	559,114	0.44	167,821	0.43	617,582	0.22	495,571	0.35	102,172	0.32	239,928	0.26
2020	340,754	0.29	76,093	0.26	596,186	0.22	1,562,622	0.69	242,468	0.67	526,819	0.31
2021	597,842	0.26	134,460	0.25	872,717	0.18	779,425	0.29	149,148	0.28	339,838	0.24
2022	1,043,592	0.20	244,895	0.20	1,194,051	0.20	408,374	0.28	69,249	0.27	542,842	0.28

Table 4.10.2. Number of Mutton Snapper sampled per calendar age for all East recreational data sources 1997-2022. Red indicates there were no fish sampled and yellow indicates the number of fish aged was less than the median number while green is the highest number of fish aged.

	CALENDAR AGE																							
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	22	23	24	26	28	TOTAL
1977	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1979	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1980	0	0	7	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
1981	0	0	4	59	19	1	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	86
1982	0	0	0	8	45	9	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65
1983	0	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
1984	0	0	17	5	0	2	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
1985	0	0	6	40	21	1	6	10	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	86
1986	0	0	3	3	21	2	0	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	33
1987	0	2	3	2	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
1988	0	0	8	12	8	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33
1990	0	0	0	1	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
1991	0	0	0	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
1992	0	0	1	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
1993	0	0	5	7	1	4	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	21
1994	0	0	1	3	2	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
1995	0	0	12	44	28	14	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	104
1996	0	0	0	2	3	2	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10
1997	0	1	1	2	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	8
2000	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2001	0	0	4	20	10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38
2002	0	0	12	30	25	13	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84
2003	0	4	39	119	108	33	14	2	2	1	0	0	0	0	1	0	0	1	0	0	0	0	0	324
2004	1	1	38	68	63	46	16	5	4	3	1	1	0	0	0	0	0	0	1	0	0	0	0	248
2005	0	2	51	273	78	24	12	4	4	1	1	1	1	0	0	1	1	0	0	0	0	0	0	454
2006	0	0	16	144	49	16	6	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	234
2007	0	2	95	197	233	53	10	1	2	2	0	0	0	0	0	0	1	0	0	0	0	0	0	596
2008	0	0	46	305	67	43	13	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	480

2009	0	0	39	197	286	24	30	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	580
2010	0	0	17	212	212	159	8	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	614
2011	0	0	7	71	145	65	35	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	324
2012	0	0	18	11	39	33	16	9	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	129
2013	0	1	30	56	4	4	7	2	3	1	1	0	0	0	0	2	0	0	0	0	0	0	0	111
2014	0	3	54	210	34	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	1	2	0	309
2015	0	1	48	115	110	9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	284
2016	0	0	40	147	80	51	5	0	0	0	1	1	0	1	0	0	0	0	0	1	1	0	0	328
2017	0	0	10	78	72	27	16	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	204
2018	0	0	1	53	71	30	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	162
2019	0	1	3	21	59	22	13	4	1	0	1	0	0	0	1	0	0	0	1	1	0	0	1	129
2020	0	0	0	1	8	9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
2021	0	0	2	28	28	21	25	4	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	111
2022	1	1	5	26	56	67	26	13	8	0	0	1	0	0	0	1	0	0	0	0	0	0	0	205

Table 4.10.3. Number of Mutton Snapper sampled per calendar age for all West recreational data sources 1997-2022. Red indicates there were no fish sampled and yellow indicates the number of fish aged was less than the median number while green is the highest number of fish aged.

	CALENDAR AGE																																						
YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	42	TOTAL
1980	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1981	0	7	25	10	3	6	1	5	1	1	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63
1982	0	2	19	27	11	2	15	5	9	3	4	0	0	0	0	2	1	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	104
1985	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1991	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
1993	0	0	5	5	6	7	5	1	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33
1994	0	1	3	3	4	1	2	1	0	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
1995	0	0	6	9	3	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22
1996	0	1	4	5	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
1997	0	2	4	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
2000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2001	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2002	0	6	8	6	6	5	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35
2003	0	0	1	1	1	3	2	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
2004	0	1	4	4	1	2	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
2005	0	1	12	9	9	6	5	3	2	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	50
2006	0	3	19	10	7	11	9	12	4	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77
2007	0	0	11	31	10	12	5	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77
2008	0	4	20	30	71	58	31	27	25	11	15	10	4	2	1	1	3	2	1	1	0	1	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	322
2009	0	1	24	104	45	122	55	38	25	33	16	13	13	4	3	1	3	3	4	1	1	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	513
2010	0	4	10	62	91	30	96	40	23	21	11	5	9	10	3	1	0	0	1	1	1	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	423
2011	0	0	16	51	67	100	32	74	17	10	7	9	2	4	9	1	2	0	2	2	0	1	0	0	2	0	0	0	0	0	0	2	1	0	0	0	0	0	0	411
2012	0	10	4	38	90	62	101	25	64	22	11	12	12	6	10	7	6	5	3	3	0	0	1	3	2	1	0	2	0	2	0	0	0	0	1	0	1	0	0	504
2013	0	4	42	9	36	53	55	58	19	23	16	14	6	2	4	7	2	2	2	2	2	1	1	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	363
2014	0	18	100	47	6	25	30	35	33	4	5	0	0	2	3	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	311
2015	1	19	55	87	59	8	23	26	30	29	6	6	5	5	2	5	3	2	4	2	2	0	1	1	2	0	0	0	0	0	0	0	0	0	0	1	0	1	1	386
2016	0	10	66	119	201	49	9	22	33	51	42	14	15	7	4	3	8	1	4	2	4	1	1	0	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	670
2017	0	6	70	107	73	119	25	1	6	19	15	20	12	8	4	0	2	2	3	3	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	499
2018	0	2	31	97	121	84	101	15	3	7	20	24	23	6	10	1	5	2	0	1	1	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	558
2019	0	2	25	91	61	36	18	10	6	3	1	3	3	6	0	1	2	0	1	0	0	0	0	0	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	273
2020	1	0	1	8	12	6	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31
2021	0	0	5	15	9	20	7	3	4	1	0	0	1	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69
2022	0	0	12	18	26	19	25	13	1	3	2	2	1	1	0	2	1	3	1	0	1	0	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	138

4.11. FIGURES

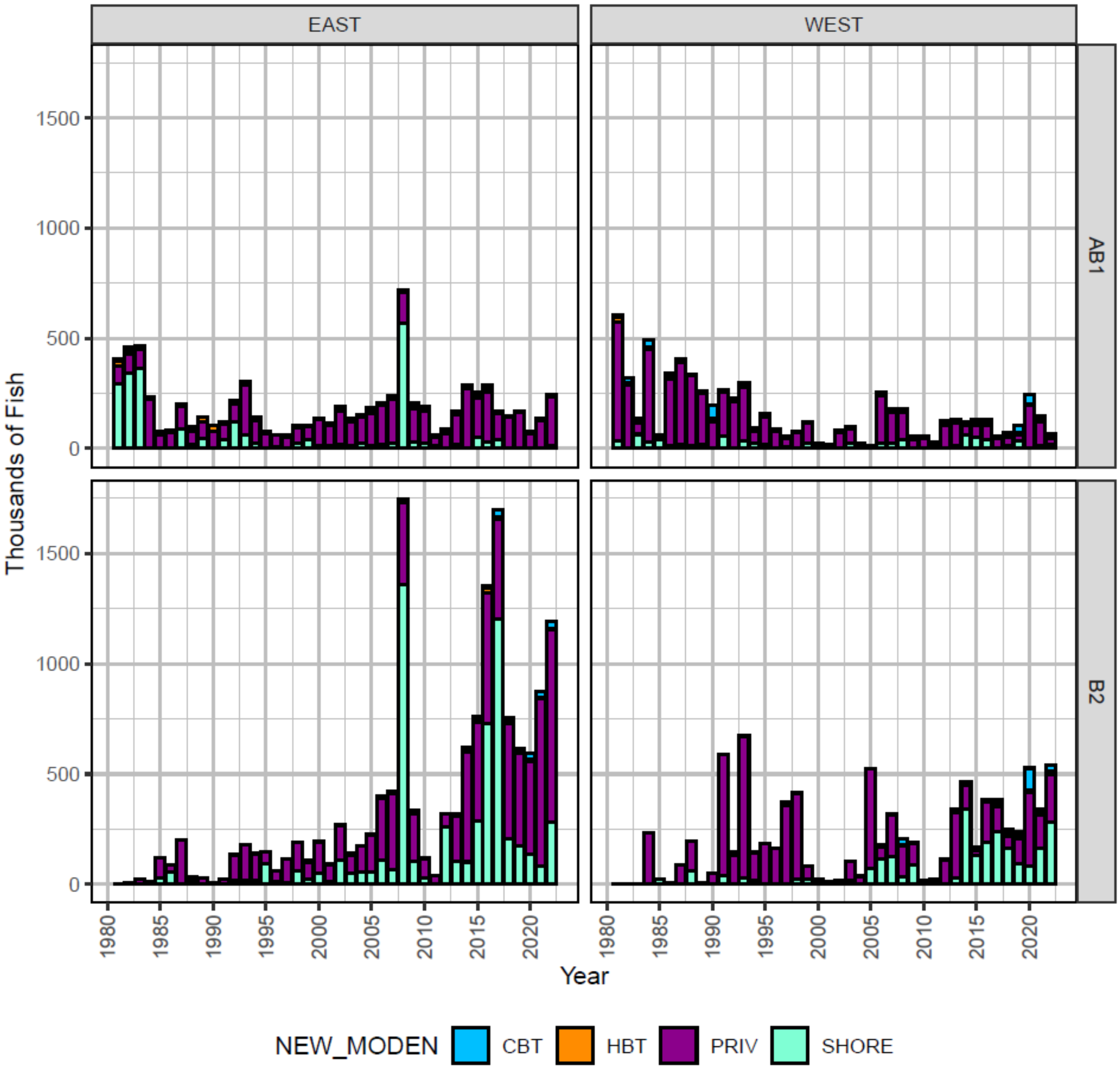

Figure 4.11.1. Annual Mutton Snapper landings (AB1) and discards (B2), in thousands of fish, by location and mode from 1981 to 2022 (MRIP, LACreel 2014+, TPWD). Note catch from the combined Private-Shore fishing mode in the LA Creel survey has been added to the Private mode. MRIP Headboat estimates are included from Texas to western Florida (1981-1985) and Virginia to Maine (1981+). This does not include estimates from SRHS.

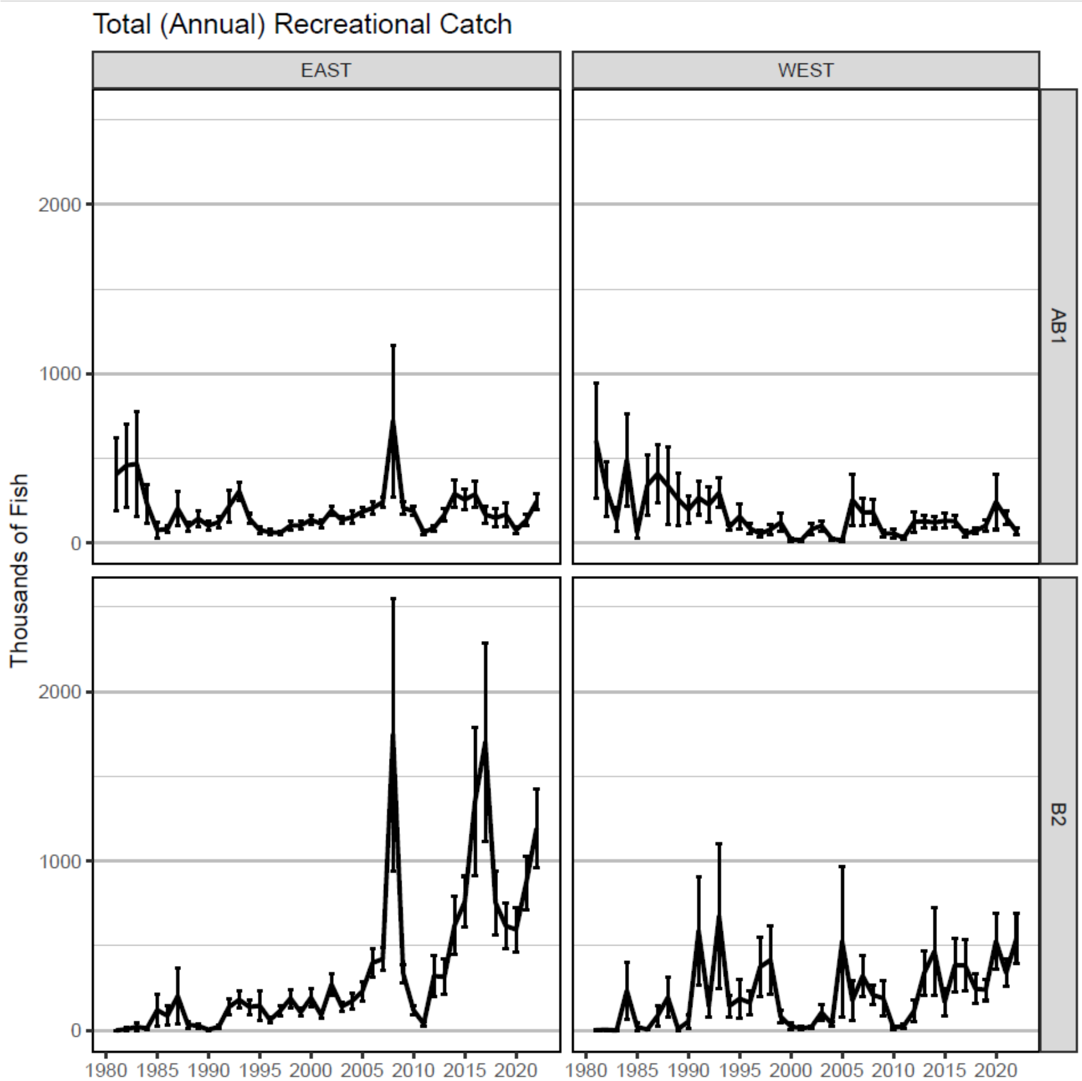

Figure 4.11.2. Mutton Snapper landings (AB1) and discards (B2), in numbers of fish, with associated coefficients of variation (CV; Dettloff et al. 2020) by year for all modes combined (MRIP, LACreel 2014+, TPWD, SRHS).

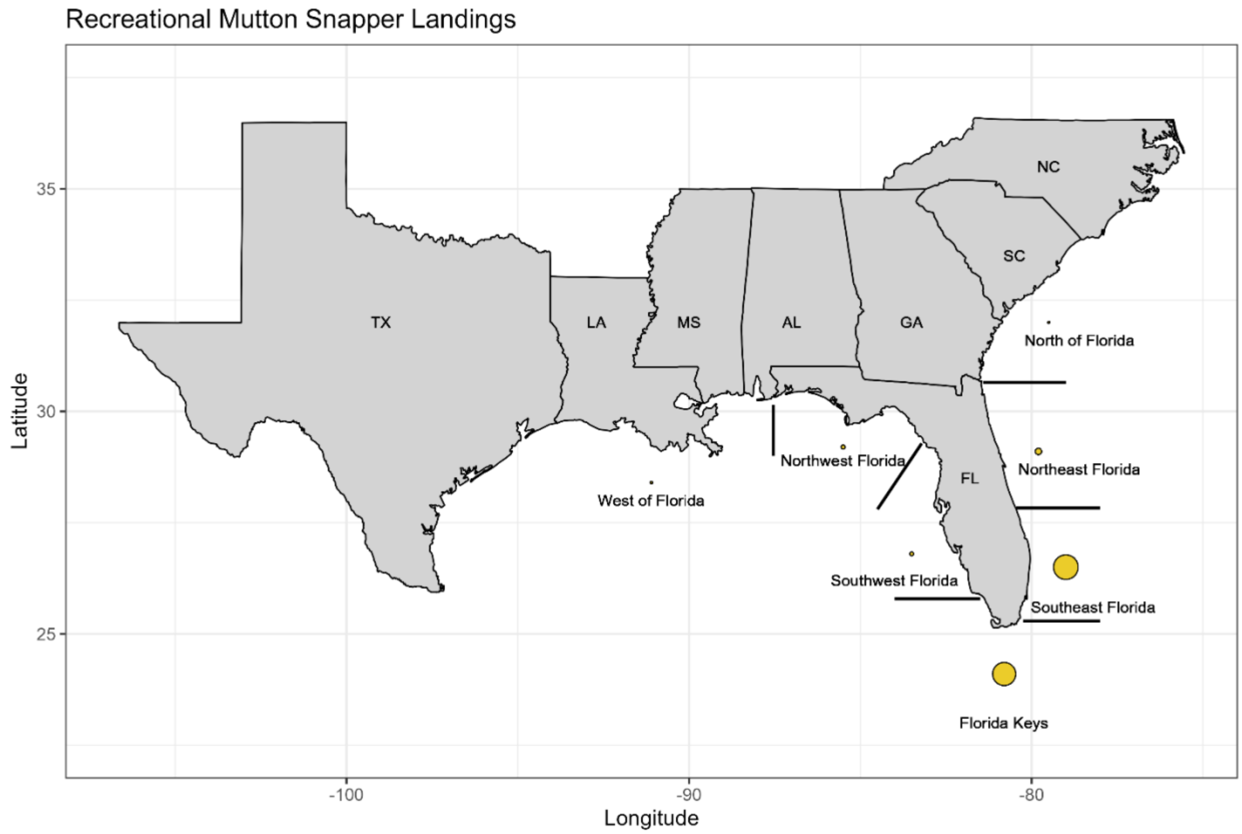

Figure 4.11.3. Distribution of total recreational landings (AB1), in thousands of fish, for Mutton Snapper by region. Estimates are combined across all surveys (MRIP, SRHS, TPWD, and LA Creel) and represent the average of 1981-2022 landings.

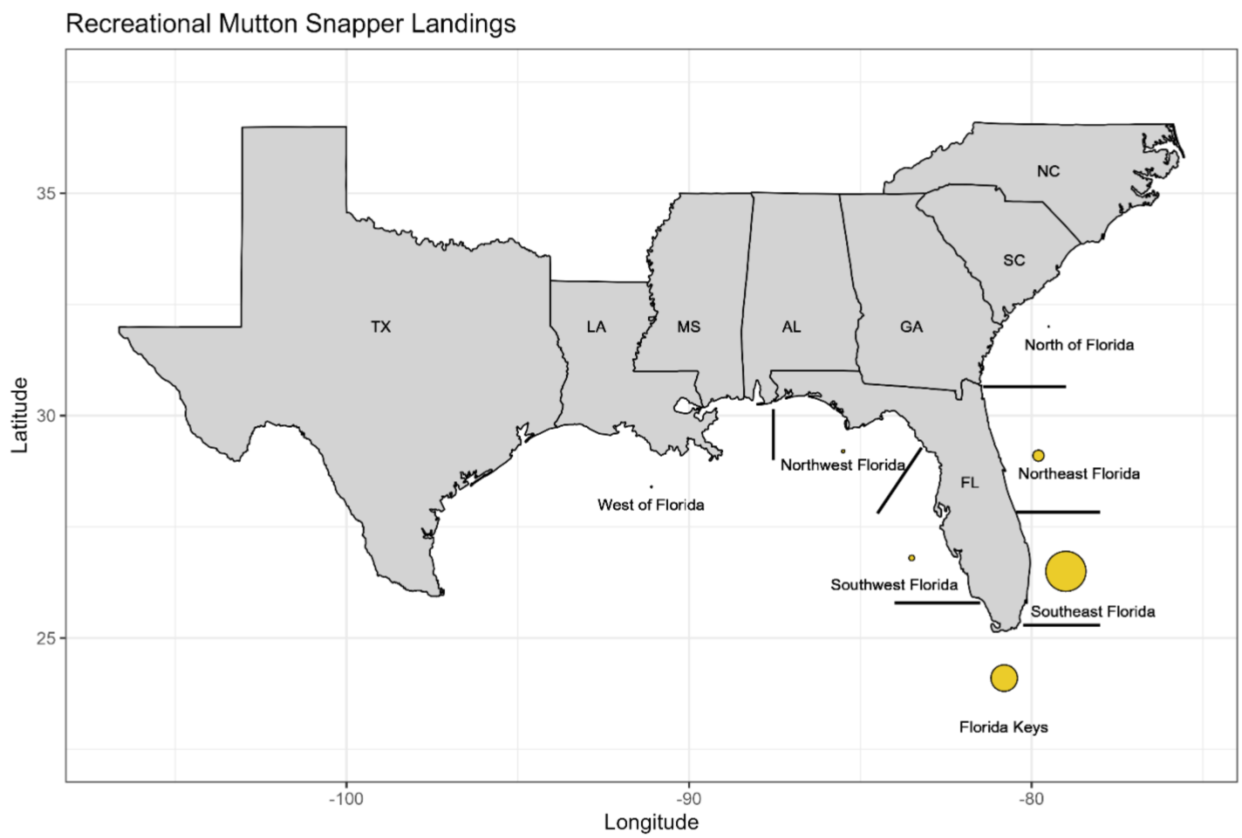

Figure 4.11.4. Distribution of total recreational releases (B2), in thousands of fish, for Mutton Snapper by region. Estimates are combined across all surveys (MRIP, SRHS, TPWD, and LA Creel) and represent the average of 2004-2022 releases.

Figure 4.11.5. Distribution of private, charter, and shore mode fishing effort (MRIP, TPWD, and LA Creel) by region. Estimates are the average number of angler trips from 1981-2022.

Figure 4.11.6. Distribution of headboat (SRHS) fishing effort by region. Estimates are the average number of angler days from 1986-2022.

5. INDICES OF POPULATION ABUNDANCE

5.1. OVERVIEW

The Index Working Group (IWG) reviewed indices and the accompanying analyses from 7 fishery independent and 5 fishery-dependent datasets from the eastern Gulf of Mexico (GOM) and the South Atlantic. Section 5.2 lists all the working papers reviewed by the IWG, which contain the full descriptions of the datasets, analytical methods, and model diagnostics. The IWG reviewed and evaluated each index following the criteria listed in Section 5.3.

One fishery-dependent and six fishery-independent indices of abundance were deemed “Suitable and Recommended” by the IWG (Table 5.8.1). Rationalizations for the recommendation or exclusion of an index are given in the ‘Comments on Adequacy for Assessment’ in Sections 5.4 (fishery-independent) and 5.5 (fishery-dependent). Annual sampling effort, proportion positive, relative abundance and coefficient of variation on the mean (CV, standard error/mean) for “Suitable and Recommended” indices are shown in Table 5.8.1. Spatial coverage and overall trends of these indices are presented in Figures 5.9.1 and 5.9.2, respectively.

5.1.1. Index Working Group (RWG) Members

Shanae Allen (lead)	FWRI, St. Petersburg, FL
Heather Christiansen	FWRI, St. Petersburg, FL
Rob Cheshire (for Nathan Bacheler) SEFSC	
Roy Crabtree	GMFMC SSC
Sean Keenan	FWRI, St. Petersburg, FL
Brian Klimek	FWRI, Cedar Key, FL
Robert Muller	FWRI, St. Petersburg, FL
James Nance	GMFMC SSC
Michaela Pawluk	SEFSC
Ted Switzer	FWRI, St. Petersburg, FL
Kevin Thompson	SEFSC
Steve Turner	SAFMC SSC

5.1.2. Terms of Reference

The IWG was tasked with completing objectives associated with the following Terms of Reference:

DW ToR #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 using a terminal year of 2022.

- Consider species identification issues between mutton snapper and other species, and correct for these instances as appropriate
- 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 adequately and reliably represent population abundance for use in assessment modeling
- Provide appropriate measures of uncertainty for the abundance indices to be used in stock assessment models
- Rank the available indices with regard to their reliability and suitability for use in assessment modeling

5.2. REVIEW OF WORKING PAPERS

Eight working papers were submitted for review to the IWG:

SEDAR 79-DW-08: Preliminary standardized catch rates of mutton snapper from the United States Gulf of Mexico and South Atlantic commercial handline and longline fisheries, 1993-2022 (Sustainable Fisheries Branch 2023)

SEDAR 79-DW-10: Standardized video counts of southeast US Atlantic mutton snapper (Lutjanus analis) from the Southeast Reef Fish Survey (Bacheler et al. 2023)

SEDAR 79-DW-13: Standardized Catch Rates of Mutton Snapper (Lutjanus analis) from the Marine Recreational Information Program (MRIP) in Southeast Florida and the Florida Keys, 1981-2022 (Allen 2023)

SEDAR 79-DW-15: Biscayne National Park Creel Survey index, 1978-2022 (Muller 2023)

SEDAR 79-DW-16: Riley's Hump Visual Census Survey, Tortugas South Ecological Reserve 2002-2015 (Muller 2023)

SEDAR 79-DW-17: Standardized visual indices for Mutton Snapper, Lutjanus analis, for the Florida Keys (1997 – 2022), Dry Tortugas (1999-2021), and Southeast Florida (2013-2022) (Muller and Allen 2023)

SEDAR 79-DW-18: Age-0 Mutton Snapper Abundance Index from Inshore Surveys of Indian River Lagoon on Florida's Atlantic Coast (Klimek et al. 2023)

SEDAR 79-DW-21: Indices of abundance for Mutton Snapper (*Lutjanus analis*) using combined data from two fishery independent video surveys (Christiansen et al. 2023)

5.3. CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATION

All indices presented to the IWG were evaluated based on the following criteria:
- Fishery Dependent or Independent
- Data Sources
- Temporal Range
- Spatial Range
- Survey Design (e.g., fixed sampling sites, stratified random etc.)
- Sampling Methodology (e.g., gear, vessels, effort etc.)
- Ages and/or sizes represented
- Analytical Methods Appropriate?

After the index was evaluated, it was deemed either Suitable or Not Suitable, following the guidance in the Terms of Reference (see section 5.1). Once all the indices were evaluated on their own merits and determined to be Suitable / Not Suitable, suitable indices then entered the second stage of review that determined whether they would be recommended for use in the assessment. Indices were then assigned one of the following categories.

- Suitable and Recommended: Based on the criteria listed above, the index met the minimum requirements for being considered for use in the assessment and was deemed to be a representative example of the population trends for a given area.

- Suitable and Not Recommended: Based on the criteria listed above, the index met the minimum requirements for being considered for use in the assessment and was deemed not to be a representative example of the population trends for a given area.

- Not Suitable (Not Recommended): Based on the criteria listed above, the index did not meet the minimum requirements for being considered for use in the assessment.

5.4. FISHERY-INDEPENDENT INDICES

5.4.1. FWRI FIM Inshore Seine Survey (Indian River Lagoon, FL)

The Florida Fish and Wildlife Conservation Commission's Fisheries Independent Monitoring (FIM) program began in 1989 with seasonal stratified random sampling in Tampa Bay. In 1996, sampling switched from seasonal to monthly and long-term data sets have been established for seven estuaries throughout Florida (Apalachicola Bay, Cedar Key, Tampa Bay, Charlotte Harbor, Northeast Florida, Northern Indian River Lagoon and Southern Indian River Lagoon). Sampling within each estuary is stratified by habitat and gear type proportional to the available sampling area. The primary gear type used to sample juvenile and adult sportfishes is a 183 x 2.5 m center bag haul seine that has a stretched mesh length of 38 mm. This seine is deployed by boat along a shoreline to cover an approximately 40 m x 103 m area before being retrieved by hand. Mutton Snapper were most commonly encountered by the two labs that sample Indian River Lagoon, Indian River (IR) and Tequesta (TQ).

Methods of Estimation

Working Paper Number: SEDAR79-DW-18

Data Type: Fishery Independent

Time Series: 1999-2022

Sampling Intensity: Monthly sampling (Table 5.8.1; Figure 1 and Tables 1 and S1 in working paper)

Size/Age Data: Primarily age-0 fish from 34 – 190 mm standard length (SL; Figure 4 in working paper).

Data Filtering Techniques: Removal of data/variables with excess zeros/low sample sizes prior to model construction. Removal of sequences with missing variable information. Size cutoff for primarily age-0 fish was chosen as 190mm SL and July-December was selected as the recruitment window.

Standardization: A generalized linear model with a negative binomial distribution was constructed to model catch of age-0 Mutton Snapper using geographic zone, shore type, bottom type, month and year as variables and temperature, depth, and salinity as covariates. Stepwise selection based on AIC was used to determine variable/covariate inclusion in the final model.

Submodel Variables:

Negative Binomial: Catch per set = Month + Year + Bottom Type + Geographic zone + Temperature + Depth + Salinity

Abundance Indices: Table 5.8.1, Figure 5.9.2; Table 3 and Figure 5 in working paper.

Uncertainty and Measures of Precision:

Least squares means and standard errors were calculated for each year along with annual coefficients of variation (CV). These annual CVs were determined by multiplying the standard error of the model by deviates derived from a standard normal distribution (n=10,000) and adding these values to the calculated least squares mean. This new sampling distribution was then used to calculate the standard deviations from which the annual CVs could be derived (Table 3 in the working paper).

Comments on Adequacy for Assessment:

This index was deemed suitable and recommended. This index was the sole index estimating age-0 relative abundance of Mutton Snapper. Although the dataset is from outside the areas of highest adult abundance, the length of the time series and fishery-independent nature of this survey are believed to adequately represent recruitment of this species for the area. A large peak in recruitment in 2007 coincided with peaks in juvenile and sub-adult abundance in subsequent years in other surveys which led to further support for this index. While not initially included in the working paper for the workshop, 2022 data will be incorporated into the final working paper. Additionally, a power analysis was conducted on this dataset supporting the combining of Tequesta and Indian River into a single estuary for tracking changes in Mutton Snapper abundance moving forward.

5.4.2. National Marine Fisheries Service's (NMFS) Reef Visual Census (RVC, Dry Tortugas and FL Keys) and Southeast Florida Coral Reef Initiative (SEFCRI, SE FL)

National Marine Fisheries Service's (NMFS) Reef Visual Census (RVC) began in 1979 with divers identifying and counting fish along Florida's reef track. The program evolved into gridding the entire reef track into 50m x 50m blocks (originally 200 m x 200 m blocks) and listing the habitats in each block (Primary Sampling Units, PSU). Primary Sampling Units are randomly sampled by habitat with the number of samples depending upon the variability of the strata. Depths sampled range from approximately 1 to 33 meters across all regions.

Methods of Estimation

Working Paper Number: SEDAR79-DW-17

Data Type: Fishery Independent

Time Series: 2013 – 2022 (Southeast Florida), 1997 – 2022 (Florida Keys), and 1999 -2021 (Dry Tortugas)

Sampling Intensity: Table 5.8.1; Tables 4a (Southeast Florida), 4b (Florida Keys), 4c (Dry Tortugas) in the working paper.

Size/Age Data: In southeast Florida, the median size of observed Mutton Snapper was 37 cm maximum TL and the interquartile range was 33 to 42 cm maximum TL (full range: 3 to 82 cm maximum TL). In the Florida Keys, the median size was 44.4 cm maximum TL and the interquartile range was 35.8 to 49.7 cm maximum TL (full range: 3.7 to 87.2 cm maximum TL). The median size of Mutton Snapper observed in the Dry Tortugas was 52 cm maximum TL with an interquartile range of 44.4 to 61.5 cm maximum TL (full range: 14.9 to 100.6 cm maximum TL). There were no ages collected in this survey because the divers only observe the fish and do not capture them.

Data Filtering Techniques: The data were filtered to remove habitats that were not on the reef track in all regions, stations with missing explanatory variables were deleted, data from months with few observations were deleted such that the Florida Keys only included data from June through September and the Dry Tortugas only included data from May through July, and southeast Florida included data from June through October. The final data set contained 3530 stations/ 1218 positive stations (35%, Southeast Florida), 10135 stations/1936 positive stations (19%, Florida Keys), and 6019 stations/1834 positive stations (30%, Dry Tortugas).

Standardization: Six model configurations were developed for each of the regions. They included a design model and five model based configurations including a negative binomial distribution model, a Poisson distribution model, and three hurdle models each of which used the same binomial model with a logit link for the proportion positive estimation and the mean number of Mutton Snapper observed were model with either a gamma, Poisson, or log-normal distribution indices all five of which used a log link. The final model was the model which had the lowest root mean square error term.

Model/Submodel Variables:

Southeast Florida

Binomial: Presence/Absence = Year + Month + Stratum + Subregion
Poisson: Number observed per station = Year + Stratum

Florida Keys

Poisson: Number observed per station = Year + Depth + Subregion + Habitat

Dry Tortugas

Negative Binomial: Number observed per station = Year + Protected Status

Abundance Indices: Table 5.8.1, Figure 5.9.2; In the working paper - Southeast Florida: Table 4a/Figure 5a, Lengths - Figure 7a, Florida Keys: Table 4b/Figure 5b, Lengths - Figure 7b, Dry Tortugas: Table 4c/Figure 5c, Lengths - Figure 7c. All the regional indices showed increases in recent years.

Uncertainty and Measures of Precision: The variability in the estimated annual index values was estimated using a Monte Carlo simulation approach with 10,000 iterations that used the least-squares mean estimates and their standard errors. Each iteration used the annual least-squares mean estimate on the linear scale and uncertainty was added by multiplying the annual least-squares mean estimate's standard error by a random normal deviate (μ=0, σ=1). After the two estimates were transformed back from their linear scales, they were multiplied together to form the annual index value. For the negative binomial model, and the Poisson model, the process was simpler because these configurations only involved a single distribution.

Comments on Adequacy for Assessment: The Index Working group deemed these indices Suitable and Recommended because the regional indices are Fishery Independent and RVC uses a random sample design. Also, the three regions cover the core area of the Mutton Snapper distribution in the SE US. The IWG accepted the use of separate indices because the lengths of the Mutton Snapper observed in the Dry Tortugas were typically larger and those observed in Southeast Florida were smaller than the lengths from the Florida Keys. Additionally, there were only three years for which sampling occurred in all regions.

5.4.3. Southeast Reef Fish Survey (SERFS, Cape Hatteras, NC to St. Lucie Inlet, FL)

The Southeast Reef Fish Survey is a collaborative trap and video survey conducted by NOAA Fisheries and the South Carolina Department of Natural Resources. SERFS has been conducted since 1990 using baited chevron traps, and video cameras were attached to traps regionwide in 2011. The spatial extent of the survey ranges from Cape Hatteras, NC, to St. Lucie Inlet, FL, from approximately 15 to 115 m deep. SERFS is conducted from late spring through early fall each year. The survey uses a simple random sampling design, selecting approximately 1,500 stations to sample out of a sampling universe of approximately 4,300 stations, all on reef habitat. Mutton Snapper were rarely caught in traps, so we used video counts only here.

Methods of Estimation

Working Paper Number: SEDAR79-DW-10

Data Type: Fishery Independent

Time Series: 2011–2022

Sampling Intensity: Table 5.8.1; Table 1 and Figure 2 in working paper.

Size/Age Data: No size or age data from videos, selectivity must be assumed.

Data Filtering Techniques: Standard filtering to remove videos that did not record properly.

Standardization: Zero-inflated negative binomial model. A step-wise backwards model selection procedure based on AIC was used to systematically exclude unnecessary parameters from the full model formulation. However, convergence issues prevented full exploration of reduced sub-models which were most likely due to low proportion positives among levels of variables.

Submodel Variables

Binomial Model: Presence/Absence =Year + Water Clarity + Current Direction + Substrate Composition + Depth + Day of Year + Latitude + Bottom Temperature

Count Model: SumCount = Year + Substrate Composition + Day of Year

Abundance Indices: Table 5.8.1, Figure 5.9.2; Table 3 and Figure 7 in the working paper

Uncertainty and Measures of Precision: Uncertainty in the index was computed using a bootstrap procedure with n = 1,000 replicates. In each replicate, a data set of the original size was created by drawing observations (rows) at random with replacement. This was done by year, to maintain the same annual sample size as in the original data. The model was fitted to each data set, and uncertainty (CVs) was computed. All of the 1,000 runs converged.

Uncertainty in the calibration factor was included in the bootstrap procedure by drawing a random value from a normal distribution with a mean of 1.683 and a standard error of 0.029 (estimates from the regression). These values, one for each bootstrap replicate, were used to scale up the 2011–2014 index estimates. Thus, this method accounts for the adjustment in the 2011–2014 estimates, as well as the corresponding CVs.

Comments on Adequacy for Assessment:

The SERFS index was deemed Suitable and Recommended by the Index Working Group because it is a fishery independent survey that primarily uses a random sampling design and has little spatial overlap with other fishery independent surveys. Additionally, the index exceeds the SEDAR best practice minimum duration of 5 years, and the CVs and proportion positive are satisfactory in most years. Since size or age data from videos were not available for this assessment, the IWG recommended using age-based knife edge selectivity between ages 2 and 3.

5.4.4. Gulf of Mexico Combined Stereo Video Survey (SW FL)

Historically, three different stationary video surveys were conducted to assess trends in reef fish relative abundance in the northern Gulf of Mexico (GOM). Two of these surveys operated in the range of Mutton Snapper (*Lutjanus analis*). The NMFS SEAMAP reef fish video survey (SRFV), carried out by NMFS Mississippi Laboratory, has the longest running time series (1992-

1997, 2002, and 2004+), followed by the Florida Fish and Wildlife Research Institute survey (FWRI, starting year 2008). While all three surveys use standardized deployment, camera field of view, and fish abundance methods to quantify fish on reef or structured habitat, there were variations in survey design and habitat characteristics collected in addition to the time period and area sampled. Historically, independent indices were submitted for each respective survey. However, in most recent reef fish stock assessments, data from these video surveys have been combined to generate combined indices more representative of the total unit stock (Thompson et al. 2019a, 2019b, 2022a). Early efforts indicated that combining data from multiple surveys with varied spatial coverage through the use of a year only model can yield spurious conclusions regarding stock abundance (Campbell 2004; Ye et al. 2004). Accordingly, we used a habitat-based approach to combine relative abundance data for generating annual trends for Mutton Snapper throughout the eastern GOM (Thompson et al. 2022b).

Methods of Estimation

Working Paper Number: SEDAR79-DW-21

Data Type: Fishery Independent

Time Series: 1993-2021

Sampling Intensity: Table 5.8.1; Table 1 in working paper.

Size/Age Data: Represents sub-adult through adult biomass; see figure 6 in working paper**.** The median size of observed Mutton Snapper was 56.6 cm maximum TL and the interquartile range was 46 to 66 cm maximum TL (full range: 27.3 to 105 cm maximum TL). There were no ages collected in this survey.

Data Filtering Techniques: For all surveys, video reads were excluded if they were unreadable due to turbidity or deployment errors. For the SFRV survey, data included in the original index run are from 1993 and on, due to different counting methods in 1992. There was either no sampling or low sampling in 1998-2001 and 2004, therefore these years were excluded from the analysis. In addition, due to issues with no Mutton Snapper observed, or insufficient data to estimate coefficients of variation, data prior to 1996 were excluded. In addition, data from 2013 and 2015 were excluded due to the survey excluding the core area of distribution for Mutton Snapper (Dry Tortugas). For the FWRI survey, data prior to 2010 was excluded from analyses because 2010 was the first year that side scan sonar was used to identify reef habitats to sample in this survey, and side-scan geoform, which is often an important explanatory variable in the analyses, was unavailable from these early years. Mutton Snapper are rarely observed north and west of statistical zone 5 or in waters deeper than 110 m; therefore, all data north of 28° N (including all data from the western Gulf) and deeper than 110m were excluded from subsequent analyses.

Standardization: Relative abundance indices were generated using a stepwise approach. First, a standardized habitat variable was created by conducting a classification and regression tree (CART) analysis for each lab to determine which lab-specific explanatory variables were important determinants of presence/absence. Terminal nodes were then assigned a habitat value of Good (more than twice the nominal frequency of occurrence), Fair, or Poor (less than half the nominal frequency of occurrence). All individual observations were then assigned values of the newly-defined habitat variable. Annual estimates of relative abundance and standard error were produced for each combination of survey and habitat, and weighted annual estimates of abundance and variability were calculated following a post-stratified design-based approach.

Submodel Variables

Retained CART variables by survey:

SFRV: presence/absence of rock, presence/absence of sponge, presence/absence of soft coral, maximum relief, depth, latitude, longitude

FWRI: presence/absence of soft corals, presence/absence of sponge, geoform, latitude, longitude, depth

Submodel for mean and standard error of Max N

MaxN=year *habitat* survey

Abundance Indices: Table 5.8.1, Figure 5.9.2; Table 4 and Figure 7 in the working paper.

Uncertainty and Measures of Precision:

The SFRV CART model had a 19.6% misclassification rate, while the FWRI CART model had a 5% misclassification rate. Coefficients of variation for final annual relative abundance estimates ranged from 0.144 to 0.652.

Comments on Adequacy for Assessment:

After review by the index working group, this index was deemed both suitable and recommended for use for Mutton Snapper. This decision was due to the fact that the survey covered the full spatial extent and range of habitats occupied by Mutton Snapper in the Gulf, the generally large sample sizes (especially in recent years), and the availability of size data from this survey. While not initially included in the working paper for the workshop, 2022 data will be incorporated into the final working paper.

5.4.5. Riley's Hump Visual Census Survey (Tortugas South Ecological Reserve)

NOAA began the visual census at Riley's Hump in July 2001 with the objective of evaluating the effectiveness of the Tortugas South Ecological Reserves on the numbers of snappers and groupers (Burton et al., 2005). Riley's Hump is a moderately deep reef with the top of the reef at approximately 30 m with some variation in height of up to 5 m (Mallinson et al. 2003). Fixed stations were established in 2001 and 2002. Divers counted fish along random transects at stations, usually two to four transects per station per day.

Methods of Estimation

Working Paper Number: SEDAR79-DW-16

Data Type: Fishery Independent

Time Series: 2002 – 2015

Sampling Intensity: Table 2 in working paper.

Size/Age Data: Divers observed the Mutton Snapper in this survey, but did not capture them; thus, there are no age samples. In 2012, divers began using laser equipped cameras to estimate the lengths of fish *in situ*. Total lengths were grouped into 5 cm bins and the length range was 35 to 80 cm (Figure 6 in the working paper).

Data Filtering Techniques: Data from 2001 were omitted because transects were 50 m long and data from 2010 were also omitted because only two stations were sampled that year. Stations that were only sampled in two or fewer years were also omitted. Ony two stations were sampled in April and no stations were sampled in August; therefore, the data were restricted to stations sampled in May through July. The final dataset had 285 stations and Mutton Snapper were observed at 199 stations (70%).

Standardization: Five models were evaluated including a negative binomial distribution model, a Poisson distribution model, and three hurdle models each of which used the same binomial model with a logit link for the proportion positive estimation and the mean number of Mutton Snapper observed were model with either a gamma, Poisson, or log-normal distribution indices all five of which used a log link. The final model was the hurdle – Poisson model which had the lowest root mean square error term (Table 1 in the working paper).

Submodel Variables

Binomial: Presence/Absence = Station + Year + Visibility category + Number of transects

Positive: Number observed = Station + Year + Month + Visibility category

Abundance Indices: Table 2 and Figure 4 in the working paper.

Uncertainty and Measures of Precision: The uncertainty in the annual estimates was derived from a Monte Carlo approach using the least square means (LS means) and their standard errors from the two submodels. In each iteration, a random normal deviate was drawn from $N(\mu = 0, \sigma = 1)$ and multiplied by the standard error and this error term was added to the LSmeans and then back transformed to the arithmetic scale. This was done for both submodels and the resulting back transformed LSmeans from each submodel were multiplied and the process was repeated 5000 times for each year. The standardized residual distributions are shown in Figure 3. The CVs of the annual index values were all less than 0.22 (Table 2 in the working paper).

Comments on Adequacy for Assessment: The DW Index group rated this index Not Suitable and Not Recommended because of the limited spatial and temporal coverage (the terminal year was 2015) and potentially nonrepresentative sampling (stations were fixed not random and sampling was geared towards spawners instead of the broader population). Lastly, the length frequency was similar to that observed in the Dry Tortugas RVC.

5.5. FISHERY-DEPENDENT INDICES

5.5.1. Recreational (Private – SE FL and FL Keys)

Mutton Snapper are caught by recreational anglers primarily in South Florida from Indian River to Monroe County. The Marine Recreational Fisheries Statistics Survey (MRFSS) was initiated in 1981 to collect catch, effort, and participation estimates from the recreational sector. Then in

2008, the Marine Recreational Information Program (MRIP) officially replaced MRFSS as a more precise and accurate method for estimating recreational catch and effort. Indices of abundance were developed for Southeast FL and the FL Keys by standardizing trip-level catch-per-unit effort (defined as average total catch per contributor) of Mutton Snapper using a delta-GLM approach (Lo, Jacobson, and Squire 1992; Dick 2004; Maunder and Punt 2004). A suite of co-occurring species was identified for each region to serve as a proxy for favorable Mutton Snapper conditions (Shertzer and Williams 2008). An agglomerative hierarchical cluster analysis was performed for each region with average linkage on the Bray-Curtis similarity measure applied to catch/abundance data for each species (i.e., total unadjusted catch [landed+released] of a species per trip).

Methods of Estimation

Working Paper Number: SEDAR79-DW-13

Data Type: Fishery Dependent

Time Series: FL Keys 1981 – 2022; SE FL 1982 – 2022

Sampling Intensity: Tables 9 and 10 in working paper.

Size/Age Data: The interquartile range of retained lengths across both regions and years is approximately 35 cm to 50 cm maximum TL, with a median of approximately 45 cm maximum TL (Figure 3 and Figure S4 in working paper).

Data Filtering Techniques: Data were limited to private mode fishing trips using hook and line gear in SE FL and the FL Keys. Trips were first removed if none of the species in the cluster were encountered. Trips were also removed if median hours fished, number of contributors, or median avidity were not available, and in addition if median hours fished exceeded 24 hours. In the FL Keys, there were very few inshore fishing trips, so these were also removed. Years with five or fewer positive observations were removed. After filtering, 14,839 trips remained for SE_FL (3,019 positive trips) and 5,003 trips in the Florida Keys (614 positive trips).

Standardization: Delta-Lognormal GLM. Explanatory variables were selected using stepwise forward selection based on a reduction in mean deviance by at least 0.5%.

Model/Submodel Variables:

FL Keys

Binomial: Presence/Absence = Year + Number of Contributors + Median Hours Fished

Normal: Log(Catch/Number of Contributors) = Year + Waters Fished

SE FL

Binomial: Presence/Absence = Year + Median Avidity

Normal: Log(Catch/Number of Contributors) = Year + Median Avidity + Waters Fished

Abundance Indices: Tables 9 and 20 and Figures 23 and 24 in working paper.

Uncertainty and Measures of Precision: Confidence intervals and annual means were estimated by simulating the distribution of the predicted means using 10,000 randomly generated residuals; each residual was a random normal deviate times the standard error for its predicted mean which was then added to the least squared means for the year factor in either log scale (for the positive model) or the logit scale (for the binomial model). Lastly, these estimates were back-transformed and multiplied together to estimate a distribution of the number per contributor and the distribution was described in terms of percentiles and a mean.

Comments on Adequacy for Assessment:

The recreational indices in SE FL and the FL Keys were deemed suitable but not recommended for use in SEDAR 79 for several reasons. First, as with any fishery dependent CPUE, caution is needed when inferring trends in abundance as changes in angler targeting behavior, fishing techniques, and regulation changes can lead to changes in CPUE that are not reflective of changes in abundance. The primary reason the IWG did not recommend the SE FL and FL Keys recreational indices was due to the overlapping spatial coverage with the fishery independent Reef Visual Census (RVC) in the FL Keys and the Southeast Florida Coral Reef Initiative (SEFCRI). Additionally, there is a low number of positive samples in FL Keys, and in southeast FL, the increase in CPUE appears to be driven by discards per unit effort (Figure 16 in the working paper). However, length information on discards is sparse and originates from other boat modes (i.e., headboat and charter) that may exhibit different retention patterns compared to the private mode. Furthermore, discards are self-reported by anglers and there are reports that undersized Mutton Snapper (< 10 in) could be misidentified as Lane Snapper.

5.5.2. Recreational (Private – Biscayne Bay National Park)

Biscayne National Park is located south of Miami and north of Key Largo and is adjacent to the Florida Keys National Marine Sanctuary. The Biscayne Creel Survey began in 1976, was discontinued in 1988, and resumed in 1992. Park personnel interview returning anglers about their fishing activity. At access points in the park, National Park samplers ask anglers where the anglers are from, whether they were fishing, how many persons were fishing, when they began fishing, how long did they spend fishing, where they spent most of their time fishing, their fishing experience, if they are aware of the fishing regulations, what they caught and whether they kept the fish or released their catch. The interviews are considered to represent a fishing trip. When additional interviewers were available, more than one access point could be sampled on the same day. In 1993, samplers began asking anglers if they may measure the angler's retained fish. The samplers measure the centerline length (fork length in cm) of the fish.

Methods of Estimation

Working Paper Number: SEDAR79-DW-15

Data Type: Fishery Dependent

Time Series: 1978 – 2022; however, there was no sampling from 1988 through 1992.

Sampling Intensity: Table 3 in working paper.

Size/Age Data: The length range was 12.7 to 93.7 cm maximum TL (Figure 6 in the working paper). There were no age samples collected.

Data Filtering Techniques: Only weekend sampling. No sampling in 1988 – 1992, and 2020. Only three trips in 1999 and two trips in 2019 no Mutton Snapper were caught in either year. The final dataset had 7821 trips and Mutton Snapper were caught on 1880 trips (24%).

Standardization: Cluster analysis was used to account for effort where Mutton Snapper were not caught. Different similarity methods and fourth-root transformation and untransformed data were compared and seven species were identified in all the configurations: Mutton Snapper, Gray Snapper, Yellowtail Snapper, Red Grouper, White Grunt, Bluestriped Grunt, and Jolthead porgy. Therefore, trips that caught any species in this group of species were included in the final data set. Five model configurations were developed. They included a negative binomial distribution model, a Poisson distribution model, and three hurdle models each of which used the same binomial model with a logit link for the proportion positive estimation and the mean number of Mutton Snapper observed were modeled with either a gamma, Poisson, or log-normal distribution, all five of which used a log link. The final model was the hurdle – Poisson model which had the lowest root mean square error term (Tabe 2 of the working paper). The criteria for including a variable in the final submodel were whether the variable was statistically significant at the 0.05 level in a Chi squared distribution and whether adding the variable reduced the mean deviance (a measure of uncertainty) by at least 0.5%.

Submodel Variables

Binomial: Presence/Absence = Year + Party composition + Hours fished

Poisson: Number per trip = Year + Party composition + Hours fished + Season

Abundance Indices: Table 3 and Figure 5 in the working paper.

Uncertainty and Measures of Precision: The uncertainty in the annual estimates was derived from a Monte Carlo approach that used the least square means (LS means) and their standard errors. In each iteration of this method, a random normal deviate was drawn from a normal distribution ($\mu = 0$, $\alpha = 1$), and multiplied by the standard error and this error term was added to the LSmeans prior to back transforming the estimate to the arithmetic scale. The hurdle model did this for both submodels and the resulting back transformed LSmeans from each submodel were multiplied. The Monte Carlo simulations were repeated 5000 times for each year. The coefficients of variation in the annual indices are in Table 3/Figure 5 of the working paper.

Comments on Adequacy for Assessment:

The DW Index group deemed this index Suitable but Not Recommended because of the small spatial scale of the survey and that the Reef Visual Census' Biscayne subregion, a fishery independent index, encompasses the same area. The group discussed the possibility of including the length measurements with the recreational fishery.

5.5.3. Commercial Longline

Landings and fishing effort of commercial vessels operating in the Gulf of Mexico and southeast U.S. Atlantic are monitored by the NMFS Southeast Fisheries Science Center through the Coastal Fisheries Logbook Program (CFLP). The program collects trip-level information from all vessels holding federal permits to fish in waters managed by the regional Fishery Management Councils. The available data span the period of 1993 (when the CFLP is considered to be fully implemented) – 2022 (the terminal year for this assessment), and span the Gulf of Mexico, and the southeast US Atlantic. Because the longline fishery operates almost exclusively in the Gulf of Mexico, only those trips occurring in the Gulf of Mexico were included.

Methods of Estimation

Working Paper Number: SEDAR79-DW-8

Data Type: Fishery Dependent

Time Series: 1993-2022

Sampling Intensity: Annual number of trips used to compute the index ranged from 62 to 230 with sample sizes by year shown in Table 2 in the working paper.

Size/Age Data: Lengths from longline gear from the Trip Interview Program (TIP) indicate an interquartile range of 62-79 cm maximum TL and a median of 71 cm maximum TL (full range: 38 to 99 cm maximum TL). The IQR of sampled calendar ages range from 6 – 11 years with a median of 7 years (full range: 2 to 40 years).

Data Filtering Techniques: The data were filtered to remove outliers and were restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip, and only a single gear reported (in this case longline). If a trip reported multiple areas fished, only the first area was used. The data were limited to trips catching at least one snapper-grouper species and were further subset using the Stephens and MacCall approach to identify trips that likely occurred over Mutton Snapper habitat (Stephens and MacCall 2004). The Stephens and MacCall procedure was fit regionally to allow for differences in assemblage structure between the northern and southern regions of the fishery.

Standardization: Catch-per-unit effort (defined as whole weight per number of sets by the number of hooks per set) of Mutton Snapper were modeled using a delta-GLM approach as a function of year, season (summer/fall), area (North/South), days at sea (factor: one day, two to four days, or five or more days), and crew size (factor: 1, 2, or 3 plus). Then stepwise AIC with a backwards selection algorithm was used to eliminate those variables that did not improve model fit.

Submodel Variables:

Binomial: Presence/Absence = Year + Season + Area + Days At Sea + Crew Size

Lognormal: Whole Weight per Number of Sets by the Number of Hooks per Set = Year + Season + Area + Days At Sea + Crew Size

Abundance Indices: Table 5.8.1, Figure 5.9.2; Table 2 and Figure 16 in the working paper.

Uncertainty and Measures of Precision: Estimates of variance were based on 1000 bootstrap runs where trips were chosen randomly with replacement (Efron and Tibshirani 1993). Annual CVs of catch rates are tabulated in Table 2 in the working paper.

Comments on Adequacy for Assessment: The index of abundance created from the commercial logbook data was considered by the IWG to be suitable when truncated to 2010 and was recommended for use in the assessment. The reasoning behind the data truncation was that the implementation of IFQs and the Red Snapper closure had led to changes of fisher behavior, such that the Stephens and MacCall subsetting procedure was no longer identifying species relationships reliably. This was demonstrated by fitting Stephens and MacCall on an annual basis and comparing the species association coefficients through time for the top species identified by the procedure when fitting to the full dataset (Figure 2 in the working paper). The instability of the species association coefficients through time suggests that the species being identified by the full model (all years included) may be mischaracterizing more recent trips, potentially leading to changes in standardized CPUE that are unrelated to changing abundance. While some of the issues described for the handline index are also present in the longline index (e.g., decrease in trips through time), truncation of the index helped to alleviate concerns regarding potential issues. Additionally, because this index covers a size range not covered by other indices, in particular larger, older fish, it was determined that the benefit of including this index outweighed potential issues the index may have.

5.5.4. Commercial Handline

Like the commercial longline index, the commercial handline index relies on data collected by the Coastal Fisheries Logbook Program (CFLP). The available data span the period of 1993 (when the CFLP is considered to be fully implemented) – 2022 (the terminal year for this assessment), and span the Gulf of Mexico, and the southeast US Atlantic.

Methods of Estimation

Working Paper Number: SEDAR79-DW-8

Data Type: Fishery Dependent

Time Series: 1993-2022

Sampling Intensity: Annual number of trips used to compute the index ranged from 219 to 1,612 with sample sizes by year shown in Table 1 in the working paper.

Size/Age Data: Lengths from handline gear from TIP indicate an interquartile range of 48-69 cm maximum TL and a median of 59 cm maximum TL (full range: 23 to 103 cm maximum TL). The IQR of sampled calendar ages range from 4 – 7 years with a median of 5 years (full range: 1 to 40 years).

Data Filtering Techniques: The data were filtered to remove outliers and were restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip, and only a single gear reported (in this case handline). If a trip reported multiple areas fished, only the first area was used. The data were limited to trips catching at least one snapper-grouper species and were further subset using the Stephens and MacCall approach to identify trips that likely occurred over Mutton Snapper habitat (Stephens and MacCall 2004). The Stephens and MacCall procedure was fit regionally to allow for differences in assemblage structure between the Gulf of Mexico and South Atlantic regions of the fishery.

Standardization: Catch-per-unit effort (defined as whole weight per hook hour) of Mutton Snapper were modeled using a delta-GLM approach as a function of year, season (summer/fall), area (North/South), days at sea (factor: one day, two to four days, or five or more days), and crew size (factor: 1, 2, or 3 plus). Then stepwise AIC with a backwards selection algorithm was used to eliminate those variables that did not improve model fit.

Submodel Variables:

Binomial: Presence/Absence = Year + Season + Area + Days At Sea + Crew Size

Lognormal: Whole weight per hook hour = Year + Season + Area + Days At Sea + Crew Size

Abundance Indices: Table 1 and Figure 15 in the working paper.

Uncertainty and Measures of Precision: Estimates of variance were based on 1000 bootstrap runs where trips were chosen randomly with replacement (Efron and Tibshirani 1993). Annual CVs of catch rates are tabulated in Table 1 in the working paper.

Comments on Adequacy for Assessment: The index of abundance created from the commercial logbook data was considered by the IWG to be suitable, but not recommended for use in the assessment. While the data cover a wide geographic range relative to that of the stock, and logbooks represent a census of the fleet, fishery-independent indices were available which covered similar spatial and temporal extents and a similar size range of fish. Fishery-independent indices are generally preferred over fishery dependent indices because it is difficult to disentangle changes in the index due to changes in abundance versus changes in fisher behavior. Additionally, the decrease through time in trips being selected by the Stephens and McCall procedure, and the decrease through time in proportion positive trips suggests the index may be problematic, and it was therefore not recommended for use.

5.6. RESEARCH RECOMMENDATIONS

- The IWG recommends analyzing past and future videos from stereo cameras deployed as part of the Southeast Reef Fish Survey (SERFS) for Mutton Snapper lengths.
- Explore methods to incorporate lengths sampled by the Biscayne Bay Creel Survey into the MRIP APAIS.
- Add Mutton Snapper to FWC FIM’s standard cull list to collect otoliths from Mutton Snapper sampled by the 183-m seine survey in the Indian River Lagoon.
- Consider incorporating power analyses for other indices similar to the exploratory power analysis of the FIM inshore seine survey.

5.7. LITERATURE CITED

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5.8. TABLES

Table 5.8.1. Sampling effort (N), proportion positive (Prop Pos), relative abundance (Std Index) scaled to a mean of one for each time series and the coefficient of variation on the mean (CV, standard error/mean) of indices deemed "Suitable and Recommended" for SEDAR 79 from west to east.

	Commercial Longline (FD)				GOM Combined Stereo Video Survey (FI)				RVC Dry Tortugas (FI)			
Year	N	Prop Pos	Std Index	CV	N	Prop Pos	Std Index	CV	N	Prop Pos	Std Index	CV
1993	121	0.53	0.41	0.28								
1994	105	0.53	0.53	0.30								
1995	130	0.53	0.86	0.23								
1996	185	0.48	0.48	0.23	42	0.214	2.959	0.652				
1997	222	0.53	0.65	0.21	54	0.167	1.295	0.340				
1998	203	0.55	0.55	0.24								
1999	129	0.53	0.61	0.27					327	0.089	0.24	0.212
2000	129	0.44	0.55	0.26					381	0.115	0.34	0.164
2001	151	0.52	0.77	0.24								
2002	103	0.53	1.39	0.26	48	0.250	1.802	0.290				
2003	167	0.49	1.08	0.23								
2004	171	0.44	1.34	0.23	26	0.423	1.316	0.349	576	0.220	0.74	0.094
2005	185	0.54	1.30	0.22	78	0.167	1.389	0.243				
2006	185	0.51	1.38	0.21	85	0.259	2.286	0.209	484	0.192	0.51	0.125
2007	153	0.54	1.06	0.26	110	0.236	1.482	0.212				
2008	155	0.49	0.80	0.26	79	0.152	1.216	0.318	653	0.277	0.87	0.081
2009	75	0.56	0.99	0.28	80	0.138	0.876	0.296				
2010	62	0.58	0.93	0.30	124	0.153	0.592	0.245	689	0.332	1.20	0.071
2011					307	0.081	1.306	0.171				
2012					320	0.088	1.324	0.176	734	0.380	1.23	0.068
2013												
2014					356	0.028	0.652	0.382	702	0.318	0.84	0.081
2015												
2016					440	0.100	0.988	0.179	535	0.402	1.63	0.069
2017					411	0.054	0.500	0.215				
2018					348	0.147	0.936	0.165	646	0.359	1.13	0.075
2019					462	0.123	1.274	0.144				
2020					464	0.099	0.372	0.157				
2021					547	0.077	0.376	0.169	292	0.623	2.24	0.082
2022												

Table 5.8.1 (continued). Sampling effort (N), proportion positive (Prop Pos), relative abundance (Std Index) scaled to a mean of one for each time series and the coefficient of variation on the mean (CV, standard error/mean) of indices deemed “Suitable and Recommended” for SEDAR 79 from west to east.

	RVC FL Keys (FI)				RVC SE FL (FI)				Indian River YOY index (FI)			
Year	**N**	**Prop Pos**	**Std Index**	**CV**	**N**	**Prop Pos**	**Std Index**	**CV**	**N**	**Prop Pos**	**Std Index**	**CV**
1993												
1994												
1995												
1996												
1997	316	0.076	0.59	0.255								
1998												
1999	376	0.077	0.49	0.216					77	0.169	0.363	0.386
2000	451	0.135	0.85	0.139					78	0.192	0.501	0.326
2001	643	0.138	0.81	0.123					76	0.171	0.573	0.35
2002	499	0.170	0.74	0.118					76	0.276	0.912	0.313
2003	377	0.170	0.85	0.132					78	0.205	0.521	0.339
2004	199	0.211	0.97	0.16					77	0.247	0.721	0.334
2005	498	0.173	0.95	0.112					75	0.213	1.323	0.34
2006	482	0.156	0.83	0.126					77	0.403	0.892	0.308
2007	606	0.226	1.31	0.093					73	0.521	3.535	0.284
2008	644	0.236	1.13	0.099					75	0.293	1.571	0.305
2009	972	0.195	0.82	0.091					73	0.219	0.513	0.343
2010	530	0.177	0.63	0.127					75	0.253	0.597	0.337
2011	780	0.167	0.62	0.105					74	0.189	0.709	0.322
2012	707	0.238	0.87	0.096					76	0.303	1.200	0.303
2013					1050	0.211	0.35	0.105	75	0.293	1.270	0.315
2014	612	0.203	1.32	0.089	565	0.290	0.50	0.114	76	0.211	1.138	0.336
2015					417	0.283	0.42	0.138	75	0.280	0.854	0.332
2016	559	0.216	1.76	0.097	462	0.390	0.92	0.097	76	0.184	0.297	0.377
2017									77	0.169	1.060	0.346
2018	633	0.292	1.66	0.092	459	0.527	1.60	0.076	78	0.167	1.337	0.331
2019									75	0.160	0.230	0.389
2020									78	0.205	1.491	0.316
2021					285	0.519	1.56	0.094	77	0.260	1.060	0.318
2022	251	0.319	2.03	0.121	292	0.493	1.65	0.093	77	0.325	1.333	0.312

Table 5.8.1 (continued). Sampling effort (N), proportion positive (Prop Pos), relative abundance (Std Index) scaled to a mean of one for each time series and the coefficient of variation on the mean (CV, standard error/mean) of indices deemed "Suitable and Recommended" for SEDAR 79 from west to east.

	SERFS video index (FI)			
Year	**N**	**Prop Pos**	**Std Index**	**CV**
1993				
1994				
1995				
1996				
1997				
1998				
1999				
2000				
2001				
2002				
2003				
2004				
2005				
2006				
2007				
2008				
2009				
2010				
2011	543	0.009	0.083	0.46
2012	1017	0.005	0.235	0.58
2013	1114	0.009	0.263	0.50
2014	1364	0.026	0.769	0.26
2015	1374	0.057	1.188	0.19
2016	1409	0.026	0.581	0.26
2017	1409	0.044	1.007	0.24
2018	1647	0.06	1.501	0.16
2019	1538	0.07	2.248	0.15
2020				
2021	1373	0.075	1.394	0.16
2022	1016	0.069	1.731	0.20

5.9. FIGURES

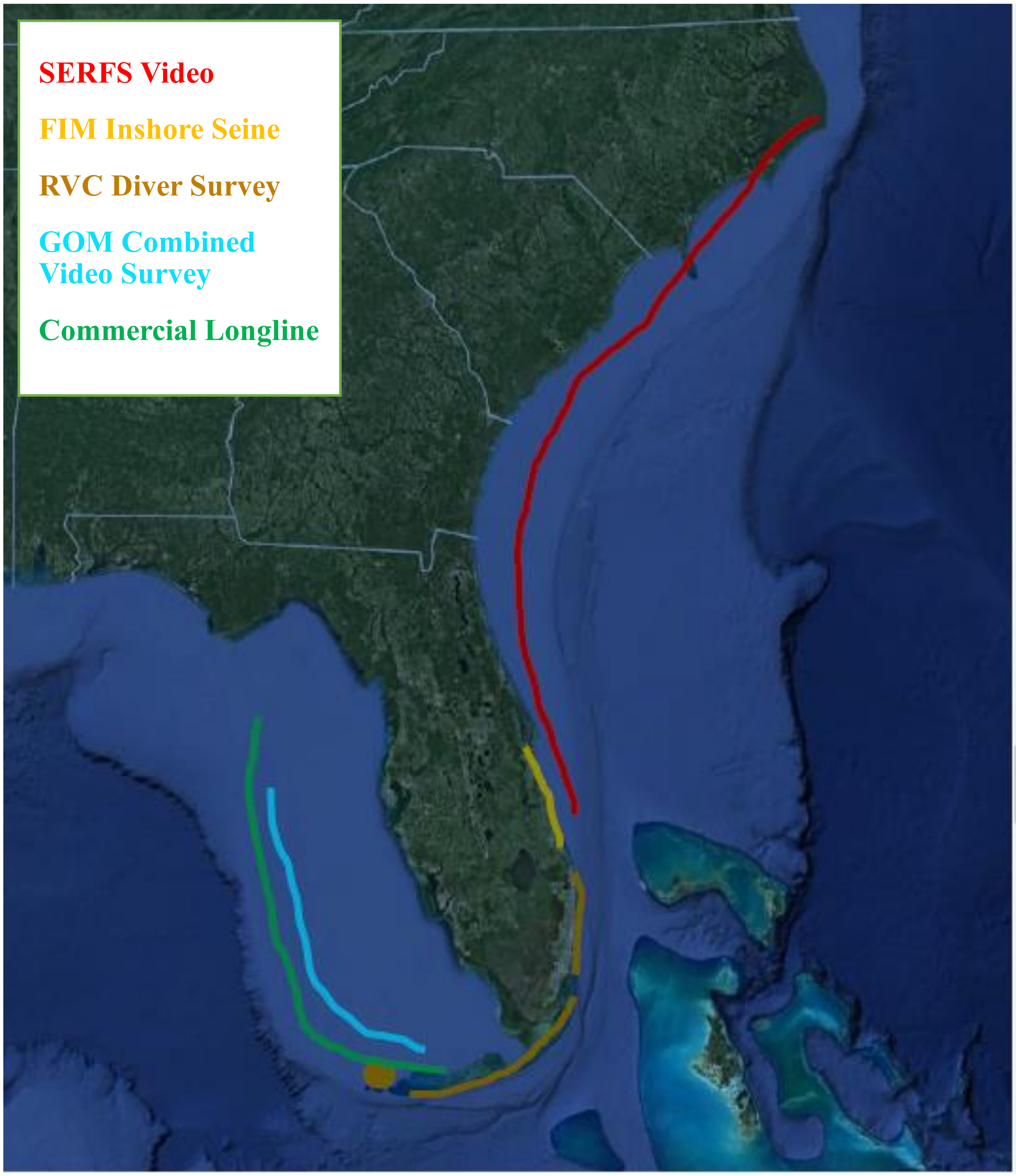

Figure 5.9.1 Spatial extent of indices found to be "Suitable and Recommended" for use in SEDAR 79.

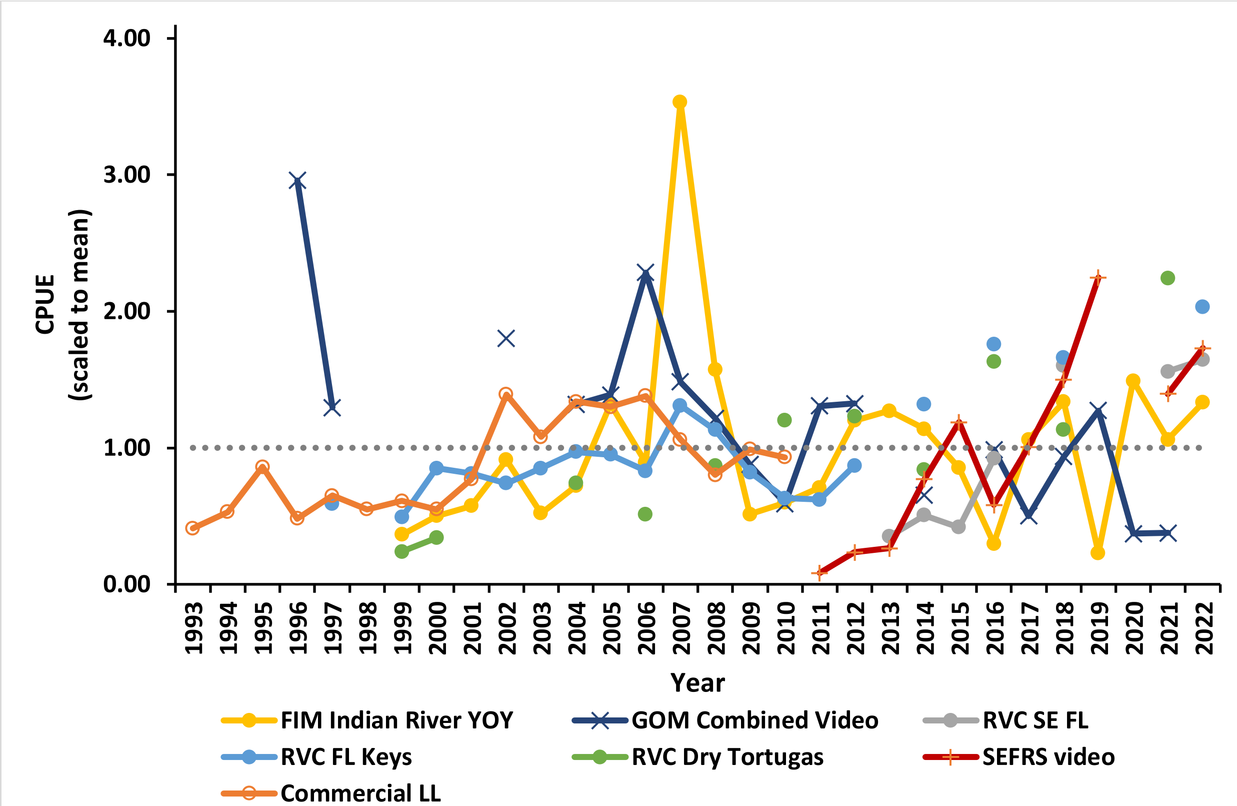

Figure 5.9.2. Relative indices of abundance found to be "Suitable and Recommended" for use in SEDAR 79.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 79

Southeastern US Mutton Snapper

SECTION III: Assessment Process Report

August 2024

Revised September 2024

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

CHANGE LOG

August 27, 2024 - Original release

September 3, 2024 – Revision

*Changes are in bold

- Page 20 - Reported discards from any other gear **(including longlines)** were minimal and lacked sufficient data to calculate a discard rate.
- Page 33 – Added '**Uncertainty, however, was not considered so it is unknown if there is a statistically significant difference from a 1:1 sex ratio**.'
- Page 39 - # of dead fish $= \sum_{fleets} \boldsymbol{N_a} \text{selectivity}_{fleet,age} * (\text{retention}_{fleet,age} + (1 - \text{retention}_{fleet,age}) * \text{release mortality rate}_{fleet})$
- Page 41 – changed 'the number of fish independently and randomly sampled' to '**the number independent and random samples'**
- Page 51 – Added Section: **3.4.11 Per-recruit Analysis**
- Page 51 – Changed Section '3.4.11 Stock Status Determination' to '**3.5 Stock Status Determination**'.
- Page 53 – Referred to age 1 recruits instead of age 0 recruits in the projection methods and results. Changed 'with the recent mean recruitment (average of last 5 years of recruitment data, 2018-2022)' to '**with the recent mean age 1 recruitment (geometric mean of the last 5 years of recruitment data; 2019-2023)**'
- Page 53 – Changed Section '3.4.11.1 Projections' to '**3.5.1 Projections**'
- Page 54 – Removed '(or constant catch)', added '**The TORs also state to evaluate the projected spawning stock biomass when catch is held constant at the equilibrium yield at $F_{40\%SPR}$, however, $F_{40\%SPR}$ is nearly equivalent to 75% of $F_{30\%SPR}$**', and changed 'For short-term projections, the recruitment in the first year of the projection (2024) was equal to the recent average (2018-2022)' to '**For short-term projections, age-1 recruitment in all projection years was equal to the recent geometric mean (2019-2023)**'.
- Page 63 – Added '**This may suggest the index demonstrated hyperstability from 1993 to 2000, so that the CPUE remained elevated even though the true abundance was depressed.**'
- Page 75 – Added results of per-recruit analysis to section '**4.7.11 Per-recruit Analysis**'. Added Table 24 and Figure 87.

- Page 75 – Changed Section '4.7.11 Stock Status' to '**4.8 Stock Status**'. Changed numbering of tables and figures from (Table 24; Figures 87-88) to (**Table 25**; **Figures 88-89**)
- Page 76 - Changed section '4.7.11.1 Projections' to '**4.8.1 Projections**'.
- Page 76 – Added '**Several short-term projection scenarios explored the effects of various fishing mortality conditions. The scenarios investigated when fishing mortality rates were either held constant at $F_{30\%SPR}$ (MFMT=0.149), 75% of $F_{30\%SPR}$ (= 0.112), or $F_{current}$ (=0.08). The TORs also state to evaluate the projected spawning stock biomass when catch is held constant at the equilibrium yield at $F_{40\%SPR}$, however, $F_{40\%SPR}$ is nearly equivalent to 75% of $F_{30\%SPR}$'**. Changed 'Short term (i.e., 5 year) projections were produced assuming predicted recruitment was equal to the average of base model estimates from 2018-2022 (3.284 million fish).' to '**Short term (i.e., 10 year) projections were produced assuming predicted age 1 recruitment was equal to the geometric mean of base model estimates from 2019-2023 (3.284 million fish)'.** Changed 'While only the first 5 years of the short-term projection are recommended for use, projections were extended into the future (i.e., until 2123) with recruitment following the stock-recruit relationship' to '**While only the first 5 years of the short-term projection are recommended for use, projections were extended into the future (i.e., until 2033)**'. Removed 'The equilibrium fishing mortality rates that achieve 30%SPR ($F_{MSYproxy}$, $F_{30\%SPR}$) were used to project the Mutton Snapper population into the future with recent average recruitment from 2024 to 2029, followed by recent long-term recruitment from 2030 to 2123'.
- Page 77 – Changed 'Short term projections under $F_{30\%SPR}$ were compared to long term projections that assumed recruitment followed the stock-recruit relationship in *all* projection years (i.e., 2024 – 2123)' to '**Short term projections were compared to long term projections that assumed recruitment followed the stock-recruit relationship in *all* projection years (i.e., 2024 – 2033)**'. Referred to Figures 90 – 92 instead of Figures 89 – 91. Removed 'from 2024 – 2029'. Removed 'As shown, both scenarios converge to the same long-term value (3,352 mt)'. Referred to **Figure 93 and Table 26** instead of Figure 92 and Table 25. Changed 'The retained yield (in pounds) for the short-term scenario was well beyond historical yields, as projected yields ranged from 3.3 million pounds to 3.6 million pounds and historical yields averaged 1.1 million pounds with a maximum of 2.4 million pounds in 2008' to '**From 2024 – 2028, retained yield (in pounds) for the short-term scenario was well beyond historical yields, as projected yields ranged from 3.27 million pounds to 3.38 million pounds and historical yields averaged 1.1 million pounds with a maximum of 2.4 million pounds in 2008'**. Added '**Retained yield (in pounds) for the other short-term projection scenarios associated with 75% of $F_{30\%SPR}$ and $F_{current}$ averaged 2.68 million pounds and 2.05 million pounds, respectively (Figure 94)'**.

Removed 'Additional short-term projection scenarios specified in the TORs (i.e., F= $F_{Current}$, F at 75% of F_{MSY}, $F_{40\%SPR}$), as well as projections requested by the SSCs (e.g., Pstar, alternative recruitment assumptions in the forecast period) will be included in an addendum report'.

- Page 82 – Added reference 'Haddon, M., 2001. Modelling and Quantitative Methods in Fisheries. Chapman and Hall, New York, 450 pp
- Page 85 – Added reference 'Walters, C.J. and Martell, S.J., 2004. Fisheries ecology and management. Princeton University Press.'
- Page 109 – Table 14: changed '2024 to 2029: Average from 2018 – 2022' to '**2024 to 2033: Average from 2019 – 2023'.** Removed '2030 to 2123: Beverton-Holt stock-recruit relationship' and 'Derived from the model estimated Beverton-Holt stock-recruit relationship'.
- Page 117 – Added '**Table 24. The yield-per-recruit (YPR), spawner-per-recruit (SSB/R), static spawning potential ratio (SPR), and total equilibrium yield in metric tons computed over a range of instantaneous fishing mortality rates (F) on age-3 Mutton Snapper**.' Changed Table 24 to **Table 25**.
- Page 118 – Changed 'Table 25. Results of the short- and long-term projections when age-3 fishing mortality rates = F30%SPR (0.149) for Southeastern US Mutton Snapper. assuming predicted recruitment from the spawner-recruit curve. Recruitment (Recruits) is in 1,000s of age-0 fish, F is age-3 instantaneous fishing mortality rate, SSB is in metric tons (female SSB), Retained Yield is in millions of pounds whole weight, and Retained Num is in thousands of fish' to **'Table 26. Results of the short- and long-term projections when age-3 fishing mortality rates = $F_{30\%SPR}$ (0.149) for Southeastern US Mutton Snapper. Long-term projections assume predicted recruitment follows the spawner-recruit curve. Short-term projections assume predicted age 1 recruitment is equal to the geometric mean from 2019 to 2023 (3.284 million). Recruitment (Recruits) is in millions of age-1 fish, F is age-3 instantaneous fishing mortality rate, SSB is in metric tons (female SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.'**
- Page 118 - Added **'Table 27. Results of the short-term projections when age-3 fishing mortality rates equal 75% $F_{30\%SPR}$ (0.112) and $F_{current}$ (0.08) for Southeastern US Mutton Snapper assuming predicted age 1 recruitment is equal to the geometric mean from 2019 to 2023 (3.284 million). Recruitment (Recruits) is in millions of age-1 fish, F is age-3 instantaneous fishing mortality rate, SSB is in metric tons (female SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.'**
- Page 207 – Added '**Figure 87. The a) yield-per-recruit, b) spawner-per-recruit, c) spawning potential ratio, and d) total equilibrium yield computed as a function of the instantaneous**

fishing mortality rate on age-3 Mutton Snapper.' Renumbered Figures 87 – 88 to **Figures 88 – 89**.

- Page 209 – Renumbered Figure 89 to Figure 90 and updated caption to '**Figure 90. Historical and projected age-3 fishing mortality rates for the long- and short-term projections when constant fishing mortality rates equal $F_{30\%SPR}$ for the SEDAR 79 Southeastern US Mutton Snapper Assessment. The green shaded area identifies the first 5 years of the projections (2024-2028).**'
- Page 210 – Renumbered Figure 90 to Figure 91 and updated caption to '**Figure 91. Historical and projected age 1 recruitment for the long- and short-term projections when constant fishing mortality rates equal $F_{30\%SPR}$ for the SEDAR 79 Southeastern US Mutton Snapper Assessment. The green shaded area identifies the first 5 years of the projections (2024-2028).**'
- Page 211 - Renumbered Figure 91 to Figure 92 and updated caption to '**Figure 92. Historical and projected spawning stock biomass for the long- and short-term projections when constant fishing mortality rates equal $F_{30\%SPR}$ for the SEDAR 79 Southeastern US Mutton Snapper Assessment. The green shaded area identifies the first 5 years of the projections (2024-2028).'**
- Page 213 - Renumbered Figure 92 to Figure 93 and updated caption to '**Figure 93. Historical and projected retained yield in millions of pounds (a) and 1000s (b) for the long- and short-term projections when constant fishing mortality rates equal $F_{30\%SPR}$ for the SEDAR 79 Southeastern US Mutton Snapper Assessment. The green shaded area identifies the first 5 years of the projections (2024-2028).'**
- Page 213 – Added **Figure 94.**

Table of Contents

1. INTRODUCTION

1.1 Workshop Time and Place

The SEDAR 79 Southeastern U.S. Mutton Snapper assessment workshop process was conducted through a series of four webinars between November 2023 to July 2024.

1.2 Terms of Reference

Assessment Workshop Terms of Reference

1. Review any changes in data and data sources 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.
    - 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 update assessment (SEDAR 15AU).
    - 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. Another continuity model will include the prior assessment configuration and terminal year with MRIP-FES landings and discards.
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 15AU) update assessment, and comment on the impacts of changes in data, assumptions or assessment methods on estimated population conditions.
4. Characterize uncertainty in the assessment and estimated values.
    - Consider uncertainty in input data, modeling approach, and model configuration.
    - Consider and include 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

5. Provide estimates of yield and productivity.
    - Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models
6. Provide estimates of population benchmarks or management criteria consistent with 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.
    - Recommend proxy values (e.g. MSY) when necessary and provide appropriate justification.
    - Compare and contrast reference values (e.g. equilibrium yield at $F_{MSYProxy}$) estimated in this assessment with values from the previous (SEDAR 15AU) update assessment, and comment on the impacts of changes in data, assumptions or assessment methods on reference point differences.
    - Define recent fishing mortality rates ($F_{Current}$) and recent spawning stock biomass ($SSB_{Current}$) that will be compared to management benchmarks as the geometric mean of the most recent three years and the terminal data year, respectively.
7. Incorporate known applicable environmental covariates into the selected model and provide justification for why any of those covariates cannot be included at the time of the assessment.
8. Provide declarations of stock status relative to management benchmarks or alternative data poor approaches if necessary.
9. Provide uncertainty distributions 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.
    - Characterize the differences in fishing mortality, virgin biomass, terminal total biomass, terminal spawning stock biomass, and equilibrium yield at $F_{MSYProxy}$ as a result of updating recreational catch and effort data from MRIP-CHTS to MRIP-FES by comparing SEDAR 15AU to a continuity model with MRIP-FES landings and discards and SEDAR 15AU configuration and terminal year.
10. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time.
    - Request estimates of retained landings in numbers and biomass from data providers for interim years between the terminal year and first year of the projections, if available, to be used to project future stock conditions. If estimates of retained landings are unavailable, use the average of the previous three years.

- Recommend levels of recruitment to be used in the projections.
- Stock projections (including yields) shall be developed in accordance with the following ($F_{Current}$ is the geometric mean of the most recent three years of data):
    - A) If stock is overfished:

        F=0, $F_{Current}$, F= F_{MSY}, F at 75% of F_{MSY}, $F_{40\%SPR}$ (current definition of F_{OY})

        F=$F_{Rebuild}$ (max exploitation that rebuild in greatest allowed time)
    - B) If overfishing is occurring:

        F= $F_{Current}$, F= F_{MSY}, F at 75% of F_{MSY}, $F_{40\%SPR}$
    - C) If stock is neither overfished nor undergoing overfishing:

        F= $F_{Current}$, F= F_{MSY}, F at 75% of F_{MSY}, $F_{40\%SPR}$
    - D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternative models to provide management advice.

11. Provide recommendations for future research and data collection.
    - Be as specific as practicable in describing sampling design and sampling intensity.
    - Emphasize items that will improve future assessment capabilities and reliability.
    - Consider data, monitoring, and assessment needs.
12. Review, evaluate, and report on the status and progress of all research recommendations listed in the last assessment, peer review reports, and SSC report concerning this stock.
13. Complete the Assessment Workshop Report in accordance with project schedule deadlines (Section III of the SEDAR Stock Assessment Report).

1.3 List of Participants

Assessment Process Participants

Shanae Allen (Lead Analyst) .... FWC/FWRI
Halie O'Farrell .... FWC/FWRI
Dustin Addis .... FWC/FWRI
Jie Cao .... SAFMC SSC
Dave Chagaris .... GMFMC SSC
Robert Muller .... FWC/FWRI
Joe O'Hop .... FWC/FWRI
Steven Saul .... GMFMC SSC
Fred Serchuk .... SAFMC SSC
Chris Swanson .... FWC/FWRI
Steve Turner .... SAFMC SSC

Council Representation

Jessica McCawley .... SAFMC
CJ Sweetman .... GMFMC

Staff

Julie Neer .... SEDAR
Judd Curtis .... SAFMC Staff
Ryan Rindone .... GMFMC Staff
Mike Schmidtke .... SAFMC Staff

Data Process Webinar Observers

Kelly Adler .... NMFS/SEFSC
Chris Bradshaw .... FWC/FWRI
Matthew Bunting .... FWC
Heather Christiansen .... FWC/FWRI
Manuel Coffill-Rivera ....
Michael Drexler .... Ocean Conservancy
Kristin Foss .... FWC/DMFM
Janette Huber .... FWC
Brian Klimek .... FWC/FWRI
Maria McGirl .... FWC
Max Lee .... Mote Marine Lab
Rich Malinowski .... NMFS
Genine McClair .... FWC
Ariel Poholek .... NMFS/SEFSC
Chloe Ramsey .... FWC
Marcel Reichert .... SAFMC SSC
Eric Schmidt .... GMFMC Industry Rep
Rebecca Scott .... FWC
Jim Tolan .... Texas

1.4 List of Assessment Workshop Working Papers and Reference Documents

Document #	Title	Authors	Date Submitted
Documents Prepared for the Assessment Process			
SEDAR79-AP-01	Weighted Length Compositions for U.S. Mutton Snapper (*Lutjanus analis*)	Shanae D. Allen	18 June 2024
SEDAR79-AP-02	A ratio-based method for calibrating MRIP-SRFS recreational fisheries estimates for southeastern US Mutton Snapper (*Lutjanus analis*)	Chloe Ramsay, Tiffanie A. Cross, Colin P. Shea, and Beverly Sauls	22 July 2024
Reference Documents			
SEDAR79-RD09	Certification Review of Florida's Proposed MRIP-SRFS Calibration Methodology for Mutton and Yellowtail Snapper	NOAA Fisheries Office of Science and Technology and the Southeast Fishery Science Center	
SEDAR79-RD10	Transition Plan for Gulf State Recreational Fishing Surveys	Gulf of Mexico Subgroup of the MRIP Transition Team	
SEDAR79-RD11	SSC Catch Level Projections Workgroup Final Report	SAFMC SSC Catch Level Projections Workgroup	

2. DATA REVIEW AND UPDATE

A detailed review of the data sources used in the SEDAR 79 Benchmark Assessment is presented in the Data Workshop report; however, there were a few new or revised data sets:

1) For the development of conditional-age-at-length data, additional otoliths were matched with lengths adding 318 age-length pairs, 56 ages were corrected, and 382 age-length pairs were removed.
2) Commercial landings estimates
   a) Removed several duplicate records from the NMFS Accumulative Landings System (ALS) prior to 1988.
   b) Added Florida Fish and Wildlife Conservation Commission trip ticket (TTK) landings estimates for 2023. Landings estimates outside of Florida from ALS and the Atlantic Coastal Cooperative Statistics Program (ACCSP) were unavailable for 2023.
3) Recreational landings and releases estimates
   a) Florida Fish and Wildlife Conservation Commission State Reef Fish Survey (SRFS) landings and releases estimates for the recreational private mode in Florida waters from 2021 – 2023 replaced estimates from National Marine Fisheries Service's (NMFS) Marine Recreational Information Program Fishing Effort Survey (MRIP-FES).
   b) MRIP (FCAL) landings and releases estimates for the recreational private mode in Florida waters from 1981- 2020 were updated by calibrating these estimates to Florida Fish and Wildlife Conservation Commission State Reef Fish Survey (SRFS) currency.
   c) Estimates of landings and releases for headboats were updated using the Southeast Region Headboat Survey through 2023.
   d) Landings and releases for charterboats, shore and non-Florida private recreational modes through 2023 were updated using MRIP (FCAL) estimates.
4) Fleet-specific length compositions were weighted by landings or releases according to SEDAR79-AP01.
5) Commercial longline index
   a) The commercial longline index from 1993 – 2010 presented in Table 5.8.1 was mistakenly copied from a previous data submission, however the correct index was presented and discussed at the Data Workshop.

6) Combined Gulf video survey index
   a) The Data and Assessment panels recommended the removal of years 2010-2015 from the FWRI survey and years 1993-1995, 2013, and 2015 from the SRFV survey, as well as the addition of 2022 data. The removal of these years was recommended because the core Mutton Snapper habitat (i.e., the Dry Tortugas) was not sampled.

The following list summarizes the main data inputs used in the SEDAR 79 assessment model:

- Stock structure and management unit
- Life history
  - Age and growth
  - Natural mortality
  - Maturity
  - Fecundity
  - Sex ratio
- Landings
  - Commercial Longline (metric tons): 1981 – 2023
  - Commercial Other (metric tons): 1981 – 2023
  - Recreational East (thousands of fish): 1981 – 2023
  - Recreational West (thousands of fish): 1981 – 2023
- Releases (thousands of fish)
  - Release mortality
  - Commercial Other: 1993 – 2023
  - Recreational East: 1981 – 2023
  - Recreational West: 1981 – 2023
- Length composition of landings (8:96 cm Maximum Total Length [Max TL], 4 cm Max TL bins)
  - Commercial Longline: 1991 – 2022
  - Commercial Other: 1989 – 2022
  - Recreational East: 1981 – 2022
  - Recreational West: 1981 – 2022
- Conditional age-at-length (1-year age bins starting at age 1, plus group for ages 40 and older)
  - Commercial Longline landings: 2001 – 2022
  - Commercial Other landings: 1992 – 2022
  - Recreational East: 1981 – 2022
  - Recreational West: 1981 – 2022
  - Fishery-independent sources: 1998-2002, 2021-2022
- Length composition of releases (8:96 cm Maximum Total Length [Max TL], 4 cm Max TL bins)
  - Commercial Other: 2013-2017
  - Recreational East: 2005 – 2023
  - Recreational West: 2005 – 2023
- Abundance indices
  - Fishery-independent

        - RVC Dry Tortugas: 1999-2000, 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2021, 2023
        - RVC FL Keys: 1997, 2000 – 2012, 2014, 2016, 2018, 2022
        - RVC SE FL: 2013 – 2016, 2018, 2021-2022
        - FIM YOY: 1999 – 2022
        - Combined Gulf Video: 1996-1997, 2002, 2004-2012, 2014, 2016-2022
        - SERFS Video: 2011-2019, 2021-2022
    - Fishery-dependent
        - Commercial longline: 1993 – 2010
- Length composition from abundance indices (8:96 cm Maximum Total Length [Max TL], 4 cm Max TL bins)
    - Fishery-independent
        - GOM Combined Video: 2004-2021
- Length composition from abundance indices (10:95 cm Maximum Total Length [Max TL], 5 cm Max TL bins)
    - Fishery-independent
        - RVC Dry Tortugas: 1999-2000, 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2021, 2023
        - RVC FL Keys: 1997, 2000 – 2012, 2014, 2016, 2018, 2022
        - RVC SE FL: 2013 – 2016, 2018, 2021-2022

The data sources and their corresponding temporal scale are presented in **Figure 1.**

A summary listing of all data sets included in the assessment, along with any revisions to the contact information for who provided the analysis, has been compiled below.

Data Component	**Data Type**	**Contributing Organizations**	**Data Providers**	**Contact Information**
Landings & Releases	Headboat Landings & Releases	SEFSC	Rob Cheshire	rob.cheshire@noaa.gov
	General Recreational (MRIP, TPWD, LACreel) Landings & MRIP Releases	SEFSC	Matt Nuttall	matthew.nuttall@noaa.gov
	FL FWC State Reef Fish Survey Private Landings & Releases	FWRI	Chloe Ramsay	chloe.ramsay@myfwc.com
	Commercial Landings – ALS	SEFSC	Alan Lowther Michael Judge	alan.lowther@noaa.gov michael.judge@noaa.gov

	Commercial Landings – Logbook	SEFSC	Sydney Alhale	sydney.alhale@noaa.gov
	Commercial Landings - Florida	FWRI ACCSP	Chris Bradshaw Mike Rinaldi	chris.bradshaw@myfwc.com mike.rinaldi@accsp.org
	Commercial Discards	SEFSC	Sarina Atkinson	sarina.atkinson@noaa.gov
Indices	Commercial Longline (pre-IFQ) Logbook Index	SEFSC	Micki Pawluk Kevin Thompson	michaela.pawluk@noaa.gov kevin.thompson@noaa.gov
	Combined Gulf Video Index	FWRI	Heather Christiansen	heather.christiansen@myfwc.com
	RVC Indices	FWRI	Robert Muller	robert.muller@myfwc.com
	Southeast Reef Fish Survey	SEFSC	Nathan Bacheler	nate.bacheler@noaa.gov
	FWRI FIM Inshore Seine Survey	FWRI	Brian Klimek	brian.klimek@myfwc.com
Length Comps	Commercial length raw data	SEFSC FWRI	Larry Beerkircher Chris Bradshaw	lawrence.beerkircher@noaa.gov chris.bradshaw@myfwc.com
	MRIP length raw data	SEFSC	Matt Nuttall	matthew.nuttall@noaa.gov
	Headboat length raw data	SEFSC	Rob Cheshire	rob.cheshire@noaa.gov
	Combined Video length comps	FWRI	Heather Christiansen	heather.christiansen@myfwc.com
	RVC length comps	FWRI	Robert Muller	robert.muller@myfwc.com
	Commercial discard length comps from reef fish observer data	SEFSC	Sarina Atkinson Gary Decossas	sarina.atkinson@noaa.gov gary.decossas@noaa.gov
	Recreational discard length comps	FWRI	Ellie Corbett	ellie.corbett@myfwc.com
	Recreational length comp development	FWRI	Shanae Allen	shanae.allen@myfwc.com
	Commercial length comp	FWRI	Shanae Allen	shanae.allen@myfwc.com

	development			
Conditional Age-at-length	Raw age data	FWRI SEFSC NC DENR SC DNR	Jessica Carroll Jesse Secord Bridget Cermak Erick Ault Jennifer Potts McLean Seward Michelle Willis	jessica.carroll@myfwc.com jesse.secord@myfwc.com bridget.cermak@myfwc.com Erick.Ault@MyFWC.com jennifer.potts@noaa.gov mclean.seward@ncdenr.gov willisc@dnr.sc.gov
	Conditional age-at-length development	FWRI	Shanae Allen	shanae.allen@myfwc.com
Life History	Reproduction	FWRI	Susan Lowerre-Barbieri	susan.lowerre-barbieri@myfwc.com
	At-sea Tagging and Immediate Release Mortality Data	FWRI	Maria McGirl	maria.mcgirl@myfwc.com
	External Growth and Natural Mortality	FWRI	Chris Swanson	chris.swanson@myfwc.com
	Morphometrics	FWRI	Shanae Allen	shanae.allen@myfwc.com

2.1 Stock Structure and Management Unit

The Mutton Snapper fishery is managed in the U.S. by the South Atlantic Fishery Management Council (SAFMC) and the Gulf of Mexico Fishery Management Council (GMFMC) as separate stock units with the boundary being U.S. Highway 1 in the Florida Keys west to the Dry Tortugas (**Figure 2.14.2** in the Data Workshop Report). The State of Florida also participates in the management of this species in state waters, while other states in the SAFMC and GMFMC jurisdictions defer to the federal management regulations for this species. The stock is predominantly concentrated in south Florida but extends west to Texas in the Gulf of Mexico and north to North Carolina on the Atlantic coast; yet, Mutton Snapper have been detected as far north as Maryland in the recreational landings. Based on the recommendations of the LHW, SEDAR 79 assumes a single closed population in the SAFMC and GMFMC jurisdictions for the purpose of stock assessment and management. This assumption is consistent with previous assessments (SEDAR 15A 2008, SEDAR 15AU 2015).

2.2 Life History Parameters

For the development of conditional-age-at-length data, additional otoliths were matched with lengths which added 318 age-length pairs, 56 ages were corrected, and 382 age-length pairs were removed due to missing auxiliary information. **Table 1** displays the updated number of age-length pairs of Mutton Snapper (n = 25,522) by year, fishery, and region. Ages sampled from tournaments or recreational longline were not included.

Beyond the addition, removal, or correction of some age-length pairs, there were no further modifications to life history parameters. These include length-length, weight-weight, and length-weight relationships, as well as average natural mortality (ages 3-42), release mortality, logistic parameters for maturity-at-age, and sex ratios. A detailed review of life history data used in the SEDAR 79 Benchmark Assessment are presented in the Data Workshop Report, and additional details on life history inputs and configurations as specified in the stock assessment model are presented in Section 3.1.3.

2.3 Fishery-Dependent Data

2.3.1 Commercial Landings

The recommendation from the Commercial Workgroup (CWG) was to combine commercial landings data of Southeastern U.S. Mutton Snapper from NMFS Accumulated Landings System (ALS) for all states (1981-1986), Florida trip ticket (TTK; 1986-2022), NMFS ALS for states west of Florida (1981-2022), and Atlantic Coastal Cooperative Statistics Program (ACCSP) for states north of Florida (1981-2022) to establish final commercial landings by region fished and gear.

Following the Data Workshop, several erroneous NMFS ALS records prior to 1988 were found and removed. Additionally, FL TTK landings estimates were compiled for 2023. Landings estimates outside of Florida from NMFS ALS and ACCSP were unavailable for 2023, however in past years these have contributed at most 11.87% of the landings with an average contribution of 2.33%.

The CWG recommended five gear groupings to characterize the Mutton Snapper fishery: hook and line, longline, trap, diving, and other. However, commercial landings were predominantly from longline and hook and line gear types (~90%, Section 3.3.1 in the Data Workshop Report). Also, further examination of lengths sampled from these gear types revealed similarities between hook and line, trap, diving, and other, although there was a paucity of lengths from trap, diving, and other gears (SEDAR 79-AP-01). Thus, commercial landings were categorized into two gear groups: longline and other. While landings in pounds (lb) were presented in the Data Workshop Report Section 3, they were converted here to metric tons (mt) for use as model inputs (**Table 2** and **Figure 2**).

The CWG estimated uncertainty in commercial fishery landings by using a similar methodology and modifying the uncertainty estimates used in SEDAR 64 (Yellowtail Snapper) and SEDAR 82 (South Atlantic Gray Triggerfish). These estimates of uncertainty are not coefficients of variation but are estimates of possible reporting error such that they represent the range in actual commercial landings relative to the reported landings. Uncertainty estimates are provided by state and time block in Table 3.10.3 in the Data Workshop Report.

Since standard errors (in log space) of landings are a necessary model input, CVs were first approximated by using the "variance sum law" to combine estimates of uncertainty across states (described in SEDAR 68-DW-31). CVs were then transformed to standard errors in log space using the approximation: $log_e(SE) = \sqrt{log_e(1 + CV^2)}$ provided in Methot et al. (2023).

While the treatment of these uncertainty estimates is slightly inconsistent, the standard errors of commercial landings are effectively ignored because the model is configured to fit the commercial landings exactly (additional details are presented in Section 3.2.3). Final commercial landings in metric tons by gear group and year, along with associated standard errors, are presented in **Table 2**.

2.3.2 Recreational Landings

Sources of recreational landings data reviewed during the Data Workshop included the Southeast Region Headboat Survey (SRHS), Marine Recreational Information Program (MRIP), Texas Parks and Wildlife Department (TPWD), and Louisiana Creel survey program (LA Creel). Landings of Mutton Snapper were compiled from 1981 through 2022 for the U.S. Atlantic and

Gulf of Mexico for four recreational fishing modes: headboats, charterboats, private and rental boats, and fishing from shore.

According to these data, the recreational landings outside of Florida comprise less than 0.2% of the total recreational landings. Recreational landings are primarily from private and shore modes, however the MRIP CV values are relatively high when split by mode, particularly for the shore mode. Length distributions appear to differ starkly by region with eastern areas catching smaller fish than western Florida (SEDAR 79-AP-01). Within regions all modes have similar length compositions, indicating that all modes catch similarly sized fish (Figures 4.11.1 and 4.11.2 in the Data Workshop Report and SEDAR 79-AP-01). Size compositions of landed fish in the Florida Keys were determined to be more similar to western Florida than the Atlantic coast. Considering this, the recommendation from the Recreational Workgroup (RWG) was to combine all fishing modes into a single "recreational" fleet, but with separate regions defined for the East (Southeast Florida, Northeast Florida, and North of Florida) and West (Florida Keys, Southwest Florida, Northwest Florida, and West of Florida).

After the Data Workshop, Mutton Snapper landings and releases by the recreational private mode in Florida waters became available from 1981 through 2023 as estimated by the Florida FWC State Reef Fish Survey (SRFS). The SRFS data for Mutton Snapper passed external peer review and was approved for use by the SEDAR 79 Assessment Panel.

This required replacing MRIP (FCAL) estimates of the landings, releases, and CVs for the recreational private mode in Florida waters (FL PR mode) from 2021 – 2023 with those from SRFS. Then, MRIP estimates from 1981 – 2020 were calibrated to SRFS currency for the FL PR mode. The SRFS survey design and calibration methods are fully documented in SEDAR 79-RD-09 (2024). Estimates of landings and releases for headboats were updated using the SRHS through 2023, whereas landings and releases for charterboats, shore, and non-Florida private (non-FL PR) recreational modes through 2023 were updated using MRIP (FCAL) estimates.

2.3.2.1 Headboat Landings

Estimates of headboat landings (in thousands of fish) of Mutton Snapper from 1981 – 2023 from the U.S. South Atlantic and the Gulf of Mexico were obtained from the SRHS (**Table 3, Figures**

3 and **5**). Data through 2022 were reviewed at the Data Workshop and documented in a working paper (SEDAR 79-DW-06).

Uncertainty estimates were also updated through 2023 using the same methodology approved by the RWG (**Table 4**). The SRHS design prevents direct estimates of variance, however a proxy CV method refined for the SEDAR 82 Gray Triggerfish research track assessment was used to spatially weight the compliance rates by the associated landings.

Relative to MRIP landings, headboat landings for Mutton Snapper comprise a small portion (between 1% and 16%) of the total recreational landings, but biological samples from dockside intercepts of headboats account for the majority of the length and age information for the recreational sector.

2.3.2.2 MRIP Landings

Marine Recreational Information Program (MRIP) estimates of recreational landings (in thousands of fish) of Mutton Snapper from 1981 – 2023 from the U.S. Atlantic and Gulf of Mexico by mode (FL PR, Non-FL PR, Shore, Charter) and region (East and West) are presented in **Table 3** and **Figure 3**. Estimates through 2023 differed very little, if at all, from what was reviewed at the Data Workshop (**Figure 4**).

Estimates of uncertainty (CVs) around landings (in numbers) by mode and region are shown in **Table 4**. Since estimates of uncertainty were not provided by mode and state and the Non-FL Private mode landings are minimal, the CVs for the private mode were attributed to the FL Private mode and uncertainty was ignored for the Non-FL Private mode.

The RWG investigated the time series to identify relatively high/low estimates of recreational landings as compared to adjacent time periods. The group investigated the high landings estimate for the East region in 2008, the majority of which comes from a single stratum: ~64% of the annual landings estimate is from the eastern Florida shore mode in wave 4 (July-August) and ocean <= 3 miles (SEDAR 79-DW-02). The estimate for this stratum was informed by intercepts from 36 angler trips, and not the result of one or two intercepts reporting relatively high landings. The group further found that this estimate coincides with strong tropical storm activity (Fay) and a strong recruitment class in 2007 (as supported by the Indian River YOY Index and age comps from the commercial and recreational sectors). Anglers report more encounters of Mutton Snapper closer to shore immediately following tropical storm activity. The group also investigated the relatively low landings in 2010-2011, which coincided with the 2010 Deepwater Horizon Oil Spill (which resulted in reduced effort and potential biological effects) and unseasonably cold temperatures experienced throughout the state of Florida in January 2010 that resulted in widespread fish kills.

Catch estimates from the early years of the MRIP survey (e.g., 1981-1985) are highly variable and tend to result in higher CVs than those estimated in subsequent years. Coupled with the relatively large landings estimates for Eastern Florida Mutton Snapper caught by the shore mode, the RWG discussed a potential recommendation to start the assessment model in 1986, as has been done in other SEDAR stock assessments. The group had no particular concerns with retaining and using the recreational data in these early years as inputs into the assessment model but recognizes that the above reasons could be used for justification of removal.

2.3.2.3 SRFS and SRFS-Calibrated Landings

Florida FWC State Reef Fish Survey (SRFS) landings were estimated for 2021-2023, while 1981 through 2020 MRIP estimates for the FL PR mode were calibrated to SRFS currency. SRFS and SRFS-calibrated landings of Mutton Snapper from 1981 – 2023 from the U.S. Atlantic and Gulf of Mexico for the FL private mode by region are shown in **Table 5** and **Figure 5**.

Landings were combined across modes and data sources by summing over headboat landings from SRHS, charter landings from MRIP (FHS), shore mode landings from MRIP (FES), non-FL private mode landings from MRIP (FES), and FL private mode landings from either SRFS (2021-2023) or SRFS calibrated to MRIP-FES (1981-2020). Estimates of uncertainty were combined in a similar manner by using the variance sum law. CVs were then transformed to standard errors (in log space) using the formula in Section 2.3.1. Landings by mode and region are shown in **Figure 5**. Landings (in 1000s of fish) and standard errors (in log space) after combining all recreational modes by region were used as model inputs and are presented in **Table 8**.

2.3.3 Commercial Releases

Mutton Snapper commercial releases were calculated using self-reported discard logbook data from the SEFSC coastal fisheries logbook program (CFLP). Discards from the vertical line (handline and electric/hydraulic “bandit” gear) fishery were calculated for fish reported as discarded alive or discarded dead. Reported discards from any other gear (including longlines) were minimal and lacked sufficient data to calculate a discard rate.

Due to limited available discard data, the methods of SEDAR32 were followed with discard rates calculated as the mean nominal discard rate among all trips that reported to the discard logbook program over the period 2002-2022 by minimum size limit. Minimum size limits changed over time with slight differences between the Gulf of Mexico and South Atlantic regions. Discard logbook data were available for only the 16” and 18” total length size limit. Those discard rates were then multiplied by the yearly fishing effort (total hook-hours fished) reported to the coastal logbook program by region (Gulf of Mexico FL Keys, Southwest FL, South Atlantic FL Keys, Southeast FL, and Northeast FL). Effort data were available for the period 1993-2022. Therefore, discards could not be estimated from 1990 to 1992. When a 12” total length size limit was in effect (South Atlantic: 1/1992 – 1/1995, Gulf: 2/1990 – 11/1999), the discard rate for the 16” size limit was used indicating a possible overestimation of discards for this management regime.

Calculated discards (in numbers) of Mutton Snapper from the commercial vertical line fishery from 1993-2022 and related standard errors are presented by subregion in Table 7 in SEDAR-79-07. Commercial discard estimates were not able to be updated through 2023 after the Data Workshop. Since landings and discard information are necessary model inputs, the commercial discard estimate for 2023 was extrapolated as the average from 2020-2022.

For the assessment model, these estimated discards and standard errors are aggregated over subregions and applied to the commercial ‘Other’ (i.e., non-longline) fleet. Total commercial discards (in thousands of fish) and standard errors (SEs) from 1993 – 2023 are presented in **Table 2**.

After the Data Workshop, the discard logbook for use in commercial discard estimates in the South Atlantic were deemed unreliable (Alhale et al. 2024). In lieu of alternative estimates of discards, the base model was configured to essentially ignore the fit to the commercial discards (see Section 3.2).

2.3.4 Recreational Releases

The RWG reviewed recreational releases of Mutton Snapper that were compiled from 1981 through 2022 for four recreational fishing modes: headboats, charterboats, private and rental boats, and fishing from shore in the U.S. Atlantic and Gulf of Mexico. Sources for discards include the Southeast Region Headboat Survey (SRHS) and Marine Recreational Information Program (MRIP). Discard data from Texas Parks and Wildlife Department (TPWD) and Louisiana Creel survey program (LA Creel) are not available and are assumed to be negligible.

As previously stated, Mutton Snapper landings and releases by the recreational private mode in Florida waters from 1981 through 2023 from SRFS became available after the Data Workshop. The SRFS data for Mutton Snapper passed external peer review and was approved for use by the SEDAR 79 Assessment Panel.

This required replacing MRIP (FCAL) estimates of the landings, releases, and CVs for the recreational private mode in Florida waters (FL PR mode) from 2021 – 2023 with those from SRFS. Then, MRIP estimates from 1981 – 2020 were calibrated to SRFS currency, again only for the FL PR mode. The SRFS survey design and calibration methods are fully documented in SEDAR 79-RD09 (2024). Estimates of landings and releases for headboats were updated using the SRHS through 2023; whereas landings and releases for charterboats, shore, and non-Florida private (non-FL PR) recreational modes through 2023 were updated using MRIP (FCAL) estimates.

2.3.4.1 Headboat Releases

Headboat releases (SRHS) from 2008 – 2023 were estimated according to methods in the Discards section from the working paper (SEDAR 79-DW-06), while releases from 1992-2007 were estimated as described in Appendix 1. Prior to the 1992 size limit increase, there were few or no MRIP Charter discards (SEDAR 79-DW-02, Table 2). The Results and Appendix sections present annual discards-in-numbers from 1992 – 2022 by region in Tables A1 and Figure A3. Variance estimates for headboat releases are unavailable, however the magnitude of releases is very low relative to the releases of other modes. Uncertainty estimates of headboat releases were therefore ignored. Headboat releases (in 1000s of fish) by region from 1992 – 2023 are presented in **Table 6** and **Figures 6-7**.

2.3.4.2 MRIP Releases

Released alive fish, compiled from MRIP for years 1981 – 2022, were reviewed and accepted by the Data Workshop. Mode-specific discard rates are based on dockside interviews (intercepts) of anglers and represent the self-reported number of fish discarded alive. The summary figures in the MRIP and headboat working papers (SEDAR 79-DW-02 and SEDAR 79-DW-06, respectively) show that the vast majority of releases originate from the private and shore modes operating in Florida.

Total discards (in thousands of fish) for shore, private, and charter modes from 1981 – 2023 are presented by region in **Table 6** and **Figure 6**, while associated measures of uncertainty (CVs) are tabulated in **Table 7**.

2.3.4.3 SRFS and SRFS-Calibrated Releases

Florida FWC State Reef Fish Survey (SRFS) releases were estimated for 2021-2023, while from 1981 through 2020 MRIP estimates for the FL PR mode were calibrated to SRFS currency. SRFS and SRFS-calibrated releases of Mutton Snapper from 1981 – 2023 from the U.S. Atlantic and Gulf of Mexico for the FL private mode by region are shown in **Table 5** and **Figure 7**.

Releases were combined across modes and data sources by summing over headboat releases from SRHS, charter releases from MRIP (FHS), shore mode releases from MRIP (FES), non-FL private mode releases from MRIP (FES), and FL private mode releases from either SRFS (2021-2023) or SRFS calibrated to MRIP-FES (1981-2020). Estimates of uncertainty were combined in a similar manner by using the variance sum law. Then CVs were transformed to standard errors (in log space) using the formula in Section 2.3.1. Releases by mode and region are shown in **Figure 7.** Releases (in 1000s of fish) and standard errors (in log space) after combining all recreational modes by region were used as model inputs and are presented in **Table 8**.

2.3.5 Fishery-Dependent Length Compositions

Weighted length compositions for SEDAR 79 were compiled for catch (landings and releases) of Mutton Snapper in the South Atlantic and Gulf of Mexico by fishery and primary gear type. Raw length composition data from fishery dependent sources may be a biased reflection of the length composition of the catch due to uneven sampling in space and time. Therefore, when calculating landings- and releases-at-length (fish landed or released per length bin in numbers), it is recommended to weight the sampled lengths of landed or released fish at the finest possible scale by the inverse of sampling proportion (SEDAR 2016; Maunder et al. 2020).

Weighted length compositions of the landings and releases are described in detail in SEDAR 79-AP-01. In brief, length compositions of landings and releases were catch-weighted according to scales that generally satisfied a minimum level of sampling and captured key differences in sampled lengths. Input sample sizes for length were initially equal to the number of trips with at least one measured Mutton Snapper. They were then down weighted using the Francis (2011) iterative procedure to estimate effective sample sizes (for additional details refer to Section 3.2).

Length compositions of landed and released alive Mutton Snapper used in the assessment model are summarized by fleet in **Figure 8**. Length samples were assigned to have occurred mid-year (July) and were not separated by sex (see Section 3.1.3). Due to time constraints, weighted length compositions were unavailable for 2023.

2.3.6 Fishery-Dependent Conditional Age-at-Length

Conditional age-at-length inputs by fleet are presented in **Figures 9-12**. This input allows the integrated models to use the information from sparse age-length data without assuming that the data was representative of ages across the full range of sizes. Effective sample sizes for the number of ages sampled in a given length bin by year were initially equal to the number of aged fish but were later down-weighted according to Francis (2011). Age samples were assigned to have occurred mid-year (July) and were not separated by sex. Age samples were unavailable for 2023.

2.3.7 Catch Per Unit of Effort Index

The Index Workgroup (IWG) recommended a single fishery-dependent biomass index of catch per unit effort from the commercial longline fishery for use in the assessment model. This index is briefly summarized below but is explained in greater detail in the Data Workshop Report Section 5 and SEDAR 79-DW-08. No changes to this index were made after the Data Workshop.

2.3.7.1 Coastal Fisheries Logbook Program Commercial Longline Index

Coastal Fisheries Logbook Program (CFLP) data were used to construct a standardized index of biomass for Mutton Snapper (see Data Workshop Report Section 5.5.3). The index was constructed using data from commercial longline trips between 1993 – 2022. Because the longline fishery operates almost exclusively in the Gulf of Mexico, only those trips occurring in the Gulf of Mexico were included. Data from all months were used to construct the index and the timing of the index was assigned to mid-year (July) in the assessment model. Index units were in whole weight per number of sets divided by the number of hooks per set and the uncertainty in the index observations was estimated through the standardization techniques used to determine the final observed index values.

The index of abundance created from the commercial logbook data was considered by the IWG to be suitable when truncated to 2010 and was recommended for use in the assessment. The reason for truncating the index was that the implementation of IFQs and the Red Snapper closure led to changes of fisher behavior, such that the Stephens and MacCall (2004) subsetting procedure was no longer identifying species relationships reliably. Additionally, because this index covers a size range not covered by other indices, in particular larger, older fish, it was determined that the benefit of including this index outweighed potential issues the index may have. Lengths of Mutton Snapper characterizing the commercial longline index were assumed to match those of commercial longline landings.

Index values and their CVs are presented in **Table 9.** No changes to this index were made after the Data Workshop, however this index differs slightly from the erroneous index in Table 5.8.1 in the Data Workshop Report. The commercial longline index that was presented in Table 5.8.1 was mistakenly copied from a previous data submission, but the correct index was presented and discussed at the Data Workshop. The corrected index, along with other fishery independent indices in the Gulf of Mexico, is shown in **Figure 13**.

2.4 Fishery-Independent Surveys

The Index Workgroup (IWG) recommended six fishery-independent abundance indices for use in the assessment model. These indices are briefly summarized below but are explained in greater detail in the Data Workshop Report Section 5 and corresponding working papers. Indices in each region are shown collectively in **Table 9** and **Figures 13-15,** and associated CVs are presented in **Figure 16**.

2.4.1 Gulf of Mexico Combined Stereo Video Survey

The Gulf of Mexico Combined Stereo Video Survey Index combines data from two stationary video surveys of reef fishes in the Gulf of Mexico; the NMFS SEAMAP reef fish video survey (SRFV) carried out by NMFS Mississippi Laboratory, which has the longest running time series (1992-1997, 2002, and 2004+), followed by the Florida Fish and Wildlife Research Institute survey (FWRI, starting year 2008).

The video surveys and index development are fully described in the Data Workshop Report Section 5.4.4 and SEDAR 79-DW-21, however several modifications to this index were made after the Data Workshop.

2.4.1.1 Gulf of Mexico Combined Stereo Video Survey Index

The Data and Assessment panels recommended the removal of years 2010-2015 from the FWRI survey and years 1993-1995, 2013, and 2015 from the SRFV survey, as well as the addition of 2022 data. The removal of these years was recommended because either the core Mutton Snapper habitat (i.e., the Dry Tortugas) was not sampled or there were no Mutton Snapper sampled.

The updated index presented in **Figure 13** shows a highly variable but stable trend from 1996 – 2010, followed by an abrupt increase in 2011, a general decline through 2019, and then a sharp decrease from 2020-2022. The index is approximately 37% of the mean from 2020-2022, whereas other indices are at least 1.5 times the mean for same period. However, trends in nominal survey means differed considerably from the combined index, leading the Assessment Panel to recommend allowing for a decrease in survey catchability (q) to account for the increased spatial coverage in mostly poor Mutton Snapper habitat in the FWRI and GFISHER surveys (see Section 3.1.11).

Sampling occurs April through October, therefore the timing of this index specified in the base model is mid-year (July 1st). Index values and their CVs are presented in **Table 9.**

2.4.1.2 Gulf of Mexico Combined Stereo Video Survey Length Composition

For the Gulf Combined Video survey, only 295 Mutton Snapper were measured for length. Thus, only a single length distribution of the number sampled by length is used as a model input (see Table 17 and Figure 45 in SEDAR 79-AP-01).

2.4.2 NMFS Reef Visual Census (RVC, Dry Tortugas and FL Keys) and Southeast Florida Coral Reef Initiative (SEFCRI/RVC, SE FL)

National Marine Fisheries Service's (NMFS) Reef Visual Census (RVC) began in 1979 with divers identifying and counting fish along Florida's reef track. The program evolved into gridding the entire reef track into 50m x 50m blocks (originally 200 m x 200 m blocks) and listing the habitats in each block (Primary Sampling Units, PSU). Primary Sampling Units are randomly sampled by habitat with the number of samples depending upon the variability of the strata. Depths sampled range from approximately 1 to 33 meters across all regions.

Separate indices were developed for Southeast Florida, the Florida Keys, and the Dry Tortugas because there are clear differences in the lengths observed by region and there were only three years for which sampling occurred in all regions. Lengths of the Mutton Snapper observed in the Dry Tortugas were typically larger and those observed in Southeast Florida were smaller than the lengths from the Florida Keys.

2.4.2.1 RVC Indices

The IWG approved three RVC indices for use in the assessment: Southeast Florida (2013 – 2022), Florida Keys (1997 – 2022), and Dry Tortugas (1999 - 2021), but oftentimes sampling occurred in non-consecutive years.

After the Data Workshop, data for 2023 in the Dry Tortugas was approved for use by the Assessment Panel. The updated index compared to that reviewed by the IWG was very similar and showed a continued increase in 2023 (**Figure 13**). Index values and the associated CVs are presented in **Table 9** and **Figures 13-14.**

Data from months with few observations were deleted such that the Florida Keys only included data from June through September, the Dry Tortugas only included data from May through July, and southeast Florida included data from June through October. For simplicity, the timing of all indices was assigned to mid-year (July 1st) in the base model.

2.4.2.2 RVC Length Compositions

The RVC divers estimate fork lengths to the nearest cm in situ, but variability in the observed fork lengths necessitates binning the fork lengths in 5 cm bins ([0,5), [5,10), [10,15), etc.). To make length types consistent with management regulations, binned fork lengths are converted to binned maximum total lengths (max TL) by first converting the midpoint of each 5 cm fork length bin to maximum total length in cm using the equation max TL = 1.071*FL + 1.552 (df = 2886, MSE = 35.41, R2 = 0.998, SEDAR 79). These maximum total lengths are then put into 5 cm max TL bins ([0,5], [5,10], [10,15], etc.). Converting fork lengths to maximum total lengths in this fashion preserves the shape of the distribution of binned fork lengths.

Length compositions weighted by index values for each of the RVC regions (Dry Tortugas, FL Keys, and SE FL) are presented in Tables 14-16 and Figures 42-44 in SEDAR 79-AP-01. Length samples were assigned to have occurred mid-year (July) and were not separated by sex. Input sample sizes for length were set equal to the number of observations of Mutton Snapper per secondary sampling unit. Effective sample sizes were then estimated using the Francis (2011) iterative re-weighting procedure.

2.4.3 Southeast Reef Fish Survey (SERFS, Cape Hatteras, NC to St. Lucie Inlet, FL)

The Southeast Reef Fish Survey is a collaborative trap and video survey conducted by NOAA Fisheries and the South Carolina Department of Natural Resources. SERFS has been conducted since 1990 using baited chevron traps, and video cameras were attached to traps regionwide in 2011. The spatial extent of the survey ranges from Cape Hatteras, NC, to St. Lucie Inlet, FL, from approximately 15 to 115 m deep. The survey uses a simple random sampling design, selecting approximately 1,500 stations to sample out of a sampling universe of approximately

4,300 stations, all on reef habitat. Mutton Snapper were rarely caught in traps, so only video counts were used to develop an index of abundance and a calibration factor was included to account for a change in camera type after 2014.

The SERFS index from 2011-2022 (no sampling occurred in 2020 due to COVID-19) was approved by the IWG. Index values and the associated CVs are presented in **Table 9** and **Figure 14**. SERFS is conducted from mid-April through October each year, but for simplicity the timing of the survey was specified as July 1st. Since size or age data from videos were not available for this assessment, the IWG recommended using age-based knife edge selectivity between ages 2 and 3.

2.4.4 FWRI FIM Inshore Seine Survey (Indian River Lagoon, FL)

The Florida Fish and Wildlife Conservation Commission's Fisheries Independent Monitoring (FIM) program monitors seven estuaries throughout Florida (Apalachicola Bay, Cedar Key, Tampa Bay, Charlotte Harbor, Northeast Florida, Northern Indian River Lagoon and Southern Indian River Lagoon). Sampling within each estuary is stratified by habitat and gear type proportional to the available sampling area. The primary gear type used to sample juvenile and adult sportfishes is a 183 x 2.5 m center bag haul seine that has a stretched mesh length of 38 mm (183-m seine). Mutton Snapper were most commonly encountered by the two labs that sample the Indian River Lagoon; Indian River (IR) and Tequesta (TQ).

The IWG approved the standardized index using data from the Indian River Lagoon (1999 - 2022). Index values and the associated CVs are presented in **Table 9** and **Figure 15**. The size cutoff for primarily age-0 fish was chosen as 19 cm standard length (SL) and months were limited to July-December to capture the recruitment window. Therefore, the timing of the index was assigned near the middle of the recruitment window (mid-September) in the base model.

2.4.5 Additional Fishery-independent Sources

Conditional age-at-length data from fishery independent sources (Vose and Shank [2003], FWRI Fisheries-Independent Monitoring, MARMAP, SERFS, South Atlantic Deepwater Longline Survey, and SFR [extension of the Vose and Shank 2003 study]) were used within the model to estimate growth but were not linked to any existing fleet or survey. These samples are summarized as conditional age-at-length by year in **Figure 17**. Input sample sizes for the number of ages sampled in a given length bin by year were set equal to the number of aged fish but were later down-weighted according to Francis (2011) to estimate effective sample sizes. These samples were assigned to have occurred mid-year (July) and were not separated by sex.

3. STOCK ASSESSMENT MODEL CONFIGURATION AND METHODS

3.1 Stock Synthesis Base Model Configuration

The base model for the SEDAR 79 southeastern U.S. Mutton Snapper stock assessment (SEDAR 79 Base Model) was developed in Stock Synthesis (SS) version 3.30.22.1. Stock Synthesis is an integrated statistical catch-at-age model that can accommodate age-structured, size-structured, and age-aggregated data (Methot and Wetzel 2013). It has 1) a population sub-model that simulates growth, maturity, fecundity, recruitment, movement, and mortality processes, 2) an observation sub-model which predicts values for the input data, 3) a statistical sub-model which characterizes goodness of fit and obtains best-fitting parameters and their associated variance via maximum likelihood, and 4) a forecast sub-model which projects various user-determined management quantities (Methot et al. 2024). Projections in Stock Synthesis start from the year following the terminal year of the assessment model utilizing the same population dynamics equations and modeling assumptions. Further descriptions of SS options, equations, and algorithms can be found in the SS user's manual (Methot et al. 2024), the NOAA Fisheries Toolbox website (http://nft.nefsc.noaa.gov/), and Methot and Wetzel (2013).

The SEDAR 79 Base Model was of moderate complexity - informed by catch data from two commercial fleets and two recreational fleets (including landings, discards, landings-at-length, conditional age-at-length), a fishery-dependent index of biomass (including length compositions), six fishery-independent abundance indices (including length compositions where available), and fishery-independent conditional age-at-length composition data that were not associated with any fleet or survey.

The model estimated 202 out of the 242 parameters including, but not limited to, growth parameters (asymptotic length [L_{inf}], von Bertalanffy growth coefficient [k], and the reference length for the start of von Bertalanffy growth [L_{min}]), virgin recruitment (*ln(R0)*), steepness (*h*), variability in recruitment (*sigmaR*), time-varying stock-recruit deviations, fishing mortality rates for each fleet and year that it was operational, length-based selectivity parameters for fleets, landings, discards, retention and indices with length composition data. Model-derived estimates include maximum sustainable yield (MSY) and MSY-proxy reference points (e.g., $F_{30\%SPR}$), and a full time series of population abundance-at-age (units: 1,000s of fish) and biomass (female spawning stock biomass, total, and exploitable in metric tons). The r4ss (Taylor et al. 2021) and ss3diags (Carvalho et al. 2021) software packages were utilized extensively to summarize and plot model outputs and perform diagnostic runs.

3.1.1 Temporal Structure

Based on elevated gonadosomatic indices and the proportion of spawning capable females, April through July is considered to be the core spawning season (SEDAR 79-DW-12). From July through December, young-of-year Mutton Snapper less than 20 cm standard length (SL) are encountered in the 183-m seine in Indian River Lagoon (SEDAR 79-DW-18). However, data limitations precluded the use of multi-season model.

Therefore, the Southeastern US Mutton Snapper population was modeled with a single season timestep, starting on January 1st as age 1, spawning on June 1st, and aging one year each January 1st through age 40+, which represents a plus group (only accounts for 1.6% of otoliths). Catch, length, conditional-age-at-length, and index data were fit from 1981 – 2023. Since there was insufficient data to include more than one season, fisheries were assumed to operate continuously throughout the year.

3.1.2 Spatial Structure

Sufficient data informing the movement of Mutton Snapper were unavailable, therefore a single area model was implemented such that fish were assumed to homogeneously settle as recruits and spawn as adults across the entire Gulf of Mexico and South Atlantic regions.

3.1.3 Life History

3.1.3.1 Morphometric and Conversion Factors

Morphometric and conversion factors that were used to produce data inputs or that were specified as model inputs were not updated after the Data Workshop. The relationship between whole weight (WW in kilograms) and maximum total length (MaxTL in centimeters; WW = $aMaxTL^b$) for both sexes combined was specified as a fixed model input (**Table 10, Figure 18**).

Although not a direct input into the model, the gutted weight (GW) to whole weight (WW) conversion (GW = 1.10*WW, NMFS ALS) was used to convert the commercial landings from gutted weight to whole weight prior to input into the model (Section 2.4 in the Data Workshop Report).

3.1.3.2 Growth

There did not appear to be regional differences in growth, nor evidence of sexual dimorphism (SEDAR 79-DW-22 and see Data Workshop Report Section 2.5.5); therefore, a single growth pattern was assumed. Growth was estimated within Stock Synthesis according to the von Bertalanffy growth function where initial values for the asymptotic length ($L\infty$), the von Bertalanffy growth coefficient (k), and the CV as a linear function of length-at-age were initially based on the external size-truncated model results (Section 2.5.5 in the Data Workshop Report, SEDAR 79-DW-22), but then were updated according to a jitter analysis (Section 3.5.1, **Table 12**).

Lmax was specified as equivalent to $L\infty$. The CV parameters were used in SS to describe the variability in length-at-age for the minimum (CVyoung) and the maximum (CVold) observed ages. The CV of mean length-at-age for intermediate ages was linearly interpolated. In the base model, growth was configured such that fish grew according to the von Bertalanffy growth model immediately upon ‘settlement’ at age-1 on January 1 (Amin = 0), beginning at a length of 28 cm (L_{min}), but L_{min} was freely estimated (**Figure 18, Tables 10-11**).

3.1.3.3 Natural Mortality

The LHW recommended Mutton Snapper natural mortality-at-age be estimated with the assumption that the instantaneous natural mortality, based on the longevity model updated by Hamel and Cope (2022), should be inversely related to fish length (Lorenzen 2022) and held constant over time (see Data Workshop Report Section 2.6).

The instantaneous natural mortality estimate was 0.129 yr^{-1} using the Hamel and Cope (2022) longevity equation with t_{max} = 42 yr (**Table 10**). Following Lorenzen (2022), age-specific natural mortality rates were derived using this estimate as the target-M (scaled between ages 3 – 42) and with the size-truncated von Bertalanffy growth model results (**Table 11**, Data Workshop Report Section 2.5.5). However, to maintain consistency with growth parameters estimated by the base model, age-specific natural mortality was specified in the base model using the Lorenzen option in Stock Synthesis scaled between ages 3 – 40. Estimated age-specific natural mortality rates were found to range from 0.30 yr^{-1} to 0.118 yr^{-1} for ages 1 to 40 years (**Table 11**, **Figure 18**).

3.1.3.4 Maturity, Fecundity, and Spawning Stock Biomass

The base model was configured as a single gender model (Ngenders = -1) where the spawning biomass is multiplied by a user-defined fraction female to produce estimates of female-specific spawning stock biomass. An analysis of biological data collected for Mutton Snapper indicated that the overall male:female sex ratio was 1.19:1.00, slightly biased toward the number of males (Section 2.8.5 in the Data Workshop Report). Uncertainty, however, was not considered so it is unknown if there is a statistically significant difference from a 1:1 sex ratio. For simplicity, the user-defined fraction female in the base model was defined as 0.50. Maturity-at-age followed a logistic equation based on parameters documented in SEDAR 79-DW-12 (**Table 5**) that included all sampling months and spawning capable or actively spawning females assigned through histology and macroscopic staging in the mature group. Parameters for the logistic function were treated as a fixed input within the SS base model **(Table 10**, **Figure 18**). Fecundity was configured as linear eggs/kg on body weight ($eggs=b+m*wt$) and parameterized such that the number of eggs was equivalent to spawning biomass by fixing b=0 and m=1 (**Table 10**).

3.1.4 Initial Conditions

Stock Synthesis requires initial equilibrium catch values as fixed inputs and the estimation of initial fishing mortality rates for each fleet. Initial equilibrium catches represent catches from a stock exhibiting a balance of removals and natural mortality by stable recruitment and growth. However, the Mutton Snapper population was not assumed to be in equilibrium prior to the assessment's start year (1981) given the reported fishing history. Initial equilibrium catches for each fleet were therefore estimated within the base model. Specified initial equilibrium catches for the commercial fleets were equal to the total reported landings in the first year (1981). For the recreational fleets, equilibrium catches were equal to the average of the reported landings in the first five years. Due to the high uncertainty associated with these starting values, coupled with the unknowable nature of initial equilibrium catches, the Assessment Panel supported setting the lambdas associated with the fits to the initial equilibrium catches to 0, thereby removing goodness of fit of the equilibrium catches from the objective function.

Initial fishing mortality rates for each fleet were freely estimated, but diffuse symmetric beta priors were applied to keep model estimates in a plausible space. Model sensitivity to equilibrium catch values and initial fishing mortality rates was evaluated via parameter profiling, and the model did not appear sensitive.

Due to model instability, steepness was assumed to be 1 in the equilibrium time period but was freely estimated thereafter. Therefore, the initial equilibrium is calculated from a recruitment level unaffected by steepness and initial age composition adjustments are applied after the initial equilibrium calculation.

The model first applies the initial fishing mortality rates to an equilibrium age composition to arrive at a preliminary initial age composition. Since the emphasis on fitting the equilibrium catch values was removed (i.e., lambda = 0), initial fishing mortality rates are informed by early length and age information. A non-equilibrium initial age composition was then achieved by applying early recruitment deviations prior to the model start year.

3.1.5 Recruitment Dynamics

The Stock Synthesis base model used the Beverton-Holt stock-recruitment model. In SS, this stock-recruitment function uses three parameters which can be simultaneously estimated: 1) steepness (*h/BH_steep*; the recruitment obtained at 20% of the virgin biomass), 2) the virgin recruitment estimated in log-space (*ln(R0)*), and 3) the standard deviation of the natural log of recruitment (*sigmaR*). *SigmaR* penalizes deviations from the spawner-recruitment curve (calculated from *ln(R0)* and steepness) and defines the difference between the arithmetic mean spawner-recruitment curve and the expected geometric mean (Methot et al 2019). All three stock-recruitment parameters were estimated within the base model.

Simple annual deviations from the stock-recruitment function, which were not constrained to sum to zero, were estimated assuming a lognormal error structure. The main recruitment deviations were estimated for the time period of greatest data-richness (1986 – 2023), which corresponds to when age data for the fleets largely became available. Additionally, early recruitment deviations were estimated for 1970 – 1985 and were informed by length composition data, a small amount of age data, and removals from natural mortality and fishing.

Expected recruitments need to be bias adjusted in SS because of its assumed lognormal error structure. The adjustment is accomplished by applying a full-bias correction to the recruitment deviations which have enough data to inform the model about the range of recruitment variability (Methot et al. 2019). Following the recommendation from Methot and Taylor (2011) to use the full bias adjustment on data-rich years, the SS base model used full bias adjustment between 1986 – 2018 after which it decreased the full bias adjustment to no bias adjustment by 2029.

3.1.6 Fleet and Survey Configuration

The fleet configuration in the base model was informed by the amount of available length and age data, observed differences in sampled lengths and ages (SEDAR 79-AW-01), and Workgroup recommendations. Four fishing fleets were included in the base model: Commercial Longline (Com LL), Commercial Other (Com Other), Recreational East (Rec E, SE FL and North), and Recreational West (Rec W, FL Keys and Gulf). The recreational fleet structure for SEDAR 79 differed from that in SEDAR 15AU, wherein the defined recreational fleets were headboat and other (shore, charter, private).

All fleets in the SEDAR 79 Base Model had associated length compositions and conditional age-at-length data; however, only the Com LL fleet had a linked CPUE index (units: whole weight per number of sets divided by the number of hooks per set). As described in Section 2.3.7.1, the index was truncated to 2010 because of the changes in fisher behavior due to the implementation of IFQs and the Red Snapper closure. As such, the CPUE was treated as an index of biomass from 1993-2010 and was assumed to reflect trends in population biomass over this time. Since the index was only based on landings, the selectivity of the index was assumed to match the retention of the commercial longline fleet.

A single fishery-independent young-of-year (YOY) survey and five fishery-independent post-YOY surveys were modeled, some with associated length compositions. The surveys were: FIM Inshore Seine Survey (FIM YOY), Gulf Combined Video Survey (Gulf Video), Reef Visual Census Dry Tortugas (RVC DT), Reef Visual Census FL Keys (RVC Keys), Reef Visual Census SE FL (RVC SE FL), and the Southeast Reef Fish Survey (SERFS).

3.1.7 Selectivity

Selectivity patterns describe the probability of capture-at-length or -age by a given fishery or gear. Selectivity can be used to model different gear types, targeting, and fish availability according to the spatial utilization of fish and/or fishery. Stock Synthesis allows selectivity to differ by length, age, or both. The SEDAR 79 Base Model was configured using length-based selectivity for all fleets, as well as the Gulf Video and RVC indices. Age-based selectivity was assumed for the SERFS index and the FIM YOY index was specified as a recruitment index. All selectivity parameters were freely estimated, except where noted (**Table 12**).

Selectivity patterns across fleets and indices were configured to be constant over time, thereby assuming that major changes in the availability of Mutton Snapper and/or changes to management regulations have not occurred so as to alter these patterns since the model's start year.

Length- or age-based selectivity can be specified in various ways in Stock Synthesis (Methot et al. 2024), however for the SEDAR 79 Base Model only one of the following three selectivity forms were applied to each fleet/index: a two-parameter single logistic function (i.e., flat-topped), a six-parameter double normal function (i.e., dome-shaped), and user-specified selectivity at age. Two parameters describe logistic selectivity: (1) the length at 50% selectivity, and (2) the difference between the length at 95% selectivity and the length at 50% selectivity. Six parameters describing the double normal function: 1) peak selectivity: beginning size (or age) for the plateau (in cm or age), 2) top: width of plateau, as logistic between peak and maximum length (or age), 3) ascending width: parameter value is ln(width), 4) descending width: parameter value is ln(width), 5) initial: selectivity at first bin, as logistic between 0 and 1, and 6) final: selectivity at last bin, as logistic between 0 and 1.

3.1.7.1 Length-based Selectivity

The SEDAR 79 Base Model was configured using length-based selectivity for all fleets, as well as the Gulf Video and RVC indices.: 1) Commercial Longline (single logistic), 2) Commercial Other (single logistic), 3) Recreational West (double normal), 4) Recreational East (double normal), 5) Gulf Video index (single logistic), and 6) RVC indices (double normal).

Double normal (i.e., dome-shaped) selectivity was implemented for the recreational fleets because limited availability of large Mutton Snapper was evident in the length composition data (SEDAR 79-AW-01) and recreational anglers may generally fish in shallower depths compared to the commercial fleets. The recreational fleets also contain landings and releases from anglers fishing from shore which invariably fish in relatively shallow depths.

Logistic selectivity (i.e., flat-topped) was modeled for the Gulf Video index because although length data are sparse, the survey encapsulates a wide range of depths and distance from shore. Dome-shaped selectivity was modeled for the RVC surveys, as it is a visual survey and operates in safe diving depths of 30-m or less.

3.1.7.2 Age-based Selectivity

Only a single index, the SERFS index, was modeled with age-based selectivity. Since sampled lengths and ages were not available for this survey, full selectivity for ages 3+ and zero selectivity otherwise was assumed for the SEDAR 79 Base Model based on IWG recommendations. The FIM YOY index assumed full selectivity at age 0 (representative of age 1 in year y+1) as it was specified as a recruitment index.

3.1.8 Length-based Retention

All fleets with releases (i.e., all except the Commercial Longline fleet) were assumed to release fish in accordance with the minimum size limit. In Stock Synthesis, retention is defined as a logistic function of size or age (Methot et al 2019). Since size regulations for southeastern U.S. Mutton Snapper are in the form of a minimum size limit in maximum total length, as opposed to a slot limit, retention was modeled as an asymptotic function with length and consisted of four parameters: (1) the inflection point, (2) the slope, (3) the asymptote, and (4) the male offset inflection (not applicable to this model and assumed to be zero). The asymptote was fixed at 100% retention since larger Mutton are rarely released, even with enacted bag limits. Therefore, only the inflection point and slope were freely estimated for all retention functions, except where noted below and in **Table 12**.

Time-varying retention functions were used to allow the lengths of releases to change according to increases in the minimum size limits. To capture discernable shifts in release lengths and to reduce the number of time blocks, time blocks for the retention functions were based only on changes in the federal minimum size limits in the South Atlantic (i.e., the jurisdiction that accounts for most of the landings) listed below.

South Atlantic Federal (3 - 200 Miles)

- 12” (305mm) TL (1/1992 – 1/1995)
- 16” (406mm) TL (1/1995 – 2/2018)
- 18” (457mm) TL (2/2018 – present)

Prior to the implementation of the size limit in the South Atlantic (i.e., pre-1992), all fish caught were assumed to be retained (i.e., landed) for the Commercial Other fleet as estimates of releases were unavailable prior to 1993. For the recreational fleets, releases were available for the entire time series (1981 – 2023) and therefore retention was not forced to align with selectivity prior to 1992. Shifts in retained and/or released lengths differed by fleet; to favor model parsimony, time-varying retention was treated differently by fleet as identified below.

Time-Varying Retention for the Commercial Other Fleet

Time Block	Inflection	Slope	Asymptote
1981 - 1991	Fixed at 10 cm MaxTL	Fixed at 1 (knife-edge)	Fixed at Maximum
1992 - 2017	Estimated	Estimated	Fixed at Maximum
2018 - 2023	Estimated	Estimated	Fixed at Maximum

Time-Varying Retention for the Recreational East and West Fleets

Time Block	Inflection	Slope	Asymptote
1981 - 1994	Estimated	Estimated	Fixed at Maximum
1995 - 2017	Estimated	Estimated	Fixed at Maximum
2018 - 2023	Estimated	Estimated	Fixed at Maximum

3.1.9 Landings

The uncertainty associated with landings and releases for the recreational fleets was much greater than that for the commercial fleets (**Table 2** and **Table 8**), leading to a different treatment in the estimation of fishing mortality rates between these two sectors. For the commercial fleets, the fishing mortality rates were specified using the 'hybrid F' option, wherein the estimated landings were practically an exact fit to the observed landings. For the recreational fleets, the fishing mortality rates were specified as parameters, allowing a reduced fit to observed landings in order to better fit other data sources (e.g., discards, indices). Treating fishing mortality rates as parameters is preferred when catch is known imprecisely and when it is acceptable to have a solution in which the estimated fishing mortality rates do not reproduce the input catch levels exactly.

3.1.10 Releases

Live and dead releases for each fleet were calculated and fit within the base model. Live releases were estimated by applying the converse of the retention function to the total catch, while dead releases were the result of assumed release mortality rates (Methot and Wetzel 2013). The total mortality can then be expressed as:

$$\text{\# of dead fish } = \sum_{fleets} N_a \text{selectivity}_{fleet,age} * (\text{retention}_{fleet,age} + (1 - \text{retention}_{fleet,age}) * \text{release mortality rate}_{fleet}).$$

Fleet-specific release mortality rates were treated as fixed model inputs (see above Section 2.2.3) and configured in SS using the following formula:

$$\text{Release Mortality Rate} = \left(1 - \frac{1-P3}{1+e^{\frac{-(L-(P1+P4*male))}{P2}}}\right).$$

The four parameters describe 1) the descending inflection point, 2) the descending slope, 3) the maximum release mortality, and 4) the male offset inflection. The fourth parameter was not applicable to this model and fixed at zero. Therefore, releases mortality rates are a logistic function of size such that mortality declines from 1.0 to an asymptotic level as fish get larger. For all fleets, the release mortality rates were treated as constant across sizes by setting a very large positive value for the descending slope (i.e. 1E+06), resulting in a denominator approximately equal to 2, and a negative value for P3 that produces a specified release mortality rate. Release mortality rates were assumed constant throughout time.

Mutton Snapper exhibit similar body size (< 100 cm total length) and life history strategies (adults reside on marine reefs) to Red Snapper and are collected with similar gear types (hook and line). Due to these similarities and a lack of data informing Mutton Snapper release mortality, release mortality estimates of Red Snapper from Ramsay et al. (2022) that included delayed mortality rather than just immediate mortality at the surface were used as proxy for the release mortality of Mutton Snapper. The Workgroup considered the primary capture depth range of Mutton Snapper to be in shallow waters of 30 meters or less for all fleets and referred to Figure 4B in Ramsay et al. (2022) to determine a release mortality at 30-meter depth to be approximately 30%. The Workgroup then decided on a 15% lower bound for a sensitivity run applied to both commercial handline and recreational fisheries to be consistent with the previous assessment, and an upper bound of 45% for symmetry.

3.1.11 Catchability

Constant catchability was assumed for all surveys except for the Combined Gulf Video Index. As discussed in Section 2.4.1.1, the Assessment Panel recommended the estimation of three catchability levels coinciding with changes to the survey design. Catchability coefficients for the Gulf Video index were estimated for a base period from 1996 – 2015, a secondary period from 2016 – 2019 (when both SRFV and FWRI survey data overlapped), and a third period from 2020 – 2022 (the unification of both surveys under GFISHER). These catchability coefficients were freely estimated and were allowed to either increase or decrease between time blocks.

3.2 Goodness of Fit and Assumed Error Structure

A maximum likelihood approach is used in Stock Synthesis to evaluate the overall goodness of fit to each data source (i.e., landings, discards, indices, length compositions, and conditional-age-at-length). Datasets contained an assumed error distribution (e.g. lognormal) and an associated likelihood determined by the difference between observed and predicted values and the variance of the error distribution. The total likelihood is the sum of the individual components' likelihoods. The global best fit to all the data was determined using a nonlinear iterative search algorithm to minimize the total negative loglikelihood across the multidimensional parameter space.

Several model components were not given any weight in the loglikelihood function (i.e., the likelihood component multiplied by the weight (lambda) value was set to zero). These zero weight components included initial equilibrium catch values for each fleet and a near-zero weight (lambda = 0.01) for the releases from the Commercial Other fleet. Setting the weight in the loglikelihood function to zero (or near zero) reflects a lack of confidence in values for these components and they were not used for fitting the model to the data and parameters.

The error structure for landings, indices, and discards was assumed to be lognormal, except where noted. For most data sources, the variance of the observations was available only as a coefficient of variation (CV). In SS, if lognormal error structures were required, CVs were converted to a standard error (SE) in log-space using the following formula:

$$SE = \sqrt{ln\,(1 + CV^2)}.$$

Within the landings data, commercial landings contained the least amount of uncertainty (**Table 2**) because the programs which collect those data consider it a census (assumed to be complete or nearly so) rather than a survey (which is from a sample). Estimates of uncertainty for recreational landings and discards varied by year and were calculated according to Sections 2.3.2 and 2.3.4 (**Table 8**).

Releases from the Commercial Other fleet were assumed to have a normal error structure with specified CVs as CVs and standard deviations provided by SEFSC applied to discard rates on the arithmetic scale (as opposed to discards on the logarithmic scale) (**Table 2**). Uncertainty in the index observations was estimated through the standardization or design-based techniques used to determine the final observed index values (**Table 9**).

Multinomial distributions were assumed for the length composition data of the landings, discards, and indices as well as the conditional age-at-length composition data of the landings and fishery-independent dataset, which have variances estimated by the input effective sample sizes. The variance of the multinomial distribution is a function of true probability and sample size; thus, an increase in sample size represents lower variance and vice versa. The effective sample size is meant to represent the number of independent and random samples each year to determine the length or age composition. The assumption of independent and random sampling is typically violated because fish caught in the same tow or set tend to be more similar to each other in length or age than are fish from different catches, and this can extend to fish caught by the same vessel. In addition, the assumption of random sampling can be violated (e.g. by sampling vessels non-randomly or by under-sampling nighttime trips or fishing areas).

The variance associated with each data source can be highly influential, especially when there are conflicts among data sources. Because true effective sample sizes are unknown, effective sample sizes for length compositions were initially set to the number of trips from which samples of Mutton Snapper were obtained to avoid over-weighting observations of lengths in the likelihoods. The effective sample sizes for conditional age-at-length were set to the number of Mutton Snapper sampled because there are fewer fish aged at a given length.

Francis (2011) and Punt (2017) have developed re-weighting procedures to adjust the effective sample sizes of length and conditional age-at-length data iteratively until the multipliers reached a stable value. Multipliers are calculated so that variability of model inputs is consistent with the model fits to mean length or mean age (Francis 2011). It was verified that weighting factors did not exceed 1, meaning that the adjusted effective sample sizes were no more than the number of sampled trips (or number aged).

A new feature available in Stock Synthesis is to apply Francis weights separately to length or age data from each fleet/survey and partition (released or landed). This allows for different weighting factors between released lengths and retained lengths, which comparatively have a much greater input effective sample size.

An alternative weighting method for composition data is to use the Dirichlet-Multinomial distribution which estimates a parameter (theta) that internally scales the input sample size (Thorson et al. 2017; Methot et al. 2023). This method was attempted but most theta parameters were poorly estimated leading to model nonconvergence; the iterative Francis method was therefore utilized.

3.3 Estimated Parameters and Derived Quantities

A total of 202 out of 242 parameters were estimated within the SEDAR 79 Base Model for southeastern U.S. Mutton Snapper (Table 12). Of the 242 total parameters, 19 were used to describe life history components, 11 estimated deviations from the initial age composition, 43 estimated annual recruitment dynamics, 4 estimated initial fishing mortality rates, 86 estimated fishing mortality rates, 9 were related to index catchabilities, and 70 described selectivity, retention and discard mortality for the four fleets and six indices. Included in Table 12 are estimated parameter values from Stock Synthesis, the range of values a parameter could take, their initial starting values, their associated standard deviations and CVs, the prior type and its standard deviation (where applicable), and the phase the parameter was either estimated (positive phase) or fixed (negative phase). Most parameter bounds were set extremely wide and may include unrealistic values, however this was intentional as it reduced the gradient and allowed the search algorithm to adequately explore the solution space to avoid finding a local minimum. The SEDAR 79 Base Model also used the soft bounds option which moves parameters away from the bounds with a weak penalty (Methot et al. 2019).

Derived quantities include annual numbers- and biomass-at-age, spawning stock biomass, fishing mortality rates-at-age, and internally calculated reference points (e.g., $F_{MSYproxy}$, $SSB_{MSYproxy}$, MSY_{proxy}). Also, recent fishing mortality rates ($F_{Current}$) and recent spawning stock biomass ($SSB_{Current}$) as the geometric mean of the most recent three years were compared to management benchmarks to determine stock status.

3.3.1 Uncertainty of Parameters and Derived Quantities

Approximate uncertainty estimates for estimated and derived quantities were calculated after model fitting based on the asymptotic standard errors from the covariance matrix determined by inverting the Hessian matrix (i.e., the matrix of second derivatives was used to determine the level of curvature in the parameter phase space and to calculate parameter correlations; Methot and Wetzel 2013). Asymptotic standard errors provided a minimum estimate of uncertainty in parameter values.

In addition, Monte Carlo Markov Chain (MCMC) analyses provided posterior distributions of model parameters and selected derived quantities. MCMC allows probabilistic reporting of the uncertainty associated with the estimated values. Estimates of population values in the terminal year of the stock assessment are often the most uncertain. Assuming the MCMC posterior distributions provide reliable estimates of model uncertainty, the probability that the estimated terminal year value is above or below the overfished/overfishing reference points can be calculated. In this way, a level of risk associated with failing to reach the reference points can be quantitatively specified. Posterior distributions of current spawning stock biomass ($SSB_{Current}$) and fishing mortality rates ($F_{Current}$) as the geometric mean of the most recent three years (2021-2023) were compared to associated reference points (i.e., MSST, MFMT).

Two MCMC chains were initially produced. For each chain, a total of 10,000,000 iterations were performed but only one out of every 2,000 iterations was saved, resulting in 5,000 potential iterations used to generate estimates of uncertainty in fishing mortality and spawning stock biomass. Visual inspection of trace plots was used to adjust appropriate levels of burn-in and thinning as well as to address any autocorrelation in the iterations. Convergence of a single chain was assessed by Geweke's diagnostic to determine whether the mean of the first 10% of the chain is not significantly different from the last 50% of the chain, while convergence of two chains was assessed using Gelman and Rubin's (1992) potential reduction scale factor implemented in the 'coda' package (Plummer et al. 2006) in R.

3.4 Model Diagnostics

Model diagnostics of the SEDAR 79 Base Model were performed in R using the 'r4ss' and 'ss3diags' (github.com/JABBAmodel/ss3diags) packages and largely follow the recommendations put forth in the Carvalho et al. (2021) 'cookbook' for integrated stock assessment models. While we briefly summarize each diagnostic here, further descriptions can be found in Carvalho et al. (2021) and references therein.

3.4.1 Model Convergence

Several approaches were used to assess convergence of the base model. First, the Hessian matrix must be invertible (i.e., there are valid solutions for all the parameters in the model). Next, the maximum gradient component (a measure of the degree to which the model converged to a local or global minimum) was compared to the final convergence criteria (0.0001, common default value). Ideally, the maximum gradient component will be less than the criterion.

Once these two criteria were met, a jitter analysis was performed on the parameter's starting values to suggest whether the base model had converged on a global solution instead of a local minimum. For this analysis, initial values were jittered by up to 10% and 200 iterations were performed.

3.4.2 Correlation Analysis

High correlation among parameters was also assessed as it can lead to poor model stability along with flat likelihood response surfaces. While some parameters will always be correlated due to their structural nature (e.g., growth and stock-recruitment parameters), many highly correlated parameters may warrant reconsideration of modeling assumptions and parameterization. Therefore, correlation among parameters was examined and any correlations with an absolute value greater than 0.7 were reported.

3.4.3 Residual Analysis

Poor overall fits and patterns in residuals were assessed in a variety of ways to identify potential model misspecification. First, model fits to landings, discards, indices, length compositions, and conditional age-at-length were evaluated via visual inspection of residuals. Overall residual patterns for each model component (indices, length compositions, and conditional age-at-length) were identified through joint residual plots (Winker et al. 2018; Carvalho et al. 2021). These plots include a Loess smoother to detect auto-correlation of residual patterns and data conflicts, as well as indicate outliers that were beyond the 3-sigma limit. Then, a non-parametric runs test (Wald and Wolfowitz, 1940) was performed on the indices, length compositions, and conditional age-at-length data to test for randomness and the presence of temporal autocorrelation in residuals. Combined root mean square error (RMSE) values were also calculated for the indices and length composition data to evaluate goodness-of-fit. Generally, undesirably high RMSEs exceed 30%.

3.4.4 Likelihood Profiles

Parameter profiling was used to elucidate model support for a range of parameter values, particularly for parameters that are often unknown or ill-informed by data (e.g., steepness, unfished recruitment, variation of recruitment deviations, natural mortality). This type of analysis can identify data conflicts and broad, not well-informed likelihood surfaces. Parameter profiling entails holding a parameter value constant at a chosen value while estimating the remaining parameters, and then evaluating the associated marginal log-likelihood (either in totality or for each data source).

Ideally, the plotted relationship between negative marginal likelihood values and the range of parameter values yields a well-defined minimum that aligns with that estimated by the base model. If a given parameter is not well estimated, the profile plot may show conflicting signals across data sources and/or a flat marginal likelihood surface. This indicates that multiple parameter values are equally likely given the data. In such instances, the parameter may not be influential in the model, or the model shows instability and model assumptions may need to be reconsidered. Likelihood profiles were done for several stock-recruitment parameters estimated in the base model (steepness and virgin recruitment [*R0*]) and the fixed average natural mortality rate.

3.4.5 Model Consistency

To measure model consistency, the base model was first subject to a retrospective analysis that removed successive years of data from the model for seven years (i.e. seven peels). Iteratively removing data from the final model year reveals the effect of a single or successive years of data on model results. If the results of this analysis show a retrospective bias (consistent patterns of increasing or decreasing model estimates and related derived quantities with each retrospective peel), it can be an indication of model misspecification of temporal dynamics. It is preferable for estimates associated with each retrospective peel to be randomly distributed around base model results. Model performance was evaluated by visual inspection of retrospective patterns and the Mohn's Rho (ρ) metric (Mohn 1999, Hurtado-Ferro et al. 2015). Based on simulation studies, a Mohn's Rho value between -0.15 to 0.2 is generally considered acceptable for long-lived species (Hurtado-Ferro et al. 2015; Carvalho et al. 2021). This work also suggested that positive values of Mohn's Rho for biomass and negative values for fishing mortality imply consistent overestimation of biomass and the highest risk for overfishing.

Additionally, an age-structured production model (ASPM) and an ASPM with estimated recruitment deviations (ASPMdev) were also developed in Stock Synthesis to investigate which processes were influencing the shape of the production function and whether composition data was influencing the variability in recruitment. For the ASPM, this was completed first by fixing all parameters to those values estimated by the base model except for the R0 parameter and the initial fishing mortality parameters. Next, the likelihood components (i.e., lambdas) for the length and age composition data were set to zero along with the recruitment deviations for both the early and main periods such that only the catch and indices of abundance were fit by the model. For the ASPMdev, recruitment deviations were also estimated and the bias-correction factor was re-adjusted following Methot and Taylor (2011). Trends in both spawning stock biomass and fishing mortality were compared between the base model, the ASPM, and the ASPMdev.

3.4.6 Model Validation (Prediction Skill)

Model validation was assessed by the predictive skill of the base model. This diagnostic evaluated whether the model's predictive capacity is consistent with the future reality. First, a one-year-ahead forecast was done on 9 retrospective model peels. Then, a forecast bias, which is an average relative error corresponding to the retrospective bias (i.e., Mohn's Rho (ρ) metric) was computed to gauge model performance and consistency with realized data in the following year.

Prediction skill of the model was gauged using the hindcasting cross-validation approach of Kell et al. (2021), which compares observations to their predicted future values. Predictive skill was evaluated for the indices, length compositions, and conditional age-at-length data. Mean absolute scaled error (MASE) is calculated as the average ratio of mean absolute error of prediction residuals and the mean absolute error of the naïve in-sampled prediction. This metric indicates whether the average model forecasts are better or worse than a random walk. For example, MASE scores >1 indicate average model forecasts are worse than a random walk (i.e., no predictive skill). However, a MASE score of 0.5 would indicate that the model forecasts twice as accurately as a naïve baseline prediction, thereby demonstrating predictive skill.

3.4.7 Sensitivity Runs

Sensitivity runs were conducted to investigate the impact of alternative assumptions or data sets on model fits and results. Key sensitivity runs are described below, but many additional exploratory runs were also implemented.

3.4.7.1 Remove S-R curve (Steepness ≈ 1)

The stock-recruitment relationship is frequently poorly estimated or can be biased due to patterns in recruitment caused by other factors. Thus, Maunder and Thorson (2019) recommend that assessments using a stock-recruitment relationship compare the performance with a model that avoids specifying such a relationship (i.e., steepness = 0.99). Due to time constraints, two selectivity parameters had to be fixed (peak selectivity for the Rec East and Rec West fleet) for this sensitivity run to improve convergence (i.e., lower the gradient). Since these selectivity parameters were not correlated with any life history or stock-recruit parameters, it should only lead to improved convergence without affecting the results of this sensitivity run.

3.4.7.2 Release Mortality

In accordance with Data Workshop recommendations (see Data Workshop Report Section 2.7), sensitivity runs examining the effect of alternative release mortality rates were performed. This was completed by configuring the fixed parameter inputs in the release mortality equation (Section 3.1.10 above) to produce the respective release mortality rates for each fleet. For all fleets, the upper bound sensitivity was set at 45% and the lower bound was set at 15%, so that the release mortality assumption in the base model of 30% is an intermediary estimate.

3.4.7.3 MRIP-FES Private Mode Landings & Releases

The sensitivity of model results to MRIP FES estimates of private mode landings and releases in Florida in lieu of SRFS estimates was also evaluated. Based on recent and on-going pilot studies, MRIP FES estimates may potentially be skewed based on the way questions were asked during the interview process (Andrews et al. 2018; Andrews 2022). Florida estimates ranged from 32% lower to 20% higher (Andrews 2022). Andrews (2022) reported that these estimates would be altered in magnitude but not in overall trends.

3.4.7.4 Jack-Knife Analysis on Indices of Abundance

A jack-knife approach to data exclusion analysis was performed wherein individual indices were removed and the model was rerun with the remaining data. The goal was to determine if any single index has an undue influence on the model. This approach is especially useful for identifying indices that may be giving conflicting abundance trend signals compared to the other indices. If notably different results are produced by removing an index, the index may not be applied appropriately given the model structure or sampling procedures may be inconsistent (e.g., an index may only be representative of a sub-unit of the stock and therefore may only reflect trends in a local sub-population rather than the entire stock). Therefore, a full index jack-knife was done for the survey data where each survey index was removed (including associated length or age composition data) and the model rerun. When an index was removed, any associated estimated parameters (e.g., selectivity parameters) were no longer estimated. To aid convergence, peak selectivity parameters for the Rec East and Rec West fleets were fixed at base model estimated values.

3.4.8 SEDAR 79 Base Model and SEDAR 15AU Comparison

To satisfy TOR 2a and 3c, results of the SEDAR 79 Base Model were compared to the previous assessment, SEDAR 15A Update 2015 (SEDAR 15AU), which had a terminal year of 2013 and was conducted in ASAP version 3. Annual values of recruits, fishing mortality rates, and spawning stock biomass were compared, as well as reference points as defined for SEDAR 79 (see Section 3.5.10). In the interest of time, reference points were internally calculated within the SEDAR 15AU Final Model (in ASAP 3) or the SEDAR 79 Base Model (in Stock Synthesis), rather than through projections.

3.4.9 SEDAR 15AU with MRIP-FES Data

In accordance with TORs 2b and 9c, SEDAR 15AU results are compared to an exploratory model with charter, private and shore mode landings and releases provided for SEDAR 79 in MRIP-FES currency. The first model retained the SEDAR 15AU configuration, all other data inputs, and terminal year (model name =’S15AU_MRIPcatch’). The goal of this sensitivity run was to capture the effect of updating recreational catch data from MRIP-CHTS to MRIP-FES units.

SEDAR 15AU base model had a terminal year of 2013 and configured the recreational fleets as “Headboat” and “MRFSS.” For the first exploratory run (’S15AU_MRIPcatch’), all inputs from SEDAR 15AU were kept unchanged except for the recreational landings and discards. While the SEDAR 79 data combines Headboat and MRIP-FES into one “Recreational” fleet, the SEDAR 15AU configuration requires them to be separated. The total MRFSS landings and discards by year were replaced with the 1981-2013 MRIP-FES landings and discards (and associated CVs) provided for SEDAR 79. All other data, including Headboat landings and discards and associated CVs, remained unchanged. The average ratios of MRIP-FES to MRFSS landings and discards are 2.05 and 3.39, respectively.

For the next exploratory model, all remaining ASAP model components related to the MRFSS fleet were updated using SEDAR 79 data (model name =’S15AU_MRIPcatch_plus’). This included the MRIP-FES landings and discards, in addition to updated catch and discard proportion catch at age and updated catch and discard weight-at-age. The SEDAR 15AU weights-at-age were configured as constant over time while those values vary over time in SEDAR 79. To adjust, the SEDAR 79 weights-at-age were averaged over time by age. It should be noted that in SEDAR 15AU, there is a single weight-at-age matrix used for all fleet catch and discards. This configuration is retained here with the updated matrix applied to all fleet catch and discards not just recreational. Every other aspect and all other data from the original SEDAR 15AU model were retained.

3.4.10 Model Bridging

A model bridging exercise was undertaken to explore differences in model results between the SEDAR 15AU Final Model and the SEDAR 79 Base Model. The goal of this exercise was to gauge the effect of configuration differences between the SEDAR 15AU Final Model and the SEDAR 79 Base Model by using the original SEDAR 15AU data with a configuration in ASAP 3 that closely resembled the SEDAR 79 Base Model configuration in Stock Synthesis.

The evaluation was conducted in a hierarchy of three steps. The first step was to evaluate the effect of using fleet-specific mean weights by age and year; the next step replaced the separate landings for the headboat and MRFSS/MRIP fleets with the Recreational East and West fleets which combined the headboat and MRFSS/MRIP landings by coast. The final step was to configure the model with the same set of indices as SEDAR 79 as much as possible. All model bridging exercises retained the same fixed natural morality-at-age, maturity-at-age, and fleet-specific release mortality as the SEDAR 15AU Final Model. **Table 13** lists the configuration in each model bridging stage.

The SEDAR 15AU Base Model assumed the same constant mean weights-at-age for all fleets (commercial longline, commercial hook and line, headboat, and MRFSS) and partitions (i.e., landings versus releases). Applying a single weight-at-age matrix may have impacted the results of the Yellowtail Snapper SEDAR 27A assessment by estimating fishing mortality rates for Yellowtail Snapper that were too low and corresponding spawning biomasses that were too high (see Section 3.4.2 in SEDAR 64). When weights-at-age matrices were restructured in SEDAR 27A to vary by fleet, partition, and year, results resembled those of the SEDAR 64 Base Model, suggesting that this configuration difference may have driven the notable differences between SEDAR 27A and SEDAR 64.

The data preparation for estimating the mean weight-at-age by year and the landings involved tallying the SEDAR 15AU recreational lengths, weights and landings for the headboats and for MRFSS/MRIP fleets by region and then recombining them into the Recreational East fleet (headboat and MRFSS/MRIP landings from north of the Florida Keys on the Atlantic) and the Recreational West fleet (headboat and MRFSS/MRIP landing from the Florida Keys and west in the Gulf of Mexico). The individual fish lengths were standardized to maximum total length prior to processing and if a fish lacked a weight, an estimated weight was calculated using the length-weight equation from SEDAR 15AU (Table 2.12). The fleet lengths and weights were grouped into 25 mm length bins as used in SEDAR 15AU, weighted by their landings and converted to ages using the SEDAR 15AU stochastic age-length key.

After the lengths and weights were converted to age frequencies by headboat and MRFSS/MRIP by coast, they could be added to produce the numbers of fish by age and year and the weight of those fish by age and year for the Recreational East and Recreational West fleets. Landings were tallied for the new fleet definitions.

The SEDAR 79 Data Working group did not retain many of the SEDAR 15AU indices and two of the accepted indices were not available in the 1981-2013 period, the Gulf of Mexico video index and the Southeast Reef Fish Survey video index). Also, they only accepted the Reef Visual Census from the Dry Tortugas and because of the individual quotas the years 2011-2013 were removed from the commercial longline index. Therefore, the final configuration bridging model included four fleets: Commercial other, Commercial longline, Recreational East, and Recreational West; three indices: commercial longline, Fishery Independent Monitoring Age-0 applied to Age-1 a year later, and the Dry Tortugas Reef Visual Census index, and fleet specific mean weight-at-age by year matrices.

3.4.11 Per-recruit Analysis

Equilibrium based yield per recruit (YPR) methods (Walters and Martell 2004) estimate the fishing mortality rate that optimizes the yield under the assumption that there is no stochasticity and the fishery has reached an equilibrium with the fishing mortality it exerts. It also assumes characteristics of natural mortality, growth, and recruitment are constant with stock size (Haddon 2001). The expected results of a yield-per-recruit (YPR) analysis are to obtain targets of fishing mortality and age at first capture in effort to evaluate regulations regarding gear types (e.g. hook/mesh sizes and minimum sizes), fishing seasons, or fishing effort (e.g. harvest strategies; Haddon 2001).

3.5 Stock Status Determination

The jurisdictional allocation of the Mutton Snapper acceptable biological catch (ABC) is 82% to the South Atlantic and 18% to the Gulf of Mexico. This was established using 50% of the mean of the catch history from 1990-2008 plus 50% of the mean of the catch history from 2006-2008 (GMFMC 2011). Therefore, the overfishing and overfished criterion for Mutton Snapper is in accordance with SAFMC definitions.

In 1998, the South Atlantic Fishery Management Council (SAFMC) passed Amendment 11 which established the proxy for optimum yield (OY) at 40% SPR for snappers and groupers. In 2018, the South Atlantic Fishery Management Council (SAFMC) passed Amendment 41 that enacted additional management measures (e.g., increasing the minimum size limit to 18 inches [45.7 cm] TL, commercial trip limits during spawning months, year-round recreational bag limits), specified the maximum sustainable yield (MSY) and minimum stock size threshold (MSST) definitions, and revised the ABC, the commercial and recreational annual catch limits (ACLs) and recreational annual catch targets (ACTs) for Mutton Snapper. Amendment 41 also designated April through June as ‘spawning months’ for Mutton Snapper in the South Atlantic, and enacted commercial trip limits during this time. These spawning months closely align with the April through July core spawning season determined by the updated maturity analysis (SEDAR 79-DW-12).

Amendment 41 changed the MSY definition to the yield produced by the fishing mortality rate at MSY (F_{MSY}) or the $F_{MSYproxy}$ (where F equals fishing mortality that, if applied constantly, would achieve MSY under equilibrium conditions). The $F_{MSYproxy}$ is $F_{30\%SPR}$, or the fishing mortality that will produce a static spawning per recruit equal to 30 percent. Amendment 41 also changed the MSST definition to 75 percent of the spawning stock biomass at MSY or MSYproxy. The South Atlantic Council set their portion of the ABC for Mutton Snapper equal to the OY (i.e., the optimum yield at 40% SPR).

For this assessment, the equilibrium fishing mortality rates that achieve 30%SPR ($F_{MSYproxy}$, $F_{30\%SPR}$) and 40%SPR (FOY, $F_{40\%SPR}$), as well as the associated reference spawning stock biomasses ($SSB_{30\%SPR}$, $SSB_{40\%SPR}$), were determined through long-term 100-year projections, assuming that equilibrium was obtained in the final 10 years of the projection (2114-2123; see Section 3.4.10.1). These long-term projections assume that recruitment in the first year and every year thereafter follows the stock-recruit curve, as recommended by Van Beveren et al. (2021). Then, short-term projections for the next 10 years (2024-2033) were used to forecast annual MSY (or OFL) values. For the short-term projections, the $F_{30\%SPR}$ that was determined for the long-term projection was applied to the stock starting in 2024 with the recent mean age 1 recruitment (geometric mean of the last 5 years of recruitment data; 2019-2023), as suggested by Van Beveren et al. (2021).

The maximum fishing mortality threshold (MFMT) is defined for the Southeastern US Mutton Snapper population as $F_{30\%SPR}$, and the minimum stock size threshold (MSST) as 75% of $SSB_{30\%SPR}$. Overfishing is defined as F > MFMT and overfished as SSB < MSST. The current condition of the stock is represented by the geometric mean of SSB ($SSB_{current}$) from the last three years (2021–2023), and the current condition of the fishery is represented by the geometric mean of F ($F_{current}$) from the last three years (2021–2023). These benchmarks are conditional on the estimated selectivity functions and the relative contributions of each fleet's fishing mortality averaged over the last three years (2021 – 2023).

3.5.1 Projections

The method to project the assessment results was developed in the R statistical computing environment by SEFSC assessment scientists (https://github.com/SEFSC/SFD-

AllocationForecasting). Deterministic projections were performed under several assumed conditions. Growth and stock-recruit parameters were kept constant as estimated by the SEDAR 79 Base Model. Also, projections were run assuming that relative F, selectivity, discarding and retention associated with the last three years (2021-2023) would remain the same into the future. Table 14 provides a summary of projection settings.

Long-term deterministic projections were first conducted to determine the equilibrium fishing mortality rates that achieve 30%SPR ($F_{MSYproxy}$, $F_{30\%SPR}$) and 40%SPR (F_{OY}, $F_{40\%SPR}$), as well as the associated reference spawning stock biomasses ($SSB_{30\%SPR}$, $SSB_{40\%SPR}$). These were 100-year projections, assuming that equilibrium was obtained in the final 10 years of the projection (2114-2123), and that recruitment in the first year and every year thereafter follows the model-estimated Beverton-Holt stock-recruitment relationship, as recommended by Van Beveren et al. (2021). Long-term projection methods use an iterative process to set fishing mortality rates each year to ensure that 1) the MSY proxy (i.e. SPR30% or $SSB_{30\%SPR}$) is achieved at equilibrium (~100yrs), and 2) annual relative fishing mortality between fleets is maintained at the average of recent years (2021-2023).

Short-term deterministic projections for OFL and ABC determination were then conducted to estimate Mutton Snapper spawning stock biomass and yield under a range of harvest scenarios given a constant fishing mortality rate scenario was achieved. Several short-term projection scenarios use a similar iterative process to explore the effects of holding fishing mortality rates constant at $F_{30\%SPR}$ (MFMT), 75% of $F_{30\%SPR}$, and recent fishing mortality rates ($F_{current}$). The TORs also state to evaluate the projected spawning stock biomass when catch is held constant at the equilibrium yield at F40%SPR, however, F40%SPR is nearly equivalent to 75% of F30%SPR. For short-term projections, age-1 recruitment in all projection years was equal to the recent geometric mean (2019-2023), as recommended by Schueller et al. (2022) and Van Beveren et al. (2021).

An additional option is to achieve fixed catch allocations (in percentage of pounds) between sectors in every year of the forecast. However, this was not applied since the SEDAR 79 model structure does not allow for allocations to be specified by jurisdiction (i.e., South Atlantic versus Gulf of Mexico). The acceptable biological catch (ABC) is apportioned 82% to the South Atlantic and 18% to the Gulf of Mexico. The South Atlantic Council then further allocated the total ACL (in numbers) between the commercial sector (17.02 percent) and recreational sector (82.98 percent). Sector allocations are not currently specified in the Gulf. Therefore, the decision as to how to determine sector allocations for an ABC (in percentage of pounds) encompassing the entire southeastern US was unclear.

4. STOCK ASSESSMENT MODEL RESULTS

4.1 Estimated Parameters and Derived Quantities

The SEDAR 79 Base Model estimated most parameters reasonably well (i.e., |CV| < 1; **Table 12**). Of the 202 active parameters, 31 exhibited poor estimation (i.e., |CV| > 1); including 8 initial age composition adjustments (associated with ages 3,4, and 6-11), 11 recruitment deviations, the initial fishing mortality rates for the commercial longline and commercial other fleets, and 10 parameters describing selectivity (i.e., the top and ascending width of the Rec East fleet selectivity, the top and ascending width of the Rec West fleet selectivity, as well as the selectivity at the last length bin, the top of the RVC Dry Tortugas index selectivity, and the top and ascending width of the RVC FL Keys index selectivity, as well as the associated selectivity at the initial and final length bins). No parameters were estimated near bounds. **Figure 19** shows parameter distribution plots along with starting values, bounds, and non-uniform priors (if applicable).

4.2 Selectivity and Retention

Estimated length-based selectivity functions for each fleet are plotted in **Figure 20a**. Mutton Snapper were fully selected at larger sizes for the commercial fleets relative to the recreational fleets. The Commercial Longline fleet reached 50% selectivity at 61 cm MaxTL, while the Commercial Other fleet reached 50% selectivity at 36 cm MaxTL. Smaller Mutton Snapper were encountered by the recreational fleets. Selectivities for both recreational fleets start around 35% for 8 – 26 cm MaxTL. The selectivity of the Recreational West fleet gradually declines after the peak at 30.01 cm MaxTL (32 cm bin), whereas the peak for the Rec East fleet falls within the 36 cm bin and quickly declines to near zero by the 64 cm bin.

The derived age-based selectivity for each fleet (via model estimated growth and population dynamics), along with the maturity-at-age ogive, show the Commercial Longline fleet generally encounters older, mature Mutton Snapper compared to the other fleets (**Figure 20b**). The recreational fleets both select ages 1 and 2 much more frequently than the commercial fleets. The Rec East fleet selects far fewer age 4+ fish compared to the Rec West and Commercial Other fleet, while the Rec West fleet selects far fewer age 6+ fish relative to the Commercial Other fleet.

Length-based selectivities of indices occurring in the Gulf (i.e., Gulf Combined Video index, Commercial Longline index, and RVC Dry Tortugas) in **Figure 21a** illustrate that similar lengths are generally encountered in the Gulf Combined Video index and the RVC Dry Tortugas until about the 58 cm MaxTL bin, but then the RVC Dry Tortugas selects fewer larger Mutton Snapper. The selectivity of the Commercial Longline index is the same as the Commercial Longline fleet selectivity.

Derived age-based selectivity for each of the Gulf indices similarly show the RVC Dry Tortugas and Gulf Combined Video as having comparable selectivity until age 7 (**Figure 21b**). Also, very few younger ages are encountered by the Commercial Longline fleet.

Estimated length-based selectivities associated with RVC indices that occur in the South Atlantic (RVC FL Keys and RVC SE FL; **Figure 22a**) and the related age-derived selectivities (**Figure 22b**) indicate that these indices encounter much smaller/younger Mutton Snapper relative to the Gulf indices, and far fewer larger/older fish. The fixed selectivity-at-age for the SERFS index shows a different pattern with knife-edge selectivity at age 3, particularly when compared to the inverse logistic estimated for the RVC SE FL index. For the RVC SE FL index, ages 1 and 2 are fully selected, age 5 is 50% selected, and ages 10+ have negligible selectivity. The selectivity of the SERFS index is unknown and was therefore based on the SERFS survey design and IWG recommendations.

Parameters related to retention are estimated for fleets with releases (Commercial Other, Rec East, and Rec West). These retention functions are time-varying; generally coinciding with changes to the minimum size limit. The changes to retention over time for each fleet are illustrated in **Figures 23a, 24a, and 25a**. Then, fleet-specific terminal year (2023) selectivity, retention, discard mortality (constant at 0.30), along with the fraction of fish kept, dead and discarded are shown in **Figures 23b, 24b, and 25b.**

Retention functions for each fleet were configured according to specifications in Section 3.1.8. For the Commercial Other fleet, releases were unavailable prior to 1993 so prior to the implementation of the minimum size limit in the South Atlantic (1981-1991) all Mutton Snapper caught were assumed to be retained and landed (**Figures 23a).** From 1992 – 2017, the model estimated an inflection point of 38.1 cm MaxTL, which was between the 12-inch TL (30.5 cm) size limit enacted from 1992-1994 and the 16-inch TL (40.6 cm) size limit enacted from 1995 - 2017. Then the estimated reflection point of 49.2 cm MaxTL from 2018-2023 aligns with the current 18-inch TL (45.7 cm) size limit.

The Rec West fleet had minimal releases estimated prior to the 1992 16-inch TL size limit, thus retention was not forced to match selectivity during that time. Due to limited data, a separate time block encapsulating only the 12-inch minimum size limit was not feasible. Therefore, the same retention function was applied from 1981 – 1995 that had an estimated inflection point at 37.3 cm MaxTL, which was greater than the 12-inch minimum size (30.5 cm). The following time period (1995 – 2017), estimated a slightly larger inflection at 42 cm MaxTL that was similar to the 16-inch minimum size limit. The final time period (2018 -2023) estimated a 46 cm inflection point, on par with the 18-inch TL (45.7 cm) size limit (**Figures 24a)**.

Lastly, the retention for Rec East fleet applied the same time blocks as the Rec West fleet. Again, due to limited data, the same retention function was applied from 1981 – 1995 that had an estimated inflection point at 33.2 cm MaxTL, which was slightly greater than the 12-inch minimum size (30.5). The following time period (1995 – 2017), estimated a slightly larger inflection at 40.6 cm MaxTL matching the 16-inch minimum size limit. The final time period (2018 -2023) estimated a 48.8 cm inflection point, which was greater than the 18-inch TL (45.7 cm) size limit (**Figures 25a)**. This may suggest that more undersized Mutton Snapper are being retained in SE FL and areas north of SE FL compared to the FL Keys and Gulf.

Compared to the Commercial Other fleet, in recent years (2018-2023) the Rec West and particularly the Rec East fleet discard more fish (grey lines in **Figures 24b** and **Figure 25b**) than are kept (purple lines in **Figures 24b** and **Figure 25b**).

4.3 Fishing Mortality

The SEDAR 79 Base Model estimates of annual instantaneous fishing mortality rates on age-3 Mutton Snapper are presented in Table 15 and Figure 26. Age-3 was based on the mid-point of the relative fleet-specific maximum selectivities. Considering fishing mortality rates of a single age allows for a comparison of fishing mortality rates across time by reducing the variability of fishing mortality rates caused by differing levels of fishing pressure across ages and years. Nonetheless, fleet-specific fishing mortality rates (i.e., instantaneous apical rates representing the fishing mortality level on the most vulnerable age class) are also presented in Table 15 and Figure 27.

The annual fishing mortality rates on age-3 Mutton Snapper have been variable but stable from 1981 - 2017 (mean age-3 F = 0.162 yr-1) but have been notably lower since 2018 (mean age-3 F = 0.073 yr-1), coinciding with additional management regulations (Figure 26a). The current fishing mortality rate (Fcurrent), calculated as the geometric mean of 2021-2023 estimates, is 0.08 yr-1.

In 2008, the age-3 fishing mortality rate was estimated to be the highest in the timeseries at 0.41 yr-1. There were very high estimated landings and releases from the recreational shore mode in 2008, as well as a marked increase in the FIM YOY index in the fall of 2007. The estimated age-3 fishing mortality rate was the lowest in the time series in 2011 at 0.04 yr-1, perhaps impacted by a cold kill in the FL Keys in January of 2010 which most likely impacted Mutton Snapper habitat, although no specific reports on Mutton Snapper mortalities were reported (Hallac et al. 2010).

Apical fishing mortality rates were minor for the commercial fleets, while the apical fishing mortality rate for the Rec West fleet generally declined since the early 1990s and those for the Rec East fleet increased but remained highly variable (Figure 27). Since the early 1990s, the apical fishing mortality rates continued to be the highest for the Rec East fleet, particularly in 2008, despite estimated declines in 2010-2011 and 2019-2020.

4.4 Recruitment

Steepness was estimated in the SEDAR 79 Base Model at 0.644 and the corresponding Beverton-Holt stock recruit relationship is shown in **Figure 28**. The estimate of sigmaR was 0.55 and ln(*R0*) at 7.83 (**Table 12**), which equates to 2.51 million age-1 Mutton Snapper.

The number of age-1 recruits remained fairly stable at nearly 1 million fish from 1981 – 2005. Then, the first peak in recruitment as estimated by the SEDAR 79 Base Model occurred during 2006 (2.6 million age-1s; **Table 16**; **Figures 29**). This peak was followed by a general decline until 2010 (347 thousand age-1s), which was the lowest in the time series. However, estimated recruitment quickly recovered thereafter and almost reached or exceeded unfished recruitment levels from 2015 – 2020 (around 2.5 million age-1s). Then, recruitment peaked at approximately 4.3 million age-1s in 2021 and 2022 before declining slightly to 3.1 million age-1s in 2023.

Recruitment deviations were generally characterized by a period of below average recruitment between 1976 and 1998 followed by above average recruitment from 2003 – 2008, then a steep decline from 2009-2011 and above average recruitment from 2012 to 2023, although the confidence intervals for some years overlapped with zero (**Figure 30**). The estimated (and applied) recruitment bias adjustment ramp is shown in **Figure 31**.

4.5 Biomass and Abundance Trajectories

Predicted total biomass (metric tons, pounds), spawning stock biomass (SSB; metric tons, pounds), abundance (1000s of fish), age-1 recruits (1000s of fish), and depletion (SSB/SSB0) for Southeastern U.S. Mutton Snapper from the SEDAR 79 Base Model from 1981 to 2023 are provided in **Table 16**. Total biomass averaged 6,455 metric tons, ranging from 3,784 metric tons in 1999 to 15,132 metric tons in 2023 (**Figure 32**). Estimates of SSB averaged 2,565 metric tons and ranged from 1,502 metric tons in 1999 to 5,898 metric tons in 2023 (**Figure 33**). The geometric mean from 2021-2023 was 5,403 metric tons ($SSB_{current}$). Both total biomass and SSB declined from 1981 to 1999, then increased gradually through 2008. While biomasses slightly declined in 2009, they quickly recovered thereafter and have accelerated rapidly in recent years (2019 – 2023).

Depletion (SSB/virgin SSB) ratio averaged 0.14 and ranged from 0.08 in 1999 to 0.33 in 2023 (**Table 16**). The mean age of Mutton Snapper was nearly 4.5 years from 1981 until 1999, then declined to age 3 in 2006, but has since increased to almost 3.5 years in recent years (**Figure 34**).

4.6 MCMC Analysis

Uncertainty estimates based on the asymptotic standard errors from the covariance matrix only provide a minimum estimate of uncertainty in parameter values and derived quantities. Therefore, Monte Carlo Markov Chain (MCMC) analyses were applied to produce posterior distributions of model parameters and selected derived quantities.

However, due to time constraints, only a single converged chain of MCMC draws was able to be produced. Out of the original 5,000 iterations, an added burn-in of 500 iterations and additional thinning (i.e., saving every 1 out of 8 iterations) resulted in 563 total iterations. For most parameters and derived quantities of interest, Geweke's diagnostic did not suggest that the mean of the first 10% of the chain was significantly different from the last 50% of the chain (**Table 17**). **Figure 35** displays trace plots for several parameters and derived quantities. In the future, it would be beneficial to explore the No-U-Turn sampler (NUTS), a Bayesian algorithm recently added to ADMB that produces chains with low autocorrelation (Monnahan et al. 2019).

Posterior distributions for steepness, ln(*R0*), unfished SSB, retained yield associated with the internally calculated $F_{30\%SPR}$ were produced, as well as the geometric mean of SSB from 2021-2023 [$SSB_{current}$] and geometric mean of age-3 fishing mortality rates from 2021-2023 [$F_{current]}$ (**Figure 36**). SEDAR 79 Base Model results mostly fall outside the interquartile range of posterior distributions, especially for $SSB_{current}$ and $F_{current}$, warranting caution on the use of these MCMC results (**Figure 36**).

4.7 Model Diagnostics

4.7.1 Model Convergence

The SEDAR 79 Base Model converged with a total objective function of 1488.01, with length compositions and conditional age-at-length from the catch and indices contributing the most to the magnitude of the likelihood function (**Figure 37**). The model contained no parameters on the bounds, had a small final gradient <0.0001, and had a positive definite Hessian matrix.

The results of the jitter analysis suggested that the SEDAR 79 Base Model had converged on a global solution but was sensitive to the initial parameter values. Of the 200 jittered runs, only 5 runs had maximum gradient < 0.0001 and 95 runs (48%) had a maximum gradient < 0.05. No jittered runs were found to contain a total likelihood lower than the base model. The range of log-likelihood values associated with only runs that had a maximum gradient < 0.05 is presented in **Figure 38**.

4.7.2 Correlation Analysis

Correlation among parameters is common in highly parametrized models but should be investigated as it can lead to poor model stability along with flat likelihood response surfaces. Several selectivity and retention parameters were highly correlated (> 90%, **Table 18**). These parameters defined the inflection points of the Rec East and Rec West during the base time period and that in the first time block (1995-2018). This may suggest there is little contrast between the base period and the first time block. Additionally, parameters defining the peak and width of the ascending limb of the double normal selectivity for the RVC Dry Tortugas were highly correlated. However, all correlated parameters were found to be structurally correlated and did not suggest model instability.

4.7.3 Residual Analysis

Joint residual patterns and overall root mean squared error (in percentage) for indices of abundance, mean length (in 4 cm bins), mean length for the RVC surveys (5 cm bins) and mean conditional age-at-length are shown in **Figure 39** and **Table 19**. Patterns in residuals across model components did not suggest any major data conflict but there does appear to be overestimation of indices from 1993 to 2000, as well as from 2010 to 2022. Mean conditional age-at-length residuals also suggest overestimation of age at length from 1981 to 2007. However, the RMSE values were below or near maximum acceptable levels (30%) for most model components (**Table 19**).

RMSE values for the FIM YOY and SERFS surveys were extremely high (74% and 85%, respectively). The CVs (i.e., uncertainty) of the SERFS index from 2011 to 2013 were approximately 50%, and the CVs associated with the FIM YOY were near 40% (**Figure 16**). Furthermore, the FIM YOY index may have low power to detect changes in abundance of Mutton Snapper as was revealed by an exploratory simulation-based power analysis (SEDAR 79-DW-18, Appendix A). The poor fit to both of these indices led to elevated overall RMSE for the indices (RMSE combined= 51.2%; **Table 19**)

While an analysis of joint residuals is useful to compare across model components, a thorough description of residual analyses for each model component and data source follows.

4.7.3.1 Landings

Except for unknown equilibrium catch values, the landings data for the commercial fleets (in metric tons) were fit exactly due to the minimal associated uncertainty in the observed values, while the predicted landings for the recreational fleets (in 1000s) were allowed to differ from the observed values (**Figure 40** and **Figure 41**, total negative log-likelihood = 55.9). The fits to the landings were comparable among the recreational fleets. The standardized residuals ranged from -1.2 to 1.5 for the Rec East fleet and -1 to 1.8 for the Rec West fleet (**Figure 41)**. Predicted landings tended to underestimate the observed values prior to the early-1990s and overestimate the observed landings starting in the mid-2000s. The landings for the Rec West fleet were particularly overestimated in recent years (2017-2023).

4.7.3.2 Releases

Estimates of releases for the Commercial Other (i.e., primarily hook and line) fleet were recently deemed unreliable (Alhale et al. 2024). However, the scale of the commercial releases is negligible relative to the recreational fleets (**Figure 42**), making this data source less consequential to model results. Nevertheless, the likelihood component for the commercial releases was considerably down-weighted (lambda =0.01) to further reduce the impact of this data source on the fits to other model components. As a result, the model fits the commercial releases poorly in some years, especially from 2018 to 2020 (**Figure 42** and **Figure 43**),

Releases from the recreational fleets were characterized by high uncertainty in most years and have generally increased throughout the time series, however low values occurred in 2010 and 2011 (**Figure 42**). For both the Rec East and Rec West fleets, the model largely overestimated releases in the 1980s and underestimated releases in following years, except for a period of underestimation during the late-1990s to mid-2000 (**Figure 43**). The model predicts releases from the Rec East fleet slightly better than those for the Rec West fleet, as standardized residuals for the Rec East fleet releases ranged from -2.2 to 0.8 whereas those for the Rec West fleet ranged from -2.4 to 2.0 (**Figure 43**).

Model estimated discard rates show a similar pattern across all fleets with releases with increases in recent years corresponding to increases in the minimum size limit for Mutton Snapper (**Figure 44**). The pattern in residuals for the recreational releases is the contrary to those for the recreational landings in some years, suggesting that the realized discard rates may be lower than the model estimated discard rate in early years and higher in later years.

4.7.3.3 Indices

As noted, most indices were fit reasonably well by the SEDAR 79 Base Model (**Figures 45-46**; **Table 19**). The model fit best to the RVC Keys index (RMSE = 20.8%; **Table 19**). The model fit the increasing trend from 1997 to 2007 well but subsequently underestimated the rate of decline from 2008 to 2011. Both the expected and observed index values increased thereafter and were in general agreement, however the expected value in 2022 overestimated the observed value.

The second-best fit index was the RVC Dry Tortugas index (RMSE = 30.4%; **Table 19**). This index increased from the start of the index in 1999 to 2010. The model overestimated the observed values in 1999 and 2000, leading to an underestimation of the rate of increase in those years. The observed index was then stable from 2010 to 2014 and increased thereafter, which was matched well by the expected values.

The Gulf Combined Video and the RVC SE FL indices had comparable fits (RMSE ≈ 35%; **Table 19**). The fit to the Gulf Combined Video was aided in large part by estimated time-varying catchability that decreased in each time block (**Figure 45h**); yet the model did not capture the decrease in the observed Gulf Video index from 2007 to 2010. The expected values for the RVC SE FL index from 2013 to 2015 overestimated the observed values and underestimated the observed values in 2018, therefore the base model underestimated the rate of increase from 2013 to 2018.

The FIM YOY index was specified as a recruitment index (in Stock Synthesis this applies to age 0s), therefore the FIM YOY index in a particular year is representative of age 1s the following year. High relative abundances of age 0s were observed in 2007 and to a lesser degree in 2008. The model grossly underestimated these high values and conversely overestimated the lowest observed index values in 2016 and 2019. The model generally overestimated age 0 relative abundances from 2015 to 2022.

The base model fit the SERFS Video index reasonably well from 2014 to 2022, however the peak in 2019 was underestimated. The observed index values for the first three years of the time series (2011-2013) were severely overestimated by the base model, however these years corresponded to very high CVs (approximately 50%). Relatedly, there was change in the camera gear in 2015 (from Canon to GoPro, SEDAR 79-DW-10) and the observed index values in years prior to 2015 were subject to calibration.

Lastly, the base model did not fit the pre-IFQ Commercial Longline CPUE particularly well (RMSE = 38.3%; **Table 19**), as observed index values from 1993 to 2000 were overestimated and observed values from 2002 to 2007 were underestimated. This may suggest the index demonstrated hyperstability from 1993 to 2000, so that the CPUE remained elevated even though the true abundance was depressed.

4.7.3.4 Length Composition

Overall, the SEDAR 79 Base Model fit the observed length compositions with 4 cm bins reasonably well, as RMSE ranged from 1.9% to 5.2% and the combined RMSE was 4% (**Table 19).** Aggregated across years, the expected length compositions were similar to the observed compositions for most fleets and surveys (**Figure 47**). The overall observed length compositions for the Commercial Other and Rec West fleets are slightly bimodal, but the assumed selectivity patterns for these fleets (single logistic and double normal, respectively) cannot accommodate bimodality. Therefore, for the Commercial Other fleet lengths between 52 cm and approximately 60 cm are overestimated in many years, whereas the surrounding peaks are underestimated (**Figure 48**). This pattern is less apparent for the Rec West fleet, but lengths included in the second peak beyond 60 cm are underestimated in most years (**Figure 48**). Additionally, the Commercial Longline retained lengths tended to be underestimated beyond 76 cm MaxTL in some years, particularly from 1996 - 2004. Otherwise, Pearson residuals did not show concerning patterns or magnitudes (**Figures 48-49**).

Fits to retained length compositions were often better than fits to discarded length compositions for each fleet, although sample sizes were notably smaller for discard length compositions. Also, sampled lengths for the Commercial Other fleet releases and the Gulf Combined Video Index.

were aggregated over several years, resulting in only a single year of input length compositions for these data sources (**Figures 48-49**).

Length compositions associated with the RVC indices used a 5 cm MaxTL bin width. The quality of fits was slightly poorer than those above, as RMSE values ranged from 6.8% to 11.2%, with a combined RMSE value of 9.3% (**Table 19**). Aggregated across years, the expected length compositions mostly aligned with the observed compositions (**Figure 50**). For the RVC Dry Tortugas, some misfitting is apparent in 2010 and 2012 as lengths less than 50 cm are underestimated, while larger lengths are overestimated (**Figure 51a**). The base model underestimated lengths from the RVC FL Keys greater than 40 cm in some years (**Figure 51b**). For lengths associated with RVC SE FL, 30 – 40 cm are underestimated in some years, and in recent years (2018-2022), 40 cm and above are overestimated (**Figure 51c**).

4.7.3.5 Conditional Age-at-Length

RMSE values associated with SEDAR 79 Base Model fits to the conditional age-at-length data for the retained catch and fishery-independent data are deemed to be acceptable (ranging from 6.3% for the Commercial Longline to 11.3% for the fishery independent data, with an overall RMSE of 8.2%).

The base model fits to mean age by year for each data source are presented in **Figure 52**. Most fits were generally acceptable, however the mean age for the Rec East fleet was generally overestimated and conversely the mean age retained by the Rec West fleet was slightly underestimated in some years. Predicted mean ages largely fell within the uncertainty bounds after down weighting input sample sizes according to Francis (2011).

The patterns in the residuals of fits to mean age were investigated further by inspecting the base model fits to age-at-length by year and data source. As shown in **Figures 53-57,** ages did not appear to be consistently under- or overestimated for a given length bin, even for the Rec East and Rec West fleets.

4.7.4 Likelihood Profiles

Likelihood profiles were used to examine the change in log-likelihood for selected model across a range of values in order to gauge the model support of a given parameter estimate and to identify conflicts among log-likelihood values of different data components. Likelihood profiles were done for two stock-recruitment parameters (*steepness* and virgin recruitment [*R0*]) and the assumed natural mortality averaged over ages 3-40 (*Average M*).

For this analysis, each profiled parameter was held constant at a chosen value and the remaining parameters were estimated. To improve convergence, the peak selectivity parameters for the Rec East and Rec West fleets were fixed at values estimated by the base model. These selectivity parameters were not correlated with any of the profiled parameters, nor should they be influenced by population dynamics. In the interest of time, all runs were considered, even those that had high gradients or non-positive definite hessians.

4.7.4.1 Steepness

Profiled values of steepness varied from 0.5 to 0.99 in increments of 0.01. The effect of varying fixed *steepness* values on the total log-likelihood (LL) value is presented in **Figure 58**. The jaggedness of the curve suggests that some runs did not converge to a global minimum. The base run estimated steepness (=0.64) resulted in the lowest LL value, however the change in LL values is less than two for a wide range of steepness values from approximately 0.54 to 0.85 (**Figure 58**).

There was some observed conflict among model components (**Figure 59**). Recruitment was the most informative model component, followed by fits to the indices. Fits to landings favored lower *steepness* values, while fits to age data improved with higher steepness values. Fits to length compositions and discards were largely uninformative of *steepness*.

However, there was little model sensitivity to changes in *steepness* values as characterized by model estimates of spawning stock biomass and particularly age-3 fishing mortality rates (**Figure 60**). For *steepness* values greater than 0.60, there were modest differences in spawning stock biomass relative to $SSB_{30\%SPR}$ and age-3 fishing mortality rates relative to $F_{30\%SPR}$ (**Figure 61**).

4.7.4.2 Unfished Recruitment

Profiled values of unfished recruitment (ln(*R0*)) ranged from 6 to 11 in increments of 0.05. The total LL value is the lowest for the base run estimated unfished recruitment ln(*R0*) (7.83; **Figure**

62), however this analysis suggests there is equal model support for unfished recruitment values between 7.25 and 8.50. Yet, there is undoubtedly poor convergence for some values of ln(*R0)* as shown by the high variability in log-likelihood values. As with *steepness*, recruitment is the most informative of ln(*R0)* (**Figure 63**). Except for particularly low values of ln(*R0*) (i.e., less than 7.10), changes in ln(R0) do not appear to affect the log-likelihood of other model components (**Figure 63**).

Derived model quantities such as spawning stock biomass and fishing mortality rates were moderately sensitive to intermediate values of unfished recruitment (**Figure 64**). Model runs with low values of ln(*R0)* less than 7.25 may have not converged as suggested by outlying high or low values of spawning stock biomass and fishing mortality rates. Base model estimates of spawning stock biomass relative to $SSB_{30\%SPR}$ ranged from nearly 1.5 to over 2.5 in the 2023 terminal year across profiled values of ln(*R0*) (**Figure 65**), however the range of age-3 fishing mortality rates relative to $F_{30\%SPR}$ was comparatively narrow for most runs (**Figure 65**).

4.7.4.3 Average Natural Mortality

Natural mortality relates directly to stock productivity and reference points, making it one of the most influential parameters in fisheries stock assessment and management. Yet, it is difficult to estimate and remains a large source of uncertainty within most stock assessment models (Maunder et al. 2023). The parameterization of natural morality-at-age in the SEDAR 79 Base Model (via the Lorenzen option) allows the average natural mortality for ages 3-40 (*Base M*) to be profiled upon to gauge the influence of this largely unknown value on model results.

Profiled values of average natural mortality for ages 3-40 (*Base M*) ranged from 0.05 to 0.50 in increments of 0.01. The total LL value was marginally improved when *Base M* was slightly less than the assumed fixed value of 0.129 (0.11 or 0.12), however there was essentially equal model support for a wide range of *Base M* values between 0.05 and 0.18 (**Figure 66**). Conversely, the model did not support *Base M* values beyond 0.20, indicating that there was some degree of information on natural mortality across all data sources.

The resulting change in log-likelihood values by model component suggests there is some data conflict between the length, age, and index information versus the landings and discards, as fits to the landings and discards were improved with higher *Base M* values (**Figure 67**).

The high level of influence of *Base M* was evident by the exceptionally wide range of spawning stock biomass estimates and fishing mortality rates across the profiled runs (**Figure 68**). There appears to be a stark bifurcation of spawning stock biomass estimates once *Base M* exceeds 0.19. Correspondingly, spawning stock biomass relative to $SSB_{30\%SPR}$ and age-3 fishing mortality rates relative to $F_{30\%SPR}$ also exhibit wide ranges (**Figure 69**). Once Base M approaches 0.17, spawning stock biomass relative to $SSB_{30\%SPR}$ becomes exceedingly high ($SSB/SSB_{30\%SPR} > 6$).

4.7.5 Model Consistency

To measure model consistency, the SEDAR 79 Base Model was first subject to a retrospective analysis that removed successive years of data from the model for seven years (i.e., removing data for 2023, 2022-2023…, and lastly 2017 - 2023) to determine the effect of recent years on model results. This analysis was also paired with one-year-ahead projections (see Carvalho et al. (2021) for additional details).

Mohn’s Rho is a measure of the severity of bias in the retrospective patterns and the forecast bias is an estimate of bias in the forecasted quantities when years of data were removed. The rule of thumb proposed by Hurtado-Ferro et al. (2015) is that for long-lived species, Mohn’s Rho values should fall between -0.15 and 0.20.

A retrospective plot of spawning stock biomass indicated a minor retrospective pattern, as estimates of spawning stock biomass based on data through 2021 were slightly higher than those estimated with additional data from 2022 and 2023 (**Figure 70**). Likewise, the retrospective plot of age-3 fishing mortality rates displayed slightly higher rates from 2012-2016 when data through 2022 or 2023 were incorporated (**Figure 70**).

According to the rule of thumb, the results of the retrospectives illustrated acceptable levels of retrospective bias and forecasting bias in spawning stock biomass (Mohn’s Rho of 0.12 and Forecasting Bias of 0.13) and age 3 fishing mortality rates (Mohn’s Rho of 0.02 and Forecasting Bias of -0.17; **Table 20** and **Figure 70**). The forecasting bias in fishing mortality rates was elevated (-0.17), which suggests that forecasts of fishing mortality rates were consistently less than realized values.

The results from the ASPM indicate that, for at least some of the timeseries, there is enough information in both the catch and index data for the production function to largely drive the stock dynamics as the general trends and scale of the ASPM and the SEDAR 79 Base Model align after 1998, when many of the indices become available (**Figure 71**). Early in the timeseries, the ASPM estimates a pronounced increase in spawning stock biomass from 1981 to 1991 followed by a steep decline through 1999, whereas the base model estimates remain mostly flat through 1991 and decrease slightly through 1999 (**Figure 71**). Fits to the indices were overall much worse by the ASPM compared to the SEDAR 79 Base Model (**Table 21**), highlighting the reliance on recruitment deviations to fit the indices. The only index that showed a substantially better fit by the ASPM was the FIM YOY index (RMSE = 74% for the base model and RMSE = 58.4% for the ASPM; **Table 21**). This may be due to the high variability in the FIM YOY index so that it is better fit by a slightly increasing constant trend and may suggest that variability in the FIM YOY index is at odds with the signal from the other indices.

When recruitment deviations were included in an ASPM (i.e., ASPMdev), fits to most indices were improved and were even comparable or superior to the index fits associated with the base model (**Table 21**). The trends in the estimated spawning stock biomass, recruitment, and fishing mortality rates closely resembled those estimated by the base model, however the ASPMdev model estimated higher spawning stock biomass and recruitment and lower fishing mortality rates than the base model (**Figure 71**). This may suggest the early length and age information informs the scale of the base model and without it, initial apical fishing mortalities rates are lower in the age-structured production models, particularly for the initial fishing mortality rate for the Rec East fleet (**Figure 72**).

4.7.6 Model Validation (Prediction Skill)

Prediction skill of the SEDAR 79 Base Model was assessed using the hindcasting cross-validation approach of Kell et al. (2021), which compares observations to their predicted future values. Mean absolute scaled error (MASE) of prediction residuals of indices, length compositions, and conditional age-at-length was calculated using nine one-step ahead hindcasting cross-validations.

MASE values for the RVC Dry Tortugas and FIM YOY indices were near 0.50 (MASE = 0.47 and 0.54, respectively; **Table 22**) which implies the base model predicts these indices about twice as accurately as a naïve baseline prediction. The SERFS video index also had a MASE score < 1 suggesting some predictive capacity of the base model. Both the RVC FL Keys and Gulf Combined Video indices had MASE scores slightly higher than 1 (MASE = 1.16 and 1.17, respectively; **Table 22**), while the RVC SE FL index was not predicted well by the base model (MASE = 1.88). Overall, the base model outperformed a naïve forecast (joint MASE = 0.81; **Table 22**).

MASE values for length compositions were generally very high, typically indicating poor predictive capacity. However, since the mean absolute errors of the prediction residuals are all minimal (< 0.05), the predictions by the base model are accurate (**Table 22**). Similarly, the MASE values for the conditional age-at-length (CAAL) data also demonstrated low mean absolute errors and all CAAL data sources were better predicted by the base model than a naïve baseline prediction (joint MASE = 0.58; **Table 22**).

4.7.7 Sensitivity Runs

Sensitivity runs were conducted to investigate the impact of alternative assumptions or data sets on model fits and results. Results for key sensitivity runs are presented below, but many additional exploratory runs were also implemented.

4.7.7.1 Remove S-R curve (Steepness ≈ 1)

Due to the inherent uncertainties surrounding the stock-recruitment relationship, Maunder and Thorson (2019) recommend that assessments using a stock-recruitment relationship compare the performance with a model that avoids specifying such a relationship and instead assumes a relationship functioning as average recruitment across time (i.e., fixing steepness at 0.99). For this sensitivity run, the peak selectivity parameters for the Rec East and Rec West fleets were fixed to improve convergence (i.e., lower the gradient). Since these selectivity parameters were not correlated with any life history or stock-recruit parameters, it should only lead to improved convergence without affecting the results of this sensitivity run.

Assuming constant mean recruitment throughout the time series led to a 2.82-point increase in the overall log-likelihood (1490.83), suggesting essentially equal model support as when estimating steepness. However, the trend in recruitment deviations increased from 1993 to 2021 which may indicate model misspecification (Merino et al. 2022), and the uncertainty associated with derived quantities decreased (e.g., retained yield at $F_{30\%SPR}$). **Figure 73** illustrates that most derived quantities for this sensitivity run (i.e., recruitment deviations, spawning stock biomass, fishing mortality rates, and reference points) remained within the confidence intervals of estimates from the SEDAR 79 Base Model. Fishing mortality rates were largely unaffected by fixing steepness at 0.99, while spawning stock biomass and $SSB_{F30\%SPR}$ decreased slightly. Recruitment deviations were modestly lower from 1993 to 2003, and somewhat higher in 2020 and 2021, while estimates of retained yield at $F_{30\%SPR}$ decreased slightly and was associated with much less uncertainty (**Figure 73)**.

4.7.7.2 Release Mortality

Sensitivity runs examining the effect of alternative release mortality rates were performed. This was completed by configuring the fixed parameter inputs in the release mortality equation (Section 3.1.10 above) to produce the respective release mortality rates for each fleet. For all fleets, the upper bound sensitivity was set at 45% and the lower bound was set at 15%, so that the release mortality assumption in the base model of 30% is an intermediary estimate.

As evidenced in **Figure 74,** the greatest change as a result of alternative release mortality rates occurred for estimates of $F_{30\%SPR}$, 75%$SSB_{30\%SPR}$, and recent fishing mortality rates since 2018 (coinciding the with 18-inch minimum size limit). Assuming a release mortality rate of 15% lowered recent fishing mortality rates and $F_{30\%SPR}$, while conversely assuming a release mortality rate of 45% increased recent Fs and $F_{30\%SPR}$ relative to the base model. There was less sensitivity in the $SSB_{30\%SPR,}$ annual spawning stock biomass, and recruitment deviations. As expected, the base model results were intermediate between these two sensitivity runs.

4.7.7.3 MRIP-FES Private Mode Landings & Releases

The sensitivity of model results to MRIP FES estimates of private mode landings and releases in Florida in lieu of SRFS estimates was also evaluated. The MRIP FES estimates of private mode landings and releases in Florida were on average nearly twice (1.89) as high as SRFS estimates in the East region (SE FL and North) and those in the West region (FL Keys and Gulf) were almost three times (2.78) as high as SRFS estimates. All other data inputs remained the same between the base model and the ‘MRIP-FES’ sensitivity run.

The effect of solely increasing the scale of landings and releases on model results was as expected. Estimated fishing mortality rates, $F_{30\%SPR}$, and recruitment deviations were largely unaffected and were therefore comparable between the two models, while spawning stock biomass and $SSB_{F30\%SPR}$ increased in tandem (**Figure 75**). The retained yield at $F_{30\%SPR}$ also increased relative to the base model estimate (**Figure 75**). Hence, fishing mortality rates relative to $F_{30\%SPR}$ and spawning stock biomass relative to $SSB_{F30\%SPR}$ were effectively equivalent among the two models (**Figure 76**).

4.7.7.4 Jack-Knife Analysis on Indices of Abundance

The effect of each index of abundance on the SEDAR 79 Base Model estimates was evaluated by removing indices one at a time and refitting the base model. This analysis identified the fishery independent RVC FL Keys index as having a dampening effect on the magnitude of spawning stock biomass, as without it, the rate of increase in spawning stock biomass estimates from 2009 to 2012 was greater relative to the base model (**Figure 77**) On the other hand, if either the fishery-dependent commercial longline index or the fishery independent RVC SE FL and Dry Tortugas indices were removed, the spawning stock biomass decreased relative to the base model. Estimates of $SSB_{F30\%SPR}$ were marginally sensitive to the removal of indices. The removal of the FIM YOY index resulted the greatest increase in $SSB_{F30\%SPR}$, while the removal of either the RVC Keys or Gulf Combined Video led to slight increases in $SSB_{F30\%SPR}$. Fishing mortality rates showed an opposite but less pronounced pattern, whereby the removal the RVC Keys index reduced fishing mortality rates slightly since 2006 and vice versa when the RVC SE FL or commercial longline indices were removed. Estimates of $F_{30\%SPR}$ were largely unaffected by the removal of indices (**Figure 77**).

Note, however, that many of the jack-knife runs fell within the bounds of uncertainty of the base model (**Figure 77**). Also, most runs had a maximum gradient > 0.0001 and extensive tests of model convergence (e.g., jitter analysis) were not performed.

4.7.8 SEDAR 79 Base Model and SEDAR 15AU Comparison

While there are substantial differences in the configuration of the SEDAR 79 Base Model in Stock Synthesis and SEDAR 15AU implemented in ASAP, the magnitude of the landings is very similar even though the recreational landings are in two different currencies (MRFSS versus MRIP-FES & SRFS).

The estimated selectivity at age is overall similar between the two assessments for the Commercial Longline and Commercial Other/H&L fleets (**Figure 78**). Likewise, the selectivity-at-age for the Rec East fleet estimated by the SEDAR 79 Base Model resembles that of the MRFSS and Headboat fleet in SEDAR 15AU. However, the selectivity-at-age for the Rec West fleet in the SEDAR 79 Base Model is much higher at older ages compared to the MRFSS and Headboat fleet selectivities in SEDAR 15AU (**Figure 78**).

A comparison of the SEDAR 79 Base Model to SEDAR 15AU shows comparable magnitudes of spawning stock biomass estimates, especially from 1996 to 2013 (**Figure 79**), but SEDAR 15AU predicts somewhat lower spawning stock biomass prior to 1996. According to the SEDAR 79, the stock began to recover in 2001 from an all-time low in 1999 - 2000, whereas the SEDAR 15AU model predicted an earlier start to the recovery (1995). The number of Age 1 recruits is also similar from 1981 through 1997, but in following years the number of recruits predicted by the SEDAR 79 Base Model is generally greater and more variable (**Figure 79**).

Age-3 fishing mortality rates estimated by SEDAR 15AU are mostly higher than those estimated by the SEDAR 79 Base Model prior to 1993, but they are very similar in trend and magnitude after that time. The age-3 fishing mortality rate associated with 30%SPR ($F_{30\%SPR}$) is somewhat lower for SEDAR 79 (0.15; see section 4.3.10) compared to SEDAR 15AU (0.18), while the spawning stock biomass associated with $F_{30\%SPR}$ in SEDAR 15AU is much less (2,108.8 metric tons or 4,649,200 lbs) than that for SEDAR 79 (3,352 metric tons or 7,389,895 pounds; see section 4.3.10; **Figure 79**). This is the main reason spawning stock biomass relative to 75% of $SSB_{30\%SPR}$ differs between the two assessments (**Figure 80**). From 2010 to 2013, the SEDAR 79 Base Model estimated spawning stock biomass was at or just above 75% of $SSB_{30\%SPR}$, while SEDAR 15AU estimated spawning stock biomass to be about 1.5 times 75% of $SSB_{30\%SPR}$ (**Figure 80**).

4.7.9 SEDAR 15AU with MRIP-FES Data

For the first exploratory run (’S15AU_MRIPcatch’), all inputs from SEDAR 15AU were kept unchanged except for replacing the MRFSS landings and discards with MRIP-FES estimates provided for SEDAR 79. The spawning stock biomass using SEDAR 79 data is higher in all years except 2013 (**Figure 81**). While estimated spawning stock biomasses are very similar with the greatest difference occurring at the beginning of the time series, the spawning stock biomass at 30%SPR is much higher when using SEDAR 79 data (**Figure 81**) resulting in an overfished status throughout the entire time series while the original SEDAR 15AU status was not overfished at the beginning and end of the time series (**Figure 81**). This result was unexpected, as an increase in the scale of the landings and releases typically increases both annual spawning stock biomass estimates and reference points, so that stock status remains unchanged.

Fishing mortality rates behaved similarly to spawning stock biomass with the MRIP-FES landings and releases data, as fishing mortality rates were fairly similar to SEDAR 15AU but slightly elevated across the time series (**Figure 82**). However, the fishing mortality at 30%SPR reference point is slightly higher but relatively close to the original reference point (**Figure 82**). As a result, the overfishing statuses over time are the same or shifted slightly by a year (**Figure 82**).

For the next exploratory model, all remaining ASAP model components related to the MRFSS fleet were updated using SEDAR 79 data (model name =’S15AU_MRIPcatch_plus’). This included the MRIP-FES landings and discards, in addition to updated catch and discard proportion catch at age and updated catch and discard weight-at-age. Results are presented in **Figures 83-84**. The spawning stock biomass using SEDAR 79 data follows the same overall pattern and similar values only after 1994. Prior to 1994 the spawning stock biomass increased while the original SEDAR15AU model decreased. The spawning stock biomass at 30%SPR is higher when using SEDAR 79 data resulting in an overfished status for the entire time series. The original SEDAR 15AU status was not overfished at the beginning and end of the time series (**Figure 83**). Fishing mortality rates behaved similarly to spawning stock biomass with the SEDAR 79 data fairly similar to the SEDAR 15AU original but slightly elevated across most of the time series. However, with the fishing mortality at 30%SPR reference point, the value is slightly lower but relatively close to the original reference point. As a result, the overfishing statuses over time are less frequent (**Figure 84**).

4.7.10 Model Bridging

For this exercise, all of the models converged, and the gradients were reasonable ranging from 5.45 e-05 to 0.0003. When fleet-specific mean weight matrices by age and year are included in the model, the spawning biomass at $F_{30\%SPR}$ went up from 2,076 mt in the base model to 2,389 mt and the fishing mortality rate at 30%SPR decreased slightly but the 3-year geometric mean of the fishing mortality rates on Age-3 fish increased from 0.12 yr^{-1} to 0.16 yr^{-1} (**Table 23; Figure 85b**). The fishing mortality rate on Age-3 fish is the age when fish are fully selected on average although the actual selectivity depends upon the gear, habitat, and experience of the fisher or angler. The spawning biomass with the fleet- specific mean weights was also higher initially and then lower after 1995 (**Figure 86a**), the average fishing mortality correspondingly was lower (**Figure 86b**), and recruitment was slightly higher (**Figure 86c**).

The next model increment was to replace the landings of recreational fleets defined by fishing mode, headboat or MRFSS/MRIP, with fleets defined by combining the modes but separating them by coast with north of the Keys being the Recreational East fleet and the Florida Kest west to the Gulf of Mexico being the Recreational West fleet. The addition of the redefined recreational fleets markedly decreased the spawning biomass at F30%SPR that went down from 2,389 mt in the mean weights model to 2,148 mt and the fishing mortality rate at 30%SPR declined to 0.04 yr^{-1} while the 3-year geometric mean of the fishing mortality rates on Age-3 fish declined from 0.16 yr^{-1} to 0.08 yr^{-1} (**Table 23; Figure 86c**). The spawning biomass with the fleet- specific mean weights and redefined recreational fleets was much higher (**Figure 86a**), the average fishing mortality was correspondingly lower (**Figure 86b**), and recruitment was similar (**Figure 86c**).

The final model was to use the indices that the SEDAR 79 Data Workshop approved but to use the SEDAR 15AU versions. The effect of using only three indices was to raise the spawning biomass at $F_{30\%SPR}$ from 2,148 mt in the mean weight and landings model to 2,782 mt and the fishing mortality rate at 30%SPR went down only 0.02 $yr^{-1}$and the 3-year geometric mean of the fishing mortality rates on Age-3 fish declined from 0.08yr^{-1} to 0.06yr^{-1} (**Table 23; Figure 86c**). The spawning biomass with the three indices was lower than the configuration with the mean weights and the revised landings (**Figure 86a**), the average fishing mortality correspondingly was slightly higher (**Figure 86b**), and recruitment was similar initially then higher since 2001 (**Figure 86c**).

4.7.11 Per-recruit Analysis

The yield-per-recruit (YPR), spawner-per-recruit (SSB/R), static spawning potential ratio (SPR), and total equilibrium yield analyses were computed as a function of the instantaneous fishing mortality rate on age-3 Mutton Snapper (**Table 24** and **Figure 87**). Presented with these values is also their relation to the Maximum Fishing Mortality Threshold (MFMT) defined as $F_{30\%SPR}$ (=0.149 y^{-1}). The amount of retained yield of Mutton Snapper at equilibrium associated with $F_{30\%SPR}$ was estimated by the SEDAR 79 base model to be at 681.87 metric tons (1,503,266 pounds whole weight), while the amount of total yield of Mutton Snapper associated with F30%SPR was estimated to be 819.98 metric tons (1,807,755 pounds whole weight).

4.8 Stock Status

The equilibrium fishing mortality rates that achieve 30%SPR ($F_{MSYproxy}$, $F_{30\%SPR}$) and 40%SPR (FOY, $F_{40\%SPR}$), as well as the associated reference spawning stock biomasses ($SSB_{30\%SPR}$, $SSB_{40\%SPR}$), were determined through long-term 100-year projections, assuming that equilibrium was obtained in the final 10 years of the projection (2114-2123). These long-term projections assume that recruitment in the first year and every year thereafter follows the stock-recruit curve, as recommended by Van Beveren et al. (2021).

The resulting status determination criteria (SDCs) for Mutton Snapper specified in SAFMC Amendments 11 and 41 are summarized below

- MSY proxy = Retained yield at $F_{30\%SPR}$ = 681.87 metric tons (1,503,266 pounds whole weight) or 290,915 fish.
- MSST = 0.75*$SSB_{30\%SPR}$ = 2,514 metric tons
- MFMT = $F_{MSYproxy}$ ($F_{30\%SPR}$) = 0.149
- F_{OY} = $F4_{0\%SPR}$ = 0.11
- OY = Retained Yield at $F_{40\%SPR}$ = 276.51 metric tons (609,600 pounds)

Overfishing is defined as F > MFMT and overfished as SSB < MSST. The current condition of the stock is represented by the geometric mean of SSB ($SSB_{current}$) from the last three years (2021–2023), and the current condition of the fishery is represented by the geometric mean of F ($F_{current}$) from the last three years (2021–2023). These benchmarks are conditional on the estimated selectivity functions and the relative contributions of each fleet's fishing mortality averaged over the last three years (2021 – 2023).

According to the SEDAR 79 Base Model, the Southeastern US Mutton Snapper population is not currently undergoing overfishing ($F_{Current}$ < MFMT) and is not overfished ($SSB_{current}$ > MSST) (**Table 25**; **Figures 88-89**). The current spawning stock biomass is 5,403 metric tons (geometric mean of 2021-2023) is above $SSB_{30\%SPR}$ at 161% of the biomass level needed to support MSY (**Figure 89**). The current fishing mortality rate is 0.08 (geometric mean of 2021-2023), which is equivalent to 53% of $F_{30\%SPR}$ (**Figure 89**).

Throughout the time series, age-3 fishing mortality rates have been variable and have been above $F_{30\%SPR}$ in numerous years prior to 2018 (**Figure 88-89**; **Table 15).** The base model estimated the lowest fishing mortality rates in 2011 and then from 2018-2023. During the 1980s, spawning stock biomass was at or near the MSST before declining below the MSST through 2010; however, since 2017 spawning stock biomass has rapidly increased beyond $SSB_{30\%SPR}$ although the uncertainty is greatest in recent years (**Figure 88-89**; **Table 16).**

4.8.1 Projections

Several short-term projection scenarios explored the effects of various fishing mortality conditions. The scenarios investigated when fishing mortality rates were either held constant at $F_{30\%SPR}$ (MFMT=0.149), 75% of $F_{30\%SPR}$ (= 0.112), or $F_{current}$ (=0.08). The TORs also state to evaluate the projected spawning stock biomass when catch is held constant at the equilibrium yield at $F_{40\%SPR}$, however, $F_{40\%SPR}$ is nearly equivalent to 75% of $F_{30\%SPR}$. Short term (i.e., 10 year) projections were produced assuming predicted age 1 recruitment was equal to the geometric mean of base model estimates from 2019-2023 (3.284 million fish). While only the first 5 years of the short-term projection are recommended for use, projections were extended into the future (i.e., until 2033).

Both short- and long-term projections assumed relative fishing mortality rates in the projection period were equal to the average from 2021-2023 (Com LL = 0.016, Com Other = 0.014, Rec East =0.75, Rec West = 0.22).

Short term projections were compared to long term projections that assumed recruitment followed the stock-recruit relationship in *all* projection years (i.e., 2024 – 2033). As shown in **Figure 90**, the instantaneous age-3 fishing mortality remains the same into the future for both the long- and short-term projections; however, the predicted recruitment is much greater compared to the long-term projection that assumed recruitment followed the stock-recruit relationship due to the recent above average recruitment (**Figure 91**). The differences among predicted spawning stock biomass in these two scenarios are illustrated in **Figure 92**.

The resulting retained yield and retained number of Mutton Snapper associated with $F_{30\%SPR}$ with either predicted recruits that equal to the recent average recruitment (i.e., short-term) or that follow the stock-recruit relationship (i.e., long-term) are presented in **Figure 93** and **Table 26**. From 2024 – 2028, retained yield (in pounds) for the short-term scenario was well beyond historical yields, as projected yields ranged from 3.27 million pounds to 3.38 million pounds and historical yields averaged 1.1 million pounds with a maximum of 2.4 million pounds in 2008. Retained yield (in pounds) for the other short-term projection scenarios associated with 75% of $F_{30\%SPR}$ and $F_{current}$ averaged 2.68 million pounds and 2.05 million pounds, respectively (**Figure 94**).

5. DISCUSSION

The SEDAR 79 Benchmark Assessment incorporated a decade of new data since the previous assessment (SEDAR 15AU; terminal year = 2013) and all historical data were procured and recompiled following SEDAR Data Best Practices as closely as possible. This assessment also revised estimates of recreational landings and discards (via SRFS and SRFS-calibrated data for the Florida private mode and MRIP-FES data for charter, shore, and non-FL private modes), reanalyzed reproduction data according to recent recommendations (Lowerre-Barbieri et al. 2022), incorporated recent methods to estimate natural mortality (Hamel and Cope 2022; Lorenzen 2022), revised release mortality rates to account for delayed mortality (Ramsay et al.

2022), and added additional fishery-independent indices of abundance while simultaneously removing several fishery-dependent CPUE timeseries.

In terms of the modelling framework, the transition from ASAP version 3 to Stock Synthesis version 3.30.22.1 required less external processing of data inputs (e.g., landings and releases can be in numbers, internal growth estimation and catch-at-age calculation), allowed for additional options for model configuration (e.g., various selectivity and retention function types by length and/or age, internal bias correction of recruitment deviations), and the application of additional model diagnostics (e.g., jitter analysis, parameter profiling, model validation). The transition to Stock Synthesis addressed many of the SEDAR 15AU Review Panel concerns with the ASAP model.

There were numerous configuration changes, but a key one was the reconfiguration of the recreational fleet. The recreational fleet configuration for SEDAR 79 Base Model grouped the headboat data with data from private, shore, and charter but split the recreational fleet into an East (i.e., SE FL and north) and West (i.e., FL Keys and Gulf) fleet to account for the apparent differences in selectivity between these two regions.

Overall, the SEDAR 79 Base Model appears to perform well, and the results of the model diagnostics suggest the base model may be suitable for use in the management of Mutton Snapper. The jitter analysis, low gradient (<0.0001), and invertible hessian lend support that the base model converged to a global solution. The base model demonstrated adequate fits to the various data components, although some residual patterns were noted (e.g., fits to Rec West landings and releases). Some of the data streams revealed very large residuals in terms of magnitude, including the FIM YOY and SERFS surveys. The FIM YOY index, however, may have low power to detect changes in abundance and the SERFS survey does not have associated length or age information to inform selectivity. The base model also exhibited model consistency as the removal of successive years of data showed minimal retrospective bias in estimates of fishing mortality rates and spawning stock biomass. Profile likelihood analyses provided support for the SEDAR 79 Base Model estimates of steepness, ln(R0), and the assumed average natural mortality. Retrospective forecasting and the hindcast cross-validation techniques also suggested the base model exhibited more predictive skill than a random-walk overall.

The dominant data inputs were the length and age compositions as these produced the greatest impact on the model fit (as measured in the total likelihood), however the ASPM and ASPMdev suggested that much of the support for estimates of absolute abundance and trend originated from the catch information and the variability in recruitment.

The MRIP-FES sensitivity run illustrated the sensitivity of the absolute scale of estimated abundance to the scale of landings and releases but importantly, estimates of fishing mortality rates and spawning stock biomass relative to management reference points remained largely unaffected. This model behavior was not portrayed by the SEDAR 15AU Final Model as only the estimate of $SSB_{30\%SPR}$ was primarily impacted by increases in MRIP-FES landings and releases. This led to a change in the overfished status determination (**Figure 81**). Model explorations and model bridging exercises that revised either SEDAR 15AU data inputs or the model configuration did not fully explain these results.

Estimates of absolute abundance are always the most uncertain, as they hinge on unknown quantities (i.e., natural mortality, equilibrium conditions) and potentially imprecise catch (landings and dead releases) values. However, the rapid increase in Mutton Snapper spawning stock biomass and recruitment in recent years, which is quite remarkable, is supported by the fishery independent indices, as most are at least 1.5 times the overall mean since 2020. The robust Southeastern US Mutton Snapper population in recent years may be a reflection of successful management measures enacted in 2018, coupled with potentially favorable environmental conditions for summer spawners such as Mutton Snapper (Shertzer et al. unpublished).

6. ACKNOWLEDGEMENTS

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7. RESEARCH RECOMMENDATIONS

This assessment, as well as many others, would greatly benefit from a better understanding of movement and stock structure, as well as recent reproduction. A better understanding of these processes may shed light on the mechanisms driving the truncated length and age distributions of Mutton Snapper observed in southeast FL. The SEDAR 79 Data Workshop report includes an extensive list of research recommendations from each working group that should be prioritized (Sections 2.11, 3.8, 4.8, 5.6).

Regarding fishery sampling effort, the next assessment would benefit from additional sampling in the FL Keys, increased sampling of commercial vertical line and other gears, additional age and length samples from private and shore recreational modes, and more information on release sizes. The length and age distributions of landed Mutton Snapper in the FL Keys appear to be intermediary between generally smaller/younger fish caught in SE FL and larger/older fish caught in the Dry Tortugas, however the FL Keys are considerably under sampled in most years. For commercial vertical line and other gears, increase the number of measured Mutton Snapper to at least 320 per year. An average of approximately 20 per month from January through August and 40 per month from September through December, especially from vessels fishing in the FL Keys and Dry Tortugas. Additional age and length samples from private and shore recreational modes are also needed. Increase length sampling in all regions for the shore mode and begin aging Mutton Snapper landed by the shore mode. For both the private and shore recreational modes, increase length sampling substantially in regions west of the FL Keys and the FL Keys to at least 150 per year and continue sampling the SE FL with the goal of reaching at least 150 per year. Also, the private and shore modes account for nearly all releases but do not contribute release lengths, undoubtedly due to the logistical challenges of sampling releases from these fishing modes.

Lastly, reliable estimates of commercial discards are currently lacking. Estimates of commercial discards from at-sea observers or other sources that are demonstrated to be more reliable than discard logbooks are needed.

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9. TABLES

Table 1. Updated number of age-length pairs of Mutton Snapper by year, fishery, and region for use in the development of conditional age-at-length data. Ages sampled from tournaments or recreational longline were not included.

Year	East (SE FL and North)				West (FL Keys and Gulf)				Total
	COM LL	COM OTHER	REC	FI	COM LL	COM OTHER	REC	FI	
1981	0	0	86	0	0	0	63	0	149
1982	0	0	65	0	0	0	104	0	169
1983	0	0	4	0	0	0	0	0	4
1984	0	0	32	0	0	0	0	0	32
1985	0	0	87	0	0	0	1	0	88
1986	0	0	33	0	0	0	0	0	33
1987	0	0	14	0	0	0	0	0	14
1988	0	0	33	0	0	0	0	0	33
1989	0	0	0	0	0	0	0	0	0
1990	0	0	6	0	0	0	0	0	6
1991	0	0	7	0	0	0	4	0	11
1992	0	46	5	0	1	6	0	0	58
1993	0	36	21	0	11	0	32	0	100
1994	0	58	10	0	5	0	19	0	92
1995	2	33	104	0	1	0	22	0	162
1996	0	150	10	0	0	0	14	0	174
1997	0	205	8	0	24	0	12	0	249
1998	0	191	0	204	3	8	0	0	406
1999	0	219	0	141	5	0	0	21	386
2000	0	201	3	152	9	1	1	113	480
2001	0	252	38	67	52	6	1	147	563
2002	0	308	84	60	93	9	34	49	637
2003	0	256	324	0	144	4	10	0	738
2004	0	145	247	0	135	21	15	0	563
2005	0	160	451	0	166	18	54	0	849
2006	0	88	234	0	401	47	77	0	847
2007	0	49	599	2	230	14	77	2	973
2008	0	232	487	0	208	133	317	7	1384
2009	0	164	613	0	136	114	481	6	1514
2010	0	401	667	0	365	115	372	6	1926
2011	0	435	356	0	227	108	379	3	1508
2012	0	123	129	5	260	203	504	4	1228
2013	0	72	111	0	255	188	363	4	993

2014	0	81	306	1	287	171	314	2	1162
2015	0	38	288	1	162	135	382	2	1008
2016	0	75	331	3	121	90	668	8	1296
2017	0	49	204	0	236	81	499	6	1075
2018	0	84	161	13	337	122	559	6	1282
2019	0	219	129	17	89	126	272	3	855
2020	0	387	19	14	17	133	31	1	602
2021	14	319	103	52	35	137	77	8	745
2022	9	414	188	23	241	42	155	56	1128
Total	25	5490	6597	755	4256	2032	5913	454	25522

Table 2. Commercial landings in weight (metric tons whole weight, mt) for the Commercial Longline and Other fleets, with log-scale standard errors (log SE) and the number of releases (1000s) for the Commercial Other fleet with associated standard errors (SE).

Year	Commercial LL		Commercial Other			
	Landings (mt)	log SE	Landings (mt)	log SE	Releases (1000s)	SE
1981	28.107	0.09	105.948	0.06		
1982	43.172	0.09	105.558	0.06		
1983	36.169	0.08	98.710	0.07		
1984	23.197	0.07	86.492	0.06		
1985	20.691	0.07	78.431	0.06		
1986	54.326	0.06	132.036	0.06		
1987	85.465	0.06	166.559	0.06		
1988	53.409	0.06	153.796	0.05		
1989	77.255	0.07	172.553	0.06		
1990	59.852	0.06	147.193	0.06		
1991	66.196	0.06	153.394	0.06		
1992	33.484	0.07	148.390	0.07		
1993	34.061	0.07	168.166	0.06	5.654	0.49
1994	22.633	0.07	139.680	0.07	6.628	0.52
1995	20.717	0.06	108.485	0.06	7.58	0.59
1996	23.013	0.08	109.286	0.06	6.801	0.54
1997	26.575	0.08	106.089	0.06	6.991	0.52
1998	36.016	0.07	125.411	0.06	5.706	0.49
1999	33.641	0.07	81.168	0.05	5.815	0.53
2000	33.420	0.07	59.404	0.05	5.922	0.53
2001	41.839	0.04	63.844	0.03	4.713	0.42
2002	36.160	0.04	69.834	0.03	4.921	0.40
2003	50.441	0.03	70.634	0.03	4.322	0.38
2004	89.358	0.03	68.062	0.03	4.157	0.39
2005	54.666	0.03	52.718	0.03	3.5	0.33

2006	88.014	0.04	42.188	0.03	3.613	0.35
2007	58.609	0.04	41.749	0.03	3.505	0.30
2008	33.533	0.03	37.874	0.04	3.127	0.25
2009	14.708	0.03	40.094	0.03	4.379	0.41
2010	16.321	0.04	41.826	0.03	3.975	0.41
2011	24.792	0.04	47.329	0.02	3.31	0.26
2012	24.144	0.05	51.119	0.03	3.555	0.31
2013	38.774	0.04	43.378	0.03	4.204	0.41
2014	56.418	0.03	46.973	0.02	5.794	0.64
2015	50.626	0.03	51.400	0.02	6.731	0.80
2016	26.161	0.03	42.015	0.03	4.934	0.52
2017	43.365	0.05	43.628	0.03	3.863	0.37
2018	51.543	0.04	49.579	0.03	5.831	0.62
2019	20.874	0.04	41.203	0.02	6.339	1.06
2020	22.620	0.05	41.780	0.03	6.194	1.10
2021	21.982	0.04	34.567	0.03	5.849	1.11
2022	25.442	0.04	33.645	0.02	4.472	0.68
2023	38.213	0.04	34.367	0.02	5.505	0.96

Table 3. SRHS and MRIP landings in numbers (1000s) by mode: Headboat (HB), Charter (CH), Shore (SH), FL Private (FL PR), and Non-FL Private (non-FL PR).

Year	East (SE FL and North)						West (FL Keys and Gulf)					
	HB	CH	SH	FL PR	non-FL PR	Total	HB	CH	SH	FL PR	non-FL PR	Total
1981	24.093	9.662	293.154	78.484	0.000	405.393	21.797	6.913	34.738	540.684	0.000	604.133
1982	17.766	14.777	341.195	84.113	0.000	457.850	13.370	22.495	3.899	281.404	0.000	321.168
1983	10.778	8.152	361.239	87.083	0.000	467.252	18.006	2.893	64.275	51.106	0.000	136.280
1984	6.598	3.175	0.000	222.392	0.000	232.164	10.912	29.579	27.776	421.883	0.000	490.150
1985	10.195	1.285	0.000	63.913	0.000	75.393	11.297	9.900	40.648	0.000	0.000	61.845
1986	8.650	0.225	0.000	74.203	0.000	83.078	12.415	14.194	12.858	301.662	0.000	341.129
1987	10.224	0.000	90.134	102.767	0.000	203.125	10.358	10.653	19.405	368.432	0.000	408.848
1988	17.244	1.787	20.341	58.111	0.000	97.484	7.740	1.339	12.333	316.635	0.047	338.094
1989	18.741	2.351	45.575	74.854	2.120	143.641	7.393	1.185	20.284	229.682	0.000	258.544
1990	24.288	0.512	0.000	78.442	0.000	103.242	15.297	60.208	0.000	106.218	15.064	196.786
1991	13.375	0.245	38.623	71.046	0.000	123.288	6.202	3.024	56.591	200.661	0.000	266.478
1992	11.071	1.184	120.708	82.716	0.000	215.679	9.655	6.564	2.619	208.097	0.033	226.968
1993	15.919	0.346	60.213	228.747	0.000	305.225	9.544	12.066	34.898	239.560	0.000	296.068
1994	13.261	1.288	22.538	106.252	0.000	143.339	11.078	4.861	23.235	55.639	0.000	94.813
1995	9.139	0.927	2.731	63.422	0.000	76.220	6.788	5.507	20.732	123.455	0.000	156.481
1996	3.813	0.730	6.540	52.903	0.000	63.985	4.988	2.553	2.819	76.529	0.117	87.006
1997	4.846	4.677	4.721	45.486	0.000	59.730	4.841	3.442	8.686	37.524	0.049	54.542

1998	3.009	3.449	25.771	70.169	0.000	102.399	4.176	5.341	2.799	67.147	0.000	79.463
1999	4.473	0.447	38.179	61.555	0.000	104.654	3.020	2.429	25.507	89.929	0.029	120.914
2000	3.213	3.622	13.861	115.611	0.000	136.307	5.015	2.515	0.000	13.573	0.000	21.104
2001	4.552	4.320	15.266	90.270	0.000	114.407	5.740	2.835	4.170	3.670	0.072	16.487
2002	3.880	15.667	16.101	155.797	0.000	191.445	4.059	6.566	4.121	66.422	0.000	81.168
2003	2.553	10.656	12.956	110.024	0.000	136.190	4.727	6.300	25.655	64.806	0.000	101.488
2004	3.508	6.472	26.053	114.622	2.118	152.773	3.926	11.423	0.000	9.818	0.000	25.167
2005	9.728	13.703	14.969	145.620	0.000	184.021	6.772	3.249	4.447	0.113	0.000	14.580
2006	1.861	9.669	16.055	178.895	0.000	206.481	8.616	7.525	22.989	214.909	0.000	254.039
2007	6.132	9.033	22.198	203.607	0.000	240.970	9.468	8.502	24.932	138.103	0.036	181.041
2008	6.644	6.123	570.369	136.350	0.000	719.486	6.209	10.342	38.676	126.763	0.036	182.026
2009	8.838	16.766	29.278	152.023	0.000	206.905	9.606	6.775	0.000	39.163	0.000	55.544
2010	8.079	12.125	24.746	143.418	0.000	188.368	6.811	6.723	3.952	39.723	0.000	57.210
2011	4.697	8.809	11.414	38.768	0.000	63.688	6.949	7.784	0.000	14.956	0.000	29.689
2012	4.563	17.746	2.189	63.794	0.000	88.293	7.809	13.739	0.000	102.479	0.000	124.028
2013	4.118	8.066	20.688	133.599	0.000	166.472	5.576	10.343	13.001	99.893	0.000	128.812
2014	10.954	9.823	3.081	265.990	0.000	289.848	6.664	7.668	61.312	45.420	0.139	121.204
2015	12.555	16.875	49.872	176.941	0.000	256.242	8.452	17.651	53.158	51.533	0.000	130.795
2016	16.129	14.331	28.167	228.901	0.000	287.528	7.298	15.019	40.395	66.425	0.000	129.137
2017	5.532	6.181	38.940	117.391	0.000	168.044	8.158	3.930	0.000	43.317	0.000	55.405
2018	3.555	3.786	0.000	140.990	0.158	148.489	9.561	12.655	11.523	37.575	0.081	71.395
2019	3.371	2.742	0.000	161.708	0.000	167.821	7.986	29.984	33.010	31.191	0.000	102.172
2020	3.325	5.476	4.317	62.975	0.000	76.093	7.549	39.389	0.000	195.530	0.000	242.468
2021	5.626	6.061	1.577	124.009	0.000	137.273	16.696	18.293	14.163	108.345	0.000	157.496
2022	3.385	8.899	13.789	218.822	0.000	244.895	5.680	16.872	18.706	27.709	0.000	68.967
2023	4.008	5.565	6.047	231.611	0.000	247.231	4.527	11.352	25.761	56.317	0.000	97.956

Table 4. SRHS and MRIP CVs associated with landings by mode: Headboat (HB), Charter (CH), Shore (SH), FL Private (FL PR), and Non-FL Private (non-FL PR).

Year	East (SE FL and North)					West (FL Keys and Gulf)				
	HB	CH	SH	FL PR	non-FL PR	HB	CH	SH	FL PR	non-FL PR
1981	0.086	0.870	0.720	0.520		0.260	1.000	0.710	0.630	
1982	0.295	0.530	0.710	0.340		0.161	0.700	1.000	0.570	
1983	0.124	0.470	0.850	0.350		0.347	0.530	1.000	0.530	
1984	0.236	0.370		0.510		0.338	0.540	0.710	0.650	
1985	0.292	0.800		0.740		0.292	0.500	0.790	0.000	
1986	0.218	1.000		0.290		0.306	0.410	1.000	0.590	
1987	0.283		1.000	0.390		0.228	0.490	1.000	0.470	
1988	0.408	0.830	1.000	0.290		0.172	0.730	1.000	0.730	
1989	0.448	0.830	0.810	0.350		0.182	0.600	1.000	0.660	
1990	0.383	0.840		0.280		0.220	0.980		0.430	
1991	0.455	1.000	0.630	0.330		0.173	0.550	1.000	0.410	
1992	0.243	0.450	0.780	0.180		0.168	0.370	1.000	0.500	
1993	0.284	1.000	0.350	0.210		0.090	0.490	0.420	0.360	
1994	0.313	0.880	0.440	0.260		0.164	0.500	0.400	0.270	
1995	0.337	0.600	0.710	0.290		0.102	0.430	0.440	0.580	
1996	0.363	0.560	0.830	0.300		0.177	0.410	0.710	0.419	
1997	0.330	0.540	1.000	0.240		0.105	0.410	0.810	0.559	
1998	0.279	0.710	0.720	0.220		0.163	0.520	1.000	0.490	
1999	0.512	0.380	0.490	0.190		0.125	0.240	0.920	0.530	
2000	0.343	0.330	1.000	0.200		0.222	0.190		0.760	
2001	0.386	0.230	0.620	0.250		0.284	0.192	1.000	0.981	
2002	0.396	0.200	0.450	0.150		0.318	0.180	1.000	0.530	
2003	0.322	0.290	0.460	0.180		0.402	0.200	0.640	0.400	
2004	0.451	0.250	0.660	0.300		0.326	0.300		0.560	
2005	0.561	0.270	0.510	0.190		0.251	0.240	1.000	1.000	
2006	0.167	0.360	0.730	0.180		0.463	0.320	1.000	0.690	
2007	0.347	0.430	0.370	0.150		0.202	0.230	1.000	0.560	
2008	0.180	0.380	0.780	0.150		0.065	0.220	0.830	0.540	
2009	0.057	0.260	0.570	0.200		0.038	0.300		0.520	
2010	0.052	0.260	0.450	0.170		0.025	0.250	1.000	0.680	
2011	0.036	0.440	0.620	0.230		0.048	0.250		0.610	
2012	0.033	0.620	1.000	0.210		0.123	0.410		0.570	
2013	0.067	0.670	0.970	0.250		0.037	0.430	0.740	0.350	
2014	0.033	0.310	0.710	0.300		0.020	0.350	0.530	0.299	
2015	0.043	0.300	0.690	0.270		0.023	0.340	0.500	0.660	
2016	0.180	0.260	0.530	0.340		0.018	0.320	0.550	0.330	
2017	0.024	0.440	0.940	0.280		0.035	0.340		0.460	
2018	0.016	0.380		0.370		0.042	0.290	0.900	0.319	
2019	0.017	0.460		0.450		0.037	0.520	0.760	0.480	
2020	0.019	0.300	1.000	0.310		0.035	0.450		0.830	
2021	0.013	0.310	1.000	0.270		0.037	0.340	0.500	0.380	
2022	0.019	0.350	0.690	0.220		0.031	0.350	0.580	0.495	
2023	0.023	0.260	1.000	0.230		0.027	0.314	0.470	0.380	

Table 5. SRFS and SRFS FCAL calibrated landings and releases in numbers (1000s) and weight (metric tons, mt) for the Florida private mode (FL PR) with associated CVs.

Year	East (SE FL and North)						West (FL Keys and Gulf)					
	Landings (1000s)	CV	Landings (mt)	CV	Releases (1000s)	CV	Landings (1000s)	CV	Landings (mt)	CV	Releases (1000s)	CV
1981	41.581	0.549	39.526	0.597	0.000		197.403	0.706	105.553	0.717	0.000	
1982	44.563	0.383	27.023	0.418	0.000		102.740	0.653	253.578	0.649	0.000	
1983	46.136	0.392	32.601	0.443	11.940	1.009	18.659	0.619	64.415	0.706	0.000	
1984	117.823	0.539	139.146	0.554	2.407	1.009	154.029	0.724	280.925	0.742	113.030	0.771
1985	33.861	0.761	49.133	0.769	49.776	1.009						
1986	39.313	0.339	47.771	0.351	17.268	0.507	110.136	0.671	207.672	0.678	1.674	1.037
1987	54.446	0.428	47.824	0.459	111.295	0.830	134.514	0.568	90.186	0.562	41.476	0.762
1988	30.787	0.339	44.673	0.385	9.807	0.614	115.603	0.796	244.834	0.794	64.160	0.875
1989	39.658	0.392	56.194	0.398	14.835	0.527	83.856	0.733	84.899	0.735	4.408	1.037
1990	41.558	0.331	59.178	0.341	2.468	0.791	38.780	0.535	28.740	0.557	23.420	0.837
1991	37.640	0.374	60.381	0.391	11.928	0.402	73.261	0.519	120.149	0.540	264.149	0.642
1992	43.823	0.252	52.062	0.278	61.974	0.412	75.976	0.593	103.223	0.595	62.290	0.571
1993	121.190	0.274	110.327	0.278	90.281	0.328	87.463	0.481	81.519	0.474	307.824	0.724
1994	56.292	0.314	67.873	0.324	66.094	0.383	20.314	0.418	18.551	0.415	59.384	0.580
1995	33.601	0.339	76.301	0.357	27.945	0.527	45.073	0.662	85.556	0.659	89.120	0.678
1996	28.028	0.348	61.101	0.360	28.177	0.346	27.941	0.527	43.180	0.512	76.534	0.528
1997	24.099	0.297	47.666	0.311	60.904	0.309	13.700	0.644	30.504	0.664	171.146	0.562
1998	37.176	0.282	63.493	0.298	68.612	0.300	24.515	0.585	51.219	0.592	184.881	0.588
1999	32.612	0.259	53.510	0.274	41.516	0.248	32.833	0.618	69.977	0.607	27.108	0.580
2000	61.250	0.266	117.185	0.272	77.946	0.291	4.956	0.824	12.997	0.835	8.520	1.037
2001	47.825	0.306	79.252	0.313	40.896	0.274	1.340	1.031	4.145	1.021	6.262	0.743
2002	82.541	0.231	113.795	0.233	86.691	0.248	24.250	0.619	30.998	0.625	4.173	0.790
2003	58.291	0.252	103.168	0.269	45.438	0.265	23.661	0.512	22.744	0.526	41.462	0.606
2004	60.726	0.348	93.609	0.350	62.858	0.274	3.585	0.644	7.624	0.647	15.099	0.562
2005	77.149	0.259	102.693	0.260	90.736	0.248	0.041	1.050	0.079	1.039	216.230	1.028
2006	94.778	0.252	133.093	0.252	155.485	0.239	78.463	0.760	109.947	0.751	26.405	0.588
2007	107.871	0.231	184.771	0.235	188.476	0.231	50.421	0.644	73.442	0.634	91.410	0.580
2008	72.238	0.231	82.426	0.233	202.814	0.282	46.281	0.627	90.855	0.632	68.829	0.453
2009	80.542	0.266	91.154	0.267	118.326	0.239	14.298	0.610	31.559	0.630	45.174	0.606
2010	75.983	0.245	115.100	0.246	45.834	0.256	14.503	0.751	27.008	0.765	6.080	0.780
2011	20.539	0.289	31.297	0.294	19.888	0.346	5.460	0.688	11.019	0.673	4.309	0.818
2012	33.798	0.274	64.109	0.279	31.567	0.282	37.415	0.653	101.880	0.662	50.180	0.669
2013	70.781	0.306	108.685	0.315	111.243	0.328	36.471	0.473	86.515	0.466	141.101	0.519
2014	140.921	0.348	165.466	0.349	274.747	0.355	16.583	0.437	24.269	0.428	53.301	0.536
2015	93.743	0.322	135.188	0.332	244.526	0.248	18.815	0.733	25.718	0.724	10.724	0.528
2016	121.271	0.383	198.233	0.388	327.374	0.355	24.252	0.459	37.829	0.457	88.144	0.615
2017	62.194	0.331	118.186	0.359	249.130	0.239	15.815	0.560	43.769	0.551	54.089	0.422

2018	74.696	0.410	141.777	0.424	284.836	0.300	13.719	0.451	17.142	0.446	28.016	0.477
2019	85.673	0.483	124.968	0.495	229.718	0.231	11.388	0.576	11.689	0.563	54.250	0.379
2020	33.364	0.356	66.477	0.377	231.339	0.265	71.388	0.889	163.615	0.878	161.658	0.502
2021	106.055	0.230	224.571	0.181	549.434	0.136	42.227	0.294	66.490	0.176	86.574	0.320
2022	99.519	0.139	168.421	0.105	457.746	0.133	13.529	0.239	24.824	0.185	142.420	0.200
2023	98.765	0.179	235.698	0.153	477.399	0.124	14.478	0.345	49.460	0.257	111.997	0.305

Table 6. SRHS and MRIP releases in numbers (1000s) by mode: Headboat (HB), Charter (CH), Shore (SH), FL Private (FL PR), and Non-FL Private (non-FL PR).

Year	East (SE FL and North)						West (FL Keys and Gulf)					
	HB	CH	SH	FL PR	non-FL PR	Total	HB	CH	SH	FL PR	non-FL PR	Total
1981	0.000	0.000	0.000	0.000	0.000	0.000	21.797	6.913	34.738	0.000	0.000	63.448
1982	0.000	0.000	7.594	0.000	0.000	7.594	13.370	22.495	3.899	0.000	0.000	39.764
1983	0.000	0.000	0.000	21.758	0.000	21.758	18.006	2.893	64.275	0.000	0.000	85.174
1984	0.000	1.514	6.058	4.386	0.000	11.959	10.912	29.579	27.776	234.463	0.000	302.730
1985	0.000	0.000	29.394	90.711	0.000	120.106	11.297	9.900	40.648	0.000	0.000	61.845
1986	0.000	0.000	55.273	31.470	0.000	86.742	12.415	14.194	12.858	3.472	0.000	42.939
1987	0.000	0.000	0.000	202.822	0.000	202.822	10.358	10.653	19.405	86.035	0.000	126.451
1988	0.000	0.000	15.892	17.872	0.000	33.764	7.740	1.339	12.333	133.090	0.000	154.502
1989	0.000	0.000	0.000	27.034	0.000	27.034	7.393	1.185	20.284	9.144	0.000	38.006
1990	0.000	0.000	0.000	4.497	0.000	4.497	15.297	60.208	0.000	48.581	3.582	127.668
1991	0.000	0.053	0.000	21.738	0.000	21.791	6.202	3.024	56.591	547.933	0.000	613.750
1992	4.448	0.868	20.079	112.941	0.000	138.336	9.655	6.564	2.619	129.211	0.000	148.049
1993	0.000	0.000	16.441	164.526	0.000	180.967	9.544	12.066	34.898	638.531	0.000	695.039
1994	0.000	0.000	18.445	120.448	0.000	138.893	11.078	4.861	23.235	123.183	0.000	162.357
1995	0.975	0.180	94.084	50.927	0.000	146.166	6.788	5.507	20.732	184.866	0.000	217.893
1996	0.421	0.147	10.566	51.349	0.000	62.483	4.988	2.553	2.819	158.757	0.859	169.976
1997	0.000	0.000	4.572	110.990	0.000	115.562	4.841	3.442	8.686	355.014	1.564	373.548
1998	0.437	0.913	63.342	125.037	0.000	189.729	4.176	5.341	2.799	383.505	4.092	399.913
1999	9.150	1.667	20.976	75.657	0.000	107.451	3.020	2.429	25.507	56.231	0.000	87.187
2000	1.170	2.407	47.833	142.047	0.000	193.457	5.015	2.515	0.000	17.674	0.000	25.204
2001	0.564	0.976	14.316	74.528	0.000	90.384	5.740	2.835	4.170	12.989	0.000	25.734
2002	0.496	3.652	109.377	157.983	0.000	271.508	4.059	6.566	4.121	8.657	0.000	23.403
2003	1.014	7.721	49.358	82.806	0.000	140.899	4.727	6.300	25.655	86.007	0.000	122.689
2004	0.263	0.885	57.652	114.550	0.000	173.350	3.926	11.423	0.000	31.321	0.000	46.669
2005	2.507	6.445	55.421	165.354	0.000	229.727	6.772	3.249	4.447	448.533	0.000	463.000
2006	0.789	7.484	107.890	283.353	0.000	399.516	8.616	7.525	22.989	54.773	0.000	93.903
2007	3.488	9.376	65.555	343.474	0.000	421.893	9.468	8.502	24.932	189.615	0.000	232.518
2008	5.278	11.746	1,359.280	369.604	0.000	1,745.908	6.209	10.342	38.676	142.775	0.000	198.002
2009	4.272	12.915	102.320	215.635	0.000	335.141	9.606	6.775	0.000	93.706	0.000	110.087

2010	2.159	5.988	28.741	83.527	0.000	120.415	6.811	6.723	3.952	12.613	0.000	30.100
2011	0.369	1.229	1.554	36.243	0.000	39.395	6.949	7.784	0.000	8.938	0.000	23.670
2012	1.062	1.162	261.530	57.527	0.000	321.280	7.809	13.739	0.000	104.090	0.000	125.639
2013	3.069	7.530	103.426	202.726	0.000	316.752	5.576	10.343	13.001	292.692	0.000	321.611
2014	8.760	8.540	101.158	500.692	0.000	619.150	6.664	7.668	61.312	110.564	0.000	186.209
2015	8.787	17.573	287.839	445.618	0.000	759.817	8.452	17.651	53.158	22.245	0.000	101.506
2016	18.528	9.664	726.923	596.599	0.000	1,351.713	7.298	15.019	40.395	182.840	0.433	245.985
2017	9.583	33.943	1,202.688	454.010	0.000	1,700.224	8.158	3.930	0.000	112.198	1.695	125.981
2018	13.135	14.569	207.544	519.078	0.000	754.325	9.561	12.655	11.523	58.114	0.000	91.853
2019	8.808	13.940	176.202	418.632	0.000	617.582	7.986	29.984	33.010	112.532	0.000	183.512
2020	10.073	29.518	135.008	421.587	0.000	596.186	7.549	39.389	0.000	335.333	0.266	382.536
2021	7.568	24.278	81.163	759.708	0.000	872.717	16.696	18.293	14.163	154.769	0.000	203.921
2022	8.726	33.105	283.944	868.277	0.000	1,194.051	5.680	16.872	18.706	219.796	0.000	261.054
2023	11.766	16.767	184.390	1,077.479	0.000	1,290.402	4.527	11.352	25.761	332.765	0.000	374.405

Table 7. SRHS and MRIP CVs associated with releases by mode: Headboat (HB), Charter (CH), Shore (SH), FL Private (FL PR), and Non-FL Private (non-FL PR).

Year	East (SE FL and North)					West (FL Keys and Gulf)				
	HB	CH	SH	FL PR	non-FL PR	HB	CH	SH	FL PR	non-FL PR
1981				0.000			0.335	0.000	0.000	
1982			1.000	0.000			0.000	1.007	0.000	
1983				1.000			0.000	0.000	0.000	
1984		1.000	1.000	1.000			0.000	0.000	0.720	
1985			1.000	1.000			0.000	0.521	0.000	
1986			1.000	0.490			0.130	0.000	1.000	
1987				0.820			0.000	0.000	0.710	
1988			1.000	0.600			0.078	3.373	0.830	
1989				0.510			0.000	0.000	1.000	
1990				0.780			0.000		0.790	
1991		1.000		0.380			0.158	0.521	0.580	
1992		0.920	1.000	0.390			0.916	1.000	0.500	
1993			0.480	0.300			0.142	0.701	0.670	
1994			0.420	0.360			0.122	0.466	0.510	
1995		0.730	0.890	0.510			0.000	0.104	0.620	
1996		1.000	1.000	0.320			0.244	0.883	0.450	
1997			1.000	0.280			1.694	0.000	0.490	
1998		0.880	0.660	0.270			0.184	5.259	0.520	
1999		0.980	0.850	0.210			0.057	0.760	0.510	
2000		0.410	0.830	0.260			0.042		1.000	
2001		0.350	0.810	0.240			0.049	0.000	0.690	
2002		0.490	0.480	0.210			0.778	0.000	0.740	
2003		0.540	0.350	0.230			0.291	0.423	0.540	
2004		0.350	0.620	0.240			0.251		0.490	
2005		0.300	0.770	0.210			0.129	10.571	0.990	
2006		0.390	0.590	0.200			0.235	5.000	0.520	
2007		0.450	0.350	0.190			0.162	3.115	0.510	
2008		0.400	0.590	0.250			1.156	0.523	0.360	
2009		0.360	0.310	0.200			0.068		0.540	
2010		0.340	0.580	0.220			0.075	0.000	0.730	
2011		0.650	1.000	0.320			0.304		0.770	
2012		0.550	0.450	0.250			0.097		0.610	
2013		0.420	0.800	0.300			0.300	1.525	0.440	
2014		0.290	0.480	0.330			0.590	4.156	0.460	
2015		0.280	0.410	0.210			0.240	1.514	0.450	
2016		0.240	0.540	0.330			0.145	3.045	0.550	
2017		0.410	0.480	0.200			2.556		0.320	

2018	0.450	0.600	0.270	0.441	7.278	0.390
2019	0.450	0.610	0.190	0.365	1.666	0.260
2020	0.390	0.650	0.230	1.815		0.420
2021	0.360	0.510	0.200	0.300	3.658	0.410
2022	0.360	0.580	0.190	0.906	4.781	0.540
2023	0.310	0.460	0.170	0.433	7.454	0.270

Table 8. Recreational landings and releases in numbers (1000s) by region for all modes combined (including SRFS and SRFS calibrated estimates for Florida private mode), with log-scale standard errors (log SE).

Year	East (SE FL and North)				West (FL Keys and Gulf)			
	Landings (1000s)	log SE	Releases (1000s)	log SE	Landings (1000s)	log SE	Releases (1000s)	log SE
1981	368.490	0.536			260.851	0.509	2.318	0.833
1982	418.300	0.539	7.594	0.833	142.504	0.459	3.925	0.833
1983	426.305	0.647	11.940	0.838	103.833	0.580		
1984	127.596	0.471	9.980	0.610	222.296	0.485	113.030	0.683
1985	45.341	0.532	79.171	0.657	61.845	0.496	21.195	0.833
1986	48.188	0.274	72.541	0.683	149.603	0.475	3.976	0.583
1987	154.804	0.556	111.295	0.724	174.929	0.431	41.476	0.676
1988	70.160	0.332	25.699	0.602	137.061	0.615	126.351	0.516
1989	108.444	0.365	14.835	0.495	112.719	0.534	4.408	0.855
1990	66.359	0.246	2.468	0.697	129.349	0.459	27.002	0.650
1991	89.882	0.312	11.982	0.386	139.078	0.464	302.921	0.529
1992	176.786	0.503	87.370	0.360	94.847	0.453	79.109	0.436
1993	197.667	0.198	106.722	0.281	143.971	0.305	342.435	0.598
1994	93.379	0.219	84.539	0.306	59.488	0.215	80.936	0.426
1995	46.398	0.254	123.184	0.624	78.100	0.386	91.287	0.603
1996	39.111	0.282	39.311	0.354	38.418	0.375	82.397	0.465
1997	38.342	0.234	65.476	0.290	30.718	0.359	191.020	0.476
1998	69.405	0.302	133.304	0.340	36.832	0.389	217.035	0.477
1999	75.711	0.268	73.309	0.276	63.818	0.461	52.588	0.450
2000	81.946	0.258	129.356	0.343	12.486	0.332	14.810	0.635
2001	71.962	0.240	56.752	0.279	14.157	0.324	6.832	0.617
2002	118.189	0.174	200.216	0.278	38.996	0.387	15.212	0.385
2003	84.456	0.189	103.531	0.205	60.343	0.331	61.405	0.427
2004	98.877	0.271	121.658	0.318	18.933	0.226	22.633	0.382
2005	115.550	0.192	155.108	0.304	14.508	0.324	291.825	0.688
2006	122.364	0.216	271.649	0.267	117.593	0.510	148.529	0.690
2007	145.233	0.182	266.895	0.184	93.360	0.420	223.654	0.403
2008	655.374	0.616	1579.118	0.480	101.543	0.409	134.906	0.284

2009	135.423	0.201	237.832	0.178	30.679	0.286	142.833	0.598
2010	120.933	0.180	82.722	0.244	31.989	0.355	10.790	0.423
2011	45.459	0.218	23.040	0.301	20.193	0.208	21.096	0.561
2012	58.296	0.246	295.320	0.385	58.963	0.408	59.667	0.526
2013	103.653	0.284	225.268	0.387	65.390	0.303	186.978	0.391
2014	164.779	0.292	393.205	0.272	92.367	0.351	408.795	0.576
2015	173.045	0.262	558.725	0.234	98.076	0.304	156.976	0.485
2016	179.899	0.267	1082.488	0.366	86.963	0.285	291.249	0.439
2017	112.846	0.361	1495.345	0.375	27.903	0.313	325.491	0.439
2018	82.195	0.361	520.083	0.285	47.539	0.261	216.569	0.379
2019	91.786	0.430	428.668	0.275	82.368	0.356	181.646	0.320
2020	46.482	0.269	405.938	0.261	118.326	0.520	353.144	0.316
2021	119.319	0.204	662.443	0.129	91.379	0.169	271.643	0.215
2022	125.592	0.135	783.521	0.222	54.787	0.230	465.466	0.202
2023	114.385	0.163	690.322	0.149	56.118	0.238	726.690	0.264

Table 9. Sampling effort (N), proportion positive (Prop Pos), relative abundance (Std Index) scaled to a mean of one for each time series and the coefficient of variation on the mean (CV, standard error/mean) of indices deemed "Suitable and Recommended" for SEDAR 79 from west to east.

	Commercial Longline (FD)				GOM Combined Stereo Video Survey (FI)				RVC Dry Tortugas (FI)			
Year	**N**	**Prop Pos**	**Std Index**	**CV**	**N**	**Prop Pos**	**Std Index**	**CV**	**N**	**Prop Pos**	**Std Index**	**CV**
1993	134	0.51	0.45	0.3								
1994	128	0.5	0.55	0.31								
1995	137	0.51	0.96	0.24								
1996	200	0.47	0.52	0.26	42	0.214	2.959	0.652				
1997	230	0.52	0.73	0.25	54	0.167	1.295	0.34				
1998	204	0.55	0.66	0.25								
1999	144	0.52	0.69	0.29					327	0.089	0.24	0.212
2000	140	0.46	0.78	0.28					381	0.115	0.34	0.164
2001	165	0.52	0.87	0.26								
2002	114	0.52	1.49	0.29	48	0.25	1.802	0.29				
2003	192	0.47	1.3	0.26								
2004	180	0.46	1.54	0.26	26	0.423	1.316	0.349	576	0.22	0.74	0.094
2005	211	0.52	1.53	0.24	78	0.167	1.389	0.243				
2006	205	0.49	1.66	0.24	85	0.259	2.286	0.209	484	0.192	0.51	0.125
2007	177	0.5	1.17	0.26	110	0.236	1.482	0.212				
2008	170	0.45	0.81	0.28	79	0.152	1.216	0.318	653	0.277	0.87	0.081
2009	80	0.51	1.09	0.33	80	0.138	0.876	0.296				
2010	62	0.56	1.2	0.31	124	0.153	0.592	0.245	689	0.332	1.2	0.071
2011					307	0.081	1.306	0.171				
2012					320	0.088	1.324	0.176	734	0.38	1.23	0.068
2013												
2014					356	0.028	0.652	0.382	702	0.318	0.84	0.081
2015												
2016					440	0.1	0.988	0.179	535	0.402	1.63	0.069
2017					411	0.054	0.5	0.215				
2018					348	0.147	0.936	0.165	646	0.359	1.13	0.075
2019					462	0.123	1.274	0.144				
2020					464	0.099	0.372	0.157				
2021					547	0.077	0.376	0.169	292	0.623	2.24	0.082
2022												
2023									300	0.597	2.56	0.088

Table 9 (continued). Sampling effort (N), proportion positive (Prop Pos), relative abundance (Std Index) scaled to a mean of one for each time series and the coefficient of variation on the mean (CV, standard error/mean) of indices deemed "Suitable and Recommended" for SEDAR 79 from west to east.

	RVC FL Keys (FI)				RVC SE FL (FI)				Indian River YOY index (FI)			
Year	**N**	**Prop Pos**	**Std Index**	**CV**	**N**	**Prop Pos**	**Std Index**	**CV**	**N**	**Prop Pos**	**Std Index**	**CV**
1993												
1994												
1995												
1996												
1997	316	0.076	0.59	0.255								
1998												
1999	376	0.077	0.49	0.216					77	0.169	0.363	0.386
2000	451	0.135	0.85	0.139					78	0.192	0.501	0.326
2001	643	0.138	0.81	0.123					76	0.171	0.573	0.35
2002	499	0.17	0.74	0.118					76	0.276	0.912	0.313
2003	377	0.17	0.85	0.132					78	0.205	0.521	0.339
2004	199	0.211	0.97	0.16					77	0.247	0.721	0.334
2005	498	0.173	0.95	0.112					75	0.213	1.323	0.34
2006	482	0.156	0.83	0.126					77	0.403	0.892	0.308
2007	606	0.226	1.31	0.093					73	0.521	3.535	0.284
2008	644	0.236	1.13	0.099					75	0.293	1.571	0.305
2009	972	0.195	0.82	0.091					73	0.219	0.513	0.343
2010	530	0.177	0.63	0.127					75	0.253	0.597	0.337
2011	780	0.167	0.62	0.105					74	0.189	0.709	0.322
2012	707	0.238	0.87	0.096					76	0.303	1.2	0.303
2013					1050	0.211	0.35	0.105	75	0.293	1.27	0.315
2014	612	0.203	1.32	0.089	565	0.29	0.5	0.114	76	0.211	1.138	0.336
2015					417	0.283	0.42	0.138	75	0.28	0.854	0.332
2016	559	0.216	1.76	0.097	462	0.39	0.92	0.097	76	0.184	0.297	0.377
2017									77	0.169	1.06	0.346
2018	633	0.292	1.66	0.092	459	0.527	1.6	0.076	78	0.167	1.337	0.331
2019									75	0.16	0.23	0.389
2020									78	0.205	1.491	0.316
2021					285	0.519	1.56	0.094	77	0.26	1.06	0.318
2022	251	0.319	2.03	0.121	292	0.493	1.65	0.093	77	0.325	1.333	0.312
2023												

Table 9 (continued). Sampling effort (N), proportion positive (Prop Pos), relative abundance (Std Index) scaled to a mean of one for each time series and the coefficient of variation on the mean (CV, standard error/mean) of indices deemed "Suitable and Recommended" for SEDAR 79 from west to east.

	SERFS video index (FI)			
Year	**N**	**Prop Pos**	**Std Index**	**CV**
1993				
1994				
1995				
1996				
1997				
1998				
1999				
2000				
2001				
2002				
2003				
2004				
2005				
2006				
2007				
2008				
2009				
2010				
2011	543	0.009	0.083	0.46
2012	1017	0.005	0.235	0.58
2013	1114	0.009	0.263	0.5
2014	1364	0.026	0.769	0.26
2015	1374	0.057	1.188	0.19
2016	1409	0.026	0.581	0.26
2017	1409	0.044	1.007	0.24
2018	1647	0.06	1.501	0.16
2019	1538	0.07	2.248	0.15
2020				
2021	1373	0.075	1.394	0.16
2022	1016	0.069	1.731	0.2
2023				

Table 10. Life history inputs for the SEDAR 79 Base Model.

	Parameterization in SS	SS Parameters		Estimated?
Length (MaxTL, cm) to whole weight (ww, kg)	$ww = aMaxTL^b$	$a = 6.63\text{E} - 06$	$b = 3.1601$	No
Length (MaxTL, cm) to age (a, yr)	$MaxTL_a = L_\infty + (L_{min} - L_\infty)e^{-k(a-Amin)}$	$L_{min} = 27.65$ $A_{min} = 0$	$L_\infty = 82.26$ $k = 0.195$	Yes, except A_{min}
Proportion Mature-at-age ($prop_{mat}$)	$prop_{mat} = \frac{1}{1 + e^{\alpha(age-\beta)}}$ $A_{50} = \frac{\alpha}{\beta}$	$\alpha = -2.535$ $\beta = -13.021$	$A_{50} = 3.48$	No
Fraction Female ($fracfem$)		$fracfem = 0.5$		No
Instantaneous Natural Mortality (M, yr^{-1})	$M = 5.4/t_{max}$	$M = 0.129$		No
Fecundity ($eggs$)	$eggs = mWW + b$	$m = 1$	$b = 0$	No

Table 11. Model-estimated length-at-age and model-calculated maturity-at-age and natural mortality-at-age versus those approved at the SEDAR 79 Data Workshop.

Calendar Age	Model Output			Data Workshop Approved			
	Max TL (cm)	M_a	Proportion Mature	Max TL (cm)	M_a	M_a (using SS estimated growth)	Proportion Mature
1	27.65	0.300	0.000	24.70	0.394	0.357	0.000
2	32.72	0.262	0.022	33.72	0.288	0.262	0.004
3	41.48	0.215	0.220	41.39	0.235	0.215	0.143
4	48.69	0.188	0.780	47.90	0.203	0.188	0.875
5	54.63	0.170	0.978	53.44	0.182	0.170	0.997
6	59.52	0.158	0.998	58.14	0.167	0.158	1.000
7	63.54	0.149	1.000	62.14	0.157	0.149	1.000
8	66.85	0.142	1.000	65.53	0.148	0.142	1.000
9	69.58	0.137	1.000	68.41	0.142	0.137	1.000
10	71.82	0.133	1.000	70.86	0.137	0.133	1.000
11	73.67	0.130	1.000	72.94	0.133	0.130	1.000
12	75.19	0.128	1.000	74.71	0.130	0.128	1.000
13	76.44	0.126	1.000	76.21	0.128	0.126	1.000
14	77.47	0.125	1.000	77.49	0.126	0.125	1.000
15	78.32	0.123	1.000	78.58	0.124	0.123	1.000
16	79.02	0.122	1.000	79.50	0.122	0.122	1.000
17	79.59	0.122	1.000	80.28	0.121	0.122	1.000
18	80.06	0.121	1.000	80.94	0.120	0.121	1.000
19	80.45	0.120	1.000	81.51	0.119	0.120	1.000
20	80.77	0.120	1.000	81.99	0.119	0.120	1.000
21	81.04	0.120	1.000	82.40	0.118	0.120	1.000
22	81.25	0.119	1.000	82.74	0.118	0.119	1.000
23	81.43	0.119	1.000	83.04	0.117	0.119	1.000
24	81.58	0.119	1.000	83.29	0.117	0.119	1.000
25	81.70	0.119	1.000	83.50	0.116	0.119	1.000
26	81.80	0.119	1.000	83.68	0.116	0.119	1.000
27	81.88	0.119	1.000	83.83	0.116	0.118	1.000
28	81.95	0.118	1.000	83.96	0.116	0.118	1.000
29	82.01	0.118	1.000	84.07	0.116	0.118	1.000
30	82.05	0.118	1.000	84.17	0.116	0.118	1.000
31	82.09	0.118	1.000	84.25	0.115	0.118	1.000
32	82.12	0.118	1.000	84.32	0.115	0.118	1.000
33	82.15	0.118	1.000	84.37	0.115	0.118	1.000
34	82.17	0.118	1.000	84.42	0.115	0.118	1.000
35	82.18	0.118	1.000	84.46	0.115	0.118	1.000
36	82.20	0.118	1.000	84.50	0.115	0.118	1.000

37	82.21	0.118	1.000	84.53	0.115	0.118	1.000
38	82.22	0.118	1.000	84.56	0.115	0.118	1.000
39	82.23	0.118	1.000	84.58	0.115	0.118	1.000
40	82.23	0.118	1.000	84.60	0.115	0.118	1.000

Table 12. List of Stock Synthesis parameters for the SEDAR 79 Base Model. The list includes expected parameter values, lower and upper bounds of the parameters, associated standard error (SE) and coefficients of variation (CV), prior type and densities (value, SD) if applicable, and the phase of estimation. Parameters designated as fixed were held at their initial values and have no associated range or SE.

	Parameter Label	Value	Range	SE	CV	Prior	Phase
1	NatM_Lorenzen_averageFem_GP_1	0.129					Fixed
2	L_at_Amin_Fem_GP_1	27.653	(2,40)	0.436	0.02		1
3	L_at_Amax_Fem_GP_1	82.265	(50,105)	0.642	0.01		2
4	VonBert_K_Fem_GP_1	0.195	(0.05,0.5)	0.005	0.03		2
5	CV_young_Fem_GP_1	0.167	(0.1,0.5)	0.007	0.04		3
6	CV_old_Fem_GP_1	0.091	(0.005,0.4)	0.004	0.04		3
7	Wtlen_1_Fem_GP_1	0.000					Fixed
8	Wtlen_2_Fem_GP_1	3.160					Fixed
9	Mat50%_Fem_GP_1	3.500					Fixed
10	Mat_slope_Fem_GP_1	-2.535					Fixed
11	Eggs_intercept_Fem_GP_1	0.000					Fixed
12	Eggs_slope_Wt_Fem_GP_1	1.000					Fixed
13	CohortGrowDev	1.000					Fixed
14	FracFemale_GP_1	0.500					Fixed
15	SR_LN(R0)	7.829	(6.5,11)	0.254	0.03		3
16	SR_BH_steep	0.644	(0.41,0.99)	0.064	0.10		3
17	SR_sigmaR	0.553	(0.1,0.8)	0.069	0.13		6
18	SR_regime	0.000					Fixed
19	SR_autocorr	0.000					Fixed
20	Early_InitAge_11	0.001	(-4,4)	0.525	730.72		6
21	Early_InitAge_10	-0.097	(-4,4)	0.518	-5.37		6
22	Early_InitAge_9	-0.008	(-4,4)	0.497	-60.29		6
23	Early_InitAge_8	0.054	(-4,4)	0.470	8.66		6
24	Early_InitAge_7	-0.077	(-4,4)	0.457	-5.96		6
25	Early_InitAge_6	0.023	(-4,4)	0.417	18.04		6
26	Early_InitAge_5	-0.443	(-4,4)	0.423	-0.95		6
27	Early_InitAge_4	-0.219	(-4,4)	0.355	-1.62		6
28	Early_InitAge_3	0.228	(-4,4)	0.284	1.25		6
29	Early_InitAge_2	-0.675	(-4,4)	0.333	-0.49		6
30	Early_InitAge_1	-0.925	(-4,4)	0.342	-0.37		6
31	Early_RecrDev_1981	-0.577	(-4,4)	0.305	-0.53		6
32	Early_RecrDev_1982	-0.109	(-4,4)	0.237	-2.17		6
33	Early_RecrDev_1983	-0.777	(-4,4)	0.315	-0.41		6
34	Early_RecrDev_1984	-0.493	(-4,4)	0.284	-0.57		6
35	Early_RecrDev_1985	-0.078	(-4,4)	0.251	-3.23		6
36	Main_RecrDev_1986	-0.065	(-4,4)	0.245	-3.78		4

37	Main_RecrDev_1987	-0.324	(-4,4)	0.253	-0.78		4
38	Main_RecrDev_1988	-0.372	(-4,4)	0.244	-0.66		4
39	Main_RecrDev_1989	-0.290	(-4,4)	0.230	-0.79		4
40	Main_RecrDev_1990	-0.107	(-4,4)	0.199	-1.86		4
41	Main_RecrDev_1991	-0.171	(-4,4)	0.185	-1.08		4
42	Main_RecrDev_1992	-0.312	(-4,4)	0.184	-0.59		4
43	Main_RecrDev_1993	-0.626	(-4,4)	0.205	-0.33		4
44	Main_RecrDev_1994	-0.551	(-4,4)	0.192	-0.35		4
45	Main_RecrDev_1995	-0.458	(-4,4)	0.180	-0.39		4
46	Main_RecrDev_1996	-0.288	(-4,4)	0.166	-0.58		4
47	Main_RecrDev_1997	-0.155	(-4,4)	0.158	-1.02		4
48	Main_RecrDev_1998	0.033	(-4,4)	0.150	4.51		4
49	Main_RecrDev_1999	0.079	(-4,4)	0.146	1.85		4
50	Main_RecrDev_2000	-0.057	(-4,4)	0.147	-2.58		4
51	Main_RecrDev_2001	-0.103	(-4,4)	0.146	-1.41		4
52	Main_RecrDev_2002	0.143	(-4,4)	0.134	0.94		4
53	Main_RecrDev_2003	0.470	(-4,4)	0.125	0.27		4
54	Main_RecrDev_2004	0.043	(-4,4)	0.136	3.18		4
55	Main_RecrDev_2005	0.935	(-4,4)	0.122	0.13		4
56	Main_RecrDev_2006	0.441	(-4,4)	0.118	0.27		4
57	Main_RecrDev_2007	0.236	(-4,4)	0.118	0.50		4
58	Main_RecrDev_2008	-0.369	(-4,4)	0.134	-0.36		4
59	Main_RecrDev_2009	-1.173	(-4,4)	0.174	-0.15		4
60	Main_RecrDev_2010	-0.415	(-4,4)	0.140	-0.34		4
61	Main_RecrDev_2011	0.412	(-4,4)	0.112	0.27		4
62	Main_RecrDev_2012	0.336	(-4,4)	0.116	0.35		4
63	Main_RecrDev_2013	0.371	(-4,4)	0.122	0.33		4
64	Main_RecrDev_2014	0.654	(-4,4)	0.120	0.18		4
65	Main_RecrDev_2015	0.939	(-4,4)	0.123	0.13		4
66	Main_RecrDev_2016	0.615	(-4,4)	0.145	0.24		4
67	Main_RecrDev_2017	0.487	(-4,4)	0.165	0.34		4
68	Main_RecrDev_2018	0.688	(-4,4)	0.181	0.26		4
69	Main_RecrDev_2019	0.442	(-4,4)	0.229	0.52		4
70	Main_RecrDev_2020	0.996	(-4,4)	0.174	0.17		4
71	Main_RecrDev_2021	0.969	(-4,4)	0.334	0.34		4
72	Main_RecrDev_2022	0.591	(-4,4)	0.325	0.55		4
73	Late_RecrDev_2023	0.000					Fixed
74	InitF_seas_1_flt_1COM_LL	0.035	(0.0001,0.3)	0.046	1.29	Sym_Beta (0.01, 0.5)	1
75	InitF_seas_1_flt_2COM_OTHER	0.033	(0.001,0.3)	0.040	1.22	Sym_Beta (0.05, 0.5)	1
76	InitF_seas_1_flt_3REC_E	0.341	(0.05,0.6)	0.188	0.55	Sym_Beta (0.10, 0.5)	1
77	InitF_seas_1_flt_4REC_W	0.118	(0.05,0.4)	0.080	0.67	Sym_Beta (0.10, 0.5)	1
78	F_fleet_3_YR_1981_s_1	0.350	(0,3)	0.208	0.59		3
79	F_fleet_3_YR_1982_s_1	0.117	(0,3)	0.072	0.61		3
80	F_fleet_3_YR_1983_s_1	0.104	(0,3)	0.073	0.70		3
81	F_fleet_3_YR_1984_s_1	0.072	(0,3)	0.032	0.45		3
82	F_fleet_3_YR_1985_s_1	0.103	(0,3)	0.044	0.43		3

83	F_fleet_3_YR_1986_s_1	0.075	(0,3)	0.022	0.30	3
84	F_fleet_3_YR_1987_s_1	0.197	(0,3)	0.090	0.45	3
85	F_fleet_3_YR_1988_s_1	0.077	(0,3)	0.025	0.33	3
86	F_fleet_3_YR_1989_s_1	0.076	(0,3)	0.026	0.35	3
87	F_fleet_3_YR_1990_s_1	0.058	(0,3)	0.017	0.29	3
88	F_fleet_3_YR_1991_s_1	0.062	(0,3)	0.018	0.30	3
89	F_fleet_3_YR_1992_s_1	0.233	(0,3)	0.076	0.32	3
90	F_fleet_3_YR_1993_s_1	0.298	(0,3)	0.058	0.20	3
91	F_fleet_3_YR_1994_s_1	0.195	(0,3)	0.041	0.21	3
92	F_fleet_3_YR_1995_s_1	0.143	(0,3)	0.038	0.27	3
93	F_fleet_3_YR_1996_s_1	0.102	(0,3)	0.026	0.26	3
94	F_fleet_3_YR_1997_s_1	0.123	(0,3)	0.027	0.22	3
95	F_fleet_3_YR_1998_s_1	0.235	(0,3)	0.061	0.26	3
96	F_fleet_3_YR_1999_s_1	0.154	(0,3)	0.036	0.23	3
97	F_fleet_3_YR_2000_s_1	0.195	(0,3)	0.047	0.24	3
98	F_fleet_3_YR_2001_s_1	0.113	(0,3)	0.025	0.22	3
99	F_fleet_3_YR_2002_s_1	0.259	(0,3)	0.048	0.19	3
100	F_fleet_3_YR_2003_s_1	0.156	(0,3)	0.029	0.19	3
101	F_fleet_3_YR_2004_s_1	0.168	(0,3)	0.042	0.25	3
102	F_fleet_3_YR_2005_s_1	0.197	(0,3)	0.042	0.21	3
103	F_fleet_3_YR_2006_s_1	0.192	(0,3)	0.041	0.21	3
104	F_fleet_3_YR_2007_s_1	0.189	(0,3)	0.034	0.18	3
105	F_fleet_3_YR_2008_s_1	0.700	(0,3)	0.163	0.23	3
106	F_fleet_3_YR_2009_s_1	0.212	(0,3)	0.036	0.17	3
107	F_fleet_3_YR_2010_s_1	0.147	(0,3)	0.027	0.18	3
108	F_fleet_3_YR_2011_s_1	0.057	(0,3)	0.013	0.22	3
109	F_fleet_3_YR_2012_s_1	0.169	(0,3)	0.042	0.25	3
110	F_fleet_3_YR_2013_s_1	0.212	(0,3)	0.058	0.28	3
111	F_fleet_3_YR_2014_s_1	0.231	(0,3)	0.050	0.21	3
112	F_fleet_3_YR_2015_s_1	0.242	(0,3)	0.046	0.19	3
113	F_fleet_3_YR_2016_s_1	0.258	(0,3)	0.061	0.24	3
114	F_fleet_3_YR_2017_s_1	0.328	(0,3)	0.093	0.28	3
115	F_fleet_3_YR_2018_s_1	0.170	(0,3)	0.043	0.25	3
116	F_fleet_3_YR_2019_s_1	0.146	(0,3)	0.038	0.26	3
117	F_fleet_3_YR_2020_s_1	0.105	(0,3)	0.024	0.23	3
118	F_fleet_3_YR_2021_s_1	0.188	(0,3)	0.032	0.17	3
119	F_fleet_3_YR_2022_s_1	0.183	(0,3)	0.036	0.20	3
120	F_fleet_3_YR_2023_s_1	0.153	(0,3)	0.029	0.19	3
121	F_fleet_4_YR_1981_s_1	0.025	(0,3)	0.020	0.80	3
122	F_fleet_4_YR_1982_s_1	0.038	(0,3)	0.019	0.51	3
123	F_fleet_4_YR_1983_s_1	0.073	(0,3)	0.047	0.65	3
124	F_fleet_4_YR_1984_s_1	0.178	(0,3)	0.076	0.43	3
125	F_fleet_4_YR_1985_s_1	0.044	(0,3)	0.021	0.47	3
126	F_fleet_4_YR_1986_s_1	0.019	(0,3)	0.011	0.59	3
127	F_fleet_4_YR_1987_s_1	0.099	(0,3)	0.041	0.42	3
128	F_fleet_4_YR_1988_s_1	0.141	(0,3)	0.059	0.42	3
129	F_fleet_4_YR_1989_s_1	0.033	(0,3)	0.019	0.58	3
130	F_fleet_4_YR_1990_s_1	0.071	(0,3)	0.030	0.43	3
131	F_fleet_4_YR_1991_s_1	0.223	(0,3)	0.082	0.37	3
132	F_fleet_4_YR_1992_s_1	0.095	(0,3)	0.032	0.34	3

133	F_fleet_4_YR_1993_s_1	0.186	(0,3)	0.053	0.29	3
134	F_fleet_4_YR_1994_s_1	0.074	(0,3)	0.016	0.22	3
135	F_fleet_4_YR_1995_s_1	0.109	(0,3)	0.037	0.34	3
136	F_fleet_4_YR_1996_s_1	0.075	(0,3)	0.023	0.30	3
137	F_fleet_4_YR_1997_s_1	0.086	(0,3)	0.026	0.30	3
138	F_fleet_4_YR_1998_s_1	0.104	(0,3)	0.032	0.31	3
139	F_fleet_4_YR_1999_s_1	0.066	(0,3)	0.023	0.34	3
140	F_fleet_4_YR_2000_s_1	0.016	(0,3)	0.005	0.33	3
141	F_fleet_4_YR_2001_s_1	0.013	(0,3)	0.004	0.33	3
142	F_fleet_4_YR_2002_s_1	0.023	(0,3)	0.007	0.31	3
143	F_fleet_4_YR_2003_s_1	0.064	(0,3)	0.019	0.30	3
144	F_fleet_4_YR_2004_s_1	0.019	(0,3)	0.004	0.24	3
145	F_fleet_4_YR_2005_s_1	0.025	(0,3)	0.008	0.33	3
146	F_fleet_4_YR_2006_s_1	0.141	(0,3)	0.068	0.48	3
147	F_fleet_4_YR_2007_s_1	0.095	(0,3)	0.030	0.31	3
148	F_fleet_4_YR_2008_s_1	0.074	(0,3)	0.019	0.25	3
149	F_fleet_4_YR_2009_s_1	0.031	(0,3)	0.009	0.28	3
150	F_fleet_4_YR_2010_s_1	0.016	(0,3)	0.005	0.30	3
151	F_fleet_4_YR_2011_s_1	0.016	(0,3)	0.004	0.23	3
152	F_fleet_4_YR_2012_s_1	0.046	(0,3)	0.016	0.36	3
153	F_fleet_4_YR_2013_s_1	0.077	(0,3)	0.021	0.28	3
154	F_fleet_4_YR_2014_s_1	0.088	(0,3)	0.027	0.31	3
155	F_fleet_4_YR_2015_s_1	0.059	(0,3)	0.016	0.27	3
156	F_fleet_4_YR_2016_s_1	0.063	(0,3)	0.017	0.26	3
157	F_fleet_4_YR_2017_s_1	0.032	(0,3)	0.009	0.29	3
158	F_fleet_4_YR_2018_s_1	0.038	(0,3)	0.010	0.25	3
159	F_fleet_4_YR_2019_s_1	0.047	(0,3)	0.013	0.27	3
160	F_fleet_4_YR_2020_s_1	0.087	(0,3)	0.025	0.29	3
161	F_fleet_4_YR_2021_s_1	0.049	(0,3)	0.009	0.18	3
162	F_fleet_4_YR_2022_s_1	0.051	(0,3)	0.011	0.21	3
163	F_fleet_4_YR_2023_s_1	0.052	(0,3)	0.012	0.23	3
164	LnQ_base_COM_LL(1)	-7.882	(-18,5)			Float
165	LnQ_base_RVC_DT(5)	-7.335	(-18,5)			Float
166	LnQ_base_RVC_KEYS(6)	-7.548	(-18,5)			Float
167	LnQ_base_RVC_SEFL(7)	-8.049	(-18,5)			Float
168	LnQ_base_FIM_YOY(8)	-7.455	(-18,5)			Float
169	LnQ_base_GOM_VID(9)	-7.068	(-15,5)	0.206	-0.03	3
170	LnQ_base_SERFS_VID(10)	-7.883	(-18,5)			Float
171	LnQ_base_GOM_VID(9)_BLK3mult_2016	0.110	(-2,2)	0.017	0.16	4
172	LnQ_base_GOM_VID(9)_BLK3mult_2020	0.257	(-2,2)	0.018	0.07	4
173	Size_inflection_COM_LL(1)	61.289	(50,90)	1.521	0.02	1
174	Size_95%width_COM_LL(1)	16.007	(1,40)	1.379	0.09	2
175	Size_inflection_COM_OTHER(2)	35.923	(8,70)	0.981	0.03	1
176	Size_95%width_COM_OTHER(2)	10.484	(-2,66)	2.060	0.20	2
177	Retain_L_infl_COM_OTHER(2)	10.000				Fixed
178	Retain_L_width_COM_OTHER(2)	1.000				Fixed
179	Retain_L_asymptote_logit_COM_OTHER(2)	9.000				Fixed
180	Retain_L_maleoffset_COM_OTHER(2)	0.000				Fixed
181	DiscMort_L_infl_COM_OTHER(2)	1.000				Fixed

182	DiscMort_L_width_COM_OTHER(2)	1.0E+06				Fixed
183	DiscMort_L_level_old_COM_OTHER(2)	-0.400				Fixed
184	DiscMort_L_male_offset_COM_OTHER(2)	0.000				Fixed
185	Size_DblN_peak_REC_E(3)	34.041	(28,45)	0.029	0.00	3
186	Size_DblN_top_logit_REC_E(3)	-5.682	(-18,3)	8.201	-1.44	3
187	Size_DblN_ascend_se_REC_E(3)	-10.018	(-40,20)	670.817	-66.96	3
188	Size_DblN_descend_se_REC_E(3)	5.358	(-2,10)	0.195	0.04	3
189	Size_DblN_start_logit_REC_E(3)	-0.720	(-20,15)	0.252	-0.35	3
190	Size_DblN_end_logit_REC_E(3)	-3.057	(-15,5)	0.244	-0.08	3
191	Retain_L_infl_REC_E(3)	33.232	(10,50)	1.617	0.05	2
192	Retain_L_width_REC_E(3)	5.748	(0,30)	1.346	0.23	2
193	Retain_L_asymptote_logit_REC_E(3)	7.000				Fixed
194	Retain_L_maleoffset_REC_E(3)	0.000				Fixed
195	DiscMort_L_infl_REC_E(3)	1.000				Fixed
196	DiscMort_L_width_REC_E(3)	1.0E+06				Fixed
197	DiscMort_L_level_old_REC_E(3)	-0.400				Fixed
198	DiscMort_L_male_offset_REC_E(3)	0.000				Fixed
199	Size_DblN_peak_REC_W(4)	30.012	(20,42)	0.041	0.00	3
200	Size_DblN_top_logit_REC_W(4)	-16.361	(-35,3)	368.832	-22.54	3
201	Size_DblN_ascend_se_REC_W(4)	-10.975	(-18,5)	42.376	-3.86	3
202	Size_DblN_descend_se_REC_W(4)	8.058	(-20,20)	0.569	0.07	3
203	Size_DblN_start_logit_REC_W(4)	-0.508	(-15,5)	0.473	-0.93	3
204	Size_DblN_end_logit_REC_W(4)	-5.355	(-15,10)	18.758	-3.50	3
205	Retain_L_infl_REC_W(4)	37.342	(15,60)	1.135	0.03	2
206	Retain_L_width_REC_W(4)	4.285	(0.1,20)	0.807	0.19	2
207	Retain_L_asymptote_logit_REC_W(4)	9.000				Fixed
208	Retain_L_maleoffset_REC_W(4)	0.000				Fixed
209	DiscMort_L_infl_REC_W(4)	1.000				Fixed
210	DiscMort_L_width_REC_W(4)	1.0E+06				Fixed
211	DiscMort_L_level_old_REC_W(4)	-0.400				Fixed
212	DiscMort_L_male_offset_REC_W(4)	0.000				Fixed
213	Size_DblN_peak_RVC_DT(5)	56.074	(5,94)	4.081	0.07	2
214	Size_DblN_top_logit_RVC_DT(5)	-2.252	(-12,25)	3.104	-1.38	3
215	Size_DblN_ascend_se_RVC_DT(5)	5.114	(-10,10)	0.565	0.11	3
216	Size_DblN_descend_se_RVC_DT(5)	4.755	(-20,35)	2.152	0.45	3
217	Size_DblN_start_logit_RVC_DT(5)	-2.818	(-15,5)	0.813	-0.29	3
218	Size_DblN_end_logit_RVC_DT(5)	-1.372	(-35,20)	1.372	-1.00	4
219	Size_DblN_peak_RVC_KEYS(6)	34.122	(17,55)	0.469	0.01	2
220	Size_DblN_top_logit_RVC_KEYS(6)	-15.047	(-30,0)	327.702	-21.78	2
221	Size_DblN_ascend_se_RVC_KEYS(6)	-6.273	(-20,30)	58.214	-9.28	3
222	Size_DblN_descend_se_RVC_KEYS(6)	6.743	(-10,30)	0.808	0.12	3
223	Size_DblN_start_logit_RVC_KEYS(6)	0.168	(-15,20)	0.719	4.27	3
224	Size_DblN_end_logit_RVC_KEYS(6)	-2.144	(-15,10)	2.544	-1.19	4
225	Size_inflection_RVC_SEFL(7)	54.284	(15,70)	2.334	0.04	1
226	Size_95%width_RVC_SEFL(7)	-9.323	(-25,5)	2.966	-0.32	2

227	Size_inflection_GOM_VID(9)	44.499	(0,95)	3.980	0.09	4
228	Size_95%width_GOM_VID(9)	18.494	(-2,60)	5.945	0.32	4
229	minage@sel=1_SERFS_VID(10)	3.000				Fixed
230	maxage@sel=1_SERFS_VID(10)	40.000				Fixed
231	Retain_L_infl_COM_OTHER(2)_BLK1add_1992	28.077	(10,45)	0.675	0.02	3
232	Retain_L_infl_COM_OTHER(2)_BLK1add_2018	39.178	(25,50)	1.651	0.04	3
233	Retain_L_width_COM_OTHER(2)_BLK1add_1992	1.584	(-5,15)	0.459	0.29	3
234	Retain_L_width_COM_OTHER(2)_BLK1add_2018	1.935	(-5,6)	0.880	0.45	3
235	Retain_L_infl_REC_E(3)_BLK2mult_1995	0.201	(-1,4)	0.049	0.24	3
236	Retain_L_infl_REC_E(3)_BLK2mult_2018	0.384	(-2,5)	0.056	0.14	3
237	Retain_L_width_REC_E(3)_BLK2mult_1995	-1.418	(-4,3)	0.254	-0.18	3
238	Retain_L_width_REC_E(3)_BLK2mult_2018	-0.645	(-3,2)	0.301	-0.47	3
239	Retain_L_infl_REC_W(4)_BLK2mult_1995	0.118	(-1,1)	0.031	0.26	3
240	Retain_L_infl_REC_W(4)_BLK2mult_2018	0.207	(-1,1)	0.033	0.16	3
241	Retain_L_width_REC_W(4)_BLK2mult_1995	-0.750	(-2.5,2)	0.217	-0.29	3
242	Retain_L_width_REC_W(4)_BLK2mult_2018	-0.699	(-3,2)	0.277	-0.40	3

Table 13. An overview of configuration settings for SEDAR 15AU Final Model (S15AU) and each model bridging exercise

	SEDAR 15AU base	**Model Bridging Exercises**		
		Mean weights	Mean weights plus landings	Mean weights, landings, plus indices
Years	1981 - 2013			
Fleets	Com H&L, Com LL, MRFSS, Headboat	Com H&L, Com LL, MRFSS, Headboat	Com H&L, Com LL, Rec East, Rec West	Com H&L, Com LL, Rec East, Rec West
Indices	Logbook HL, Logbook LL, Headboat, MRFSS, FIM YOY, NMFS-UM RVC, Riley Hump	Logbook HL, Logbook LL, Headboat, MRFSS, FIM YOY, NMFS-UM RVC, Riley Hump	Logbook HL, Logbook LL, Headboat, MRFSS, FIM YOY, NMFS-UM RVC, Riley Hump	Logbook LL, FIM YOY, NMFS-UM RVC
# of Mean Weight-at-age Matrices	1 for fleets, 1 for SSB, 1 for Jan 1	10 for fleets (based on SEDAR 79 Data), 1 for SSB, 1 for Jan 1	10 for fleets (based on SEDAR 79 Data), 1 for SSB, 1 for Jan 1	10 for fleets (based on SEDAR 79 Data), 1 for SSB, 1 for Jan 1
Time-varying Mean Weight-at-age?	No	Yes, for fleets. Constant WAA for SSB and Jan 1	Yes, for fleets. Constant WAA for SSB and Jan 1	Yes, for fleets. Constant WAA for SSB and Jan 1

Table 14. Settings used for Southeastern U.S. Mutton Snapper projections based on the SEDAR 79 Base Model.

Parameter	Value	Comment
Relative F Average	Average from 2021-2023	Average relative fishing mortality (apical F) over terminal three years of model
Selectivity	Average from 2021-2023	Fleet specific selectivity over terminal three years of model estimated
Recruitment		
Long Term Projections	Beverton-Holt stock-recruit relationship	Derived from the model estimated Beverton-Holt stock-recruit relationship
Short Term Projections	2024 to 2033: Average from 2019 - 2023	Recent Average
Allocation Ratio	None	

Table 15. Annual estimates of instantaneous apical fishing mortality rates by fleet, as well as estimates of annual instantaneous fishing mortality rates on age-3 Southeastern U.S. Mutton Snapper combined across all fleets for the SEDAR 79 Base Model. Apical fishing mortality rates represent the instantaneous fishing mortality level on the most vulnerable age class for each fleet.

Year	Commercial Longline	Commercial Other	Rec West	Rec East	Age 3 Total F
Equil Catch	0.04	0.03	0.12	0.34	
1981	0.01	0.02	0.02	0.35	0.26
1982	0.01	0.02	0.04	0.12	0.12
1983	0.01	0.02	0.07	0.10	0.13
1984	0.01	0.02	0.18	0.07	0.19
1985	0.01	0.01	0.04	0.10	0.11
1986	0.01	0.02	0.02	0.07	0.08
1987	0.02	0.03	0.10	0.20	0.22
1988	0.02	0.03	0.14	0.08	0.17
1989	0.02	0.03	0.03	0.08	0.10
1990	0.02	0.03	0.07	0.06	0.11
1991	0.02	0.03	0.22	0.06	0.22
1992	0.01	0.03	0.10	0.23	0.24
1993	0.01	0.04	0.19	0.30	0.35
1994	0.01	0.04	0.07	0.20	0.20

1995	0.01	0.03	0.11	0.14	0.16
1996	0.01	0.03	0.08	0.10	0.12
1997	0.01	0.03	0.09	0.12	0.13
1998	0.02	0.04	0.10	0.24	0.21
1999	0.01	0.02	0.07	0.15	0.14
2000	0.01	0.02	0.02	0.19	0.12
2001	0.02	0.02	0.01	0.11	0.08
2002	0.01	0.02	0.02	0.26	0.16
2003	0.02	0.02	0.06	0.16	0.13
2004	0.03	0.02	0.02	0.17	0.11
2005	0.02	0.01	0.03	0.20	0.13
2006	0.03	0.01	0.14	0.19	0.19
2007	0.02	0.01	0.10	0.19	0.16
2008	0.01	0.01	0.07	0.70	0.41
2009	0.00	0.01	0.03	0.21	0.13
2010	0.00	0.01	0.02	0.15	0.09
2011	0.01	0.01	0.02	0.06	0.04
2012	0.01	0.01	0.05	0.17	0.12
2013	0.01	0.01	0.08	0.21	0.16
2014	0.01	0.01	0.09	0.23	0.18
2015	0.01	0.01	0.06	0.24	0.17
2016	0.01	0.01	0.06	0.26	0.18
2017	0.01	0.01	0.03	0.33	0.19
2018	0.01	0.01	0.04	0.17	0.07
2019	0.00	0.01	0.05	0.15	0.07
2020	0.00	0.00	0.09	0.11	0.07
2021	0.00	0.00	0.05	0.19	0.08
2022	0.00	0.00	0.05	0.18	0.08
2023	0.00	0.00	0.05	0.15	0.07

Table 16. Predicted total biomass (metric tons, pounds), spawning stock biomass (SSB; metric tons, pounds), abundance (1000s of fish), age-1 recruits (1000s of fish), and depletion (SSB/SSB0) for Southeastern U.S. Mutton Snapper from the SEDAR 79 Base Model. Virgin is the estimated unfished condition while Initial is the estimated initial conditions of the stock before the model start year.

Year	Total Biomass (mt)	Total Biomass (lbs.)	SSB (mt)	SSB (lbs.)	Abundance (000s)	Age-1 Recruits (000s)	SSB/ SSB0
Virgin	38,589	85,074,081	17,778	39,194,175	14,371	2,513	1.00
Initial	6,942	15,303,656	2,377	5,241,330	7,160	2,513	0.13
1981	5,794	12,773,370	2,199	4,848,643	4,486	908	0.12
1982	5,786	12,755,821	2,423	5,342,676	3,714	646	0.14
1983	6,092	13,430,038	2,579	5,686,156	3,860	1,080	0.15
1984	6,038	13,310,988	2,558	5,639,683	3,427	568	0.14
1985	5,771	12,722,708	2,489	5,486,814	3,188	746	0.14
1986	5,930	13,072,934	2,543	5,606,922	3,529	1,107	0.14
1987	6,068	13,377,237	2,485	5,478,833	3,825	1,126	0.14
1988	5,729	12,630,334	2,323	5,122,192	3,548	855	0.13
1989	5,477	12,074,549	2,269	5,001,247	3,321	786	0.13
1990	5,518	12,164,652	2,301	5,071,794	3,338	842	0.13
1991	5,541	12,215,601	2,219	4,891,633	3,505	1,018	0.12
1992	5,085	11,209,457	2,054	4,527,364	3,345	937	0.12
1993	4,846	10,683,236	1,900	4,188,844	3,109	778	0.11
1994	4,278	9,431,563	1,757	3,874,201	2,560	543	0.10
1995	4,125	9,093,264	1,710	3,770,782	2,380	558	0.10
1996	3,979	8,771,389	1,672	3,685,662	2,331	602	0.09
1997	3,947	8,702,583	1,634	3,602,503	2,440	704	0.09
1998	3,906	8,611,290	1,565	3,449,172	2,589	792	0.09
1999	3,784	8,341,951	1,502	3,312,177	2,763	930	0.08
2000	3,859	8,507,210	1,524	3,359,202	2,980	948	0.09
2001	4,036	8,896,810	1,607	3,541,722	3,051	836	0.09
2002	4,313	9,509,496	1,719	3,790,822	3,144	825	0.10
2003	4,511	9,945,173	1,796	3,959,013	3,396	1,102	0.10
2004	4,779	10,536,518	1,860	4,100,152	4,066	1,570	0.10
2005	4,980	10,978,611	1,947	4,293,211	4,069	1,046	0.11
2006	5,733	12,639,946	2,028	4,470,595	5,641	2,625	0.11
2007	5,731	12,635,515	2,101	4,631,973	5,614	1,640	0.12
2008	6,092	13,429,884	2,149	4,737,993	5,405	1,364	0.12
2009	5,651	12,459,300	2,260	4,982,265	4,164	754	0.13
2010	5,863	12,925,246	2,522	5,559,743	3,432	347	0.14

2011	6,241	13,758,570	2,774	6,116,586	3,430	787	0.16
2012	6,839	15,076,492	2,907	6,409,756	4,602	1,891	0.16
2013	7,034	15,507,716	2,846	6,274,966	5,248	1,793	0.16
2014	7,236	15,951,572	2,780	6,127,962	5,685	1,839	0.16
2015	7,570	16,689,877	2,855	6,293,683	6,507	2,410	0.16
2016	8,199	18,076,054	2,998	6,609,517	7,956	3,249	0.17
2017	8,624	19,012,356	3,169	6,987,455	8,126	2,406	0.18
2018	9,199	20,281,291	3,480	7,671,284	7,981	2,176	0.20
2019	10,325	22,762,481	4,028	8,879,790	8,792	2,777	0.23
2020	11,294	24,898,317	4,527	9,979,962	8,977	2,330	0.25
2021	12,688	27,972,659	4,944	10,898,539	11,057	4,300	0.28
2022	13,965	30,786,857	5,410	11,925,958	12,659	4,382	0.30
2023	15,132	33,359,869	5,898	13,002,562	12,611	3,138	0.33

Table 17. Geweke's diagnostic used to determine convergence of a single MCMC chain of selected parameters and derived quantities for the SEDAR 79 Base Model.

Parameter/Derived Quantity	Z-Score	p-value
Recr_Virgin	-0.7905	0.42926
SSB_Virgin	-0.9202	0.35746
SR_BH_steep	-0.1614	0.87176
SR_sigmaR	0.98357	0.32533
F_2021	1.27813	0.2012
F_2022	1.63342	0.10238
F_2023	0.82382	0.41004
SSB_2021	-0.3299	0.74145
SSB_2022	-0.3605	0.7185
SSB_2023	-0.5318	0.59488
F30%SPR	0.68777	0.4916
SSB_30%SPR	-0.9318	0.35145
Ret_Catch_F30%SPR	-0.6592	0.50977
SPRratio_2023	0.8731	0.38261

Table 18. Summary of correlated parameters with correlation coefficients exceeding 0.7 for the SEDAR 79 Base Model.

Parameter 1	Parameter 2	Correlation
Retain_L_infl_REC_E(3)_BLK2mult_1995	Retain_L_infl_REC_E(3)	-0.99
Retain_L_infl_REC_W(4)_BLK2mult_1995	Retain_L_infl_REC_W(4)	-0.95
Retain_L_width_REC_E(3)_BLK2mult_1995	Retain_L_width_REC_E(3)	-0.92
Size_DblN_ascend_se_RVC_DT(5)	Size_DblN_peak_RVC_DT(5)	0.91
Size_DblN_end_logit_RVC_KEYS(6)	Size_DblN_descend_se_RVC_KEYS(6)	-0.90
Size_DblN_descend_se_REC_E(3)	Size_DblN_top_logit_REC_E(3)	-0.89
Retain_L_infl_REC_W(4)_BLK2mult_2018	Retain_L_infl_REC_W(4)	-0.89
Retain_L_infl_REC_E(3)_BLK2mult_2018	Retain_L_infl_REC_E(3)	-0.89
Retain_L_infl_REC_E(3)_BLK2mult_2018	Retain_L_infl_REC_E(3)_BLK2mult_1995	0.88
Retain_L_width_REC_W(4)_BLK2mult_1995	Retain_L_width_REC_W(4)	-0.87
Retain_L_infl_REC_W(4)_BLK2mult_2018	Retain_L_infl_REC_W(4)_BLK2mult_1995	0.86
Size_95%width_COM_LL(1)	Size_inflection_COM_LL(1)	0.83
Size_DblN_end_logit_REC_W(4)	Size_DblN_descend_se_REC_W(4)	-0.82
VonBert_K_Fem_GP_1	L_at_Amax_Fem_GP_1	-0.82
Size_DblN_descend_se_RVC_DT(5)	Size_DblN_top_logit_RVC_DT(5)	-0.82
Retain_L_width_COM_OTHER(2)_BLK1add_2018	Retain_L_infl_COM_OTHER(2)_BLK1add_2018	0.81
Size_DblN_end_logit_RVC_DT(5)	Size_DblN_descend_se_RVC_DT(5)	-0.80
Size_95%width_GOM_VID(9)	Size_inflection_GOM_VID(9)	0.77
Retain_L_width_REC_E(3)_BLK2mult_2018	Retain_L_width_REC_E(3)	-0.76
Size_inflection_GOM_VID(9)	LnQ_base_GOM_VID(9)	0.76
SR_BH_steep	SR_LN(R0)	-0.72
Retain_L_width_REC_E(3)_BLK2mult_2018	Retain_L_width_REC_E(3)_BLK2mult_1995	0.71
CV_young_Fem_GP_1	L_at_Amin_Fem_GP_1	-0.70

Table 19. Joint residual summary statistics for the SEDAR 79 Base Model. N = number of observations to compute each statistic. RMSE = root mean squared error (as a percentage) associated with each data source and for each model component.

Model Component	Data Source	RMSE (%)	N
Indices of Abundance	COM_LL	38.3	18
	FIM_YOY	74	24
	GOM_VID	34.5	20
	RVC_DT	30.4	12
	RVC_KEYS	20.8	18
	RVC_SEFL	35	7
	SERFS_VID	84.9	11
	Combined	51.2	110
Mean Length (4 cm bins)	COM_LL	3.2	31
	COM_OTHER	5.2	34
	GOM_VID	1.9	1
	REC_E	3.5	42
	REC_W	3.7	42
	Combined	4	150
Mean Length (5 cm bins)	RVC_DT	6.8	12
	RVC_KEYS	11.2	19
	RVC_SEFL	7	7
	Combined	9.3	38
Mean Conditional Age-at-Length	COM_LL	6.3	21
	COM_OTHER	7.6	31
	FI_AGE	11.3	7
	REC_E	9	28
	REC_W	8.3	22
	Combined	8.2	109

Table 20. Retrospective analysis and retrospective forecast spawning stock biomass (SSB) and age-3 fishing mortality (F) for the last seven terminal years and combined (grey rows) for the SEDAR 79 Base Model. The rule of thumb of the acceptable range of Mohn's Rho values is -0.15 to 0.20 for longer-lived species (Hurtado-Ferro et al. 2015).

Type	Peel	Mohn's Rho	Forcast Mohn's Rho
SSB	2022	0.03	0.04
SSB	2021	0.13	0.17
SSB	2020	0.13	0.11
SSB	2019	0.07	0.12
SSB	2018	0.11	0.06
SSB	2017	0.22	0.21
SSB	2016	0.14	0.20
SSB	Combined	0.12	0.13
F	2022	0.05	-0.26
F	2021	-0.05	-0.30
F	2020	0.20	-0.06
F	2019	0.01	-0.45
F	2018	0.06	-0.20
F	2017	-0.03	0.82
F	2016	-0.09	-0.75
F	Combined	0.02	-0.17

Table 21. Index root mean square error (RMSE %) values from the SEDAR 79 Base Model, the age-structured production model (ASPM), and the ASPM with estimated recruitment deviations (ASPMdev).

Index	Base Model	ASPM	ASPMdev
Commercial LL CPUE	38.3	52.7	33.3
FIM YOY	74	58.4	70.6
Gulf Video	34.5	33.4	34.7
RVC Dry Tortugas	30.4	46.2	33.0
RVC FL Keys	20.8	30.6	19.2
RVC SE FL	35	60.3	36.5
SERFS Video	84.9	103	85.8
Combined	51.2	55.6	49.9

Table 22. Hindcast cross-validation summary statistics for the SEDAR 79 Base Model. N = number of observations to compute each statistic. MASE = mean absolute scaled error, with values < 1 (in green) indicative of superior prediction skill over a naïve baseline forecast (random walk) and values > 1 (in red) indicative of poor prediction skill. Model MAE = mean absolute error of model prediction residuals. Naïve MAE = mean absolute error of naïve predictions.

Model Component	Data Source	MASE	Model MAE	Naive MAE	N
Index of Abundance	RVC_DT	0.47	0.22	0.48	4
	RVC_KEYS	1.16	0.21	0.18	3
	RVC_SEFL	1.88	0.60	0.32	5
	FIM_YOY	0.54	0.48	0.88	8
	GOM_VID	1.17	0.46	0.39	7
	SERFS_VID	0.74	0.34	0.46	7
	Joint	0.81	0.41	0.50	34
Length Composition	COM_LL	0.66	0.03	0.04	7
	COM_OTHER	2.68	0.05	0.02	8
	REC_E	2.00	0.04	0.02	8
	REC_W	1.52	0.03	0.02	8
	Joint	1.50	0.04	0.02	31
Conditional Age-at-Length	COM_LL	0.64	0.06	0.09	7
	COM_OTHER	0.41	0.04	0.09	8
	REC_E	0.55	0.04	0.07	7
	REC_W	0.68	0.10	0.15	8
	FI_AGE	0.39	0.02	0.06	1
	Joint	0.58	0.06	0.10	31

Table 23. Comparison of the reference points (75% of spawning biomass at $F_{30\%SPR}$ – $75\%SSB_{F30\%SPR}$, fishing mortality rate corresponding to spawning potential ratio of 30% - $F_{30\%SPR}$), the geometric mean of spawning stock biomass from 2011-2013 (SSB-Geo), and the geometric mean of fishing mortality rate on age-3 fish from 2011-2013 (F-Geo) between SEDAR 15AU Final Model and the three model bridging exercises.

Configuration	75% $SSB_{F30\%SPR}$	SSB-Geo	$F_{30\%SPR}$	F-Geo
SEDAR 15AU base	1557	2223	0.18	0.12
Mean weights	1791	1849	0.17	0.16
Mean weights and landings	1611	3655	0.15	0.08
Mean weights, landings, and indices	2087	3597	0.11	0.05

Table 24. The yield-per-recruit (YPR), spawner-per-recruit (SSB/R), static spawning potential ratio (SPR), and total equilibrium yield in metric tons computed over a range of instantaneous fishing mortality rates (F) on age-3 Mutton Snapper.

Age-3 F	YPR	SSB/R	SPR	Total Yield (mt)
0.000	0.000	7.073	1.000	0.72
0.008	0.068	6.550	0.926	167.75
0.017	0.127	6.073	0.858	311.52
0.025	0.180	5.637	0.797	434.56
0.034	0.227	5.239	0.741	539.08
0.042	0.269	4.875	0.689	627.00
0.051	0.306	4.540	0.642	700.01
0.059	0.339	4.233	0.598	759.60
0.067	0.368	3.951	0.558	807.07
0.076	0.393	3.691	0.522	843.57
0.084	0.416	3.452	0.488	870.10
0.093	0.436	3.231	0.457	887.54
0.101	0.454	3.027	0.428	896.70
0.109	0.470	2.838	0.401	898.25
0.118	0.483	2.664	0.377	892.79
0.126	0.495	2.503	0.354	880.88
0.135	0.506	2.353	0.333	862.98
0.143	0.515	2.214	0.313	839.51
0.152	0.523	2.085	0.295	810.84
0.160	0.530	1.965	0.278	777.29
0.168	0.536	1.853	0.262	739.14
0.177	0.541	1.749	0.247	696.66
0.185	0.545	1.652	0.233	650.04
0.194	0.549	1.561	0.221	599.50
0.202	0.552	1.477	0.209	545.19
0.210	0.554	1.398	0.198	487.27
0.219	0.556	1.324	0.187	425.85
0.227	0.557	1.255	0.177	361.04
0.236	0.558	1.191	0.168	292.95
0.244	0.559	1.130	0.160	221.65
0.253	0.559	1.073	0.152	147.20
0.261	0.559	1.020	0.144	69.67
0.269	0.559		0.137	
0.278	0.558		0.130	
0.286	0.557		0.124	
0.295	0.556		0.118	
0.303	0.555		0.113	
0.311	0.554		0.107	
0.320	0.553		0.103	
0.328	0.551		0.098	

Table 25. The stock status determination criterion for Southeastern U.S. Mutton Snapper according to the South Atlantic Fishery Management Council (SAFMC) and the Gulf of Mexico Fishery Management Council (GMFMC). Note: values of MSST and OY are currently undefined for the GMFMC and they default to the definition provided below by the SAFMC.

South Atlantic and Gulf of Mexico Fishery Management Councils

Criteria	Definition	Base Model Value
$F_{30\%SPR}$	The fishing mortality rate associated with 30% SPR and the proxy used for F_{MSY}	0.149 yr^{-1}
$F_{40\%SPR}$	The fishing mortality rate associated with 40% SPR and the proxy used for F_{OY}	0.11 yr^{-1}
MFMT (Maximum Fishing Mortality Threshold)	$F_{30\% SPR}$	0.149 yr^{-1}
F_{OY}	$F_{40\%SPR}$	0.11 yr^{-1}
$F_{current}$ (recent average fishing mortality rate on age-3 fish)	The geometric mean of F on age-3 fish for 2021 - 2023	0.08 yr^{-1}
$SSB_{F30\%SPR}$	The estimated spawning stock biomass associated with F at 30% SPR	3,352 mt (7,389,895 lbs.)
MSST (Minimum Stock Size Threshold)	$0.75*SSB_{F30\%SPR}$	2,514 mt (5,542,421 lbs.)
$SSB_{current}$ (recent average of SSB)	The geometric mean of SSB for 2021 - 2023	5,403 mt (11,911,576 lbs.)
MSY proxy (Maximum Sustainable Yield Proxy)	Yield at $F_{30\%SPR}$	681.87 mt (1,503,266 lbs.)

Table 26. Results of the short- and long-term projections when age-3 fishing mortality rates = $F_{30\%SPR}$ (0.149) for Southeastern US Mutton Snapper. Long-term projections assume predicted recruitment follows the spawner-recruit curve. Short-term projections assume predicted age 1 recruitment is equal to the geometric mean from 2019 to 2023 (3.284 million). Recruitment (Recruits) is in millions of age-1 fish, F is age-3 instantaneous fishing mortality rate, SSB is in metric tons (female SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	Long-Term Projections					Short-Term Projections				
Year	Age 1 Recruits	F	SSB	Retained Yield	Retained Num	Age 1 Recruits	F	SSB	Retained Yield	Retained Num
2024	1.966	0.149	6,488	3,278,980	627,789	3,284	0.149	6,488	3,280,143	628,742
2025	2.026	0.149	6,864	3,372,143	623,832	3,284	0.149	6,867	3,384,760	630,618
2026	2.061	0.149	6,974	3,249,912	564,280	3,284	0.149	7,029	3,363,706	605,530
2027	2.070	0.149	6,821	3,023,751	495,817	3,284	0.149	7,089	3,313,030	583,152
2028	2.057	0.149	6,584	2,814,305	446,663	3,284	0.149	7,118	3,270,355	568,844
2029	2.035	0.149	6,342	2,650,664	415,719	3,284	0.149	7,130	3,239,178	560,244
2030	2.012	0.149	6,109	2,523,697	395,653	3,284	0.149	7,130	3,216,409	554,984
2031	1.989	0.149	5,889	2,421,114	381,362	3,284	0.149	7,123	3,199,290	551,639
2032	1.965	0.149	5,682	2,335,047	370,254	3,284	0.149	7,112	3,186,071	549,426
2033	1.942	0.149	5,490	2,261,068	361,084	3,284	0.149	7,098	3,175,662	547,907

Table 27. Results of the short-term projections when age-3 fishing mortality rates equal 75% $F_{30\%SPR}$ (0.112) and $F_{current}$ (0.08) for Southeastern US Mutton Snapper assuming predicted age 1 recruitment is equal to the geometric mean from 2019 to 2023 (3.284 million). Recruitment (Recruits) is in millions of age-1 fish, F is age-3 instantaneous fishing mortality rate, SSB is in metric tons (female SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	Short-Term Projections - 75% $F_{30\%SPR}$					Short-Term Projections - $F_{current}$				
Year	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2024	3.284	0.112	6,565	2,498,073	479,551	3.284	0.080	6,631	1,811,994	348,293
2025	3.284	0.112	7,160	2,662,320	497,423	3.284	0.080	7,419	1,985,255	371,812
2026	3.284	0.112	7,547	2,725,359	491,431	3.284	0.080	8,022	2,084,741	376,453
2027	3.284	0.112	7,822	2,752,377	483,445	3.284	0.080	8,512	2,151,561	377,279
2028	3.284	0.112	8,047	2,772,615	478,662	3.284	0.080	8,942	2,206,166	378,545
2029	3.284	0.112	8,233	2,791,436	476,385	3.284	0.080	9,319	2,253,469	380,361
2030	3.284	0.112	8,386	2,808,849	475,505	3.284	0.080	9,646	2,294,626	382,360
2031	3.284	0.112	8,513	2,824,461	475,332	3.284	0.080	9,930	2,330,278	384,303
2032	3.284	0.112	8,618	2,838,173	475,501	3.284	0.080	10,177	2,361,052	386,090
2033	3.284	0.112	8,705	2,850,076	475,824	3.284	0.080	10,389	2,387,571	387,685

10. FIGURES

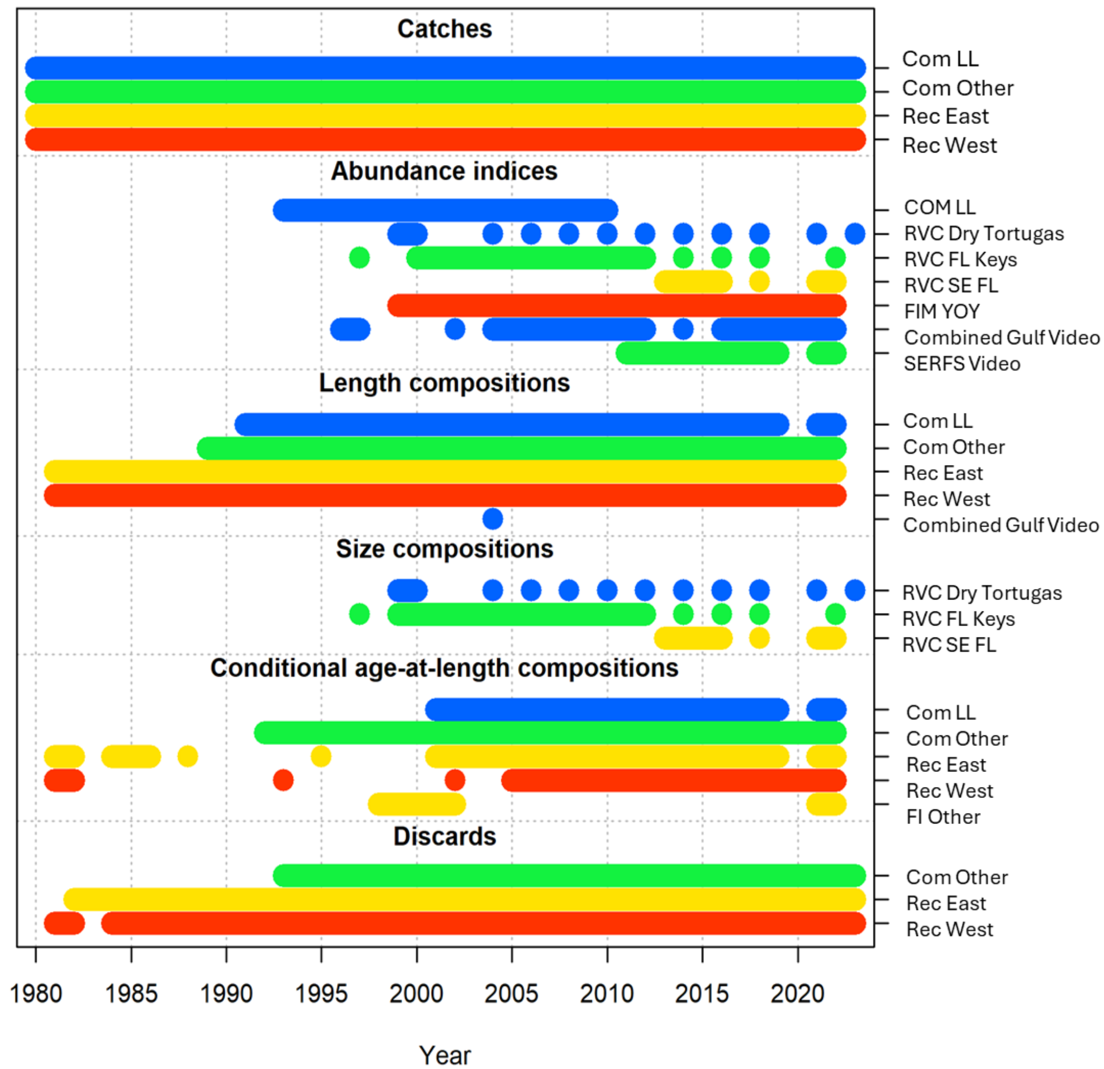


Figure 1. Data sources used in the Southeastern US Mutton Snapper Stock Synthesis assessment model.

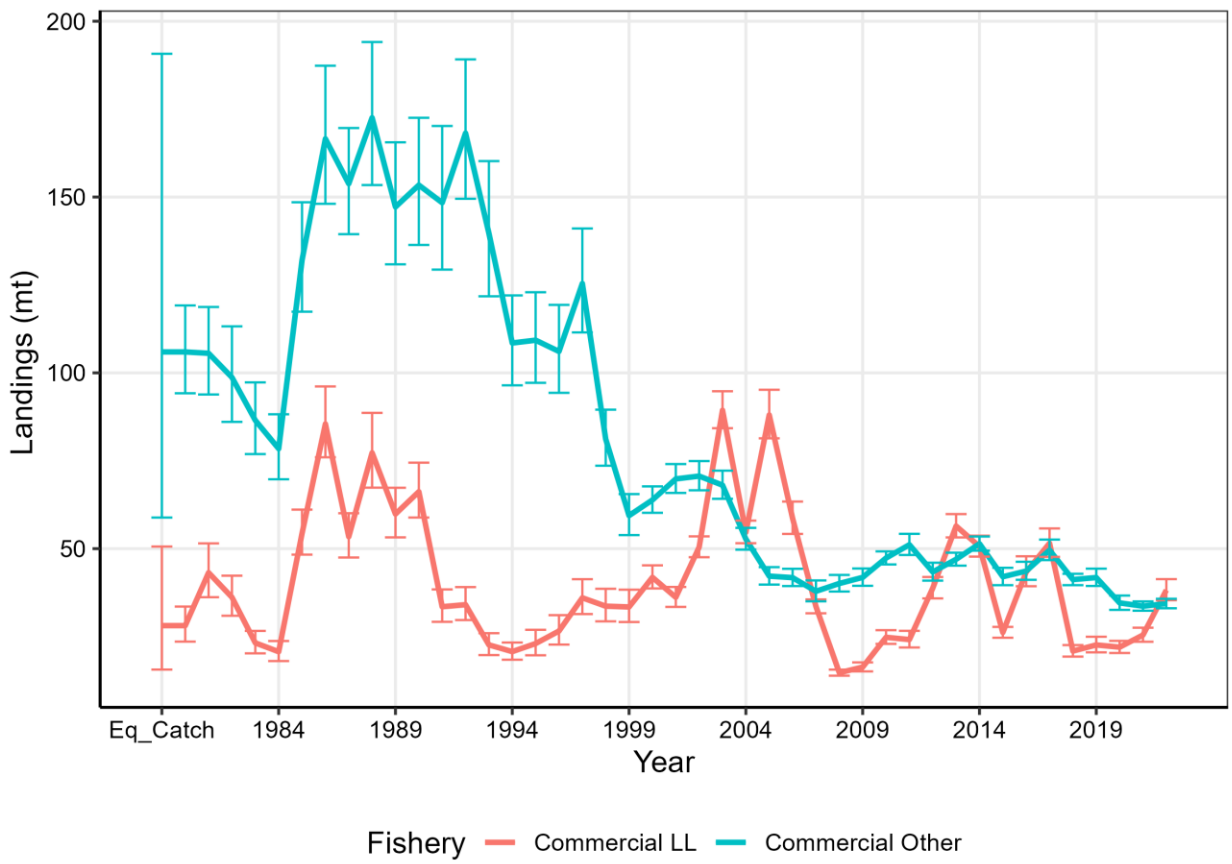


Figure 2. Observed commercial landings in weight (metric tons, mt) for Southeastern US Mutton Snapper and associated uncertainty, 1981-2023.

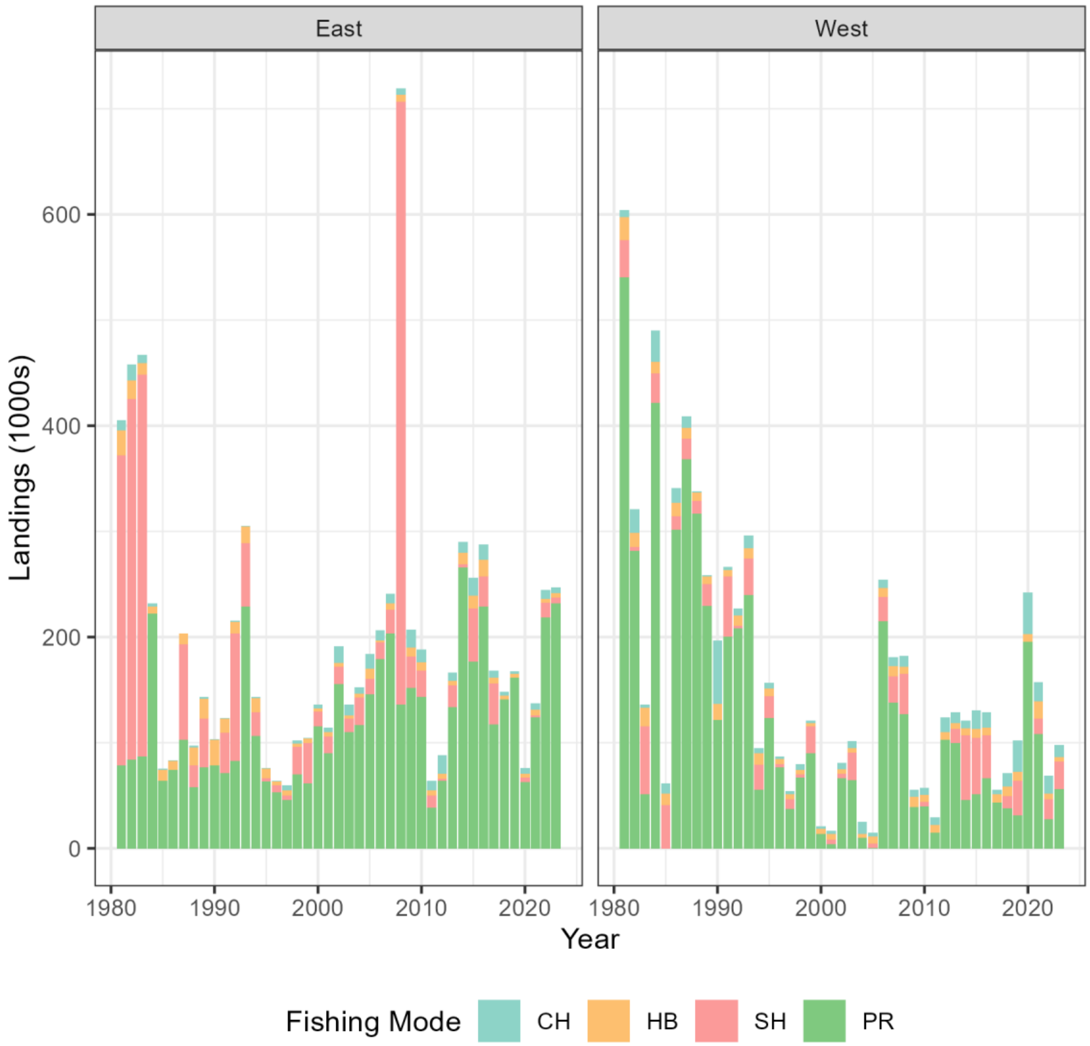
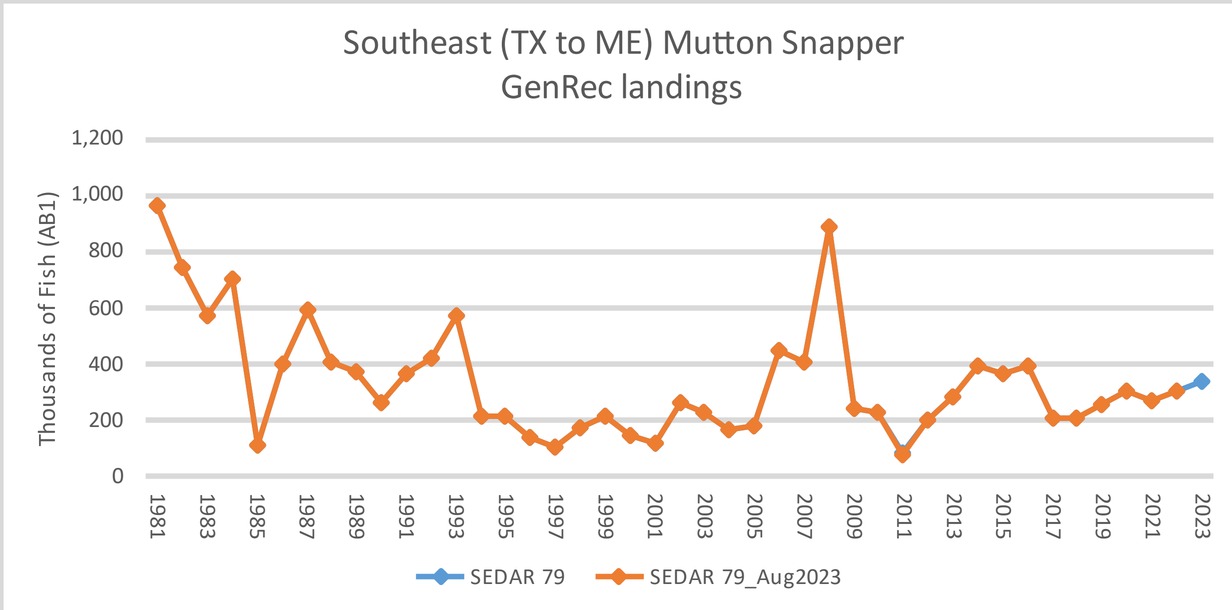


Figure 3. Observed recreational landings in numbers (1000s) for Southeastern US Mutton Snapper using data from SRHS (HB) and MRIP (CH, SH, PR), 1981-2023.



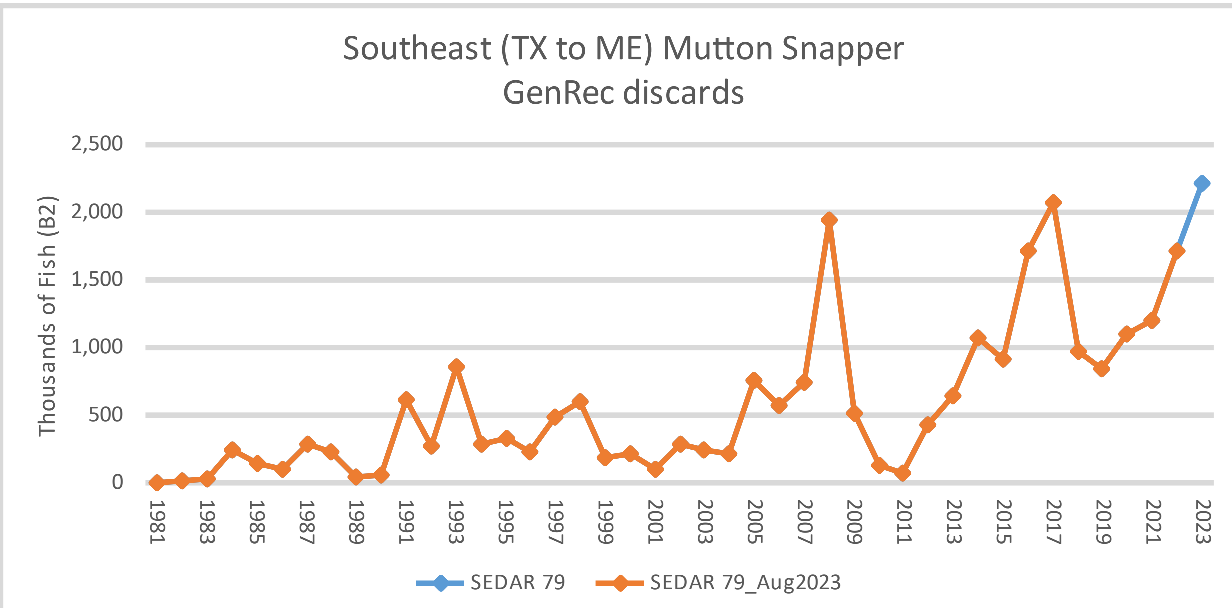


Figure 4. A comparison of observed recreational landings and releases in numbers (1000s) for Southeastern US Mutton Snapper using only MRIP data from 1981-2022 (orange) and 1981-2023 (blue).

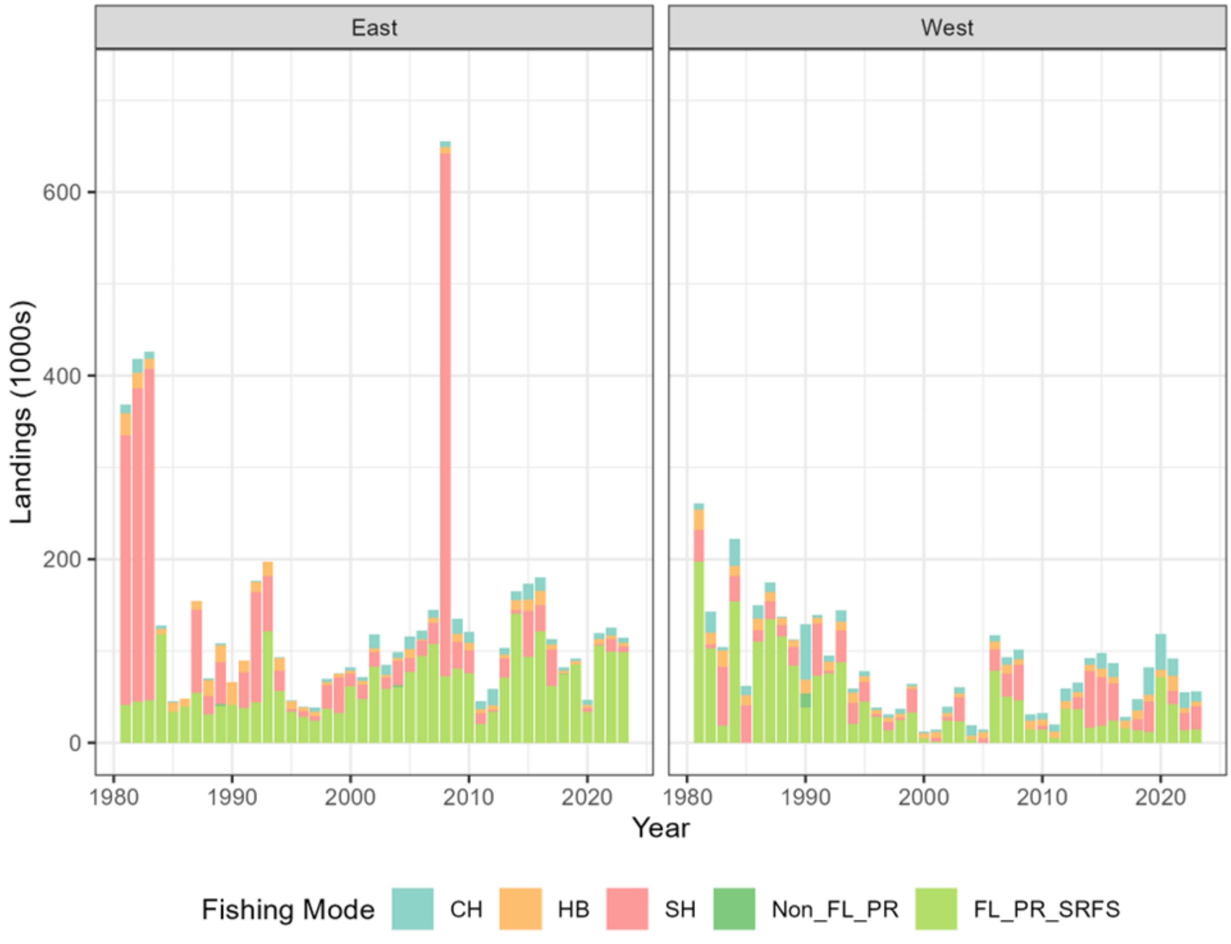


Figure 5. Observed recreational landings in numbers (1000s) for Southeastern US Mutton Snapper using data from SRHS (HB), MRIP (CH, SH, Non-FL PR), and SRFS (FL PR), 1981-2023.

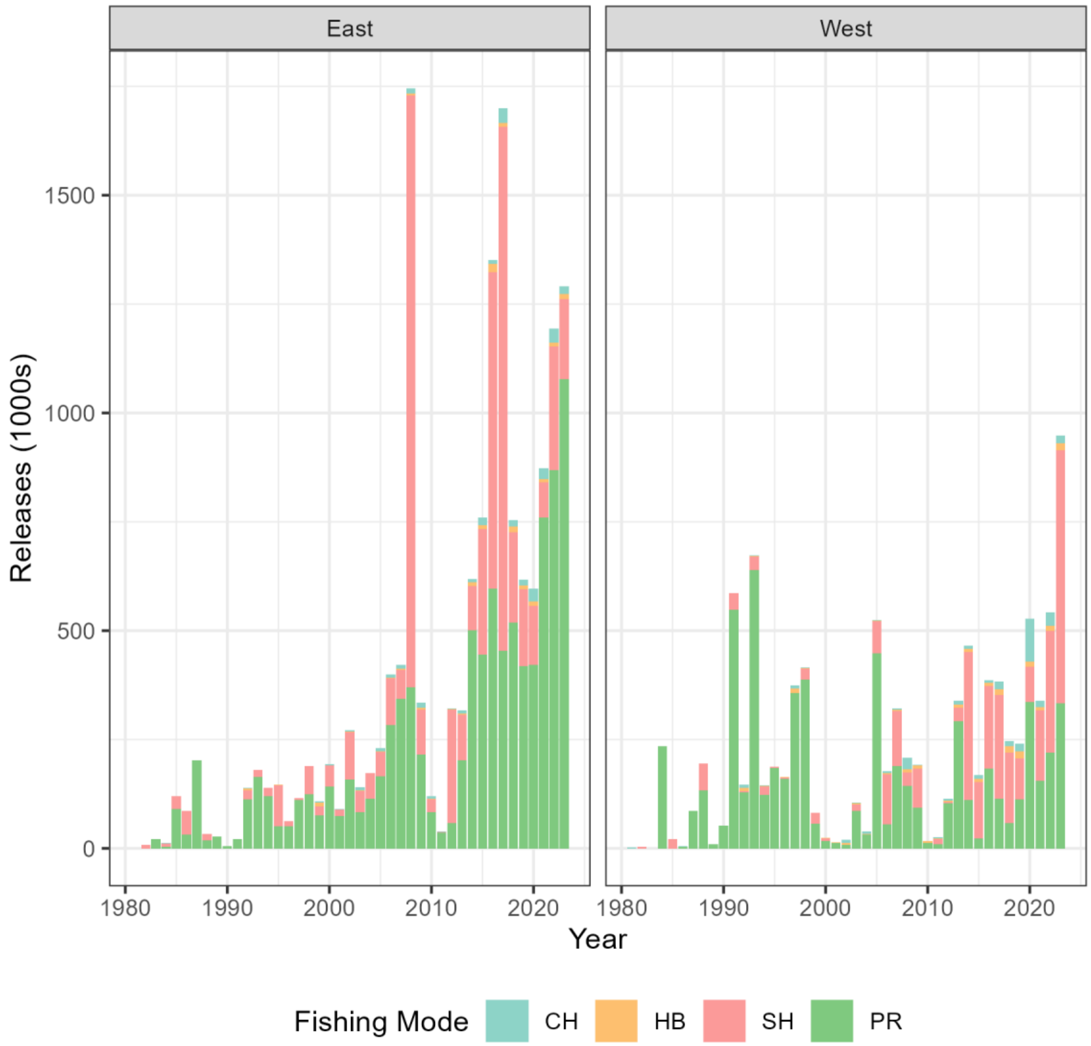


Figure 6. Observed recreational releases in numbers (1000s) for Southeastern US Mutton Snapper using data from SRHS (HB) and MRIP (CH, SH, PR), 1981-2023.

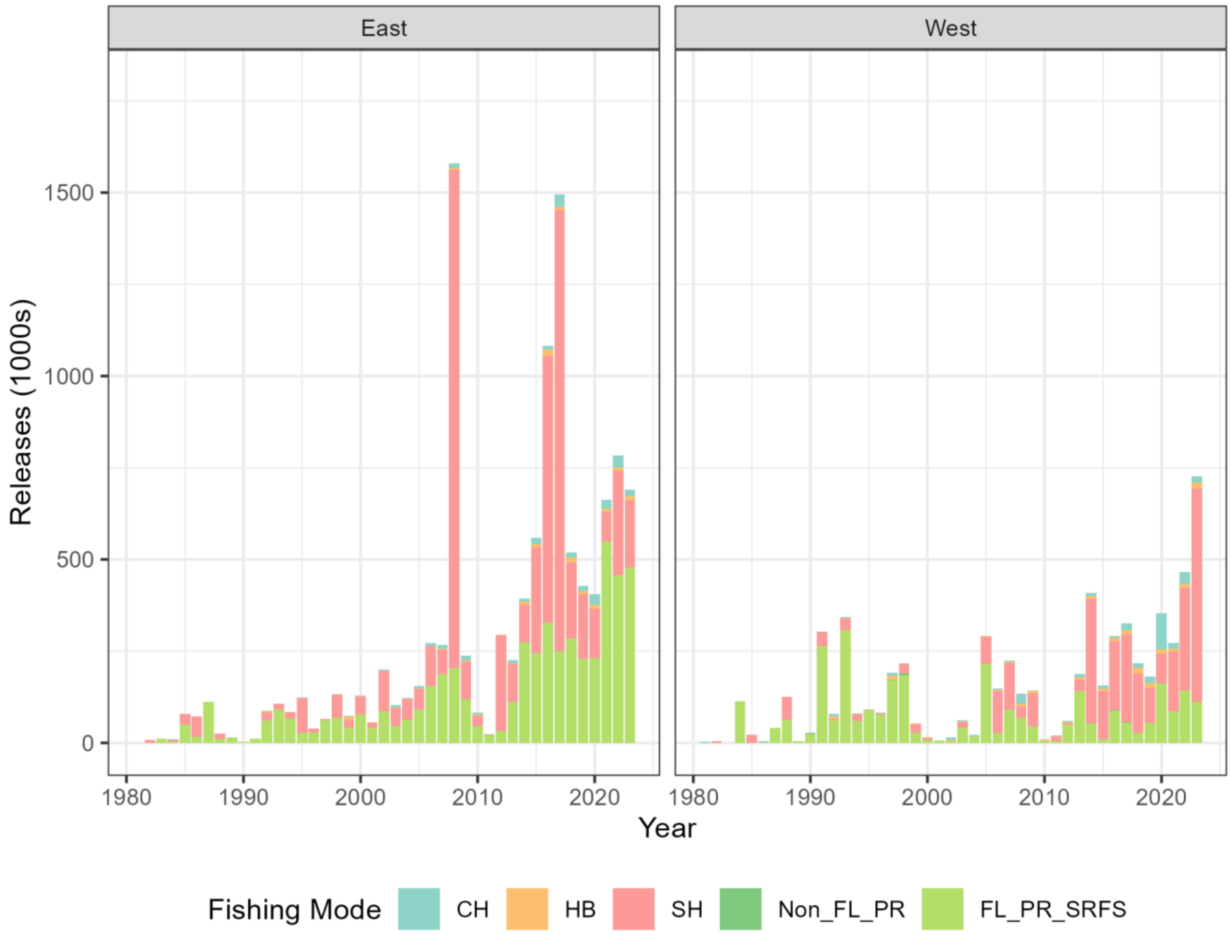


Figure 7. Observed recreational releases in numbers (1000s) for Southeastern US Mutton Snapper using data from SRHS (HB), MRIP (CH, SH, Non-FL PR), and SRFS (FL PR), 1981-2023.

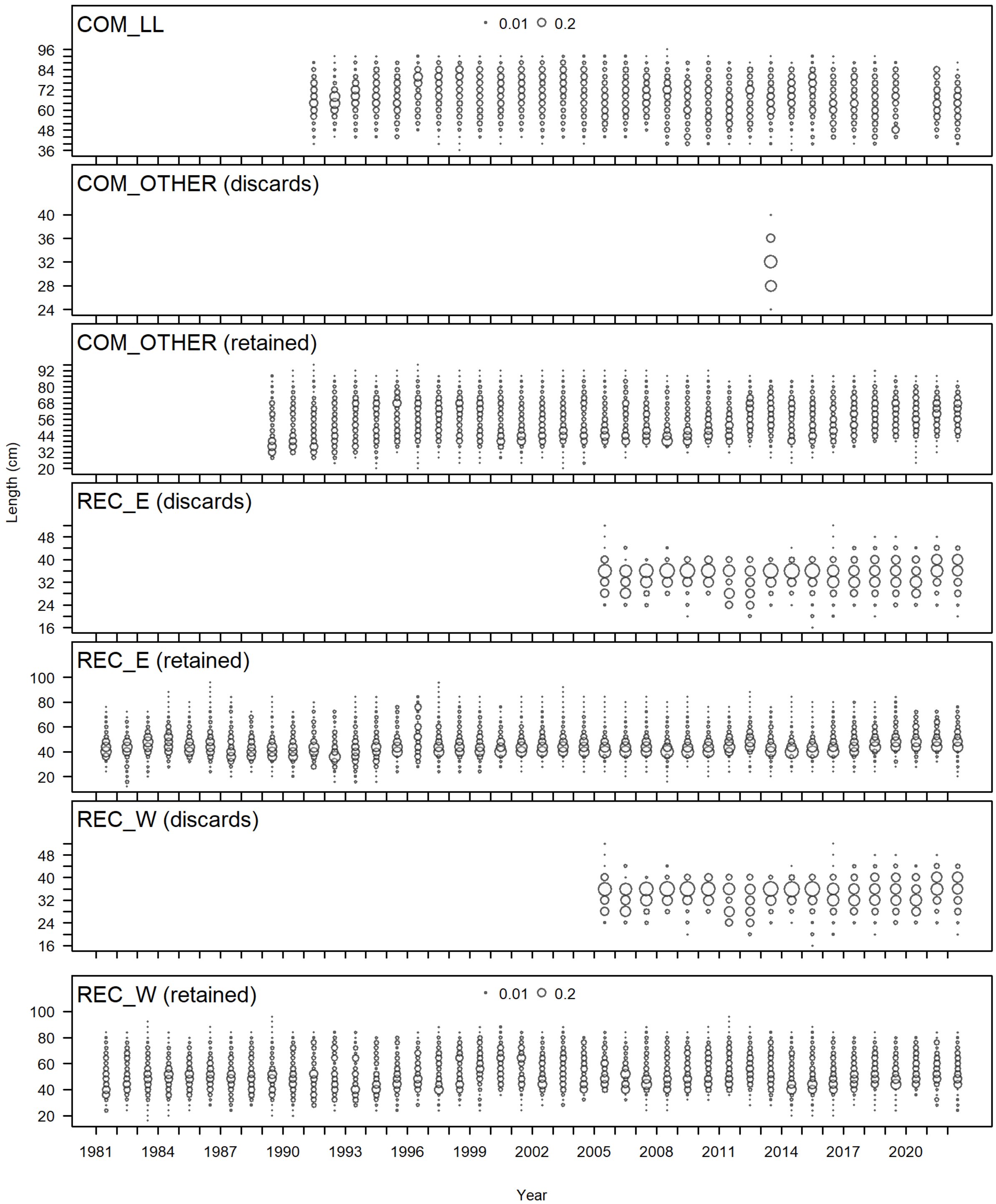


Figure 8. Catch-weighted length compositions (4 cm Max TL bins) of Southeastern US Mutton Snapper landings and releases by fleet, 1981-2022.

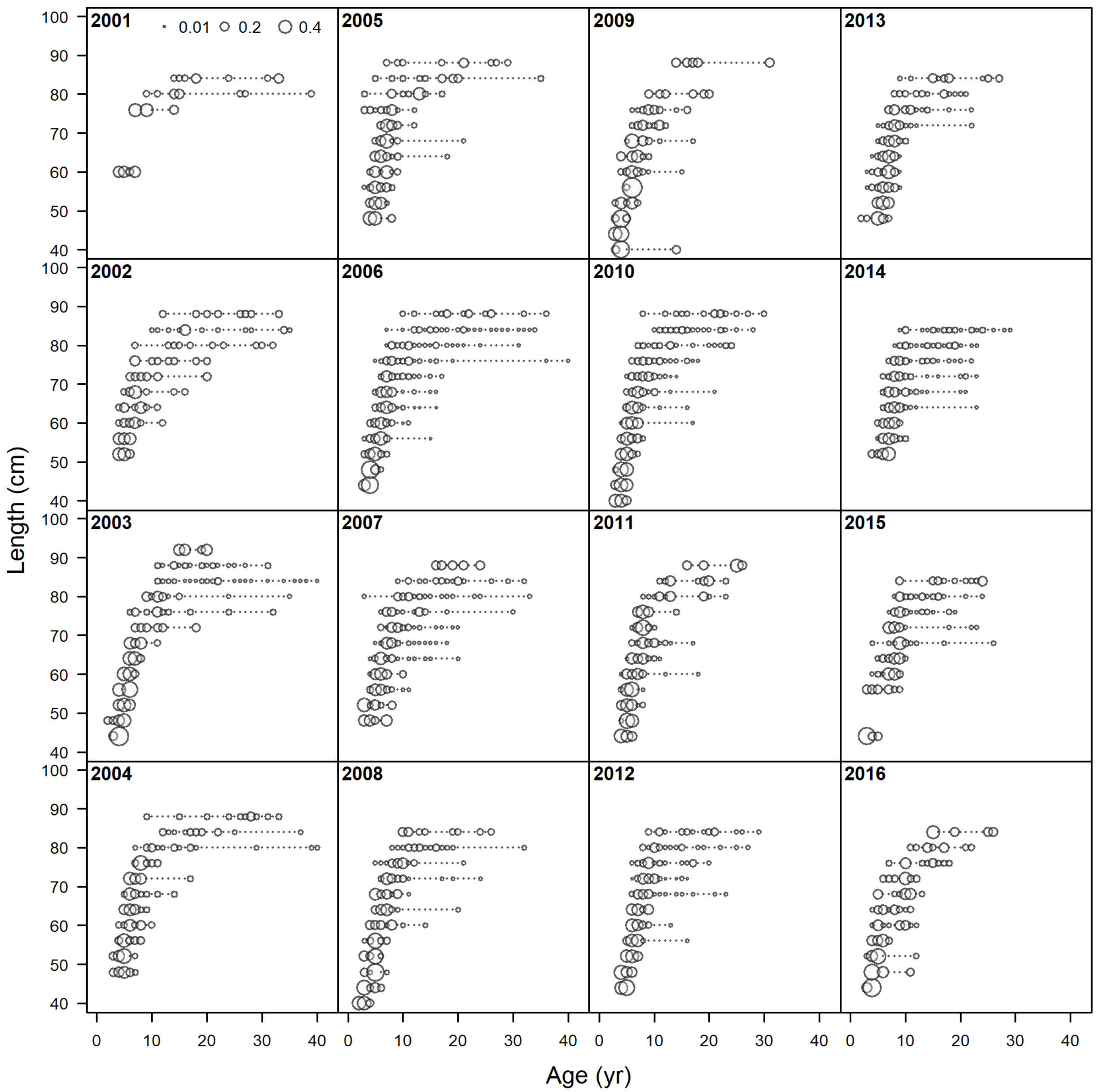


Figure 9. Observed conditional age-at-length in 4 cm Max TL bins of Southeastern US Mutton Snapper for the commercial Longline fleet, 2001-2022.

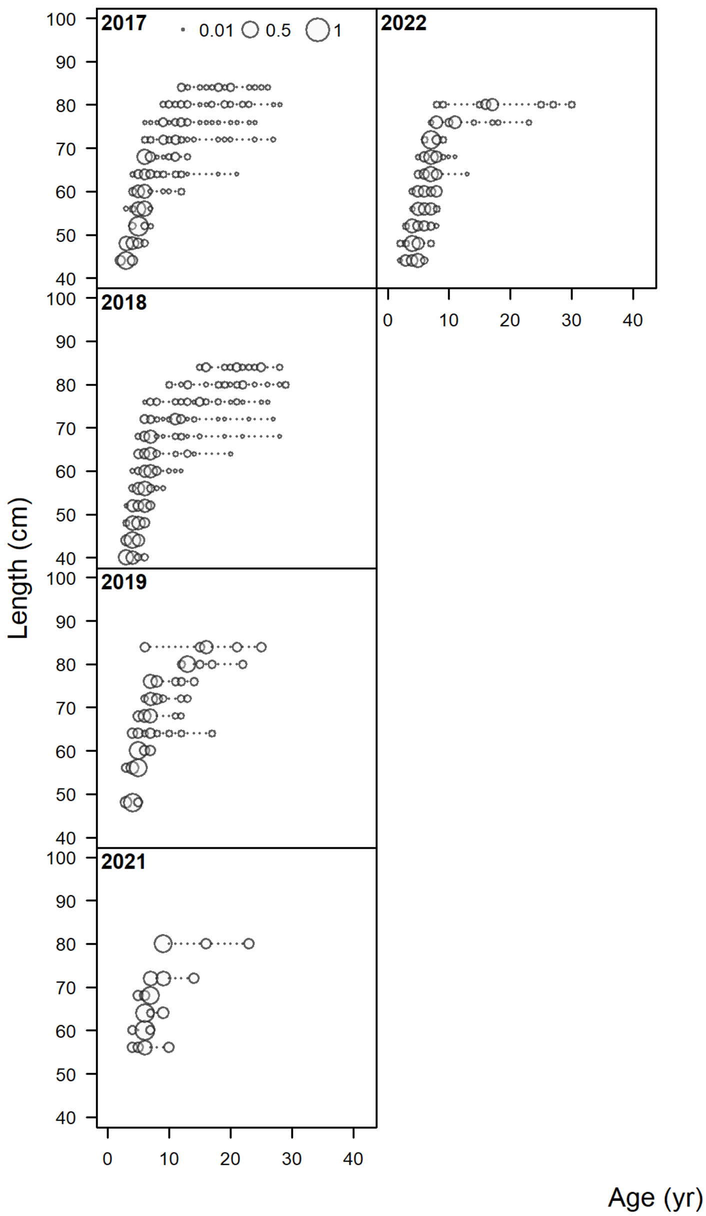


Figure 9 (continued). Observed conditional age-at-length in 4 cm Max TL bins of Southeastern US Mutton Snapper for the Commercial Longline fleet, 2001-2022.

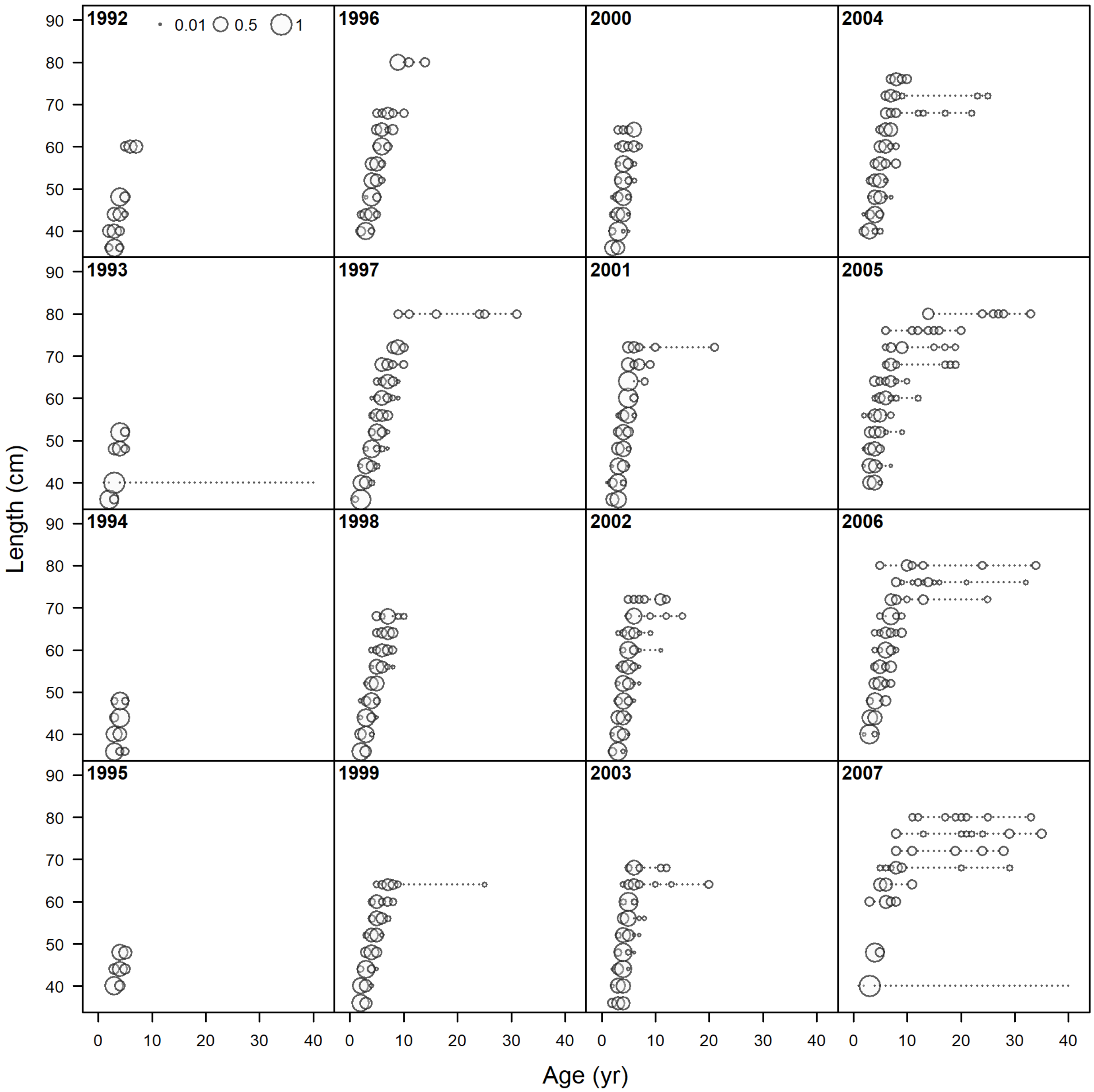


Figure 10. Observed conditional age-at-length in 4 cm Max TL bins of Southeastern US Mutton Snapper for the Commercial Other fleet, 1992-2022.

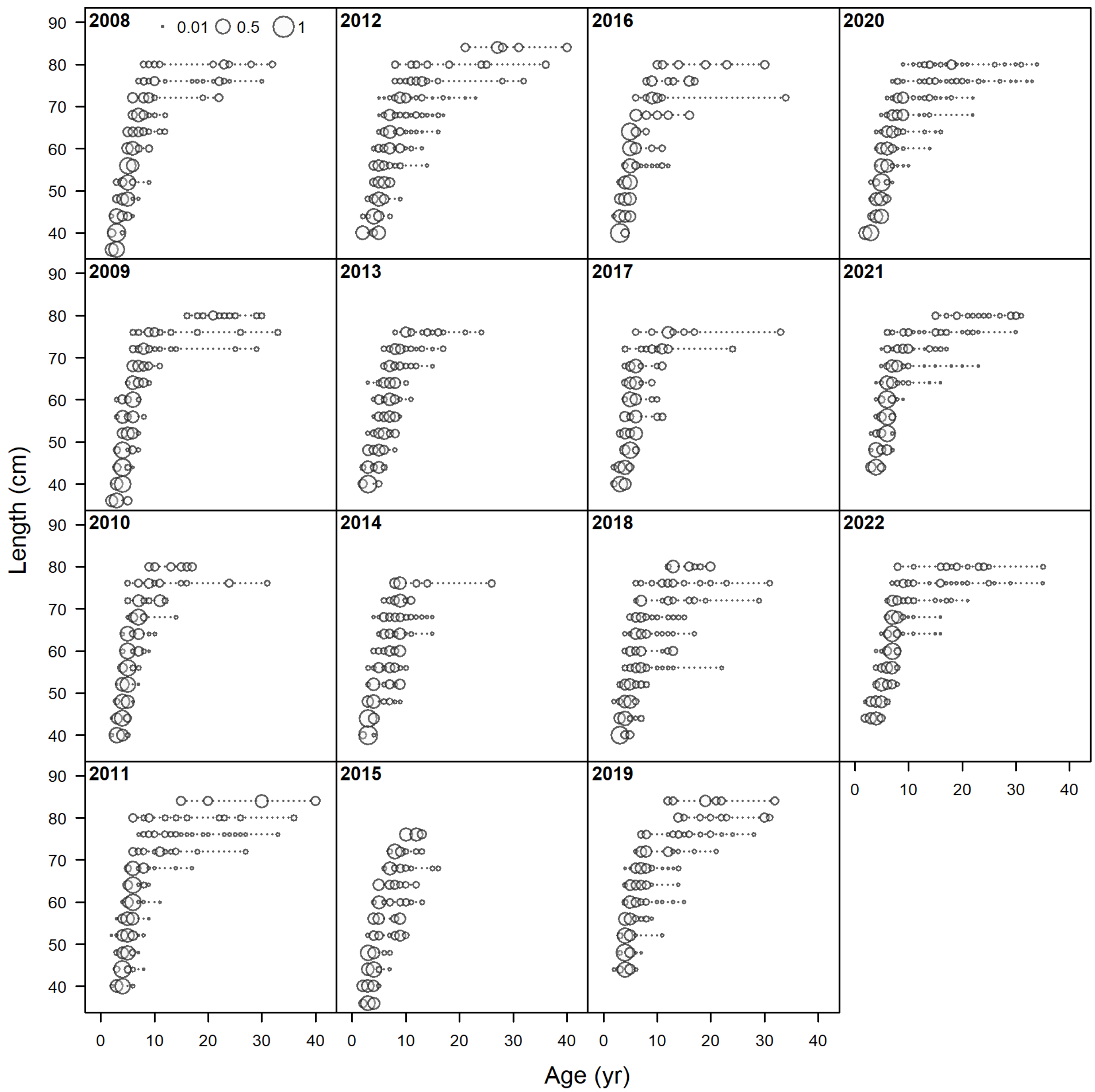


Figure 10 (continued). Observed conditional age-at-length in 4 cm Max TL bins of Southeastern US Mutton Snapper for the Commercial Other fleet, 1992-2022.

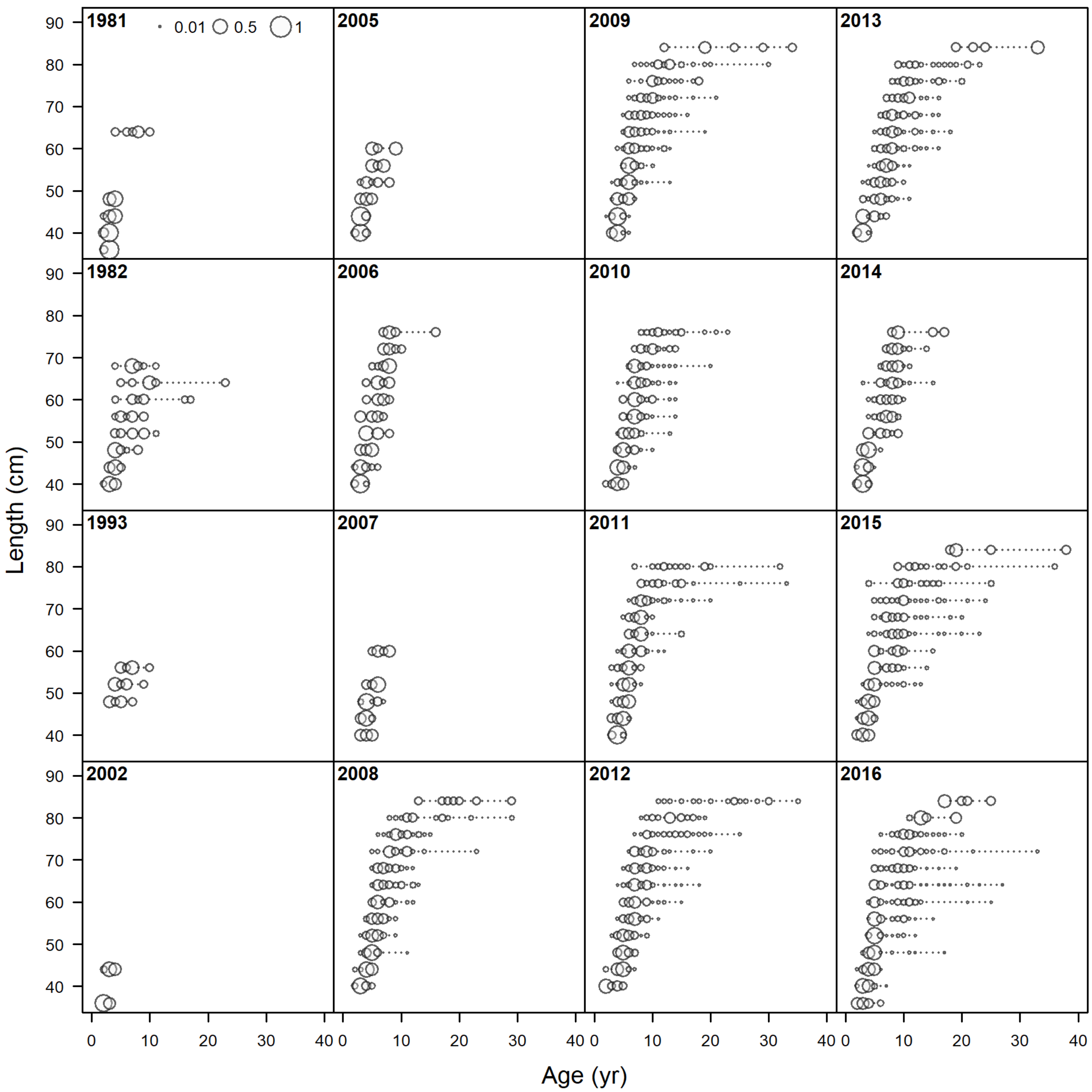


Figure 11. Observed conditional age-at-length in 4 cm Max TL bins of Southeastern US Mutton Snapper for the Recreational West fleet, 1981-2022.

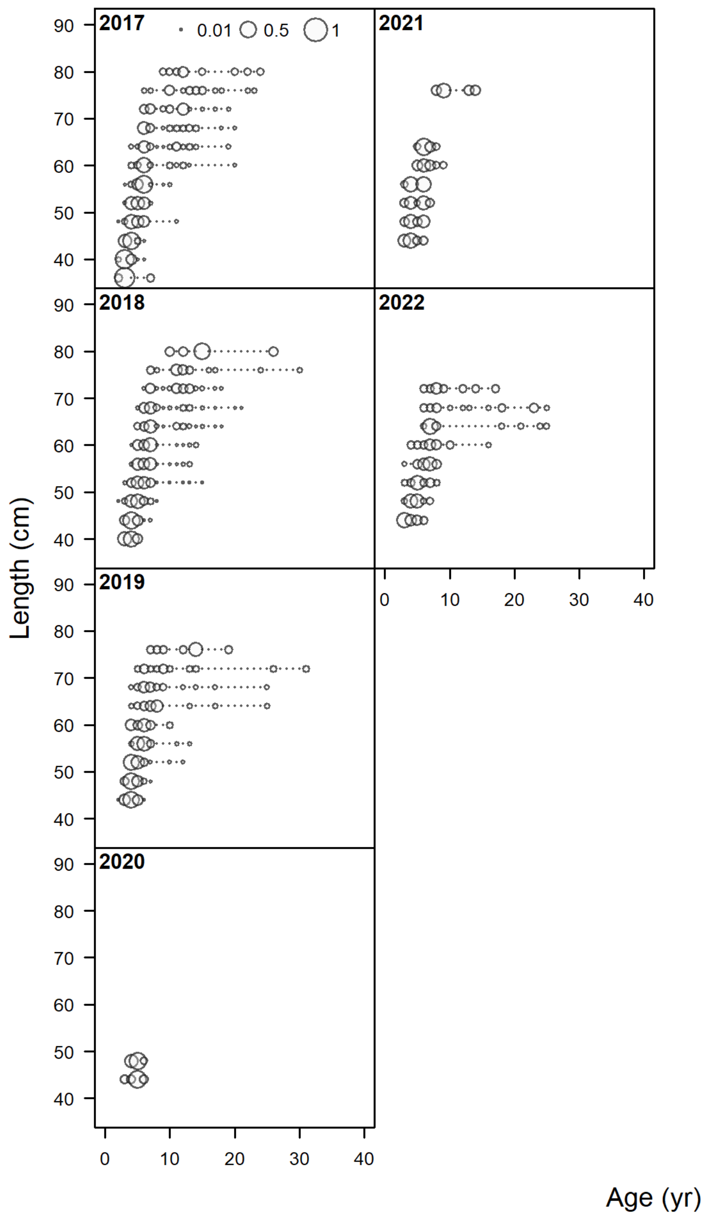


Figure 11 (continued). Observed conditional age-at-length in 4 cm Max TL bins of Southeastern US Mutton Snapper for the Recreational West fleet, 1981-2022.

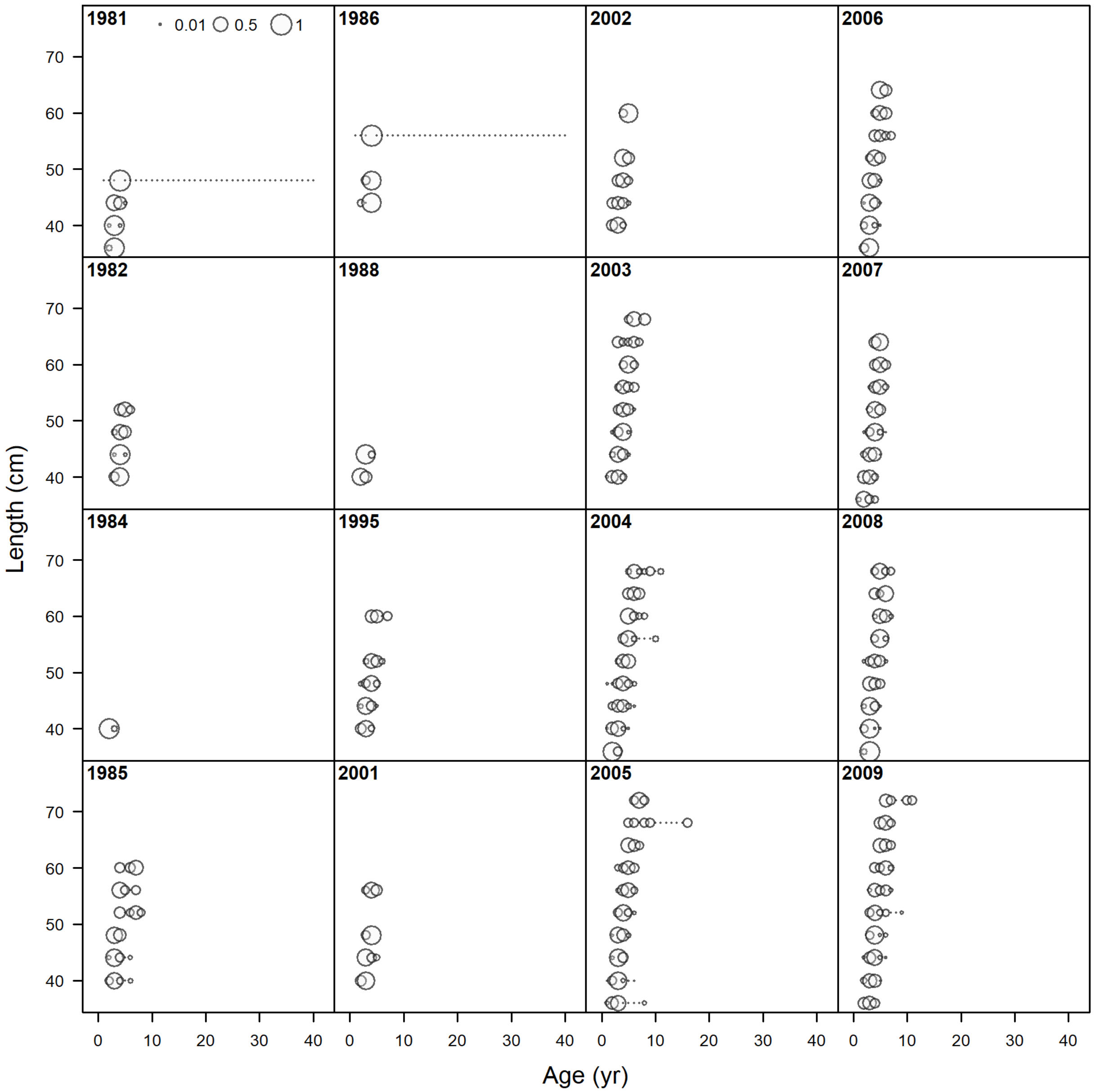


Figure 12. Observed conditional age-at-length in 4 cm Max TL bins of Southeastern US Mutton Snapper for the Recreational East fleet, 1981-2022.

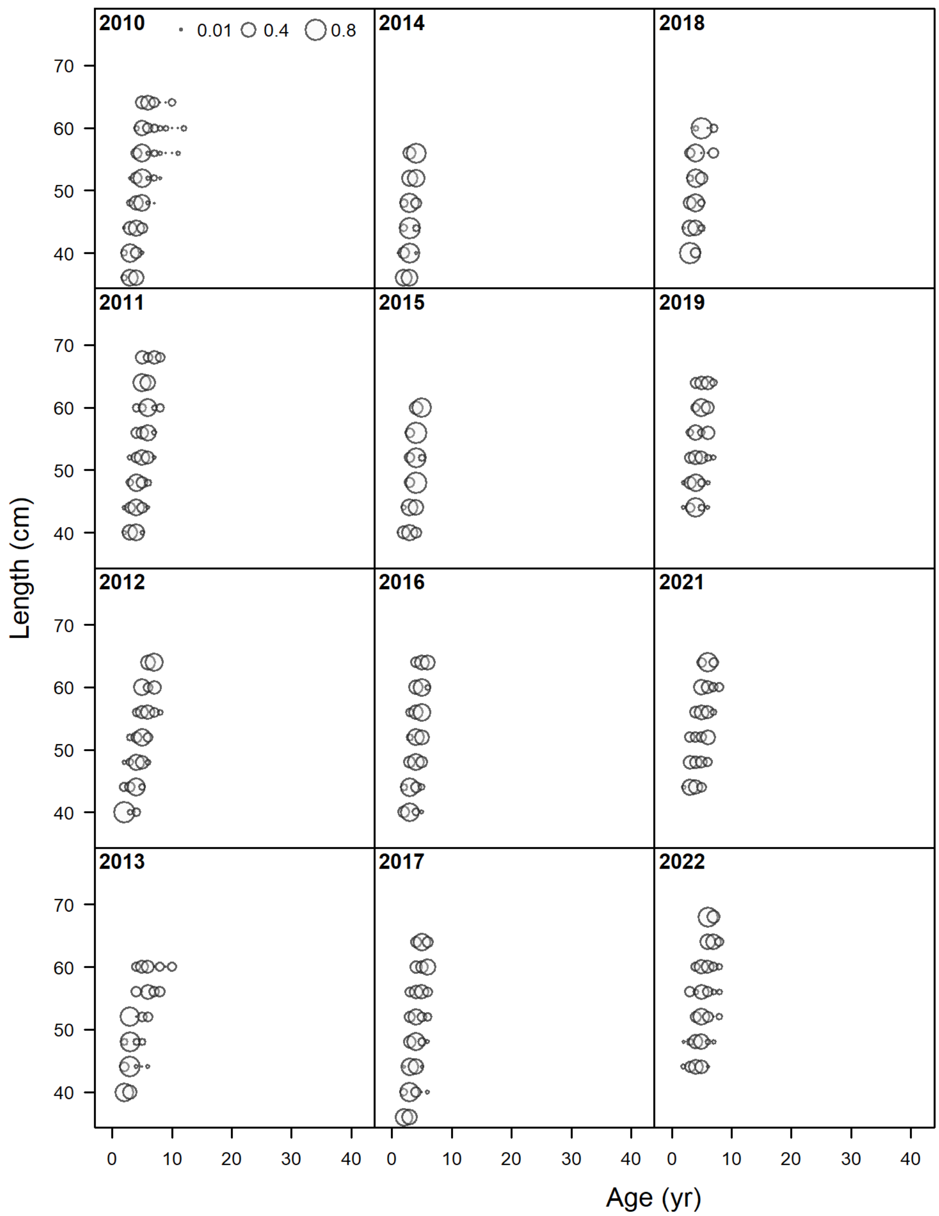


Figure 12 (continued). Observed conditional age-at-length in 4 cm Max TL bins of Southeastern US Mutton Snapper for the Recreational East fleet, 1981-2022.

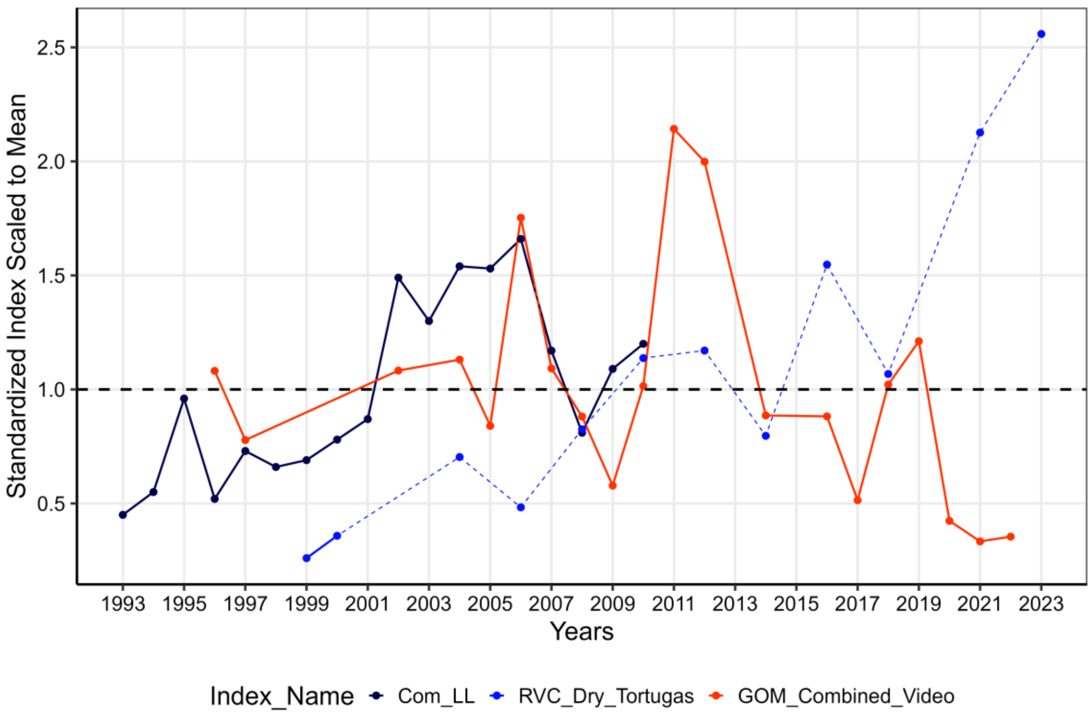


Figure 13. Indices of Southeastern US Mutton Snapper occurring in the Gulf of Mexico, 1993-2023. Non-consecutive years are joined by the dashed line.

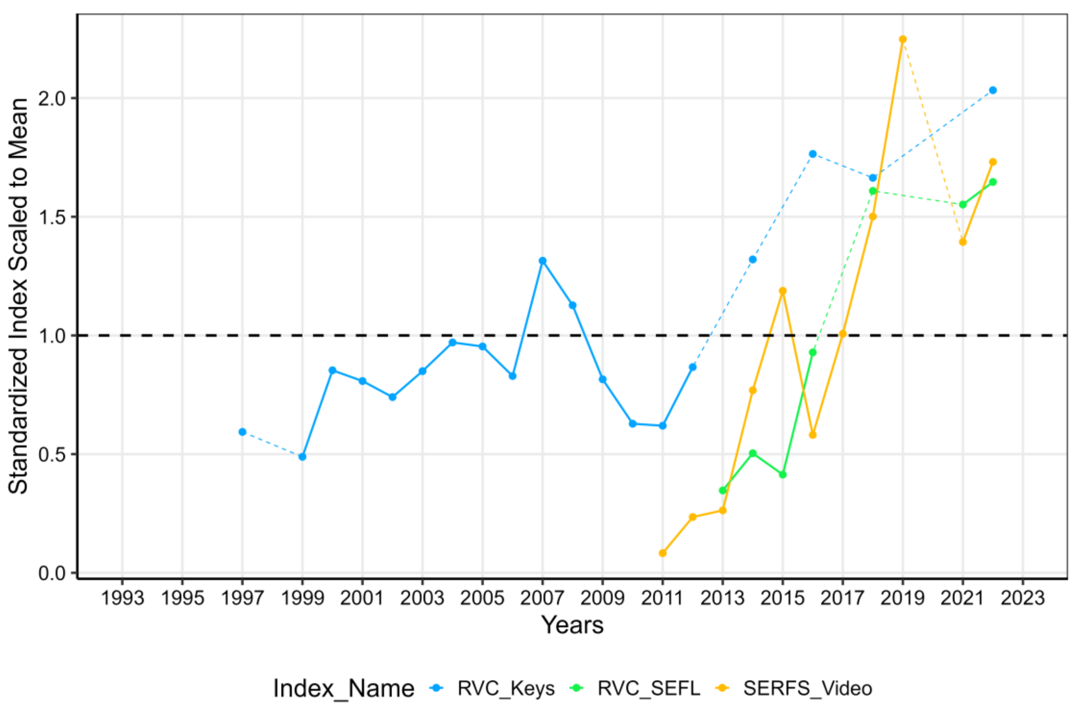


Figure 14. Indices of Southeastern US Mutton Snapper occurring in the South Atlantic, 1997-2022. Non-consecutive years are joined by the dashed line.

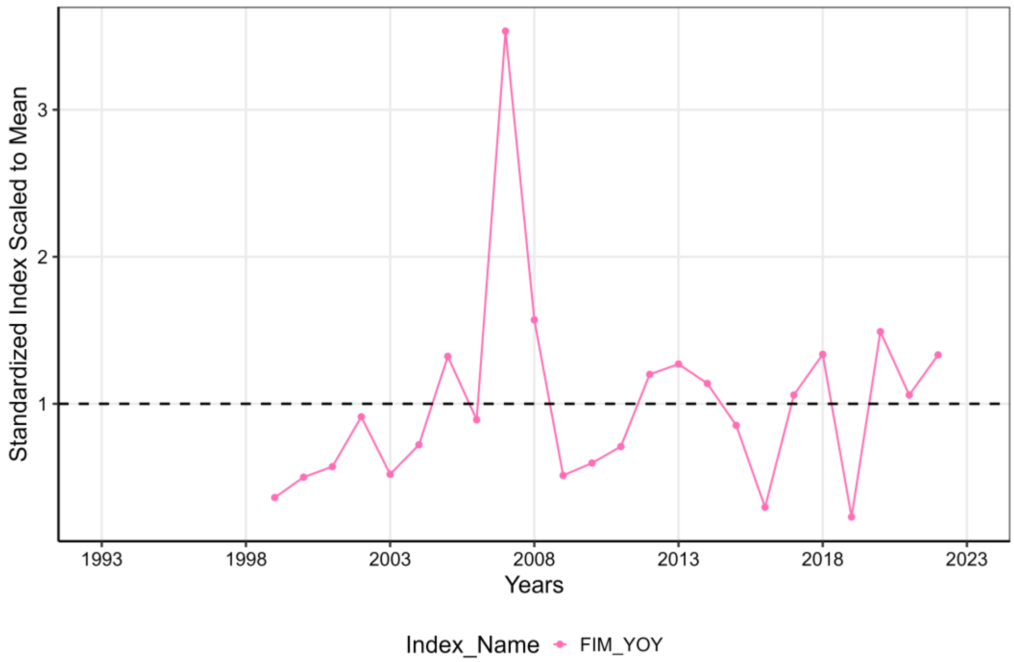


Figure 15. Fishery-independent young-of-year index of Southeastern US Mutton Snapper occurring in the Indian River Lagoon, FL, 1999-2022.

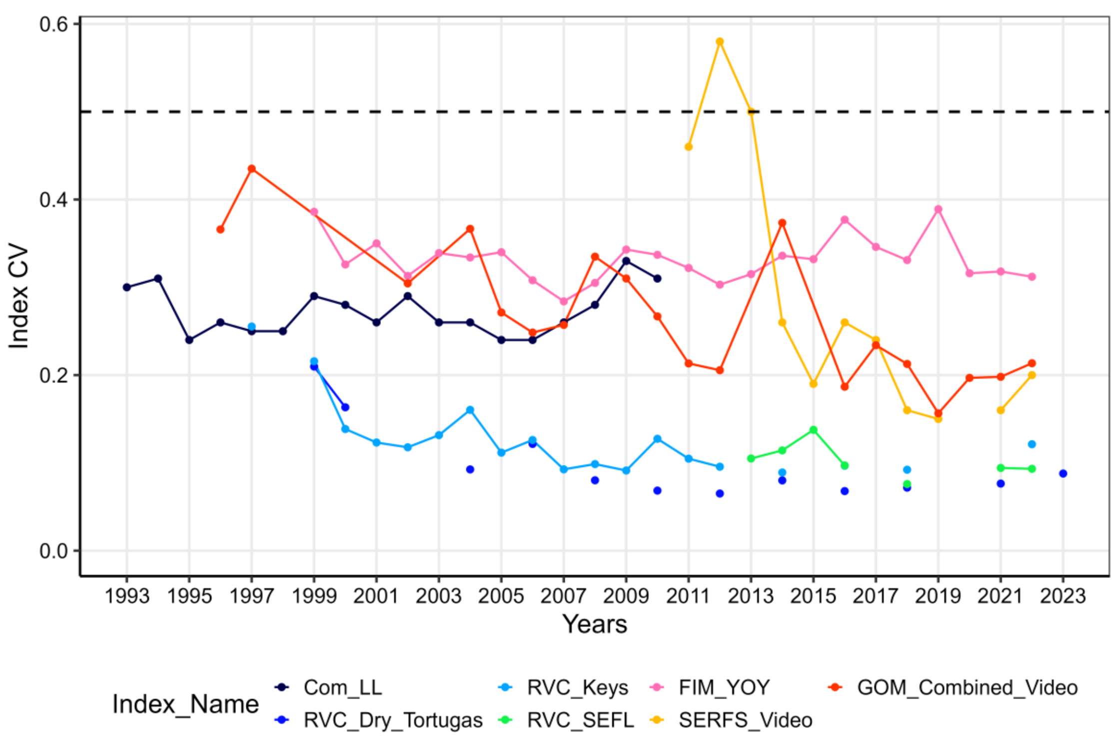


Figure 16. Annual CVs of indices of Southeastern US Mutton Snapper, 1993-2023.

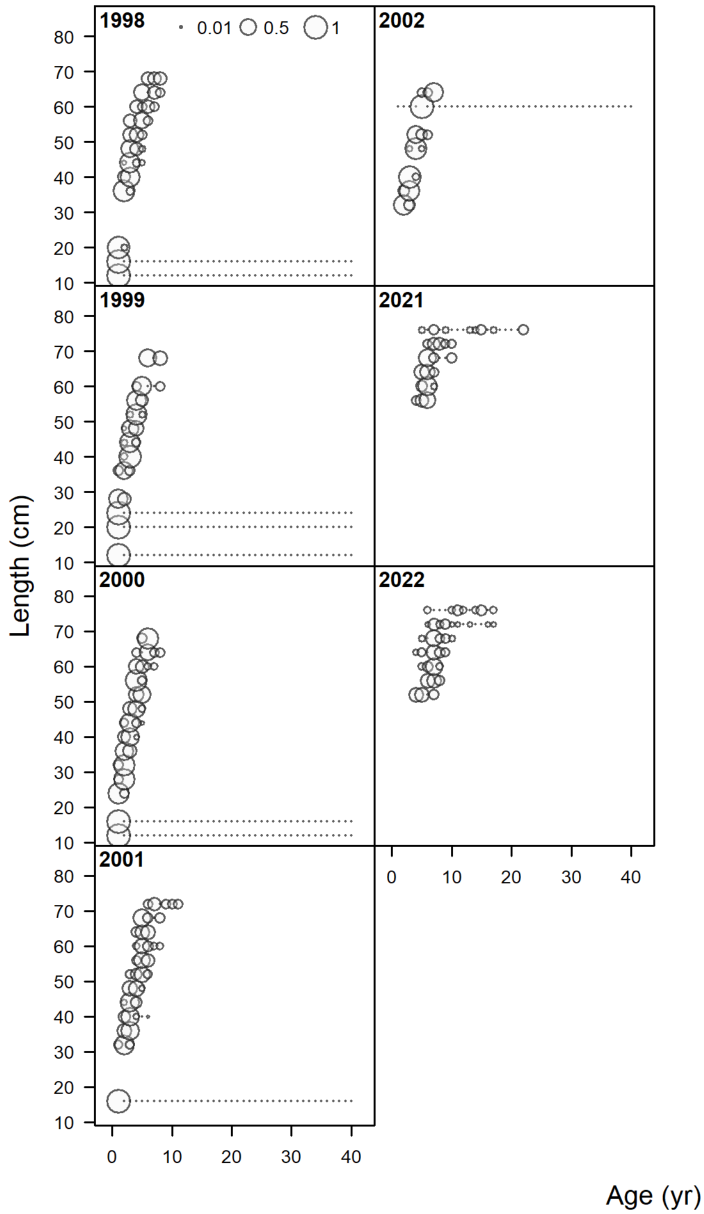


Figure 17. Observed conditional age-at-length in 4 cm Max TL bins of Southeastern US Mutton Snapper from fishery independent sources, 1998-2022.

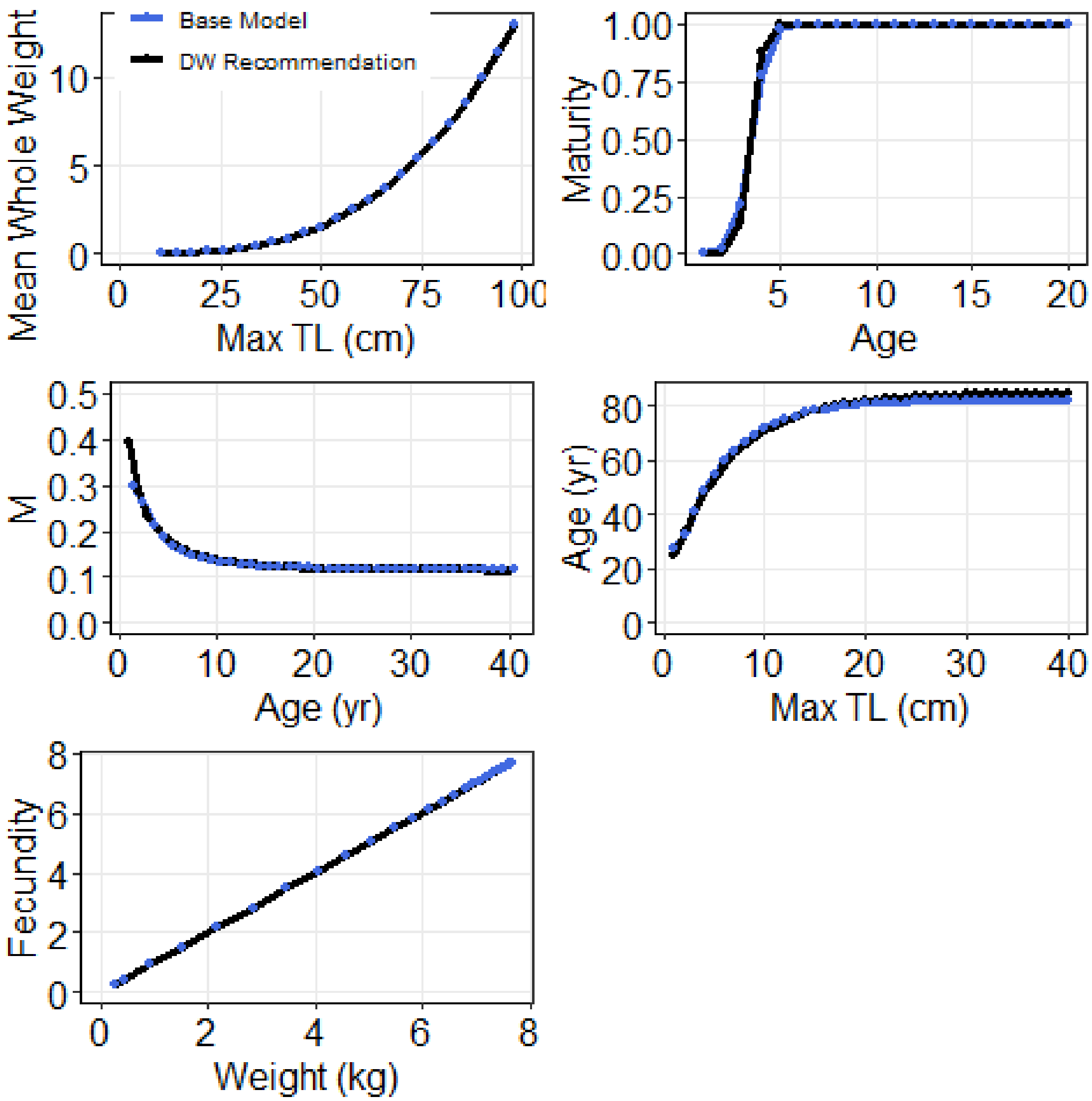


Figure 18. Life history relationships for Southeastern US Mutton Snapper including mean weight-at length and fecundity (proportion female = 0.5 is not shown but required by Stock Synthesis as an input), as well as recommended (black) and estimated (blue) maturity-at-age, natural mortality-at-age, and growth curves.

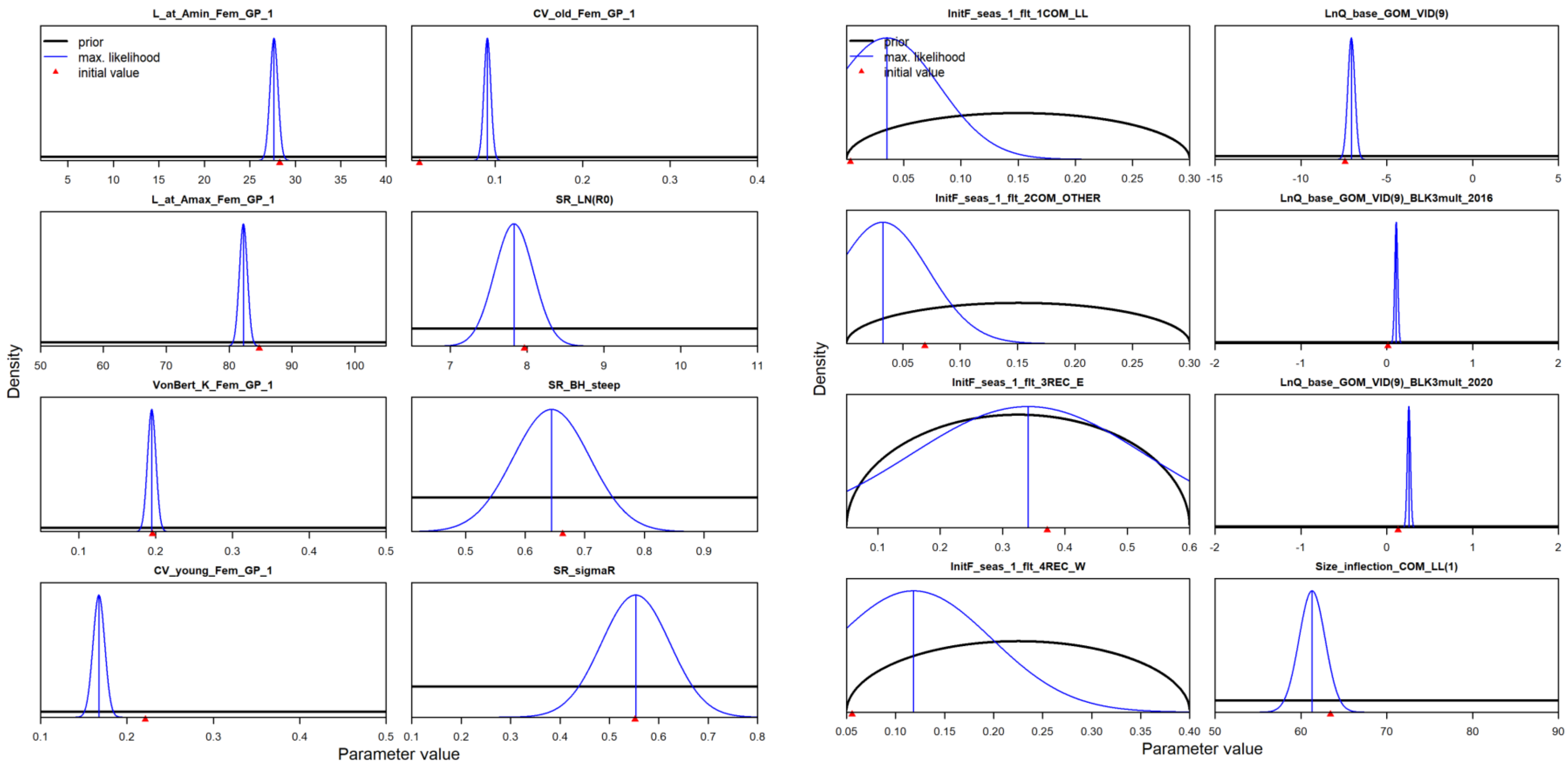


Figure 19. Parameter distribution (blue line) plots along with starting values (red arrow), parameter bounds (min and max values on the x-axis), and priors (black lines). Recruitment deviation parameters and estimated fishing mortality rate parameters are not included. Note: parameter point estimates from a jitter analysis were used as the starting values for this final model run.

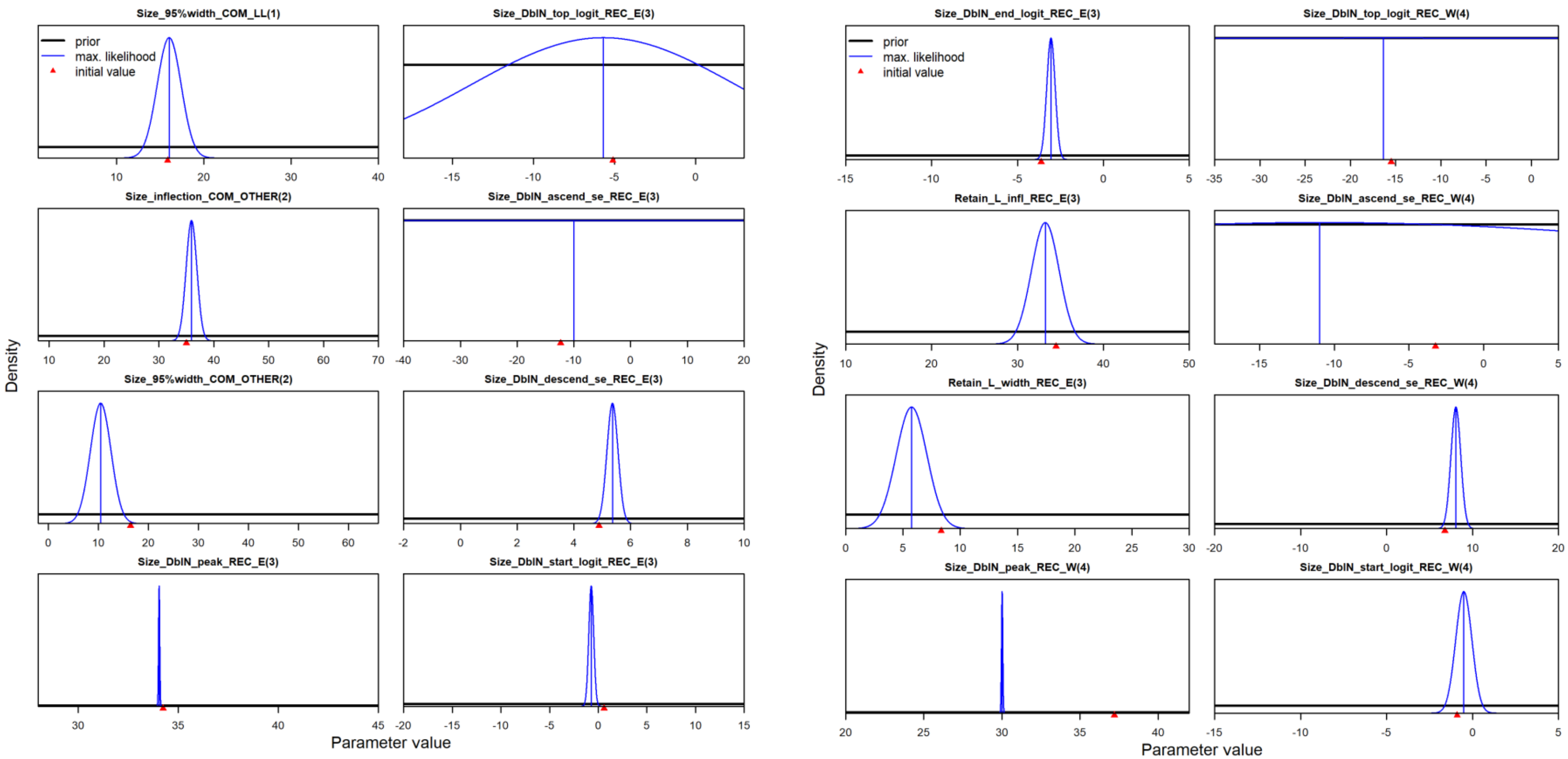


Figure 19 (continued). Parameter distribution (blue line) plots along with starting values (red arrow), parameter bounds (min and max values on the x-axis), and priors (black lines). Recruitment deviation parameters and estimated fishing mortality rate parameters are not included. Note: parameter point estimates from a jitter analysis were used as the starting values for this final model run.

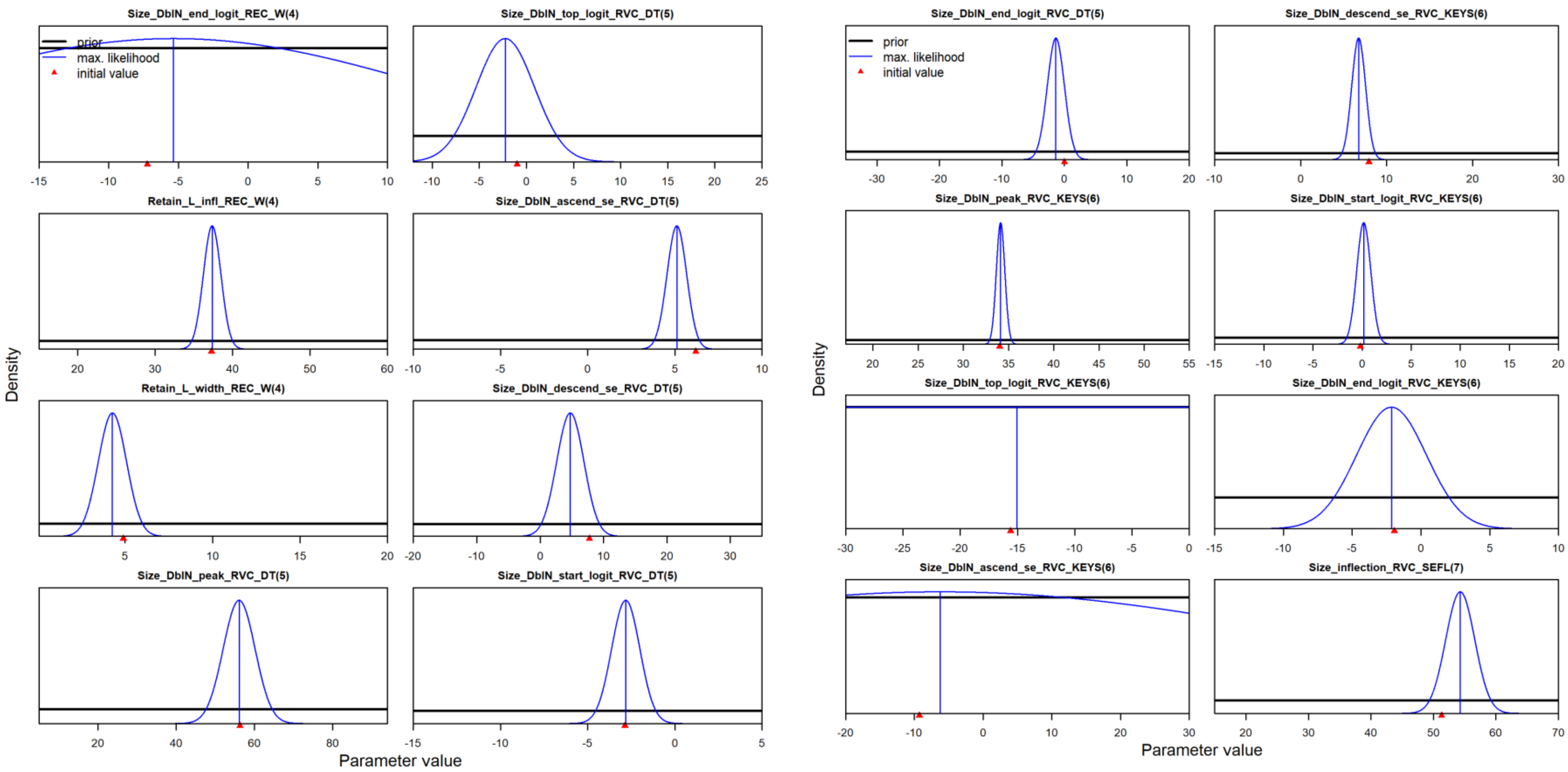


Figure 19 (continued). Parameter distribution (blue line) plots along with starting values (red arrow), parameter bounds (min and max values on the x-axis), and priors (black lines). Recruitment deviation parameters and estimated fishing mortality rate parameters are not included. Note: parameter point estimates from a jitter analysis were used as the starting values for this final model run.

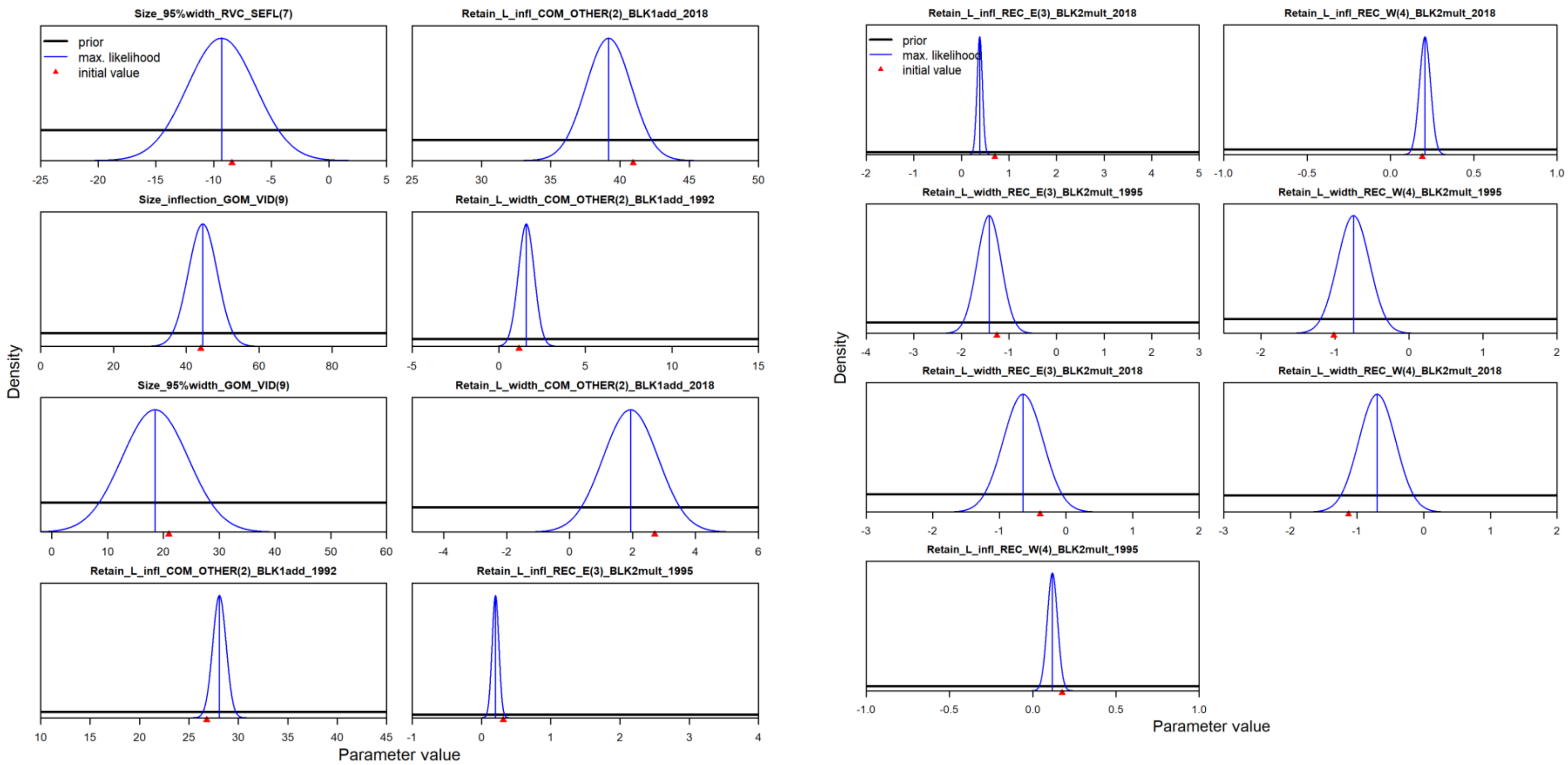


Figure 19 (continued). Parameter distribution (blue line) plots along with starting values (red arrow), parameter bounds (min and max values on the x-axis), and priors (black lines). Recruitment deviation parameters and estimated fishing mortality rate parameters are not included. Note: parameter point estimates from a jitter analysis were used as the starting values for this final model run.

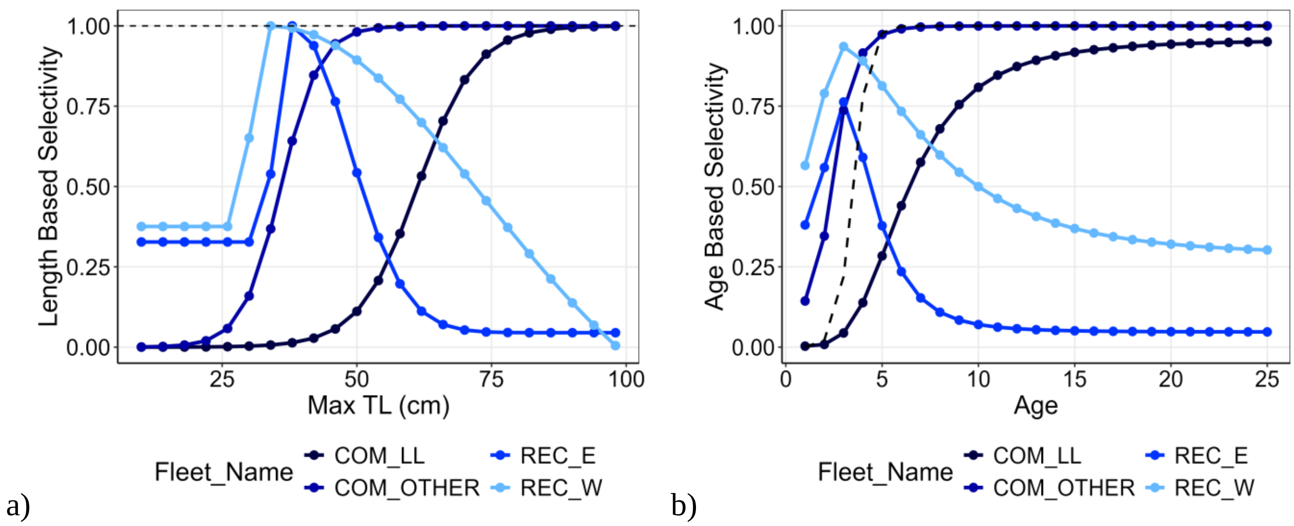


Figure 20. Length-based selectivity (a) for each fleet in the SEDAR 79 Base Model and related age-derived selectivity (b).

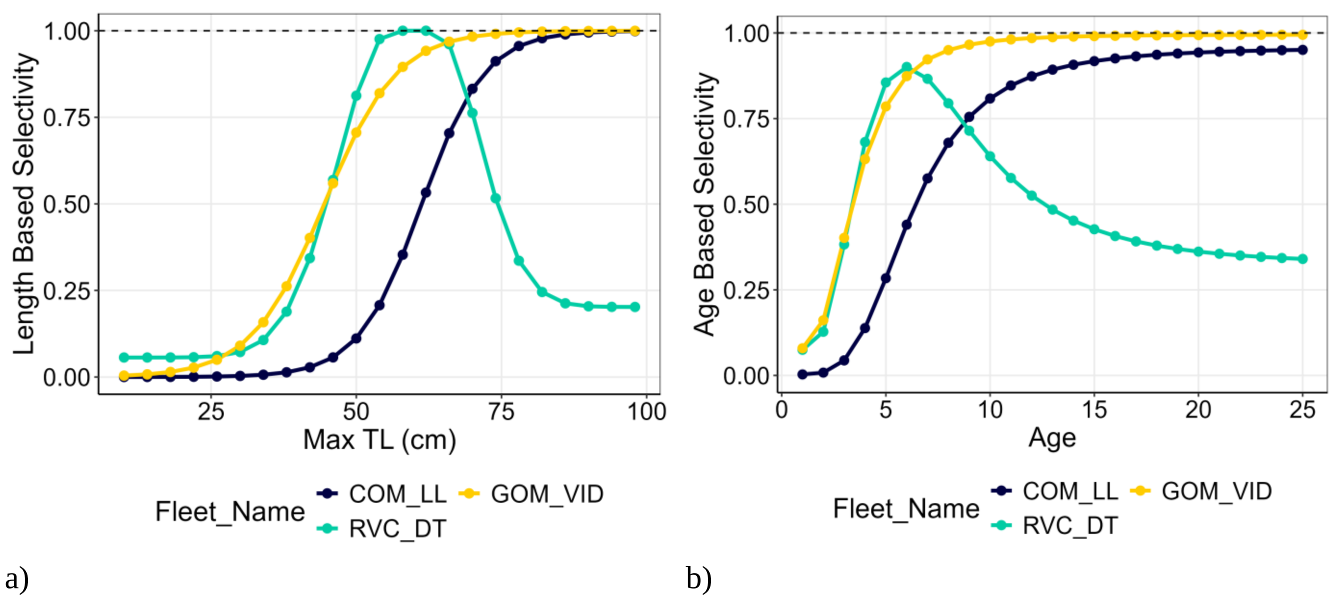
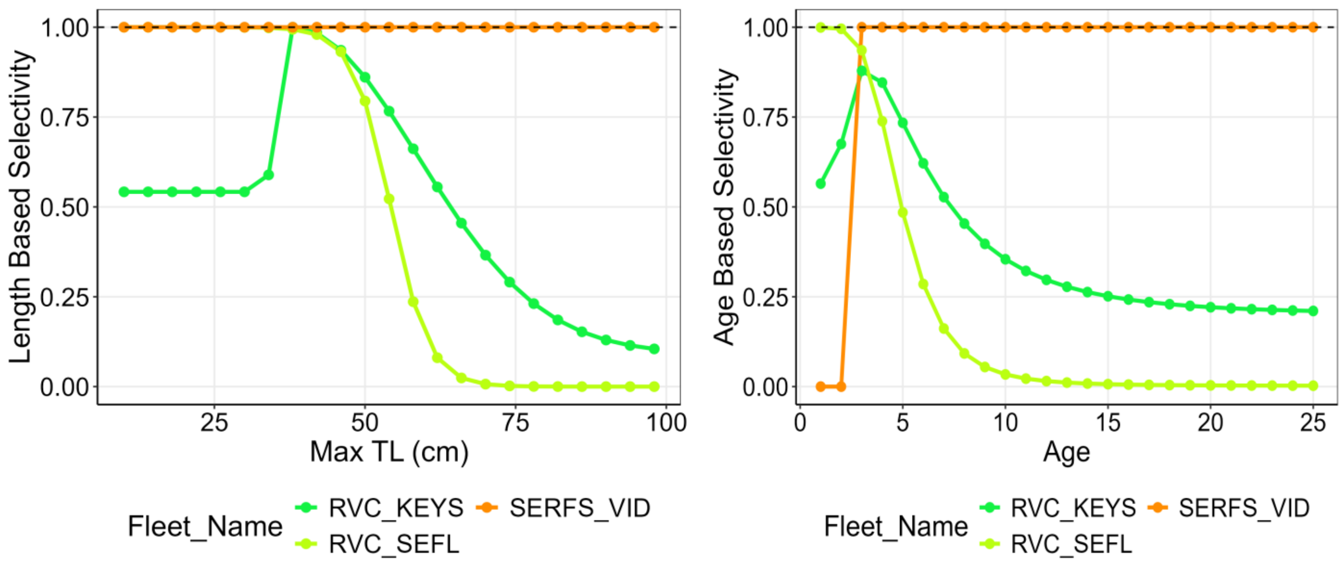
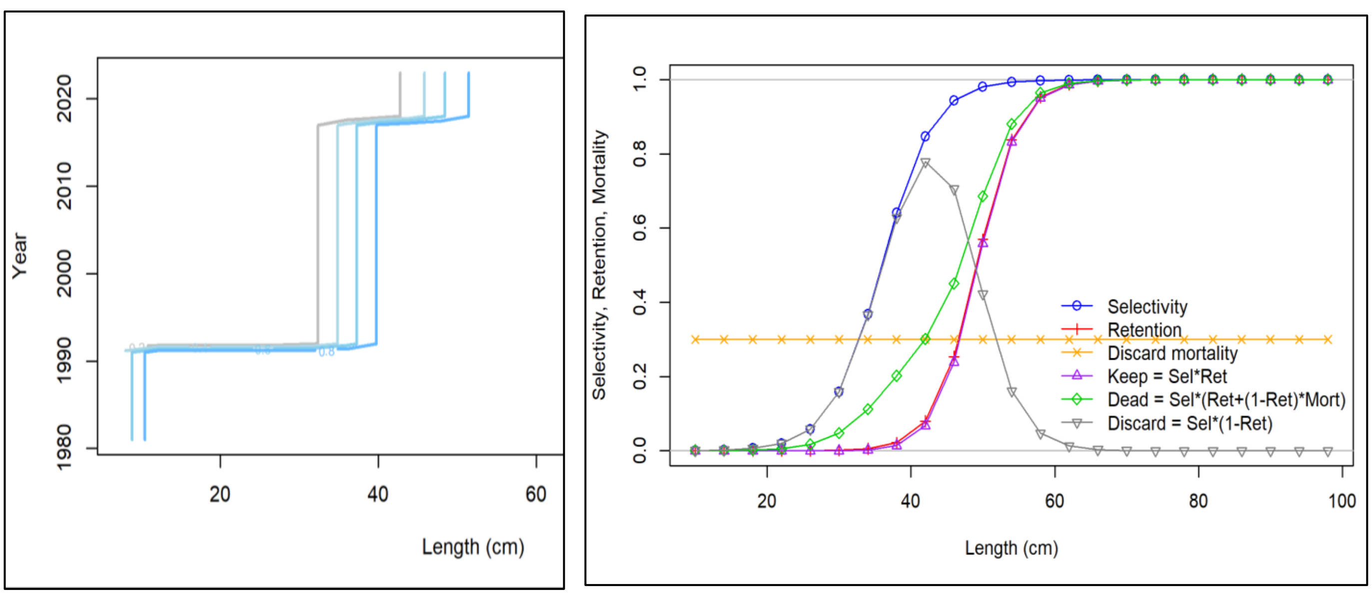


Figure 21. Length-based selectivity (a) for indices in the SEDAR 79 Base Model occurring in the Gulf and related age-derived selectivity (b).



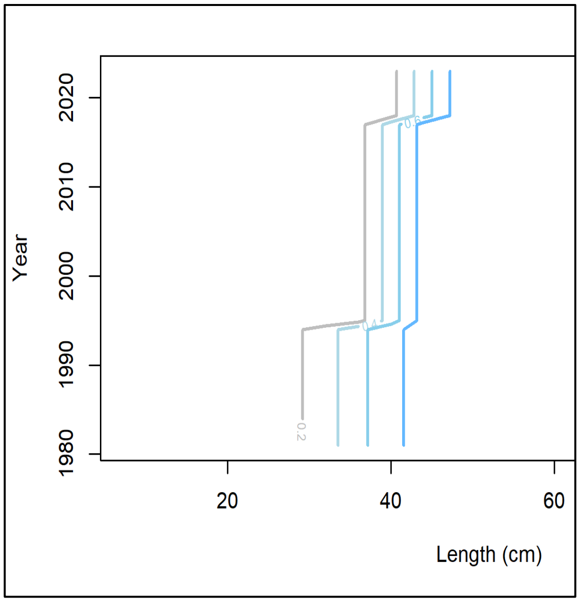
a) b)

Figure 22. Length-based selectivity (a) for indices in the SEDAR 79 Base Model occurring in the South Atlantic and related age-based selectivity (b). Age-based selectivity is derived from length-based selectivity for the RVC indices but was specified for the SERFS index.

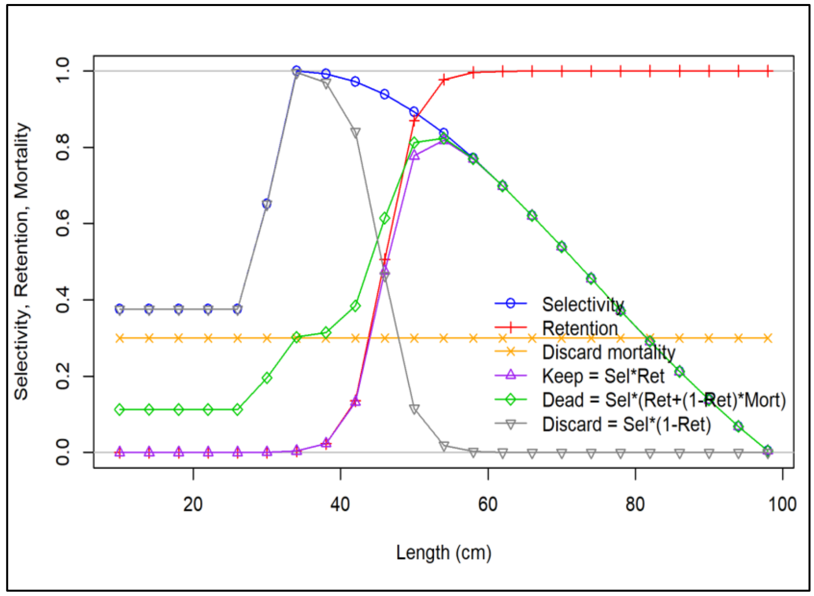


a) b)

Figure 23. Time-varying retention (a) for the Commercial Other fleet in the SEDAR 79 Base Model and the related interplay between terminal year (2023) selectivity, retention, discard mortality (constant at 0.30), along with the fraction of fish kept, dead and discarded (2024, b).

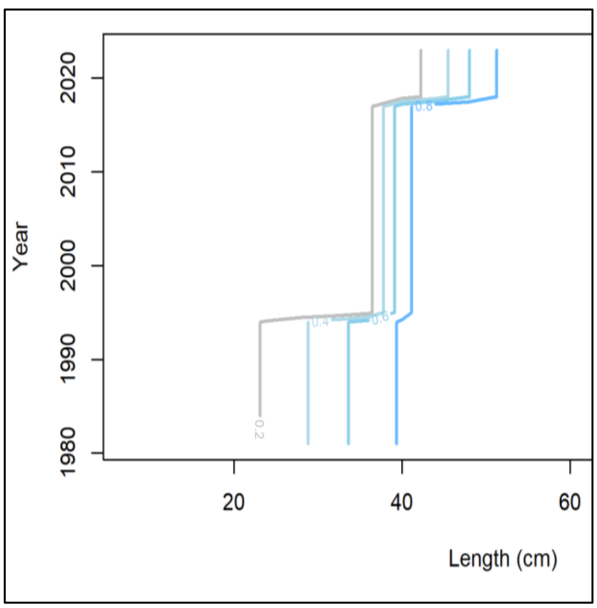


a)

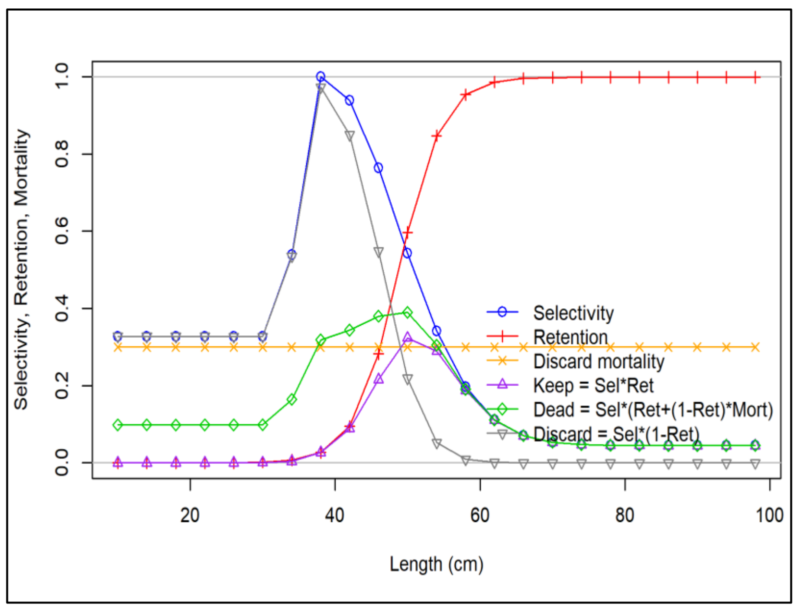


b)

Figure 24. Time-varying retention (a) for the Rec West fleet in the SEDAR 79 Base Model and the related interplay between terminal year (2023) selectivity, retention, discard mortality (constant at 0.30), along with the fraction of fish kept, dead and discarded (2024, b).



a)



b)

Figure 25. Time-varying retention (a) for the Rec East fleet in the SEDAR 79 Base Model and the related interplay between terminal year (2023) selectivity, retention, discard mortality (constant at 0.30), along with the fraction of fish kept, dead and discarded (2024, b).

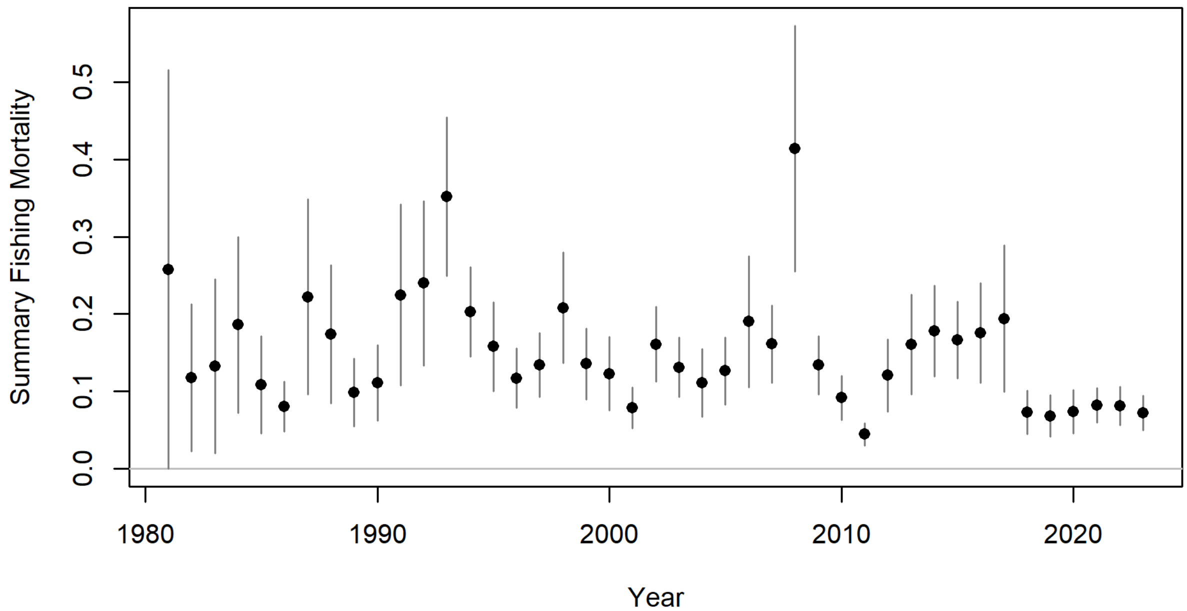


Figure 26. Annual instantaneous fishing mortality rates for age-3 Southeastern U.S. Mutton Snapper with approximate 95% confidence intervals.

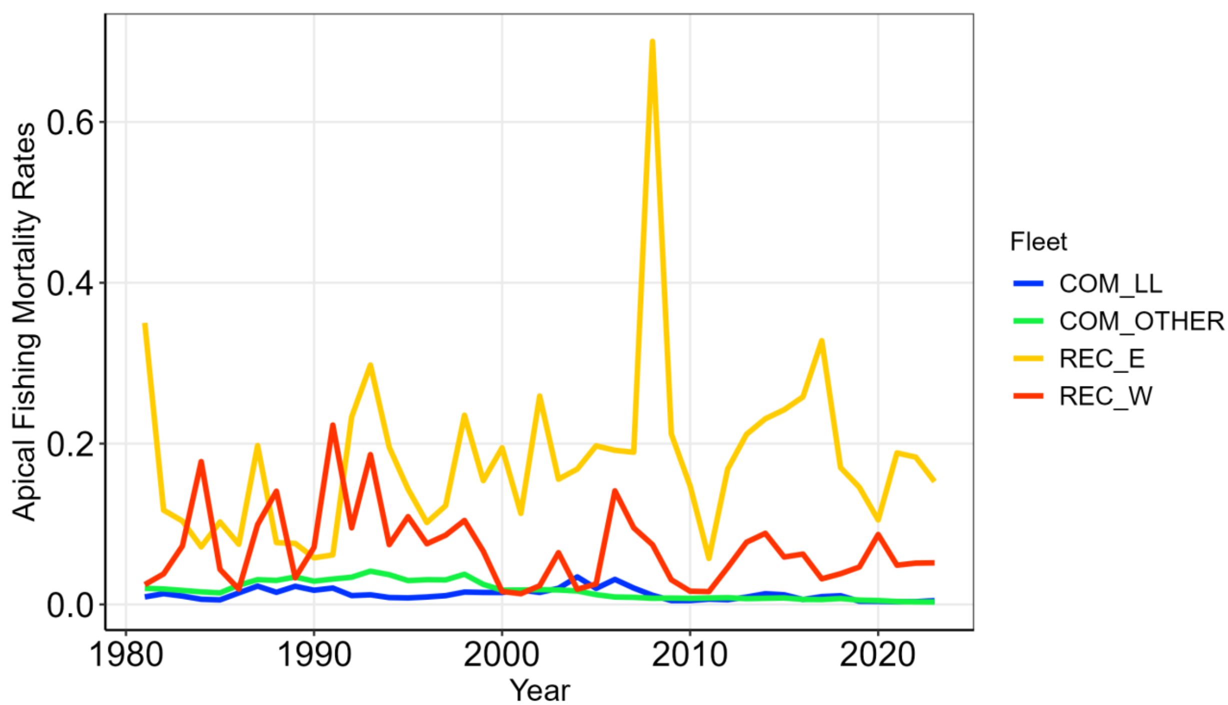


Figure 27. Annual fleet-specific instantaneous apical fishing mortality rates for Southeastern U.S. Mutton Snapper. Apical Fs represents the instantaneous fishing mortality level on the most vulnerable age class for each fleet (i.e., the age corresponding to a selectivity equal to 1).

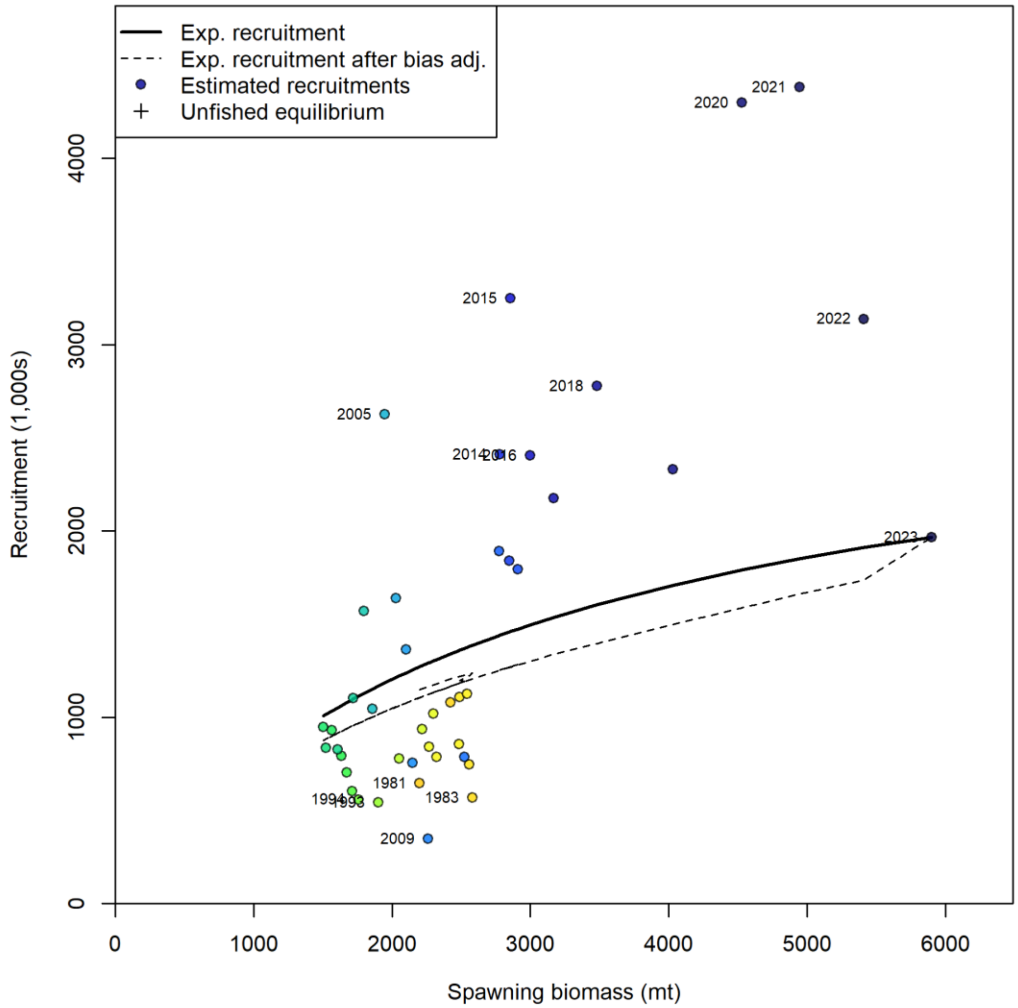


Figure 28. Expected stock-recruitment relationship for Southeastern U.S. Mutton Snapper. Steepness was estimated at 0.644 and sigmaR was estimated at 0.55. Plotted are expected annual recruitments from the SEDAR 79 Base Model (circles), expected recruitment from the stock-recruit relationship (black line), and bias adjusted recruitment from the stock-recruit relationship (dashed line). Point colors indicate year, with warmer colors indicating earlier years and cooler colors showing later years.

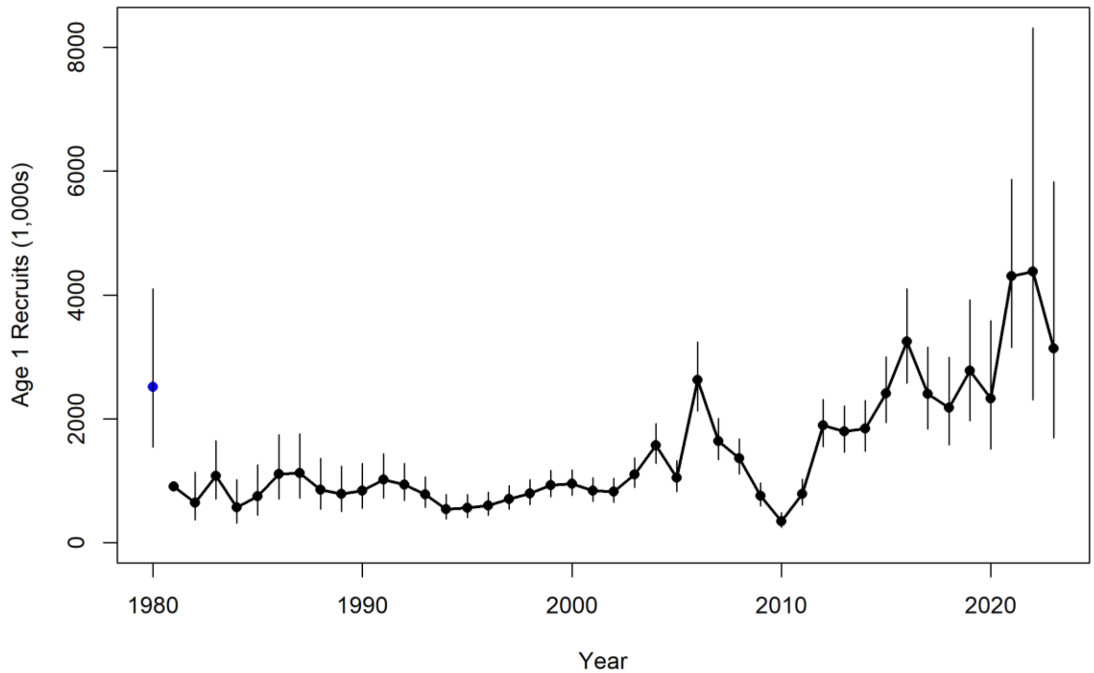


Figure 29. Estimated Age-1 recruitment (in 1,000s) with approximate 95% confidence intervals for Southeastern U.S. Mutton Snapper. Virgin recruitment is shown in blue.

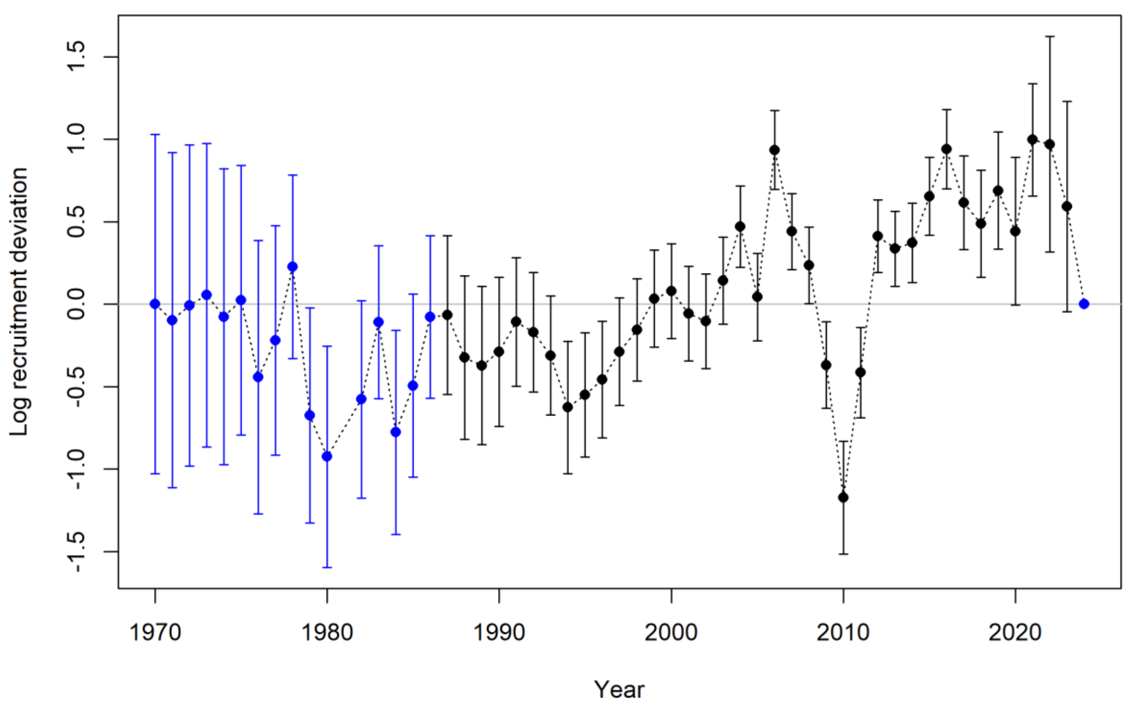


Figure 30. Estimated log-scale Age-1 recruitment deviations with 95% confidence intervals for Southeastern U.S. Mutton Snapper (steepness and SigmaR were estimated at 0.644 and 0.55, respectively). Blue dots identify early and late recruitment deviations.

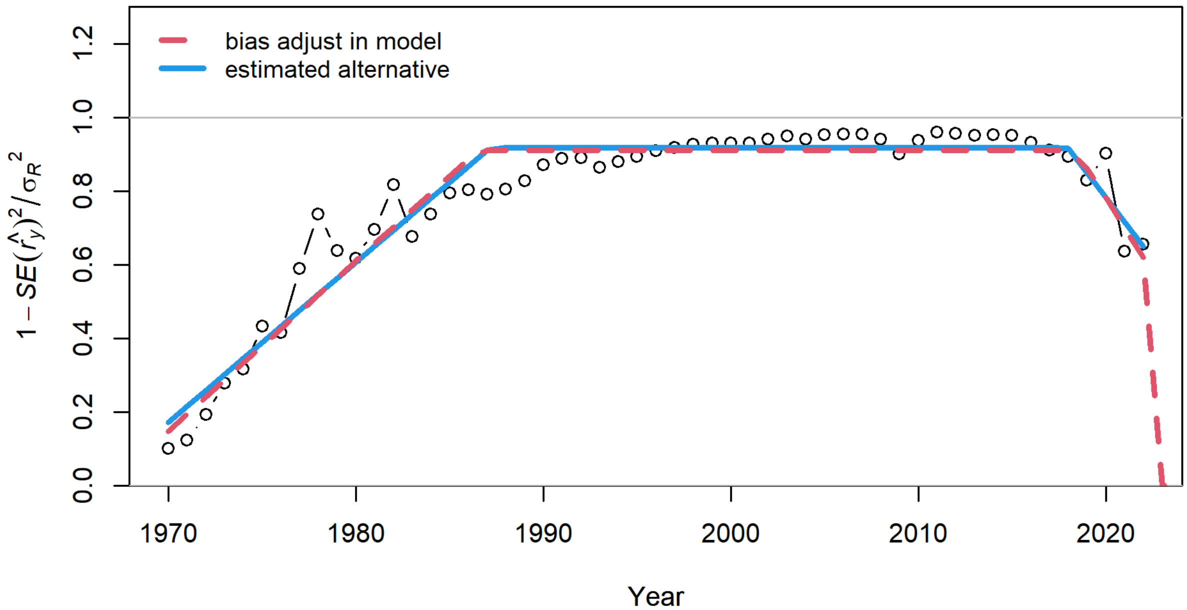


Figure 31. Points are transformed variances. Red line shows current settings for bias adjustment specified for the SEDAR 79 Base Run, which coincides with the least squares estimate of alternative bias adjustment relationship for recruitment deviations (dashed red line). For more information, see Methot and Taylor (2011).

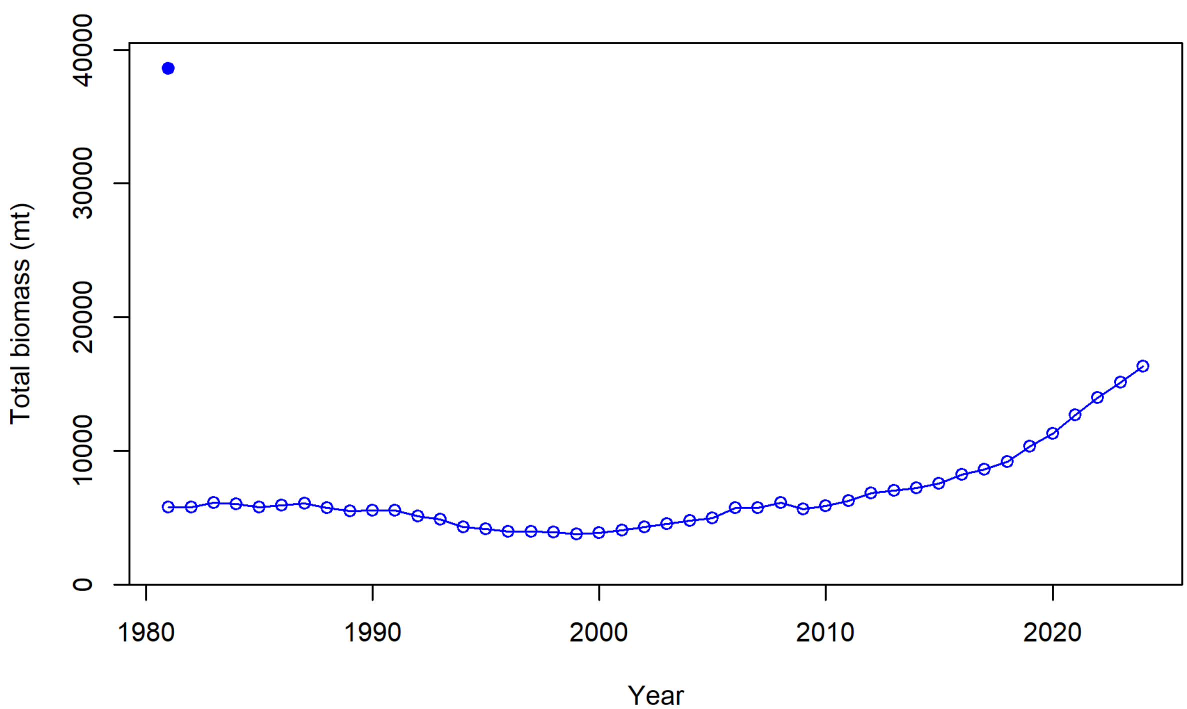


Figure 32. Estimate of total biomass (metric tons) for Southeastern U.S. Mutton Snapper. Unfished total biomass is shown by the solid blue point in 1980.

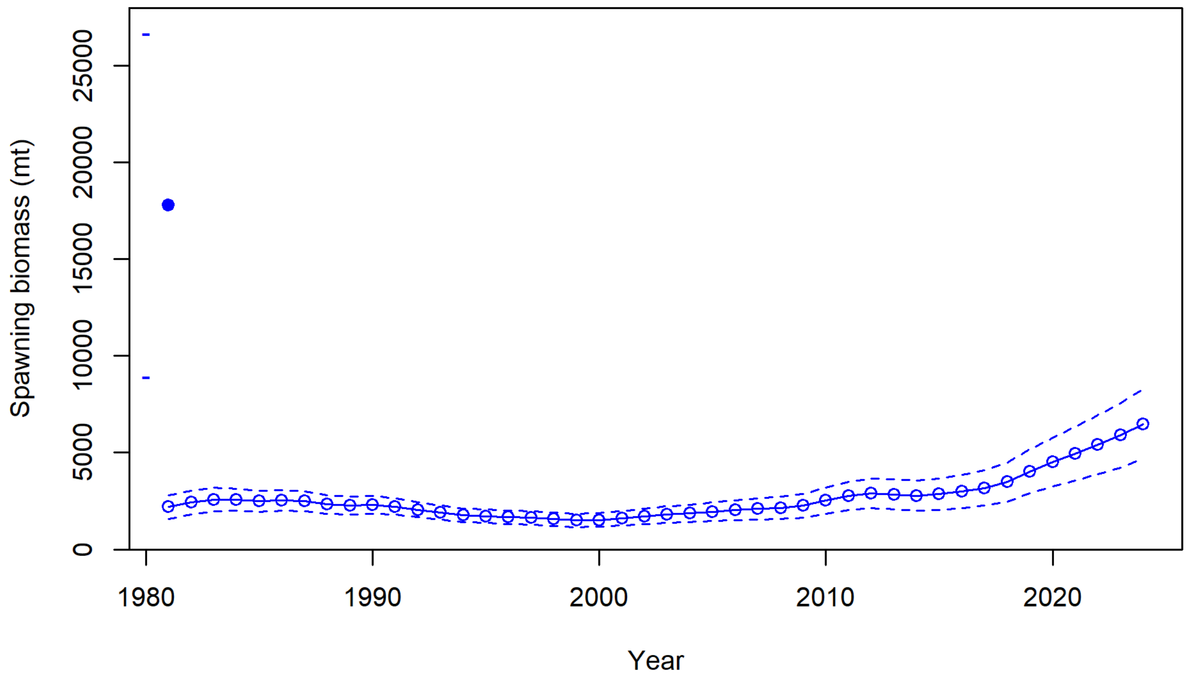


Figure 33. Estimate of female spawning stock biomass (metric tons) with approximate 95% confidence intervals for Southeastern U.S. Mutton Snapper. Unfished spawning stock biomass is shown by the solid blue point in 1980.

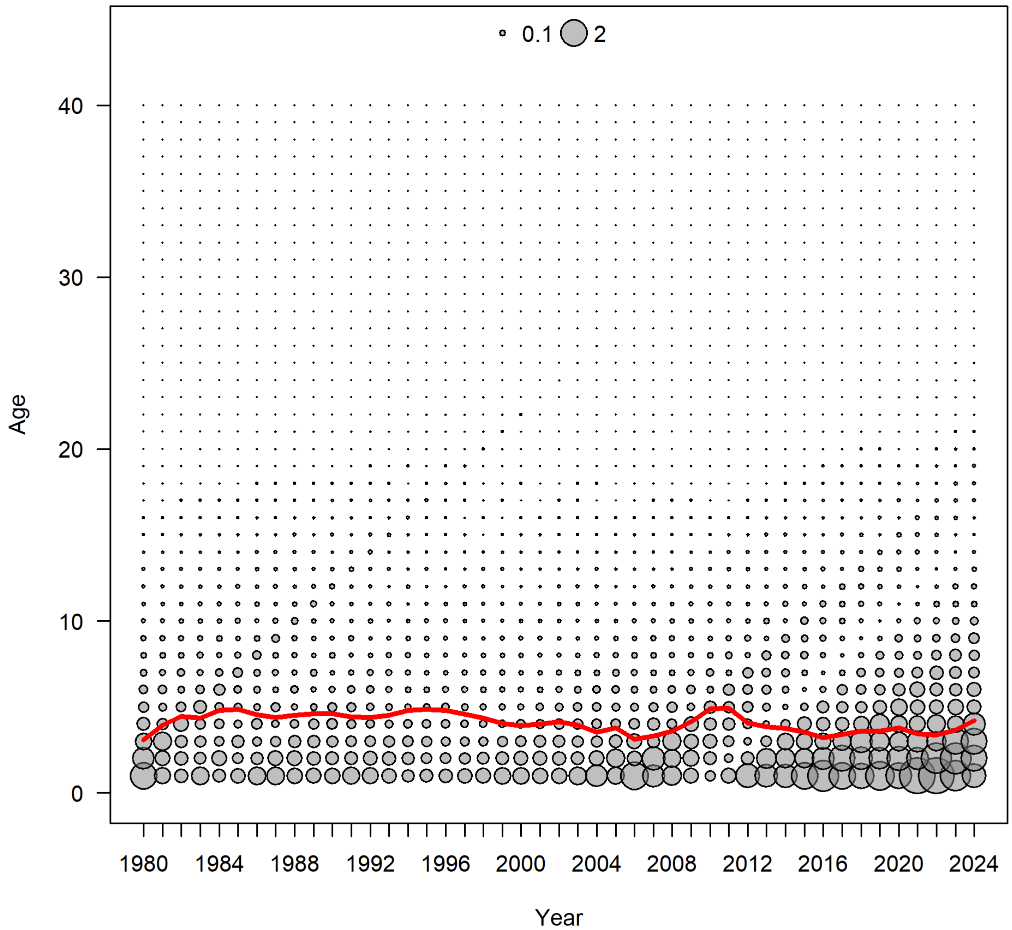


Figure 34. Expected numbers-at-age (bubbles) and mean age (red line) at the middle of the year (max ~ 3.7 million) for Southeastern U.S. Mutton Snapper.

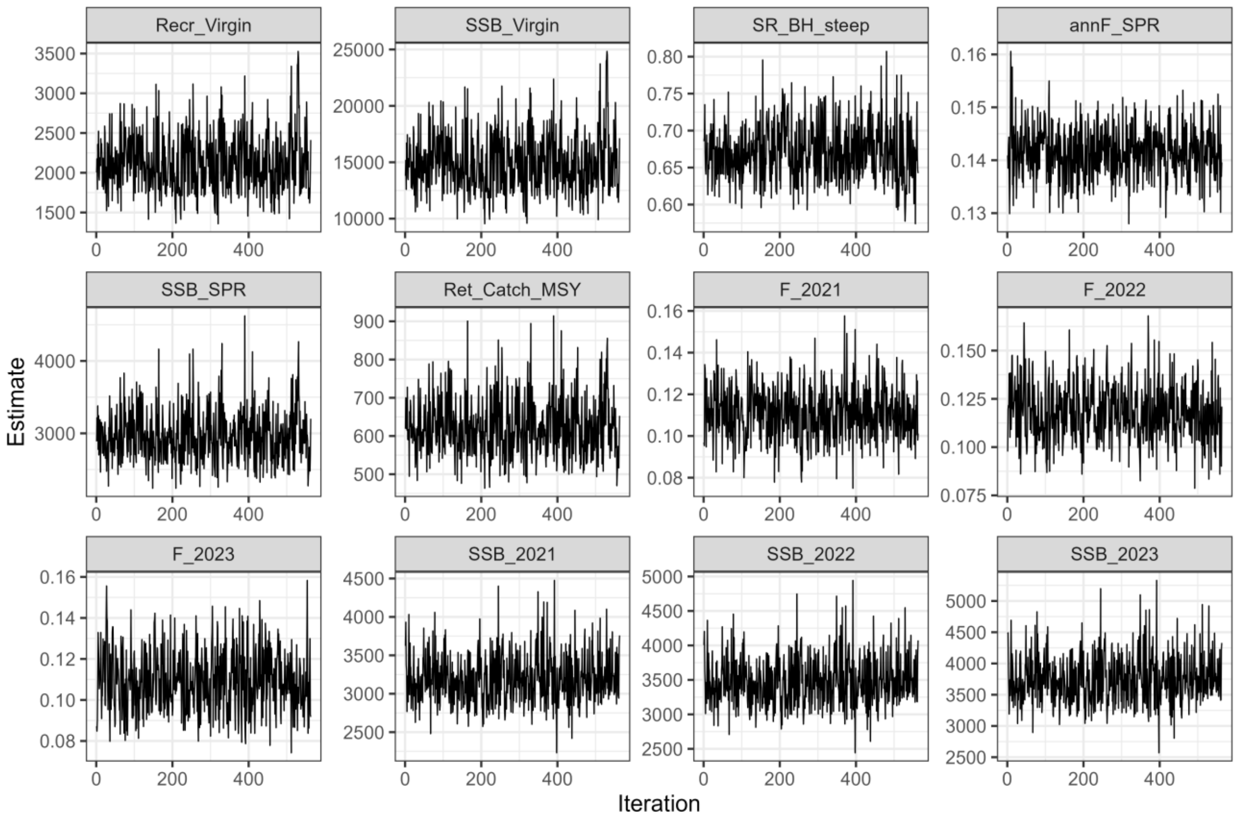


Figure 35. Traceplot of a single MCMC chain for selected parameters and derived quantities.

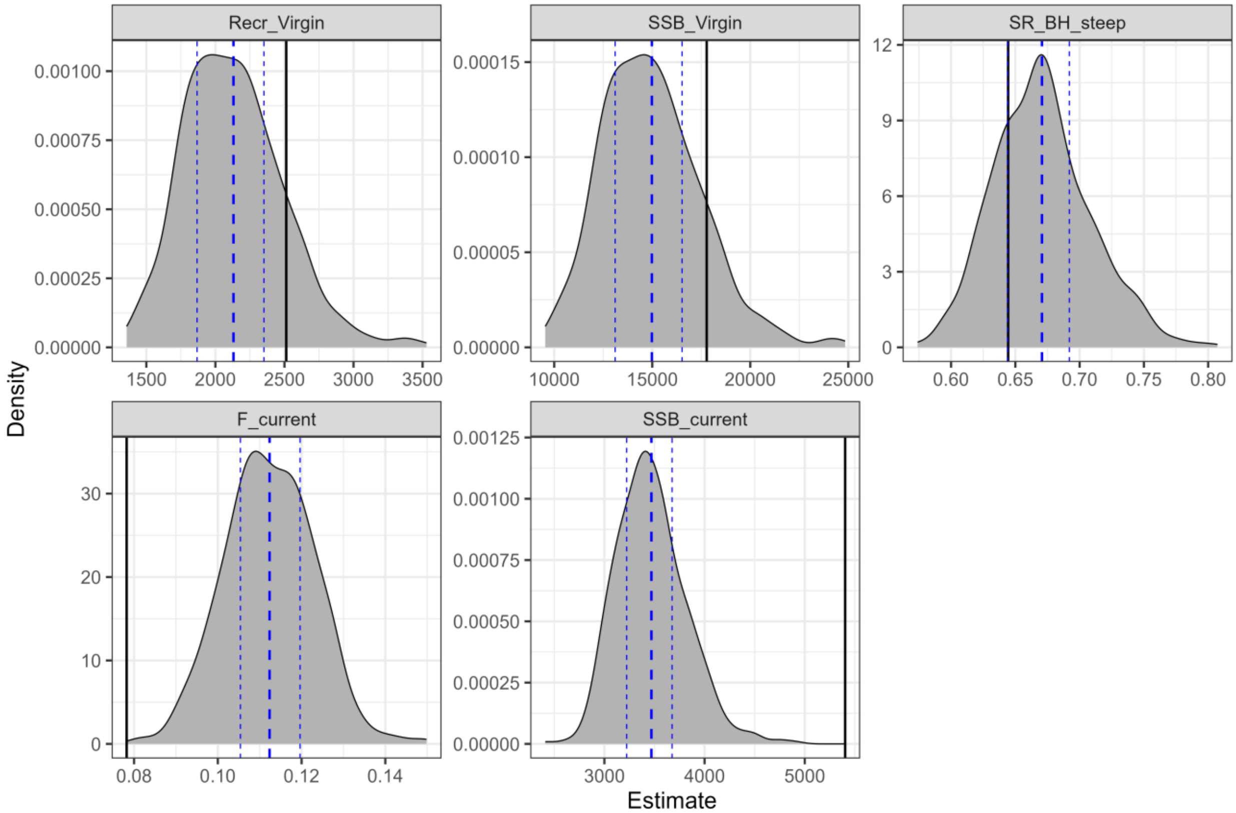


Figure 36. Posterior distribution of selected parameters and derived quantities. Blue dotted lines indicate the mean and interquartile range. SEDAR 79 Base Model run estimates are shown in black

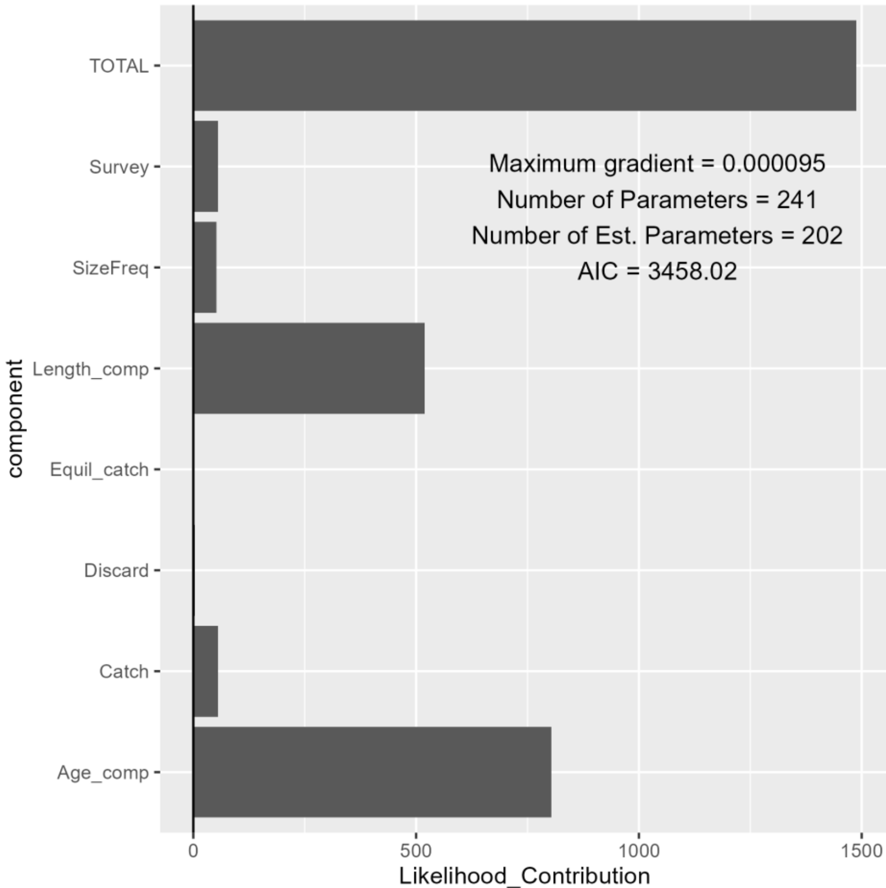


Figure 37. Magnitude of the components of the likelihood function for the SEDAR 79 Base Model.

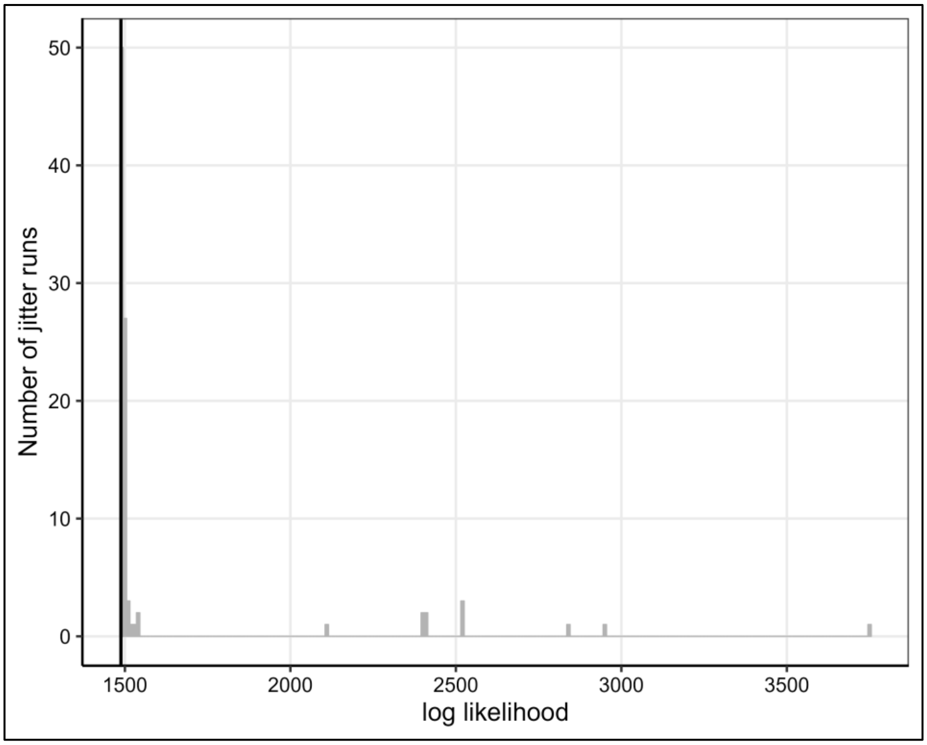


Figure 38. Histogram of log-likelihood values associated with jittered runs that had a maximum gradient < 0.05. The log-likelihood value associated with the base model is shown by the black line. No jitter run (regardless of maximum gradient) found a lower log-likelihood value than the base model.

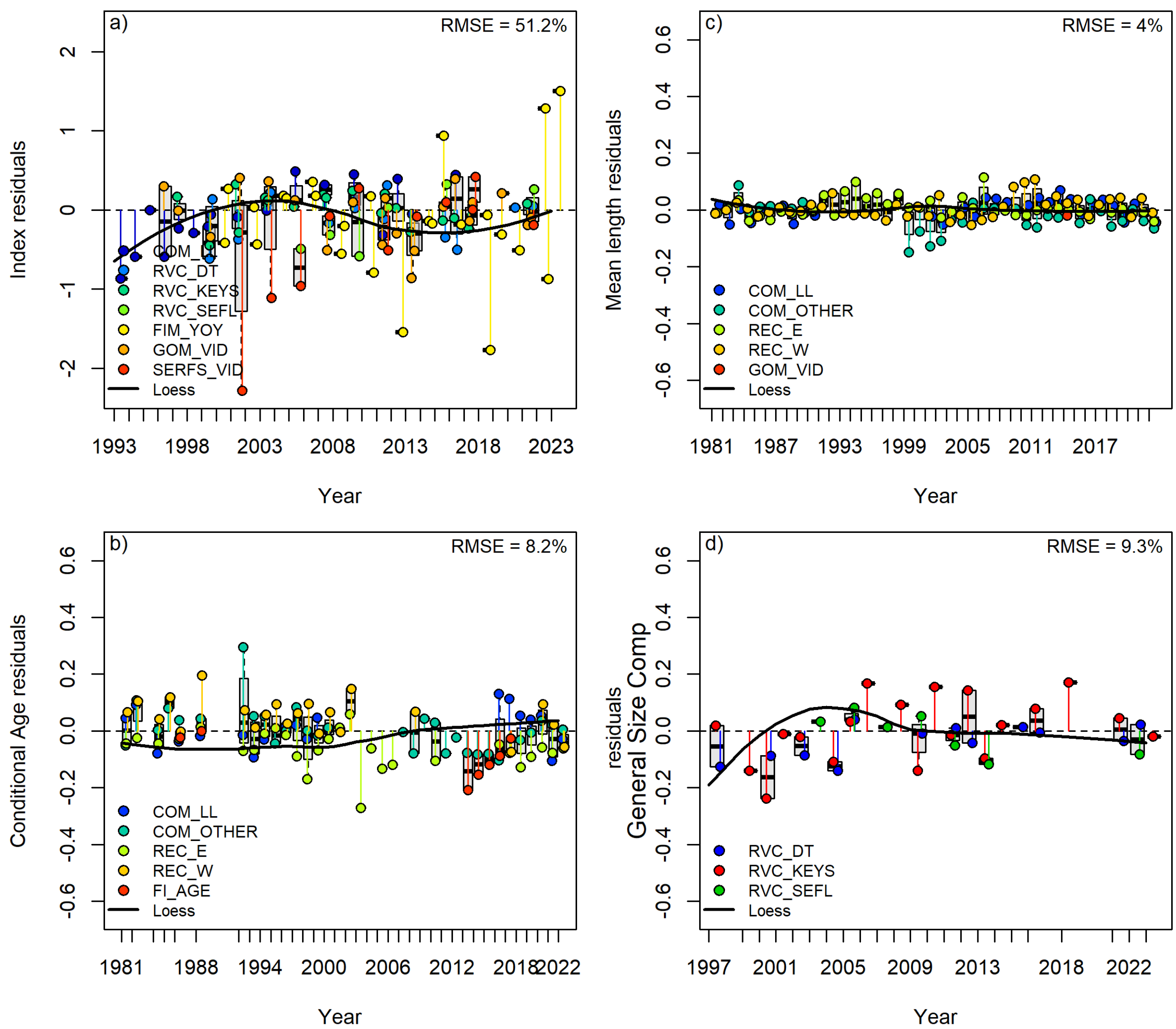


Figure 39. Joint residual plots for a) the indices of abundance, b) the annual mean length, c) annual mean conditional age, and d) annual mean general size composition (i.e., RVC lengths) estimates from the SEDAR 79 Base Model. Vertical lines with points show the residuals, boxplots show residual medians and quantiles, and solid black lines are a loess smoother. Root-mean squared errors (RMSE, as a percentage) are included in the upper right-hand corner of each plot.

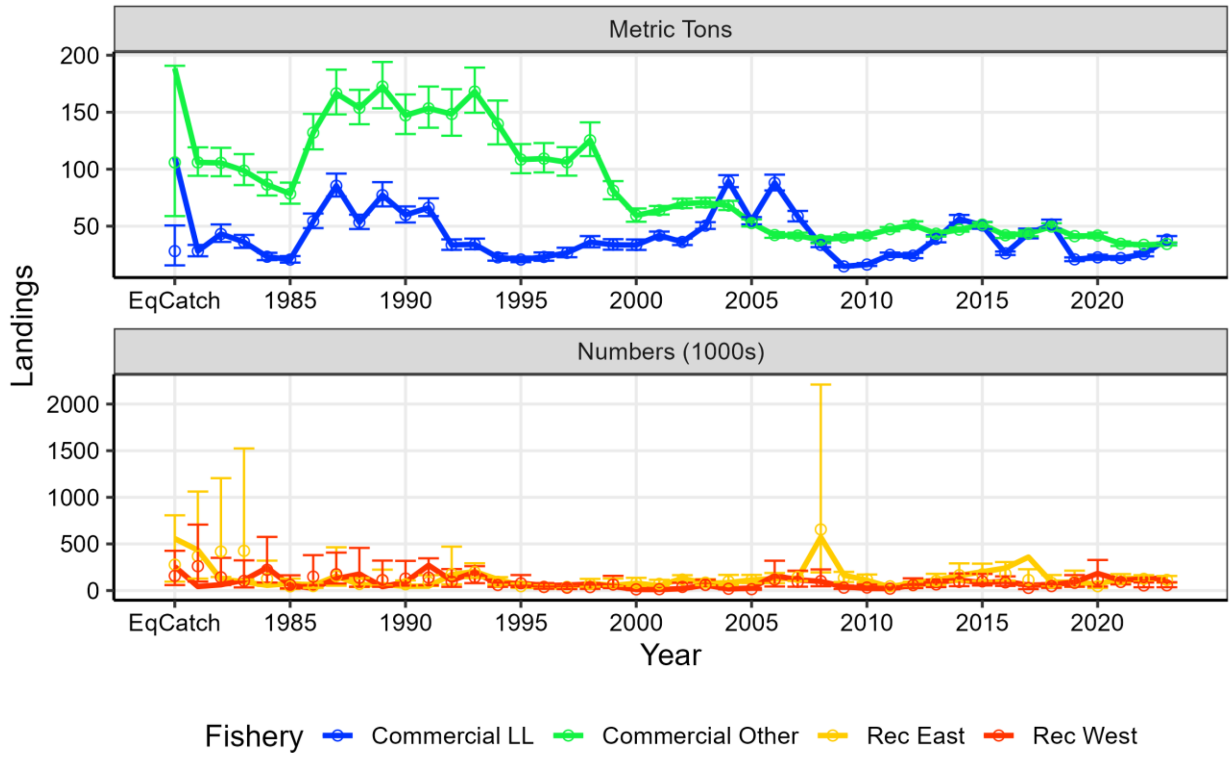


Figure 40. Observed (open circles and error bars) and predicted (solid lines) landings for the commercial fleets (in metric tons) and the recreational fleets (in 1000s) for the SEDAR 79 Base Model. Input and predicted equilibrium catch values are shown in the first year.

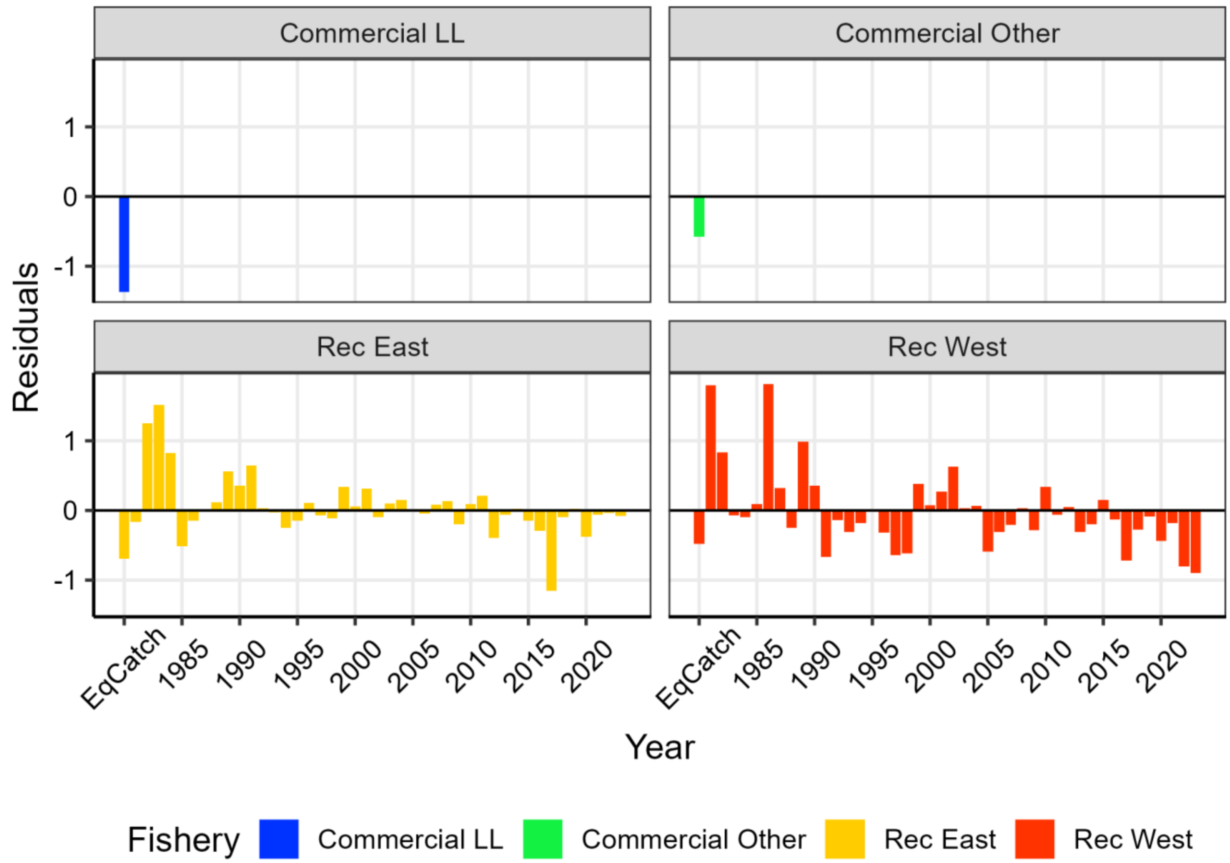


Figure 41. Residuals [log(observed) – log(predicted)] of the fit to the landings for the Commercial Longline, Commercial Other, Rec East, and Rec West fleets for the SEDAR 79 Base Model. Residuals for the equilibrium catch values are shown in the first year.

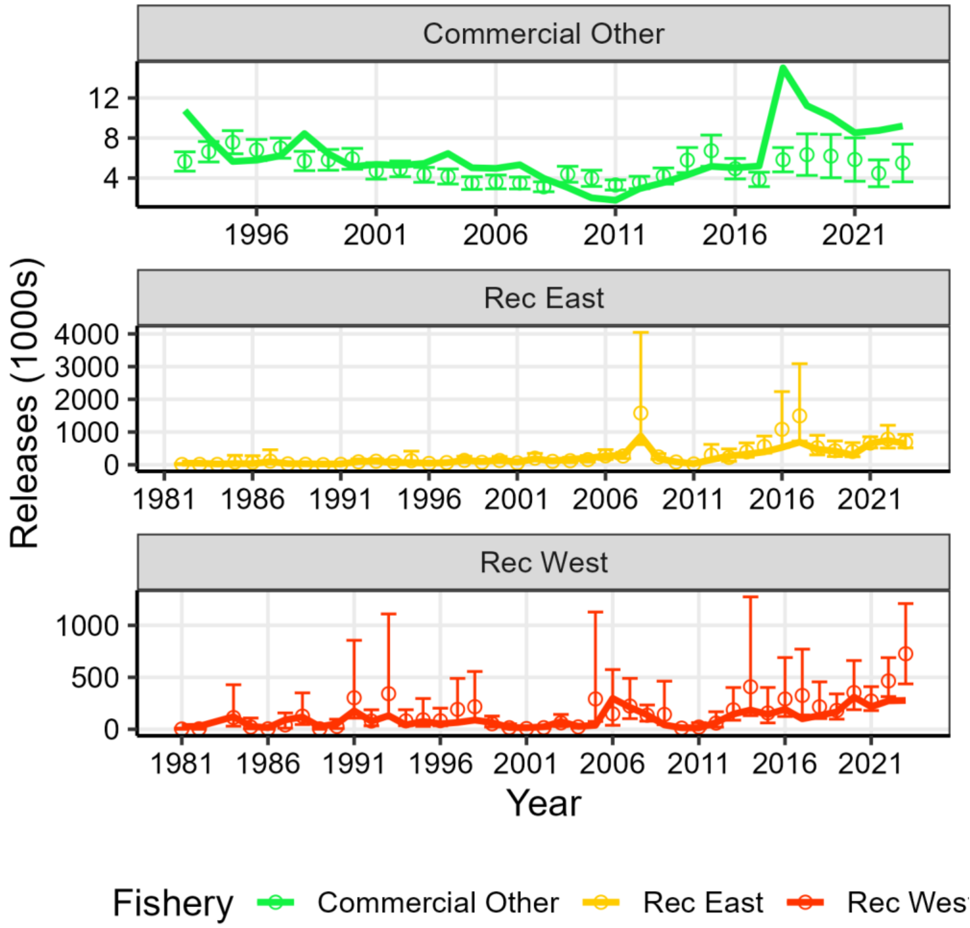


Figure 42. Observed (open circles and error bars) and predicted (solid lines) releases (in 1000s) for the Commercial Other fleet and the recreational fleets for the SEDAR 79 Base Model.

Figure 43. Residuals [log(observed) – log(predicted)] of the fit to the releases for the Commercial Other, Rec East, and Rec West fleets for the SEDAR 79 Base Model.

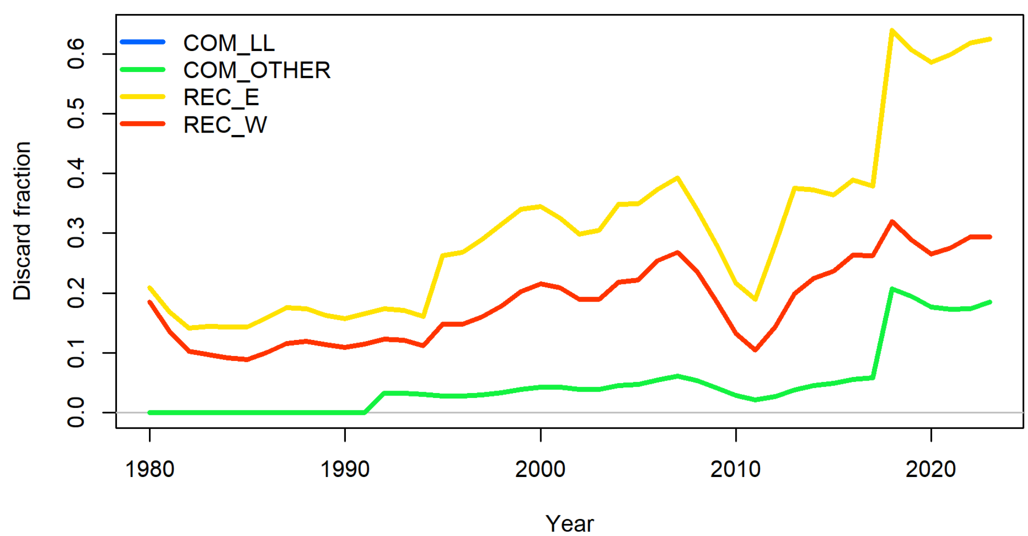
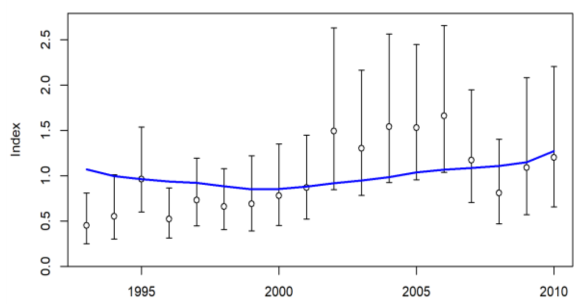
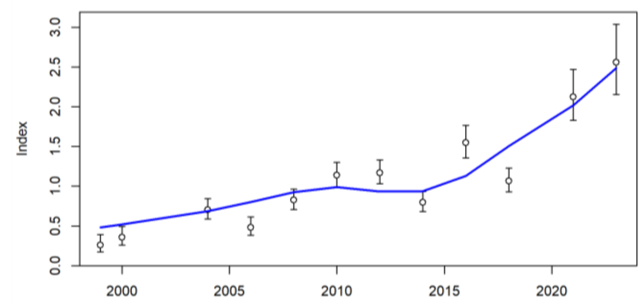


Figure 44. Estimated discard fractions for the Commercial Other, Rec East, and Rec West fleets by the SEDAR 79 Base Model.

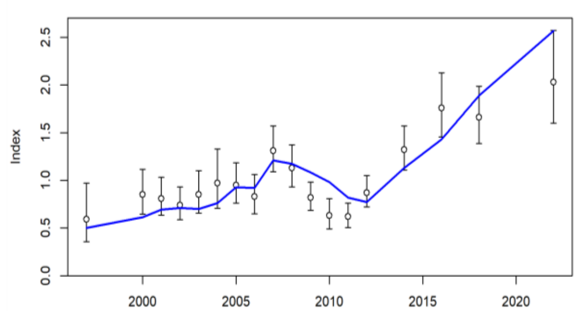
a) Commercial Longline



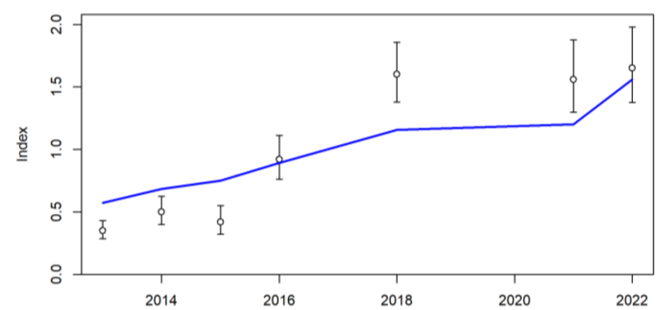
b) RVC Dry Tortugas



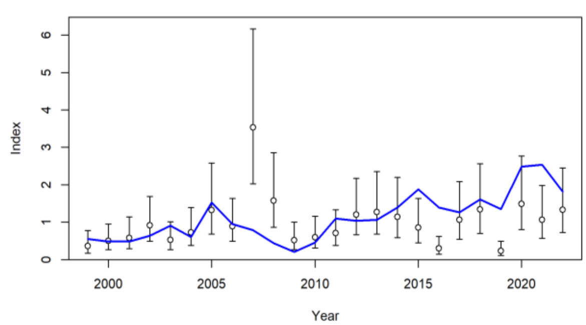
c) RVC FL Keys



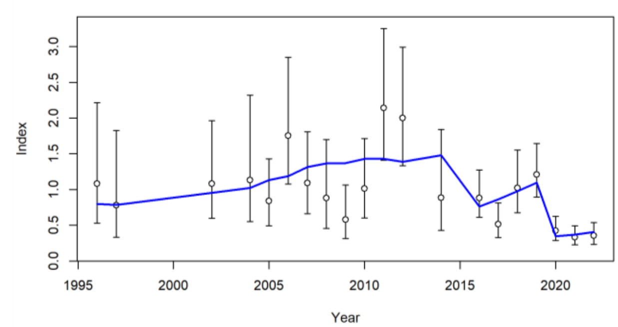
d) RVC SE FL



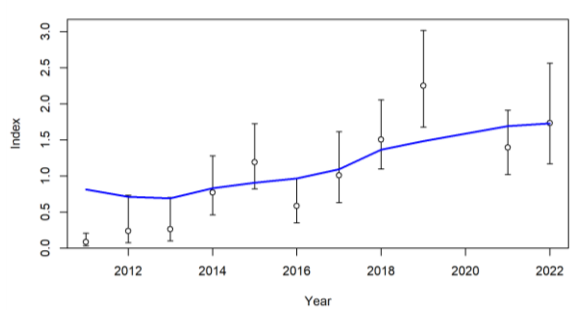
e) FIM YOY



f) Gulf Combined Video



g) SERFS Video



h) Gulf Combined Video Catchability

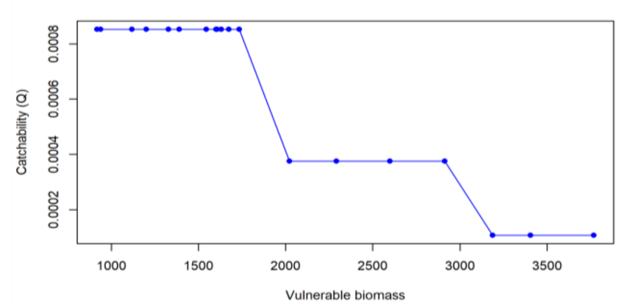


Figure 45. Observed (open circles and error bars) and predicted (solid lines) indices of abundance for the SEDAR 79 Base Model. Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Also shown are estimated catchability coefficients for the Gulf Combined Vido Index (**h**).

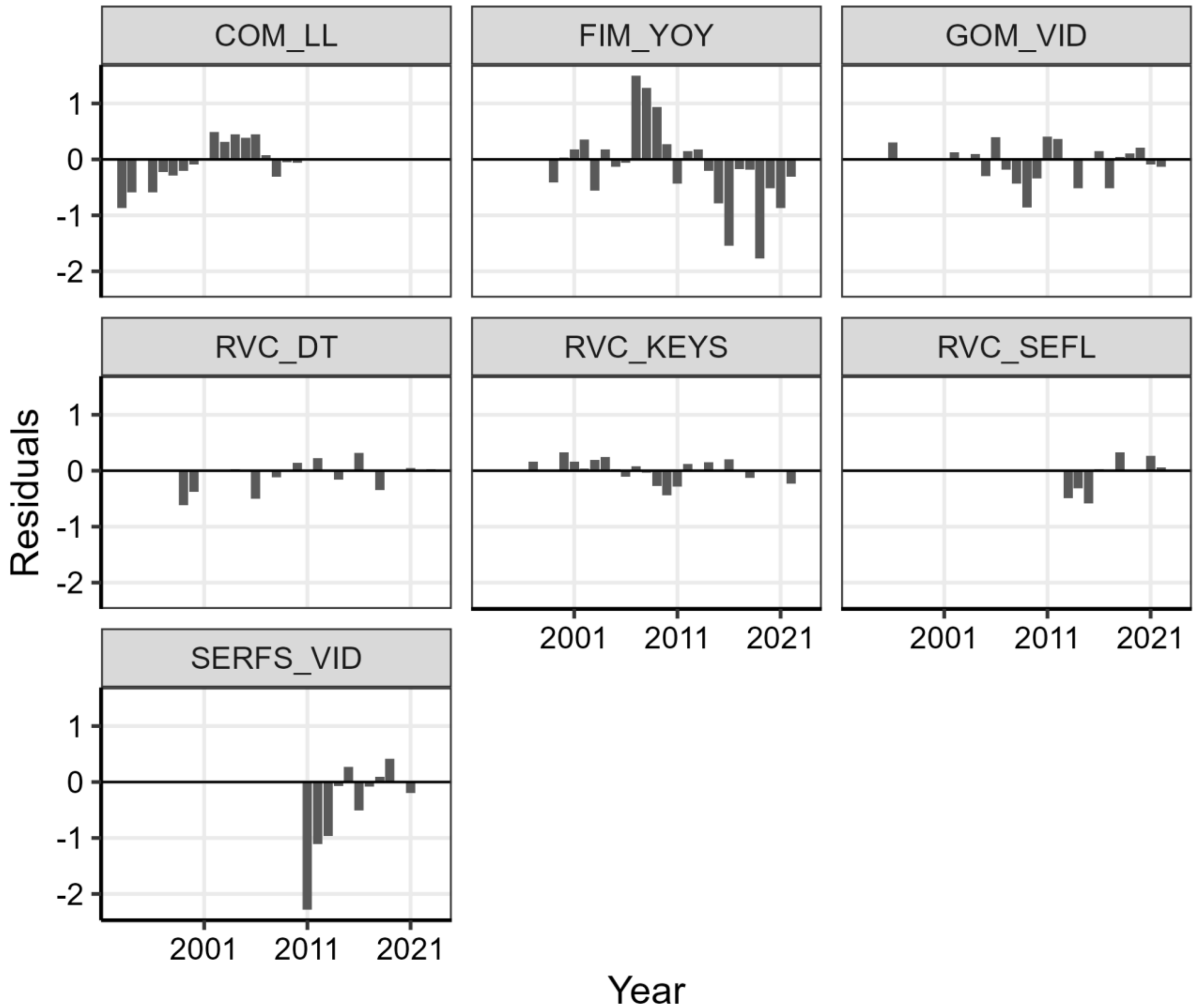


Figure 46. Residuals [log(observed) – log(predicted)] of the fit to the indices of abundance for the SEDAR 79 Base Model.

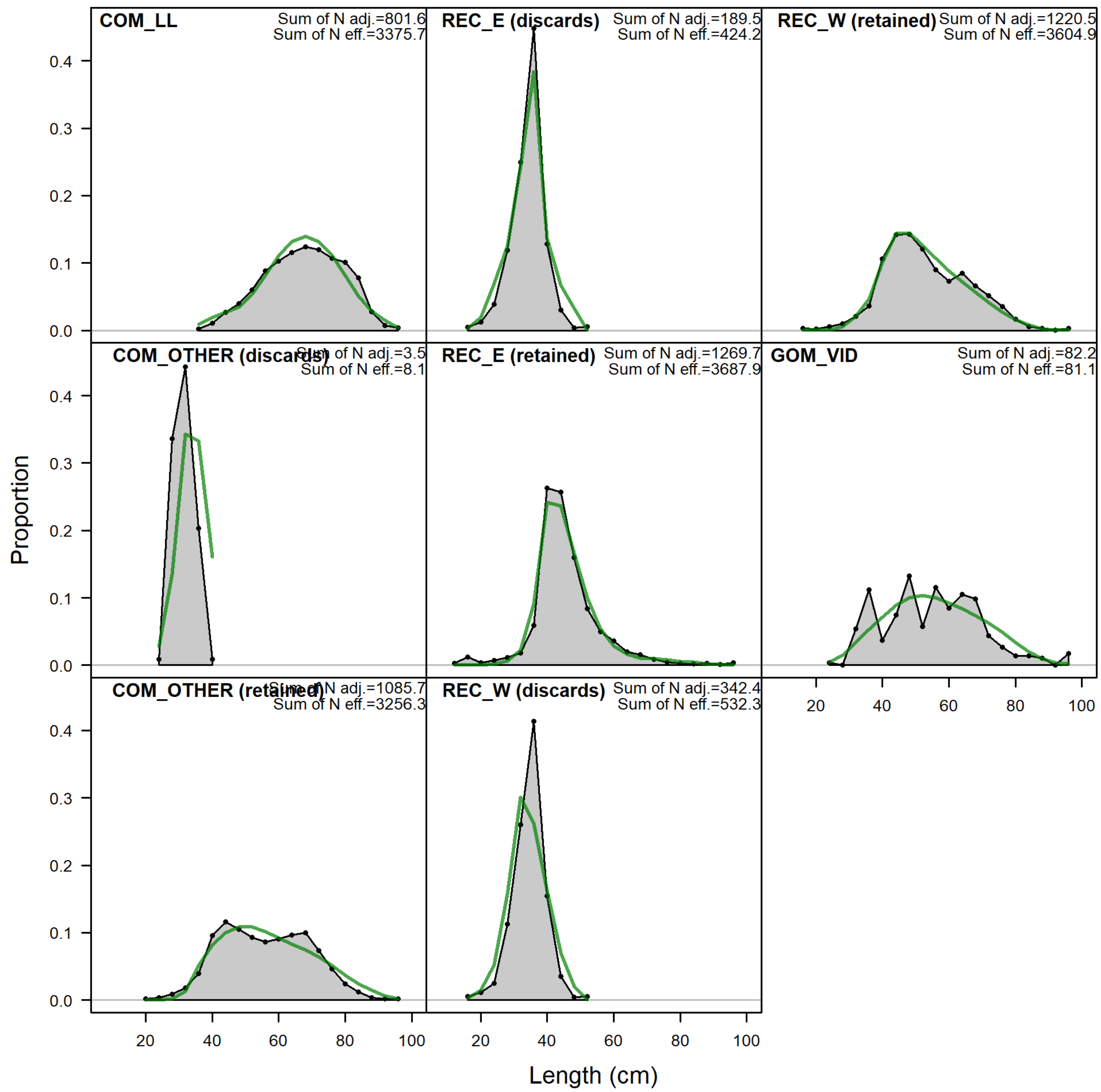


Figure 47. Model fits to the length composition (4 cm Max TL binwidth) of discarded (i.e., released) or retained catch aggregated across years within a given fleet or survey for Southeastern U.S. Mutton Snapper. Green lines represent expected length compositions, while grey shaded regions represent observed length compositions. 'N adj.' is the input sample size after data-weighting adjustment. ‘N eff.’ is the calculated effective sample size used in the McAllister-Ianelli tuning method. Abbreviations include: Commercial Longline (COM_LL), Commercial Other (COM_OTH), Recreational East (REC_E), Recreational West (REC_W), and Gulf Combined Video (GOM_VID).

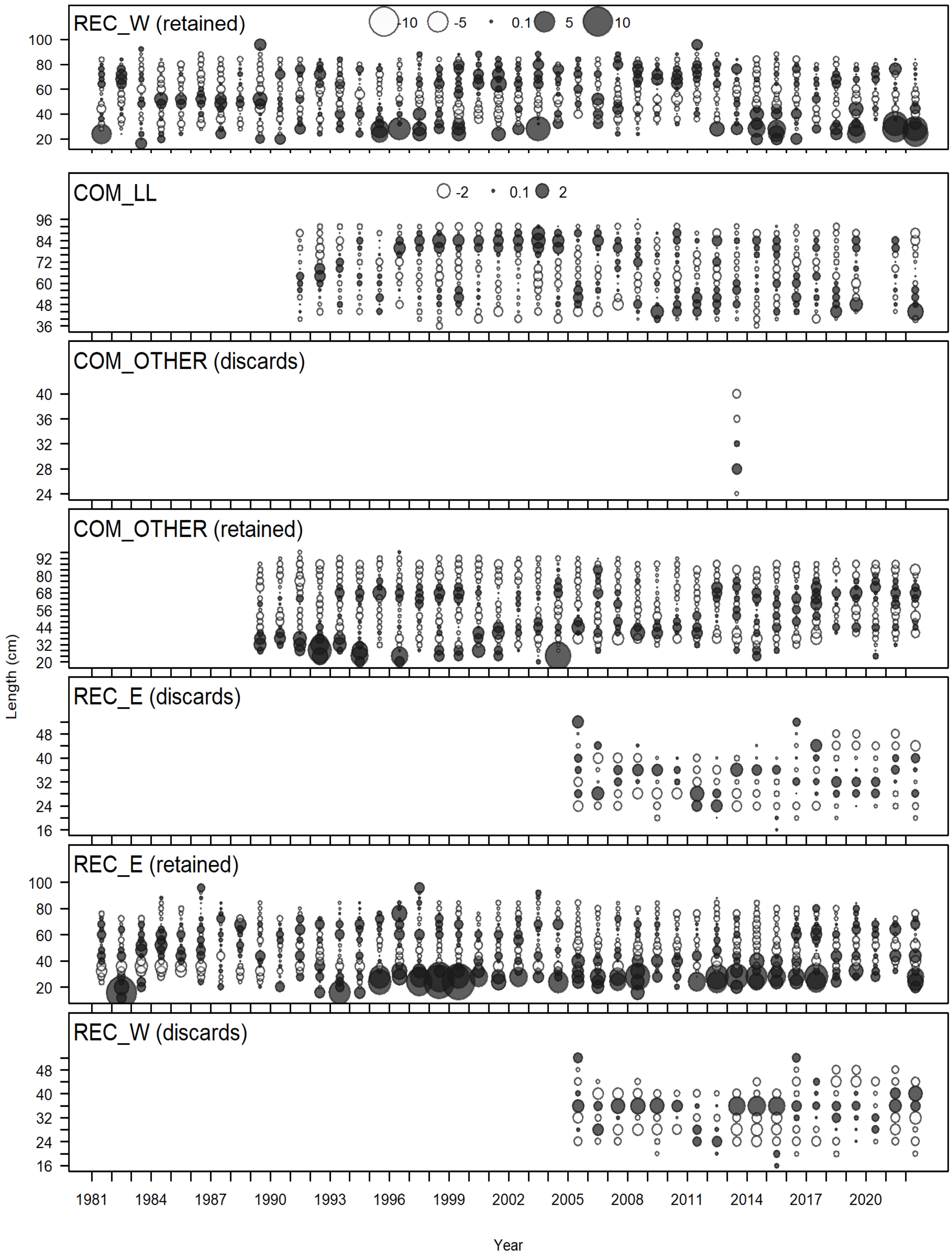


Figure 48. Pearson residuals for retained and discarded length compositions of Southeastern US Mutton Snapper by fleet for SEDAR 79. Closed bubbles are positive residuals (observed > expected), and open bubbles are negative residuals (observed < expected).

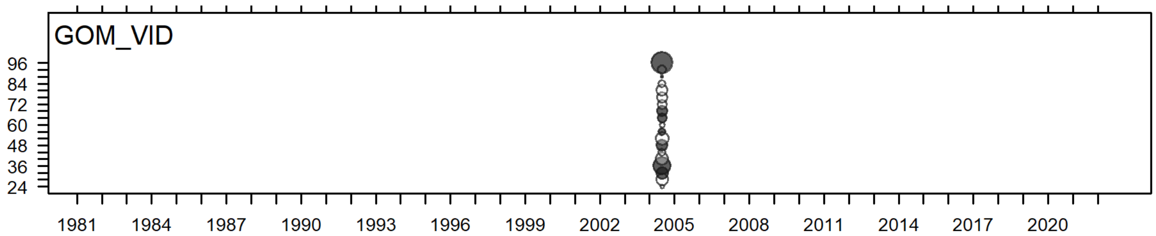


Figure 49. Pearson residuals for Gulf Combined Video length compositions of Southeastern US Mutton Snapper for SEDAR 79. Closed bubbles are positive residuals (observed > expected), and open bubbles are negative residuals (observed < expected).

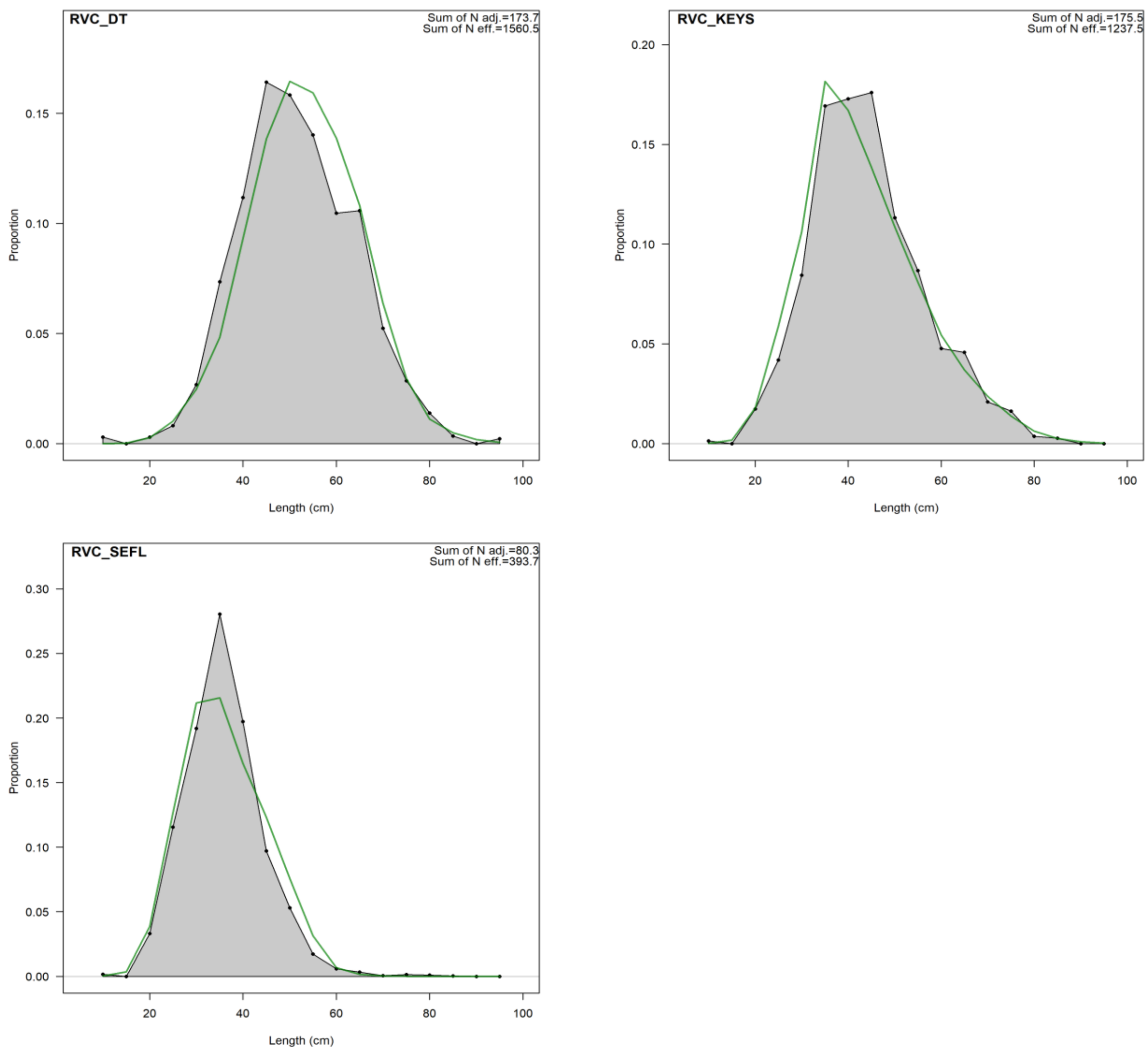


Figure 50. Model fits to the length composition (5 cm Max TL bin width) aggregated across years within RVC surveys for Southeastern U.S. Mutton Snapper. Green lines represent expected length compositions, while grey shaded regions represent observed length compositions. 'N adj.' is the input sample size after data-weighting adjustment.

a) RVC Dry Tortugas

b) RVC FL Keys

c) RVC SE FL

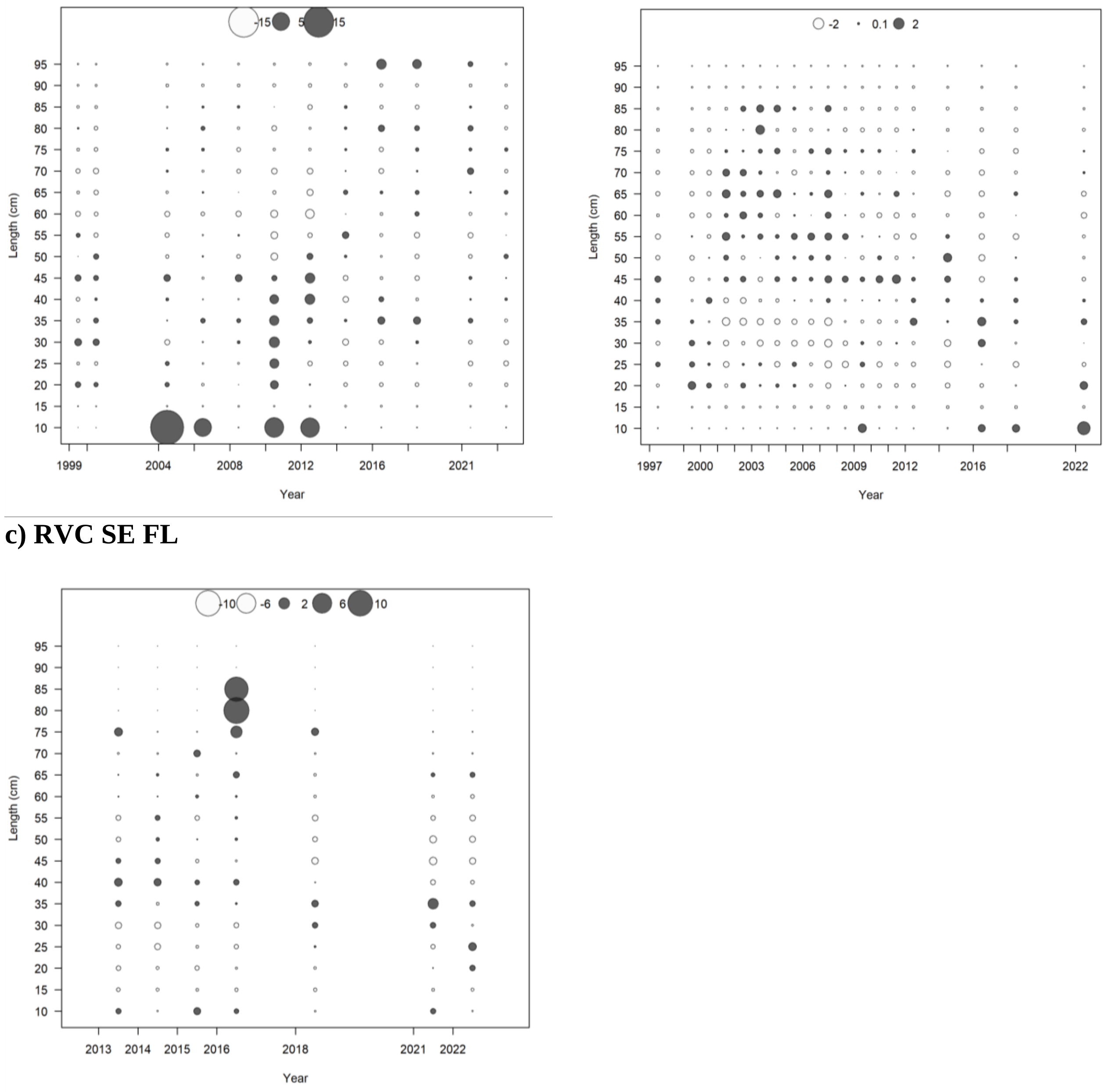
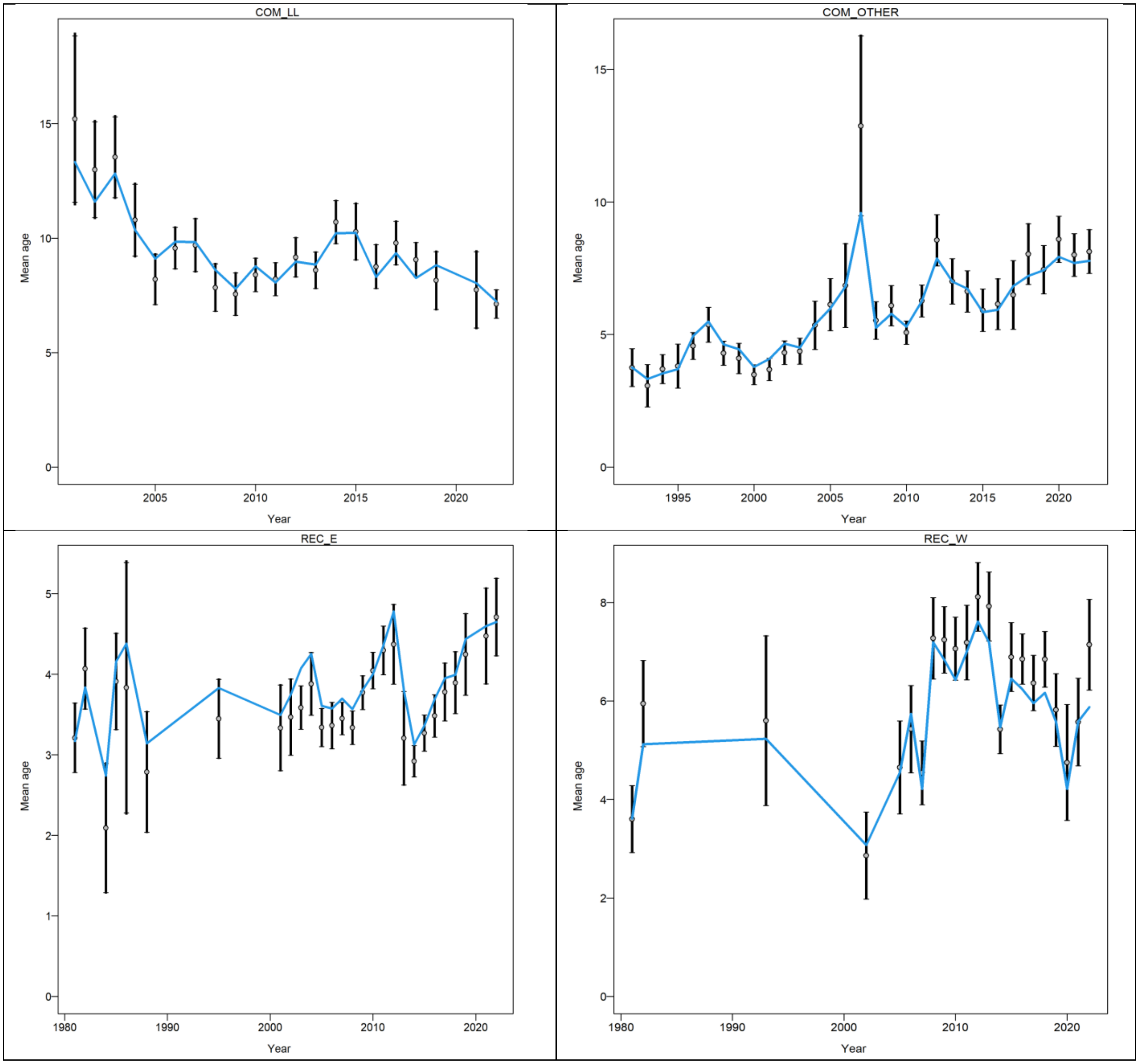


Figure 51. Pearson residuals for RVC length compositions (5 cm MaxTL bin width) of Southeastern US Mutton Snapper by fleet for SEDAR 79. Closed bubbles are positive residuals (observed > expected), and open bubbles are negative residuals (observed < expected).



COM_LL
COM_OTHER
REC_E
REC_W
Mean age
Year

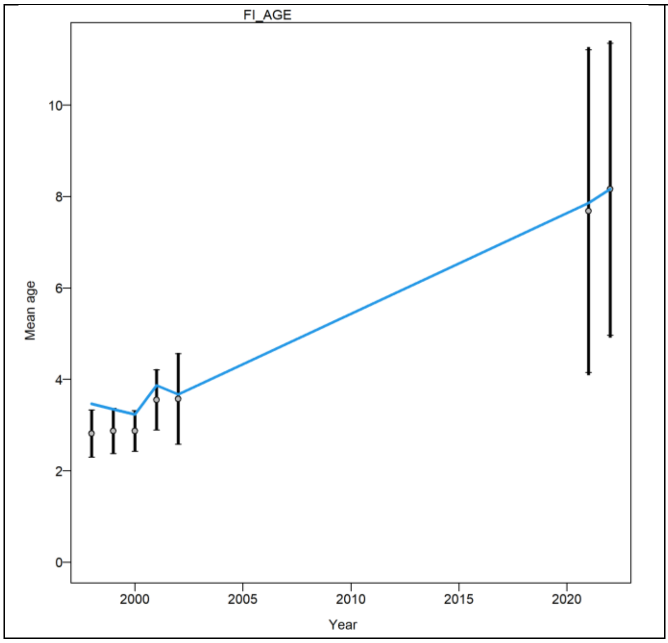


Figure 52. Mean ages of Southeastern U.S. Mutton Snapper from conditional age-at-length data aggregated across length bins for each fleet and the fishery-independent data source (observed --dots with 95% confidence intervals and predicted --black line).

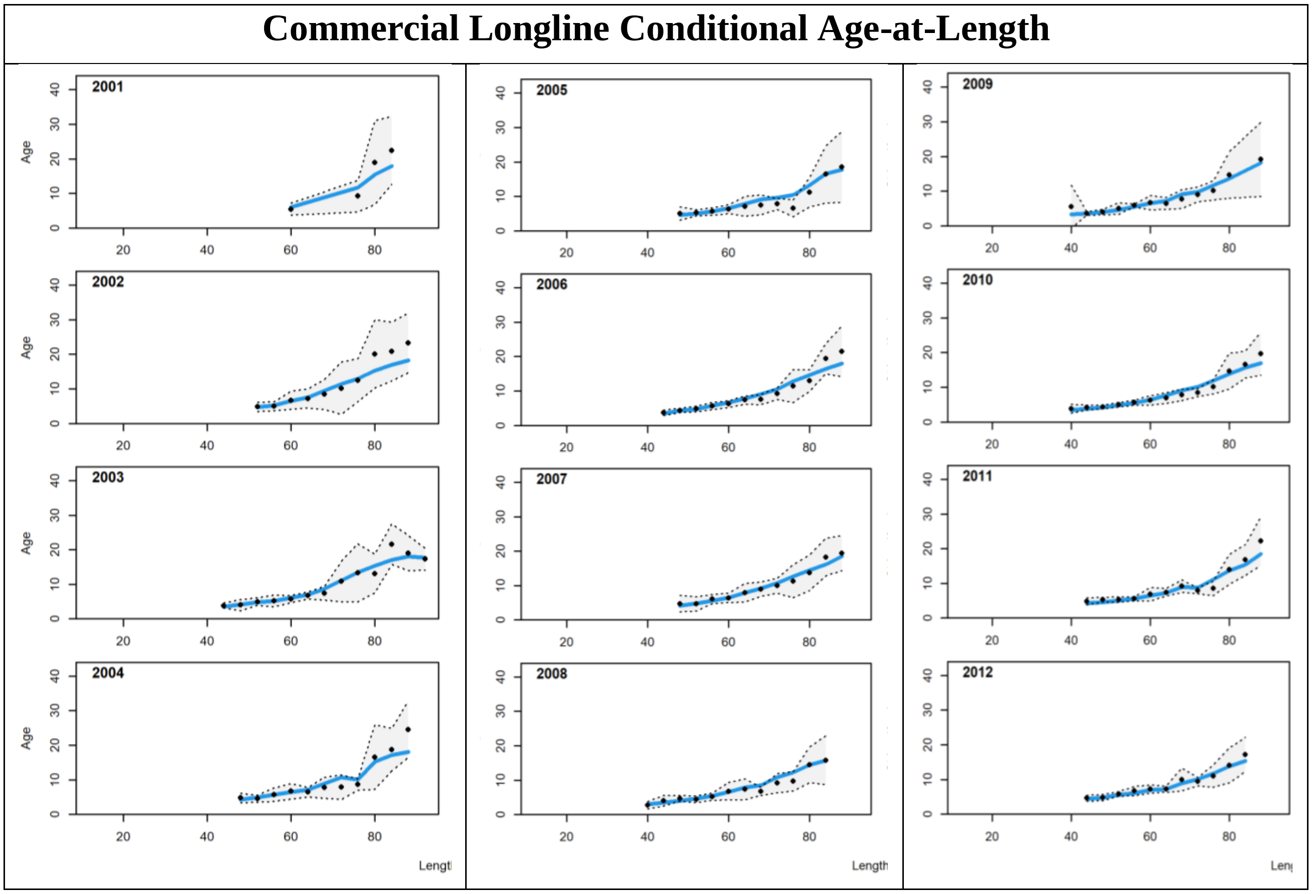


Figure 53. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Commercial Longline fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

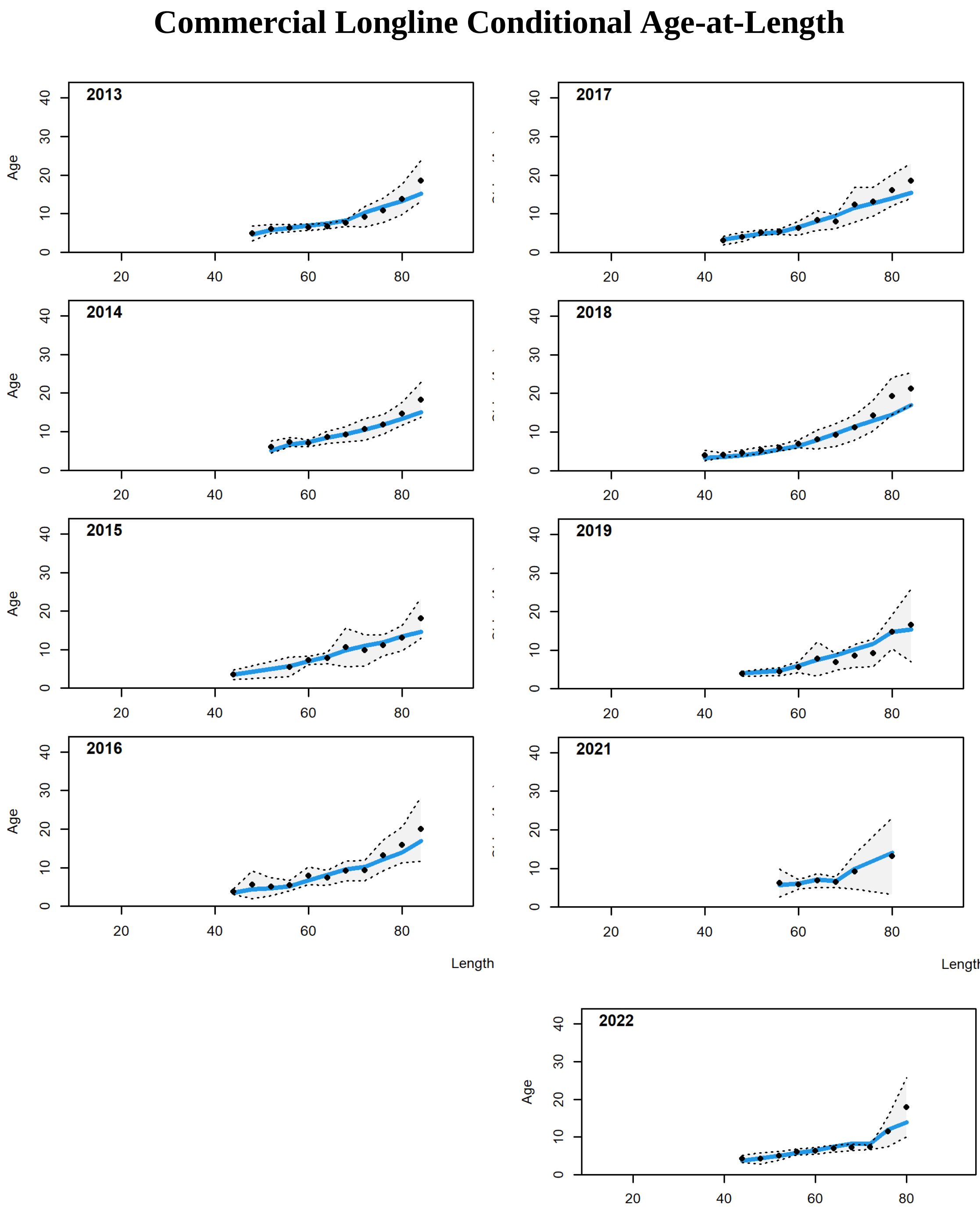


Figure 53 continued. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Commercial Longline fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

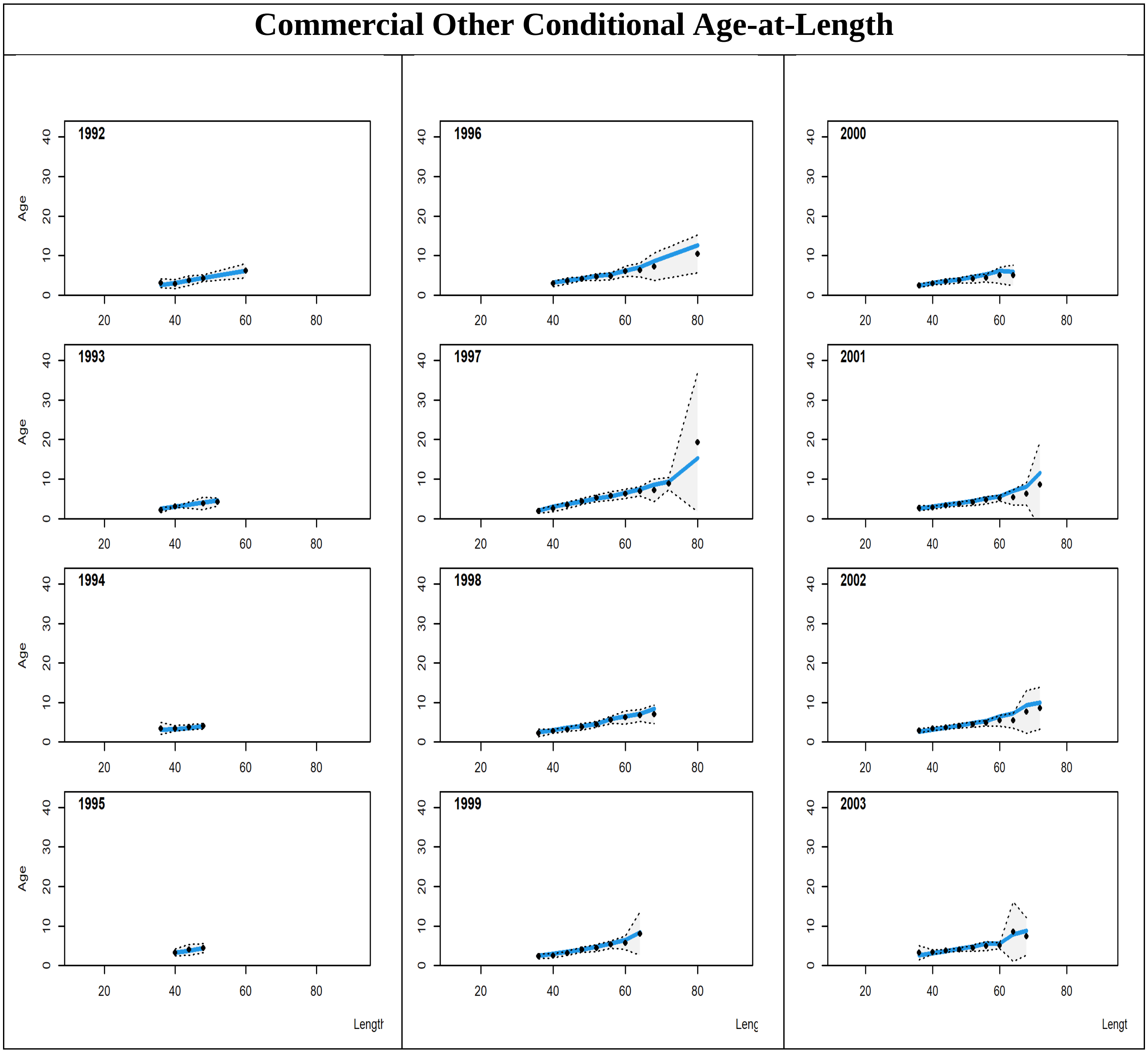


Figure 54. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Commercial Other fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

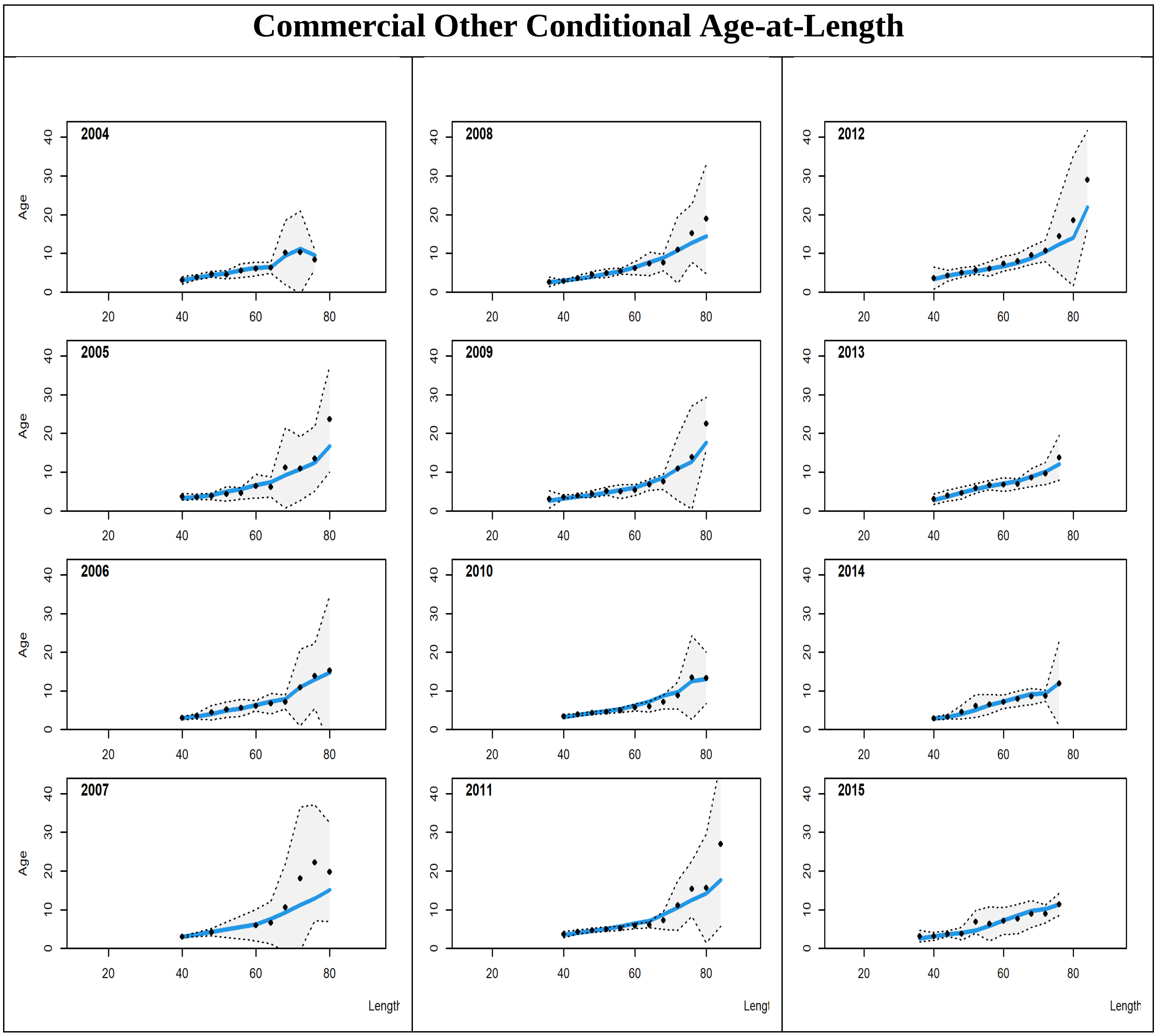


Figure 54 continued. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Commercial Other fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

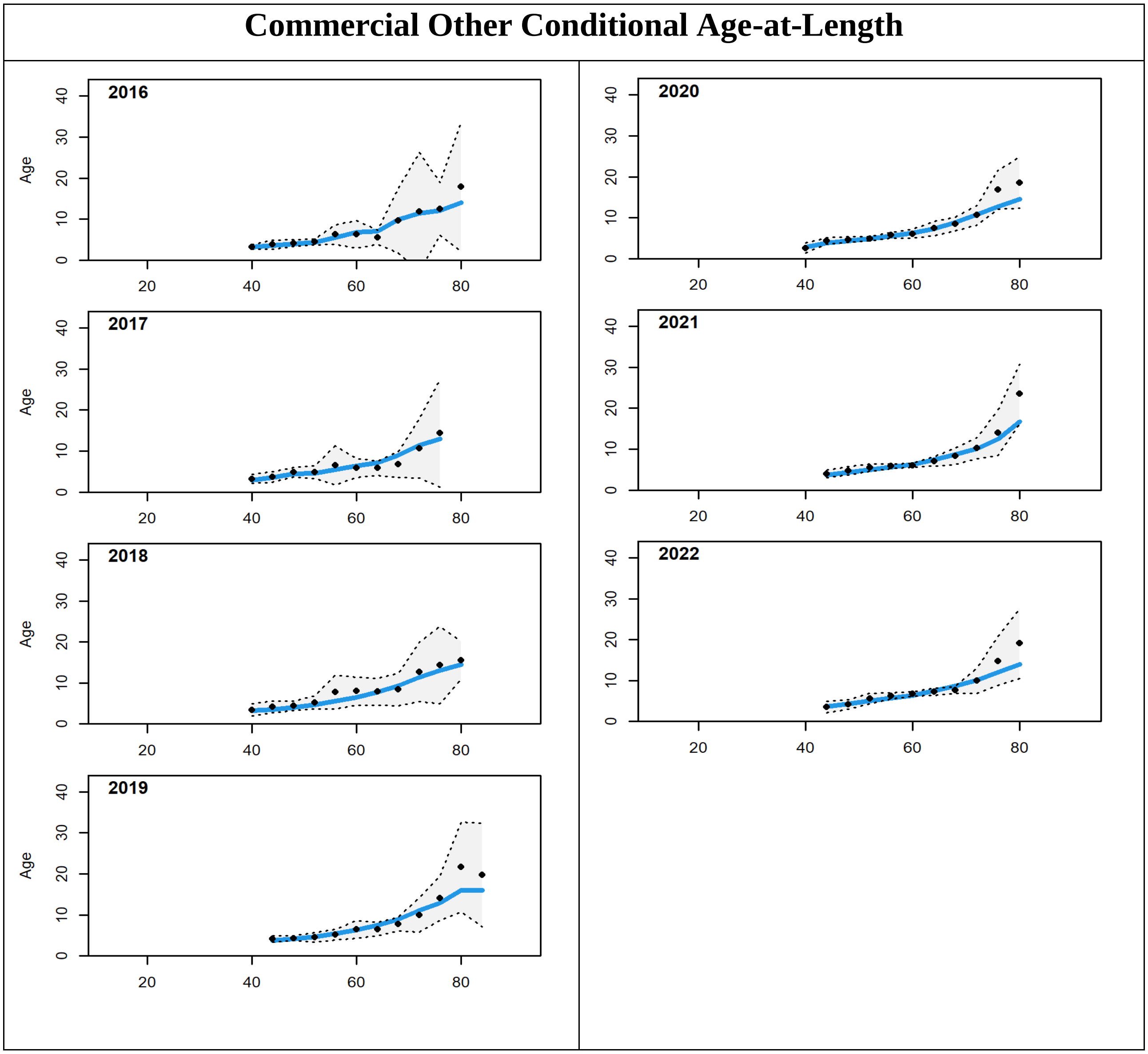


Figure 54 continued. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Commercial Other fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

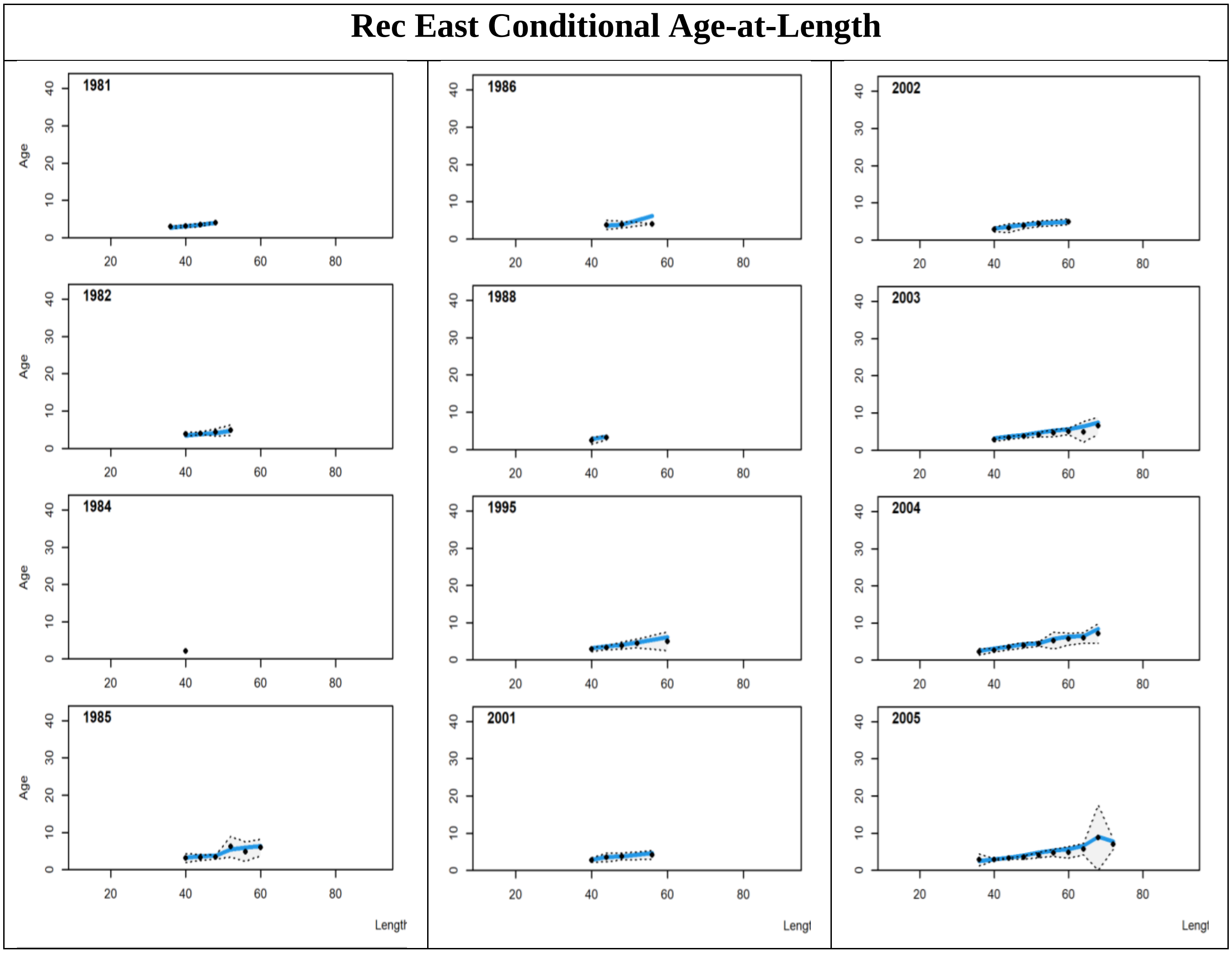


Figure 55. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Recreational East fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

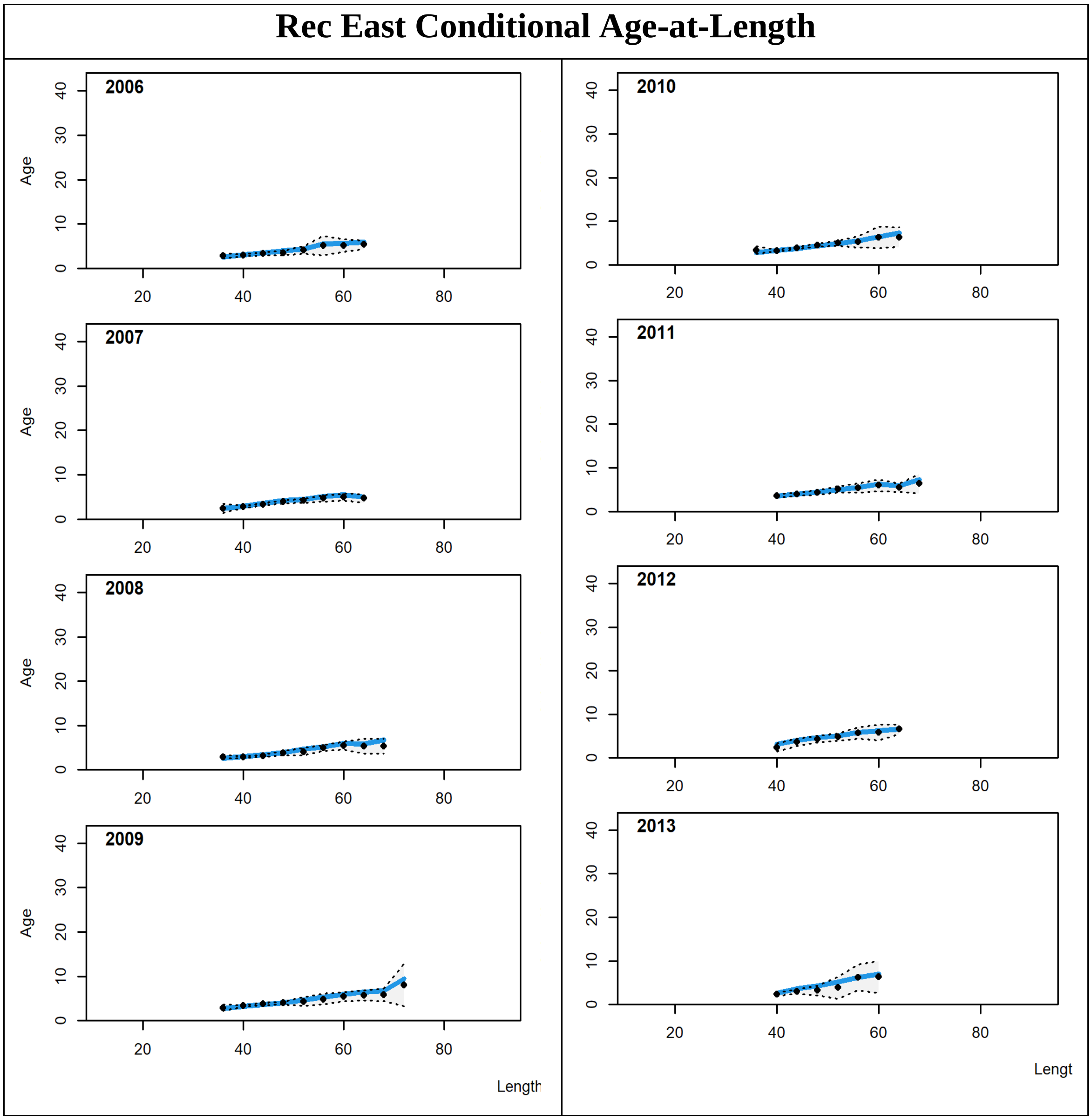


Figure 55 continued. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Recreational East fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

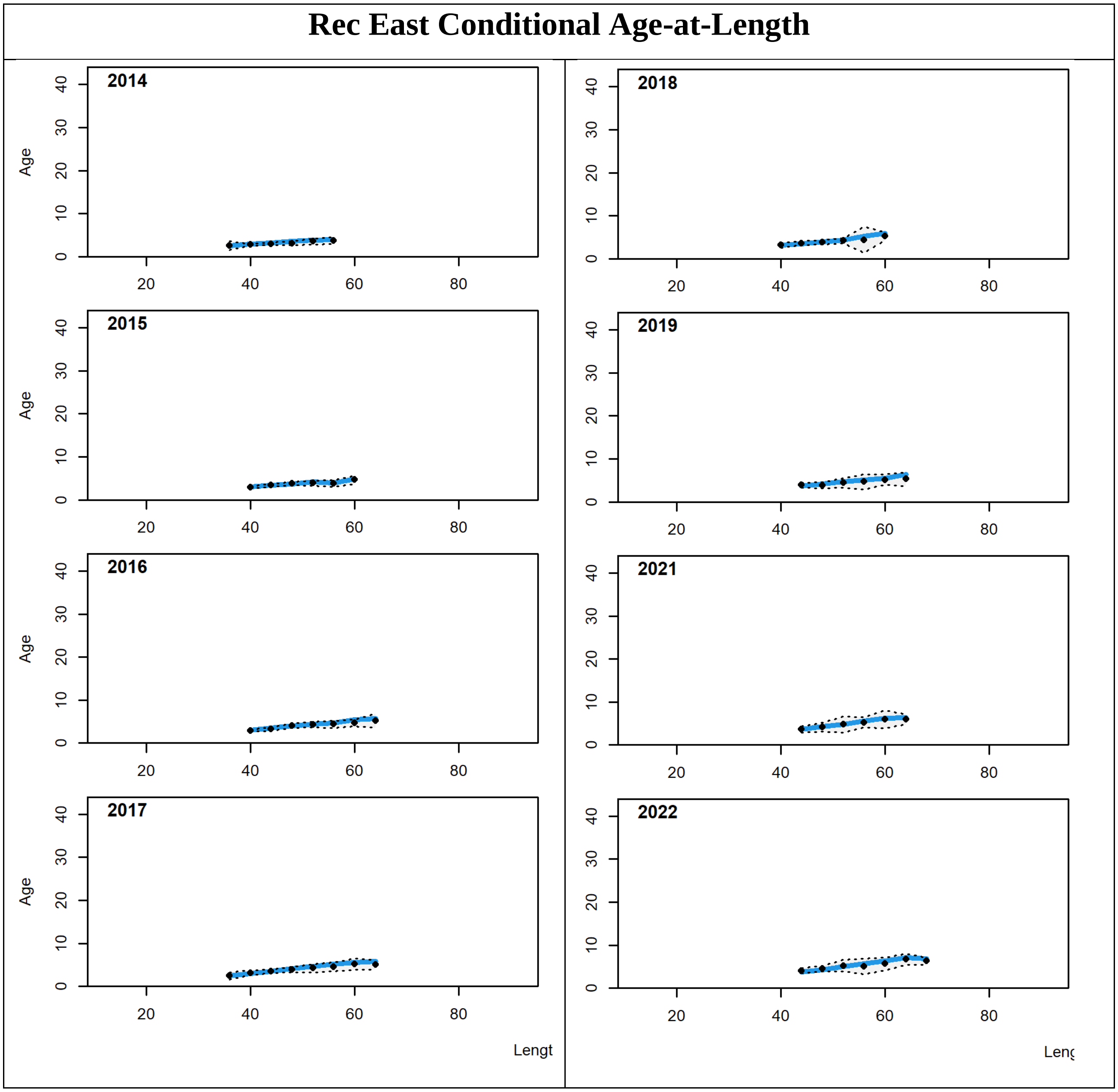


Figure 55 continued. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Recreation East fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

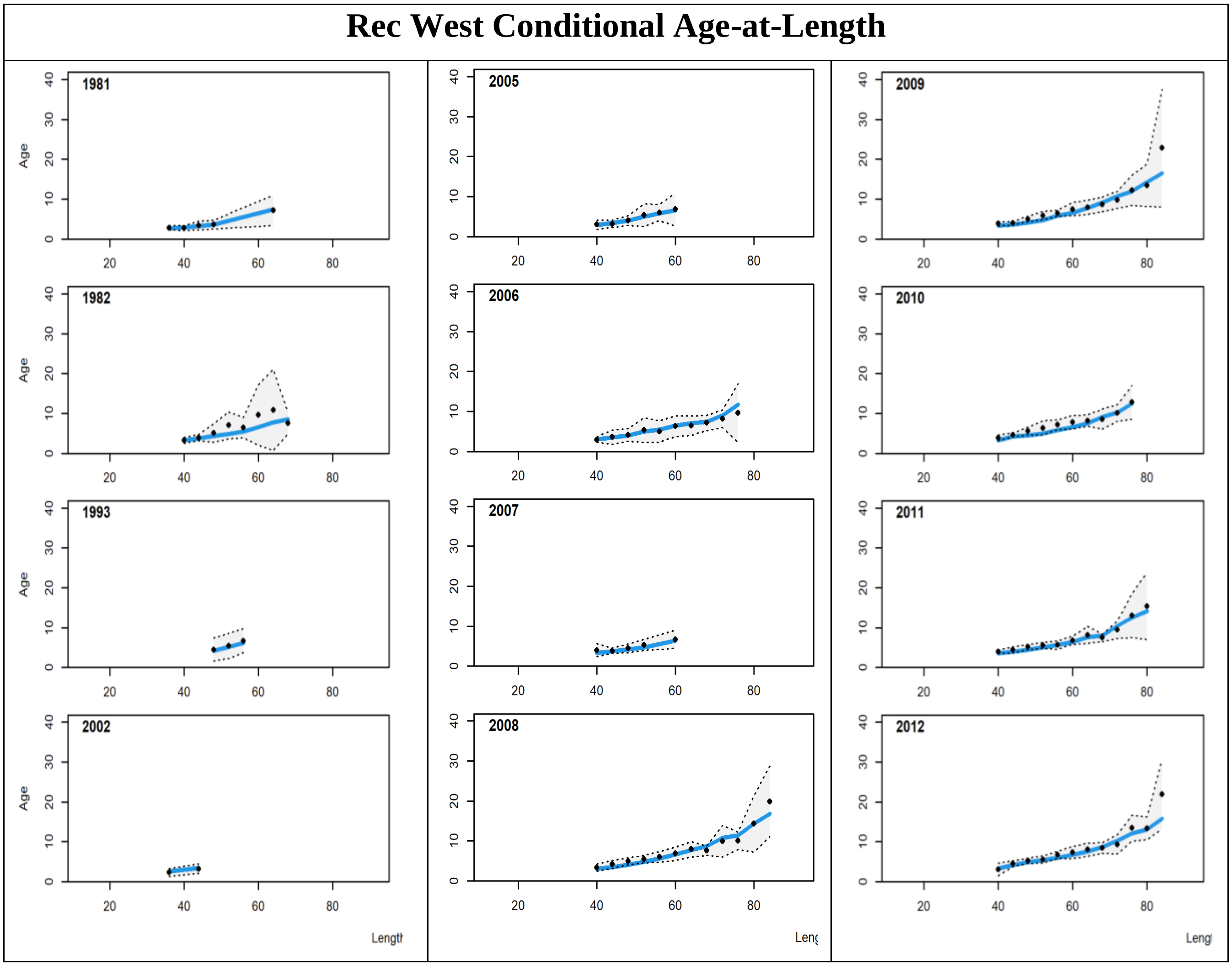


Figure 56. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Recreation West fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

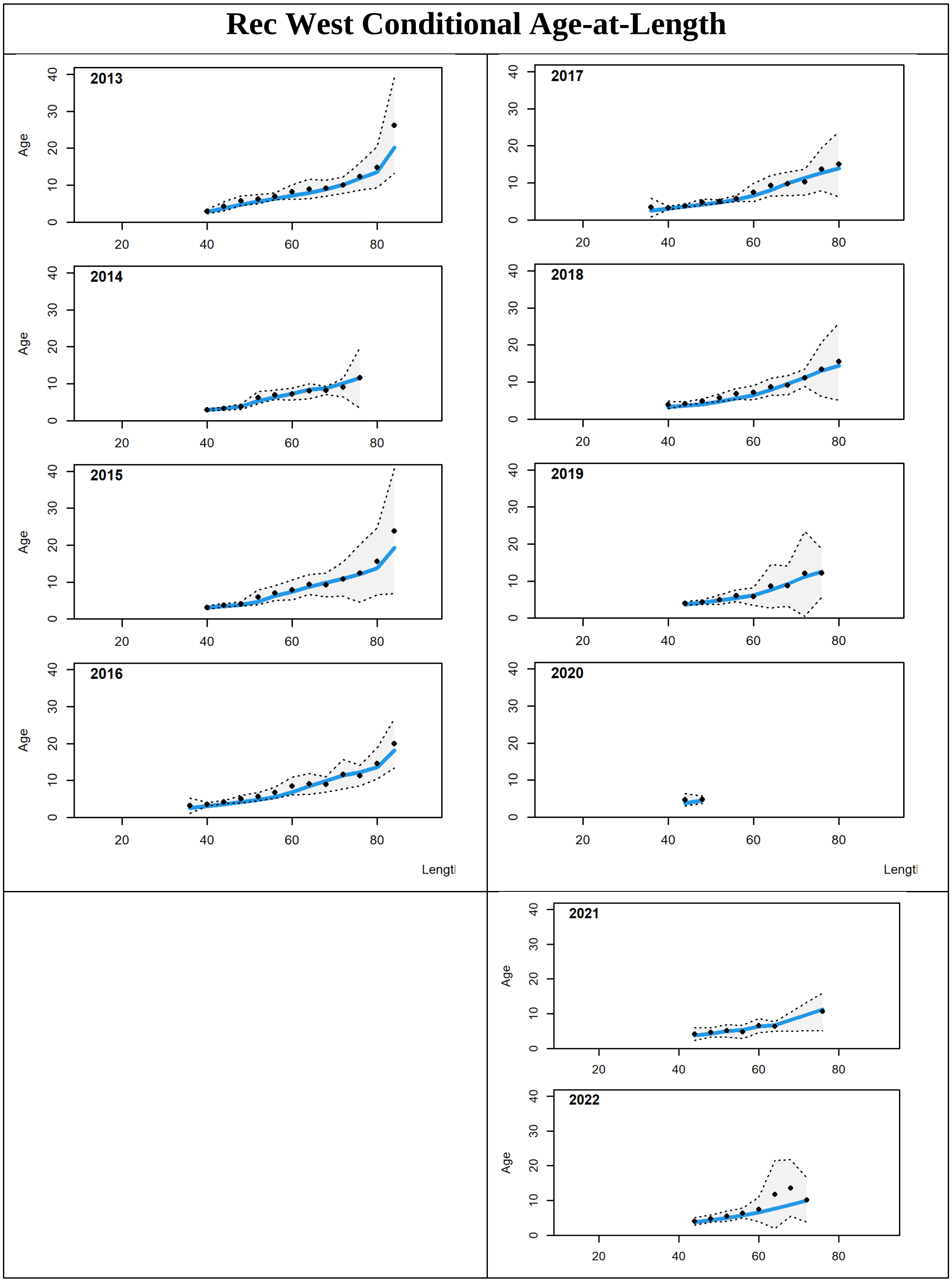


Figure 56 continued. SEDAR 79 Base Model fits to the annual conditional age-at-length data from retained catch by the Recreation West fleet for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

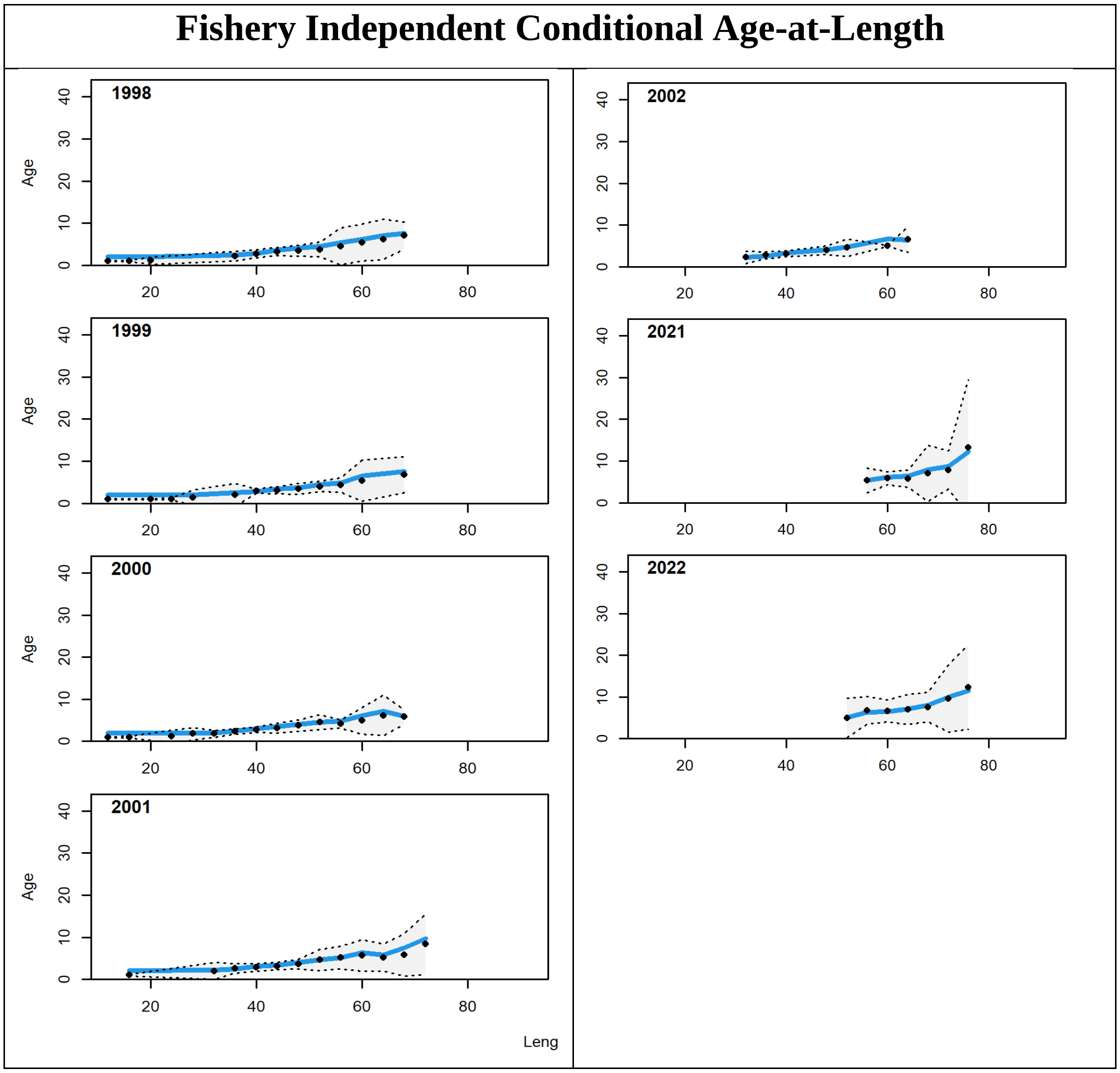


Figure 57. SEDAR 79 Base Model fits to the annual conditional age-at-length data from fishery independent data sources for Southeastern U.S. Mutton Snapper. Blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals.

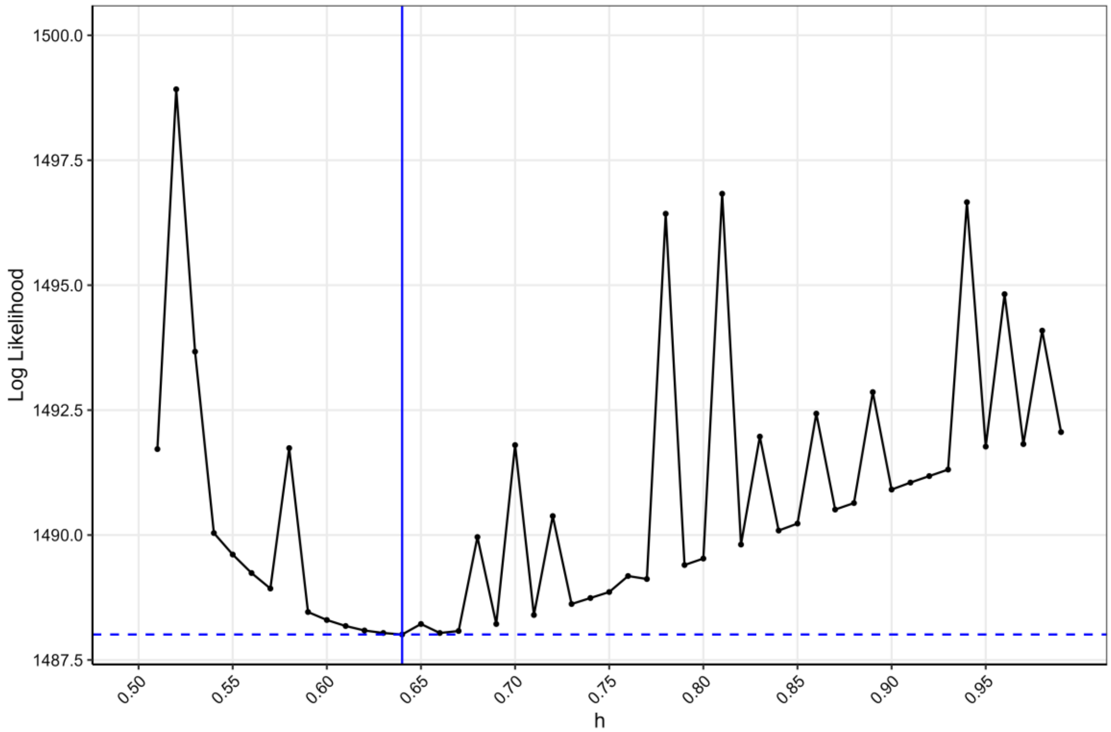


Figure 58. The likelihood profile for steepness (*h*) of the Beverton – Holt stock-recruit function for Southeastern U.S. Mutton Snapper. The black line indicates the negative log-likelihood value across the range of fixed values tested. The estimate of steepness from the SEDAR 79 Base Model was 0.644. The dashed horizontal line is the SEDAR 79 Base Model log-likelihood value of 1488.01. The approximate 95% confidence interval of the SEDAR 79 Base Model log-likelihood value is 1489.97 (1488.01 + 1.97).

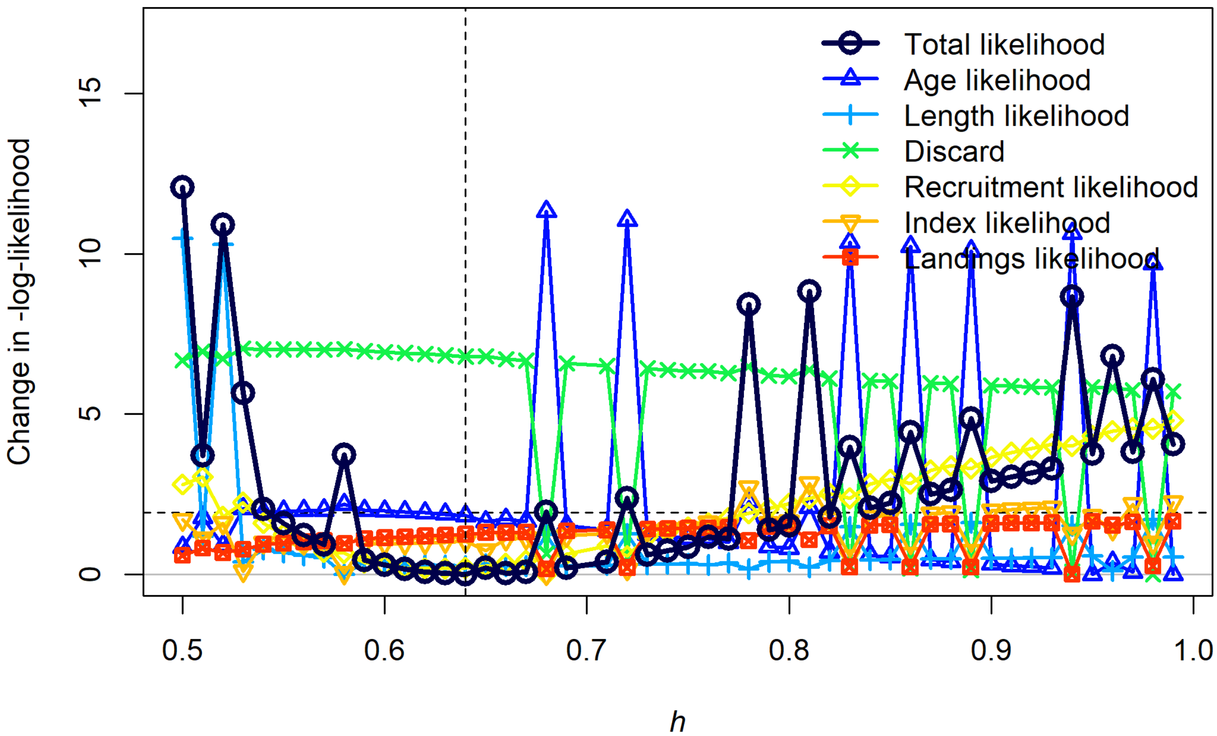


Figure 59. The likelihood profile for steepness (*h*) of the Beverton – Holt stock-recruit function for Southeastern U.S. Mutton Snapper by model component. Colored lines indicate the negative log-likelihood value associated with each model component across the range of fixed values tested. The estimate of steepness from the SEDAR 79 Base Model was 0.644. The dashed horizontal line the approximate 95% confidence interval of the SEDAR 79 Base Model log-likelihood value (1.97).

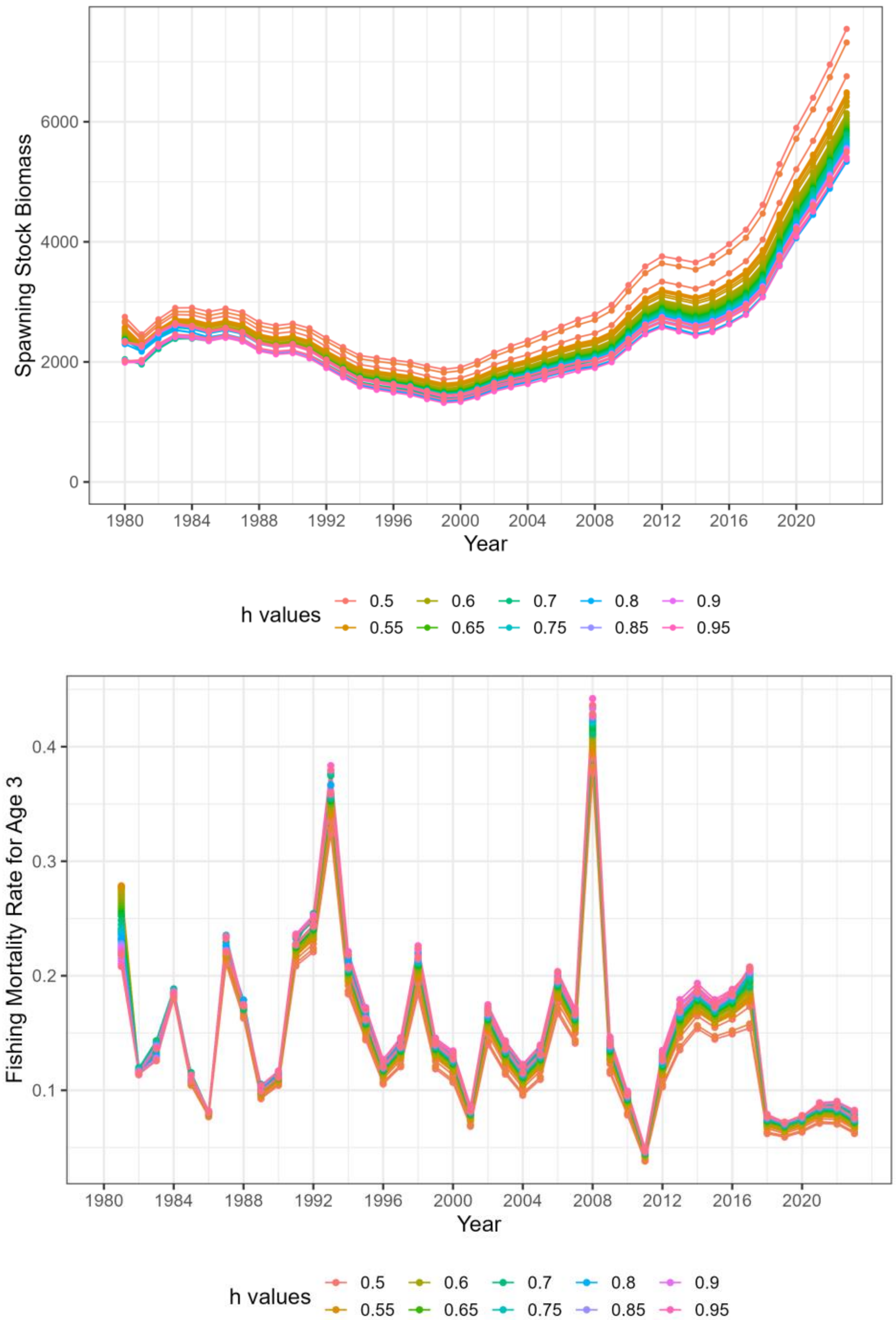


Figure 60. Trends in spawning stock biomass (SSB; top) and age 3 fishing mortality rates (F; bottom) for Southeastern U.S. Mutton Snapper when profiling across a range of fixed steepness (*h*) values in the SEDAR 79 Base Model.

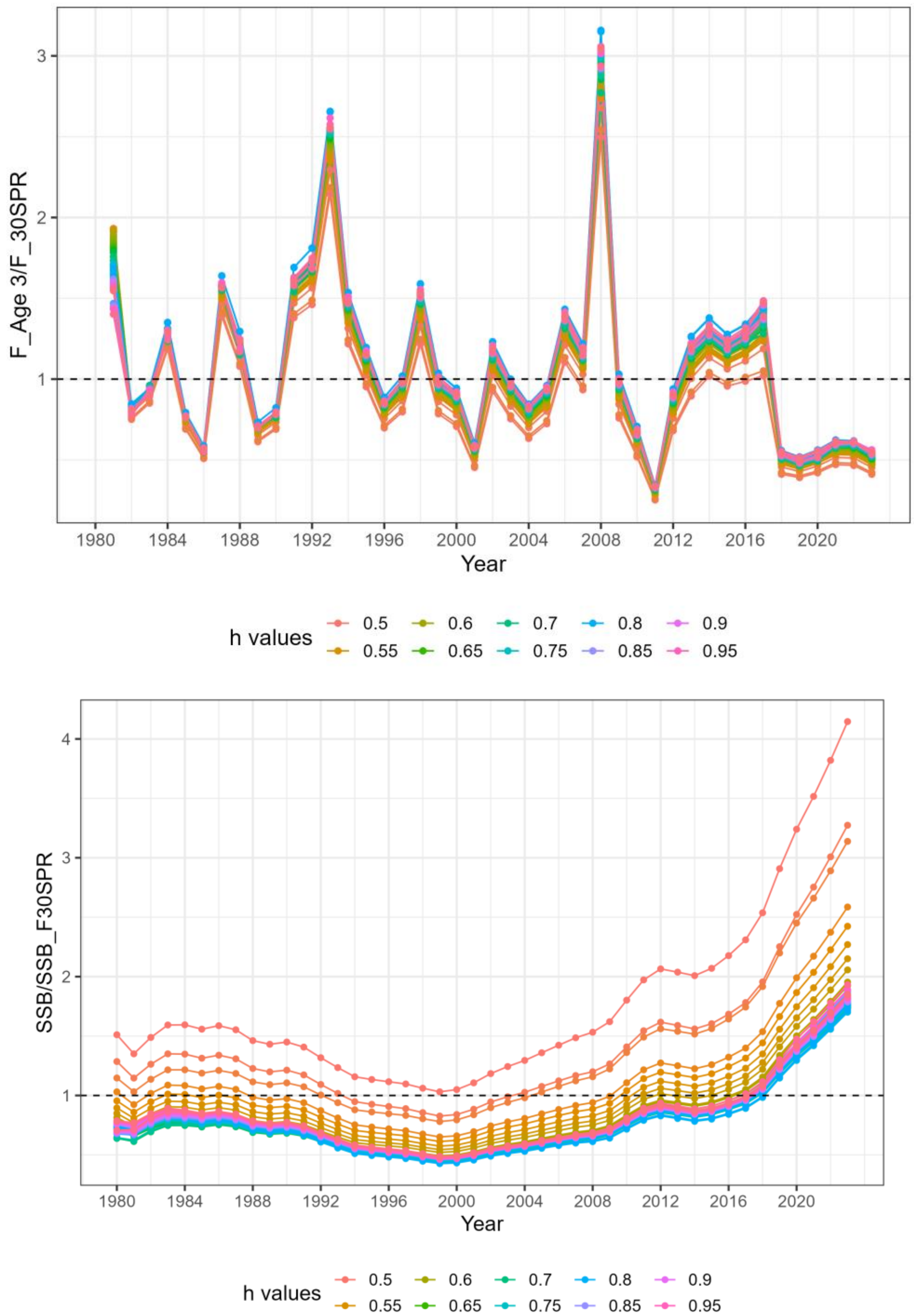


Figure 61. Spawning stock biomass relative to $SSB_{30\%SPR}$ (SSB/SSB_30SPR; top) and age 3 fishing mortality rates relative to $F_{30\%SPR}$ (F/ $F_{30\%SPR}$; bottom) for Southeastern U.S. Mutton Snapper when profiling across a range of fixed steepness (*h*) values in the SEDAR 79 Base Model.

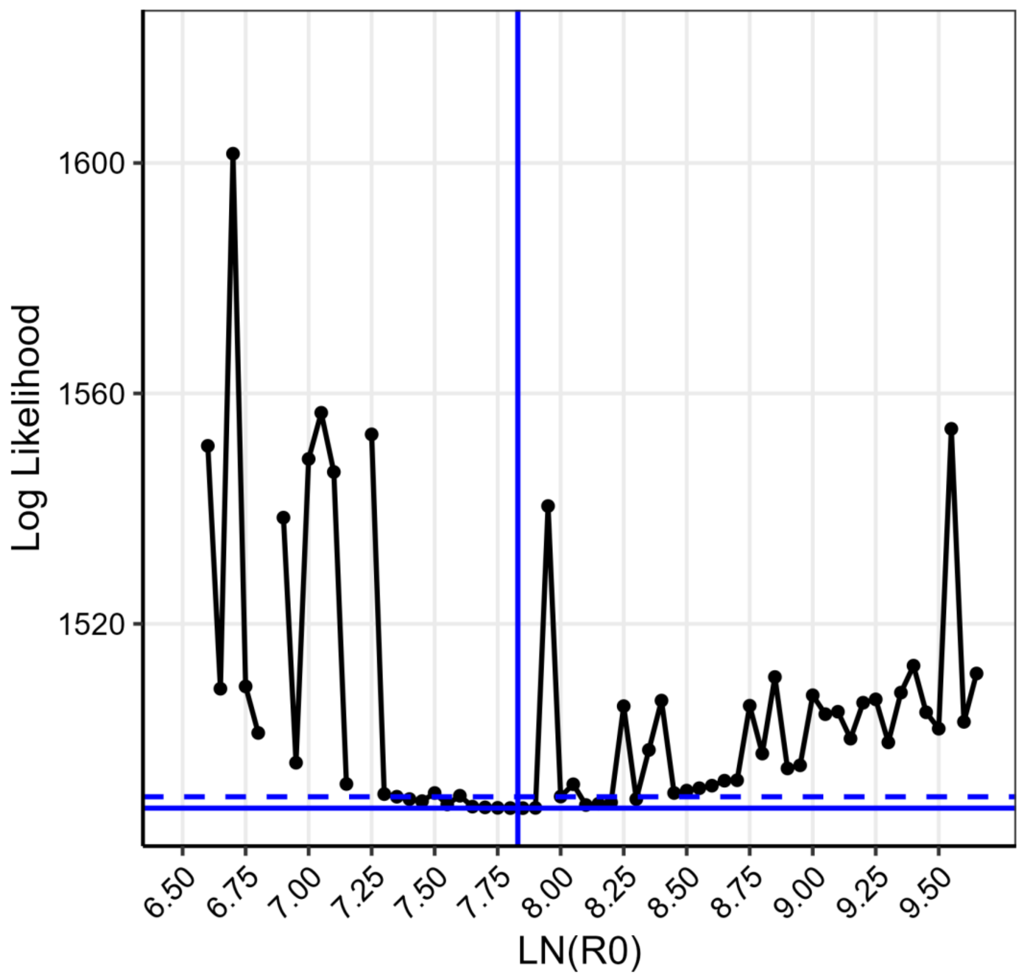


Figure 62. The likelihood profile for the natural log of the virgin recruitment parameter (ln(*R0*)) of the Beverton – Holt stock-recruit function for Southeastern U.S. Mutton Snapper. The black line indicates the negative log-likelihood value across the range of fixed values tested. The estimate of ln(R0) from the SEDAR 79 Base Model was 7.82 (blue vertical line). The solid horizontal line is the SEDAR 79 Base Model log-likelihood value of 1488.01, and the dashed blue line is the approximate 95% confidence interval of the SEDAR 79 Base Model log-likelihood value is 1489.97 (1488.01 + 1.97).

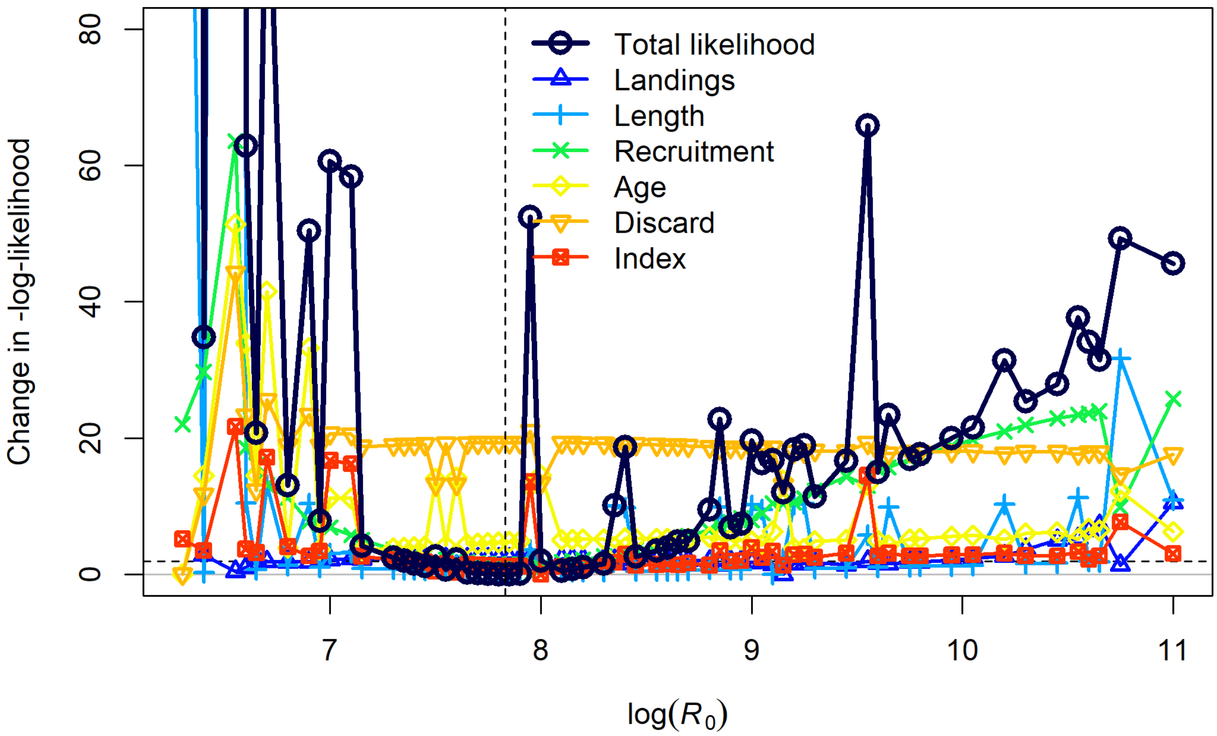


Figure 63. The likelihood profile for the natural log of the virgin recruitment parameter (ln(*R0*)) of the Beverton – Holt stock-recruit function for Southeastern U.S. Mutton Snapper by model component. Colored lines indicate the negative log-likelihood value associated with each model component across the range of fixed values tested. The estimate of ln(*R0*) from the SEDAR 79 Base Model was 7.82. The dashed horizontal line the approximate 95% confidence interval of the SEDAR 79 Base Model log-likelihood value (1.97).

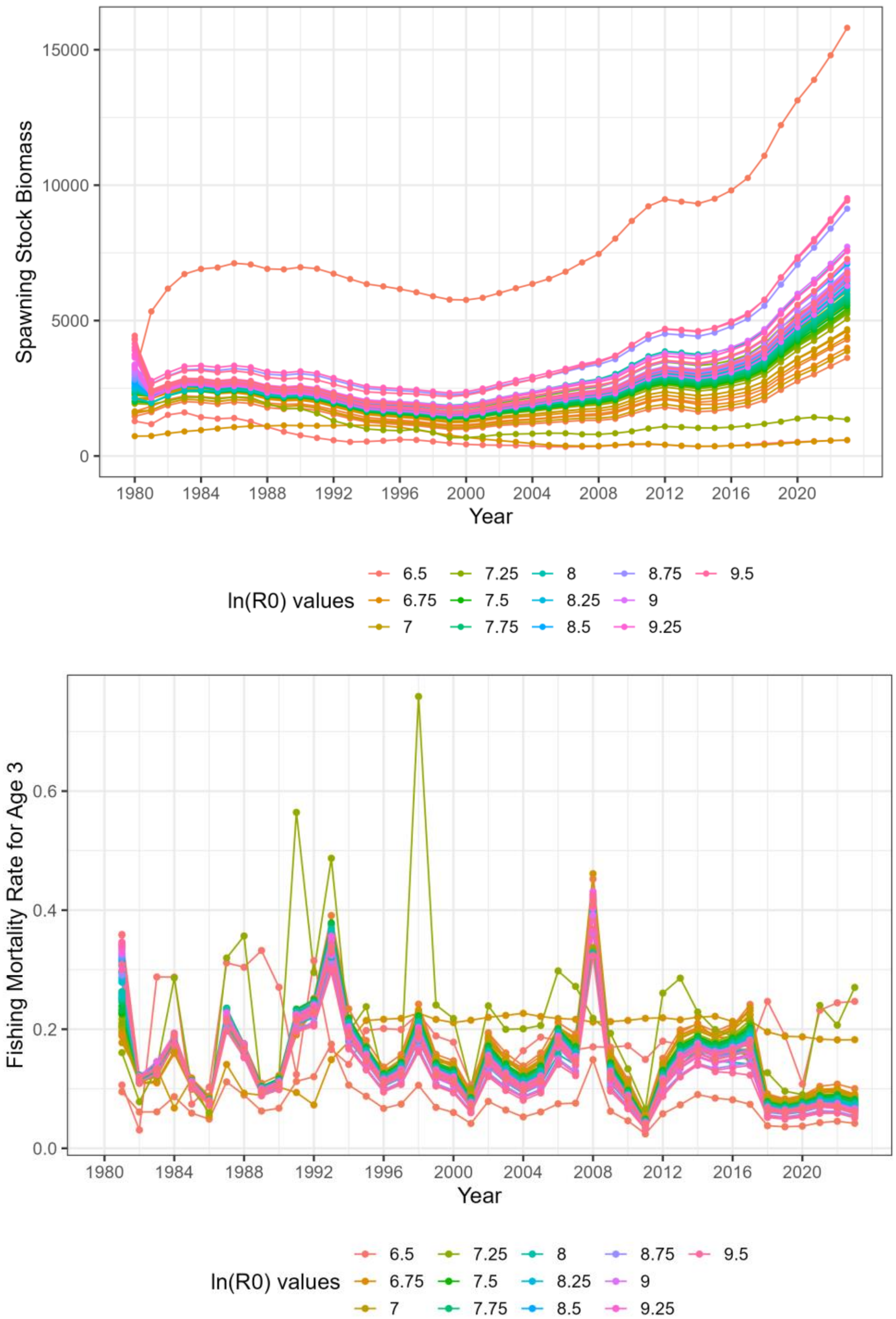


Figure 64. Trends in spawning stock biomass (SSB; top) and age 3 fishing mortality rates (F; bottom) for Southeastern U.S. Mutton Snapper when profiling across a range of fixed virgin recruitment (*ln(R0)*) values in the SEDAR 79 Base Model.

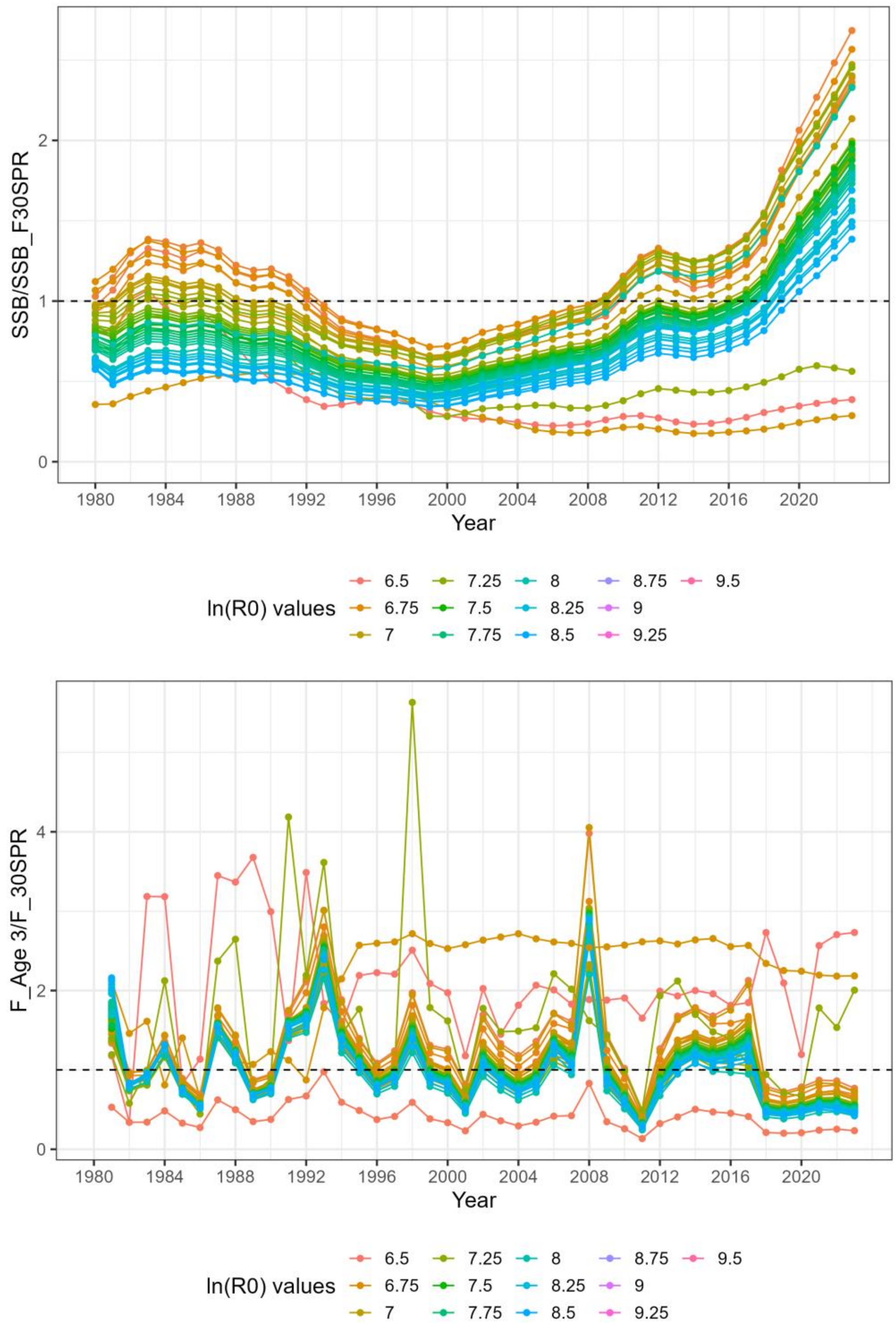


Figure 65. Spawning stock biomass relative to $SSB_{30\%SPR}$ (SSB/SSB_30SPR; top) and age 3 fishing mortality rates relative to $F_{30\%SPR}$ (F/ $F_{30\%SPR}$; bottom) for Southeastern U.S. Mutton Snapper when profiling across a range of fixed virgin recruitment (*ln(R0)*) values in the SEDAR 79 Base Model.

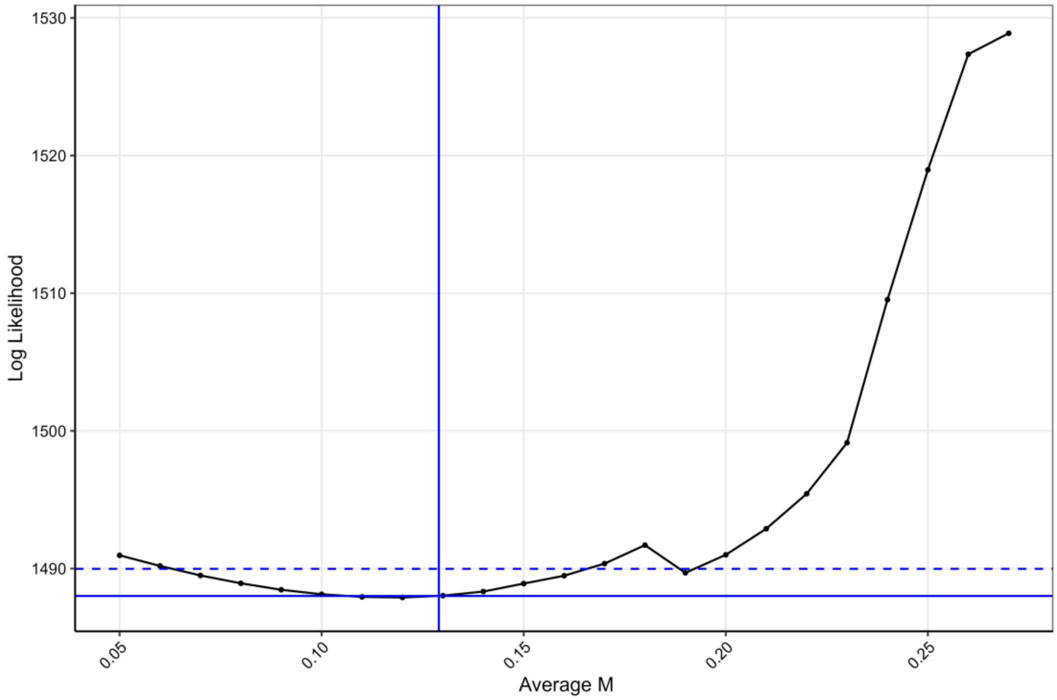


Figure 66. The likelihood profile for the assumed average natural mortality (*Base M*) for Southeastern U.S. Mutton Snapper. The black line indicates the negative log-likelihood value across the range of fixed values tested. The fixed value of *Base M* from the SEDAR 79 Base Model was 0.129 (blue vertical line). The solid horizontal line is the SEDAR 79 Base Model log-likelihood value of 1488.01, and the dashed blue line is the approximate 95% confidence interval of the SEDAR 79 Base Model log-likelihood value is 1489.97 (1488.01 + 1.97).

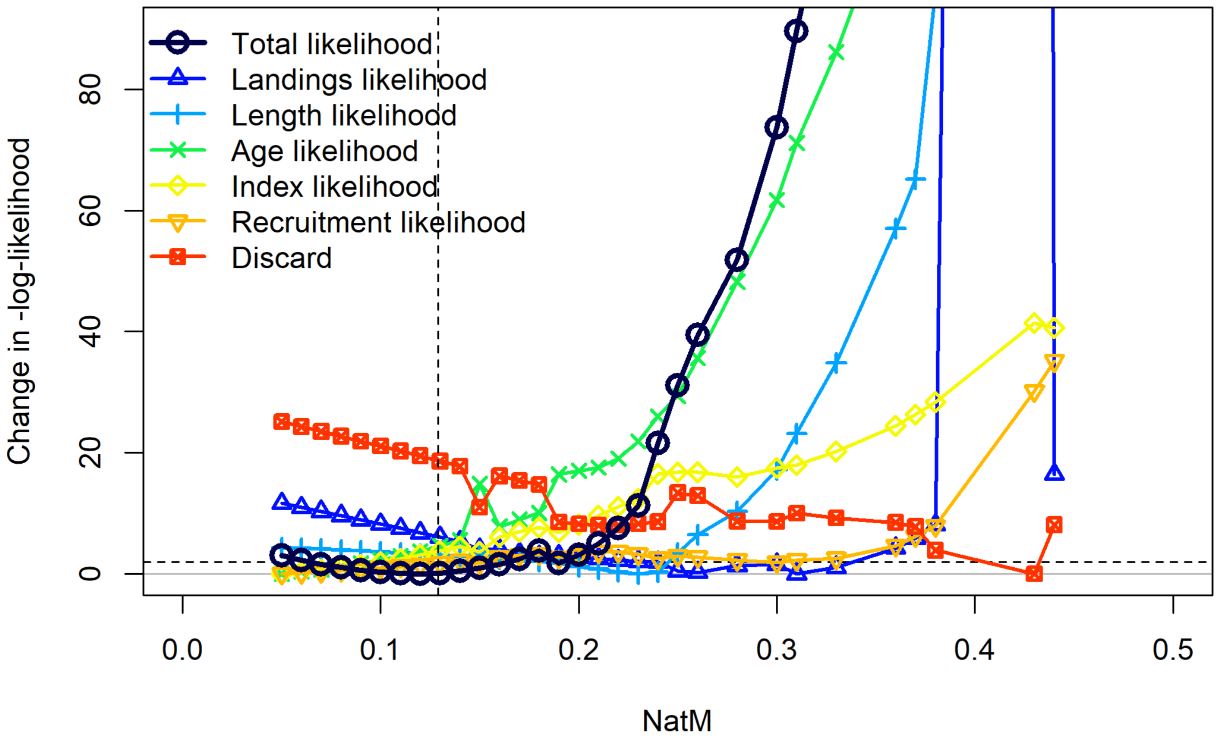


Figure 67. The likelihood profile for the assumed average natural mortality (*Base M*) for Southeastern U.S. Mutton Snapper by model component. Colored lines indicate the negative log-likelihood value associated with each model component across the range of fixed values tested. The fixed value of *Base M* from the SEDAR 79 Base Model was 0.129. The dashed horizontal line the approximate 95% confidence interval of the SEDAR 79 Base Model log-likelihood value (1.97).

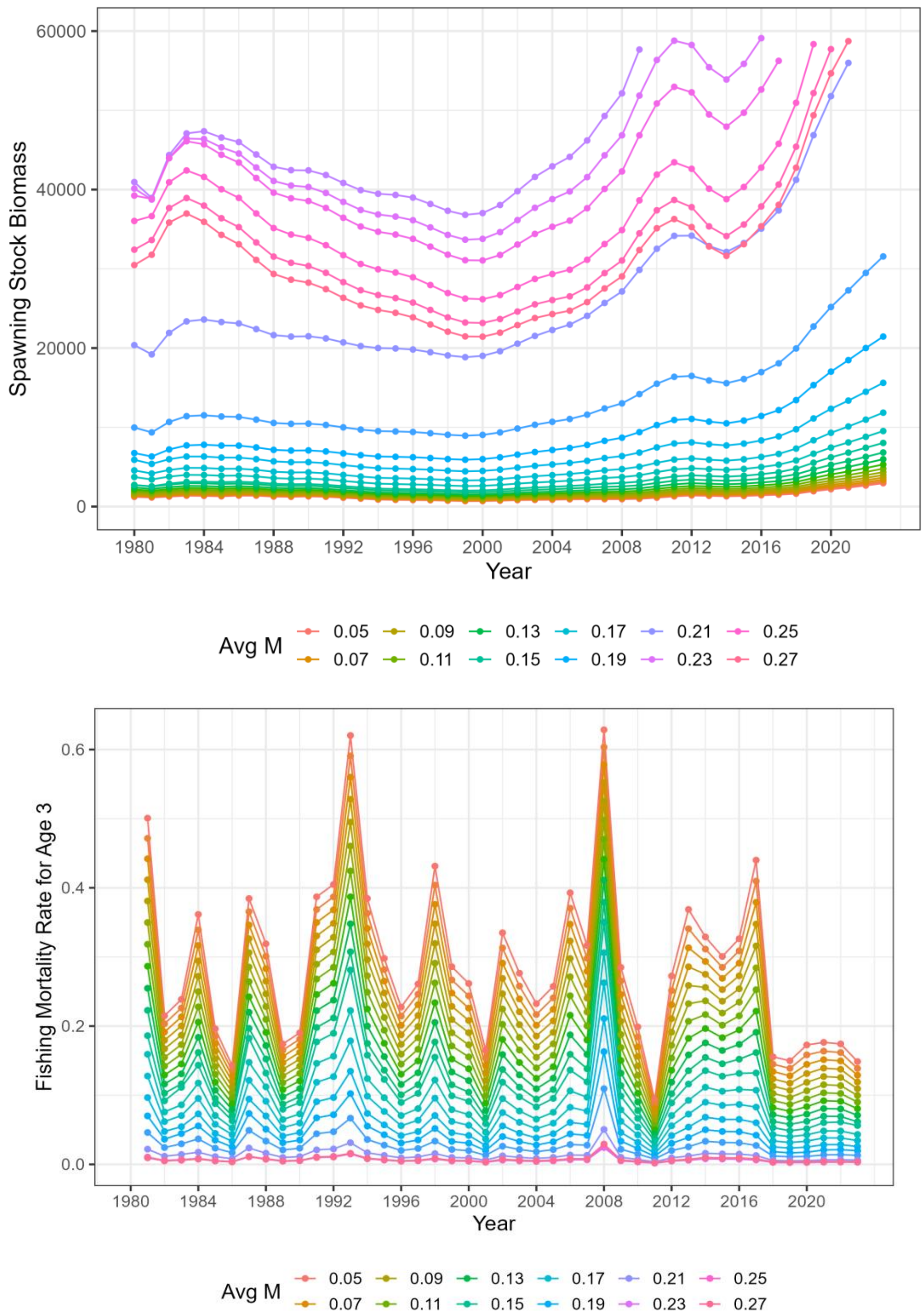


Figure 68. Trends in spawning stock biomass (SSB in metric tons truncated to 60,000 mt; top) and age 3 fishing mortality rates (F; bottom) for Southeastern U.S. Mutton Snapper when profiling across a range of average natural mortality (*Base M*) values in the SEDAR 79 Base Model.

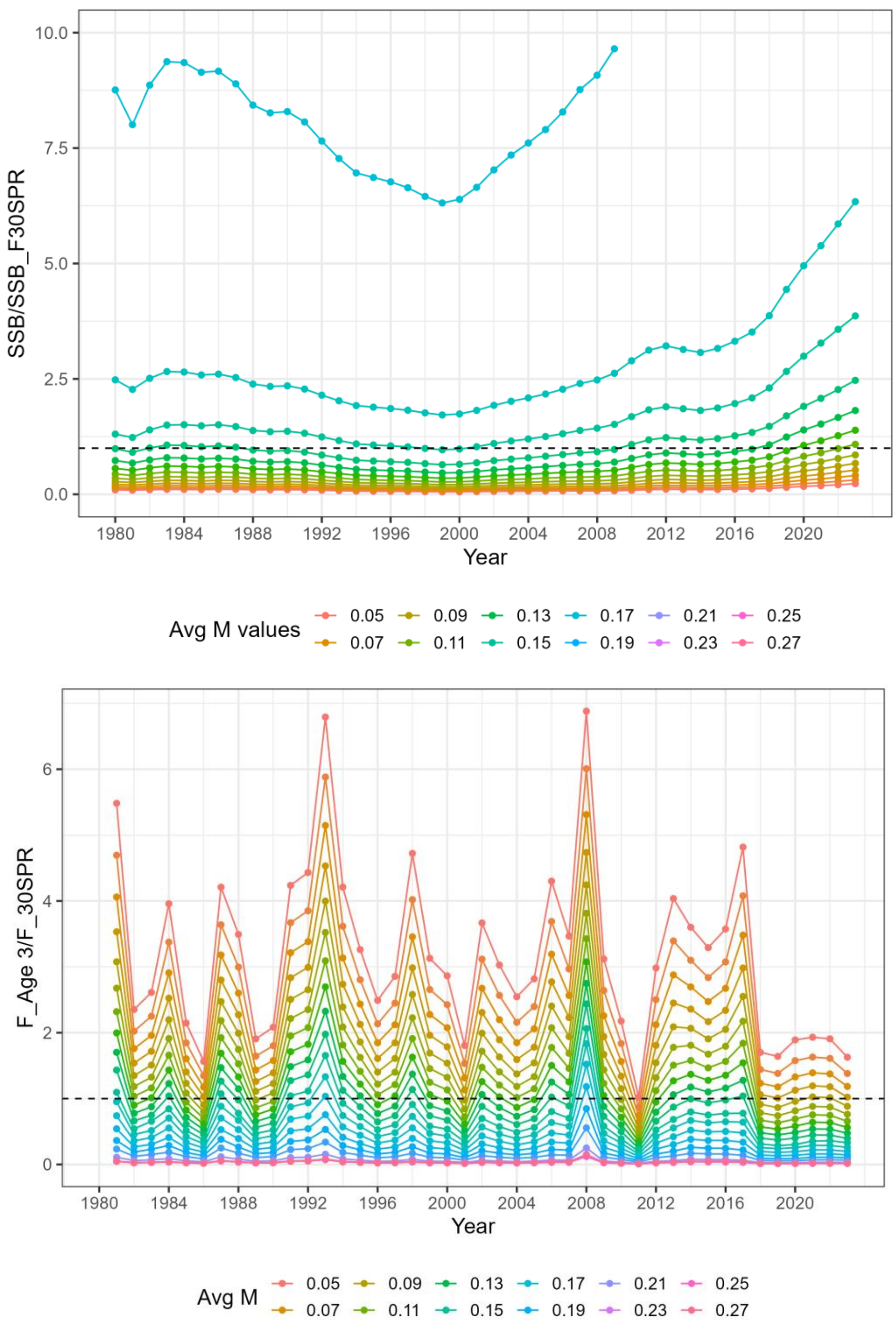


Figure 69. Spawning stock biomass relative to $SSB_{30\%SPR}$ (SSB/SSB_30SPR truncated to 10; top) and age 3 fishing mortality rates relative to $F_{30\%SPR}$ (F/ $F_{30\%SPR}$; bottom) for Southeastern U.S. Mutton Snapper when profiling across a range of average natural mortality (*Base M*) values in the SEDAR 79 Base Model.

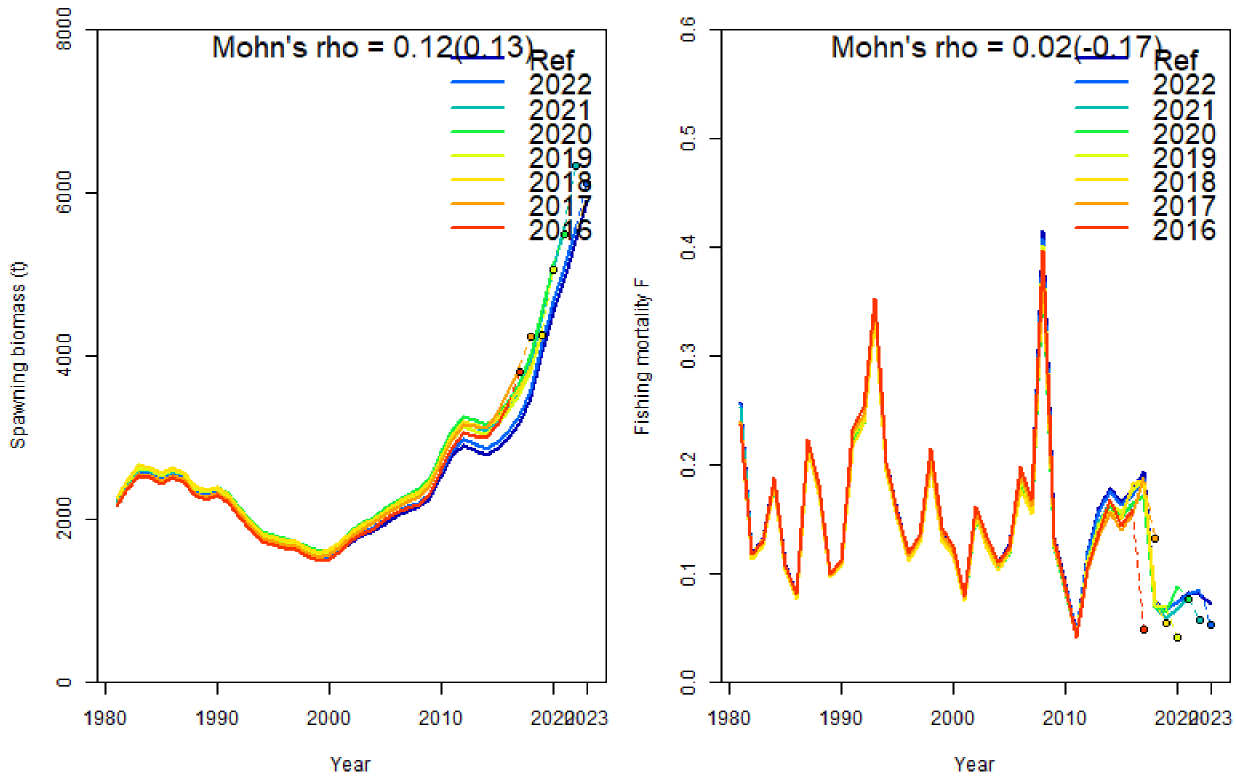


Figure 70. Retrospective analysis of spawning stock biomass and age-3 fishing mortality estimates for Southeastern US Mutton Snapper conducted by removing seven years of observations, one year at a time sequentially. The retrospective results are shown for the entire time series and for the most recent years only. Mohn's rho statistic and the corresponding 'forecast rho' values (in parentheses) are printed at the top of each panel. One-year-ahead projections denoted by color-coded dashed lines with terminal points shown for each model.

a)

b)

c)

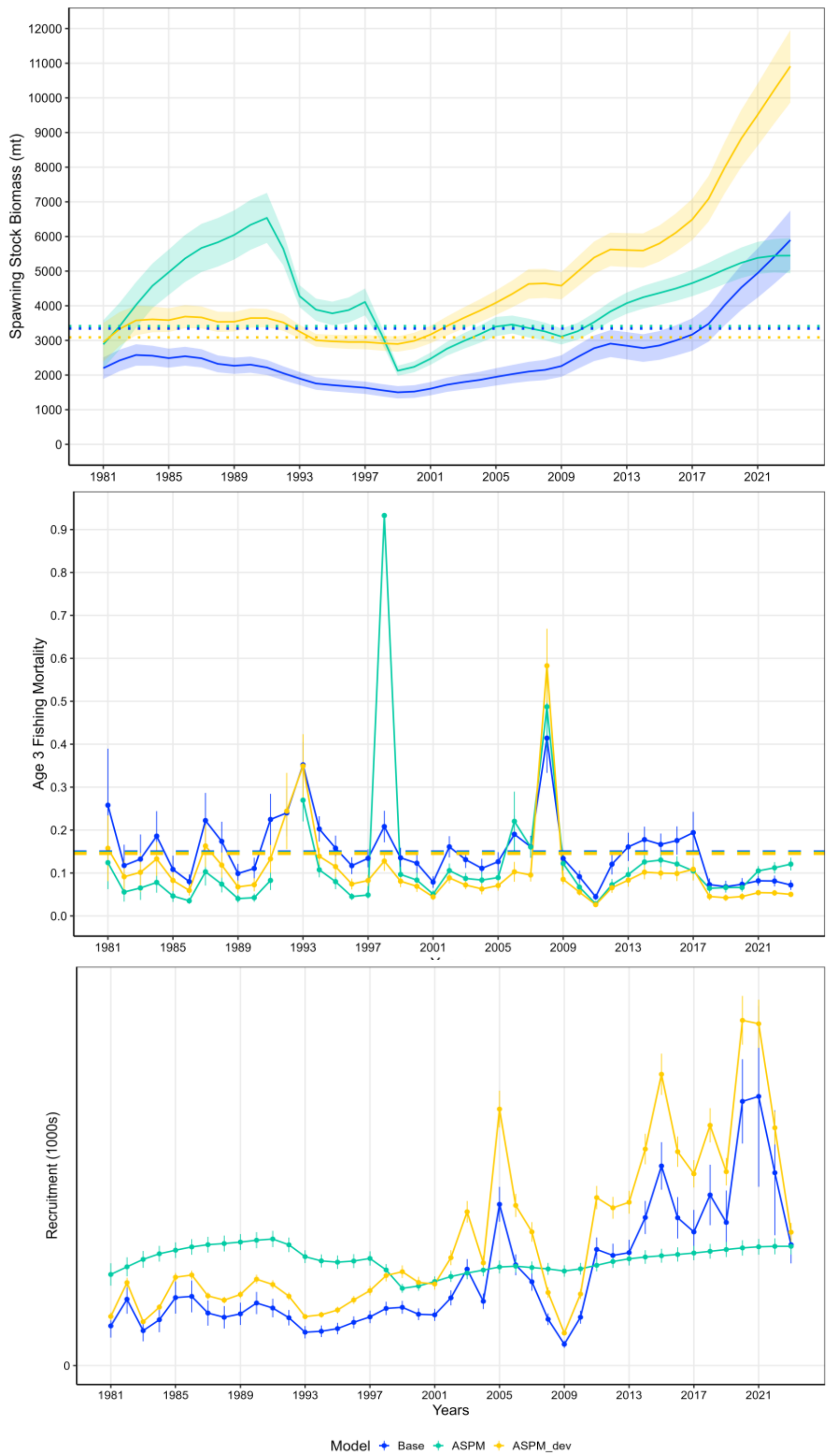


Figure 71. Comparison between the SEDAR 79 Base Model (Base), the deterministic Age-Structured-Production Model (ASPM), and the ASPM with recruitment deviations (ASPM_dev) showing a) spawning stock biomass, b) age-3 fishing mortality rates, and c) estimated recruitment.

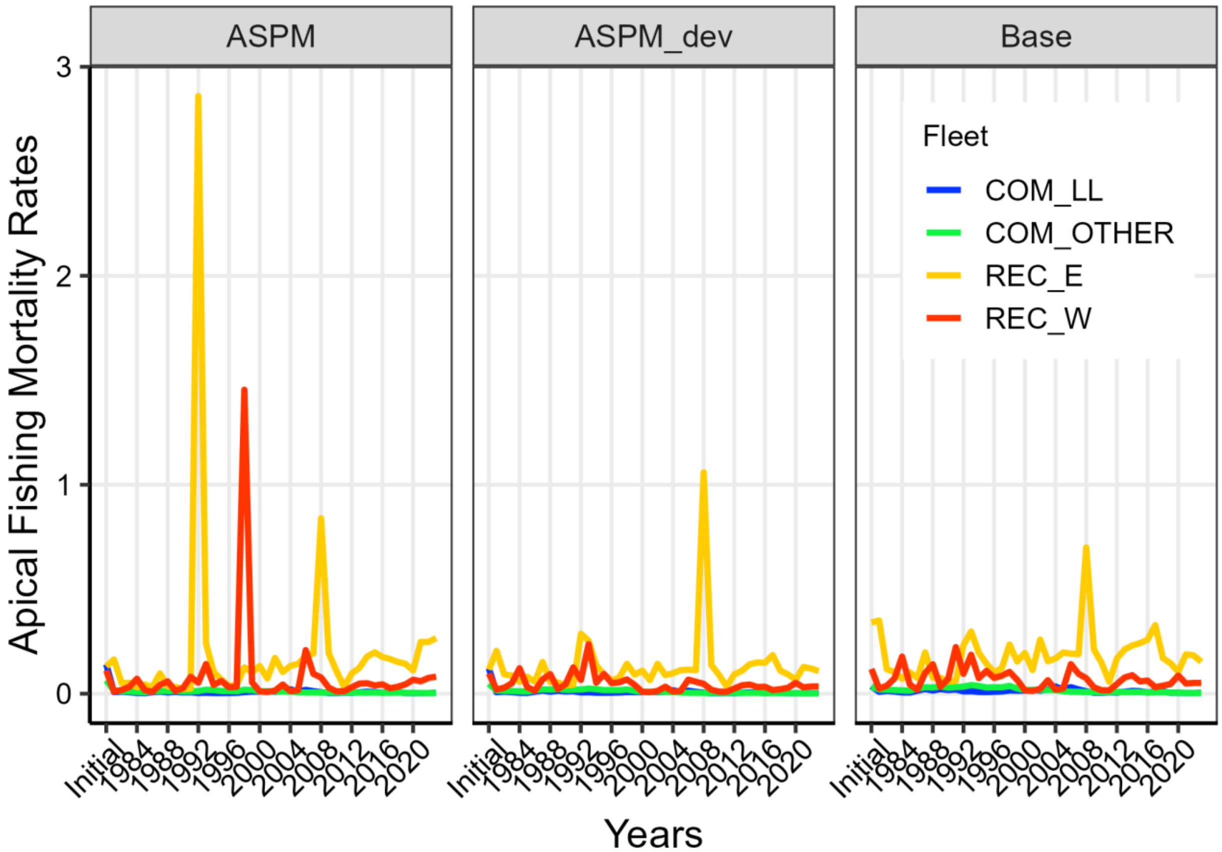


Figure 72. Comparison of apical fishing mortality rates estimated by the SEDAR 79 Base Model (Base), the deterministic Age-Structured-Production Model (ASPM), and the ASPM with recruitment deviations (ASPM_dev).

Figure 73. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with 75%$SSB_{F30\%SPR}$), recruitment deviations, and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with steepness fixed at 0.99 ('steepness-1').

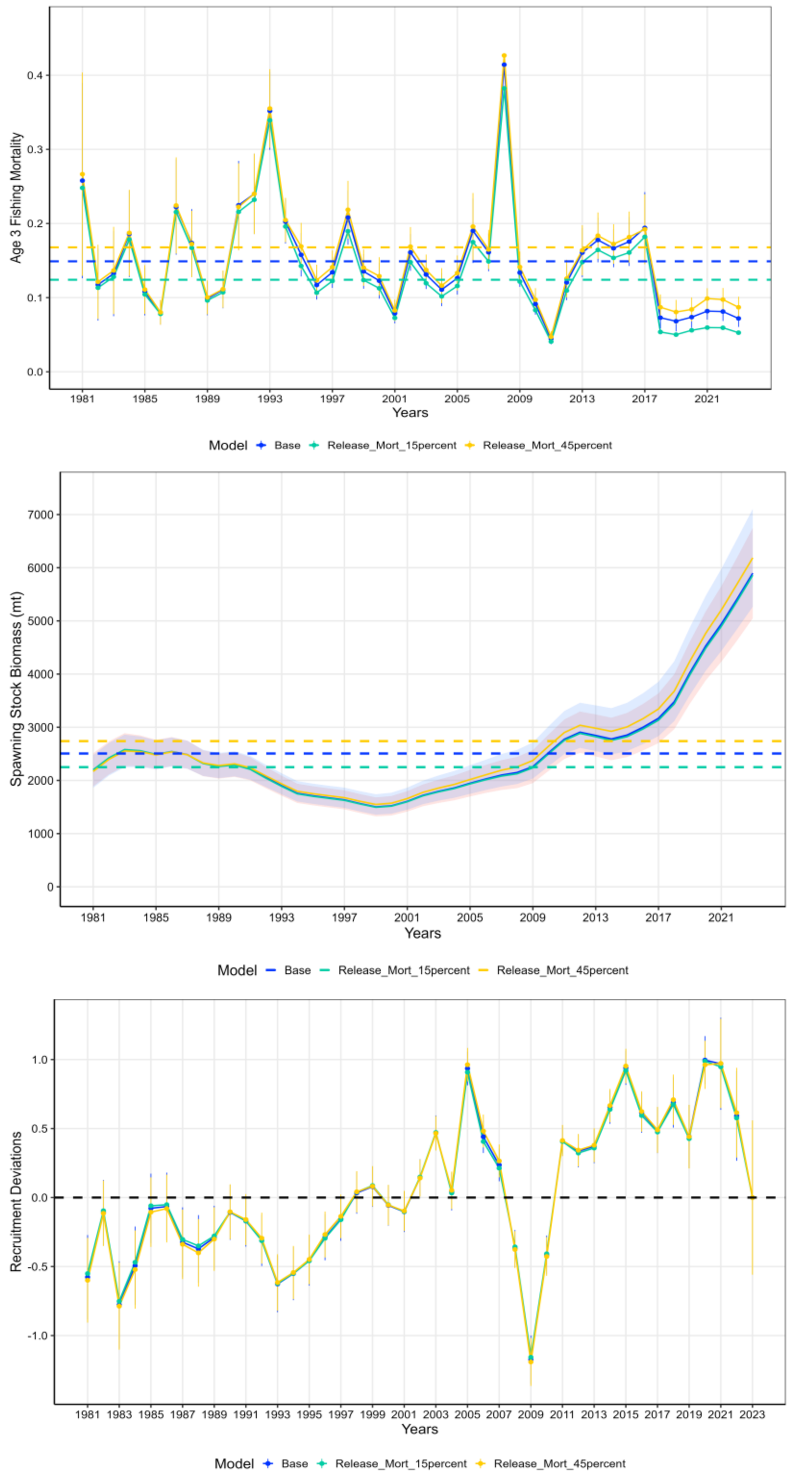


Figure 74. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with $75\%SSB_{F30\%SPR}$), and recruitment deviations by the SEDAR 79 Base Model ('Base' in blue), the Base Model with release mortality fixed at 0.15 ('Release_Mort_15percent' in green), and the Base Model with release mortality fixed at 0.45 ('Release_Mort_45percent' in yellow).

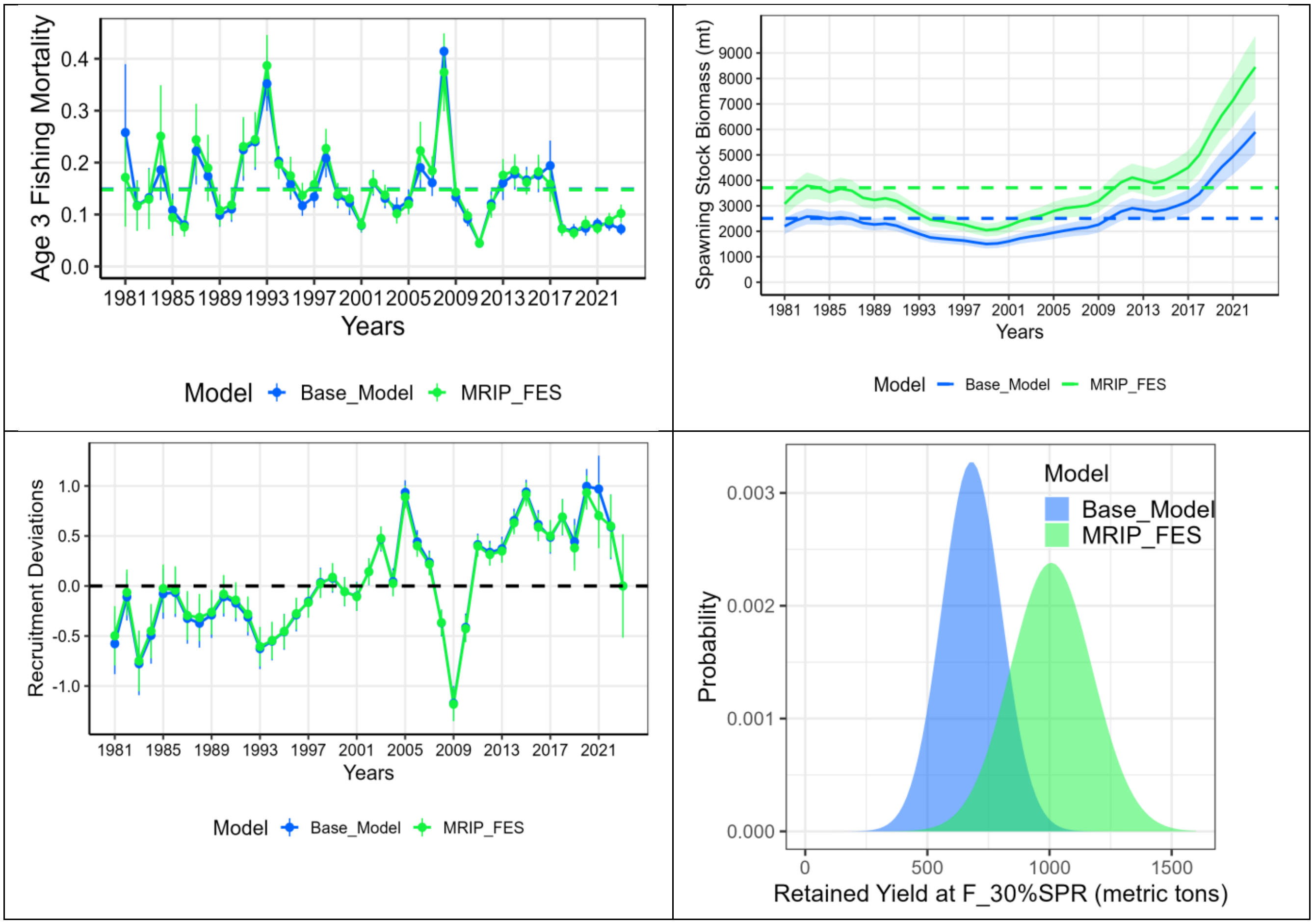


Figure 75. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with 75%$SSB_{F30\%SPR}$), recruitment deviations, and retained yield at $F_{30\%SPR}$ by the SEDAR 79 Base Model ('Base Model' in blue) and the Base Model with MRIP-FES Florida-only private mode landings and releases ('MRIP_FES' in green).

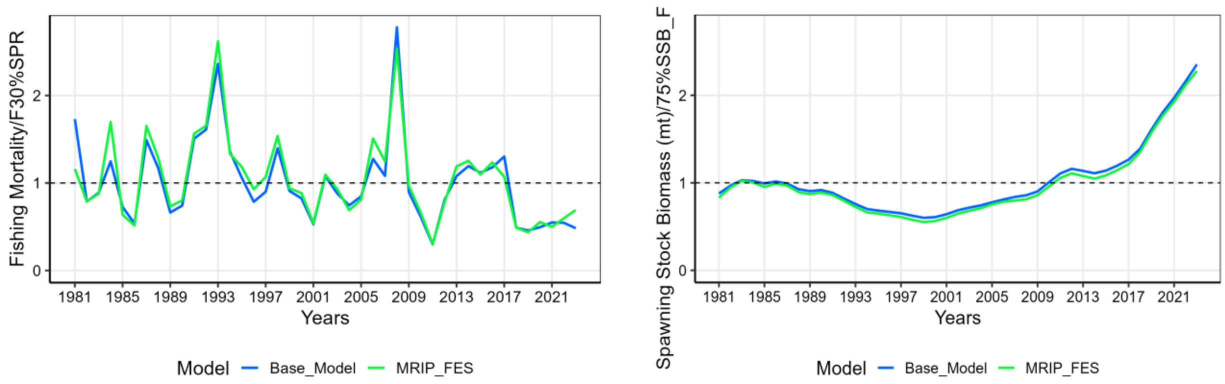


Figure 76. Comparison of fishing mortality rates relative to $F_{30\%SPR}$ and spawning stock biomass relative to $75\%SSB_{F30\%SPR}$ by the SEDAR 79 Base Model ('Base Model' in blue) and the Base Model with MRIP-FES Florida-only private mode landings and releases ('MRIP_FES' in green).

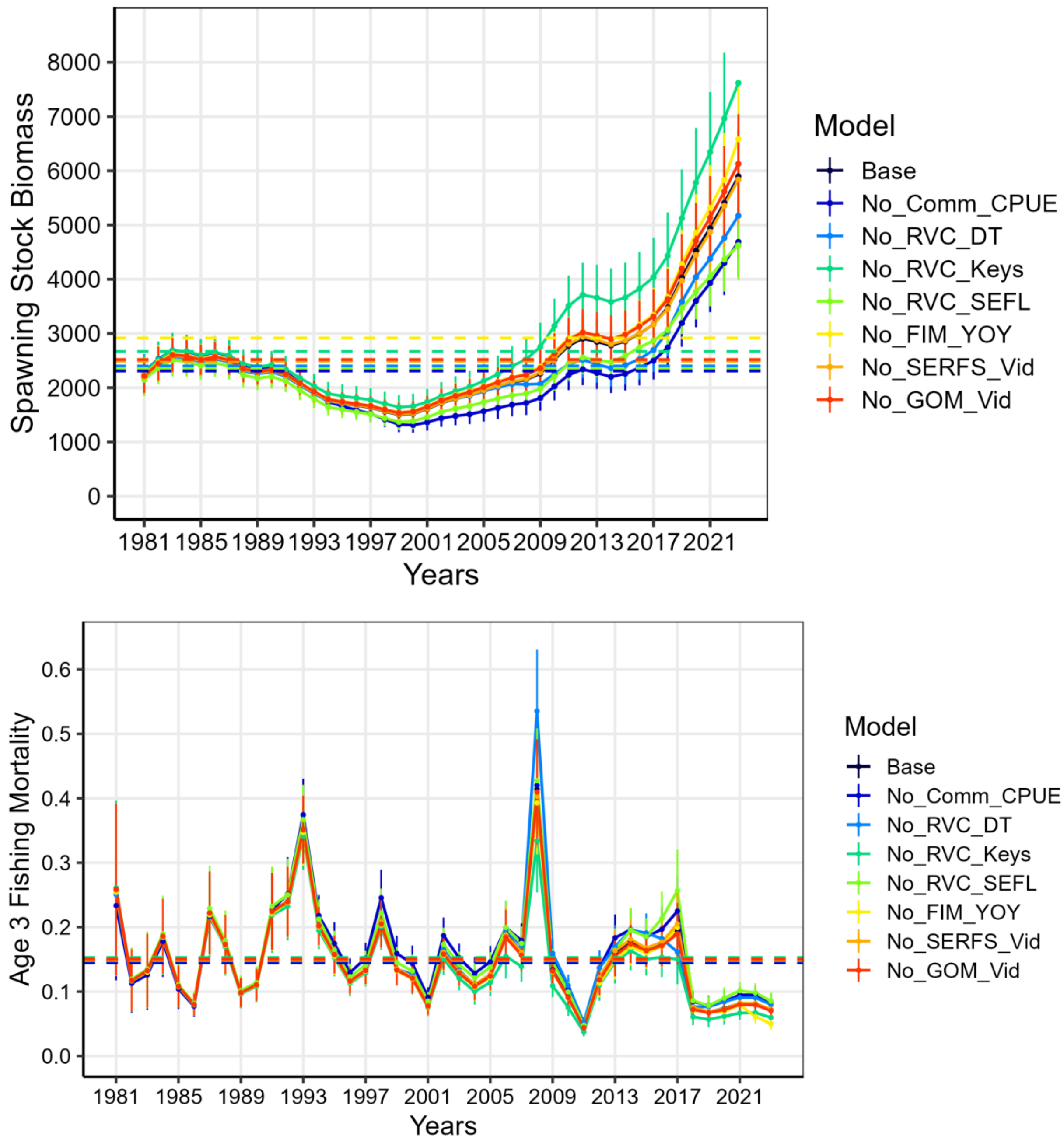


Figure 77. Comparison of fishing mortality rates relative to $F_{30\%SPR}$ and spawning stock biomass relative to $75\%SSB_{F30\%SPR}$ by the SEDAR 79 Base Model ('Base Model' in dark blue) and when a single index of abundance is removed.

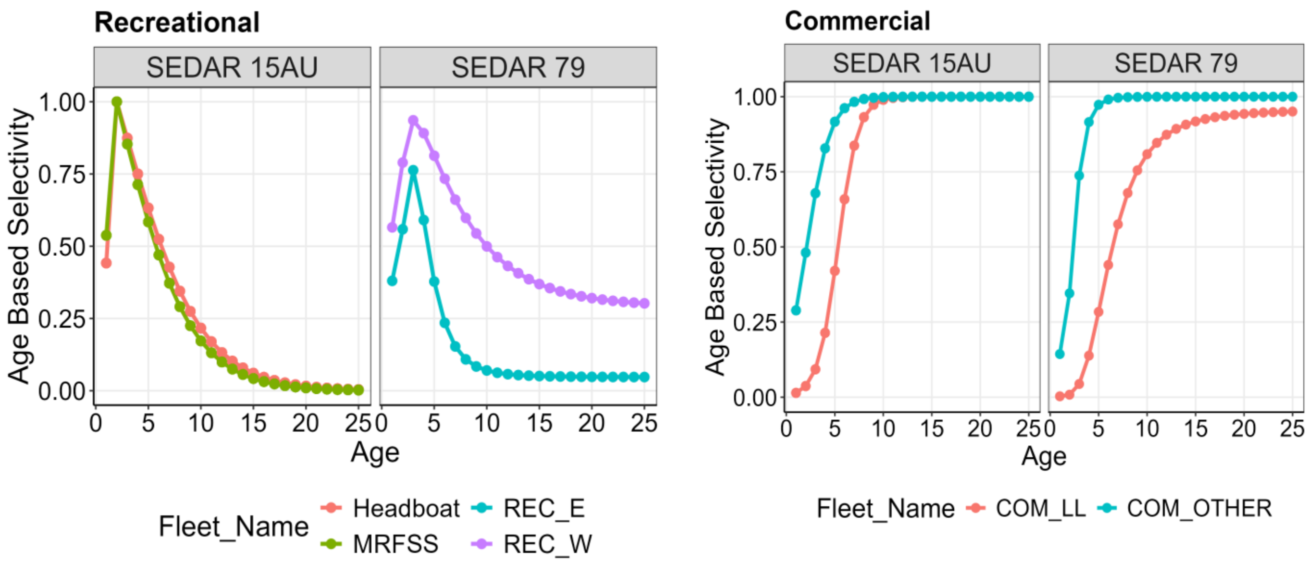


Figure 78. Comparison of age-based selectivity estimated by the SEDAR 79 Base Model and SEDAR 15AU Final Model for each sector (i.e., recreational and commercial).

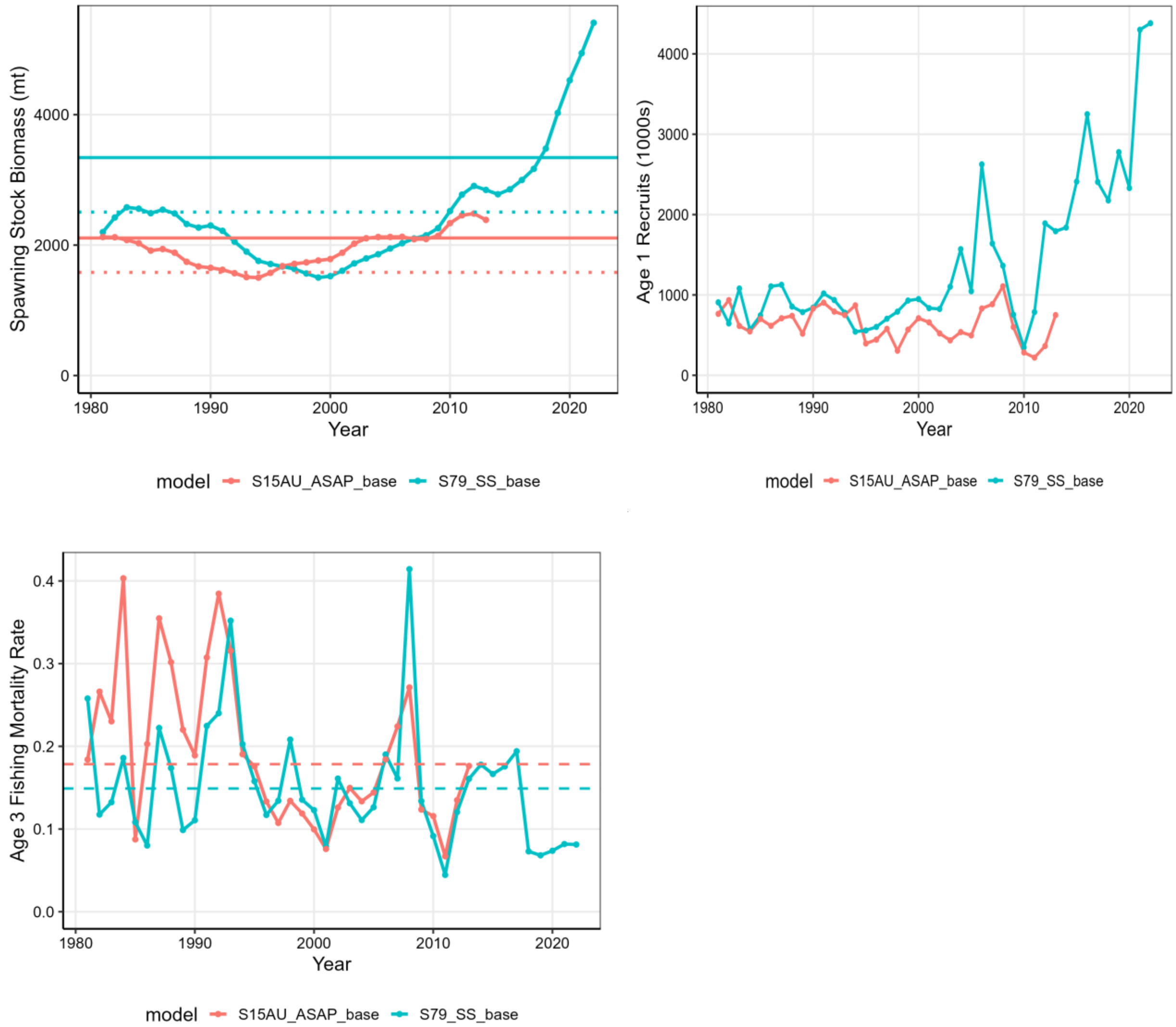


Figure 79. Comparison of spawning stock biomass ($SSB_{30\%SPR}$ shown by solid lines, 75% of $SSB_{30\%SPR}$ shown by dotted lines), age 1 recruits, and age-3 fishing mortality rates ($F_{30\%SPR}$ shown by dashed lines) estimated by the SEDAR 79 Base Model and the SEDAR 15AU Final Model.

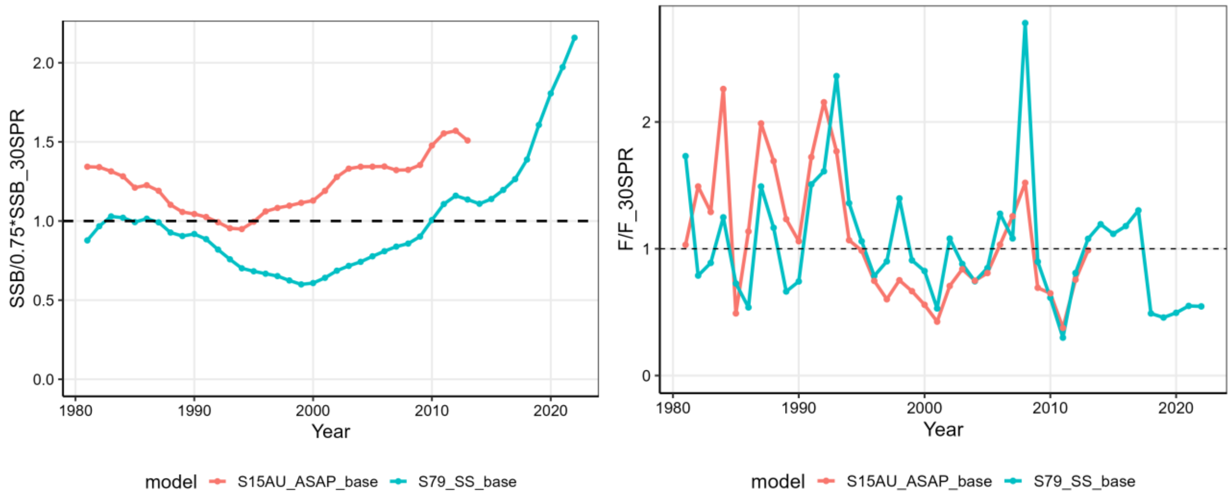


Figure 80. Comparison of spawning stock biomass relative to 75%$SSB_{F30\%SPR}$ and fishing mortality rates relative to $F_{30\%SPR}$ and estimated by the SEDAR 79 Base Model and the SEDAR 15AU Final Model.

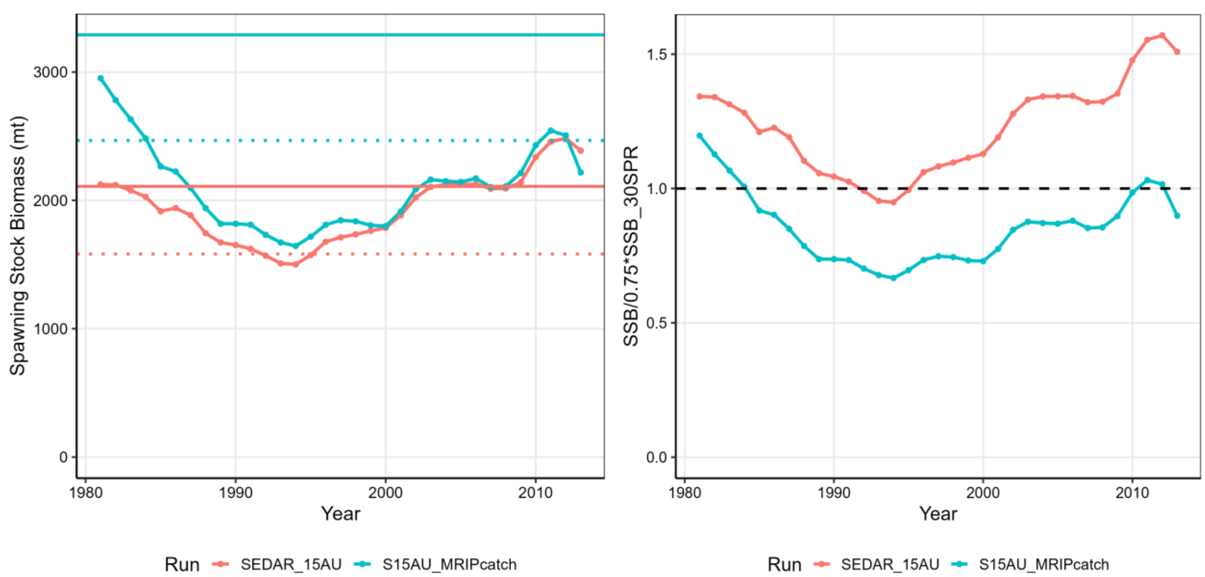


Figure 81. Comparison of spawning stock biomass ($SSB_{30\%SPR}$ shown by solid lines, 75% of $SSB_{30\%SPR}$ shown by dotted lines) and spawning stock biomass relative to 75% $SSB_{30\%SPR}$ estimated by the SEDAR 15AU Final Model and a model with MRIP-FES landings and releases (S15AU_MRIPcatch).

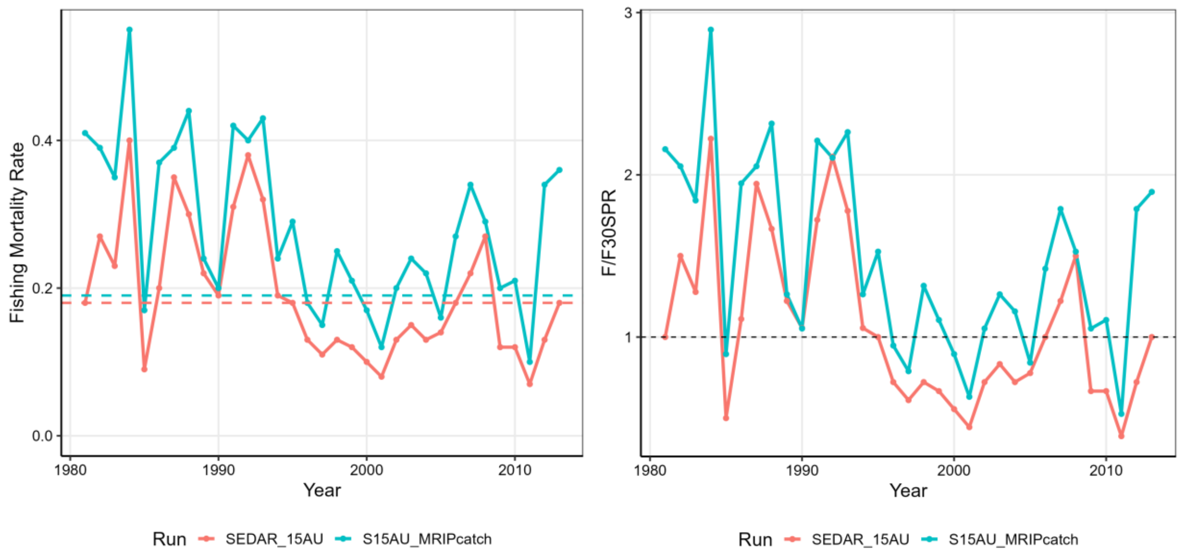


Figure 82. Comparison of fishing mortality rates ($F_{30\%SPR}$ shown by solid lines) and fishing mortality rates relative to $F_{30\%SPR}$ estimated by the SEDAR 15AU Final Model and a model with MRIP-FES landings and releases (S15AU_MRIPcatch).

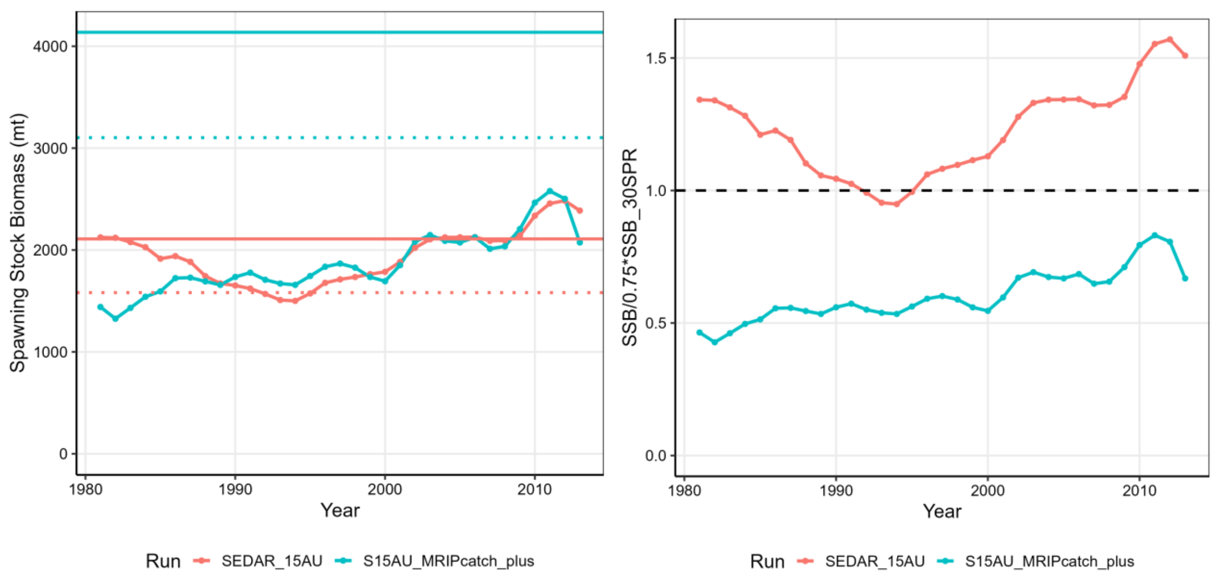


Figure 83. Comparison of spawning stock biomass ($SSB_{30\%SPR}$ shown by solid lines, 75% of $SSB_{30\%SPR}$ shown by dotted lines) and spawning stock biomass relative to 75% $SSB_{30\%SPR}$ estimated by the SEDAR 15AU Final Model and a model with MRIP-FES landings and releases plus updated proportion catch-at-age, release-at-age, and mean weights-at-age (S15AU_MRIPcatch_plus).

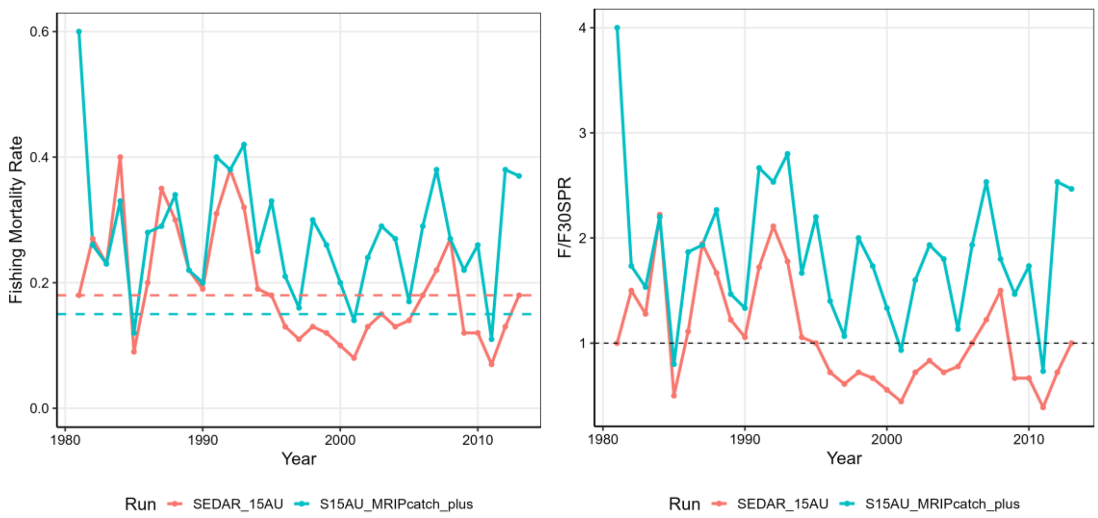
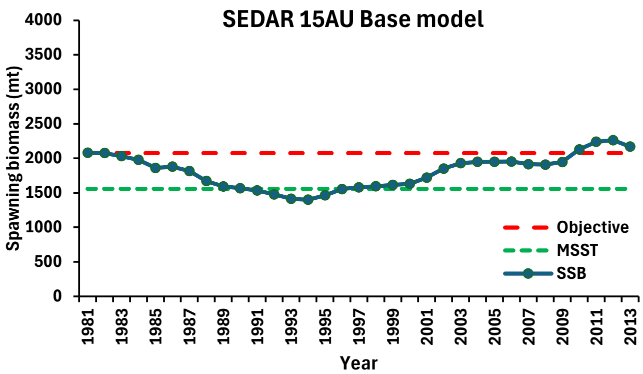
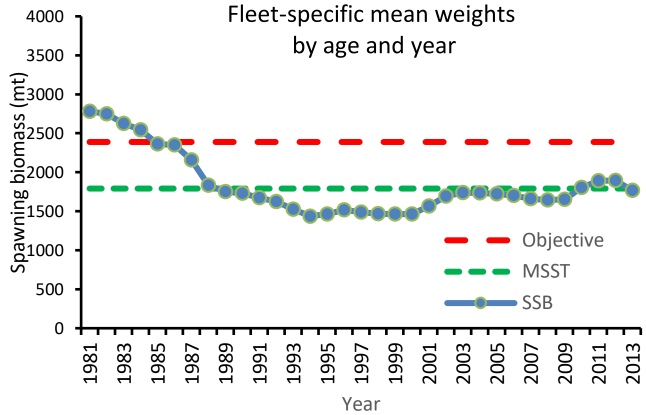


Figure 84. Comparison of fishing mortality rates ($F_{30\%SPR}$ shown by solid lines) and fishing mortality rates relative to $F_{30\%SPR}$ estimated by the SEDAR 15AU Final Model and a model with MRIP-FES landings and releases plus updated proportion catch-at-age, release-at-age, and mean weights-at-age (S15AU_MRIPcatch_plus).

a.



b.



c.

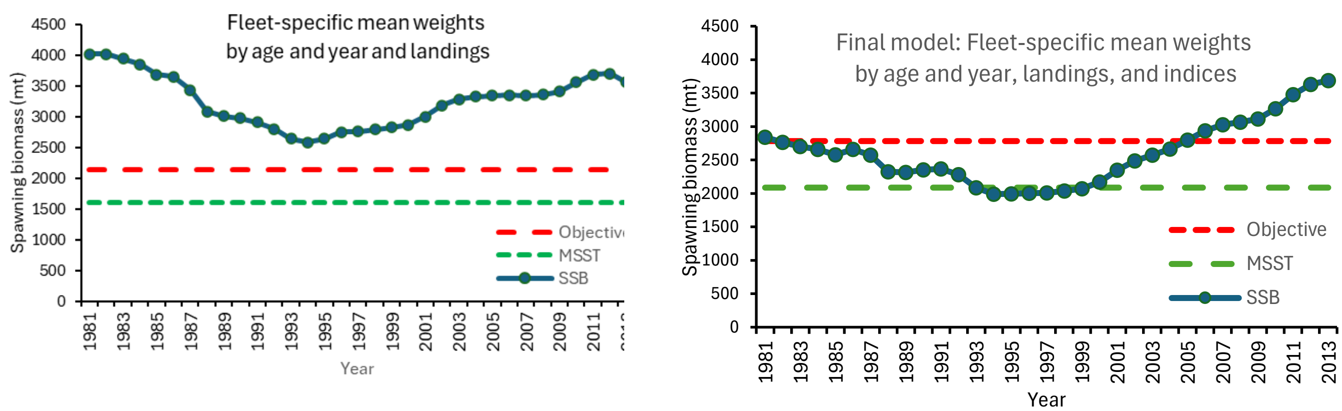


Figure 85. Plots of spawning biomass by year showing the Objective ($SSB_{F30\%SPR}$), the MSST (75% of $SSB_{F30\%SPR}$) and the annual spawning biomass estimates for the SEDAR 15AU base model and the three model bridging models.

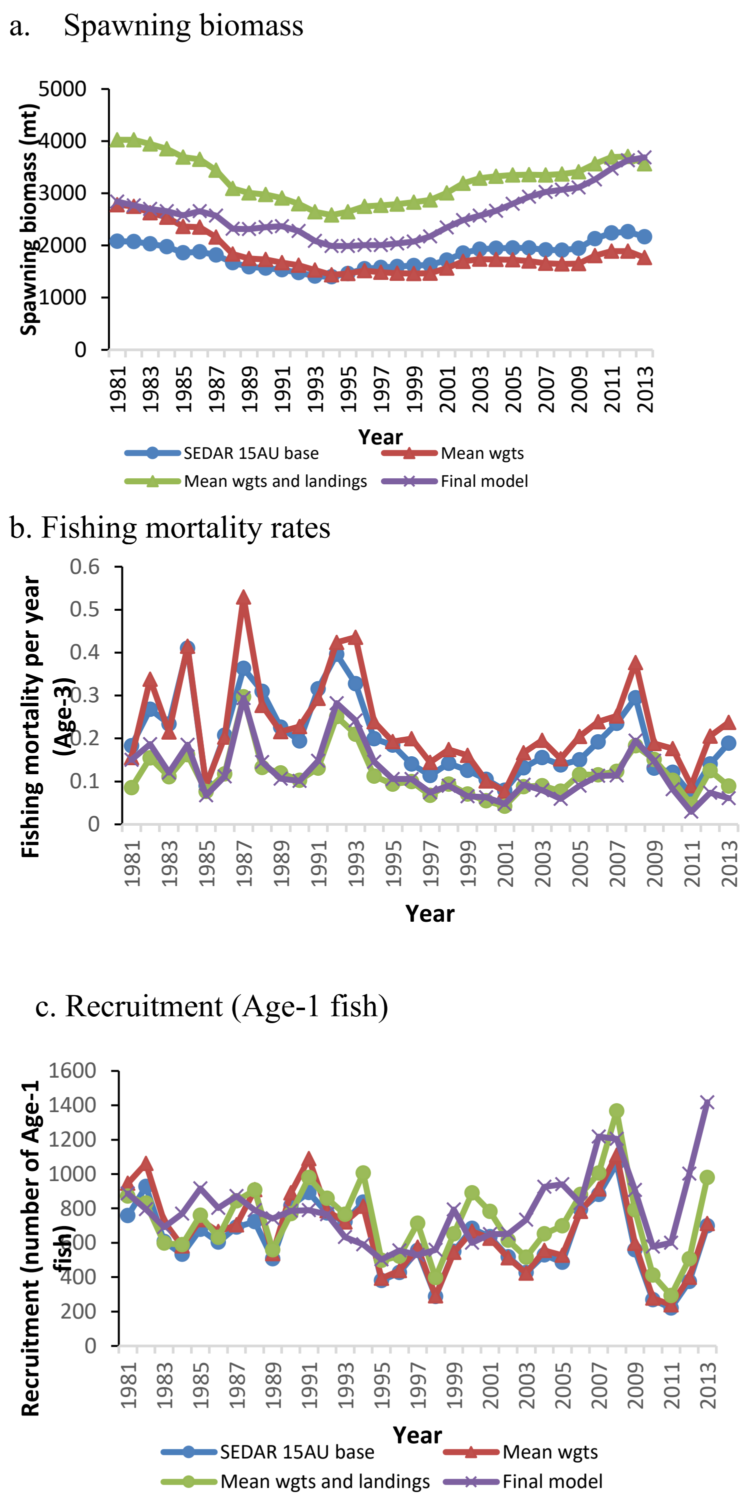


Figure 86. Trajectories of spawning biomass (mt), fishing mortality of age-3 fish (yr^{-1}), and recruitment (Age-1 fish) for the SEDAR 15AU base model and the three model bridging models.

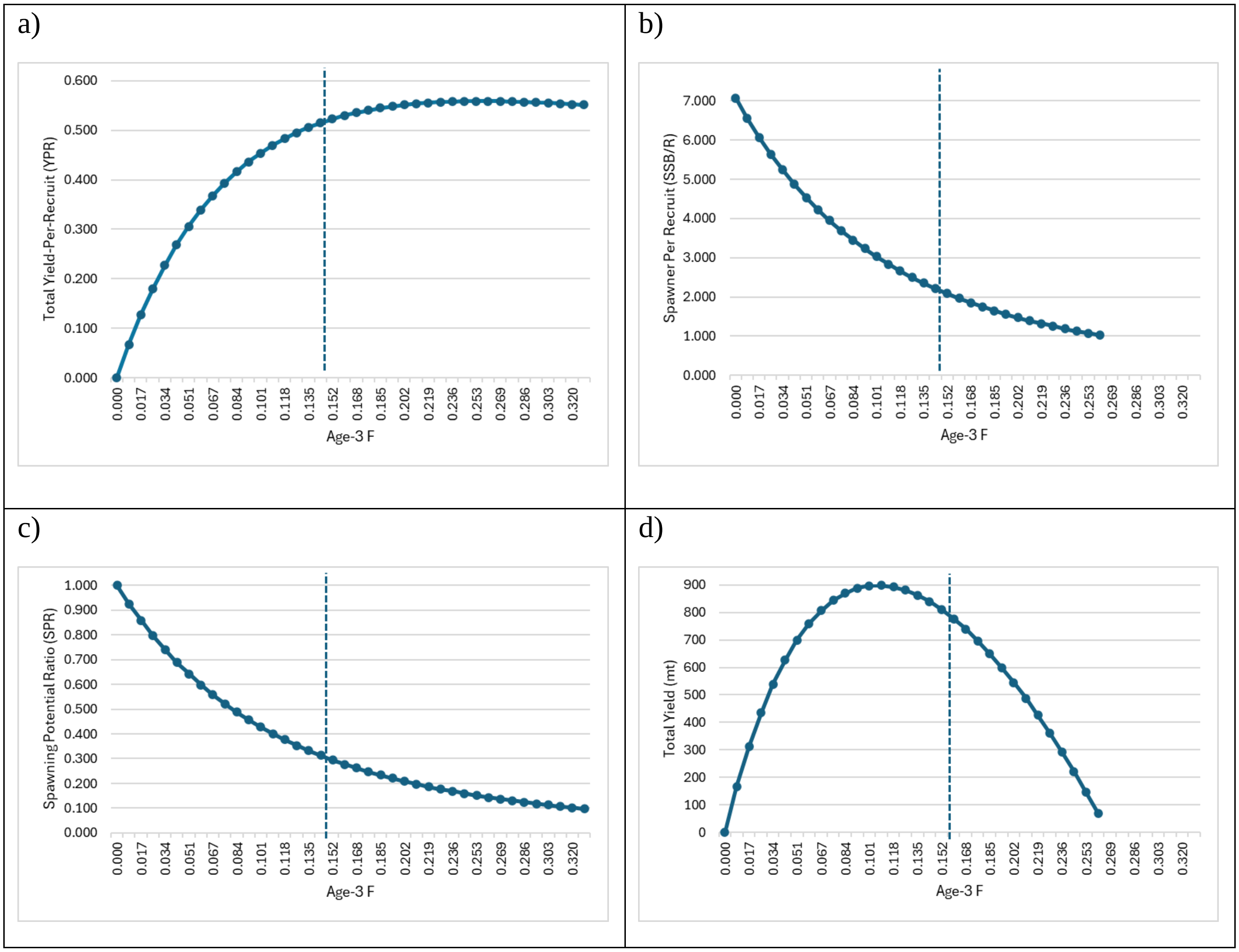


Figure 87. The a) yield-per-recruit, b) spawner-per-recruit, c) spawning potential ratio, and d) total equilibrium yield computed as a function of the instantaneous fishing mortality rate on age-3 Mutton Snapper.

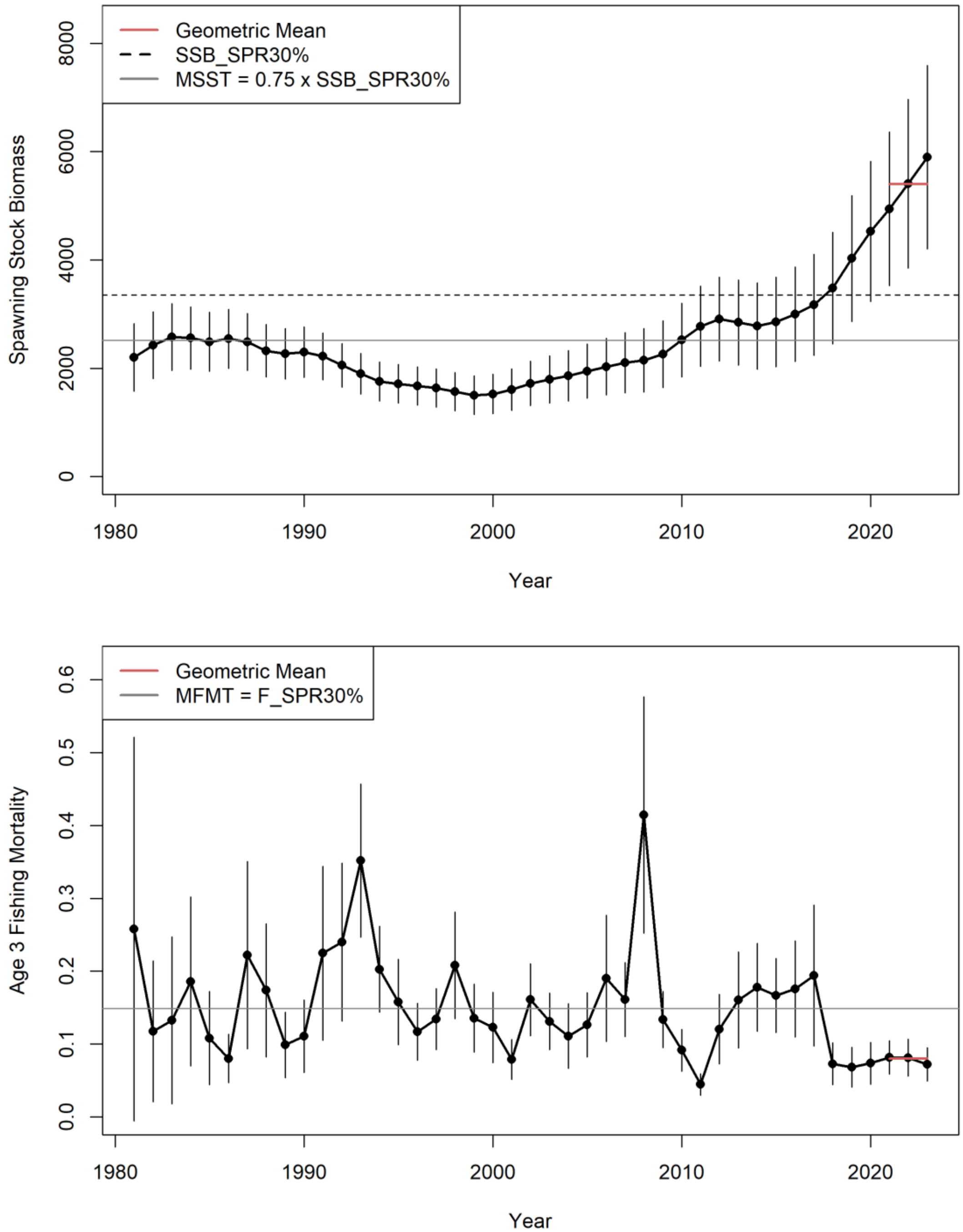


Figure 88. Time series of female spawning stock biomass (in metric tons) and age-3 fishing mortality rates, current spawning stock biomass and fishing mortality rates (red lines), as well as status determination criteria for the SEDAR 79 Southeastern US Mutton Snapper Assessment**.**

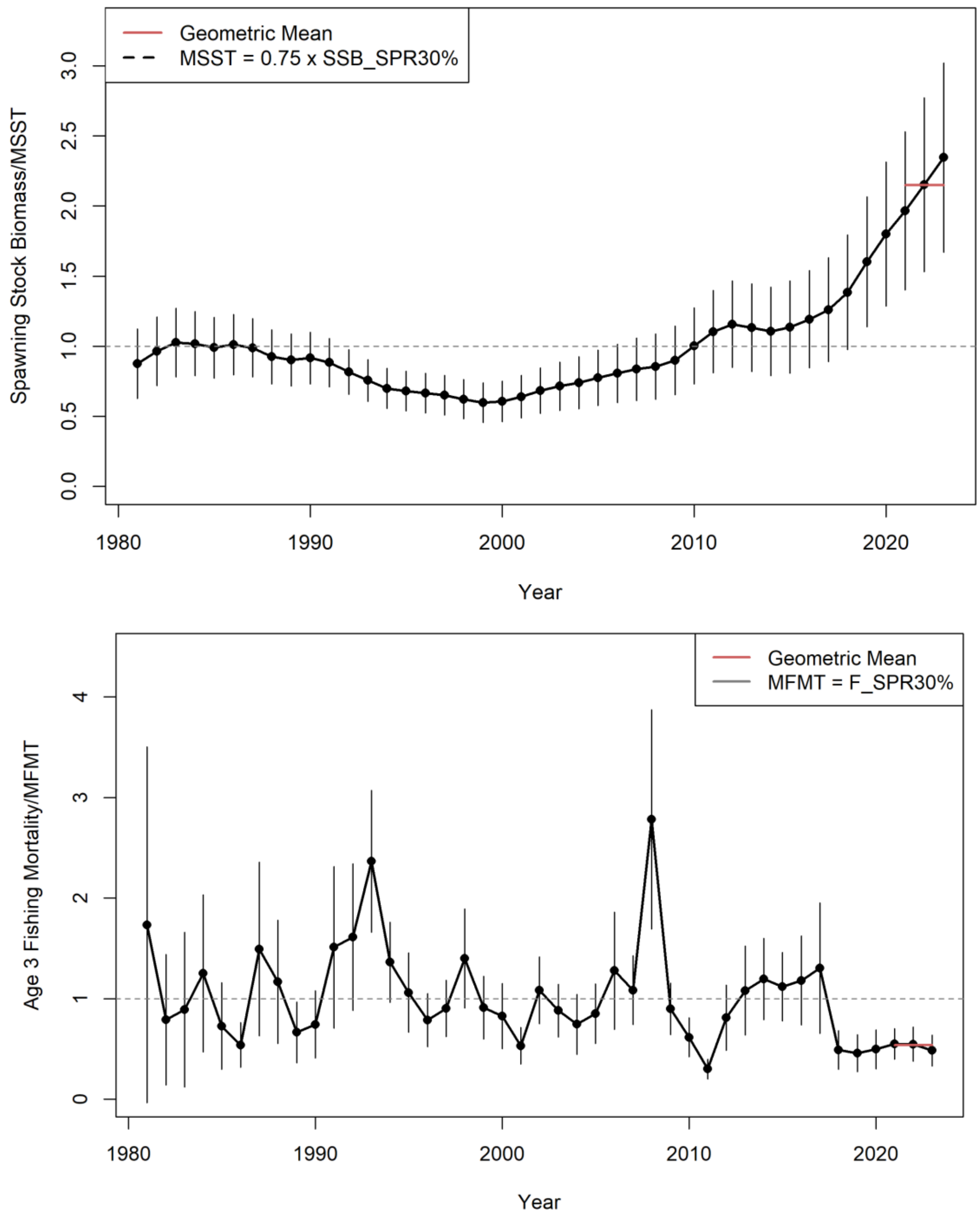


Figure 89. Time series of female spawning stock biomass (in metric tons) and age-3 fishing mortality rates with respect to status determination criteria for the SEDAR 79 Southeastern US Mutton Snapper Assessment**.**

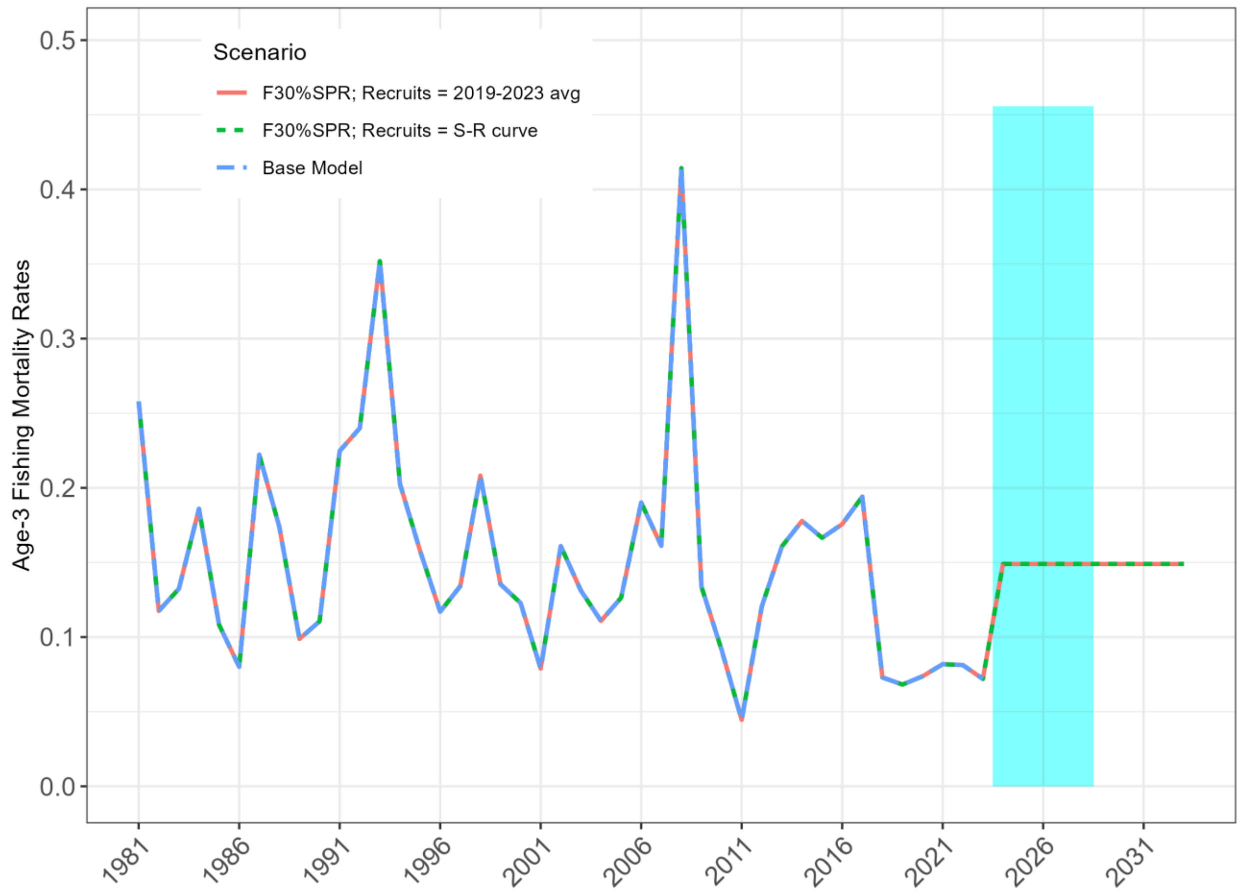


Figure 90. Historical and projected age-3 fishing mortality rates for the long- and short-term projections when constant fishing mortality rates equal $F_{30\%SPR}$ for the SEDAR 79 Southeastern US Mutton Snapper Assessment. The green shaded area identifies the first 5 years of the projections (2024-2028).

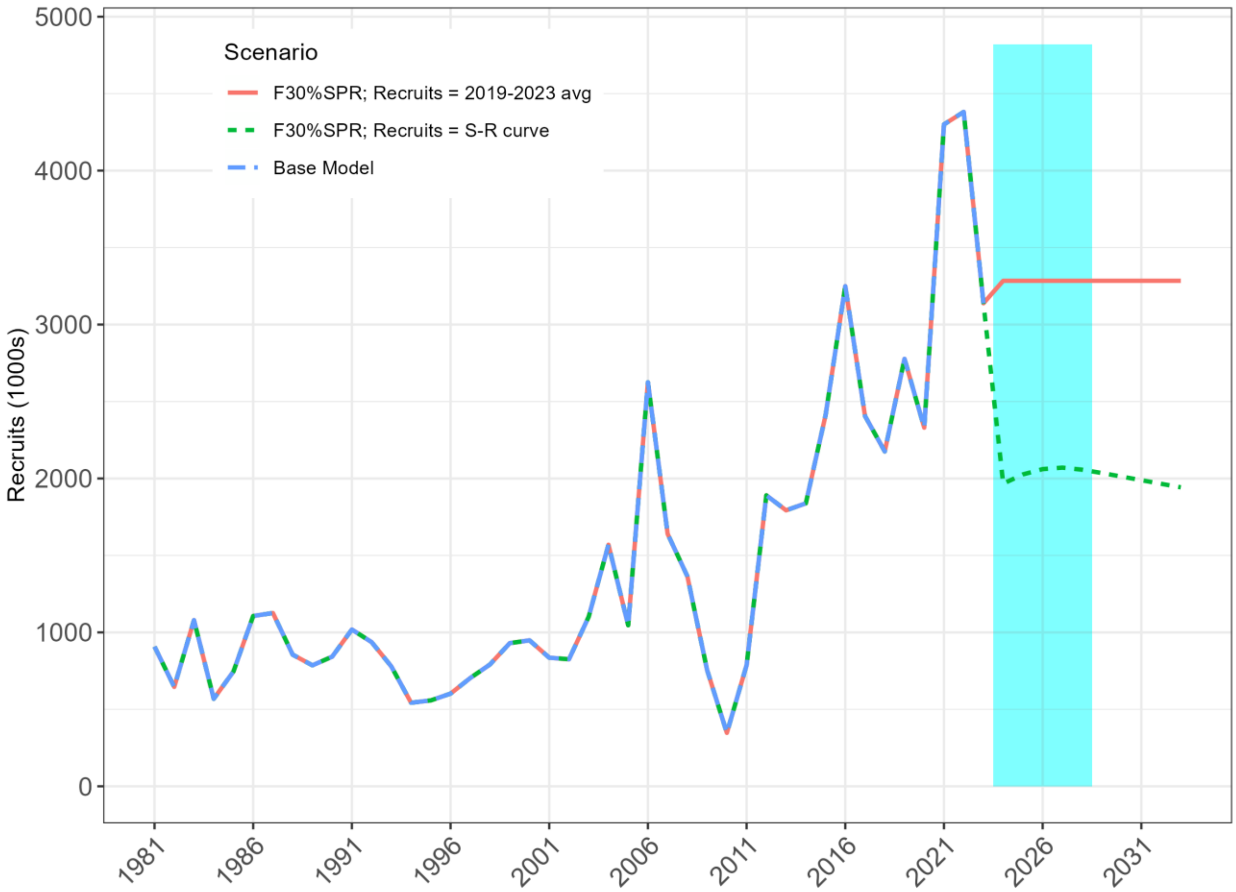


Figure 91. Historical and projected age 1 recruitment for the long- and short-term projections when constant fishing mortality rates equal $F_{30\%SPR}$ for the SEDAR 79 Southeastern US Mutton Snapper Assessment. The green shaded area identifies the first 5 years of the projections (2024-2028).

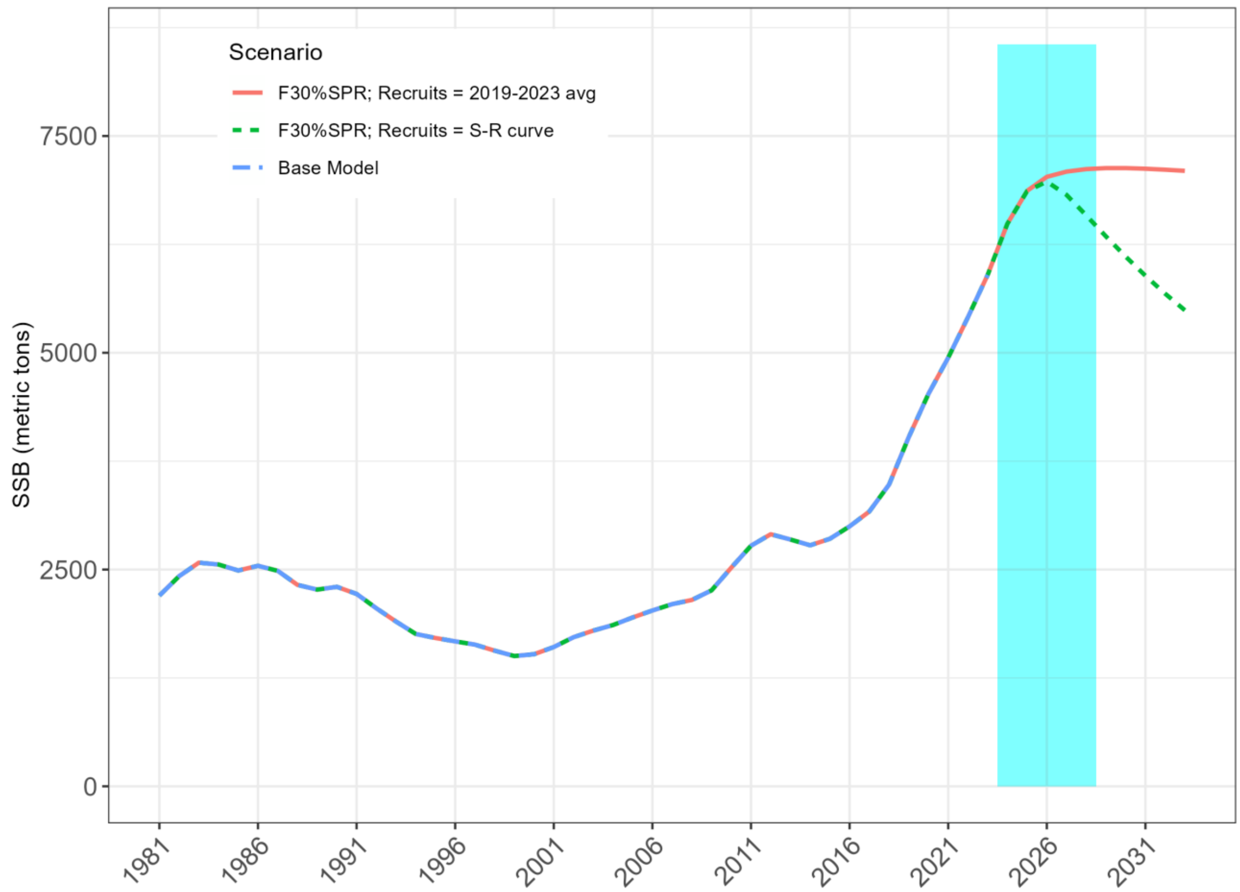
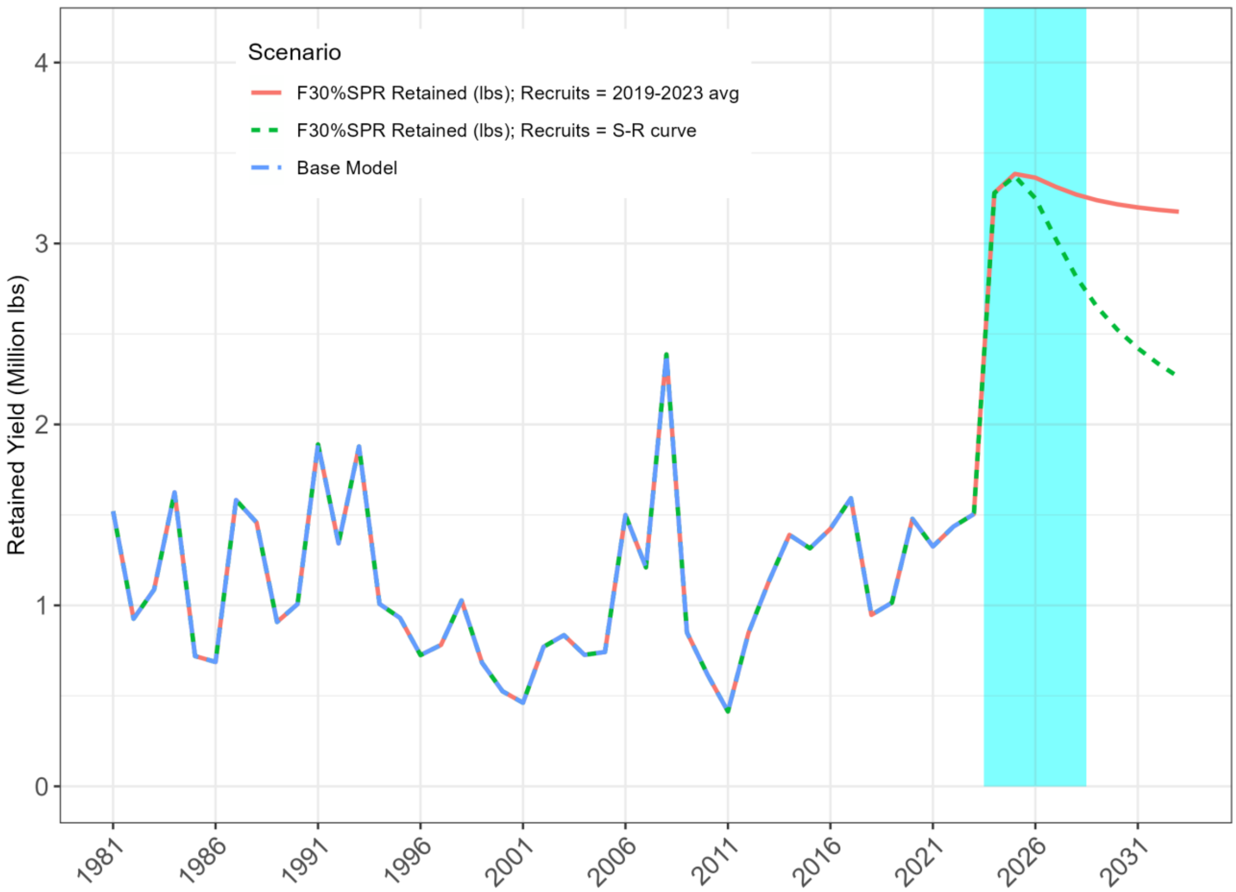
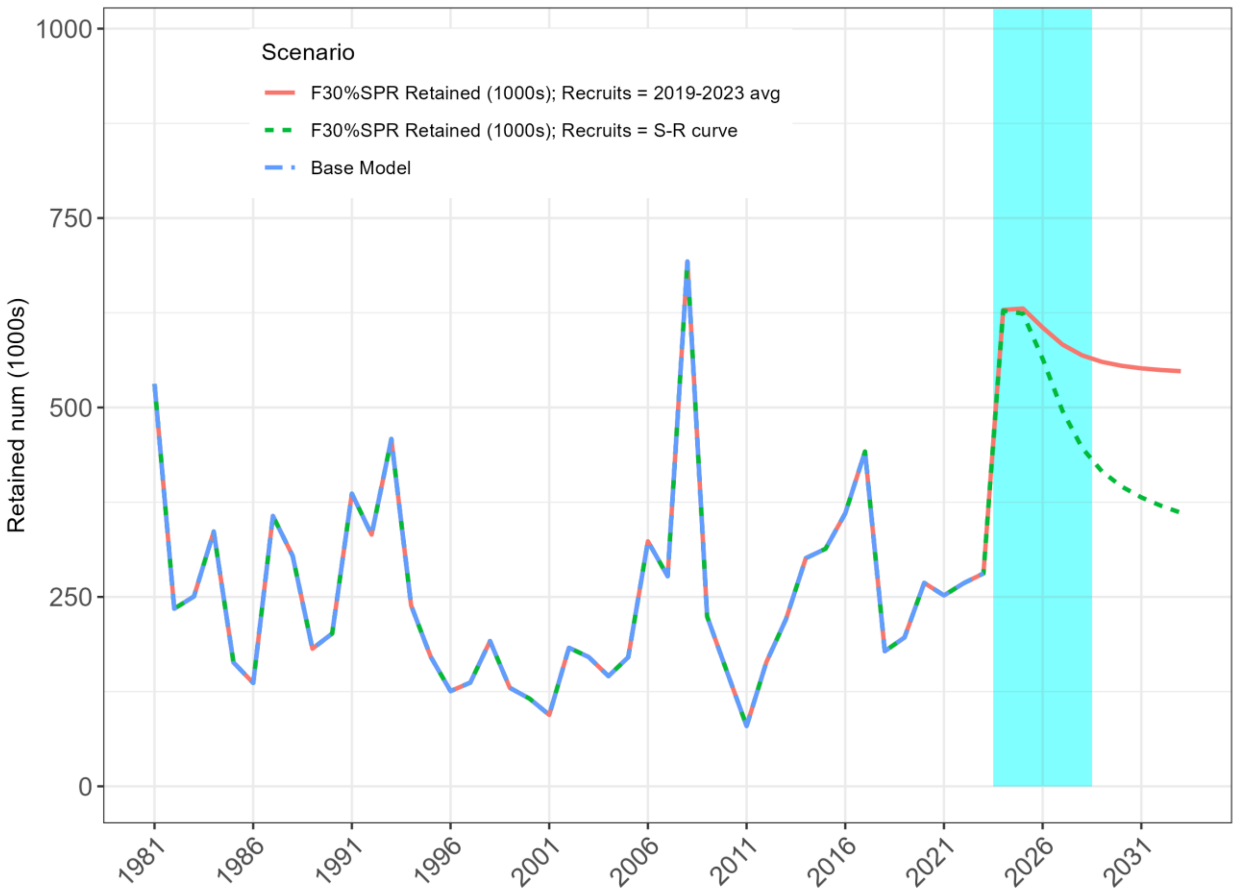


Figure 92. Historical and projected spawning stock biomass for the long- and short-term projections when constant fishing mortality rates equal $F_{30\%SPR}$ for the SEDAR 79 Southeastern US Mutton Snapper Assessment. The green shaded area identifies the first 5 years of the projections (2024-2028).

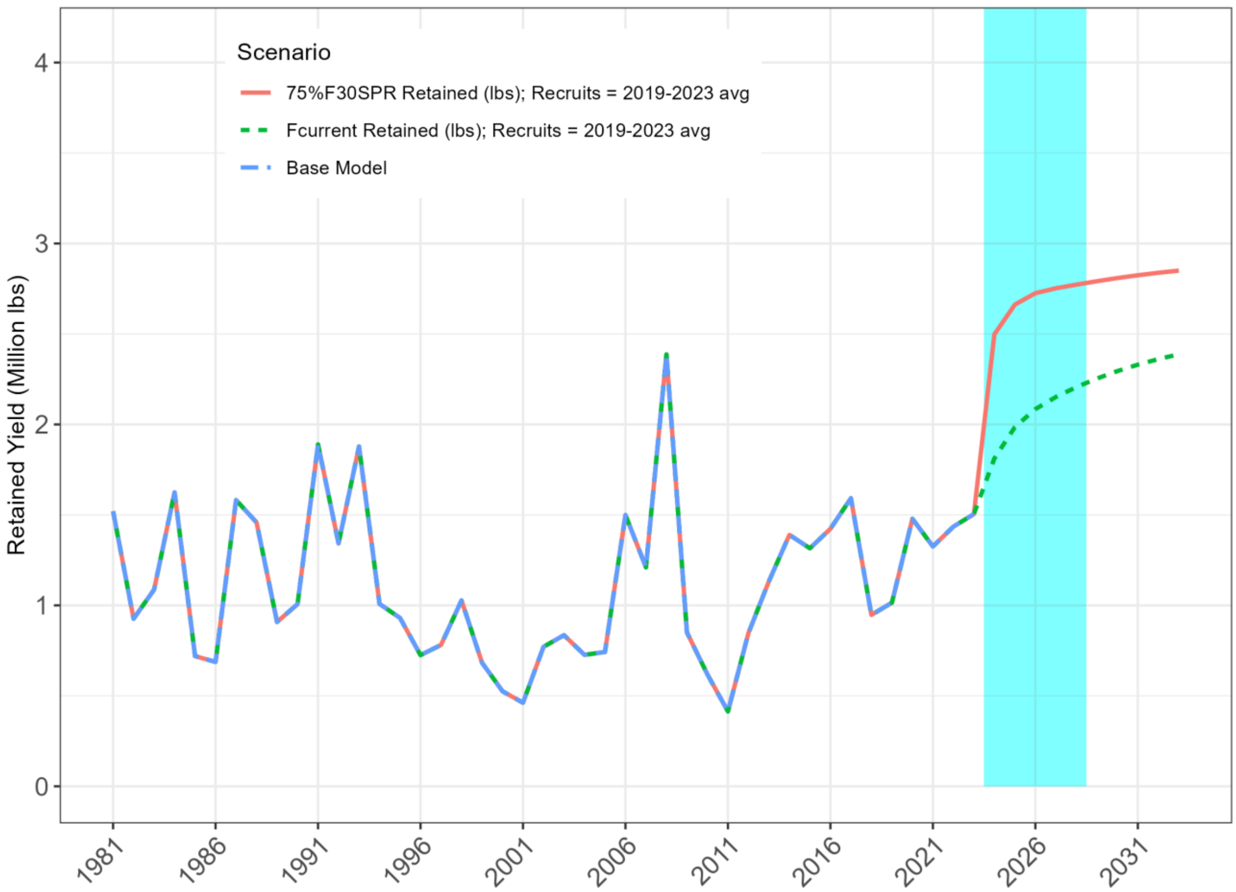

Scenario
F30%SPR Retained (lbs); Recruits = 2019-2023 avg
F30%SPR Retained (lbs); Recruits = S-R curve
Base Model
Retained Yield (Million lbs)
0
1
2
3
4
1981
1986
1991
1996
2001
2006
2011
2016
2021
2026
2031

a)

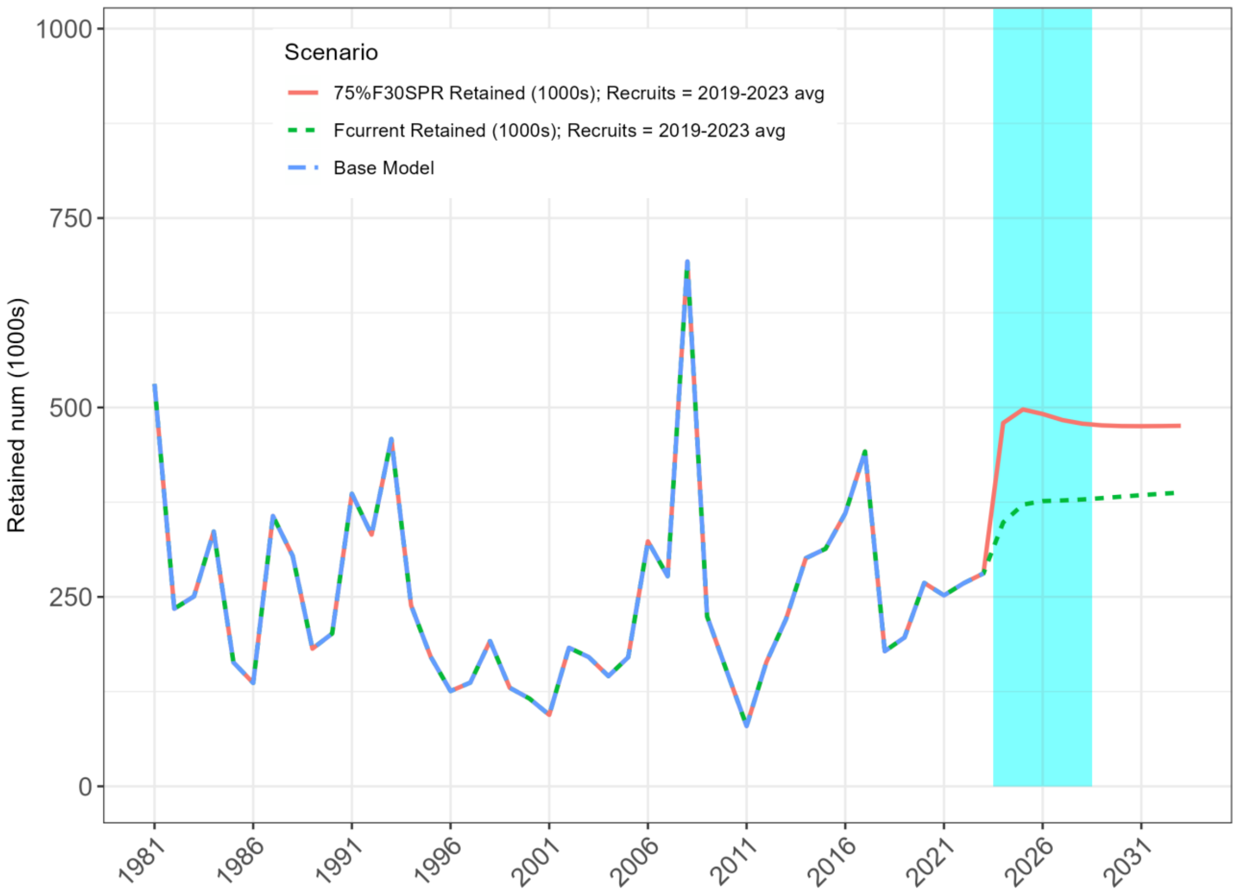


b)

Figure 93. Historical and projected retained yield in millions of pounds (a) and 1000s (b) for the long- and short-term projections when constant fishing mortality rates equal $F_{30\%SPR}$ for the SEDAR 79 Southeastern US Mutton Snapper Assessment. The green shaded area identifies the first 5 years of the projections (2024-2028).


Scenario
75%F30SPR Retained (lbs); Recruits = 2019-2023 avg
Fcurrent Retained (lbs); Recruits = 2019-2023 avg
Base Model
Retained Yield (Million lbs)
0
1
2
3
4
1981
1986
1991
1996
2001
2006
2011
2016
2021
2026
2031

a)



b)

Figure 94. Historical and projected retained yield in millions of pounds (a) and 1000s (b) for short-term projections when constant fishing mortality rates equal 75% of $F_{30\%SPR}$ and $F_{current}$ for the SEDAR 79 Southeastern US Mutton Snapper Assessment. The green shaded area identifies the first 5 years of the projections (2024-2028).

Appendix

Starter File:

```
#V3.30.22.1;_safe;_compile_date:_Jan 30 2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.1
#_Stock_Synthesis_is_a_work_of_the_U.S._Government_and_is_not_subject_to_copyright_protection_in_the_United_States.
#_Foreign_copyrights_may_apply._See_copyright.txt_for_more_information.
#_User_support_available_at:NMFS.Stock.Synthesis@noaa.gov
#_User_info_available_at:https://vlab.noaa.gov/group/stock-synthesis
#_Source_code_at:_https://github.com/nmfs-ost/ss3-source-code

S79data.dat
S79control.ctl
0 # 0=use init values in control file; 1=use ss.par
1 # run display detail (0 = minimal; 1=one line per iter; 2=each logL)
1 # detailed output (0=minimal for data-limited, 1=high (w/ wtatage.ss_new), 2=brief, 3=custom)
#COND: custom report options: -100 to start with minimal; -101 to start with all; -number to remove, +number to add, -999 to end
0 # write 1st iteration details to echoinput.sso file (0,1)
4 # write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all; 3=every_iter,all_parms; 4=every,active)
2 # write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)
0 # Include prior_like for non-estimated parameters (0,1)
1 # Use Soft Boundaries to aid convergence (0,1) (recommended)
#
3 # Number of datafiles to produce:  0 turns off all *.ss_new; 1st is data_echo.ss_new, 2nd is data_expval.ss, 3rd and higher are data_boot_**N.ss,
20 # Turn off estimation for parameters entering after this phase
#
0 # MCeval burn interval
1 # MCeval thin interval
0 # jitter initial parm value by this fraction
-1 # min yr for sdreport outputs (-1 for styr); #_1979
-2 # max yr for sdreport outputs (-1 for endyr+1; -2 for endyr+Nforecastyrs); #_2123
0 # N individual STD years
#COND: vector of year values if N>0
0.0001 # final convergence criteria (e.g. 1.0e-04)
0 # retrospective year relative to end year (e.g. -4)
1 # min age for calc of summary biomass
1 # Depletion basis:  denom is: 0=skip; 1=X*SPBvirgin; 2=X*SPBmsy; 3=X*SPB_styr; 4=X*SPB_endyr; 5=X*dyn_Bzero;  values>=11 invoke N multiyr (up to 9!) with 10's digit; >100 invokes log(ratio)
0.3 # Fraction (X) for Depletion denominator (e.g. 0.4)
4 # SPR_report_basis:  0=skip; 1=(1-SPR)/(1-SPR_tgt); 2=(1-SPR)/(1-SPR_MSY); 3=(1-SPR)/(1-SPR_Btarget); 4=rawSPR
4 # F_std_reporting_units: 0=skip; 1=exploitation(Bio); 2=exploitation(Num); 3=sum(Apical_F's); 4=mean F for range of ages (numbers weighted); 5=unweighted mean F for range of ages
 3 3 # min and max age over which mean F will be calculated, with F=Z-M
0 # F_std_scaling: 0=no scaling; 1=F/Fspr; 2=F/Fmsy; 3=F/Fbtgt; where F means annual F_std, Fmsy means F_std@msy; values >=11 invoke N multiyr (up to 9!) using 10's digit; >100 invokes log(ratio)
0 # MCMC output detail: integer part (0=default; 1=adds obj func components; 2= +write_report_for_each_mceval); and decimal part (added to SR_LN(R0) on first call to mcmc)
0 # ALK tolerance ***disabled in code
-1 # random number seed for bootstrap data (-1 to use long(time) as seed): # 1722874317
3.30 # check value for end of file and for version control
```

Forecast File:

```
#V3.30.22.1;_safe;_compile_date:_Jan 30 2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.1
# for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for endyr, neg number for rel. endyr
2 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy; 2=calc F_spr,F0.1,F_msy; 3=add F_Blimit;
1 # Do_MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt) or F0.1; 4=set to F(endyr); 5=calc F(MEY) with MSY_unit options
# if Do_MSY=5, enter MSY_Units; then list fleet_ID, cost/F, price/mt, include_in_Fmey_scaling; # -fleet_ID to fill; -9999 to terminate
0.3 # SPR target (e.g. 0.40)
0.1 # Biomass target (e.g. 0.40)
#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF, beg_recr_dist, end_recr_dist, beg_SRparm, end_SRparm (enter actual year, or values of #0 or -integer to be rel. endyr)
 -999 2023 2021 2023 2021 2023 -999 2023 -999 2023
1 #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below
#
1 # Forecast: -1=none; 0=simple_1yr; 1=F(SPR); 2=F(MSY) 3=F(Btgt) or F0.1; 4=Ave F (uses first-last relF yrs); 5=input annual F scalar
# where none and simple require no input after this line; simple sets forecast F same as end year F
100 # N forecast years
1 # Fmult (only used for Do_Forecast==5) such that apical_F(f)=Fmult*relF(f)
-12345  # code to invoke new format for expanded fcast year controls
# biology and selectivity vectors are updated annually in the forecast according to timevary parameters, so check end year of blocks and dev vectors
# input in this section directs creation of means over historical years to override any time_vary changes
# Factors implemented so far: 1=M, 4=recr_dist, 5=migration, 10=selectivity, 11=rel_F, 12=recruitment
# rel_F and Recruitment also have additional controls later in forecast.ss
# input as list: Factor, method (0, 1), st_yr, end_yr
# Terminate with -9999 for Factor
# st_yr and end_yr input can be actual year; <=0 sets rel. to timeseries endyr; Except -999 for st_yr sets to first year if time series
```

```
# Method = 0 (or omitted) continue using time_vary parms; 1  use mean of derived factor over specified year range
# Factor method st_yr end_yr
 1 1 -999 2023 # natmort; use:  1 1 1981 2023
 4 1 -999 2023 # recr_dist; use:  4 1 1981 2023
 10 1 2021 2023 # selectivity; use:  10 1 2021 2023
 11 1 2021 2023 # rel_F; use:  11 1 2021 2023
 12 1 2018 2022 # recruitment; use:  12 1 2018 2022
-9999 0 0 0
#
2 # Control rule method (0: none; 1: ramp does catch=f(SSB), buffer on F; 2: ramp does F=f(SSB), buffer on F; 3: ramp does catch=f(SSB), buffer on catch; 4: ramp does F=f(SSB), buffer on catch)
# values for top, bottom and buffer exist, but not used when Policy=0
0.3 # Control rule inflection for constant F (as frac of Bzero, e.g. 0.40); must be > control rule cutoff, or set to -1 to use Bmsy/SSB_unf
0.1 # Control rule cutoff for no F (as frac of Bzero, e.g. 0.10)
1 # Buffer:  enter Control rule target as fraction of Flimit (e.g. 0.75), negative value invokes list of [year, scalar] with filling from year to YrMax
#
3 #_N forecast loops (1=OFL only; 2=ABC; 3=get F from forecast ABC catch with allocations applied)
3 # First forecast loop with stochastic recruitment
0 # Forecast base recruitment:  0= spawn_recr; 1=mult*spawn_recr_fxn; 2=mult*VirginRecr; 3=deprecated; 4=mult*mean_over_yr_range
# for option 4, set phase for fore_recr_devs to -1 in control to get constant mean in MCMC, else devs will be applied
1 # Value multiplier is ignored
0 # not used
#
2024  # FirstYear for caps and allocations (should be after years with fixed inputs)
0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error)
0 # Do West Coast gfish rebuilder output: 0=no; 1=yes
2024 # Rebuilder:  first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
2024 # Rebuilder:  year for current age structure (Yinit) (-1 to set to endyear+1)
1 # fleet relative F:  1=use mean over year range; 2=read seas, fleet, alloc list below
# Note that fleet allocation values is used directly as F if Do_Forecast=4
3 # basis for fcast catch tuning and for fcast catch caps and allocation  (2=deadbio; 3=retainbio; 5=deadnum; 6=retainnum); NOTE: same units for all fleets
# Conditional input if relative F choice = 2
# enter list of: fleet number, max annual catch for fleets with a max; terminate with fleet=-9999
-9999 -1
# enter list of area ID and max annual catch; terminate with area=-9999
-9999 -1
# enter list of fleet number and allocation group assignment, if any; terminate with fleet=-9999
-9999 -1
#_if N allocation groups >0, list year, allocation fraction for each group
# list sequentially because read values fill to end of N forecast
# terminate with -9999 in year field
# no allocation groups
#
3 # basis for input Fcast catch: -1=read basis with each obs; 2=dead catch; 3=retained catch; 99=input apical_F; NOTE: bio vs num based on fleet's catchunits
#enter list of Fcast catches or Fa; terminate with line having year=-9999
#_Yr Seas Fleet Catch(or_F)
-9999 1 1 0
#
999 # verify end of input
```

Control File:

```
#V3.30.22.1;_safe;_compile_date:_Jan 30 2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.1
#_Stock_Synthesis_is_a_work_of_the_U.S._Government_and_is_not_subject_to_copyright_protection_in_the_United_States.
#_Foreign_copyrights_may_apply._See_copyright.txt_for_more_information.
#_User_support_available_at:NMFS.Stock.Synthesis@noaa.gov
#_User_info_available_at:https://vlab.noaa.gov/group/stock-synthesis
#_Source_code_at:_https://github.com/nmfs-ost/ss3-source-code

#_data_and_control_files: S79data.dat // S79control.ctl
0  # 0 means do not read wtatage.ss; 1 means read and use wtatage.ss and also read and use growth parameters
1  #_N_Growth_Patterns (Growth Patterns, Morphs, Bio Patterns, GP are terms used interchangeably in SS3)
1 #_N_platoons_Within_GrowthPattern
#_Cond 1 #_Platoon_within/between_stdev_ratio (no read if N_platoons=1)
#_Cond sd_ratio_rd < 0: platoon_sd_ratio parameter required after movement params.
#_Cond  1 #vector_platoon_dist_(-1_in_first_val_gives_normal_approx)
#
4 # recr_dist_method for parameters:  2=main effects for GP, Area, Settle timing; 3=each Settle entity; 4=none (only when N_GP*Nsettle*pop==1)
1 # not yet implemented; Future usage: Spawner-Recruitment: 1=global; 2=by area
1 #  number of recruitment settlement assignments
0 # unused option
#GPattern month  area  age (for each settlement assignment)
 1 13 1 1
#
#_Cond 0 # N_movement_definitions goes here if Nareas > 1
#_Cond 1.0 # first age that moves (real age at begin of season, not integer) also cond on do_migration>0
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, source=1 dest=2, age1=4, age2=10
#
3 #_Nblock_Patterns
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 2 2 2 #_blocks_per_pattern
# begin and end years of blocks
 1992 2017 2018 2024
 1995 2017 2018 2024
 2016 2019 2020 2024
#
# controls for all timevary parameters
1 #_time-vary parm bound check (1=warn relative to base parm bounds; 3=no bound check); Also see env (3) and dev (5) options to constrain with base bounds
#
# AUTOGEN
 1 1 1 1 1 # autogen: 1st element for biology, 2nd for SR, 3rd for Q, 4th reserved, 5th for selex
# where: 0 = autogen time-varying parms of this category; 1 = read each time-varying parm line; 2 = read then autogen if parm min==-12345
#
#_Available timevary codes
#_Block types: 0: P_block=P_base*exp(TVP); 1: P_block=P_base+TVP; 2: P_block=TVP; 3: P_block=P_block(-1) + TVP
#_Block_trends: -1: trend bounded by base parm min-max and parms in transformed units (beware); -2: endtrend and infl_year direct values; -3: end and infl as fraction of base range
#_EnvLinks:  1: P(y)=P_base*exp(TVP*env(y));  2: P(y)=P_base+TVP*env(y);  3: P(y)=f(TVP,env_Zscore) w/ logit to stay in min-max;  4: P(y)=2.0/(1.0+exp(-TVP1*env(y) - TVP2))
#_DevLinks:  1: P(y)*=exp(dev(y)*dev_se;  2: P(y)+=dev(y)*dev_se;  3: random walk;  4: zero-reverting random walk with rho;  5: like 4 with logit transform to stay in base min-max
#_DevLinks(more):  21-25 keep last dev for rest of years
#
#_Prior_codes:  0=none; 6=normal; 1=symmetric beta; 2=CASAL's beta; 3=lognormal; 4=lognormal with biascorr; 5=gamma
#
# setup for M, growth, wt-len, maturity, fecundity, (hermaphro), recr_distr, cohort_grow, (movement), (age error), (catch_mult), sex ratio
#_NATMORT
6 #_natM_type:_0=1Parm;
1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate;_5=BETA:_Maunder_link_to_maturity;_6=Lorenzen_range
3 #_minimum age for Lorenzen
40 #_maximum age for Lorenzen; read 1P per morph
#
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=age_specific_K_incr; 4=age_specific_K_decr; 5=age_specific_K_each; 6=NA; 7=NA;
8=growth cessation
0 #_Age(post-settlement) for L1 (aka Amin); first growth parameter is size at this age; linear growth below this
999 #_Age(post-settlement) for L2 (aka Amax); 999 to treat as Linf
-998 #_exponential decay for growth above maxage (value should approx initial Z; -999 replicates 3.24; -998 to not allow growth above maxage)
0  #_placeholder for future growth feature
#
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
0 #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4 logSD=F(A)
#
2 #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pattern; 4=read age-fecundity; 5=disabled; 6=read length-maturity
2 #_First_Mature_Age
5 #_fecundity_at_length option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b; (4)eggs=a+b*L; (5)eggs=a+b*W
0 #_hermaphroditism option:  0=none; 1=female-to-male age-specific fxn; -1=male-to-female age-specific fxn
1 #_parameter_offset_approach for M, G, CV_G:  1- direct, no offset**; 2- male=fem_parm*exp(male_parm); 3: male=female*exp(parm) then old=young*exp(parm)
#_** in option 1, any male parameter with value = 0.0 and phase <0 is set equal to female parameter
#
#_growth_parms
#_ LO HI INIT PRIOR PR_SD PR_type PHASE env_var&link dev_link dev_minyr dev_maxyr dev_PH Block Block_Fxn
# Sex: 1  BioPattern: 1  NatMort
 0.1 0.4 0.129 0.203 0.31 0 -99 0 0 0 0 0 0 0 # NatM_Lorenzen_averageFem_GP_1
# Sex: 1  BioPattern: 1  Growth
 2 40 27.6533 20 10 0 1 0 0 0 0 0 0 0 # L_at_Amin_Fem_GP_1
 50 105 82.2646 84.7 10 0 2 0 0 0 0 0 0 0 # L_at_Amax_Fem_GP_1
 0.05 0.5 0.194626 0.163 0.8 0 2 0 0 0 0 0 0 0 # VonBert_K_Fem_GP_1
 0.1 0.5 0.16741 0.15 0.8 0 3 0 0 0 0 0 0 0 # CV_young_Fem_GP_1
 0.005 0.4 0.091251 0.05 0.8 0 3 0 0 0 0 0 0 0 # CV_old_Fem_GP_1
# Sex: 1  BioPattern: 1  WtLen
 0 3 6.63e-06 6.63e-06 0.8 0 -99 0 0 0 0 0 0 0 # Wtlen_1_Fem_GP_1
 1 4 3.1601 3.1601 0.8 0 -99 0 0 0 0 0 0 0 # Wtlen_2_Fem_GP_1
# Sex: 1  BioPattern: 1  Maturity&Fecundity
 1 4 3.5 3.5 1.1 0 -99 0 0 0 0 0 0 0 # Mat50%_Fem_GP_1
 -3 -0.05 -2.535 -2.535 0.787 0 -99 0 0 0 0 0 0 0 # Mat_slope_Fem_GP_1
 -3 3 0 0 0.8 0 -99 0 0 0 0 0 0 0 # Eggs_intercept_Fem_GP_1
 -3 3 1 1 0.8 0 -99 0 0 0 0 0 0 0 # Eggs_slope_Wt_Fem_GP_1
# Hermaphroditism
#  Recruitment Distribution
#  Cohort growth dev base
 0 1 1 0 0 0 -99 0 0 0 0 0 0 0 # CohortGrowDev
#  Movement
#  Platoon StDev Ratio
#  Age Error from parameters
#  catch multiplier
#  fraction female, by GP
 0.5 0.5 0.5 0.5 0 0 -99 0 0 0 0 0 0 0 # FracFemale_GP_1
#  M2 parameter for each predator fleet
#
#_no timevary MG parameters
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#
#_seasonal_effects_on_biology_parms
 0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
#_ LO HI INIT PRIOR PR_SD PR_type PHASE
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#
3 #_Spawner-Recruitment; Options: 1=NA; 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop; 7=survival_3Parm; 8=Shepherd_3Parm;
9=RickerPower_3parm
0  # 0/1 to use steepness in initial equ recruitment calculation
0  #  future feature:  0/1 to make realized sigmaR a function of SR curvature
#_       LO        HI      INIT     PRIOR     PR_SD   PR_type   PHASE   env-var   use_dev   dev_mnyr   dev_mxyr   dev_PH   Block   Blk_Fxn #
parm_name
       6.5        11   7.82919         7        10         0         3         0         0         0         0         0         0         0 # SR_LN(R0)
      0.41      0.99  0.644384       0.7       0.9         0         3         0         0         0         0         0         0         0 # SR_BH_steep
       0.1       0.8  0.553219       0.6       0.2         0         6         0         0         0         0         0         0         0 # SR_sigmaR
        -5         5         0         0         0         0       -99         0         0         0         0         0         0         0 # SR_regime
         0         0         0         0         0         0       -99         0         0         0         0         0         0         0 # SR_autocorr
#_no timevary SR parameters
2 #do_recdev:  0=none; 1=devvector (R=F(SSB)+dev); 2=deviations (R=F(SSB)+dev); 3=deviations (R=R0*dev; dev2=R-f(SSB)); 4=like 3 with sum(dev2) adding
penalty
1986 # first year of main recr_devs; early devs can precede this era
2022 # last year of main recr_devs; forecast devs start in following year
4 #_recdev phase
1 # (0/1) to read 13 advanced options
 1970 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
 6 #_recdev_early_phase
 -7 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
 0 #_lambda for Fcast_recr_like occurring before endyr+1
 1966.8 #_last_yr_nobias_adj_in_MPD; begin of ramp
 1986.5 #_first_yr_fullbias_adj_in_MPD; begin of plateau
 2018.4 #_last_yr_fullbias_adj_in_MPD
 2029.7 #_end_yr_for_ramp_in_MPD (can be in forecast to shape ramp, but SS3 sets bias_adj to 0.0 for fcast yrs)
 0.9102 #_max_bias_adj_in_MPD (typical ~0.8; -3 sets all years to 0.0; -2 sets all non-forecast yrs w/ estimated recdevs to 1.0; -1 sets biasadj=1.0 for all yrs w/
recdevs)
 0 #_period of cycles in recruitment (N parms read below)
 -4 #min rec_dev
 4 #max rec_dev
 0 #_read_recdevs
#_end of advanced SR options
#
#Fishing Mortality info
0.3 # F ballpark value in units of annual_F
-2001 # F ballpark year (neg value to disable)
4 # F_Method:  1=Pope midseason rate; 2=F as parameter; 3=F as hybrid; 4=fleet-specific parm/hybrid (#4 is superset of #2 and #3 and is recommended)
3 # max F (methods 2-4) or harvest fraction (method 1)
# read list of fleets that do F as parameter; unlisted fleets stay hybrid, bycatch fleets must be included with start_PH=1, high F fleets should switch early
# (A) fleet, (B) F_starting_value (used if start_PH=1), (C) start_PH for parms (99 to stay in hybrid, <0 to stay at starting value)
# (A) (B) (C)  (terminate list with -9999 for fleet)
 1 0.01 99 # COM_LL
 2 0.05 99 # COM_OTHER
 3 0.0347176 3 # REC_E
 4 0.000365389 3 # REC_W
-9999 1 1 # end of list
4 #_number of loops for hybrid tuning; 4 good; 3 faster; 2 enough if switching to parms is enabled
#
#_initial_F_parms; for each fleet x season that has init_catch; nest season in fleet; count = 4
#_for unconstrained init_F, use an arbitrary initial catch and set lambda=0 for its logL
#_ LO HI INIT PRIOR PR_SD  PR_type  PHASE
 0.0001 0.3 0.0353763 0.01 0.5 1 1 # InitF_seas_1_flt_1COM_LL
 0.001 0.3 0.0325694 0.05 0.5 1 1 # InitF_seas_1_flt_2COM_OTHER
 0.05 0.6 0.3409 0.1 0.5 1 1 # InitF_seas_1_flt_3REC_E
 0.05 0.4 0.118346 0.1 0.5 1 1 # InitF_seas_1_flt_4REC_W
#
#_Q_setup for fleets with cpue or survey data
#_1:  fleet number
#_2:  link type: (1=simple q, 1 parm; 2=mirror simple q, 1 mirrored parm; 3=q and power, 2 parm; 4=mirror with offset, 2 parm)
#_3:  extra input for link, i.e. mirror fleet# or dev index number
#_4:  0/1 to select extra sd parameter
#_5:  0/1 for biasadj or not
#_6:  0/1 to float
#_   fleet      link link_info  extra_se   biasadj     float  #  fleetname
         1         1         0         0         1         1  #  COM_LL
         5         1         0         0         1         1  #  RVC_DT
         6         1         0         0         1         1  #  RVC_KEYS
         7         1         0         0         1         1  #  RVC_SEFL
         8         1         0         0         1         1  #  FIM_YOY
         9         1         0         0         1         0  #  GOM_VID
        10         1         0         0         1         1  #  SERFS_VID
-9999 0 0 0 0 0
#
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#_Q_parms(if_any);Qunits_are_ln(q)
#_     LO     HI     INIT     PRIOR     PR_SD     PR_type     PHASE   env-var   use_dev   dev_mnyr   dev_mxyr    dev_PH     Block    Blk_Fxn  #
parm_name
      -18      5   -7.88225      -7      1      0     -2     0     0     0     0     0     0     0  #  LnQ_base_COM_LL(1)
      -18      5   -7.33485      -8      1      0     -1     0     0     0     0     0     0     0  #  LnQ_base_RVC_DT(5)
      -18      5   -7.54841      -8      1      0     -1     0     0     0     0     0     0     0  #  LnQ_base_RVC_KEYS(6)
      -18      5   -8.04934      -8      1      0     -1     0     0     0     0     0     0     0  #  LnQ_base_RVC_SEFL(7)
      -18      5   -7.45529      -8      1      0     -1     0     0     0     0     0     0     0  #  LnQ_base_FIM_YOY(8)
      -15      5   -7.06752      -8      1      0      3     0     0     0     0     0     3     0  #  LnQ_base_GOM_VID(9)
      -18      5   -7.88324      -8      1      0     -1     0     0     0     0     0     0     0  #  LnQ_base_SERFS_VID(10)
# timevary Q parameters
#_     LO     HI     INIT     PRIOR     PR_SD     PR_type     PHASE  #  parm_name
       -2      2   0.109681      -2      1      0    4  # LnQ_base_GOM_VID(9)_BLK3mult_2016
       -2      2   0.256633      -2      1      0    4  # LnQ_base_GOM_VID(9)_BLK3mult_2020
# info on dev vectors created for Q parms are reported with other devs after tag parameter section
#
#_size_selex_patterns
#Pattern:_0;  parm=0; selex=1.0 for all sizes
#Pattern:_1;  parm=2; logistic; with 95% width specification
#Pattern:_5;  parm=2; mirror another size selex; PARMS pick the min-max bin to mirror
#Pattern:_11; parm=2; selex=1.0  for specified min-max population length bin range
#Pattern:_15; parm=0; mirror another age or length selex
#Pattern:_6;  parm=2+special; non-parm len selex
#Pattern:_43; parm=2+special+2;  like 6, with 2 additional param for scaling (mean over bin range)
#Pattern:_8;  parm=8; double_logistic with smooth transitions and constant above Linf option
#Pattern:_9;  parm=6; simple 4-parm double logistic with starting length; parm 5 is first length; parm 6=1 does desc as offset
#Pattern:_21; parm=2+special; non-parm len selex, read as pairs of size, then selex
#Pattern:_22; parm=4; double_normal as in CASAL
#Pattern:_23; parm=6; double_normal where final value is directly equal to sp(6) so can be >1.0
#Pattern:_24; parm=6; double_normal with sel(minL) and sel(maxL), using joiners
#Pattern:_2;  parm=6; double_normal with sel(minL) and sel(maxL), using joiners, back compatibile version of 24 with 3.30.18 and older
#Pattern:_25; parm=3; exponential-logistic in length
#Pattern:_27; parm=special+3; cubic spline in length; parm1==1 resets knots; parm1==2 resets all
#Pattern:_42; parm=special+3+2; cubic spline; like 27, with 2 additional param for scaling (mean over bin range)
#_discard_options:_0=none;_1=define_retention;_2=retention&mortality;_3=all_discarded_dead;_4=define_dome-shaped_retention
#_Pattern Discard Male Special
 1 0 0 0 # 1 COM_LL
 1 2 0 0 # 2 COM_OTHER
 24 2 0 0 # 3 REC_E
 24 2 0 0 # 4 REC_W
 24 0 0 0 # 5 RVC_DT
 24 0 0 0 # 6 RVC_KEYS
 1 0 0 0 # 7 RVC_SEFL
 0 0 0 0 # 8 FIM_YOY
 1 0 0 0 # 9 GOM_VID
 0 0 0 0 # 10 SERFS_VID
 0 0 0 0 # 11 FI_AGE
#
#_age_selex_patterns
#Pattern:_0; parm=0; selex=1.0 for ages 0 to maxage
#Pattern:_10; parm=0; selex=1.0 for ages 1 to maxage
#Pattern:_11; parm=2; selex=1.0  for specified min-max age
#Pattern:_12; parm=2; age logistic
#Pattern:_13; parm=8; age double logistic. Recommend using pattern 18 instead.
#Pattern:_14; parm=nages+1; age empirical
#Pattern:_15; parm=0; mirror another age or length selex
#Pattern:_16; parm=2; Coleraine - Gaussian
#Pattern:_17; parm=nages+1; empirical as random walk  N parameters to read can be overridden by setting special to non-zero
#Pattern:_41; parm=2+nages+1; // like 17, with 2 additional param for scaling (mean over bin range)
#Pattern:_18; parm=8; double logistic - smooth transition
#Pattern:_19; parm=6; simple 4-parm double logistic with starting age
#Pattern:_20; parm=6; double_normal,using joiners
#Pattern:_26; parm=3; exponential-logistic in age
#Pattern:_27; parm=3+special; cubic spline in age; parm1==1 resets knots; parm1==2 resets all
#Pattern:_42; parm=2+special+3; // cubic spline; with 2 additional param for scaling (mean over bin range)
#Age patterns entered with value >100 create Min_selage from first digit and pattern from remainder
#_Pattern Discard Male Special
 10 0 0 0 # 1 COM_LL
 10 0 0 0 # 2 COM_OTHER
 10 0 0 0 # 3 REC_E
 10 0 0 0 # 4 REC_W
 10 0 0 0 # 5 RVC_DT
 10 0 0 0 # 6 RVC_KEYS
 10 0 0 0 # 7 RVC_SEFL
 0 0 0 0 # 8 FIM_YOY
 10 0 0 0 # 9 GOM_VID
 11 0 0 0 # 10 SERFS_VID
 0 0 0 0 # 11 FI_AGE
#
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#_ LO HI INIT PRIOR PR_SD PR_type PHASE env-var use_dev dev_mnyr dev_mxyr dev_PH Block Blk_Fxn #
parm_name
# 1 COM_LL LenSelex
 50 90 61.2887 60 1 0 1 0 0 0 0 0 0 0 # Size_inflection_COM_LL(1)
 1 40 16.0065 10 1 0 2 0 0 0 0 0 0 0 # Size_95%width_COM_LL(1)
# 2 COM_OTHER LenSelex
 8 70 35.9227 30 1 0 1 0 0 0 0 0 0 0 # Size_inflection_COM_OTHER(2)
 -2 66 10.484 3 1 0 2 0 0 0 0 0 0 0 # Size_95%width_COM_OTHER(2)
 0 60 10 36 1 0 -1 0 0 0 0 0 1 1 # Retain_L_infl_COM_OTHER(2)
 1e-05 25 1 2.5 1 0 -3 0 0 0 0 0 1 1 # Retain_L_width_COM_OTHER(2)
 -15 15 9 9 1 0 -3 0 0 0 0 0 0 0 #
Retain_L_asymptote_logit_COM_OTHER(2)
 -1 1 0 0 99 0 -99 0 0 0 0 0 0 0 # Retain_L_maleoffset_COM_OTHER(2)
 0.5 1.5 1 1 1 0 -99 0 0 0 0 0 0 0 # DiscMort_L_infl_COM_OTHER(2)
 10000 1e+08 1e+06 1e+06 1 0 -99 0 0 0 0 0 0 0 #
DiscMort_L_width_COM_OTHER(2)
 -1.5 0 -0.4 -0.4 1 0 -99 0 0 0 0 0 0 0 # DiscMort_L_level_old_COM_OTHER(2)
 -1 2 0 0 99 0 -99 0 0 0 0 0 0 0 # DiscMort_L_male_offset_COM_OTHER(2)
# 3 REC_E LenSelex
 28 45 34.0405 35 1 0 3 0 0 0 0 0 0 0 # Size_DblN_peak_REC_E(3)
 -18 3 -5.6816 -3 1 0 3 0 0 0 0 0 0 0 # Size_DblN_top_logit_REC_E(3)
 -40 20 -10.0177 2 1 0 3 0 0 0 0 0 0 0 # Size_DblN_ascend_se_REC_E(3)
 -2 10 5.35843 5 1 0 3 0 0 0 0 0 0 0 # Size_DblN_descend_se_REC_E(3)
 -20 15 -0.720172 -5 1 0 3 0 0 0 0 0 0 0 # Size_DblN_start_logit_REC_E(3)
 -15 5 -3.05664 0 1 0 3 0 0 0 0 0 0 0 # Size_DblN_end_logit_REC_E(3)
 10 50 33.2317 42 1 0 2 0 0 0 0 0 2 0 # Retain_L_infl_REC_E(3)
 0 30 5.74767 2 1 0 2 0 0 0 0 0 2 0 # Retain_L_width_REC_E(3)
 -15 15 7 9 1 0 -3 0 0 0 0 0 0 0 # Retain_L_asymptote_logit_REC_E(3)
 -1 1 0 0 99 0 -99 0 0 0 0 0 0 0 # Retain_L_maleoffset_REC_E(3)
 0.5 1.5 1 1 1 0 -99 0 0 0 0 0 0 0 # DiscMort_L_infl_REC_E(3)
 10000 1e+08 1e+06 1e+06 1 0 -99 0 0 0 0 0 0 0 # DiscMort_L_width_REC_E(3)
 -1.5 0 -0.4 -0.4 1 0 -99 0 0 0 0 0 0 0 # DiscMort_L_level_old_REC_E(3)
 -1 2 0 0 99 0 -99 0 0 0 0 0 0 0 # DiscMort_L_male_offset_REC_E(3)
# 4 REC_W LenSelex
 20 42 30.012 37 1 0 3 0 0 0 0 0 0 0 # Size_DblN_peak_REC_W(4)
 -35 3 -16.3605 -5 1 0 3 0 0 0 0 0 0 0 # Size_DblN_top_logit_REC_W(4)
 -18 5 -10.9752 3 1 0 3 0 0 0 0 0 0 0 # Size_DblN_ascend_se_REC_W(4)
 -20 20 8.05844 -5 1 0 3 0 0 0 0 0 0 0 # Size_DblN_descend_se_REC_W(4)
 -15 5 -0.508401 -10 1 0 3 0 0 0 0 0 0 0 # Size_DblN_start_logit_REC_W(4)
 -15 10 -5.35512 -1 1 0 3 0 0 0 0 0 0 0 # Size_DblN_end_logit_REC_W(4)
 15 60 37.3415 40 1 0 2 0 0 0 0 0 2 0 # Retain_L_infl_REC_W(4)
 0.1 20 4.28484 2 1 0 2 0 0 0 0 0 2 0 # Retain_L_width_REC_W(4)
 -15 15 9 9 1 0 -3 0 0 0 0 0 0 0 # Retain_L_asymptote_logit_REC_W(4)
 -1 1 0 0 99 0 -99 0 0 0 0 0 0 0 # Retain_L_maleoffset_REC_W(4)
 0.5 1.5 1 1 1 0 -99 0 0 0 0 0 0 0 # DiscMort_L_infl_REC_W(4)
 10000 1e+08 1e+06 1e+06 1 0 -99 0 0 0 0 0 0 0 # DiscMort_L_width_REC_W(4)
 -1.5 0 -0.4 -0.4 1 0 -99 0 0 0 0 0 0 0 # DiscMort_L_level_old_REC_W(4)
 -1 2 0 0 99 0 -99 0 0 0 0 0 0 0 # DiscMort_L_male_offset_REC_W(4)
# 5 RVC_DT LenSelex
 5 94 56.0737 40 1 0 2 0 0 0 0 0 0 0 # Size_DblN_peak_RVC_DT(5)
 -12 25 -2.25168 -1 1 0 3 0 0 0 0 0 0 0 # Size_DblN_top_logit_RVC_DT(5)
 -10 10 5.11419 4 1 0 3 0 0 0 0 0 0 0 # Size_DblN_ascend_se_RVC_DT(5)
 -20 35 4.7551 5 1 0 3 0 0 0 0 0 0 0 # Size_DblN_descend_se_RVC_DT(5)
 -15 5 -2.81808 -10 1 0 3 0 0 0 0 0 0 0 # Size_DblN_start_logit_RVC_DT(5)
 -35 20 -1.37175 0 1 0 4 0 0 0 0 0 0 0 # Size_DblN_end_logit_RVC_DT(5)
# 6 RVC_KEYS LenSelex
 17 55 34.1216 40 1 0 2 0 0 0 0 0 0 0 # Size_DblN_peak_RVC_KEYS(6)
 -30 0 -15.0472 -2 1 0 2 0 0 0 0 0 0 0 # Size_DblN_top_logit_RVC_KEYS(6)
 -20 30 -6.27337 5 1 0 3 0 0 0 0 0 0 0 # Size_DblN_ascend_se_RVC_KEYS(6)
 -10 30 6.74308 5 1 0 3 0 0 0 0 0 0 0 # Size_DblN_descend_se_RVC_KEYS(6)
 -15 20 0.168323 -10 1 0 3 0 0 0 0 0 0 0 # Size_DblN_start_logit_RVC_KEYS(6)
 -15 10 -2.14379 -2 1 0 4 0 0 0 0 0 0 0 # Size_DblN_end_logit_RVC_KEYS(6)
# 7 RVC_SEFL LenSelex
 15 70 54.2835 50 1 0 1 0 0 0 0 0 0 0 # Size_inflection_RVC_SEFL(7)
 -25 5 -9.32302 10 1 0 2 0 0 0 0 0 0 0 # Size_95%width_RVC_SEFL(7)
# 8 FIM_YOY LenSelex
# 9 GOM_VID LenSelex
 0 95 44.4988 50 1 0 4 0 0 0 0 0 0 0 # Size_inflection_GOM_VID(9)
 -2 60 18.4935 10 1 0 4 0 0 0 0 0 0 0 # Size_95%width_GOM_VID(9)
# 10 SERFS_VID LenSelex
# 11 FI_AGE LenSelex
# 1 COM_LL AgeSelex
# 2 COM_OTHER AgeSelex
# 3 REC_E AgeSelex
# 4 REC_W AgeSelex
# 5 RVC_DT AgeSelex
# 6 RVC_KEYS AgeSelex
# 7 RVC_SEFL AgeSelex
# 8 FIM_YOY AgeSelex
# 9 GOM_VID AgeSelex
```

```
# 10   SERFS_VID AgeSelex
          3          3          3          3         99          0       -99          0          0          0          0          0          0          0  #  minage@sel=1_SERFS_VID(10)
         40         40         40         40         99          0       -99          0          0          0          0          0          0          0  #  maxage@sel=1_SERFS_VID(10)
# 11   FI_AGE AgeSelex
#_No_Dirichlet parameters
# timevary selex parameters
#_          LO            HI          INIT         PRIOR         PR_SD       PR_type    PHASE  #  parm_name
            10            45       28.0773             0             1             0      3  # Retain_L_infl_COM_OTHER(2)_BLK1add_1992
            25            50       39.1775             0             1             0      3  # Retain_L_infl_COM_OTHER(2)_BLK1add_2018
            -5            15       1.58399             0             1             0      3  # Retain_L_width_COM_OTHER(2)_BLK1add_1992
            -5             6       1.93547             0             1             0      3  # Retain_L_width_COM_OTHER(2)_BLK1add_2018
            -1             4      0.200757             0             1             0      3  # Retain_L_infl_REC_E(3)_BLK2mult_1995
            -2             5      0.384465             0             1             0      3  # Retain_L_infl_REC_E(3)_BLK2mult_2018
            -4             3      -1.41847             0             1             0      3  # Retain_L_width_REC_E(3)_BLK2mult_1995
            -3             2     -0.645126             0             1             0      3  # Retain_L_width_REC_E(3)_BLK2mult_2018
            -1             1      0.117593             0             1             0      3  # Retain_L_infl_REC_W(4)_BLK2mult_1995
            -1             1      0.207313             0             1             0      3  # Retain_L_infl_REC_W(4)_BLK2mult_2018
          -2.5             2     -0.749728             0             1             0      3  # Retain_L_width_REC_W(4)_BLK2mult_1995
            -3             2     -0.699084             0             1             0      3  # Retain_L_width_REC_W(4)_BLK2mult_2018
# info on dev vectors created for selex parms are reported with other devs after tag parameter section
#
0   #  use 2D_AR1 selectivity? (0/1)
#_no 2D_AR1 selex offset used
#_specs:  fleet, ymin, ymax, amin, amax, sigma_amax, use_rho, len1/age2, devphase, before_range, after_range
#_sigma_amax>amin means create sigma parm for each bin from min to sigma_amax; sigma_amax<0 means just one sigma parm is read and used for all bins
#_needed parameters follow each fleet's specifications
# -9999  0 0 0 0 0 0 0 0 0 0 # terminator
#
# Tag loss and Tag reporting parameters go next
0  # TG_custom:  0=no read and autogen if tag data exist; 1=read
#
# Input variance adjustments factors: 
 #_1=add_to_survey_CV
 #_2=add_to_discard_stddev
 #_3=add_to_bodywt_CV
 #_4=mult_by_lencomp_N
 #_5=mult_by_agecomp_N
 #_6=mult_by_size-at-age_N
 #_7=mult_by_generalized_sizecomp
#_Factor  Fleet  Value
      4      1  0.540883
      4      2       0.5
      4      3       0.5
      4      4       0.5
      4      9  0.363863
      5      1  0.172178
      5      2  0.090496
      5      3  0.105103
      5      4   0.10641
      5     11  0.028688
      7      5  0.087615
      7      6 0.0906557
      7      7 0.0659219
 -9999   1    0  # terminator
#
1 #_maxlambdaphase
1 #_sd_offset; must be 1 if any growthCV, sigmaR, or survey extraSD is an estimated parameter
# read 5 changes to default Lambdas (default value is 1.0)
# Like_comp codes:  1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch; 9=init_equ_catch; 
# 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin; 17=F_ballpark; 18=initEQregime
#like_comp fleet  phase  value  sizefreq_method
 2 2 1 0.01 1
 9 1 1 0 1
 9 2 1 0 1
 9 3 1 0 1
 9 4 1 0 1
-9999  1  1  1  1  #  terminator
#
0 # (0/1/2) read specs for more stddev reporting: 0 = skip, 1 = read specs for reporting stdev for selectivity, size, and numbers, 2 = add options for M,Dyn.  #Bzero, SmryBio
999
```

Data File:

```
#V3.30.22.1;_safe;_compile_date:_Jan 30 2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.1
#_Stock_Synthesis_is_a_work_of_the_U.S._Government_and_is_not_subject_to_copyright_protection_in_the_United_States.
#_Foreign_copyrights_may_apply._See_copyright.txt_for_more_information.
#_User_support_available_at:NMFS.Stock.Synthesis@noaa.gov
```

```
#_User_info_available_at:https://vlab.noaa.gov/group/stock-synthesis
#_Source_code_at:_https://github.com/nmfs-ost/ss3-source-code

#_Start_time: Mon Aug  5 12:11:57 2024
#_echo_input_data
#C this comment will be stored because it starts with #C.  It will be written to output files

#V3.30.22.1;_safe;_compile_date:_Jan 30 2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.1
1981 #_StartYr
2023 #_EndYr
1 #_Nseas
 12 #_months/season
6 #_Nsubseasons (even number, minimum is 2)
6 #_spawn_month
-1 #_Nsexes: 1, 2, -1  (use -1 for 1 sex setup with SSB multiplied by female_frac parameter)
40 #_Nages=accumulator age, first age is always age 0
1 #_Nareas
11 #_Nfleets (including surveys)
#_fleet_type: 1=catch fleet; 2=bycatch only fleet; 3=survey; 4=predator(M2)
#_sample_timing: -1 for fishing fleet to use season-long catch-at-age for observations, or 1 to use observation month;  (always 1 for surveys)
#_fleet_area:  area the fleet/survey operates in
#_units of catch:  1=bio; 2=num (ignored for surveys; their units read later)
#_catch_mult: 0=no; 1=yes
#_rows are fleets
#_fleet_type fishery_timing area catch_units need_catch_mult fleetname
 1 -1 1 1 0 COM_LL  # 1
 1 -1 1 1 0 COM_OTHER  # 2
 1 -1 1 2 0 REC_E  # 3
 1 -1 1 2 0 REC_W  # 4
 3 1 1 2 0 RVC_DT  # 5
 3 1 1 2 0 RVC_KEYS  # 6
 3 1 1 2 0 RVC_SEFL  # 7
 3 1 1 2 0 FIM_YOY  # 8
 3 1 1 2 0 GOM_VID  # 9
 3 1 1 2 0 SERFS_VID  # 10
 3 1 1 2 0 FI_AGE  # 11
#Bycatch_fleet_input_goes_next
#a:  fleet index
#b:  1=include dead bycatch in total dead catch for F0.1 and MSY optimizations and forecast ABC; 2=omit from total catch for these purposes (but still include the mortality)
#c:  1=Fmult scales with other fleets; 2=bycatch F constant at input value; 3=bycatch F from range of years
#d:  F or first year of range
#e:  last year of range
#f:  not used
# a   b   c   d   e   f
#_Catch data: yr, seas, fleet, catch, catch_se
#_catch_se:  standard error of log(catch)
#_NOTE:  catch data is ignored for survey fleets
-999 1 1 28.1073 0.3
1981 1 1 28.1073 0.09
1982 1 1 43.172 0.09
1983 1 1 36.1694 0.08
1984 1 1 23.1971 0.07
1985 1 1 20.6911 0.07
1986 1 1 54.3262 0.06
1987 1 1 85.4651 0.06
1988 1 1 53.4092 0.06
1989 1 1 77.2553 0.07
1990 1 1 59.8519 0.06
1991 1 1 66.1964 0.06
1992 1 1 33.4839 0.07
1993 1 1 34.0614 0.07
1994 1 1 22.6328 0.07
1995 1 1 20.7175 0.06
1996 1 1 23.0134 0.08
1997 1 1 26.5746 0.08
1998 1 1 36.0159 0.07
1999 1 1 33.6414 0.07
2000 1 1 33.4199 0.07
2001 1 1 41.8393 0.04
2002 1 1 36.1604 0.04
2003 1 1 50.4415 0.03
2004 1 1 89.3579 0.03
2005 1 1 54.6663 0.03
2006 1 1 88.0144 0.04
2007 1 1 58.6092 0.04
2008 1 1 33.5329 0.03
2009 1 1 14.7076 0.03
2010 1 1 16.3212 0.04
2011 1 1 24.7919 0.04
```

2012 1 1 24.1437 0.05
2013 1 1 38.7738 0.04
2014 1 1 56.4183 0.03
2015 1 1 50.6255 0.03
2016 1 1 26.161 0.03
2017 1 1 43.3655 0.05
2018 1 1 51.5428 0.04
2019 1 1 20.8737 0.04
2020 1 1 22.6201 0.05
2021 1 1 21.9821 0.04
2022 1 1 25.4415 0.04
2023 1 1 38.2131 0.04
-999 1 2 105.948 0.3
1981 1 2 105.948 0.06
1982 1 2 105.558 0.06
1983 1 2 98.7098 0.07
1984 1 2 86.4918 0.06
1985 1 2 78.4306 0.06
1986 1 2 132.036 0.06
1987 1 2 166.559 0.06
1988 1 2 153.796 0.05
1989 1 2 172.553 0.06
1990 1 2 147.193 0.06
1991 1 2 153.394 0.06
1992 1 2 148.39 0.07
1993 1 2 168.166 0.06
1994 1 2 139.68 0.07
1995 1 2 108.485 0.06
1996 1 2 109.286 0.06
1997 1 2 106.089 0.06
1998 1 2 125.411 0.06
1999 1 2 81.1678 0.05
2000 1 2 59.4042 0.05
2001 1 2 63.844 0.03
2002 1 2 69.834 0.03
2003 1 2 70.6345 0.03
2004 1 2 68.062 0.03
2005 1 2 52.7183 0.03
2006 1 2 42.1881 0.03
2007 1 2 41.7486 0.03
2008 1 2 37.8744 0.04
2009 1 2 40.0944 0.03
2010 1 2 41.8264 0.03
2011 1 2 47.3289 0.02
2012 1 2 51.1189 0.03
2013 1 2 43.3779 0.03
2014 1 2 46.9735 0.02
2015 1 2 51.4001 0.02
2016 1 2 42.0148 0.03
2017 1 2 43.6285 0.03
2018 1 2 49.5786 0.03
2019 1 2 41.2034 0.02
2020 1 2 41.78 0.03
2021 1 2 34.5673 0.03
2022 1 2 33.6451 0.02
2023 1 2 34.3669 0.02
-999 1 3 277.206 0.545138
1981 1 3 368.49 0.54
1982 1 3 418.3 0.54
1983 1 3 426.305 0.65
1984 1 3 127.596 0.47
1985 1 3 45.3407 0.53
1986 1 3 48.1879 0.27
1987 1 3 154.804 0.56
1988 1 3 70.1595 0.33
1989 1 3 108.444 0.37
1990 1 3 66.3588 0.25
1991 1 3 89.8824 0.31
1992 1 3 176.786 0.5
1993 1 3 197.667 0.2
1994 1 3 93.3793 0.22
1995 1 3 46.3984 0.25
1996 1 3 39.1106 0.28
1997 1 3 38.342 0.23
1998 1 3 69.405 0.3
1999 1 3 75.7106 0.27
2000 1 3 81.9465 0.26
2001 1 3 71.9623 0.24
2002 1 3 118.189 0.17
2003 1 3 84.4561 0.19

2004 1 3 98.8773 0.27
2005 1 3 115.55 0.19
2006 1 3 122.364 0.22
2007 1 3 145.233 0.18
2008 1 3 655.374 0.62
2009 1 3 135.423 0.2
2010 1 3 120.933 0.18
2011 1 3 45.4592 0.22
2012 1 3 58.2964 0.25
2013 1 3 103.653 0.28
2014 1 3 164.779 0.29
2015 1 3 173.045 0.26
2016 1 3 179.899 0.27
2017 1 3 112.846 0.36
2018 1 3 82.1955 0.36
2019 1 3 91.7857 0.43
2020 1 3 46.482 0.27
2021 1 3 119.319 0.2
2022 1 3 125.592 0.14
2023 1 3 114.385 0.16
-999 1 4 158.266 0.505741
1981 1 4 260.851 0.508925
1982 1 4 142.504 0.459349
1983 1 4 103.833 0.579679
1984 1 4 222.296 0.484816
1985 1 4 61.8453 0.495938
1986 1 4 149.603 0.475171
1987 1 4 174.929 0.430981
1988 1 4 137.061 0.614924
1989 1 4 112.719 0.533964
1990 1 4 129.349 0.459001
1991 1 4 139.078 0.464344
1992 1 4 94.8465 0.452579
1993 1 4 143.971 0.304926
1994 1 4 59.4878 0.215125
1995 1 4 78.0999 0.385864
1996 1 4 38.4176 0.374758
1997 1 4 30.7183 0.358664
1998 1 4 36.8315 0.388831
1999 1 4 63.818 0.460783
2000 1 4 12.486 0.331838
2001 1 4 14.157 0.324434
2002 1 4 38.9964 0.386515
2003 1 4 60.3428 0.330874
2004 1 4 18.9333 0.225631
2005 1 4 14.5084 0.323808
2006 1 4 117.593 0.509969
2007 1 4 93.3596 0.42034
2008 1 4 101.543 0.409029
2009 1 4 30.6792 0.286181
2010 1 4 31.9895 0.354606
2011 1 4 20.1931 0.207977
2012 1 4 58.9634 0.408031
2013 1 4 65.39 0.302789
2014 1 4 92.3665 0.350579
2015 1 4 98.076 0.304183
2016 1 4 86.9633 0.285139
2017 1 4 27.9031 0.313148
2018 1 4 47.5388 0.261147
2019 1 4 82.3681 0.355807
2020 1 4 118.326 0.519791
2021 1 4 91.3786 0.16947
2022 1 4 54.7873 0.229979
2023 1 4 56.1177 0.238458
-9999 0 0 0 0
#
#_CPUE_and_surveyabundance_and_index_observations
#_Units: 0=numbers; 1=biomass; 2=F; 30=spawnbio; 31=exp(recdev); 36=recdev; 32=spawnbio*recdev; 33=recruitment; 34=depletion(&see Qsetup); 35=parm_dev(&see Qsetup)
#_Errtype: -1=normal; 0=lognormal; 1=lognormal with bias correction; >1=df for T-dist
#_SD_Report: 0=not; 1=include survey expected value with se
#_note that link functions are specified in Q_setup section of control file
#_Fleet Units Errtype SD_Report
1 1 0 1 # COM_LL
2 0 0 0 # COM_OTHER
3 0 0 0 # REC_E
4 0 0 0 # REC_W
5 0 0 1 # RVC_DT
6 0 0 1 # RVC_KEYS
7 0 0 1 # RVC_SEFL

8 33 0 1 # FIM_YOY
9 0 0 1 # GOM_VID
10 0 0 1 # SERFS_VID
11 0 0 0 # FI_AGE
#_yr month fleet obs stderr
1993 7 1 0.45 0.3 #_ COM_LL
1994 7 1 0.55 0.31 #_ COM_LL
1995 7 1 0.96 0.24 #_ COM_LL
1996 7 1 0.52 0.26 #_ COM_LL
1997 7 1 0.73 0.25 #_ COM_LL
1998 7 1 0.66 0.25 #_ COM_LL
1999 7 1 0.69 0.29 #_ COM_LL
2000 7 1 0.78 0.28 #_ COM_LL
2001 7 1 0.87 0.26 #_ COM_LL
2002 7 1 1.49 0.29 #_ COM_LL
2003 7 1 1.3 0.26 #_ COM_LL
2004 7 1 1.54 0.26 #_ COM_LL
2005 7 1 1.53 0.24 #_ COM_LL
2006 7 1 1.66 0.24 #_ COM_LL
2007 7 1 1.17 0.26 #_ COM_LL
2008 7 1 0.81 0.28 #_ COM_LL
2009 7 1 1.09 0.33 #_ COM_LL
2010 7 1 1.2 0.31 #_ COM_LL
1999 7 5 0.260035 0.209743 #_ RVC_DT
2000 7 5 0.35831 0.163335 #_ RVC_DT
2004 7 5 0.703498 0.092547 #_ RVC_DT
2006 7 5 0.482901 0.121606 #_ RVC_DT
2008 7 5 0.825004 0.080194 #_ RVC_DT
2010 7 5 1.13756 0.068447 #_ RVC_DT
2012 7 5 1.17051 0.065103 #_ RVC_DT
2014 7 5 0.796631 0.08003 #_ RVC_DT
2016 7 5 1.54748 0.067893 #_ RVC_DT
2018 7 5 1.0678 0.071821 #_ RVC_DT
2021 7 5 2.12635 0.076444 #_ RVC_DT
2023 7 5 2.55878 0.087885 #_ RVC_DT
1997 7 6 0.59 0.255 #_ RVC_KEYS
2000 7 6 0.85 0.139 #_ RVC_KEYS
2001 7 6 0.81 0.123 #_ RVC_KEYS
2002 7 6 0.74 0.118 #_ RVC_KEYS
2003 7 6 0.85 0.132 #_ RVC_KEYS
2004 7 6 0.97 0.16 #_ RVC_KEYS
2005 7 6 0.95 0.112 #_ RVC_KEYS
2006 7 6 0.83 0.126 #_ RVC_KEYS
2007 7 6 1.31 0.093 #_ RVC_KEYS
2008 7 6 1.13 0.099 #_ RVC_KEYS
2009 7 6 0.82 0.091 #_ RVC_KEYS
2010 7 6 0.63 0.127 #_ RVC_KEYS
2011 7 6 0.62 0.105 #_ RVC_KEYS
2012 7 6 0.87 0.096 #_ RVC_KEYS
2014 7 6 1.32 0.089 #_ RVC_KEYS
2016 7 6 1.76 0.097 #_ RVC_KEYS
2018 7 6 1.66 0.092 #_ RVC_KEYS
2022 7 6 2.03 0.121 #_ RVC_KEYS
2013 7 7 0.35 0.105 #_ RVC_SEFL
2014 7 7 0.5 0.114 #_ RVC_SEFL
2015 7 7 0.42 0.138 #_ RVC_SEFL
2016 7 7 0.92 0.097 #_ RVC_SEFL
2018 7 7 1.6 0.076 #_ RVC_SEFL
2021 7 7 1.56 0.094 #_ RVC_SEFL
2022 7 7 1.65 0.093 #_ RVC_SEFL
1999 9.5 8 0.363 0.386 #_ FIM_YOY
2000 9.5 8 0.501 0.326 #_ FIM_YOY
2001 9.5 8 0.573 0.35 #_ FIM_YOY
2002 9.5 8 0.912 0.313 #_ FIM_YOY
2003 9.5 8 0.521 0.339 #_ FIM_YOY
2004 9.5 8 0.721 0.334 #_ FIM_YOY
2005 9.5 8 1.323 0.34 #_ FIM_YOY
2006 9.5 8 0.892 0.308 #_ FIM_YOY
2007 9.5 8 3.535 0.284 #_ FIM_YOY
2008 9.5 8 1.571 0.305 #_ FIM_YOY
2009 9.5 8 0.513 0.343 #_ FIM_YOY
2010 9.5 8 0.597 0.337 #_ FIM_YOY
2011 9.5 8 0.709 0.322 #_ FIM_YOY
2012 9.5 8 1.2 0.303 #_ FIM_YOY
2013 9.5 8 1.27 0.315 #_ FIM_YOY
2014 9.5 8 1.138 0.336 #_ FIM_YOY
2015 9.5 8 0.854 0.332 #_ FIM_YOY
2016 9.5 8 0.297 0.377 #_ FIM_YOY
2017 9.5 8 1.06 0.346 #_ FIM_YOY
2018 9.5 8 1.337 0.331 #_ FIM_YOY

2019 9.5 8 0.23 0.389 #_ FIM_YOY
2020 9.5 8 1.491 0.316 #_ FIM_YOY
2021 9.5 8 1.06 0.318 #_ FIM_YOY
2022 9.5 8 1.33 0.312 #_ FIM_YOY
1996 7 9 1.081 0.366 #_ GOM_VID
1997 7 9 0.778 0.435 #_ GOM_VID
2002 7 9 1.083 0.304 #_ GOM_VID
2004 7 9 1.131 0.367 #_ GOM_VID
2005 7 9 0.84 0.271 #_ GOM_VID
2006 7 9 1.753 0.248 #_ GOM_VID
2007 7 9 1.092 0.257 #_ GOM_VID
2008 7 9 0.881 0.335 #_ GOM_VID
2009 7 9 0.578 0.31 #_ GOM_VID
2010 7 9 1.015 0.267 #_ GOM_VID
2011 7 9 2.143 0.213 #_ GOM_VID
2012 7 9 1.999 0.206 #_ GOM_VID
2014 7 9 0.886 0.373 #_ GOM_VID
2016 7 9 0.882 0.187 #_ GOM_VID
2017 7 9 0.514 0.234 #_ GOM_VID
2018 7 9 1.021 0.213 #_ GOM_VID
2019 7 9 1.211 0.156 #_ GOM_VID
2020 7 9 0.424 0.197 #_ GOM_VID
2021 7 9 0.334 0.198 #_ GOM_VID
2022 7 9 0.354 0.214 #_ GOM_VID
2011 7 10 0.083 0.46 #_ SERFS_VID
2012 7 10 0.235 0.58 #_ SERFS_VID
2013 7 10 0.263 0.5 #_ SERFS_VID
2014 7 10 0.769 0.26 #_ SERFS_VID
2015 7 10 1.188 0.19 #_ SERFS_VID
2016 7 10 0.581 0.26 #_ SERFS_VID
2017 7 10 1.007 0.24 #_ SERFS_VID
2018 7 10 1.501 0.16 #_ SERFS_VID
2019 7 10 2.248 0.15 #_ SERFS_VID
2021 7 10 1.394 0.16 #_ SERFS_VID
2022 7 10 1.731 0.2 #_ SERFS_VID
-9999 1 1 1 1 # terminator for survey observations
#
3 #_N_fleets_with_discard
#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)
#_discard_errtype: >0 for DF of T-dist(read CV below); 0 for normal with CV; -1 for normal with se; -2 for lognormal; -3 for trunc normal with CV
note: only enter units and errtype for fleets with discard
note: discard data is the total for an entire season, so input of month here must be to a month in that season
#_Fleet units errtype
2 3 -1 # COM_OTHER
3 3 -2 # REC_E
4 3 -2 # REC_W
#_yr month fleet obs stderr
1993 7 2 5.654 0.491 #_ COM_OTHER
1994 7 2 6.628 0.52 #_ COM_OTHER
1995 7 2 7.58 0.59 #_ COM_OTHER
1996 7 2 6.801 0.538 #_ COM_OTHER
1997 7 2 6.991 0.515 #_ COM_OTHER
1998 7 2 5.706 0.492 #_ COM_OTHER
1999 7 2 5.815 0.529 #_ COM_OTHER
2000 7 2 5.922 0.531 #_ COM_OTHER
2001 7 2 4.713 0.418 #_ COM_OTHER
2002 7 2 4.921 0.401 #_ COM_OTHER
2003 7 2 4.322 0.378 #_ COM_OTHER
2004 7 2 4.157 0.385 #_ COM_OTHER
2005 7 2 3.5 0.325 #_ COM_OTHER
2006 7 2 3.613 0.351 #_ COM_OTHER
2007 7 2 3.505 0.302 #_ COM_OTHER
2008 7 2 3.127 0.252 #_ COM_OTHER
2009 7 2 4.379 0.406 #_ COM_OTHER
2010 7 2 3.975 0.413 #_ COM_OTHER
2011 7 2 3.31 0.257 #_ COM_OTHER
2012 7 2 3.555 0.314 #_ COM_OTHER
2013 7 2 4.204 0.411 #_ COM_OTHER
2014 7 2 5.794 0.64 #_ COM_OTHER
2015 7 2 6.731 0.798 #_ COM_OTHER
2016 7 2 4.934 0.523 #_ COM_OTHER
2017 7 2 3.863 0.369 #_ COM_OTHER
2018 7 2 5.831 0.619 #_ COM_OTHER
2019 7 2 6.339 1.059 #_ COM_OTHER
2020 7 2 6.194 1.104 #_ COM_OTHER
2021 7 2 5.849 1.107 #_ COM_OTHER
2022 7 2 4.472 0.683 #_ COM_OTHER
2023 7 2 5.505 0.96 #_ COM_OTHER
1982 7 3 7.59435 0.83 #_ REC_E
1983 7 3 11.9396 0.84 #_ REC_E

1984 7 3 9.9796 0.61 #_ REC_E
1985 7 3 79.1706 0.66 #_ REC_E
1986 7 3 72.5409 0.68 #_ REC_E
1987 7 3 111.295 0.72 #_ REC_E
1988 7 3 25.6994 0.6 #_ REC_E
1989 7 3 14.8347 0.49 #_ REC_E
1990 7 3 2.46762 0.7 #_ REC_E
1991 7 3 11.9818 0.39 #_ REC_E
1992 7 3 87.3695 0.36 #_ REC_E
1993 7 3 106.722 0.28 #_ REC_E
1994 7 3 84.5391 0.31 #_ REC_E
1995 7 3 123.184 0.62 #_ REC_E
1996 7 3 39.3114 0.35 #_ REC_E
1997 7 3 65.4761 0.29 #_ REC_E
1998 7 3 133.304 0.34 #_ REC_E
1999 7 3 73.309 0.28 #_ REC_E
2000 7 3 129.356 0.34 #_ REC_E
2001 7 3 56.7523 0.28 #_ REC_E
2002 7 3 200.216 0.28 #_ REC_E
2003 7 3 103.531 0.21 #_ REC_E
2004 7 3 121.658 0.32 #_ REC_E
2005 7 3 155.108 0.3 #_ REC_E
2006 7 3 271.649 0.27 #_ REC_E
2007 7 3 266.895 0.18 #_ REC_E
2008 7 3 1579.12 0.48 #_ REC_E
2009 7 3 237.832 0.18 #_ REC_E
2010 7 3 82.7223 0.24 #_ REC_E
2011 7 3 23.0397 0.3 #_ REC_E
2012 7 3 295.32 0.38 #_ REC_E
2013 7 3 225.268 0.39 #_ REC_E
2014 7 3 393.205 0.27 #_ REC_E
2015 7 3 558.725 0.23 #_ REC_E
2016 7 3 1082.49 0.37 #_ REC_E
2017 7 3 1495.34 0.37 #_ REC_E
2018 7 3 520.083 0.28 #_ REC_E
2019 7 3 428.668 0.27 #_ REC_E
2020 7 3 405.938 0.26 #_ REC_E
2021 7 3 662.443 0.13 #_ REC_E
2022 7 3 783.521 0.22 #_ REC_E
2023 7 3 690.322 0.15 #_ REC_E
1981 7 4 2.3183 0.83 #_ REC_W
1982 7 4 3.92493 0.83 #_ REC_W
1984 7 4 113.03 0.68 #_ REC_W
1985 7 4 21.1946 0.83 #_ REC_W
1986 7 4 3.97637 0.58 #_ REC_W
1987 7 4 41.476 0.68 #_ REC_W
1988 7 4 126.351 0.52 #_ REC_W
1989 7 4 4.40807 0.85 #_ REC_W
1990 7 4 27.0019 0.65 #_ REC_W
1991 7 4 302.921 0.53 #_ REC_W
1992 7 4 79.1091 0.44 #_ REC_W
1993 7 4 342.435 0.6 #_ REC_W
1994 7 4 80.9358 0.43 #_ REC_W
1995 7 4 91.2865 0.6 #_ REC_W
1996 7 4 82.3967 0.46 #_ REC_W
1997 7 4 191.02 0.48 #_ REC_W
1998 7 4 217.035 0.48 #_ REC_W
1999 7 4 52.5881 0.45 #_ REC_W
2000 7 4 14.8099 0.64 #_ REC_W
2001 7 4 6.83238 0.62 #_ REC_W
2002 7 4 15.2123 0.38 #_ REC_W
2003 7 4 61.4045 0.43 #_ REC_W
2004 7 4 22.6327 0.38 #_ REC_W
2005 7 4 291.825 0.69 #_ REC_W
2006 7 4 148.529 0.69 #_ REC_W
2007 7 4 223.654 0.4 #_ REC_W
2008 7 4 134.906 0.28 #_ REC_W
2009 7 4 142.833 0.6 #_ REC_W
2010 7 4 10.79 0.42 #_ REC_W
2011 7 4 21.0959 0.56 #_ REC_W
2012 7 4 59.6665 0.53 #_ REC_W
2013 7 4 186.978 0.39 #_ REC_W
2014 7 4 408.795 0.58 #_ REC_W
2015 7 4 156.976 0.48 #_ REC_W
2016 7 4 291.249 0.44 #_ REC_W
2017 7 4 325.491 0.44 #_ REC_W
2018 7 4 216.569 0.38 #_ REC_W
2019 7 4 181.646 0.32 #_ REC_W
2020 7 4 353.144 0.32 #_ REC_W
2021 7 4 271.643 0.21 #_ REC_W

2022 7 4 465.466 0.2 #_ REC_W
2023 7 4 726.69 0.26 #_ REC_W
-9999 0 0 0.0 0.0 # terminator for discard data
#
0 #_use meanbodysize_data (0/1)
#_COND_0 #_DF_for_meanbodysize_T-distribution_like
note: type=1 for mean length; type=2 for mean body weight
#_yr month fleet part type obs stderr
-9999 0 0 0 0 0 0 # terminator for mean body size data
#
set up population length bin structure (note - irrelevant if not using size data and using empirical wtatage
2 # length bin method: 1=use databins; 2=generate from binwidth,min,max below; 3=read vector
4 # binwidth for population size comp
8 # minimum size in the population (lower edge of first bin and size at age 0.00)
96 # maximum size in the population (lower edge of last bin)
2 # use length composition data (0/1/2) where 2 invokes new comp_control format
#_mintailcomp: upper and lower distribution for females and males separately are accumulated until exceeding this level.
#_addtocomp: after accumulation of tails; this value added to all bins
#_combM+F: males and females treated as combined sex below this bin number
#_compressbins: accumulate upper tail by this number of bins; acts simultaneous with mintailcomp; set=0 for no forced accumulation
#_Comp_Error: 0=multinomial, 1=dirichlet using Theta*n, 2=dirichlet using beta, 3=MV_Tweedie
#_ParmSelect: consecutive index for dirichlet or MV_Tweedie
#_minsamplesize: minimum sample size; set to 1 to match 3.24, minimum value is 0.001
#
#_Using new list format for composition controls
#_use negative fleet value to fill for all higher numbered fleets (recommended!)
#_must enter in fleet, partition order; but only need to enter for used combos
#_fleet = -9999 to terminate list
#_fleet partition mintailcomp addtocomp combM+F CompressBins CompError ParmSelect minsamplesize
 -1 0 0 0.0001 0 0 0 0 0.01
 2 1 0 0.0001 0 0 0 0 0.01
 2 2 0 0.0001 0 0 0 0 0.01
 3 1 0 0.0001 0 0 0 0 0.01
 3 2 0 0.0001 0 0 0 0 0.01
 4 1 0 0.0001 0 0 0 0 0.01
 4 2 0 0.0001 0 0 0 0 0.01
 -5 0 0 0.0001 0 0 0 0 0.01
 -6 0 0 0.0001 0 0 0 0 0.01
 -7 0 0 0.0001 0 0 0 0 0.01
 -8 0 0 0.0001 0 0 0 0 0.01
 -9 0 0 0.0001 0 0 0 0 0.01
 -10 0 0 0.0001 0 0 0 0 0.01
 -11 0 0 0.0001 0 0 0 0 0.01
 -9999 0 0 0 0 0 0 0 0
sex codes: 0=combined; 1=use female only; 2=use male only; 3=use both as joint sexxlength distribution
partition codes: (0=combined; 1=discard; 2=retained
23 #_N_LengthBins; then enter lower edge of each length bin
 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80 84 88 92 96
#_yr month fleet sex part Nsamp datavector(female-male)
 1991 7 1 0 0 21 0 0 0 0 0 0 0 0 109.328 327.985 546.641 546.641 1967.91 2623.88 3717.16 2623.88 2405.22 2405.22 1202.61 983.954 218.656 0 0
 1992 7 1 0 0 19 0 0 0 0 0 0 0 0 0 27.3198 136.599 382.477 764.955 1447.95 2486.1 2513.42 983.513 327.838 109.279 191.239 54.6396 27.3198 0
 1993 7 1 0 0 25 0 0 0 0 0 0 0 0 0 170.449 340.898 298.285 511.347 639.183 1193.14 1704.49 1747.1 1107.92 511.347 127.837 255.673 42.6122 0
 1994 7 1 0 0 38 0 0 0 0 0 0 0 0 0 78.2548 136.946 176.073 391.274 684.729 880.366 841.239 684.729 704.293 665.165 528.22 176.073 39.1274 0
 1995 7 1 0 0 33 0 0 0 0 0 0 0 0 0 220.872 138.045 386.527 303.699 579.79 690.226 552.181 469.354 635.008 469.354 303.699 165.654 0 0
 1996 7 1 0 0 24 0 0 0 0 0 0 0 0 0 0 48.2838 241.419 386.27 386.27 337.986 675.973 337.986 820.824 1158.81 531.122 96.5676 48.2838 0
 1997 7 1 0 0 29 0 0 0 0 0 0 0 0 0 34.8503 17.4252 104.551 296.228 348.503 400.779 540.18 731.857 662.157 766.708 853.833 714.432 278.803 52.2755 0
 1998 7 1 0 0 73 0 0 0 0 0 0 0 0 7.87767 31.5107 70.8991 252.086 417.517 638.091 582.948 669.602 898.055 921.688 905.932 1189.53 1110.75 315.107 31.5107 0
 1999 7 1 0 0 91 0 0 0 0 0 0 0 0 0 149.791 264.631 554.228 689.04 694.033 753.95 828.846 833.839 823.853 873.783 833.839 224.687 34.9513 0
 2000 7 1 0 0 69 0 0 0 0 0 0 0 0 0 13.2875 59.7936 219.243 385.336 538.142 651.086 850.397 783.96 910.191 876.972 916.835 724.167 152.806 26.5749 0
 2001 7 1 0 0 64 0 0 0 0 0 0 0 0 0 67.4824 242.937 391.398 512.866 701.817 1052.72 1147.2 1174.19 1147.2 1228.18 917.76 404.894 53.9859 0
 2002 7 1 0 0 55 0 0 0 0 0 0 0 0 0 30.5631 137.534 244.505 397.321 626.544 825.205 840.486 978.021 779.36 718.234 932.176 779.36 336.195 45.8447 0
 2003 7 1 0 0 70 0 0 0 0 0 0 0 0 0 202.863 343.306 514.959 686.613 702.217 842.661 1029.92 1451.25 1451.25 1529.27 1420.04 827.056 202.863 0
 2004 7 1 0 0 62 0 0 0 0 0 0 0 0 0 35.1453 246.017 843.487 1230.09 1651.83 1616.68 2214.15 2249.3 1932.99 2143.86 2741.33 2143.86 808.342 281.162 0
 2005 7 1 0 0 73 0 0 0 0 0 0 0 0 0 151.595 631.644 1187.49 1591.74 1718.07 1465.42 1566.48 1414.88 985.365 808.505 631.644 480.05 126.329 0
 2006 7 1 0 0 78 0 0 0 0 0 0 0 0 0 286.156 572.312 1017.44 1875.91 2352.84 2098.48 2162.07 2448.23 2034.89 1716.94 1621.55 699.493 190.771 0
 2007 7 1 0 0 54 0 0 0 0 0 0 0 0 0 0 215.089 394.33 1147.14 1398.08 1720.71 2043.35 1828.26 1218.84 1469.78 788.661 250.938 35.8482 0
 2008 7 1 0 0 47 0 0 0 0 0 0 0 0 0 200.584 229.238 515.786 372.512 458.477 515.786 630.405 974.263 1346.78 888.298 687.715 429.822 143.274 0 28.6548
 2009 7 1 0 0 27 0 0 0 0 0 0 0 0 0 159.395 371.922 185.961 239.092 292.224 531.316 292.224 478.185 371.922 451.619 159.395 79.6975 132.829 0 0
 2010 7 1 0 0 52 0 0 0 0 0 0 0 0 0 45.2514 153.855 217.207 253.408 398.212 307.709 262.458 362.011 443.464 380.112 190.056 208.156 135.754 9.05028 0
 2011 7 1 0 0 33 0 0 0 0 0 0 0 0 0 44.7265 201.269 335.449 626.171 626.171 648.534 603.808 603.808 380.175 290.722 357.812 268.359 111.816 0 0
 2012 7 1 0 0 45 0 0 0 0 0 0 0 0 0 17.6603 88.3017 229.585 423.848 547.471 494.49 459.169 529.81 900.678 423.848 335.547 406.188 17.6603 0 0
 2013 7 1 0 0 36 0 0 0 0 0 0 0 0 0 93.5756 62.3837 280.727 249.535 935.756 1310.06 1154.1 1154.1 998.139 717.413 592.645 499.07 124.767 31.1919 0
 2014 7 1 0 0 40 0 0 0 0 0 0 0 0 45.1932 0 45.1932 135.58 316.353 949.058 1220.22 1988.5 1898.12 1988.5 1988.5 1400.99 1084.64 90.3864 0 0
 2015 7 1 0 0 39 0 0 0 0 0 0 0 0 0 196.486 392.972 130.991 261.981 720.449 1440.9 916.935 1047.93 1375.4 1768.37 1506.39 916.935 130.991 130.991 0
 2016 7 1 0 0 32 0 0 0 0 0 0 0 0 0 0 353.595 309.395 618.79 353.595 839.787 883.986 618.79 397.794 530.392 397.794 265.196 44.1993 44.1993 0
 2017 7 1 0 0 50 0 0 0 0 0 0 0 0 0 34.6835 173.418 381.519 658.987 797.721 936.456 1422.03 901.772 797.721 971.139 1040.51 554.937 173.418 0 0
 2018 7 1 0 0 64 0 0 0 0 0 0 0 0 0 278.675 712.17 681.206 928.918 1238.56 1269.52 928.918 1269.52 1052.77 897.954 712.17 402.531 123.856 30.9639 0
 2019 7 1 0 0 34 0 0 0 0 0 0 0 0 0 0 193.665 677.829 193.665 338.915 242.082 532.58 726.245 532.58 435.747 532.58 387.331 48.4164 0 0
 2021 7 1 0 0 26 0 0 0 0 0 0 0 0 0 0 134.383 201.575 201.575 537.533 604.725 739.108 403.15 537.533 268.767 470.341 470.341 0 0 0
 2022 7 1 0 0 79 0 0 0 0 0 0 0 0 0 55.3525 424.369 239.861 424.369 645.779 608.877 811.836 774.935 627.328 405.918 239.861 36.9017 18.4508 0 0

1989 7 2 0 2 26.634 0 0 0 0 0 2288.9 9127.03 12170.7 8849.43 3553.11 3534.05 2128.97 3783.09 5545.35 3026.47 4252.57 881.957 1225.24 916.748 484.165 666.068 0 0
1990 7 2 0 2 52.745 0 0 0 0 0 0 4203.55 7835.04 7472.92 5731.27 2958.5 2634.3 3210.77 3873.84 4077.49 3479.51 3030.16 2164.61 808.025 427.918 102.815 205.272 0
1991 7 2 0 2 62.667 0 0 0 0 0 2404.2 5784.55 9228.98 4943.16 4125.5 4258.44 3872.81 3768.4 4238.35 5278.79 2332.49 1998.69 192.142 1011.97 707.498 10.5822 51.701 10.5822
1992 7 2 0 2 81.467 0 0 0 0 260.644 1563.87 3437.77 3811.2 4902.1 6207.14 5160.92 3701.92 3406 3038.4 2937.74 3586.62 2952.49 2283.53 1183.53 558.502 64.706 0 0
1993 7 2 0 2 59.534 0 0 0 0 0 219.591 2756.75 6086.22 4210 3655.09 4199.43 5867.64 4555.24 3396.86 5715.07 7425.92 5355.15 2395.3 1383.05 903.906 119.205 22.9416 0
1994 7 2 0 2 45.434 0 0 0 103.353 378.825 837.943 1101.88 2387.42 4538.34 4462.58 5282.47 2709.01 2674.83 4151.32 5239.45 5850.72 3949.7 1862.31 690.461 207.495 91.8237 0 0
1995 7 2 0 2 47 0 0 0 0 0 0 36.7948 1165.83 3298.08 3001.24 3098.27 2455.09 2465.53 2521.53 1620.38 6344.18 3094.93 2843.02 1444.95 740.799 63.3341 63.3341 0
1996 7 2 0 2 51.701 0 0 0 74.0057 259.02 37.0028 109.388 403.79 2474.89 4039.52 3556.86 3405.61 3136.47 2864.09 4156.99 4516.32 3373.22 1501.4 1074.45 878.025 255.944 36.5179 134.651
1997 7 2 0 2 68.934 0 0 0 0 0 46.5771 93.1543 754.25 2658.46 2812.66 3992.78 2623.51 3352.88 4610.47 4582.8 4025.71 3325.04 1842.19 922.173 364.764 170.836 0 0
1998 7 2 0 2 66.845 0 0 0 0 98.5766 255.677 318.517 798.45 4274.53 4573.88 2790.38 2996.2 3321 3804.5 4921.44 5813.75 3844.86 2242.49 614.729 314.115 367.203 67.1566 0
1999 7 2 0 2 86.168 0 0 0 0 47.9644 143.893 45.9291 1300.26 2307.1 2808.53 2382.81 1587.21 1829.28 2247.5 3062.56 3363.24 2563.4 1096.76 914.803 247.631 84.3635 20.0775 0
2000 7 2 0 2 96.09 0 0 0 0 0 189.855 144.806 1657.86 3138.73 2229.02 1839 1218.15 1165.13 1537.41 1227.52 1576.24 1295.97 805.828 385.41 271.595 43.2403 15.0166 0
2001 7 2 0 2 97.657 0 0 0 0 34.4431 101.622 206.659 767.287 4002.82 3863.05 2275.23 1944.86 1497.41 1255.82 1452.91 1379.61 1147.96 612.819 379.468 256.446 31.7395 0 0
2002 7 2 0 2 90.868 0 0 0 0 0 26.2731 38.8973 1057.4 3003.95 3335.98 2503.59 2499.49 2317.63 2146.49 1873.18 1658.86 1236.29 642.153 366.945 456.487 38.8973 81.0135 0
2003 7 2 0 2 56.401 0 0 0 10.6929 0 0 42.7021 327.598 2592.42 4091.36 3853.14 2090.12 1702.73 2001.08 1879.42 1770.46 1086.01 759.144 435.195 236.788 180.692 26.2582 0
2004 7 2 0 2 55.878 0 0 0 0 340.101 0 170.05 612.539 2463.47 2907.75 2225.76 1510.83 1102.08 1093 1443.17 2197.71 1882.88 1331.08 617.807 477.117 186.894 29.2193 0
2005 7 2 0 2 60.578 0 0 0 0 0 0 0 325.905 2089.33 3854.82 2665.17 1775.48 1650.98 884.403 1097.5 942.923 722.883 376.258 360.111 168.881 35.3485 45.2 0
2006 7 2 0 2 44.389 0 0 0 0 0 39.4957 0 78.9914 2147.9 1808.96 1040.69 800.001 806.085 1240.18 934.355 1521.7 353.122 725.8 514.82 551.937 0 54.6907 0
2007 7 2 0 2 50.134 0 0 0 0 0 0 0 81.8977 1910.32 1921.36 2313.67 1288.84 941.924 1592.49 947.702 1074.63 389.209 434.752 129.958 156.658 0 11.0397 0
2008 7 2 0 2 46.478 0 0 0 0 0 0 0 323.254 3786.92 2565.89 1336.09 916.242 597.265 604.984 685.305 522.063 367.761 606.629 255.225 49.2002 53.5192 0 0
2009 7 2 0 2 52.223 0 0 0 0 0 0 69.8898 397.846 2542.92 2548.66 2089.51 795.934 925.014 737.927 779.808 666.551 627.155 447.446 305.958 166.089 28.2608 0 0
2010 7 2 0 2 39.689 0 0 0 0 0 0 0 112.185 1477.18 2702.76 2461.94 1840.77 1407.92 1263.16 776.981 694.023 351.049 499.296 212.205 134.251 15.0042 30.0083 0
2011 7 2 0 2 54.834 0 0 0 0 0 0 112.942 112.942 1760.57 2064.92 1511.19 2304.13 1426.2 1258.65 854.07 638.978 530.557 481.51 211.937 95.768 0 0 0
2012 7 2 0 2 67.89 0 0 0 0 0 0 0 26.0009 404.413 976.86 1560.39 1909.52 1708.81 1557.86 2175.11 2235.63 2082.24 658.986 303.809 220.828 38.9894 0 0
2013 7 2 0 2 64.234 0 0 0 0 0 49.6587 99.3174 133.143 409.265 868.188 910.444 1627.59 1679.82 1114.4 1656.27 1376.59 1516.09 1072.34 437.806 159.032 0 0 0
2014 7 2 0 2 63.19 0 0 0 0 26.0978 76.5364 26.8777 103.414 1879.82 1190.65 1434.78 1036.42 991.148 1203.61 1801.26 1827.45 941.09 421.739 184.336 256.736 0 0 0
2015 7 2 0 2 65.801 0 0 0 0 0 45.2298 90.4596 474.538 1393.72 2459.77 1178.44 1621.87 821.392 1331.92 1143.52 1302.77 874.84 623.74 284.58 137.657 14.0929 0 0
2016 7 2 0 2 51.178 0 0 0 0 0 0 6.91595 227.866 1245.42 1465.46 2120.1 1315.61 1598.82 679.147 1407.02 830.072 909.951 573.732 266.512 62.2436 86.2694 0 0
2017 7 2 0 2 56.923 0 0 0 0 0 0 0 174.996 643.672 1414.38 957.682 1815.4 929.936 1804.16 1520.45 1160.22 1306.14 840.563 259.085 135.683 82.5569 0 0
2018 7 2 0 2 53.789 0 0 0 0 0 0 0 0 418.959 1320.77 1555.91 1812.46 1373.61 1736.94 1503.53 1871.17 1056.29 835.374 629.129 91.9136 55.2299 110.46 0
2019 7 2 0 2 81.99 0 0 0 0 0 0 0 0 78.3491 992.466 1316.65 1290.9 1035.61 1222.88 1415.8 1738.23 864.933 749.861 218.136 260.253 69.1647 0 0
2020 7 2 0 2 104.445 0 0 0 0 0 6.34675 0 0 0 69.9853 791.634 1003.14 1526.4 1685.57 1296.85 1325.37 1035.29 1254.58 818.871 542.626 31.6631 56.3412 0 0
2021 7 2 0 2 81.467 0 0 0 0 0 0 10.5382 0 21.9962 611.667 833.447 1048.66 898.051 1810.94 1400.07 1362.8 870.581 629.008 215.417 39.0213 25.3516 0 0
2022 7 2 0 2 86.168 0 0 0 0 0 0 0 0 15.9785 495.596 1058.64 713.222 1304.56 940.174 1356.91 1438.8 921.19 523.447 226.087 11.5278 0 0 0
2013 -7 2 0 1 7 0 0 0 0 1 38 50 23 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2014 7 -2 0 1 7 0 0 0 0 1 38 50 23 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2015 7 -2 0 1 7 0 0 0 0 1 38 50 23 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2016 7 -2 0 1 7 0 0 0 0 1 38 50 23 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2017 -7 -2 0 1 7 0 0 0 0 1 38 50 23 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1981 7 3 0 2 58.823 0 0 0 0 0.603 3.016 4.826 60.326 115.827 99.539 57.31 22.321 14.478 13.875 4.826 5.429 2.413 0.603 0 0 0 0 0
1982 7 3 0 2 36.377 0 1.16206 15.107 9.296 5.81 20.917 9.296 29.051 92.965 130.15 82.506 30.213 9.296 8.134 10.459 2.324 1.162 0 0 0 0 0 0
1983 7 3 0 2 55.211 0 0 0 2.792 8.377 9.308 3.723 16.754 54.916 96.801 120.071 82.839 33.508 19.546 8.377 8.377 1.862 0 0 0 0 0 0
1984 7 3 0 2 50.825 0 0 0 0 0 4.232 6.651 10.883 32.044 44.74 41.112 42.322 21.161 17.533 6.651 2.418 1.209 0.605 0 0 0.605 0 0
1985 7 3 0 2 61.919 0 0 0 0 0 0 1.259 6.714 18.463 19.582 12.169 6.154 4.196 3.916 0.839 1.119 0.559 0.28 0.14 0 0 0 0
1986 7 3 0 2 57.533 0 0 0 0 1.356 0.581 2.905 7.359 13.943 18.785 15.88 7.94 5.81 1.743 2.711 1.356 1.162 0.581 0.387 0.194 0.194 0 0.194
1987 7 3 0 2 39.473 0 0 0 1.191 1.191 4.765 23.231 46.463 39.314 18.466 20.849 14.892 10.126 7.148 3.574 1.787 5.361 2.383 1.191 1.191 0 0 0
1988 7 3 0 2 38.699 0 0 0 0 0.684 0.684 4.789 19.155 20.865 17.102 11.63 8.893 3.42 2.736 2.736 4.447 0.342 0 0 0 0 0 0
1989 7 3 0 2 55.211 0 0 0 0.293 0 0.879 4.397 31.367 35.471 36.643 16.416 8.501 2.345 3.225 0.586 2.052 0.293 0.586 0.293 0.293 0 0 0
1990 7 3 0 2 25.542 0 0 0 1.135 0.567 2.269 4.538 21.556 20.422 20.989 11.913 5.105 6.807 4.538 1.702 1.135 0.567 0 0 0 0 0 0
1991 7 3 0 2 22.962 0 0 0 0 0 8.912 4.456 10.398 26.737 34.907 14.111 2.228 8.17 2.971 5.942 0.743 2.971 0 0.743 0 0 0 0
1992 7 3 0 2 32.249 0 0 1.089 0 2.179 14.161 25.054 71.893 28.321 19.607 13.071 9.804 13.071 1.089 3.268 6.536 6.536 0 0 0 0 0 0
1993 7 3 0 2 37.409 0 0 5.723 2.861 7.631 17.169 33.384 45.784 53.414 47.691 31.476 17.169 11.446 15.261 3.815 6.677 1.908 1.908 0.954 0.954 0 0 0
1994 7 3 0 2 27.089 0 0 0.819 0 0 7.372 16.382 12.286 23.753 33.582 16.382 8.191 8.191 3.276 4.095 4.914 1.638 0.819 0.819 0.819 0 0 0
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2021 7 3 0 1 21.934 0 0 0 0 18.4205 37.262 145.095 348.319 262.202 61.3481 7.63758 0 0 0 0 0 0 0 0 0 0 0 0
2022 7 3 0 1 31.58 0 0 0 10.7229 24.3662 163.819 208.246 377.169 345.675 72.7792 0 0 0 0 0 0 0 0 0 0 0 0 0
1981 7 4 0 2 55.452 0 0 0 0 22.395 4.072 22.395 85.623 99.875 52.933 59.967 60.082 42.338 30.933 46.294 30.238 25.009 15.408 6.455 0.116 0 0 0
1982 7 4 0 2 71.348 0 0 0 0 0.402 2.621 9.415 16.61 40.932 49.447 35.86 28.282 20.838 19.172 30.654 29.468 21.239 11.386 2.488 2.354 0 0 0
1983 7 4 0 2 70.239 0 0 0.346 0 0.426 1.037 5.532 7.687 11.916 16.837 23.728 20.892 15.119 6.499 8.839 8.654 5.75 1.763 0.853 0.161 0.081 0.161 0
1984 7 4 0 2 78.372 0 0 0 0.991 1.981 2.013 12.911 43.751 35.985 43.718 79.864 108.498 57.909 29.307 26.303 18.249 18.474 4.187 3.004 3.004 0 0 0
1985 7 4 0 2 70.239 0 0 0 0 0.153 0.306 1.07 4.5 5.349 7.097 9.966 11.171 5.569 5.075 4.243 2.375 3.242 1.238 0.492 0 0 0 0
1986 7 4 0 2 76.524 0 0 0 0 0 3.361 5.963 17.495 37.7 36.905 49.011 56.308 43.586 36.935 21.031 13.8 7.693 8.56 2.71 0.036 0.036 0 0
1987 7 4 0 2 67.651 0 0 0 0 5.011 10.021 24.051 18.073 30.274 53.323 77.48 69.743 30.008 18.122 33.596 14.66 13.588 5.501 4.394 1.002 0 0 0
1988 7 4 0 2 42.513 0 0 0 0 0 3.773 13.726 28.898 41.34 31.871 50.936 40.862 25.69 16.86 25.569 20.673 20.754 11.802 5.299 0.04 0 0 0
1989 7 4 0 2 63.954 0 0 0 0.789 0 0.789 10.252 26.062 34.837 15.397 50.196 56.505 22.457 7.373 11.479 6.66 8.925 3.405 1.778 0.826 0.025 0 0.789
1990 7 4 0 2 48.798 0 0 0 0.967 0 1.933 10.668 11.151 17.505 30.283 27.689 25.344 16.716 10.326 8.77 9.36 16.751 6.872 1.969 0.483 0 0 0
1991 7 4 0 2 23.659 0 0 0 0 0 16.094 20.717 29.893 18.458 18.563 32.292 48.421 7.092 16.164 14.009 4.868 16.268 21.101 2.469 0.07 0 0 0
1992 7 4 0 2 38.816 0 0 0 0 1.245 1.383 16.186 11.343 29.188 26.832 19.638 25.311 11.891 3.318 24.342 9.819 25.035 11.619 7.191 2.628 0 0 0
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1995 7 4 0 2 28.835 0 0 0 0 1.425 2.851 2.851 7.225 15.776 28.604 24.23 20.15 13.122 9.14 8.846 6.093 1.719 8.748 5.701 0 0 0 0
1996 7 4 0 2 25.878 0 0 0 0 0 2.643 0.671 1.343 10.027 11.998 16.655 6.713 9.815 6.671 4.657 8.684 2.6 3.229 0.629 0.671 0 0 0
1997 7 4 0 2 41.404 0 0 0 0 0.27 0.54 0.451 1.218 11.292 7.092 5.148 3.614 3.251 4.516 6.185 4.785 2.437 1.804 1.353 0.135 0.451 0 0
1998 7 4 0 2 42.513 0 0 0 0 0 0.449 1.509 1.346 10.642 12.721 7.176 5.423 4.648 4.403 11.905 7.094 5.463 4.566 1.671 0.449 0 0 0
1999 7 4 0 2 48.428 0 0 0 0 0.561 1.121 3.364 0.042 4.527 5.648 12.417 13.019 19.228 15.262 11.94 10.384 6.894 9.095 6.811 0.042 0.561 0 0
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2003 7 4 0 2 60.627 0 0 0 0 2.612 0.5 2.815 9.15 11.058 11.3 10.096 10.205 7.89 12.004 8.391 6.78 2.557 4.371 1.056 0.704 0 0
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2008 7 4 0 2 79.481 0 0 0 0 0.048 0 0.966 4.395 27.868 23.275 30.936 19.404 13.464 9.259 14.376 14.226 9.742 8.967 4.721 0.428 0 0 0
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2015 7 4 0 2 87.984 0 0 0 0.323 0.645 1.653 0.645 4.515 24.315 32.256 12.501 12.104 9.361 3.192 9.65 6.862 7.307 3.029 1.216 1.212 0.041 0 0
2016 7 4 0 2 102.401 0 0 0 0.268 0 0 1.086 4.03 22.427 23.538 18.544 11.579 11.101 8.272 9.293 7.541 2.928 5.895 2.554 0.081 0 0 0
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 2005 7 -9 0 0 226 0 0 0 0 1 0 16 33 11 22 39 17 34 25 31 29 13 8 4 4 3 0 5
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 2014 7 -9 0 0 226 0 0 0 0 1 0 16 33 11 22 39 17 34 25 31 29 13 8 4 4 3 0 5
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 2016 7 -9 0 0 226 0 0 0 0 1 0 16 33 11 22 39 17 34 25 31 29 13 8 4 4 3 0 5
 2017 7 -9 0 0 226 0 0 0 0 1 0 16 33 11 22 39 17 34 25 31 29 13 8 4 4 3 0 5
 2018 7 -9 0 0 226 0 0 0 0 1 0 16 33 11 22 39 17 34 25 31 29 13 8 4 4 3 0 5
 2019 7 -9 0 0 226 0 0 0 0 1 0 16 33 11 22 39 17 34 25 31 29 13 8 4 4 3 0 5
 2020 7 -9 0 0 226 0 0 0 0 1 0 16 33 11 22 39 17 34 25 31 29 13 8 4 4 3 0 5
 2021 -7 -9 0 0 226 0 0 0 0 1 0 16 33 11 22 39 17 34 25 31 29 13 8 4 4 3 0 5
-9999 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
#
40 #_N_age_bins
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
1 #_N_ageerror_definitions
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001
#_mintailcomp: upper and lower distribution for females and males separately are accumulated until exceeding this level.
#_addtocomp:  after accumulation of tails; this value added to all bins
#_combM+F: males and females treated as combined sex below this bin number
#_compressbins: accumulate upper tail by this number of bins; acts simultaneous with mintailcomp; set=0 for no forced accumulation
#_Comp_Error:  0=multinomial, 1=dirichlet using Theta*n, 2=dirichlet using beta, 3=MV_Tweedie
#_ParmSelect:  consecutive index for dirichlet or MV_Tweedie
#_minsamplesize: minimum sample size; set to 1 to match 3.24, minimum value is 0.001
#
#_mintailcomp addtocomp combM+F CompressBins CompError ParmSelect minsamplesize
0 1e-07 0 0 0 0 0.01 #_fleet:1_COM_LL
0 1e-07 0 0 0 0 0.01 #_fleet:2_COM_OTHER
0 1e-07 0 0 0 0 0.01 #_fleet:3_REC_E
0 1e-07 0 0 0 0 0.01 #_fleet:4_REC_W
0 1e-07 0 0 0 0 0.01 #_fleet:5_RVC_DT
0 1e-07 0 0 0 0 0.01 #_fleet:6_RVC_KEYS
0 1e-07 0 0 0 0 0.01 #_fleet:7_RVC_SEFL
0 1e-07 0 0 0 0 0.01 #_fleet:8_FIM_YOY
0 1e-07 0 0 0 0 0.01 #_fleet:9_GOM_VID
0 1e-07 0 0 0 0 0.01 #_fleet:10_SERFS_VID
0 1e-07 0 0 0 0 0.01 #_fleet:11_FI_AGE
3 #_Lbin_method_for_Age_Data: 1=poplenbins; 2=datalenbins; 3=lengths
# sex codes:  0=combined; 1=use female only; 2=use male only; 3=use both as joint sexxlength distribution
# partition codes:  (0=combined; 1=discard; 2=retained
#_yr month fleet sex part ageerr Lbin_lo Lbin_hi Nsamp datavector(female-male)
 2001 7 1 0 2 1 60 60 7 0 0 0 2 2 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2001 7 1 0 2 1 76 76 5 0 0 0 0 0 0 2 0 2 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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2021 7 11 0 2 1 64 64 12 0 0 0 0 5 5 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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-9999  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
#
0 #_Use_MeanSize-at-Age_obs (0/1)
#
0 #_N_environ_variables
# -2 in yr will subtract mean for that env_var; -1 will subtract mean and divide by stddev (e.g. Z-score)
#Yr Variable Value
#
# Sizefreq data. Defined by method because a fleet can use multiple methods
-3 # N sizefreq methods to read (or -1 for expanded options)
3 # N sizefreq methods to read
# each row below has entry for each sizefreq method
#_ 1 2 3  # Method
 18 18 18 #_Sizefreq N bins
 2 2 2 #_Sizefreq units(1=bio/2=num)
 3 3 3 #_Sizefreq scale(1=kg/2=lbs/3=cm/4=inches)
 1e-07 1e-07 1e-07 #_Sizefreq:  small constant to add to comps
 12 19 7 #_Sizefreq number of obs per method
 0 0 0 #_Comp_Error:  0=multinomial, 1=dirichlet using Theta*n, 2=dirichlet using beta, 3=MV_Tweedie
 0 0 0 #_ParmSelect: consecutive index for dirichlet or MV_Tweedie comp_error
#_Sizefreq bins. one row for each method
```

#Note: negative value for first bin makes it accumulate all smaller fish vs. truncate small fish
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
#_method year month fleet sex partition SampleSize <data>
1 1999 7 5 0 0 29 0 0 0.00156 0 0.0078 0.00156 0.00312 0.01872 0.01092 0.0156 0.00312 0.00624 0.00156 0.00156 0.00156 0 0 0
1 2000 7 5 0 0 44 0 0 0.00127886 0 0.00895203 0.0102309 0.0115097 0.0214209 0.0246181 0.00895203 0.00767317 0.00511544 0 0.00127886 0 0 0 0
1 2004 7 5 0 0 127 0.00490452 0 0.00163484 0.0040871 0.00081742 0.00953602 0.0196181 0.0416884 0.0286097 0.02534 0.0188007 0.0188007 0.0138961 0.00735678 0.00245226 0.00081742 0 0
1 2006 7 5 0 0 93 0.000986667 0 0 0.000986667 0.00296 0.0108533 0.0138133 0.0187467 0.02368 0.0197333 0.0138133 0.0148 0.00690667 0.00493333 0.00296 0.000986667 0 0
1 2008 7 5 0 0 181 0 0 0.000724673 0.00217402 0.00851491 0.0184792 0.0266317 0.0543505 0.0326103 0.035509 0.0181168 0.0210155 0.00869607 0.00289869 0.00144935 0.00144935 0 0
1 2010 7 5 0 0 229 0.00137661 0 0.00344152 0.00929211 0.0206491 0.0311458 0.0545481 0.0600546 0.038373 0.0351035 0.0227141 0.0275322 0.00825966 0.00688305 0 0.00137661 0 0
1 2012 7 5 0 0 279 0.00129427 0 0.000647137 0 0.00582423 0.0129427 0.0388282 0.0627723 0.0679494 0.0530653 0.0271798 0.0310626 0.0155313 0.00970706 0.00323569 0 0 0
1 2014 7 5 0 0 223 0 0 0 0.000668512 0.00133702 0.0147073 0.0140387 0.0207239 0.030083 0.0407792 0.0314201 0.0354311 0.0193868 0.0100277 0.00401107 0.00200554 0 0
1 2016 7 5 0 0 215 0 0 0 0.0031618 0.00863928 0.0464027 0.0577888 0.0590499 0.0696932 0.0559184 0.0445324 0.0457205 0.017145 0.00801583 0.013805 0.000890648 0 0.00445324
1 2018 7 5 0 0 232 0 0 0 0.00299582 0.0104854 0.0314561 0.0322051 0.0411925 0.0441884 0.032954 0.0411925 0.0307072 0.0157281 0.00973642 0.00599164 0 0 0.00224687
1 2021 7 5 0 0 182 0 0 0 0 0.00666167 0.0366392 0.0549588 0.0932633 0.0899325 0.07994 0.07994 0.0666167 0.0566242 0.0183196 0.0116579 0.00333083 0 0.00166542
1 2023 7 5 0 0 149 0 0 0 0 0.0081677 0.0326708 0.081677 0.103458 0.138851 0.111625 0.0925672 0.0925672 0.0326708 0.0245031 0.00272257 0 0 0
2 1997 7 6 0 0 24 0 0 0 0.0133389 0.0044463 0.0311241 0.0289009 0.0333472 0.0044463 0 0.0044463 0 0 0 0 0 0 0
2 1999 7 6 0 0 29 0 0 0.0106832 0.0133541 0.0213665 0.0240373 0.0133541 0.00534162 0.00267081 0.00801243 0 0 0 0 0 0 0 0
2 2000 7 6 0 0 61 0 0 0.00786556 0.014158 0.0251698 0.0319877 0.0445725 0.0194028 0.0173042 0.00734014 0.00314622 0.00157311 0 0 0 0 0 0
2 2001 7 6 0 0 89 0 0 0.00125677 0.00251354 0.00879738 0.00879738 0.0188515 0.0301625 0.0238786 0.0263922 0.0109967 0.016338 0.0106825 0.00345612 0.00125677 0 0 0
2 2002 7 6 0 0 85 0 0 0.00537887 0.00941302 0.011206 0.00956183 0.0143436 0.0316744 0.0125507 0.0145678 0.016809 0.00986126 0.00896478 0.00268943 0.000896478 0.00179296 0 0
2 2003 7 6 0 0 64 0 0 0.00353497 0.0118903 0.00385633 0.0102835 0.0244234 0.0154253 0.0205671 0.0244234 0.0162814 0.0167108 0.00642721 0.00514177 0.0089981 0.00385633 0 0
2 2004 7 6 0 0 42 0 0 0.00676724 0 0.00902299 0.0157902 0.0225575 0.0406034 0.0293247 0.0236853 0.00451149 0.027069 0.00338362 0.00902299 0 0.00451149 0 0
2 2005 7 6 0 0 86 0 0 0.00615383 0.0205128 0.0123077 0.025641 0.0317948 0.0307691 0.0215384 0.0246153 0.0102564 0.00717947 0 0.00102564 0 0.00102564 0 0
2 2006 7 6 0 0 75 0 0 0.00118908 0.00594539 0.00713447 0.0202143 0.0285379 0.0303215 0.0249706 0.0261597 0.00832355 0.00772901 0.00237816 0.00475631 0 0 0 0
2 2007 7 6 0 0 137 0 0 0.00170417 0.00596458 0.0136333 0.0274797 0.0483557 0.0498469 0.0323792 0.0313141 0.0198109 0.0183198 0.00681667 0.00681667 0.000852083 0.00255625 0 0
2 2008 7 6 0 0 152 0 0 0.0043659 0.00349272 0.0183368 0.0456237 0.0416943 0.0454054 0.0218295 0.0235759 0.00960498 0.00611226 0.0043659 0.00349272 0 0 0 0
2 2009 7 6 0 0 190 0.000526709 0 0.00158013 0.0121143 0.0184348 0.0268622 0.0294957 0.0305491 0.0158013 0.0121143 0.00526709 0.00632051 0.00210684 0.00263355 0 0 0 0
2 2010 7 6 0 0 94 0 0 0 0.000882083 0.00617458 0.0149954 0.0229342 0.0344013 0.0220521 0.0132312 0.00352833 0.00441042 0.00176417 0.00264625 0 0 0 0
2 2011 7 6 0 0 130 0 0 0 0.00174042 0.00638153 0.0121829 0.0179843 0.0365487 0.016824 0.0104425 0.00580139 0.0110226 0.00406097 0.00232056 0 0 0 0
2 2012 7 6 0 0 168 0 0 0.0011802 0.00472081 0.0112119 0.0324556 0.0247842 0.0253743 0.0230139 0.0147525 0.0141624 0.0112119 0.00531091 0.00531091 0.0017703 0 0 0
2 2014 7 6 0 0 124 0 0 0.000876367 0.00635366 0.0138028 0.0592284 0.0533234 0.0472607 0.0439744 0.0197919 0.0103078 0.0026291 0.00388055 0.00467454 0.000876367 0 0 0
2 2016 7 6 0 0 121 0.00123599 0 0.00412079 0.0252364 0.0763224 0.124098 0.0691858 0.0291496 0.0126689 0.00865193 0.00494396 0.00123599 0 0 0 0 0 0
2 2018 7 6 0 0 185 0.000898121 0 0.00538873 0.00898121 0.0349513 0.0777611 0.0757385 0.0567307 0.0356249 0.0107775 0.0134718 0.0116756 0.00359248 0 0 0 0 0
2 2022 7 6 0 0 80 0.00540974 0 0.0324584 0.0189341 0.0513925 0.113604 0.0703266 0.0378682 0.0351633 0.0243438 0.00270487 0.00270487 0.0108195 0.00540974 0 0 0 0
3 2013 7 7 0 0 222 0.000400299 0 0.00426959 0.019481 0.0262845 0.0425646 0.0334914 0.0184138 0.00600449 0.0024018 0.0016012 0.000400299 0 0.000400299 0 0 0 0
3 2014 7 7 0 0 164 0 0 0.0063473 0.0142814 0.0309431 0.0483981 0.0626796 0.036497 0.0174551 0.0103144 0.00158682 0.000793412 0 0 0 0 0 0
3 2015 7 7 0 0 118 0.000965759 0 0.00289728 0.0193152 0.0328358 0.0502195 0.0434591 0.0202809 0.0144864 0.000965759 0.00193152 0 0.000965759 0 0 0 0 0
3 2016 7 7 0 0 180 0.000930167 0 0.0144176 0.0414706 0.0690649 0.0952658 0.0916233 0.0482924 0.0353463 0.0140306 0.0027905 0.00302304 0 0.00186033 0.0027905 0.000930167 0 0
3 2018 7 7 0 0 242 0 0.019458 0.083819 0.176619 0.213289 0.137204 0.0583739 0.0376687 0.00299353 0.00199569 0 0 0.000997845 0 0 0 0
3 2021 7 7 0 0 148 0.00177455 0 0.0204074 0.047913 0.171245 0.305223 0.0905023 0.031942 0.0177456 0.0124219 0.00354911 0.00354911 0 0 0 0 0 0
3 2022 7 7 0 0 144 0 0 0.0575885 0.183616 0.155656 0.206568 0.0893039 0.0350539 0.0166923 0 0 0.0050077 0 0 0 0 0 0
#
0 # do tags (0/1/2); where 2 allows entry of TG_min_recap
#
0 #   morphcomp data(0/1)
Nobs, Nmorphs, mincomp
yr, seas, type, partition, Nsamp, datavector_by_Nmorphs
#
0 # Do dataread for selectivity priors(0/1)
Yr, Seas, Fleet, Age/Size, Bin, selex_prior, prior_sd
feature not yet implemented
#
999

SEDAR

Southeast Data, Assessment, and Review

SEDAR 79

Southeastern US Mutton Snapper

SECTION IV: Research Recommendations

SEDAR
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Table of Contents

1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

1.1 LIFE HISTORY RESEARCH RECOMMENDATIONS

1.1.1 Stock Definition

The LHW recommended expanding genetic sampling to other areas parts of the defined unit stock (e.g., northeastern Florida or on the West Florida Shelf) to either reinforce or challenge current hypothesized boundaries of the Mutton Snapper stock within southeastern U.S. waters. In addition, the presence of Mutton Snapper larvae sampled at stations across the Straits of Florida between the east Florida shelf (e.g., off Biscayne Bay) and the Great Bahama Bank (D'Alessandro et al. 2010) suggests possible connectivity between the two regions. There is no genetic data published from Mutton Snapper in the Bahamas (Carson et al. [2011] comments about it being a less well-documented aggregation area) and investigating this could provide insight into any connection with southeastern Florida as well as any potential source and sink dynamics. While genetic analyses for Mutton Snapper have been conducted from elsewhere in the Caribbean (e.g., Puerto Rico, St. Croix, St. Thomas, Cuba, Belize) and support a homogenous stock, there is no genetic information available from populations observed off the Yucatan peninsula in the southwest Gulf of Mexico.

1.1.2 Morphometrics and Conversion Factors

The LHW recommends additional length measurements in 'maximum' total length be taken across both fishery-dependent and fishery-independent programs to better align with current management regulations and the length units used within the assessment model(s).

1.1.3 Age and Growth

The number of otoliths sampled and available for this assessment had significantly increased from the number available in the previous update assessment and was adequate for use in developing models for growth and tracking strong year classes through time (albeit once they've entered the fishery, about age-3). Yet, the LHW noted a paucity of fishery-independent age data particularly for pre-fishery individuals aged 0 – 2 years and also greater than age ~8 years. Of the ongoing fishery-independent surveys which track young Mutton Snapper throughout the Florida Keys and southeast Florida regions, otolith-derived age information was largely collected from the Indian River Lagoon system.

The LHW, therefore, expressed an interest in the need to increase fishery-independent age sampling of these younger and older parts of the population. Such information could help further our understanding of ontogeny and recruitment throughout the Florida Keys and allow for earlier detection of strong year classes, rather than waiting for them to be sampled from the fishery. Information of older fish also makes possible fishery-independent estimates of L_∞, which is currently not feasible. The LHW also understands that implicit in this is the probable expansion of fishery-independent surveys targeting these parts of the Mutton Snapper population and may be considered a 'heavy lift'.

1.1.4 Natural Mortality

The field of natural mortality is not yet in a position to establish 'best practices' (Maunder et al. 2023) and suggested 'good practices' are often trade-offs between reliability and availability of the data. More direct methods of estimating mortality, such as mark-recapture or acoustic telemetry tagging, are generally recommended over empirical methods but are largely unavailable for Mutton Snapper. Therefore, tagging studies for this species are recommended for the purposes of estimating mortality. Effort into acoustic telemetry tagging requires a large enough array of detectors to minimize incomplete detections and the candidacy of Mutton Snapper may need to be evaluated if movement out of the array area is for extended periods (i.e., are the change in numbers due to mortality or migration). But acoustic telemetry will also help alleviate the human reporting issues within conventional tagging.

1.1.5 Release Mortality

Future research is recommended to obtain a more accurate estimate of Mutton Snapper discard mortality, which could include similar work conducted by Forrestal et al. (2017) on the development of physiological parameters or acoustic tagging of Mutton Snapper releases at a series of depths to evaluate post release mortality. In addition, studies that quantify Mutton

Snapper immediate and delayed mortality of discards caught from commercial fishing gears are needed to validate the assumption that discard mortalities are comparable among fisheries.

Depredation (the removal of fish from fishing gear by non-target species) of Mutton Snapper is a concern among commercial, charter, and headboat captains primarily in the Gulf of Mexico in recent years (GMFMC Staff 2023 and Workgroup discussions). However, depredation is currently not explicitly incorporated in estimates of discard mortality. Attempts should be made to measure depredation rates from either existing or new surveys and provide recommendations on how to incorporate this information in a stock assessment model.

1.1.6 Reproduction

The LHW emphasized that additional research is needed to better understand Mutton Snapper reproduction in the southeastern U.S., and it is important to note that all reproductive data used here were largely more than 10 years old. A common problem sampling for maturity is that truly immature fish are often smaller than legal size and/or are located in habitat differing from adult habitat. Histological data from the Florida Keys, especially from fishery-independent sources on immature fish, is needed and should be collected throughout the year given the recent best practices developed and conducted here for determining size- and age-at-maturity and spawning seasonality. Furthermore, because reproductive timing in spring and summer-spawning fish is tightly coupled to temperature (Lowerre-Barbieri et al. 2011) spawning seasonality may have changed with climate change. Data are also suggestive of potential migration through SE Florida to Keys spawning grounds and possibly even a second spawning season. Therefore, understanding all these processes will be critical to estimating annual fecundity in this species.

1.1.7 Movement and Migration

The movement data presented here for Mutton Snapper is recent and unpublished but is already challenging previous understandings for this species. The LHW, therefore, recommended continual investigation of the movement and migration rates between the Florida Keys, southeast Florida, and southwest Florida (e.g., through increased tagging) as well as to continue examining migration distances and catchment areas of Mutton Snapper traveling to known spawning aggregations. The LHW also recommended further investigation into ontogenetic shifting of juveniles from nearshore areas to reef habitat as this is not well documented within south Florida waters.

1.2 COMMERCIAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

Biological Sampling

- Increased observer and EM coverage in the Gulf and South Atlantic fisheries
- Recommend the observer program investigate the allocation of some observer coverage for focused trips to aid in future SEDARs as a subset of existing strata

    - For Mutton Snapper, this may include allocating addition effort to increase the probability of Mutton encounters in areas of higher population density (SE FL, FL Keys)
- Allocating funding to support research on predator depredation and effect on landings and discards

1.3 RECREATIONAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

- Study effect of hurricanes on mutton movement
- Continuation of FES pilot study
- Continued evaluation of appropriate SRFS/FES calibration
- Improve precision of MRIP estimates for the shore mode
- Study rates of depredation on recreational fishing

1.4 MEASURES OF POPULTAION ABUNDANCE RESEARCH RECOMMENDATIONS

- The IWG recommends analyzing past and future videos from stereo cameras deployed as part of the Southeast Reef Fish Survey (SERFS) for Mutton Snapper lengths.
- Explore methods to incorporate lengths sampled by the Biscayne Bay Creel Survey into the MRIP APAIS.
- Add Mutton Snapper to FWC FIM's standard cull list to collect otoliths from Mutton Snapper sampled by the 183-m seine survey in the Indian River Lagoon.
- Consider incorporating power analyses for other indices similar to the exploratory power analysis of the FIM inshore seine survey.

2. ASSESSMENT PROCESS RESEARCH RECOMMENDATIONS

This assessment, as well as many others, would greatly benefit from a better understanding of movement and stock structure, as well as recent reproduction. A better understanding of these processes may shed light on the mechanisms driving the truncated length and age distributions of Mutton Snapper observed in southeast FL. The SEDAR 79 Data Workshop report includes an extensive list of research recommendations from each working group that should be prioritized (Sections 2.11, 3.8, 4.8, 5.6).

Regarding fishery sampling effort, the next assessment would benefit from additional sampling in the FL Keys, increased sampling of commercial vertical line and other gears, additional age and length samples from private and shore recreational modes, and more information on release sizes. The length and age distributions of landed Mutton Snapper in the FL Keys appear to be intermediary between generally smaller/younger fish caught in SE FL and larger/older fish caught in the Dry Tortugas, however the FL Keys are considerably under sampled in most years. For commercial vertical line and other gears, increase the number of measured Mutton Snapper to at least 320 per year. An average of approximately 20 per month from January through August and 40 per month from September through December, especially from vessels fishing in the FL Keys and Dry Tortugas. Additional age and length samples from private and shore recreational modes are needed. Increase length sampling in all regions for the shore mode and begin aging Mutton Snapper landed by the shore mode. For both the private and shore recreational modes, increase length sampling substantially in regions west of the FL Keys and the FL Keys to at least 150 per year and continue sampling the SE FL with the goal of reaching at least 150 per year. Also, the private and shore modes account for nearly all releases but do not contribute release lengths, undoubtedly due to the logistical challenges of sampling releases from these fishing modes.

Lastly, reliable estimates of commercial discards are currently lacking. Estimates of commercial discards from at-sea observers or other sources that are demonstrated to be more reliable than discard logbooks are needed.

3. REVIEW PANEL RESEARCH RECOMMENDATIONS

The RP supports the research recommendations identified by the Data and Assessment stages for the Southeastern US Mutton Snapper assessment processes.

The RP also recommends that this stock is assessed sooner than 10 years given the uncertainties associated with the scale of the population. The dome-shaped selectivity of the recreational fishery on the east coast of Florida is especially concerning. The stock may be overestimated if larger snapper are underrepresented in the recreational catch monitoring programs.

The following recommendations are ordered by priority.

Short-term (within six months)

- Continue efforts to generate MCMC samples to refine the estimation of parameter uncertainty and support stochastic projections.
- Consider statistical methods for making probabilistic statements regarding current status of the stock that accounts for uncertainty in both the reference points and stock size or rates. MCMC methods would provide the necessary joint samples for this computation. Alternatively, it may be possible to use the variance covariance matrix to approximate the probability of being above or below a given reference point.

Longer-term

- The model estimated strong dome-shaped selectivity curves for both recreational sectors (east and west), but there remains uncertainty about whether those older/larger fish are less vulnerable to recreational fishing, or whether they are missing from the recreational catch data. It was discussed that Mutton Snapper are often caught as part of an aggregate snapper-grouper trips, and the lack of schooling during most of the year likely precludes high catches as a regular occurrence. Further, some fraction of the offshore recreational vessels use private docks and launches for their trips. Finally, most length-composition information on the recreational fishery comes from monitoring of headboat removals. Thus, samples currently collected in the recreational surveys may not be representative of the fish actually taken in the recreational fishery. We believe improved methods and data collection are needed to better quantify the size/age composition of the recreational sectors.

- A study of the size/age based vertical distribution of Mutton Snapper would be helpful to better understand the availability of fish to fishing gear and the video sampling equipment.
- Consider alternative approaches for longline catch rate standardization, ideally allowing the most recent (2011 to 2023) data to be included.
- Explore the application of spatiotemporal models to the combined Gulf video survey data to monitor distribution shifts and generate an index that accounts for the changes in the survey.
- Though it would be ideal to estimate movement rates and work toward a spatial assessment model, a simpler model that accounts for coarse spatial differences could still be constructed. For instance, a two-box model estimating the portion of each age group inhabiting the West vs East might be feasible. A well-designed conventional tagging program could be a cost-effective and efficient method to help inform this analysis.
- In addition, a high and low- reward floy tagging program can also be used to inform levels of recreational removals by comparing returns from the commercial fishery relative to the recreational fishery.
- If funds permit, data storage tags could be deployed to complement the results from the conventional tagging program.
- Consider close-kin-mark-recapture (CKMR). There is an active fishery with length and age sampling, meaning there is scope for collecting genetic samples, and the population is relatively small, meaning CKMR population estimation may be feasible with relatively few samples. These data also help with defining stock boundaries.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 79

Southeastern US Mutton Snapper

SECTION V: Review Workshop Report

September 2024

SEDAR
4055 Faber Place Drive, Suite 201
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1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 79 Review Workshop was held in St. Petersburg, Florida September 10-12, 2024.

1.2 TERMS OF REFERENCE

1. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:
   a) Are data decisions made by the DW and AW panels sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are input data series reliable and applied properly within the assessment model?
2. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and considering the following:
   a) Are methods scientifically sound and robust?
   b) Are assessment models configured properly and consistent with standard practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings and consider 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 reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

4. Evaluate the stock projections, including discussing strengths and weaknesses, and consider 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 the significant sources of uncertainty in the population, data sources, and assessment methods
   - Ensure that the implications of uncertainty in technical conclusions are 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. Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation, and peer review of fishery management information.
8. Provide suggestions on key improvements in data or modeling approaches that should be considered when scheduling the next assessment.
9. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and 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

Amy Schueller (Chair)..SAFMC SSC
Michael Allen..GMFMC SSC
Adriana Nogueira Gassent..CIE Reviewer
John Neilson..CIE Reviewer
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2. REVIEW PANEL REPORT

An independent peer review of the SEDAR 79 Mutton Snapper Research Track Stock Assessment was conducted during an in-person Review Workshop on September 10-12, 2024, in St. Petersburg, FL. The data, analyses, and stock modeling presented were part of a Benchmark Stock Assessment (called "assessment" in this report).

The Review Panel appreciated the collegial nature of the review deliberations. The Assessment Team was responsive to the Review Panel's comments, questions, and requests for additional analyses. The Review Panel thanks the entire Assessment Team for the significant amount of work involved and for the reports detailing the data, analyses, exploration, and modeling. In particular, the panel acknowledges Shanae Allen (Assessment Lead) and other Florida Fish and Wildlife Conservation Commission staff who presented an overview of the assessment, provided additional clarification and analyses, and answered Review Panel questions. The Review Panel also thanks SEDAR and South Atlantic Fisheries Management Staff for their invaluable assistance during the review process.

During the review workshop, the Review Panel was able to conduct a thorough review of the Mutton Snapper assessment. This report summarizes its findings and recommendations.

Executive Summary

An independent peer review of the SEDAR 79 Mutton Snapper benchmark assessment was conducted during an in-person Review Workshop on September 10-12, 2024, in St. Petersburg, FL. The Review Panel consisted of Amy Schueller (Chair; SAFMC SSC), Mike Allen (GMFMC SSC), Alexei Sharov (SAFMC SSC), Paul Regular (CIE), Adriana Nogueira (CIE), and John Neilson (CIE).

The Review Panel concluded that the modeling approaches used for Mutton Snapper were appropriate, the data and assessment decisions were technically sound, and the stock assessment is useful for providing management advice. The diagnostics presented by the assessment team were thorough and included jitter analyses, a retrospective analysis, sensitivity runs, and likelihood profiles. Generally, the patterns in the diagnostics were as expected. During the review, data and model inputs, assumptions, and uncertainties were discussed, and then, detailed in this report. Some significant uncertainties included the assumption of stock structure, the use of the indices of abundance, the accuracy of recreational removals, mortality rates from discarding, the form of the selectivity curves, recruitment, and the associated reference points. Finally, the MCMC analysis was not working properly at the conclusion of the workshop; thus, the MCMC results could not be used to provide uncertainty to the projections analyses. While the Review Panel deemed the projection methods to be appropriate, we also recommend continued exploration of the model and code to enable stochastic projections in the future.

The Review Panel concluded that the assumption of one stock was reasonable but noted that the unit stock for the area should be investigated further through the use of tagging and genetics. The Review Panel discussed the standardization, selection, and treatment of the indices of abundance. Overall, the indices of abundance provided information on a range of sizes and ages across a broad spatial distribution and were considered to represent Mutton Snapper well in this assessment. The data for the video survey in the Gulf of Mexico could have been considered further with standardization using spatial considerations given the geographic changes in coverage. In addition, the longline index could use further exploration to address possible hyperstability. Both of these topics were noted as sources of uncertainty. The accuracy of recreational removals was considered through the exploration of several sensitivity runs using the recreational data from the MRIP program as well as the state run Florida Reef Fish Survey. The decision to use the Florida Reef Fish Survey for the private boat mode removals was uncertain, but had a small impact on the outcomes of the overall assessment. The discard mortality rate was based on an estimate for red snapper, another species in the snapper-grouper complex. Sensitivity runs were used to address this uncertainty, but the Review Panel recommends further research into discard mortality rates. Selectivity was assumed to be dome-shaped for the recreational fleets. The Review Panel could not determine if the selectivities for the recreational fleets were indeed dome-shaped, or if the appearance of the length information was simply a remnant of poor data sampling across the recreational fleets. In light of that, the Review Panel requested some additional sensitivity runs addressing the selectivity of the recreational east and west fleets. Further exploration and improvement in catch sampling would reduce this uncertainty. Finally, the assumption of a Beverton Holt stock- recruitment with an estimable steepness value was extensively discussed by the Review Panel. The assumptions made for the base run regarding the stock-recruitment curve were ultimately considered appropriate by the Review Panel. However, the choice of 30% SPR as a proxy for MSY was not supported as it did not align with the estimates of MSY. That value, as calculated internally, was close to the value of 40% SPR. The Review Panel recommended using a fishing mortality rate of F = 0.11 as the benchmark for stock status.

ADDRESSING THE REVIEW WORKSHOP TERMS OF REFERENCE

1) ***Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:***

a) Are data decisions made by the DW and AW sound and robust?

Overall, the data decisions made by the DW and AW panels were sound and robust. Southeastern U.S. Mutton Snapper was treated as a single population based on a combination of genetic and biological evidence. While some studies suggest genetic homogeneity throughout Florida and the Caribbean, larval drift and tagging studies indicate minimal connectivity between the two regions. This evidence supported the assumption of demographic independence for Southeastern U.S. Mutton Snapper. Although evidence of connectivity is not entirely conclusive, treating the stock as a single unit remains the most practical approach for both assessment and management purposes.

Within the region, different methods were considered for estimating recreational fishery removals. The assessment team evaluated estimates from the Marine Recreational Information Program (MRIP) and the State Reef Fish Survey (SRFS) from Florida. Ultimately, SRFS estimates were deemed more reliable for the Florida private boat mode, as the survey is better suited for rare-event species like Mutton Snapper with higher and more consistent sampling effort. Using three years of concurrent data from the SRFS and MRIP surveys, a calibration factor was applied to the MRIP series, converting it to SRFS units. This calibration exercise resulted in a significant reduction in removal estimates, as SRFS tends to report lower estimates than MRIP. While it was suggested that this discrepancy might be related to the order of the questions or over-reporting of trips in MRIP, the exact cause remains unknown. Thus, the decision to use the SRFS series is somewhat tentative, and the team performed a sensitivity test to assess the impact of this decision.

Another important data decision involved the treatment of the combined Gulf video survey, which has evolved over time and expanded into sub-optimal Mutton Snapper habitat. As a result, recent declines in the index appear to be artifacts of these changes in survey design. Rather than creating a new index based solely on core habitat, the team chose to use the existing index while allowing the catchability coefficient (q) to adjust in the model to reflect the survey changes. This was a reasonable choice, allowing the model to internally calibrate the survey, but it effectively down-weighted the survey's contribution to recent trends. Moving forward, spatiotemporal analyses could be useful for monitoring range expansions and producing a continuous time series of population trends.

Overall, the assessment's approach to data decisions was appropriate and supported by the available evidence. However, continued research and further investigation into survey discrepancies are recommended for future assessments.

b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

Yes, data uncertainties were acknowledged and reported throughout the assessment process. This assessment lies within the data-moderate to data-rich spectrum, and the team integrated a wide range of fishery-dependent and fishery-independent data to inform trends in the stock using a conditional age-at-length model.

As with most assessments, fishery removals carry inherent uncertainty, and the team carefully considered and incorporated this uncertainty into the model. Estimates of recreational removals are particularly uncertain. In recognition of this, the model was not forced to fit these data exactly. However, this added flexibility does not fully explain the large discrepancy between recreational removal estimates from the SRFS and MRIP surveys; a sensitivity test was therefore conducted to examine the impact of the different estimates.

Another area of uncertainty concerns mortality from discarding undersized Mutton Snapper. Due to a lack of species-specific data, Mutton Snapper were assumed to experience a similar release mortality as Red Snapper which, according to a recent meta-analysis, was roughly 30%. This was considered a coarse approximation, and sensitivity tests using higher and lower rates were conducted to assess the impact of this assumption.

Six fishery-independent indices of abundance and one fishery-dependent index of biomass were used in the assessment. Uncertainty levels were estimated for each index on an annual basis and these estimates were provided to the model. The combined Gulf video survey presented the greatest challenge, as changes in the survey design led to the inclusion of sub-optimal Mutton Snapper habitat. While this issue was addressed by allowing the model to estimate changes in catchability, an external spatio-temporal analysis would help confirm whether these adjustments are realistic. The longline CPUE series also presented some challenges. In an effort to produce an index of population changes, the team standardized these data and truncated the series to 2010 to avoid changes in rates stemming from significant management changes. However, the resulting index series was not fit well by the model, with runs of positive or negative residuals. It was acknowledged that this index may be hyperstable and the reliability of this series was discussed.

In summary, data uncertainties were appropriately addressed, with key uncertainties regarding survey estimates, connectivity, and anomalous data points explicitly recognized and accounted for in the model.

c) Are input data series reliable and applied properly within the assessment model?

The input data series used in the assessment were generally reliable and applied appropriately within the model. As previously mentioned, the estimates of recreational catch remain somewhat uncertain, particularly given the substantial difference in scale between the two independent surveys (SRFS and MRIP). However, because the majority of the recreational series is derived from MRIP, the assessment is insensitive, in relative terms, to the units of recreational removals.

With regard to the fishery-independent surveys, it is difficult to guarantee that any individual index is fully representative of stock-wide changes, as none of the indices cover the entire stock area. Nonetheless, the structure of the selectivity curves was carefully considered to integrate information from the seven indices, which together encompass the full stock range. The combined Gulf video index posed challenges due to changes in survey design, but this was implicitly addressed by allowing the model to estimate changes in q. The longline CPUE series was truncated to end in 2010 as subsequent changes in regulations likely conflate indications of changes in the population. Still, concerns were raised regarding hyperstability of the truncated series. The longline CPUE series was standardized using a method that subsets trips based on the occurrence of related species. Explanatory variables included in the standardization included year, month, season, days at sea, and crew size. Future assessments should consider modifying the standardization method to improve its reliability (e.g., subsetting the data for index fishermen that have an established history of fishing Mutton Snapper) or consider removing this series from the model.

In conclusion, while there are some uncertainties, input data series were applied correctly and contributed meaningfully to the overall assessment.

2) Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data. Consider the following:

a) Are the methods scientifically sound and robust?

The integrated stock assessment model used in the assessment is a well-accepted state of the art approach (Stock Synthesis). The method has been applied in a scientifically sound and robust manner, following best practices in stock assessment. Moreover, a comprehensive suite of diagnostic tests was presented to demonstrate the robustness of the model, including residual diagnostics, retrospective analyses, hindcast cross-validation, jitter analysis, likelihood profiling, and comparison with age-structured production analyses. The base case model produced satisfactory results for most of these diagnostics. The assessment report also included various sensitivity runs to evaluate the impact of different assumptions.

b) Are assessment models configured properly and consistent with standard practices?

Given the diagnostics completed for Mutton Snapper, the review panel (RP) concluded that the models were configured appropriately and consistent with standard practices. There was some discussion over the form of the selectivity curve and the choice of the plus group age. The mutton snapper assessment is relatively data-rich, and the available data are appropriate for the analyses that were undertaken. Of particular importance given the importance of the scale of discards in the recreational fishery, the assessment used a novel proxy approach for treatment of post-release and delayed mortality, and those estimates are included in the assessment.

Biological parameters, such as natural mortality, were configured using the best available information and following the latest best practices. A Beverton-Holt curve was chosen as the stock-recruitment relationship and recruitment-deviations were estimated, allowing for significant deviations from mean levels of recruitment. The model was configured to estimate recruitment at age 1, following recent recommendations from the literature.

The assumed shape of the selectivity curves for the fisheries and survey indices were discussed at length. The RP questioned the validity of the dome-shape assumption applied to the reef visual surveys; however, sufficient evidence was provided to support the conclusion that larger and older snapper are less available to these surveys. The flat-top assumption for the combined Gulf and SERFS video surveys was also justified by their spatial extent and depth-coverage. The dome-shape assumption for the recreational west and east fisheries were also questioned and sensitivity tests showed that stock size estimates decrease when a flat-top shape is assumed; however, this comes at a cost of fitting the length-composition data poorly. The panel agreed that the dome-shape provides the best explanation of the data, but cautioned that the assessment and projection may overestimate stock size if larger snapper are underrepresented in the recreational fishery monitoring programs.

The use of age 40 as the plus group was also questioned. Given the limited portion of data informing trends out to these larger ages, the panel wondered whether a smaller plus group, such as 25+ or 30+ would be more appropriate. However, the general consensus was that the plus group configuration would be more of a concern if it were too young of an age, such as 10+. The base model configuration of 40+ was retained to capture the little information available out to these older ages.

c) Are the methods appropriate for the available data?

In general, yes. Instead of using an age-structured model, which would have required extensive data pre-processing, the team opted for a conditional age-at-length approach. This method allowed them to incorporate length and age data whenever available, minimizing the number of assumptions and maximizing the use of raw, unprocessed information. This approach aligns with best practices in stock assessment.

There could be further scope for exploration of the commercial fishery CPUE data, possibly using methods for subsetting the data for index fishermen with an established history of fishing Mutton Snapper.

3) Evaluate the assessment findings and consider 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?

In general, yes, population estimates are consistent. Most fisheries-independent indices indicate that the population is increasing and these patterns are reflected in the base-case model as well as the simpler production models. Retrospective estimates were also consistent, showing no patterns or bias across years. The convergence of the base model is optimal, even though its sensitivity suggests further refinement.

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?

According to the assessment, the stock is not overfished and is not undergoing overfishing. The spawning output is increasing in the most recent years, indicating a low probability of overfishing. The geometric mean SSB for 2021 - 2023 is above 75% of SSB at 40% SPR and 75% of SSB at MSY (Figure 1 below). The geometric mean fishing mortality for age-3 for 2021 - 2023 is below the F associated with SPR40% and MSY (Figure 2 below). The retrospective analysis, bridging analysis, and most of the sensitivity runs presented did not change the perception of the stock status and supported the conclusion that the stock is not overfished nor is overfishing occurring. However, two sensitivity runs, which investigated alternative selectivity assumptions for the recreational fleets, did affect the perception of the stock status, showing a more depressed status and warrant further investigation in future assessments [1) Flat topped selectivity for both recreational fleets and 2) fixing the eastern recreational fleet selectivity to match the western recreational selectivity curve as estimated by the base model]. The RP expressed concern that the base model estimates a dome-shaped curve for the eastern recreational fleet, which suggests that no large fish are being caught. This is likely due to the lack of samples from that fleet.

The second day of the meeting, the RP requested the estimate of MSY produced given that steepness was estimated. The calculated value of MSY was 5583.61, which is very close to SPR 40% (Table 1 below). The RP recommended the use of MSY or SPR 40% instead of SPR 30%, and to update the figures for stock status.

The RP also requested before the end of the meeting to see the confidence intervals around SSB at MSY, which would consider the uncertainty in the steepness parameter.

In the following days after the meeting, the assessment team provided the new calculations. These calculations were conducted in two ways: internally within the Stock Synthesis base model and through long-term projections assuming equilibrium was obtained and recruitment followed the stock-recruitment curve. Only the internal calculations could include confidence intervals. The results were very similar, but differences arose because SS uses total dead biomass (retained + dead discards), whereas the projections used only retained biomass. The RP preferred the internal calculations since they account for losses from retained removals and discarding, and they allow us to provide the associated uncertainty. Confidence intervals around the MSY, F at MSY, and SSB at MSY were not too wide. The RP then further discussed whether to recommend SPR 40% or MSY, and we preferred the MSY-based approach as it is more aligned with long-term sustainability and takes into account the impact of the fishing pressure on the recruitment. However, the steepness estimate in the base model has some uncertainty as evidenced by the likelihood profile, and the S-R relationship is uncertain. Since the results are very similar (F = 0.11), the RP decided to recommend both reference points. This provides a middle ground that optimizes yield while still accounting for uncertainties in recruitment and environmental variability.

Figures and table provided by the lead analyst:

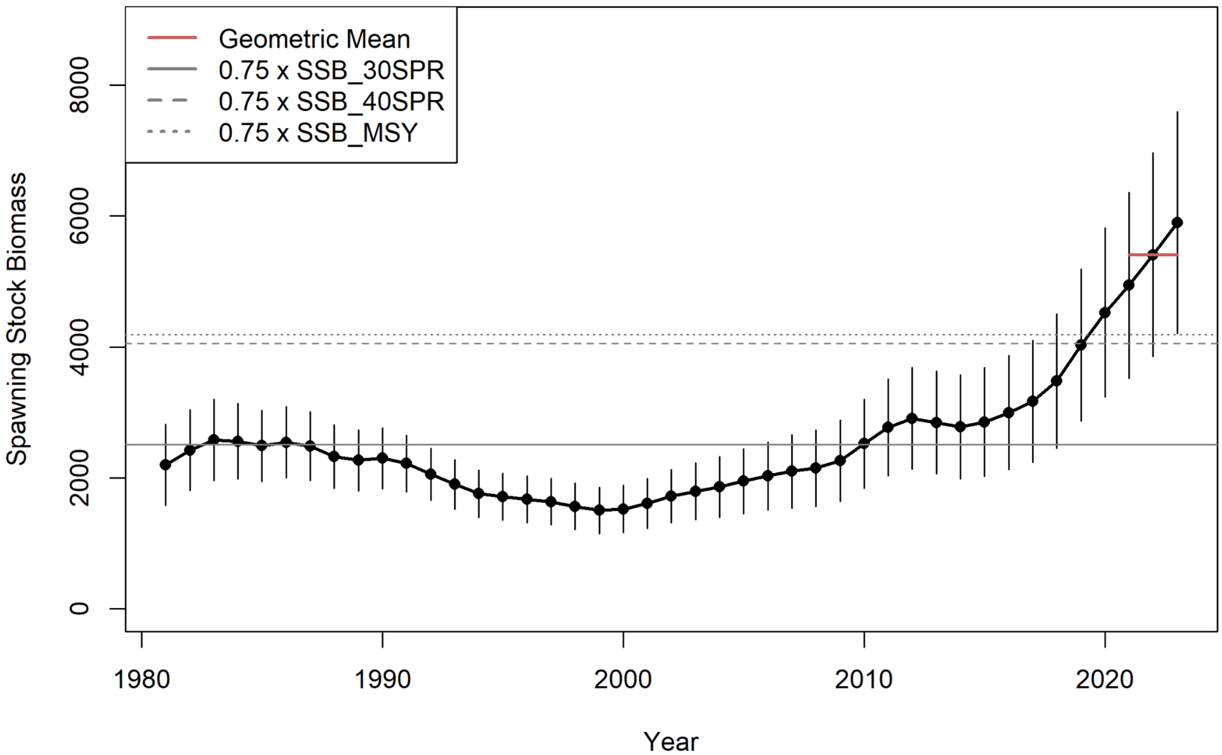

Figure 1. Spawning stock biomass over time with the different reference points that were requested by the RP.

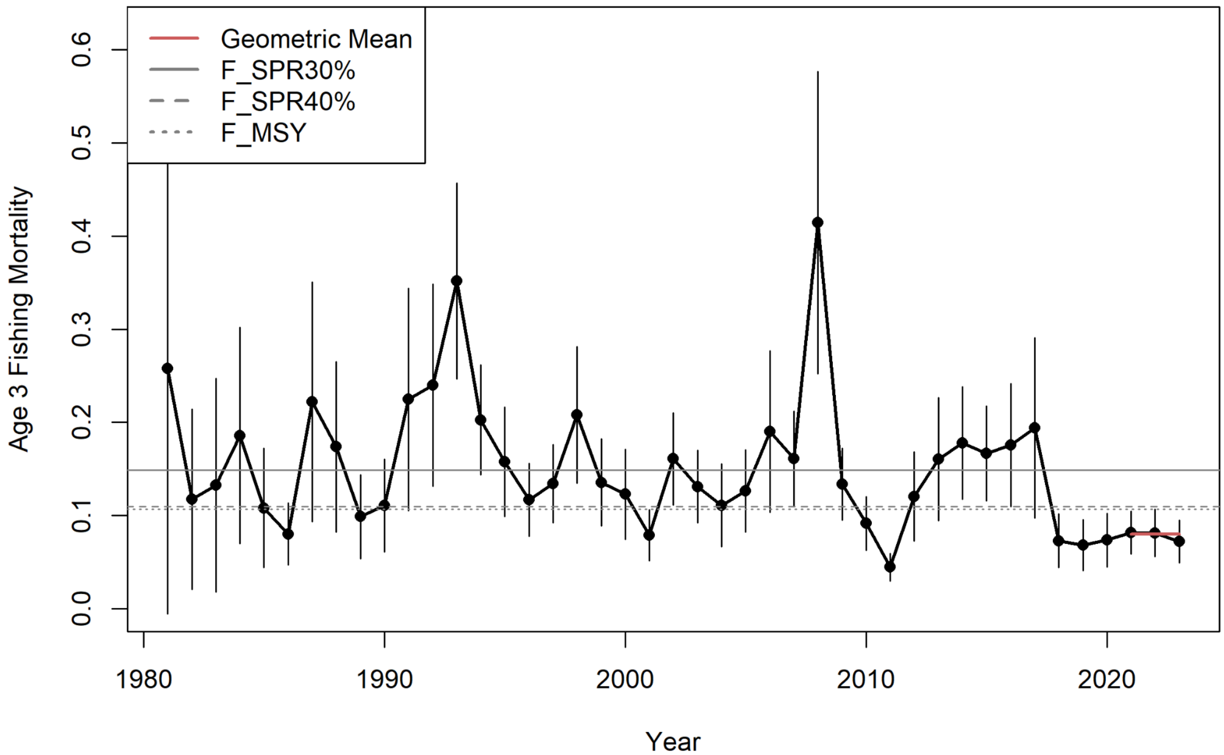

Figure 2. Age 3 fishing mortality over time with the different reference points that were requested by the RP.

Table 1. Projections calculated internally with SS3 for the base model.

MSY						SPR 40%						SPR 30%					
Derived	Estimate	SE	95% CI			Derived	Estimate	SE	95% CI			Derived	Estimate	SE	95% CI		
SSB_MS	5'583.61	1'722.63	2'207.26	-	8'959.96	SSB_40S	5'404.06	1'041.20	3'363.31	-	7'444.81	SSB_30S	3'341.70	584.697	2'195.69	-	4'487.71
75%SSB_	4'187.71					75%SSB_	4'053.05					75%SSB_	2'506.28				
SPR_MS	0.409	0.046	0.32	-	0.50	SPR	0.4					SPR	0.3				
F_MSY	0.107	0.015	0.08	-	0.14	F_40SPR	0.11	0.005	0.10	-	0.12	F_30SPR	0.149	0.006313	0.14	-	0.16
Dead_Catch MSY	898.54	175.135	555.28	-	1'241.80	Dead_Catch 40SP	898.14	173.261	558.55	-	1'237.73	Dead_Catch 30SP	819.98	144.62	536.53	-	1'103.44
Ret_Catch MSY	768	154.115	465.93	-	1'070.07	Ret_Catch 40SPR	766.18	148.91	474.32	-	1'058.04	Ret_Catch 30SPR	680.57	121.703	442.03	-	919.11

a) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

A Beverton-Holt curve was selected as the stock-recruitment relationship, and recruitment deviations were estimated. Steepness was estimated within the model to be 0.63, suggesting a moderate relationship between SSB and recruits. Fixing steepness was discussed by the RP. When fixing steepness to 1, the model estimated a sharp decrease in virgin recruits and SSB. However, this adjustment did not significantly change the overall population dynamics estimates (SSB and fishing mortality). There is considerable uncertainty in the SR curve. Due to the high uncertainty, it could be challenging to predict future stock conditions, particularly if assuming that the higher recruitment in recent years will continue in the future.

b) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

The stock status determination methods for the stock are robust and appropriate. Therefore, the quantities estimated for this stock are reliable.

4. Evaluate the stock projections, including discussing strengths and weaknesses, and consider the following:

a) Are the methods consistent with accepted practices and available data?

Yes, robust methods were used for projections. The RP had much discussion regarding projections and whether 3-year average recruitment vs. the stock recruit curve would be more appropriate. The recent recruitment deviations were higher than average values predicted from the stock-recruit curve; however, it remains uncertain whether high recruitment will continue into the future. Alternately, the stock recruit curve with estimated steepness predicted much lower recruitment than the recent average, leading to more conservative projections. The RP felt that the methods used for projections are appropriate, but we did not pick a scenario (stock recruit versus recent average recruitment) for projections. Retaining both allows for the evaluation of a range of possible future stock trends. This was considered especially important as these are deterministic projections (i.e., they do not account for any of the uncertainties estimated by the model). The SSC for both South Atlantic and Gulf Councils should discuss these projection options for use in future management advice.

Projections methods could include a distribution of recruitment in the future, to incorporate the uncertainty. Analysts were hoping to use the MCMC for this purpose but, as of this report, the MCMC was not yet working and reliable.

The RP felt it would be useful to add discards to the tables for projections, for comparison to the F, yield, and SSB estimates, which were then provided and were added to the report as part of the addendum.

b) Are the methods appropriate for the assessment model and outputs?

Yes, the methods used and the base model were deemed appropriate. Alternate model outputs were requested, provided, and discussed in detail. The result of this was that the base model was considered appropriate with no changes needed to the structure or model parameters.

c) Are the results informative and robust, and useful to support inferences of probable future conditions?

The review panel felt that the results were robust and informative, and the inferences were supported regarding future conditions, pending the SSC decision on the future recruitment scenario.

d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Yes, uncertainties are fully acknowledged and discussed; however, uncertainties are not fully reflected in the deterministic projections. While projections based on MCMC samples would better account for model uncertainties, MCMC results were deemed unreliable and therefore not used. In lieu of stochastic projections, alternate projections considering recent average recruitment versus the stock recruit curve were presented clearly.

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 the significant sources of uncertainty in the population, data sources, and assessment methods***

Uncertainty in the data sources

The SEDAR 79 assessment of Mutton Snapper was based on the Stock Synthesis (SS3) model (Methot and Wentzel, 2013), which provides an opportunity for the use of a set of standard approaches to investigating uncertainty. The tools used in SEDAR 79 included examination of residual plots, likelihood profiles, sensitivity runs, retrospective analyses, and jitter analyses. In addition, an MCMC modeling approach was undertaken.

Uncertainty in input data was specified through reported estimates of standard errors and CVs for the annual estimates of catch (both commercial and recreational), discards, and fishery-dependent and fishery-independent indices of abundance. Standard errors or CVs of landings and indices are necessary model inputs. However, the uncertainty in commercial fishery landings in the end was effectively ignored because the model was configured to fit the commercial landings exactly. Furthermore, commercial discard estimates in the South Atlantic were deemed unreliable, and the base model was configured to essentially ignore the fit to the commercial discards. Thus, the uncertainty in commercial landings and discards was underrepresented in the assessment, but is thought to have a relatively insignificant impact, due to the relatively low contribution to the total removals.

Estimates of uncertainty in recreational landings and releases estimated by MRIP and SRFS were based on standard probability-based survey methods. Uncertainty in the index observations was estimated through the standardization techniques used to determine the final observed index values. Index values and their CVs were reported for a review.

Uncertainty in the assessment method

Process and model uncertainty in the SEDAR 79 base model within SS3 were considered through the growth, natural mortality, fishing mortality, survey catchability, and stock-recruitment relationship. Estimation uncertainty was included as part of the fitting process. SS3 model output provided estimated parameter values (202), the range of values a parameter could take, their initial starting values, their associated standard deviations and CVs, the prior type and its standard deviation (where applicable), and the phase the parameter was either estimated (positive phase) or fixed (negative phase). The RP agrees with the approach taken in the estimation of model parameters.

Approximate uncertainty estimates for estimated and derived quantities based on the asymptotic standard errors from the covariance matrix provide a minimum estimate of uncertainty in parameter values and derived quantities. To better characterize the uncertainty, MCMC analyses were run to provide posterior distributions of model parameters and selected derived quantities.

Posterior distributions for steepness, ln(R0), unfished SSB, and retained yield associated with the internally calculated F at 30% SPR were produced, as well as the geometric mean of SSB from 2021-2023 [SSB current] and geometric mean of age 3 fishing mortality rates from 2021-2023 [F current]. When compared, base model results mostly fall outside the interquartile range of posterior distributions derived through MCMC, especially for SSB current and F current, warranting caution on the use of MCMC results.

Model convergence was further investigated with a jitter analysis to test the effect of the parameter's starting values and verify whether the base model had converged on a global solution instead of a local minimum. The results of the jitter analysis suggested that the base model had converged on a global solution but was sensitive to the initial parameter values. No jittered runs were found to contain a total likelihood lower than the base model, suggesting that the model converged reliably.

Correlation among parameters was examined, and any correlations with an absolute value greater than 0.7 were reported. Several selectivity and retention parameters were highly correlated. The RP agrees that all correlated parameters were structurally correlated and did not suggest model instability.

Poor overall fits and patterns in residuals were assessed in a variety of ways to identify potential model misspecification. Model fits to landings, discards, indices, length compositions, and conditional age-at-length were evaluated via visual inspection of residuals. Overall residual patterns for each model component (indices, length compositions, and conditional age-at-length) were identified through joint residual plots (Winker et al. 2018; Carvalho et al. 2021). Patterns in residuals across model components did not suggest any major data conflict but there does appear to be overestimation of some indices from 1993 to 2000, as well as from 2010 to 2022. Mean conditional age-at-length residuals also suggest overestimation of age at length from 1981 to 2007.

Combined root mean square error (RMSE) values were also calculated for the indices and length composition data to evaluate goodness-of-fit. The RMSE values were below or near maximum acceptable levels (30%) for most model components. However, RMSE values for the FIM YOY and SERFS surveys were extremely high. The poor fit to both of these indices led to elevated overall RMSE for the indices.

Parameter profiling was used to elucidate model support for a range of parameter values, particularly for parameters that are often unknown or ill-informed by data (e.g., steepness, unfished recruitment, variation of recruitment deviations, natural mortality). Likelihood profiles were done for two stock-recruitment parameters (steepness and virgin recruitment [R0]) and the assumed natural mortality averaged over ages 3-40 (Average M).

Profiled values of steepness included 0.5 to 0.99 in increments of 0.01. The base run estimated steepness (0.64) resulted in the lowest log likelihood (LL) value. However, the change in LL values was less than two for a wide range of steepness values from approximately 0.54 to 0.85. The jaggedness of the LL profile curve suggests that some runs did not converge to a global minimum. The panel discussed the steepness profiling results and agreed that while there was a minimum value detected, the flatness of the curve suggests a wider range for possible steepness values. However, there was little model sensitivity to changes in steepness values as characterized by model estimates of spawning stock biomass and particularly age-3 fishing mortality rates.

Profiled values of average natural mortality suggested that the total LL value was marginally improved when the base model M was slightly less than the assumed fixed value of 0.129 (0.11 or 0.12). The model was tested with a range of M values. The high level of influence of the value of M on the model results was evident by the exceptionally wide range of spawning stock biomass estimates and fishing mortality rates across the profiled runs. The Panel recognizes the difficulty in pinpointing the true value of natural mortality but agrees that the base run estimate of M should be considered as the best available estimate of M at this time.

Additionally, an age-structured production model (ASPM) and an ASPM with estimated recruitment deviations (ASPMdev) were also developed in Stock Synthesis to investigate which processes were influencing the shape of the production function and whether composition data were influencing the variability in recruitment. The results from the ASPM indicate that, for at least some of the timeseries, there is enough information in both the catch and index data for the production function to largely drive the stock dynamics. The general trends and scale of the ASPM and the SEDAR 79 base model align after 1998, when many of the indices became available.

Sensitivity runs were conducted to investigate the impact of alternative assumptions or data sets on model fits and results, including fixing steepness at 1, examining the effect of alternative release mortality rates were performed, sensitivity of model results to MRIP FES estimates of private mode landings and releases.

In addition, the effect of each index of abundance on the SEDAR 79 Base Model estimates was evaluated by removing indices one at a time and refitting the base model. Estimates of SSB at F 30% SPR were marginally sensitive to the removal of indices.

Unfortunately, short-term and long-term forecasts were completed as deterministic projections, without the consideration of the uncertainty in the terminal year estimates of numbers at age and fishing mortality (or any other parameters). Using the posterior distribution of N and F at age from the MCMC analysis would be more appropriate in the forward projections, but technical difficulties precluded direct application of the MCMC output. Therefore, no uncertainty measures were included in the projections. The Panel recommends that this should be addressed in future assessments.

- ***Ensure that the implications of uncertainty in technical conclusions are clearly stated***

Overall, the uncertainty in the data and the assessment model was extensively explored and quantified where possible. The assessment results with respect to the status of the stock appear to be generally robust relative to the range of uncertainties considered in the assessment. An exception is the sensitivity run that considered the impacts of excluding the commercial longline CPUE and the Indian River Young of the Year indices. In that case, the trend of relative biomass, while tracking the base model results, was displaced lower so that the stock remained in an overfished condition until 2017 (compared with 2010 in the base model) and the current status was somewhat less optimistic. Other exceptions were the runs requested by the RP regarding the selectivity configuration of the recreational east and west fleets. Using a selectivity that is less dome-shaped led to less optimistic stock assessment outcomes.

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***

The RP supports the research recommendations identified by the Data and Assessment stages for the Southeastern US Mutton Snapper assessment processes.

The RP also recommends that this stock is assessed sooner than 10 years given the uncertainties associated with the scale of the population. The dome-shaped selectivity of the recreational fishery on the east coast of Florida is especially concerning. The stock may be overestimated if larger snapper are underrepresented in the recreational catch monitoring programs.

The following recommendations are ordered by priority.

Short-term (within six months)

- Continue efforts to generate MCMC samples to refine the estimation of parameter uncertainty and support stochastic projections.
- Consider statistical methods for making probabilistic statements regarding current status of the stock that accounts for uncertainty in both the reference points and stock size or rates. MCMC methods would provide the necessary joint samples for this computation. Alternatively, it may be possible to use the variance covariance matrix to approximate the probability of being above or below a given reference point.

Longer-term

- The model estimated strong dome-shaped selectivity curves for both recreational sectors (east and west), but there remains uncertainty about whether those older/larger fish are less vulnerable to recreational fishing, or whether they are missing from the recreational catch data. It was discussed that Mutton Snapper are often caught as part of an aggregate snapper-grouper trips, and the lack of schooling during most of the year likely precludes high catches as a regular occurrence. Further, some fraction of the offshore recreational vessels use private docks and launches for their trips. Finally, most length-composition information on the recreational fishery comes from monitoring of headboat removals. Thus, samples currently collected in the recreational surveys may not be representative of the fish actually taken in the recreational fishery. We believe improved methods and data collection are needed to better quantify the size/age composition of the recreational sectors.

- A study of the size/age based vertical distribution of Mutton Snapper would be helpful to better understand the availability of fish to fishing gear and the video sampling equipment.
- Consider alternative approaches for longline catch rate standardization, ideally allowing the most recent (2011 to 2023) data to be included.
- Explore the application of spatiotemporal models to the combined Gulf video survey data to monitor distribution shifts and generate an index that accounts for the changes in the survey.
- Though it would be ideal to estimate movement rates and work toward a spatial assessment model, a simpler model that accounts for coarse spatial differences could still be constructed. For instance, a two-box model estimating the portion of each age group inhabiting the West vs East might be feasible. A well-designed conventional tagging program could be a cost-effective and efficient method to help inform this analysis.
- In addition, a high and low- reward floy tagging program can also be used to inform levels of recreational removals by comparing returns from the commercial fishery relative to the recreational fishery.
  If funds permit, data storage tags could be deployed to complement the results from the conventional tagging program.
- Consider close-kin-mark-recapture (CKMR). There is an active fishery with length and age sampling, meaning there is scope for collecting genetic samples, and the population is relatively small, meaning CKMR population estimation may be feasible with relatively few samples. These data also help with defining stock boundaries.

- ***Provide recommendations on possible ways to improve the SEDAR process***

The data review and assessment review processes are closely linked and data decisions affect model choices. Having at least one of the review panel members present at the data meeting may be useful for guiding discussions at the assessment review meeting.

7. ***Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation, and peer review of fishery management information.***

The RP considered the assessment to be appropriate, well-documented, and completed with care and diligence. The approaches, results, and conclusions are well supported with comprehensive analyses that follow published best practices for stock assessments. Given such attributes, the RP concluded that the work presented by the assessment team is the best available science.

Panel participants did not identify any critical data or analytical approaches that would improve the existing assessment.

8. ***Provide suggestions on key improvements in data or modeling approaches that should be considered when scheduling the next assessment.***

All the research recommendations mentioned in TOR 6 will improve the data and modeling approaches. Key improvements in data or modeling approaches are:

<u>Improvements in data:</u>

- Explore the uncertainties in the Commercial LL CPUE index, and consider excluding that index from the assessment.
- Explore the use of spatial temporal models for the survey indices estimates, specially the GULF survey.
- Continue investigating spatial dynamics and consider including tagging data (if available) in the next assessment.
- Collect and incorporate data from all recreational modes.

<u>Improvements in modeling approaches:</u>

- Explore the selectivity in the recreational east fleet where it seems that larger sizes are not caught and/or sampled. A change in the sample design of data collection from the recreational fleet should be considered.
- Implement stochastic projections to propagate uncertainty and enable the evaluation of risks associated with various fishing scenarios.

9. ***Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and 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.***

This report completes the task in ToR 9.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 79

Southeastern US Mutton Snapper

SECTION VI: Post-Review Workshop Addenda

September 2024

SEDAR
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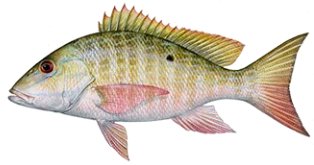

SEDAR 79 Southeastern US Mutton Snapper Benchmark Assessment Addendum

Fish and Wildlife Research Institute

Florida Fish and Wildlife Conservation Commission

September 2024

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1. INTRODUCTION

The SEDAR 79 Southeastern Mutton Snapper Assessment Review Workshop (RW) took place September 10-12, 2024, in St. Petersburg, FL. During the RW, the SEDAR 79 RW Panel requested additional details or analyses from the analytical team, which are summarized below.

2. ADDITIONAL DATA PLOTS

The RW Panel requested that landings per fleet be presented in the same figure to better understand the landings contribution of each fleet. **Figure 1a** illustrates landings in numbers per fleet while **Figure 1b** presents the proportion landed (in numbers) by fleet. Similarly, **Figure 2a** and **Figure 2b** present landings in pounds per fleet and the proportion landed (in weight) by fleet, respectively.

3. ADDITIONAL BASE MODEL RESULTS

The RW Panel wished to investigate additional results of the Base Model. First, numbers-at-age estimated by the Base Model are shown in **Figure 3**. This illustrates not only increases in age-1 recruits in recent years but also of older ages (ages 8+).

Second, the RW Panel questioned the age associated with the maximum fishing mortality rates by year and fleet. The maximum fishing mortality rate associated with the commercial longline fleet is age 17 in all years, while the maximum fishing mortality rate for both recreational fleets (Rec East and Rec West) occur at age 3 (**Table 1**). The commercial other fleet is the only fleet for which annual maximum fishing mortality rates vary across ages, ranging from age 10 to age 14 (**Table 1**).

This led to a discussion of alternative ages for the reported fishing mortality rates. The SEDAR 79 Base Model specifies age 3 as the basis of the reported fishing mortality rates and associated reference points. The RW Panel additionally requested estimates of fishing mortality rates associated with age 10 and as a weighted average of ages 3 – 5. The Base Model results under each of these scenarios are presented in **Figure 4** with 30% SPR reference points and **Figure 5** with 40% SPR reference points.

The RW Panel wanted to further explore the effects of removing the commercial longline index and requested additional plots of model fits. **Figure 6** presents the fits to all other indices when the commercial longline index is removed, as well as the estimated catchability over time for the Gulf Combined Video Index.

Lastly, the RW Panel requested that the projected number of live releases be added to the projection tables presented in the SAR in Tables 26 and 27 (**Table 2** and **Table 3** in this document).

4. ADDITIONAL REFERENCE POINTS

The RW Panel wished to consider additional reference points associated with maximum sustainable yield (MSY; based on maximizing dead catch biomass), maximum sustainable retained yield (MSRY; based on maximizing retained biomass), and 40%SPR for the Base Model.

The reference points were calculated in two ways; first, internally within the Stock Synthesis Base Model (**Table 4**) and then via long-term (100 year) projections assuming equilibrium was obtained in the final 10 years of the projection (2114-2123) and recruitment in the first year and every year thereafter follows the stock-recruit curve (**Table 5**). Note that Stock Synthesis only uses total dead catch biomass (retained and dead releases) as the quantity that is optimized when searching for F_{MSY}, therefore the MSRY (maximum sustainable retained yield) scenario is not shown for the SS internally calculated reference points.

From this analysis it was determined that F_{MSY} (0.107) is nearly equivalent to $F_{40\%SPR}$ (0.11), and corresponds to 75% of $F_{30\%SPR}$. While the F_{MSY} can be estimated, it is highly uncertain due to the uncertainty in the stock-recruit relationship. The estimated SPR associated with MSY is 0.409 and the approximate 95% confidence interval is 0.32 - 0.50. The fishing mortality rate that maximizes retained biomass (F_{MSRY}) was slightly less (estimated to be 0.10 via long term projections) and was associated with a slightly higher SPR (0.43).

4.1 Sensitivity Runs with 40%SPR Reference Points

The results of each sensitivity run that were described in the SEDAR 79 SAR (listed below) are presented in **Figures 7 – 10** with added reference points associated with 40%SPR.

1. Remove S-R curve (Steepness ≈ 1)
2. Release Mortality equal to 15% and 45%
3. MRIP-FES Private Mode Landings & Releases
4. Jack-Knife Analysis on Indices of Abundance

5. ADDITIONAL SENSITIVITY RUNS

Several additional sensitivity runs were requested by the RW Panel and the results of which are presented below. An additional sensitivity run investigated the effect of an erroneously omitted index value and related standard error for the RVC FL Keys survey in 1999. This was confirmed after the Review Workshop but was shared with the RW Panel shortly thereafter.

5.1 Start Year = 1986

The RW Panel was concerned with the high uncertainty associated with the recreational landings prior to 1986. To test the Base Model sensitivity to the inclusion of years 1981 – 1985, the start year was set to 1986, and all landings and release data were removed prior to 1986. **Figures 11-12** illustrate that there were minor differences in model results when the time series was truncated to 1986 – 2023.

5.2 Remove first 3 years from SERFS video index

Similarly, the uncertainty associated with the SERFS video index for the initial three years of the survey (2011-2013) was very high (CVs ranged from 0.46 – 0.58), but a sensitivity run removing these three years from index showed negligible deviations from the SEDAR 79 Base Model (**Figures 13 – 14**).

5.3 Estimate F parameters for all fleets

When annual fishing mortality rate parameters are estimated for all fleets, estimated landings are not an exact fit to the observed landings and account for associated error in the landings data. However, since the landings associated with the commercial fleets have such low standard errors on the log scale (ranging from 0.03 to 0.09 for the Commercial Longline fleet and from 0.02 to 0.07 for the Commercial Other fleet) and the commercial landings are very low relative to the recreational fleets (**Figure 1**), the results are virtually indistinguishable from the SEDAR 79 Base Model (**Figures 15 – 16**).

5.4 Alternative selectivity assumption for Rec fleets

Two sensitivity runs investigated the effect of alternative selectivity assumptions for the recreational fleets. The first sensitivity run assumed single logistic (i.e., flat topped) selectivity for both Rec East and Rec West fleets. The second sensitivity run fixed the Rec East selectivity to the less domed Rec West selectivity as estimated by the SEDAR 79 Base Model.

The impetus for exploring the alternative selectivity assumptions for the recreational fleets (i.e., 'less domed' compared to the Base Model) is the possibility that larger fish in the population are vulnerable to the recreational fishery but are under sampled to a large degree. Consistent under sampling of larger Mutton Snapper is plausible since fish landed on private property are not intercepted and therefore are not measured. Anglers that have access to a private dock may have boats with higher powered engines and may fish in areas further offshore, landing larger fish compared to anglers returning to public boat docks.

The overall log-likelihood increased since the fits to the recreational length comps deteriorated, especially for the Rec East fleet (**Figure 17**; **Table 6**). The effects on model results are shown in **Table 6 and Figures 18 - 19**. Compared to the Base Model, estimated fishing mortality rates, $F_{30\%SPR}/F_{40\%SPR}$, and annual estimated spawning stock biomasses all decreased markedly but the spawning stock biomass reference points only declined slightly leading differences in perceived stock status.

5.5 Include RVC FL Keys 1999 Data Point

It was discovered that a single data point from the RVC FL Keys index in 1999 was mistakenly omitted from the SEDAR 79 Base Model. When this data point (and related standard error on the log scale) is included, the observed and expected index values for the RVC FL Keys survey as well as the other indices show nearly identical fits as the SEDAR 79 Base Model (**Figure 20)**. This is expected as the omitted data point was consistent with neighboring years. Correspondingly, the results of this sensitivity run are equivalent to the SEDAR 79 Base Model results (**Figures 21-22**).

4. TABLES

Table 1. Fishing mortality rates by age (only ages 1 to 17 are shown), year, and fleet as estimated by the SEDAR 79 Base Model. Maximum fishing mortality rates (rounded to five decimal points) are highlighted in light red.

		Calendar Age																
Fleet	**Yr**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
COM_LL	1981	0.000	0.000	0.000	0.001	0.003	0.004	0.005	0.006	0.007	0.008	0.008	0.008	0.008	0.008	0.009	0.009	0.009
COM_LL	1982	0.000	0.000	0.001	0.002	0.004	0.006	0.008	0.009	0.010	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012
COM_LL	1983	0.000	0.000	0.000	0.001	0.003	0.005	0.006	0.007	0.008	0.008	0.009	0.009	0.009	0.009	0.010	0.010	0.010
COM_LL	1984	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006
COM_LL	1985	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
COM_LL	1986	0.000	0.000	0.001	0.002	0.004	0.006	0.008	0.010	0.011	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013
COM_LL	1987	0.000	0.000	0.001	0.003	0.006	0.010	0.013	0.016	0.017	0.018	0.019	0.020	0.020	0.021	0.021	0.021	0.021
COM_LL	1988	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.011	0.012	0.013	0.013	0.013	0.014	0.014	0.014	0.014
COM_LL	1989	0.000	0.000	0.001	0.003	0.006	0.010	0.013	0.015	0.017	0.018	0.019	0.020	0.020	0.020	0.021	0.021	0.021
COM_LL	1990	0.000	0.000	0.001	0.002	0.005	0.008	0.010	0.012	0.013	0.014	0.015	0.015	0.016	0.016	0.016	0.016	0.016
COM_LL	1991	0.000	0.000	0.001	0.003	0.006	0.009	0.012	0.014	0.015	0.016	0.017	0.018	0.018	0.018	0.019	0.019	0.019
COM_LL	1992	0.000	0.000	0.000	0.002	0.003	0.005	0.006	0.007	0.008	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.010
COM_LL	1993	0.000	0.000	0.001	0.002	0.003	0.005	0.007	0.008	0.009	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.011
COM_LL	1994	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008
COM_LL	1995	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008
COM_LL	1996	0.000	0.000	0.000	0.001	0.003	0.004	0.005	0.006	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009
COM_LL	1997	0.000	0.000	0.000	0.002	0.003	0.005	0.006	0.007	0.008	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.010
COM_LL	1998	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.012	0.012	0.013	0.013	0.014	0.014	0.014	0.014	0.014
COM_LL	1999	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.011	0.012	0.013	0.013	0.013	0.014	0.014	0.014	0.014
COM_LL	2000	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.011	0.012	0.013	0.013	0.013	0.013	0.014	0.014	0.014
COM_LL	2001	0.000	0.000	0.001	0.002	0.005	0.008	0.010	0.012	0.014	0.015	0.015	0.016	0.016	0.016	0.016	0.017	0.017
COM_LL	2002	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.011	0.012	0.013	0.013	0.013	0.014	0.014	0.014	0.014
COM_LL	2003	0.000	0.000	0.001	0.003	0.006	0.009	0.012	0.014	0.015	0.016	0.017	0.018	0.018	0.018	0.018	0.019	0.019
COM_LL	2004	0.000	0.000	0.002	0.005	0.010	0.015	0.020	0.023	0.026	0.028	0.029	0.030	0.031	0.031	0.031	0.032	0.032
COM_LL	2005	0.000	0.000	0.001	0.003	0.006	0.009	0.011	0.014	0.015	0.016	0.017	0.017	0.018	0.018	0.018	0.018	0.019
COM_LL	2006	0.000	0.000	0.001	0.004	0.009	0.014	0.018	0.021	0.024	0.025	0.026	0.027	0.028	0.028	0.029	0.029	0.029
COM_LL	2007	0.000	0.000	0.001	0.003	0.006	0.009	0.012	0.014	0.015	0.016	0.017	0.018	0.018	0.019	0.019	0.019	0.019
COM_LL	2008	0.000	0.000	0.001	0.002	0.003	0.005	0.007	0.008	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.011	0.011
COM_LL	2009	0.000	0.000	0.000	0.001	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
COM_LL	2010	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005
COM_LL	2011	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006
COM_LL	2012	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
COM_LL	2013	0.000	0.000	0.000	0.001	0.003	0.004	0.005	0.006	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.009
COM_LL	2014	0.000	0.000	0.001	0.002	0.004	0.006	0.008	0.009	0.010	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012

COM_LL	2015	0.000	0.000	0.001	0.002	0.003	0.005	0.007	0.008	0.009	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.011
COM_LL	2016	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
COM_LL	2017	0.000	0.000	0.000	0.001	0.003	0.004	0.006	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009
COM_LL	2018	0.000	0.000	0.000	0.001	0.003	0.005	0.006	0.007	0.008	0.009	0.009	0.009	0.010	0.010	0.010	0.010	0.010
COM_LL	2019	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004
COM_LL	2020	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004
COM_LL	2021	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
COM_LL	2022	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
COM_LL	2023	0.000	0.000	0.000	0.001	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
COM_LL	2024	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007
COM OTHER	1981	0.003	0.007	0.015	0.018	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
COM OTHER	1982	0.003	0.007	0.014	0.018	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
COM OTHER	1983	0.003	0.006	0.013	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
COM OTHER	1984	0.002	0.005	0.012	0.014	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
COM OTHER	1985	0.002	0.005	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
COM OTHER	1986	0.003	0.008	0.018	0.022	0.023	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
COM OTHER	1987	0.004	0.011	0.023	0.028	0.030	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
COM OTHER	1988	0.004	0.010	0.022	0.027	0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
COM OTHER	1989	0.005	0.012	0.025	0.031	0.033	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
COM OTHER	1990	0.004	0.010	0.021	0.027	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
COM OTHER	1991	0.005	0.011	0.023	0.029	0.031	0.031	0.031	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
COM OTHER	1992	0.005	0.012	0.025	0.031	0.033	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
COM OTHER	1993	0.006	0.014	0.031	0.038	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
COM OTHER	1994	0.005	0.013	0.027	0.034	0.036	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037
COM OTHER	1995	0.004	0.010	0.022	0.027	0.029	0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
COM OTHER	1996	0.004	0.011	0.023	0.028	0.030	0.030	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
COM OTHER	1997	0.004	0.011	0.023	0.028	0.030	0.030	0.030	0.030	0.030	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
COM OTHER	1998	0.005	0.013	0.028	0.034	0.037	0.037	0.037	0.037	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038
COM OTHER	1999	0.004	0.009	0.018	0.023	0.024	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
COM OTHER	2000	0.003	0.006	0.013	0.016	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
COM OTHER	2001	0.003	0.006	0.013	0.016	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
COM OTHER	2002	0.003	0.006	0.014	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
COM OTHER	2003	0.003	0.006	0.013	0.016	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
COM OTHER	2004	0.002	0.006	0.012	0.015	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
COM OTHER	2005	0.002	0.004	0.009	0.011	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
COM OTHER	2006	0.001	0.003	0.007	0.008	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
COM OTHER	2007	0.001	0.003	0.007	0.008	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

COM OTHER	2008	0.001	0.003	0.006	0.007	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
COM OTHER	2009	0.001	0.003	0.006	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
COM OTHER	2010	0.001	0.003	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
COM OTHER	2011	0.001	0.003	0.006	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
COM OTHER	2012	0.001	0.003	0.006	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
COM OTHER	2013	0.001	0.002	0.005	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
COM OTHER	2014	0.001	0.003	0.006	0.007	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
COM OTHER	2015	0.001	0.003	0.006	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
COM OTHER	2016	0.001	0.002	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	0.006
COM OTHER	2017	0.001	0.002	0.004	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	0.006
COM OTHER	2018	0.001	0.003	0.005	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
COM OTHER	2019	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
COM OTHER	2020	0.001	0.002	0.004	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
COM OTHER	2021	0.001	0.001	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
COM OTHER	2022	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
COM OTHER	2023	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
COM OTHER	2024	0.001	0.002	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	0.006
REC EAST	1981	0.133	0.196	0.267	0.207	0.132	0.082	0.054	0.038	0.029	0.025	0.022	0.020	0.019	0.018	0.018	0.017	0.017
REC EAST	1982	0.045	0.066	0.089	0.069	0.044	0.028	0.018	0.013	0.010	0.008	0.007	0.007	0.006	0.006	0.006	0.006	0.006
REC EAST	1983	0.039	0.058	0.079	0.061	0.039	0.024	0.016	0.011	0.009	0.007	0.006	0.006	0.006	0.005	0.005	0.005	0.005
REC EAST	1984	0.027	0.040	0.055	0.042	0.027	0.017	0.011	0.008	0.006	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004
REC EAST	1985	0.039	0.057	0.078	0.061	0.039	0.024	0.016	0.011	0.009	0.007	0.006	0.006	0.006	0.005	0.005	0.005	0.005
REC EAST	1986	0.028	0.042	0.057	0.044	0.028	0.018	0.011	0.008	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004
REC EAST	1987	0.075	0.110	0.151	0.117	0.075	0.046	0.030	0.021	0.017	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
REC EAST	1988	0.029	0.043	0.059	0.045	0.029	0.018	0.012	0.008	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004
REC EAST	1989	0.029	0.042	0.058	0.045	0.029	0.018	0.012	0.008	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004
REC EAST	1990	0.022	0.032	0.044	0.034	0.022	0.014	0.009	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
REC EAST	1991	0.023	0.034	0.047	0.036	0.023	0.014	0.009	0.007	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003
REC EAST	1992	0.089	0.130	0.178	0.138	0.088	0.055	0.036	0.025	0.020	0.016	0.014	0.013	0.013	0.012	0.012	0.012	0.011
REC EAST	1993	0.113	0.166	0.227	0.176	0.112	0.070	0.046	0.032	0.025	0.021	0.018	0.017	0.016	0.016	0.015	0.015	0.015
REC EAST	1994	0.074	0.109	0.149	0.115	0.074	0.046	0.030	0.021	0.016	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
REC EAST	1995	0.055	0.080	0.109	0.085	0.054	0.034	0.022	0.016	0.012	0.010	0.009	0.008	0.008	0.007	0.007	0.007	0.007
REC EAST	1996	0.039	0.057	0.078	0.060	0.038	0.024	0.016	0.011	0.009	0.007	0.006	0.006	0.006	0.005	0.005	0.005	0.005
REC EAST	1997	0.047	0.069	0.094	0.073	0.046	0.029	0.019	0.013	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.006
REC EAST	1998	0.089	0.132	0.180	0.139	0.089	0.055	0.036	0.026	0.020	0.017	0.015	0.013	0.013	0.012	0.012	0.012	0.012

REC EAST	1999	0.059	0.086	0.118	0.091	0.058	0.036	0.024	0.017	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.008	0.008
REC EAST	2000	0.074	0.109	0.149	0.115	0.074	0.046	0.030	0.021	0.016	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
REC EAST	2001	0.043	0.063	0.086	0.067	0.043	0.027	0.017	0.012	0.010	0.008	0.007	0.006	0.006	0.006	0.006	0.006	0.006
REC EAST	2002	0.099	0.145	0.198	0.153	0.098	0.061	0.040	0.028	0.022	0.018	0.016	0.015	0.014	0.014	0.013	0.013	0.013
REC EAST	2003	0.059	0.087	0.119	0.092	0.059	0.037	0.024	0.017	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.008	0.008
REC EAST	2004	0.064	0.094	0.128	0.099	0.064	0.040	0.026	0.018	0.014	0.012	0.010	0.010	0.009	0.009	0.009	0.008	0.008
REC EAST	2005	0.075	0.110	0.150	0.116	0.075	0.046	0.030	0.021	0.017	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
REC EAST	2006	0.073	0.107	0.146	0.113	0.072	0.045	0.029	0.021	0.016	0.013	0.012	0.011	0.010	0.010	0.010	0.010	0.009
REC EAST	2007	0.072	0.106	0.144	0.112	0.072	0.044	0.029	0.021	0.016	0.013	0.012	0.011	0.010	0.010	0.010	0.009	0.009
REC EAST	2008	0.266	0.391	0.534	0.414	0.265	0.164	0.107	0.076	0.059	0.049	0.044	0.040	0.038	0.037	0.036	0.035	0.034
REC EAST	2009	0.081	0.118	0.162	0.125	0.080	0.050	0.032	0.023	0.018	0.015	0.013	0.012	0.011	0.011	0.011	0.011	0.010
REC EAST	2010	0.056	0.082	0.112	0.087	0.056	0.035	0.023	0.016	0.012	0.010	0.009	0.008	0.008	0.008	0.007	0.007	0.007
REC EAST	2011	0.022	0.032	0.044	0.034	0.022	0.013	0.009	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
REC EAST	2012	0.064	0.094	0.129	0.100	0.064	0.040	0.026	0.018	0.014	0.012	0.010	0.010	0.009	0.009	0.009	0.008	0.008
REC EAST	2013	0.080	0.118	0.161	0.125	0.080	0.050	0.032	0.023	0.018	0.015	0.013	0.012	0.011	0.011	0.011	0.011	0.010
REC EAST	2014	0.088	0.129	0.176	0.136	0.087	0.054	0.035	0.025	0.019	0.016	0.014	0.013	0.013	0.012	0.012	0.012	0.011
REC EAST	2015	0.092	0.135	0.185	0.143	0.091	0.057	0.037	0.026	0.020	0.017	0.015	0.014	0.013	0.013	0.012	0.012	0.012
REC EAST	2016	0.098	0.144	0.197	0.152	0.098	0.061	0.040	0.028	0.022	0.018	0.016	0.015	0.014	0.013	0.013	0.013	0.013
REC EAST	2017	0.125	0.183	0.250	0.194	0.124	0.077	0.050	0.036	0.028	0.023	0.020	0.019	0.018	0.017	0.017	0.016	0.016
REC EAST	2018	0.065	0.095	0.130	0.101	0.064	0.040	0.026	0.018	0.014	0.012	0.011	0.010	0.009	0.009	0.009	0.008	0.008
REC EAST	2019	0.055	0.081	0.111	0.086	0.055	0.034	0.022	0.016	0.012	0.010	0.009	0.008	0.008	0.008	0.007	0.007	0.007
REC EAST	2020	0.040	0.059	0.080	0.062	0.040	0.025	0.016	0.011	0.009	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.005
REC EAST	2021	0.072	0.105	0.144	0.111	0.071	0.044	0.029	0.020	0.016	0.013	0.012	0.011	0.010	0.010	0.010	0.009	0.009
REC EAST	2022	0.070	0.102	0.140	0.108	0.069	0.043	0.028	0.020	0.015	0.013	0.011	0.010	0.010	0.010	0.009	0.009	0.009
REC EAST	2023	0.058	0.085	0.117	0.090	0.058	0.036	0.023	0.017	0.013	0.011	0.009	0.009	0.008	0.008	0.008	0.008	0.008
REC EAST	2024	0.126	0.186	0.254	0.196	0.126	0.078	0.051	0.036	0.028	0.023	0.021	0.019	0.018	0.017	0.017	0.017	0.016
REC WEST	1981	0.014	0.019	0.023	0.022	0.020	0.018	0.016	0.015	0.013	0.012	0.011	0.011	0.010	0.009	0.009	0.009	0.008
REC WEST	1982	0.021	0.030	0.036	0.034	0.031	0.028	0.025	0.023	0.021	0.019	0.018	0.016	0.015	0.015	0.014	0.013	0.013
REC WEST	1983	0.041	0.057	0.068	0.065	0.059	0.053	0.048	0.043	0.040	0.036	0.034	0.031	0.030	0.028	0.027	0.026	0.025
REC WEST	1984	0.100	0.140	0.166	0.158	0.144	0.130	0.117	0.106	0.097	0.089	0.082	0.077	0.072	0.069	0.066	0.063	0.061
REC WEST	1985	0.025	0.034	0.041	0.039	0.035	0.032	0.029	0.026	0.024	0.022	0.020	0.019	0.018	0.017	0.016	0.015	0.015
REC WEST	1986	0.011	0.015	0.018	0.017	0.015	0.014	0.013	0.011	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.007	0.007
REC WEST	1987	0.056	0.078	0.093	0.088	0.081	0.073	0.066	0.059	0.054	0.050	0.046	0.043	0.040	0.038	0.037	0.035	0.034
REC WEST	1988	0.080	0.111	0.132	0.125	0.114	0.103	0.093	0.084	0.077	0.070	0.065	0.061	0.057	0.054	0.052	0.050	0.048
REC WEST	1989	0.019	0.026	0.031	0.030	0.027	0.024	0.022	0.020	0.018	0.017	0.015	0.014	0.013	0.013	0.012	0.012	0.011

REC WEST	1990	0.040	0.056	0.066	0.063	0.058	0.052	0.047	0.042	0.039	0.035	0.033	0.031	0.029	0.027	0.026	0.025	0.024
REC WEST	1991	0.126	0.176	0.209	0.199	0.181	0.164	0.147	0.133	0.121	0.111	0.103	0.096	0.091	0.086	0.082	0.079	0.077
REC WEST	1992	0.054	0.075	0.089	0.085	0.077	0.070	0.063	0.057	0.052	0.048	0.044	0.041	0.039	0.037	0.035	0.034	0.033
REC WEST	1993	0.105	0.147	0.174	0.166	0.152	0.137	0.123	0.111	0.101	0.093	0.086	0.080	0.076	0.072	0.069	0.066	0.064
REC WEST	1994	0.042	0.059	0.070	0.066	0.060	0.055	0.049	0.044	0.040	0.037	0.034	0.032	0.030	0.029	0.027	0.026	0.026
REC WEST	1995	0.062	0.086	0.102	0.097	0.089	0.080	0.072	0.065	0.059	0.055	0.050	0.047	0.044	0.042	0.040	0.039	0.038
REC WEST	1996	0.043	0.060	0.071	0.067	0.061	0.055	0.050	0.045	0.041	0.038	0.035	0.033	0.031	0.029	0.028	0.027	0.026
REC WEST	1997	0.049	0.068	0.081	0.077	0.070	0.063	0.057	0.052	0.047	0.043	0.040	0.037	0.035	0.033	0.032	0.031	0.030
REC WEST	1998	0.059	0.082	0.098	0.093	0.085	0.077	0.069	0.062	0.057	0.052	0.048	0.045	0.042	0.040	0.039	0.037	0.036
REC WEST	1999	0.037	0.052	0.062	0.059	0.054	0.049	0.044	0.040	0.036	0.033	0.031	0.029	0.027	0.026	0.024	0.023	0.023
REC WEST	2000	0.009	0.013	0.015	0.014	0.013	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.007	0.006	0.006	0.006	0.006
REC WEST	2001	0.008	0.011	0.012	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.005	0.005
REC WEST	2002	0.013	0.018	0.022	0.021	0.019	0.017	0.015	0.014	0.013	0.012	0.011	0.010	0.009	0.009	0.009	0.008	0.008
REC WEST	2003	0.036	0.051	0.060	0.057	0.052	0.047	0.043	0.038	0.035	0.032	0.030	0.028	0.026	0.025	0.024	0.023	0.022
REC WEST	2004	0.011	0.015	0.018	0.017	0.015	0.014	0.012	0.011	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.007	0.006
REC WEST	2005	0.014	0.020	0.024	0.023	0.021	0.019	0.017	0.015	0.014	0.013	0.012	0.011	0.010	0.010	0.009	0.009	0.009
REC WEST	2006	0.080	0.112	0.132	0.126	0.115	0.104	0.093	0.084	0.077	0.071	0.065	0.061	0.057	0.055	0.052	0.050	0.049
REC WEST	2007	0.054	0.075	0.089	0.085	0.077	0.070	0.063	0.057	0.052	0.048	0.044	0.041	0.039	0.037	0.035	0.034	0.033
REC WEST	2008	0.042	0.059	0.070	0.066	0.060	0.055	0.049	0.044	0.040	0.037	0.034	0.032	0.030	0.029	0.027	0.026	0.026
REC WEST	2009	0.017	0.024	0.029	0.027	0.025	0.022	0.020	0.018	0.017	0.015	0.014	0.013	0.012	0.012	0.011	0.011	0.011
REC WEST	2010	0.009	0.013	0.015	0.015	0.013	0.012	0.011	0.010	0.009	0.008	0.008	0.007	0.007	0.006	0.006	0.006	0.006
REC WEST	2011	0.009	0.013	0.015	0.014	0.013	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.007	0.006	0.006	0.006	0.005
REC WEST	2012	0.026	0.036	0.043	0.041	0.037	0.034	0.030	0.028	0.025	0.023	0.021	0.020	0.019	0.018	0.017	0.016	0.016
REC WEST	2013	0.044	0.061	0.072	0.069	0.063	0.057	0.051	0.046	0.042	0.039	0.036	0.033	0.031	0.030	0.029	0.027	0.027
REC WEST	2014	0.050	0.070	0.083	0.079	0.072	0.065	0.058	0.053	0.048	0.044	0.041	0.038	0.036	0.034	0.033	0.031	0.030
REC WEST	2015	0.033	0.047	0.055	0.053	0.048	0.043	0.039	0.035	0.032	0.029	0.027	0.025	0.024	0.023	0.022	0.021	0.020
REC WEST	2016	0.035	0.049	0.059	0.056	0.051	0.046	0.041	0.037	0.034	0.031	0.029	0.027	0.025	0.024	0.023	0.022	0.022
REC WEST	2017	0.018	0.025	0.030	0.028	0.026	0.023	0.021	0.019	0.017	0.016	0.015	0.014	0.013	0.012	0.012	0.011	0.011
REC WEST	2018	0.022	0.030	0.036	0.034	0.031	0.028	0.025	0.023	0.021	0.019	0.018	0.016	0.016	0.015	0.014	0.014	0.013
REC WEST	2019	0.026	0.037	0.044	0.041	0.038	0.034	0.031	0.028	0.025	0.023	0.022	0.020	0.019	0.018	0.017	0.017	0.016
REC WEST	2020	0.049	0.069	0.081	0.077	0.071	0.064	0.057	0.052	0.047	0.043	0.040	0.038	0.035	0.034	0.032	0.031	0.030
REC WEST	2021	0.028	0.039	0.046	0.043	0.040	0.036	0.032	0.029	0.027	0.024	0.023	0.021	0.020	0.019	0.018	0.017	0.017
REC WEST	2022	0.029	0.041	0.048	0.046	0.042	0.038	0.034	0.031	0.028	0.026	0.024	0.022	0.021	0.020	0.019	0.018	0.018
REC WEST	2023	0.029	0.041	0.048	0.046	0.042	0.038	0.034	0.031	0.028	0.026	0.024	0.022	0.021	0.020	0.019	0.018	0.018
REC WEST	2024	0.054	0.076	0.090	0.086	0.078	0.071	0.064	0.058	0.052	0.048	0.045	0.042	0.039	0.037	0.036	0.034	0.033

Table 2. Results of the projections when age-3 fishing mortality rates = $F_{30\%SPR}$ (0.149) for Southeastern US Mutton Snapper and either predicted age-1 recruitment follows the spawner-recruit curve or predicted age-1 recruitment is equal to the geometric mean from 2019 to 2023 (3.284 million). Recruitment (Recruits) is in millions of age-1 fish, F is age-3 instantaneous fishing mortality rate, SSB is in metric tons (female SSB), Retained Yield is in pounds (whole weight), and Retained and Released Num are in numbers of fish.

	Recruits = S-R Curve $F = F_{30\%SPR}$						Recruits = 2019-2023 avg $F = F_{30\%SPR}$					
Year	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Released Num**	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Released Num**
2024	1.966	0.149	6,488	3,278,980	627,789	1,224,767	3.284	0.149	6,488	3,280,143	628,742	1,844,997
2025	2.026	0.149	6,864	3,372,143	623,832	973,316	3.284	0.149	6,867	3,384,760	630,618	1,694,199
2026	2.061	0.149	6,974	3,249,912	564,280	816,997	3.284	0.149	7,029	3,363,706	605,530	1,635,621
2027	2.070	0.149	6,821	3,023,751	495,817	763,513	3.284	0.149	7,089	3,313,030	583,152	1,618,291
2028	2.057	0.149	6,584	2,814,305	446,663	748,840	3.284	0.149	7,118	3,270,355	568,844	1,613,371
2029	2.035	0.149	6,342	2,650,664	415,719	742,116	3.284	0.149	7,130	3,239,178	560,244	1,611,911
2030	2.012	0.149	6,109	2,523,697	395,653	735,257	3.284	0.149	7,130	3,216,409	554,984	1,611,442
2031	1.989	0.149	5,889	2,421,114	381,362	727,472	3.284	0.149	7,123	3,199,290	551,639	1,611,282
2032	1.965	0.149	5,682	2,335,047	370,254	719,230	3.284	0.149	7,112	3,186,071	549,426	1,611,220
2033	1.942	0.149	5,490	2,261,068	361,084	710,879	3.284	0.149	7,098	3,175,662	547,907	1,611,193

Table 3. Results of the projections when the number of recruits is equal to the recent (2019-2023) geometric mean and age-3 fishing mortality rates equal 75% $F_{30\%SPR}$ (0.112) and Fcurrent (0.08) for Southeastern US Mutton Snapper assuming predicted age 1 recruitment is equal to the geometric mean from 2019 to 2023 (3.284 million). Recruitment (Recruits) is in millions of age-1 fish, F is age-3 instantaneous fishing mortality rate, SSB is in metric tons (female SSB), Retained Yield is in pounds (whole weight), and Retained and Released Num are in numbers of fish.

	Recruits = 2019-2023 avg F = 75% F30%SPR						Recruits = 2019-2023 avg F = Fcurrent					
Year	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Released Num**	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Released Num**
2024	3.284	0.112	6,565	2,498,073	479,551	1,401,786	3.284	0.080	6,631	1,811,994	348,293	1,014,735
2025	3.284	0.112	7,160	2,662,320	497,423	1,307,562	3.284	0.080	7,419	1,985,255	371,812	959,507
2026	3.284	0.112	7,547	2,725,359	491,431	1,270,669	3.284	0.080	8,022	2,084,741	376,453	937,997
2027	3.284	0.112	7,822	2,752,377	483,445	1,259,725	3.284	0.080	8,512	2,151,561	377,279	931,733
2028	3.284	0.112	8,047	2,772,615	478,662	1,256,565	3.284	0.080	8,942	2,206,166	378,545	929,928
2029	3.284	0.112	8,233	2,791,436	476,385	1,255,608	3.284	0.080	9,319	2,253,469	380,361	929,379
2030	3.284	0.112	8,386	2,808,849	475,505	1,255,296	3.284	0.080	9,646	2,294,626	382,360	929,197
2031	3.284	0.112	8,513	2,824,461	475,332	1,255,184	3.284	0.080	9,930	2,330,278	384,303	929,135
2032	3.284	0.112	8,618	2,838,173	475,501	1,255,144	3.284	0.080	10,177	2,361,052	386,090	929,112
2033	3.284	0.112	8,705	2,850,076	475,824	1,255,129	3.284	0.080	10,389	2,387,571	387,685	929,104

Table 4. MSY (maximizing dead catch biomass), 40%SPR, and 30%SPR reference points for Southeastern U.S. Mutton Snapper calculated internally within the Stock Synthesis SEDAR 79 Base Model.

MSY (dead catch biomass)				40% SPR			
Derived Quantity	Estimate	SE	95% CI	Derived Quantity	Estimate	SE	95% CI
SSB_{MSY}	5,583.61	1,722.63	2,207.26 - 8,959.96	$SSB_{40\%SPR}$	5,404.06	1,041.20	3,363.31 - 7,444.81
$75\%SSB_{MSY}$	4,187.71			$75\%SSB_{40\%SPR}$	4,053.05		
SPR	0.409	0.046	0.32 - 0.50	SPR	0.4		
F_MSY	0.107	0.015	0.08 - 0.14	F_40SPR	0.11	0.005	0.10 - 0.12
Dead Catch MSY (mt)	898.54	175.135	555.28 - 1,241.80	Dead Catch 40SPR (mt)	898.14	173.261	558.55 - 1,237.73
Retained Catch MSY (mt)	768	154.115	465.93 - 1,070.07	Retained Catch 40SPR (mt)	766.18	148.91	474.32 - 1,058.04

30% SPR			
Derived Quantity	Estimate	SE	95% CI
$SSB_{30\%SPR}$	3,341.70	584.7	2,195.69 - 4,487.71
$75\%SSB_{30\%SPR}$	2,506.28		
SPR	0.3		
F_30SPR	0.149	0.006	0.14 - 0.16
Dead Catch 30SPR (mt)	819.98	144.62	536.53 - 1,103.44
Retained Catch 30SPR (mt)	680.57	121.7	442.03 - 919.11

Table 5. MSY (dead catch biomass), Maximum sustainable retained yield (MSRY), 40%SPR, and 30%SPR reference points for Southeastern U.S. Mutton Snapper calculated via long-term (100 year) projections assuming equilibrium was obtained in the final 10 years of the projection (2114-2123) and recruitment in the first year and every year thereafter follows the stock-recruit curve.

MSY (dead catch biomass)		**MSRY (retained biomass)**		**SPR 40%**	
Derived Quantity	Estimate	Derived Quantity	Estimate	Derived Quantity	Estimate
SSB_MSY	5,591.66	SSB_ MSRY	5,953.01	SSB_40SPR	5,406.25
75%SSB_MSY	4,193.74	75%SSB_ MSRY	4,464.76	75%SSB_40SPR	4,054.69
SPR	0.409	SPR	0.427	SPR	0.4
F_MSY	0.107	F_ MSRY	0.101	F_40SPR	0.11
Dead_Catch_MSY (mt)	898.77	Dead_Catch_MSRY (mt)	897.11	Dead_Catch_40SPR (mt)	898.4
Dead_Catch_MSY (num)	488,907	Dead_Catch_MSRY (num)	481,502	Dead_Catch_40SPR (num)	492,189
Ret_Catch_MSY (mt)	768.25	Ret_Catch_MSRY (mt)	769.67	Ret_Catch_40SPR (mt)	766.42
Ret_Catch_MSY (num)	275,918	Ret_Catch_MSRY (num)	274,034	Ret_Catch_40SPR (num)	276,528

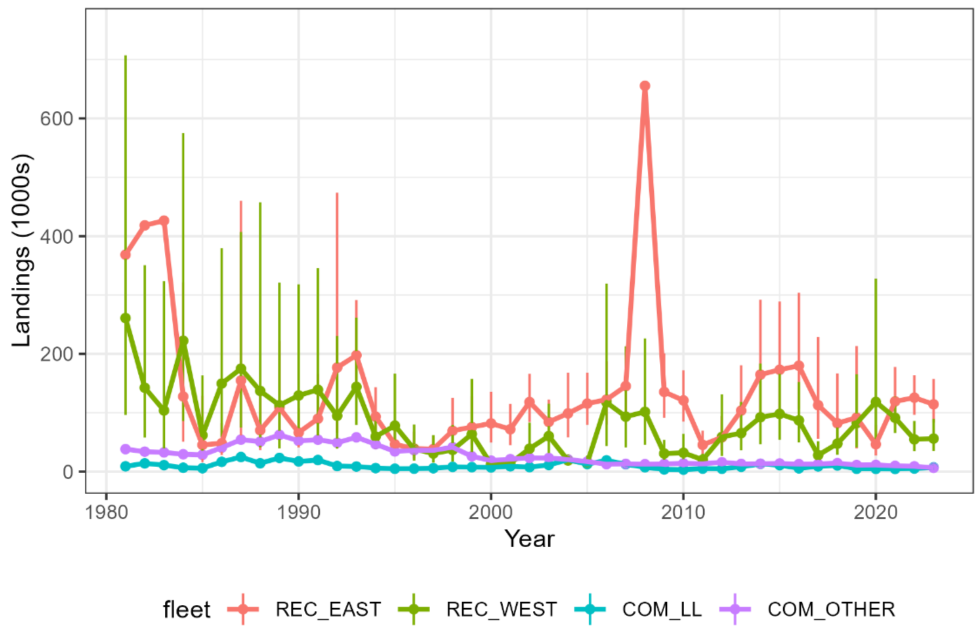
SPR 30%	
Derived Quantity	Estimate
SSB_30SPR	3,352.00
75%SSB_30SPR	2,514.00
SPR	0.3
F_30SPR	0.149
Dead_Catch_30SPR (mt)	821.28
Dead_Catch_30SPR (num)	492,834
Ret_Catch_30SPR (mt)	681.87
Ret_Catch_30SPR (num)	260,873

Table 6. Comparison of log-likelihoods, selected parameters, and derived quantities as estimated by the SEDAR 79 Base Model ('Base Model') and the Base Model when either flat-top selectivity is assumed for the Rec West and Rec East fleets (model = "Rec Flat Top") or the Rec East selectivity is fixed at the Base Model estimates for Rec West (model="Rec E equal Rec W_Base").

	Base_Model	Rec_Flat_Top	Rec_East = Rec_West_Base
TOTAL_like	1488.01	1857.27	1687.85
Survey_like	55.285	56.871	60.085
Length_comp_like	519.391	722.314	658.537
Age_comp_like	803.328	937.915	845.27
Parm_priors_like	1.156	1.456	1.55
Recr_Virgin_millions	2.513	2.278	2.167
SR_LN(R0)	7.829	7.731	7.681
SR_BH_steep	0.644	0.757	0.759
L_at_Amax_Fem_GP_1	82.265	82.494	85.845
VonBert_K_Fem_GP_1	0.195	0.153	0.153
SSB_unfished_thousand_mt	17.778	15.005	14.812
SSB_2023_thousand_mt	5.898	4.306	3.885
F_2023	0.072	0.041	0.056
Ret_Catch_30SPR_mt	680.57	1066.45	897.427
Ret_Catch_40SPR_mt	767.994	1078.21	894.937
F_30SPR	0.149	0.067	0.083
F_40SPR	0.110	0.046	0.059
SSB_30SPR_thousand_mt	3.342	3.586	3.55
SSB_40SPR_thousand_mt	5.404	5.217	5.159

5. FIGURES

a)



b)

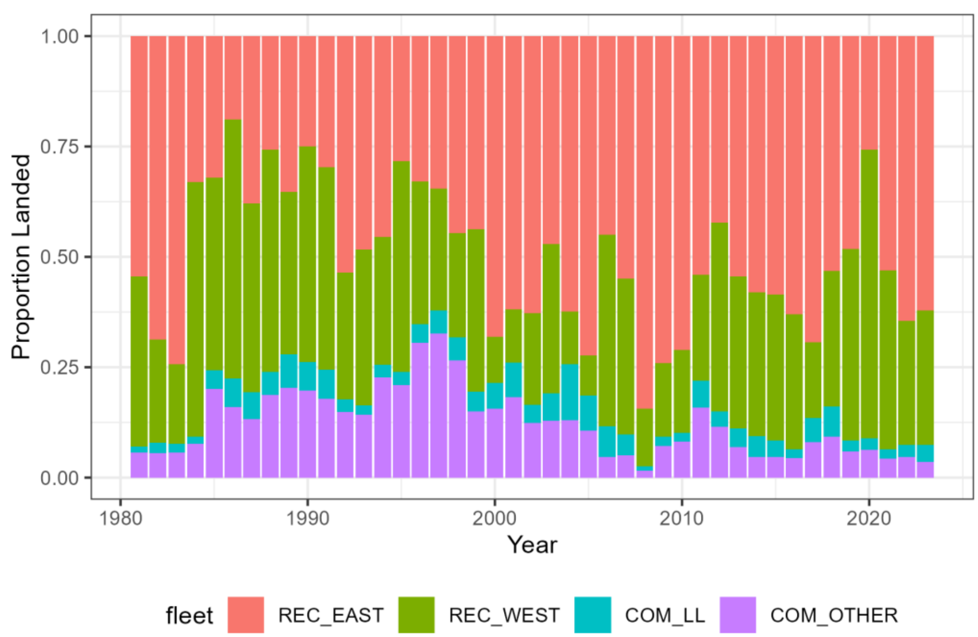


Figure 1. Landings in numbers (a) and proportion landed (b) by fleet for Southeastern Mutton Snapper. Recreational landings include Florida private-mode landings from the State Reef Fish Survey (SRFS). Approximate 95% confidence intervals (CI) are shown in Figure 1a, unless the CI exceeds the plot bounds.

a)
b)

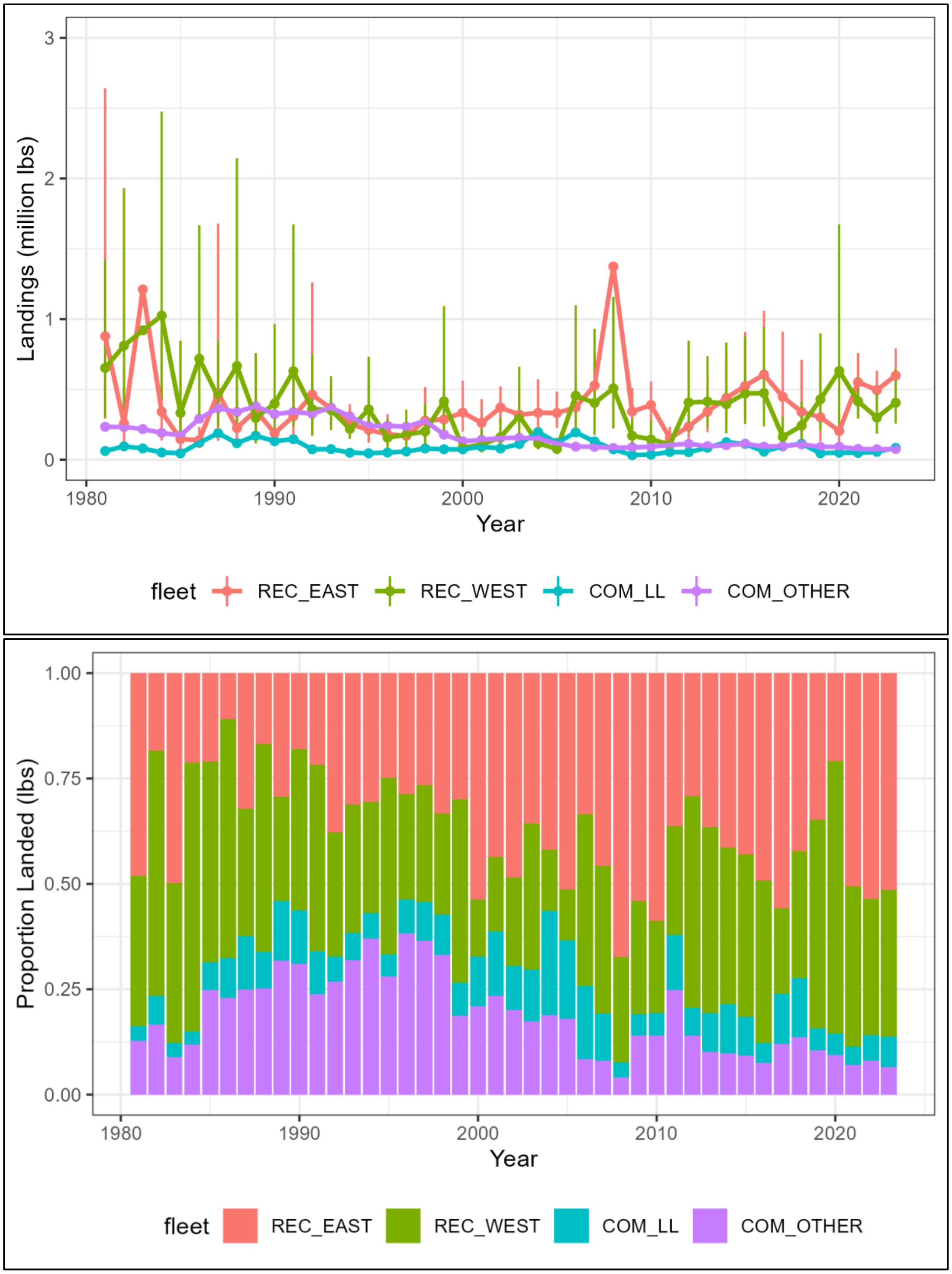


Figure 2. Landings in pounds (a) and proportion landed (b) by fleet for Southeastern Mutton Snapper. Recreational landings include Florida private-mode landings from the State Reef Fish Survey (SRFS). Approximate 95% confidence intervals (CI) are shown in Figure 2a, unless the CI exceeds the plot bounds.

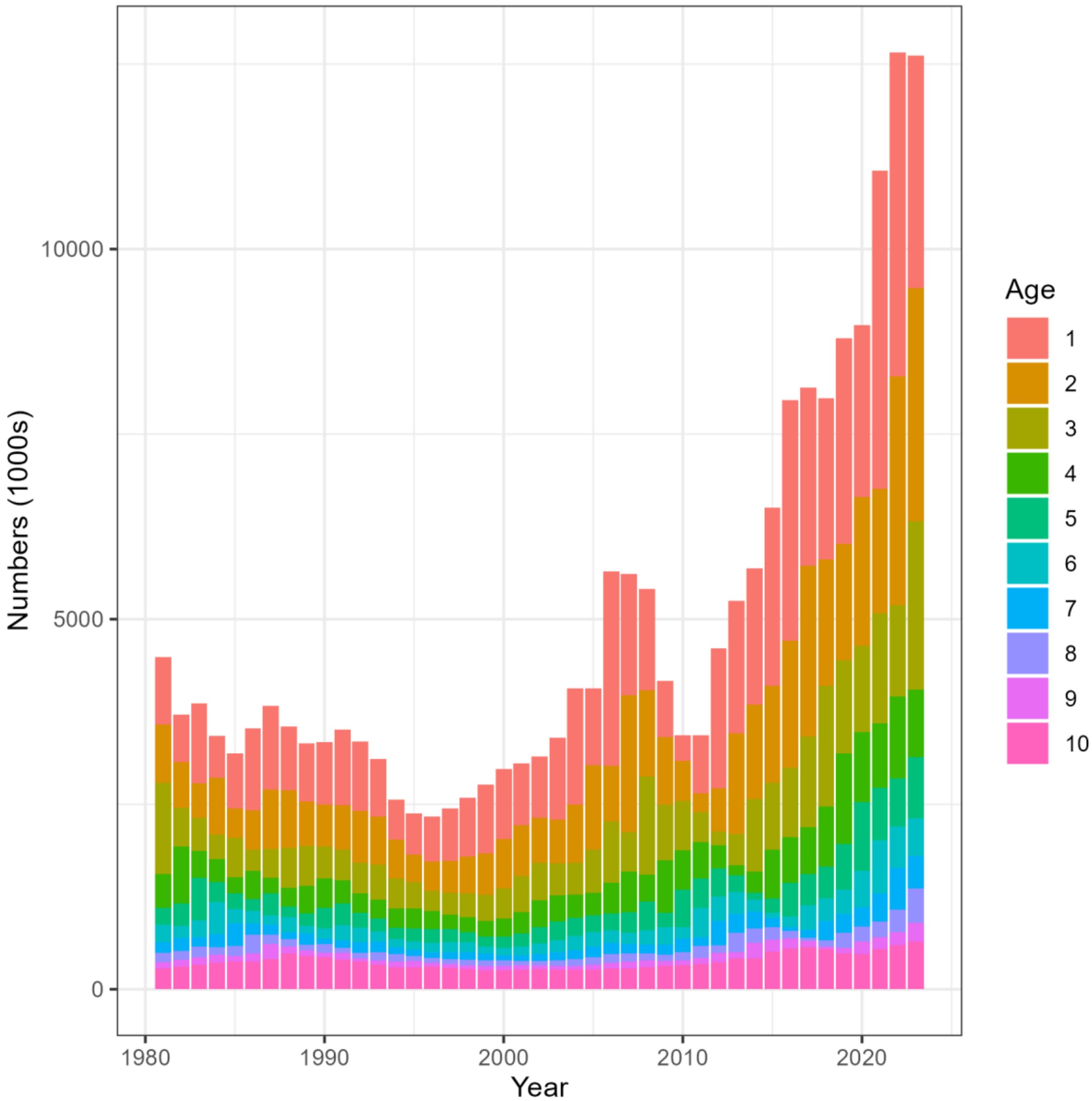


Figure 3. Stacked bar plot of the estimated numbers-at-age by year according to the SEDAR 79 Base Model.

a)

b)

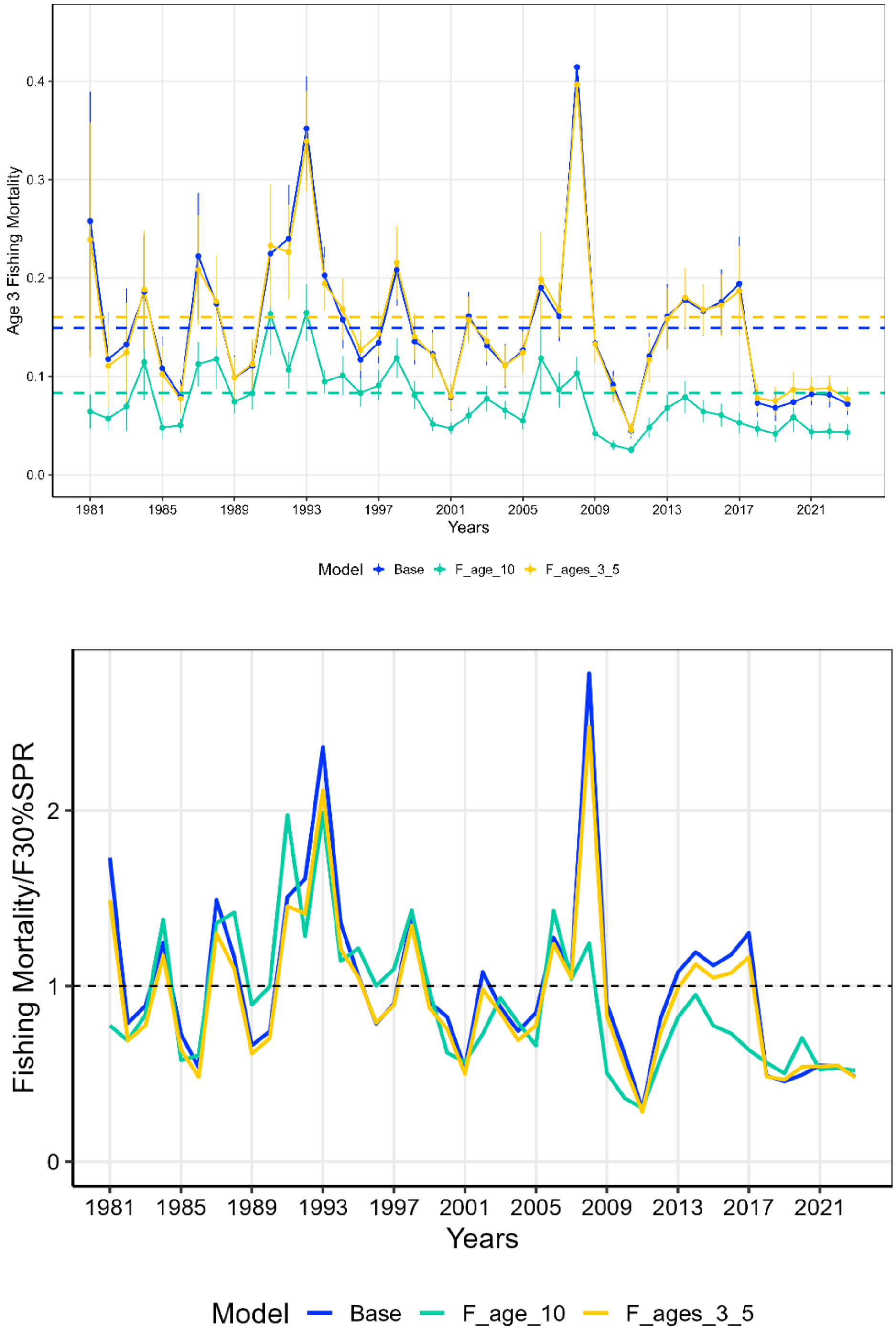
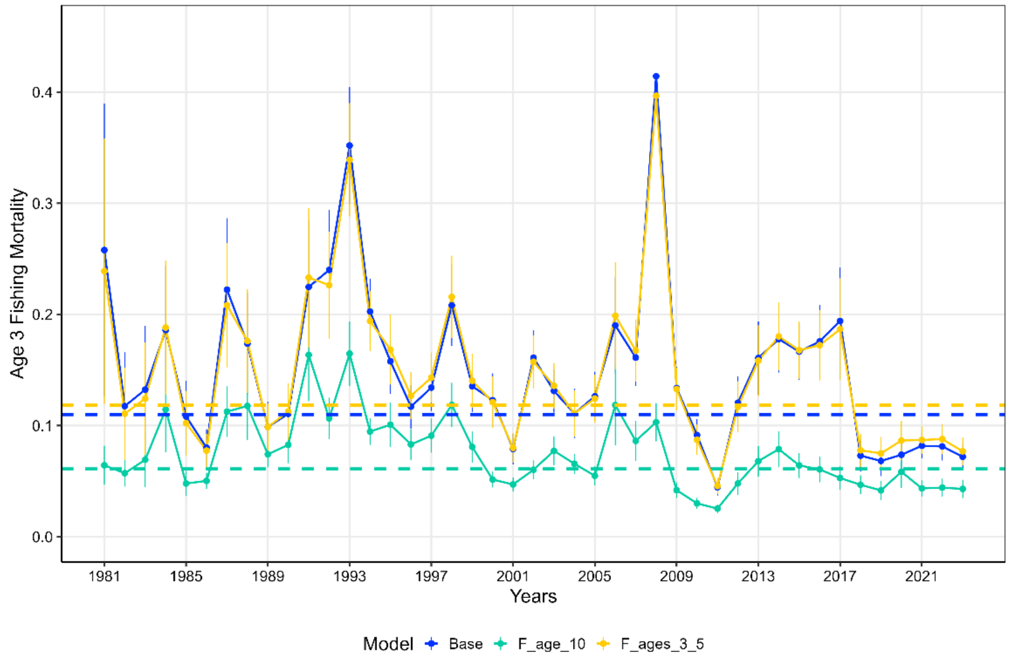


Figure 4. Comparison of fishing mortality rates with $F_{30\%SPR}$ for age 3, age 10, and ages 3 -5 (weighted average by the numbers at age) and as a ratio (b) as estimated by the SEDAR 79 Base Model.

a)



b)

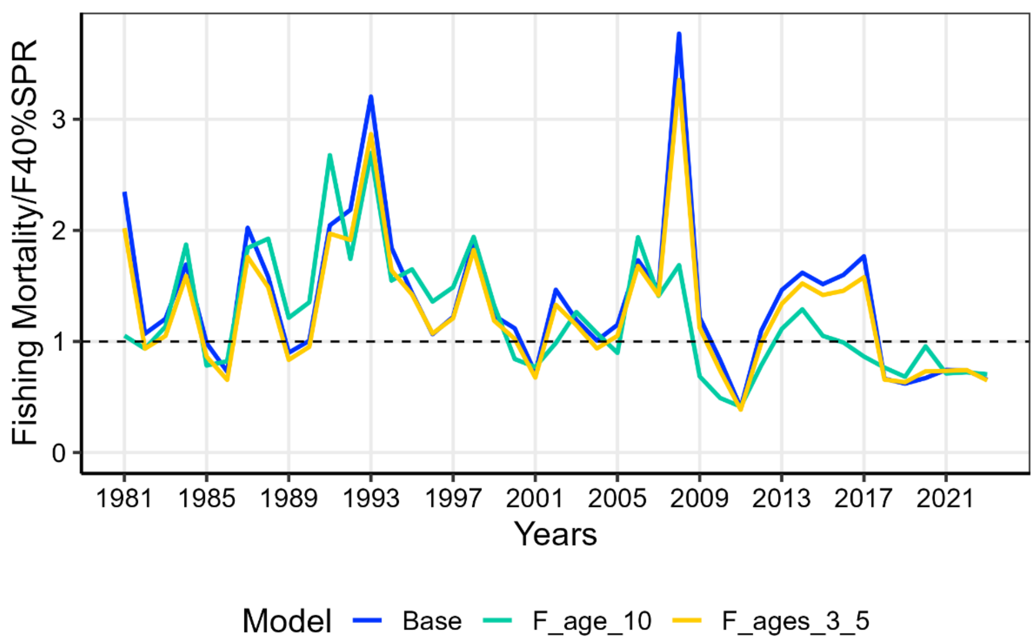
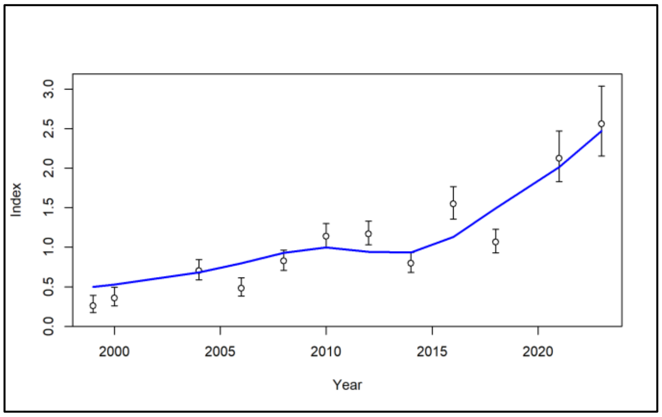
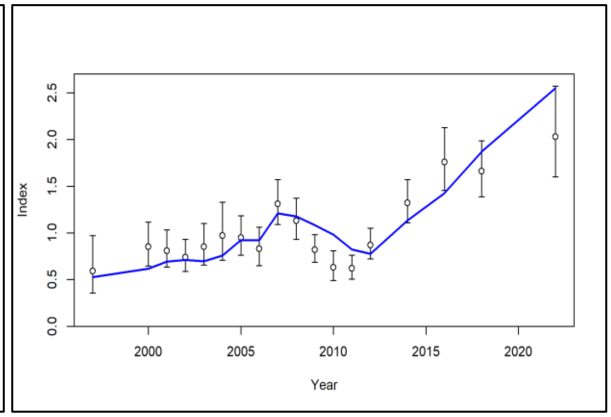


Figure 5. Comparison of fishing mortality rates with $F_{40\%SPR}$ for age 3, age 10, and ages 3 -5 (weighted average by the numbers at age) and as a ratio (b) as estimated by the SEDAR 79 Base Model.

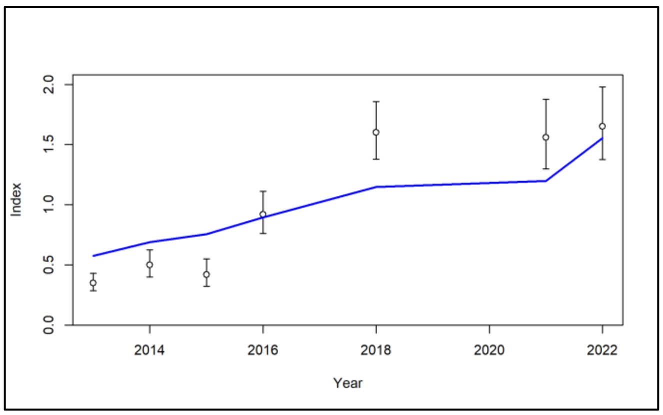
a) RVC Dry Tortugas Index



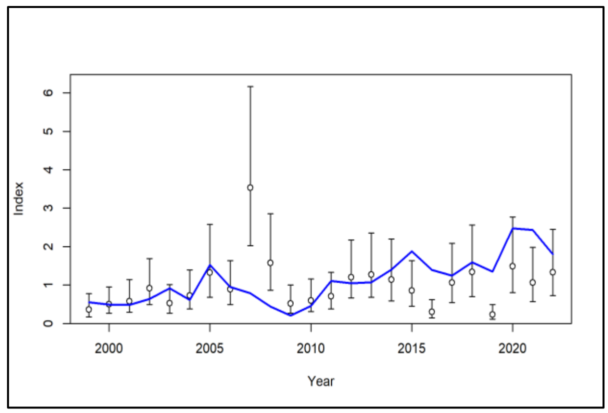
b) RVC FL Keys Index



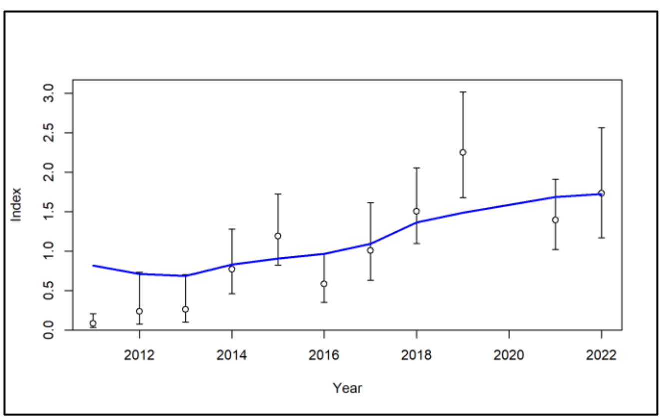
c) RVC SE FL Index



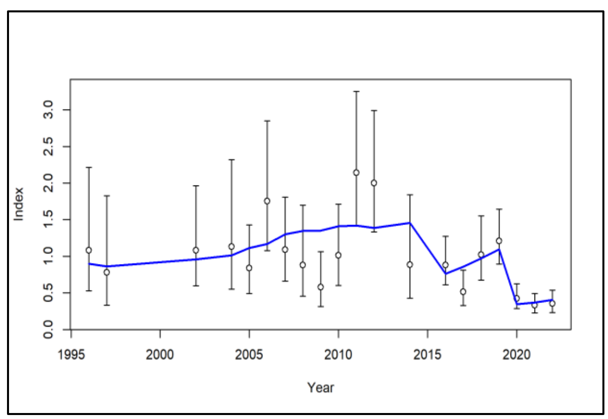
d) FIM YOY Index



e) SERFS Video Index



f) Gulf Combined Video Index



g) Estimated Catchability for the Gulf Combined Video Index

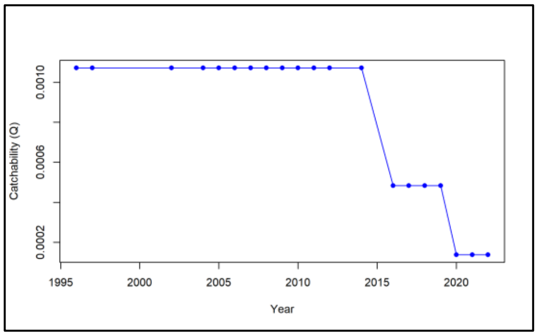
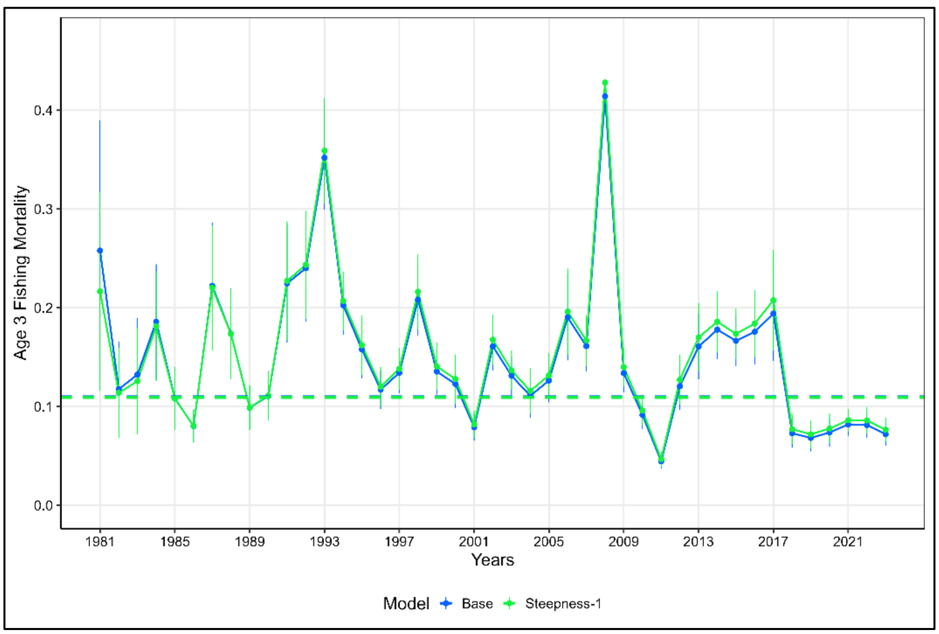
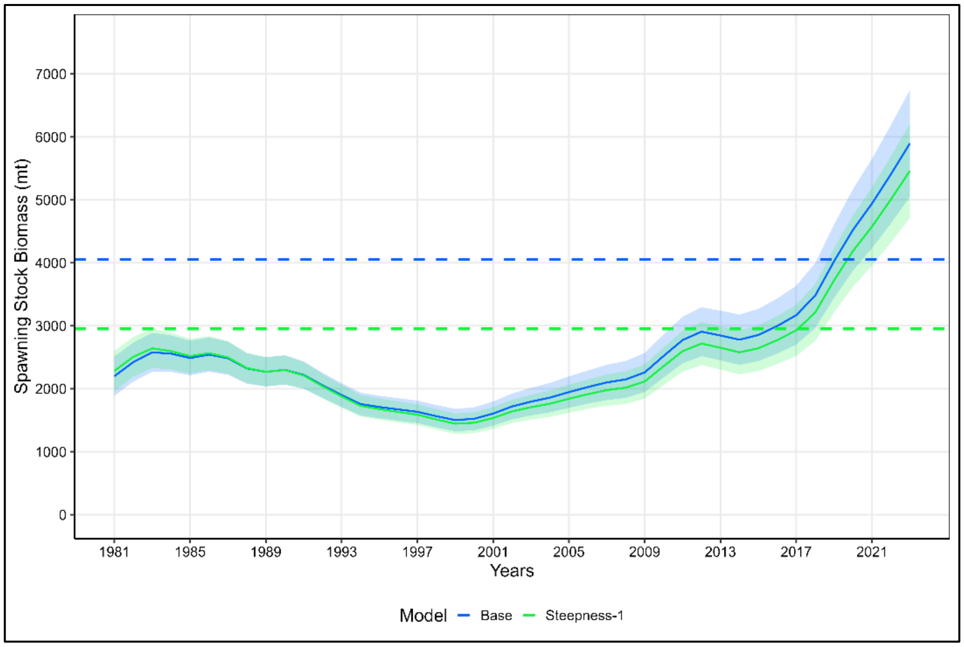


Figure 6. SEDAR 79 Base Model fits to indices when the Commercial Longline Index was removed.



a)



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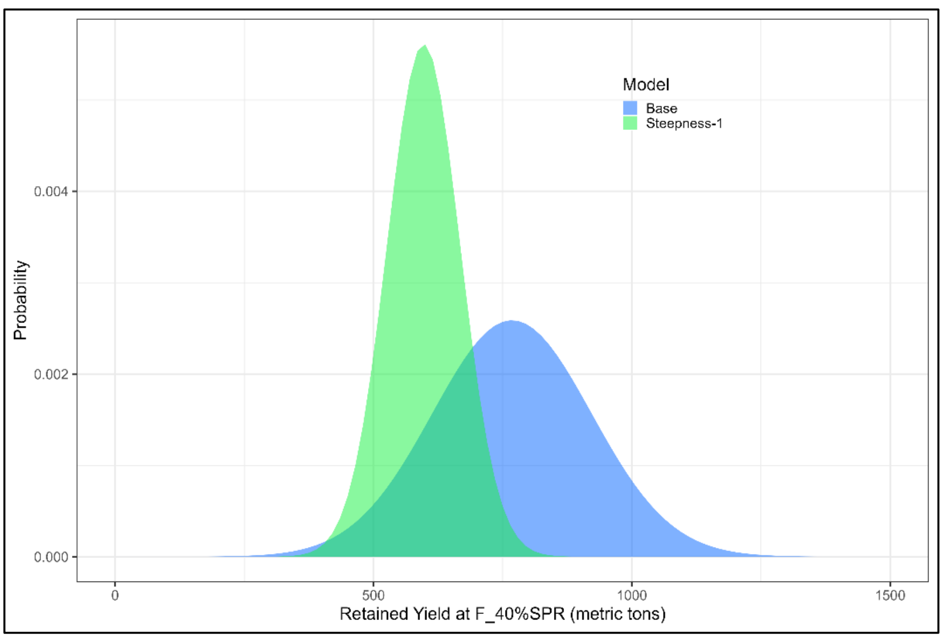
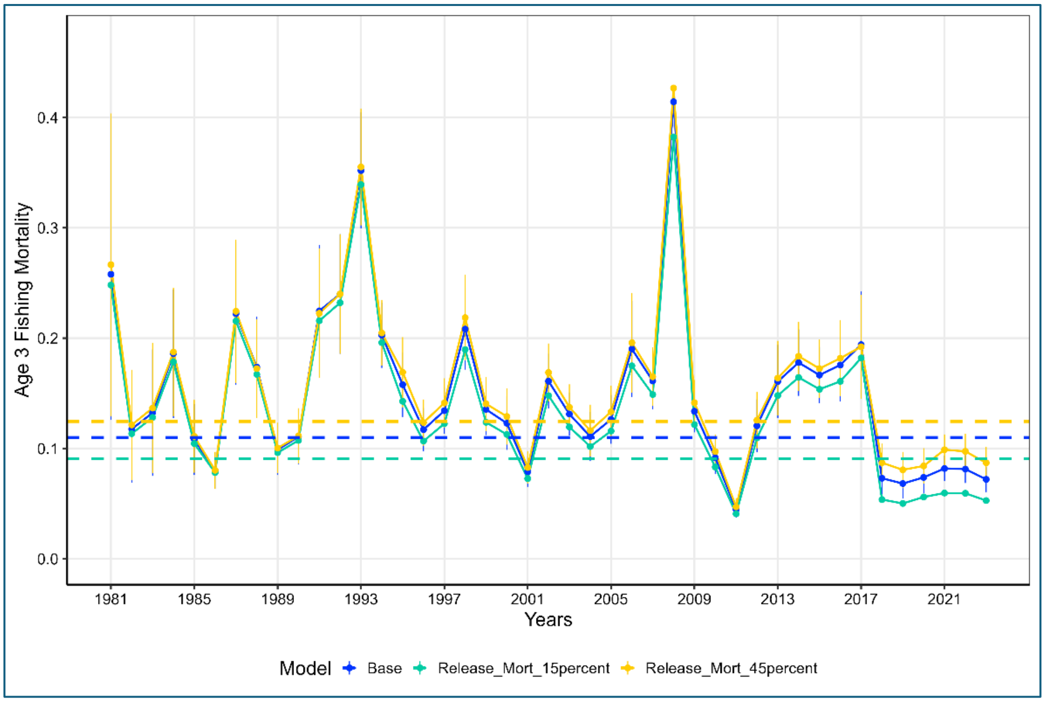
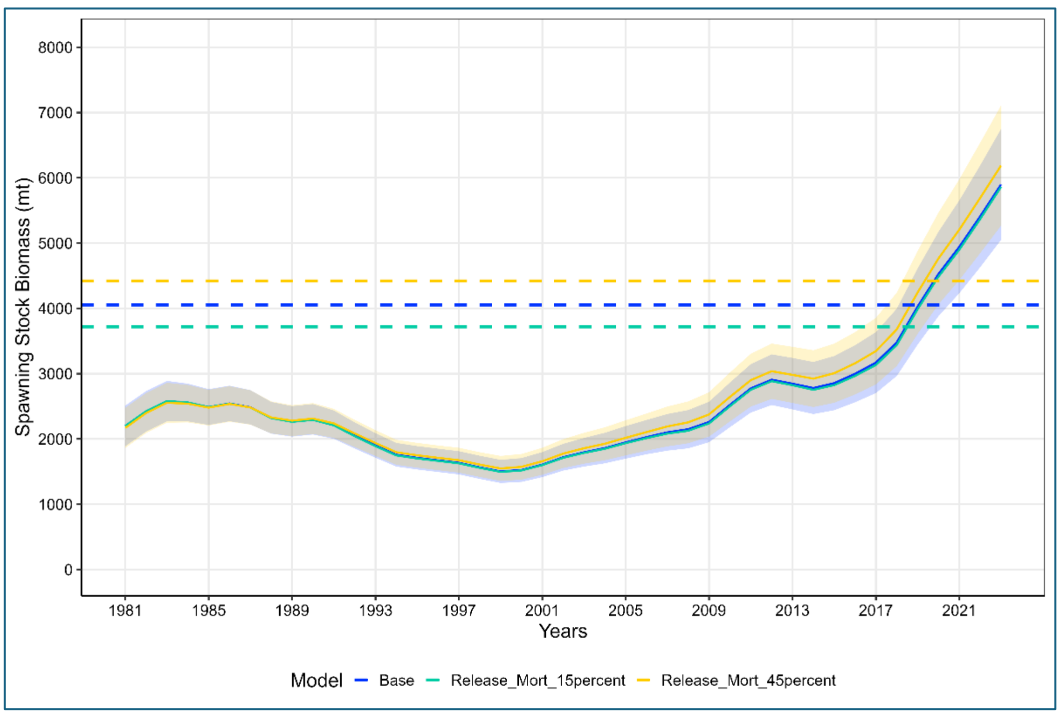


c)

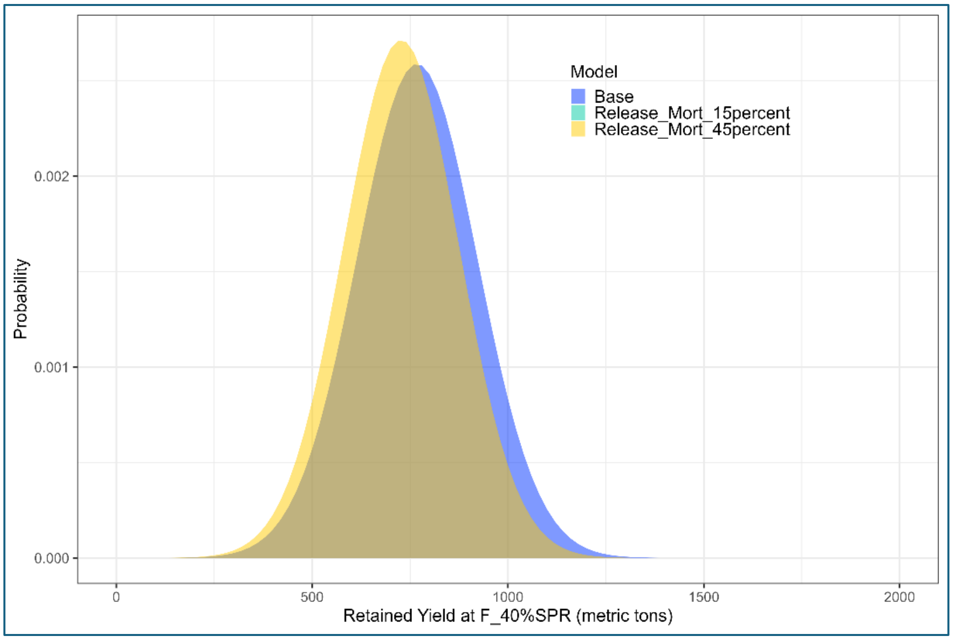
Figure 7. Comparison of fishing mortality rates (with $F_{40\%SPR}$), spawning stock biomass (with $75\%SSB_{F40\%SPR}$), and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with steepness fixed at 0.99 ('steepness-1').


Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model Base Release_Mort_15percent Release_Mort_45percent

a)

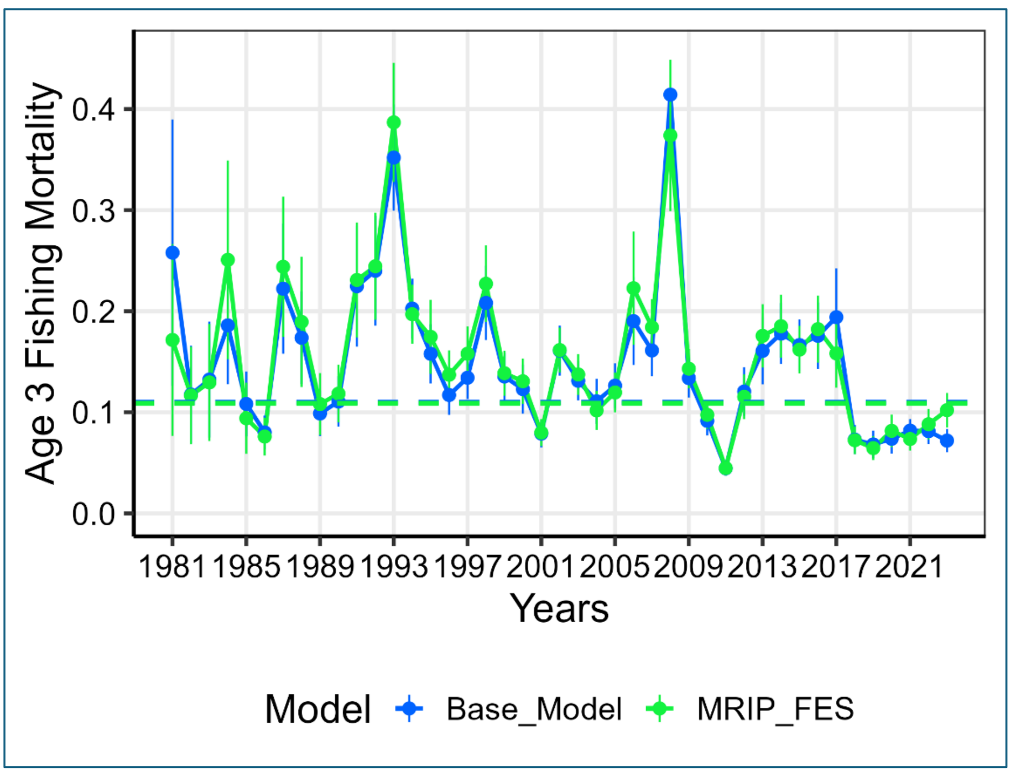

Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
8000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model Base Release_Mort_15percent Release_Mort_45percent

b)

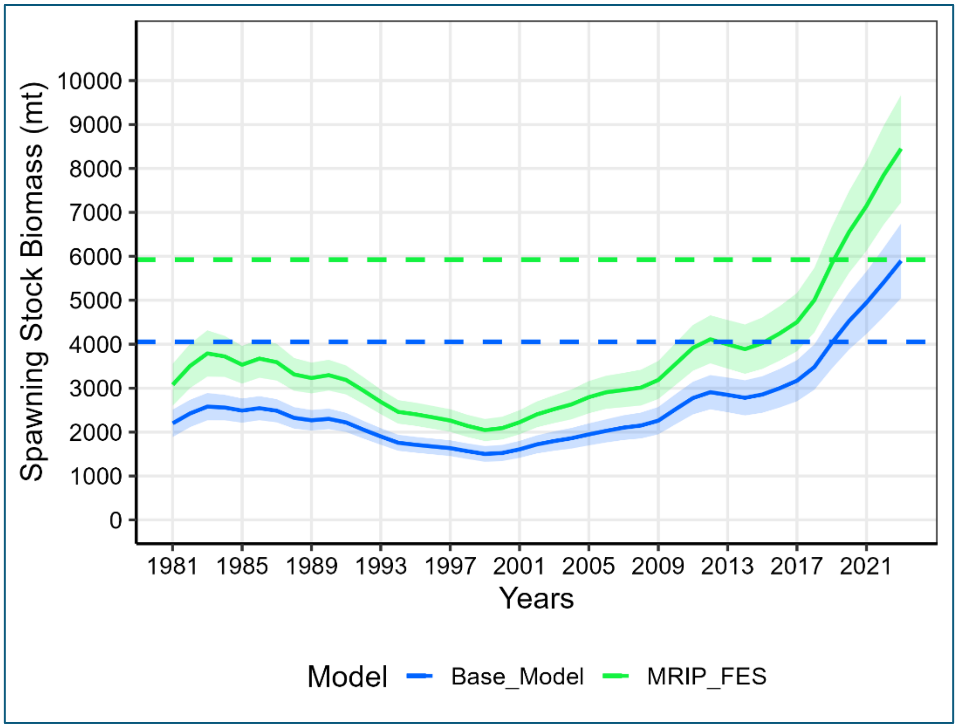


c)

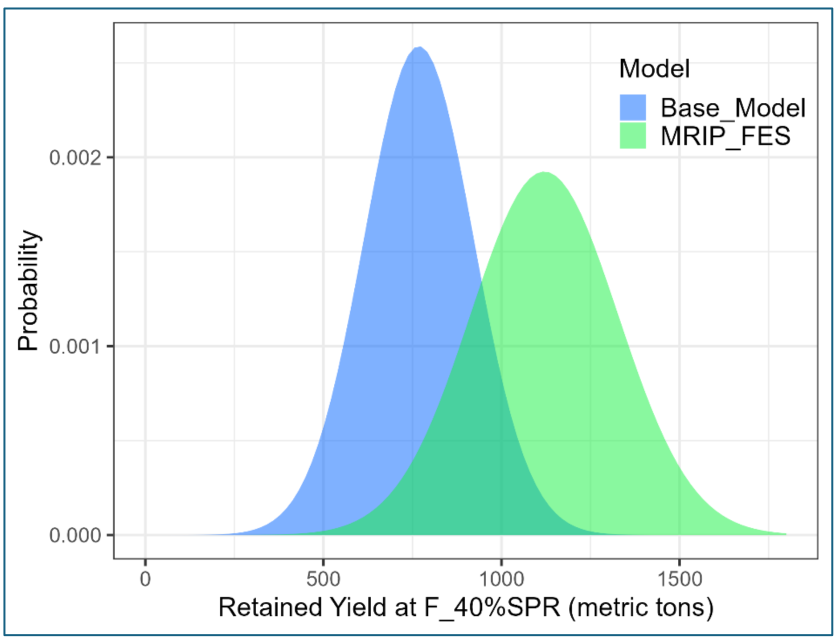
Figure 8. Comparison of fishing mortality rates (with $F_{40\%SPR}$), spawning stock biomass (with $75\%SSB_{F40\%SPR}$), and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with release mortality equal to 15% and 45%, respectively.



a)

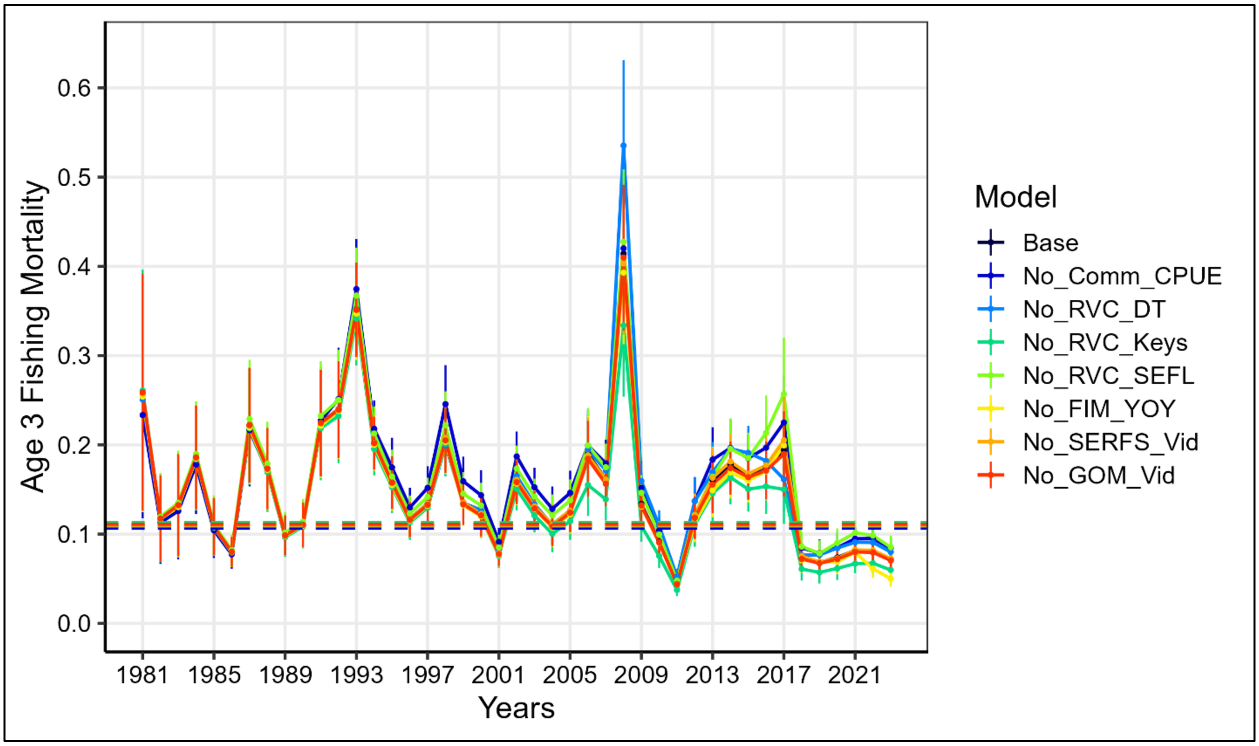


b)

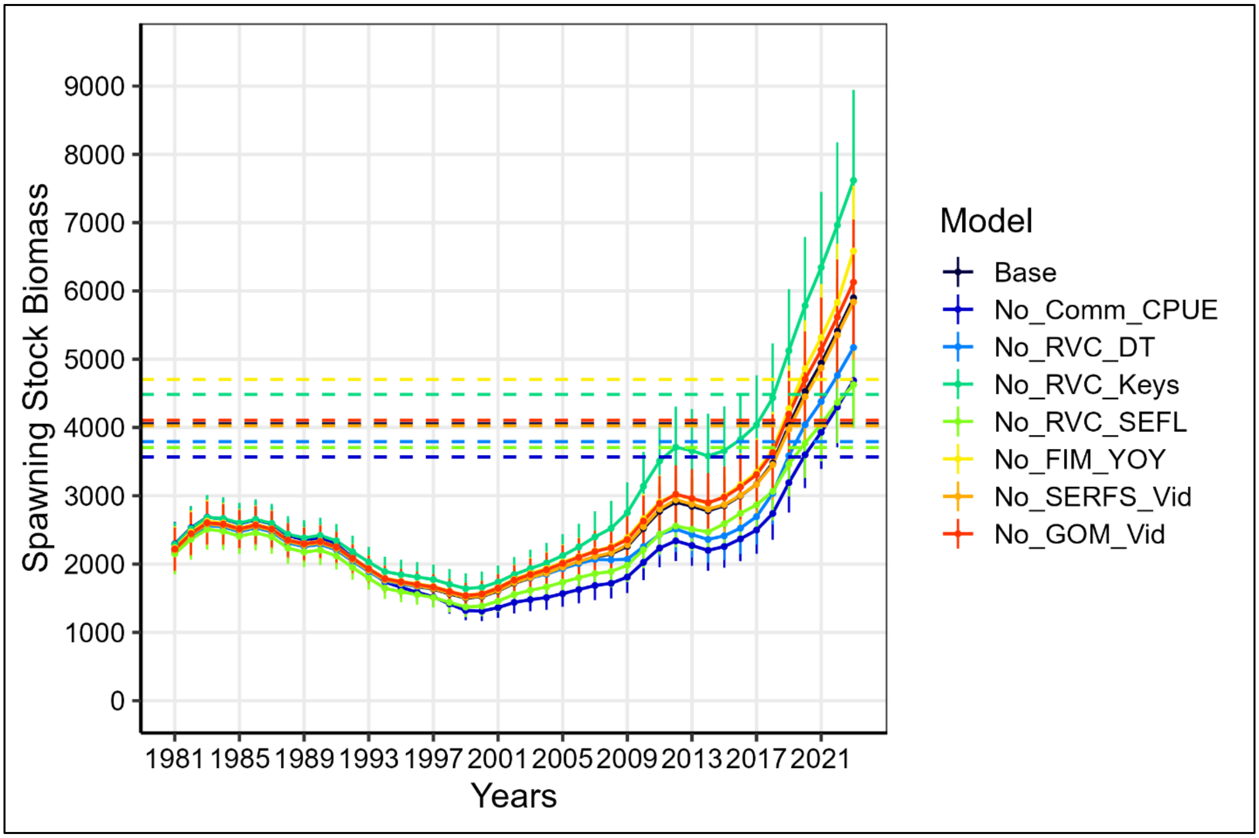


c)

Figure 9. Comparison of fishing mortality rates (with $F_{40\%SPR}$), spawning stock biomass (with $75\%SSB_{F40\%SPR}$), and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with MRIP-FES Florida-only private mode landings and releases ('MRIP_FES' in green).

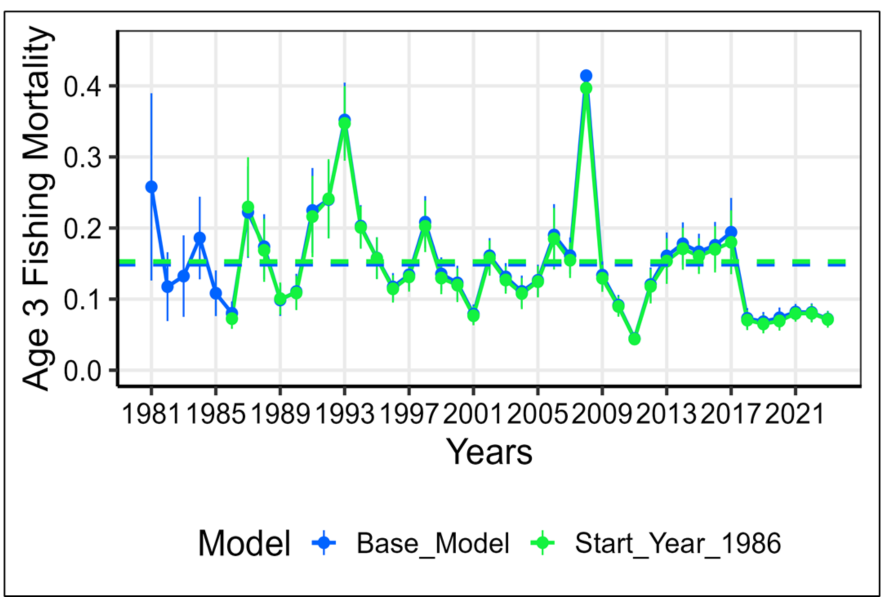

Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
No_Comm_CPUE
No_RVC_DT
No_RVC_Keys
No_RVC_SEFL
No_FIM_YOY
No_SERFS_Vid
No_GOM_Vid

a)

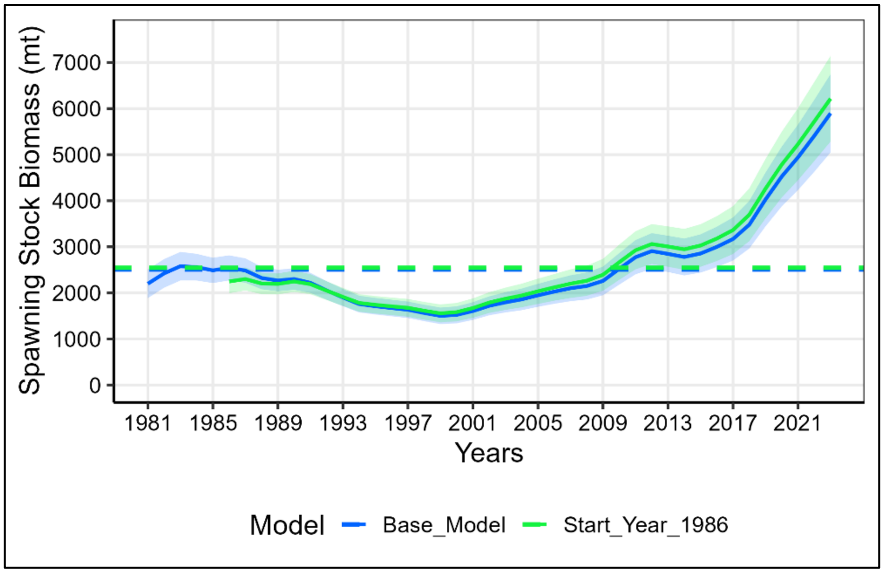


b)

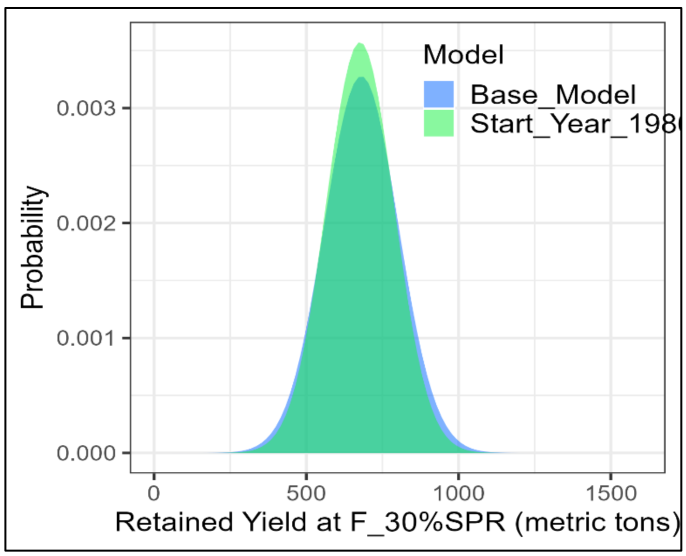
Figure 10. Comparison of fishing mortality rates with $F_{40\%SPR}$ and spawning stock biomass with $75\%SSB_{F40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when a single index of abundance is removed.



a)

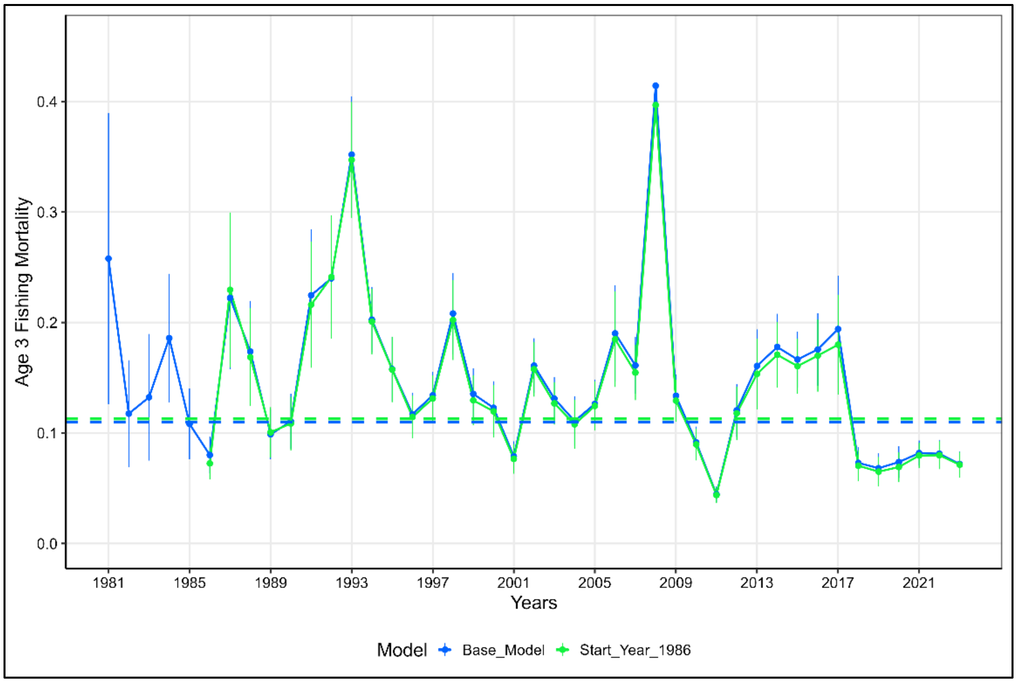


b)

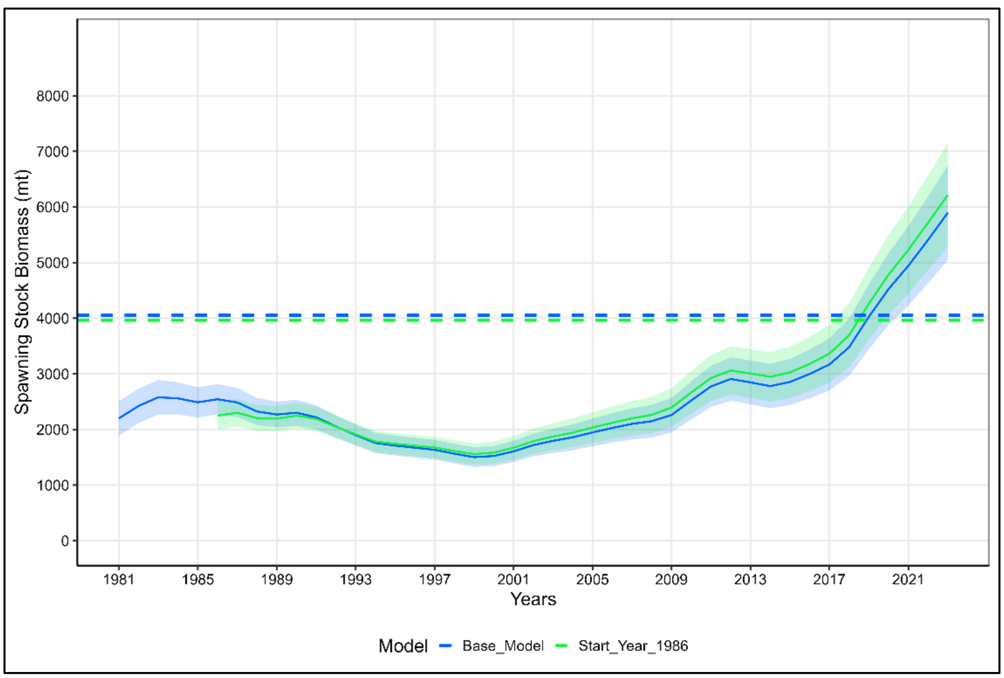


c)

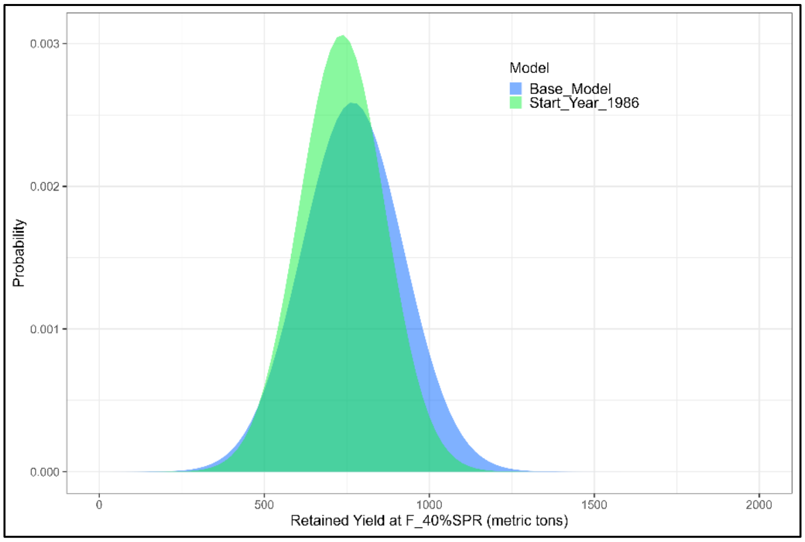
Figure 11. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with $75\%SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with a start year of 1986.


Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base_Model
Start_Year_1986

a)

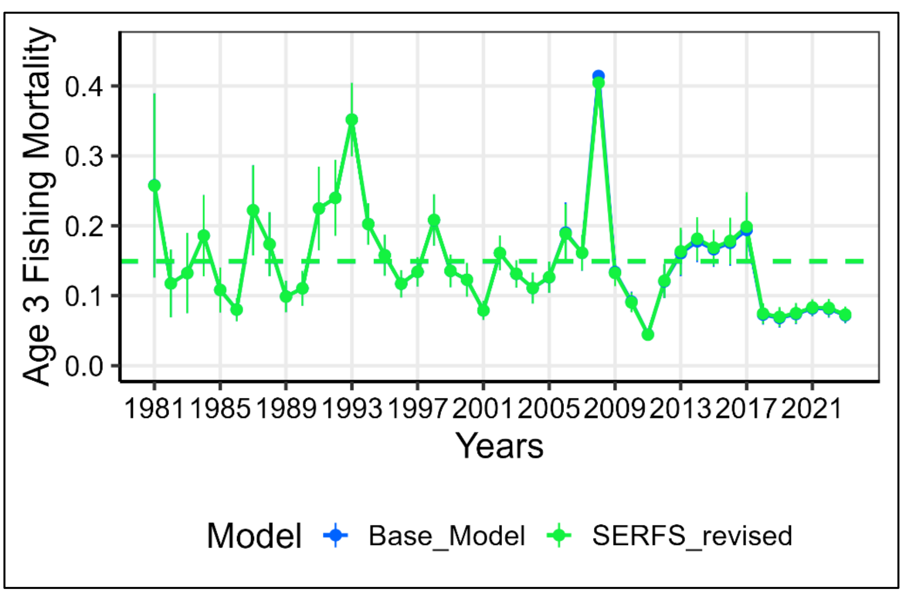

Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
8000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base_Model
Start_Year_1986

b)

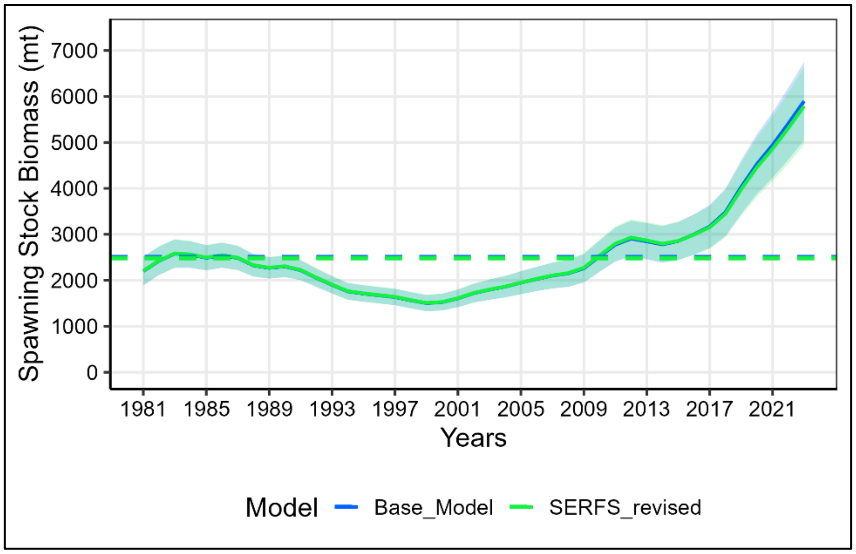


c)

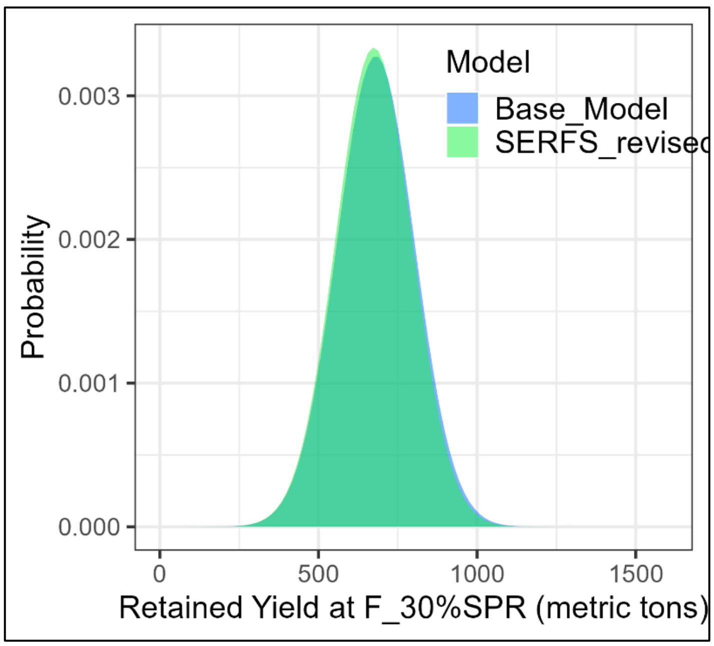
Figure 12. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with $75\%SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with a start year of 1986.



a)

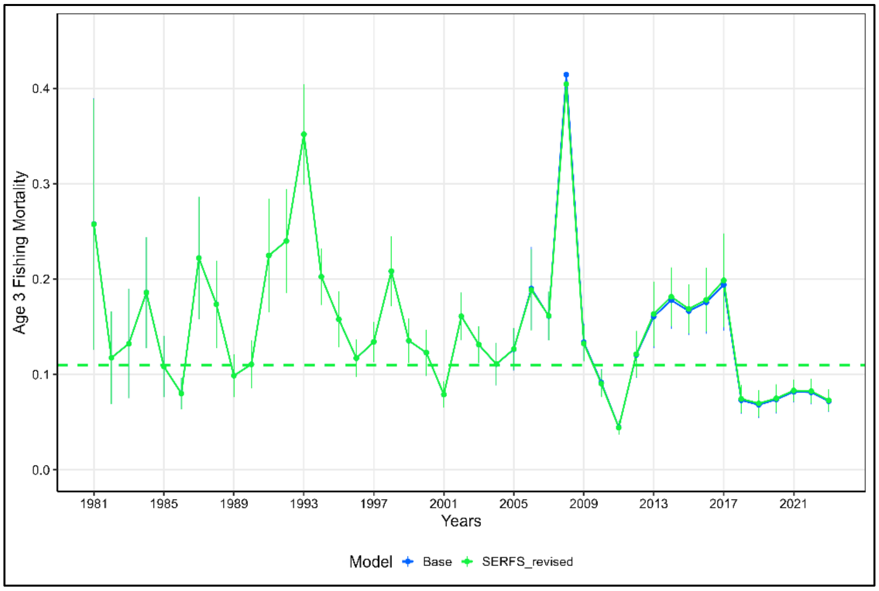


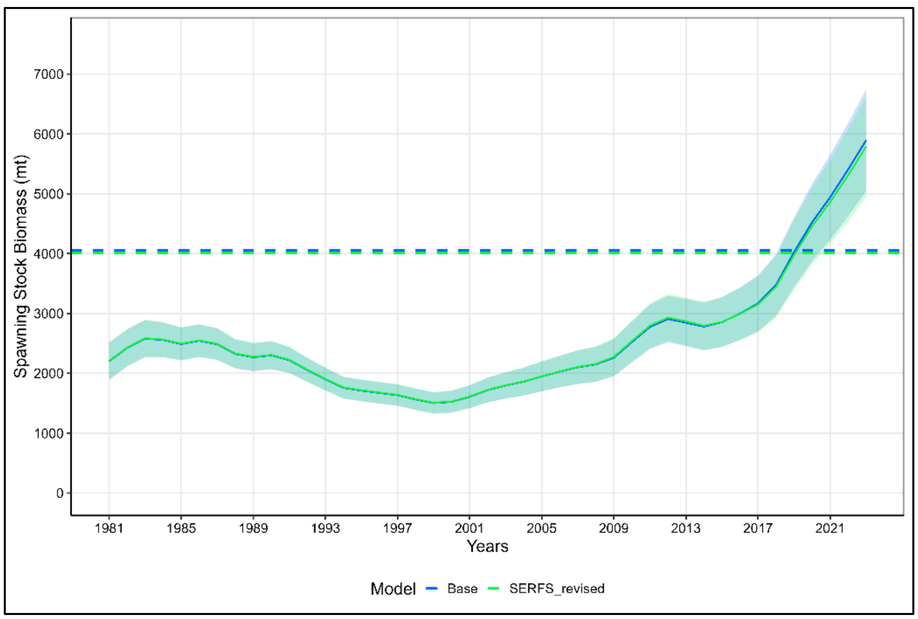
b)

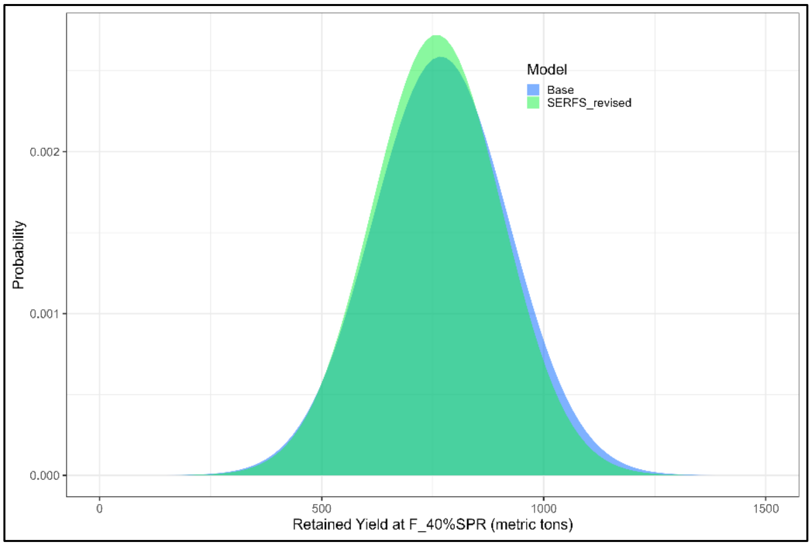


c)

Figure 13. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with $75\%SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with the first 3 years of the SERFS index removed (2011-2013).

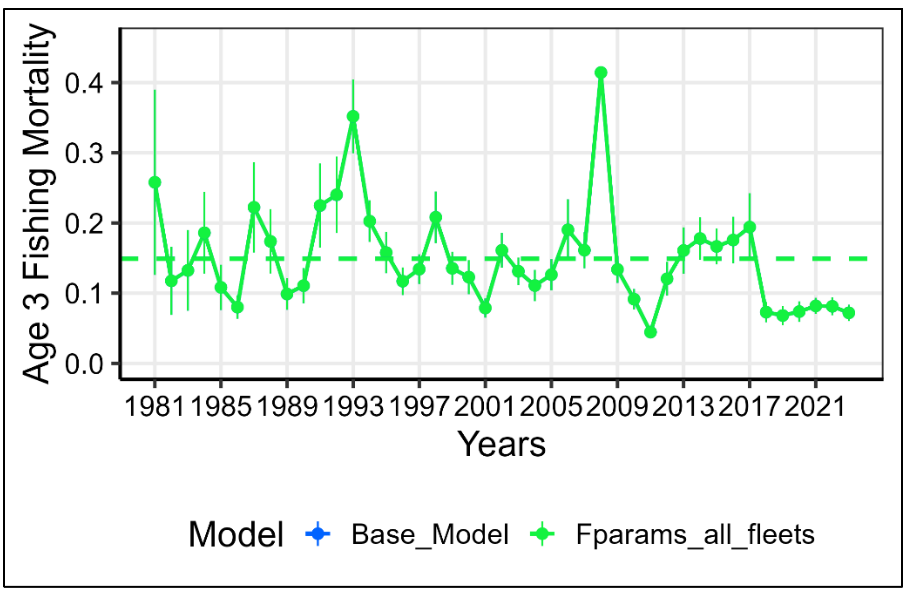

Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model Base SERFS_revised
a)


Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model Base SERFS_revised
b)

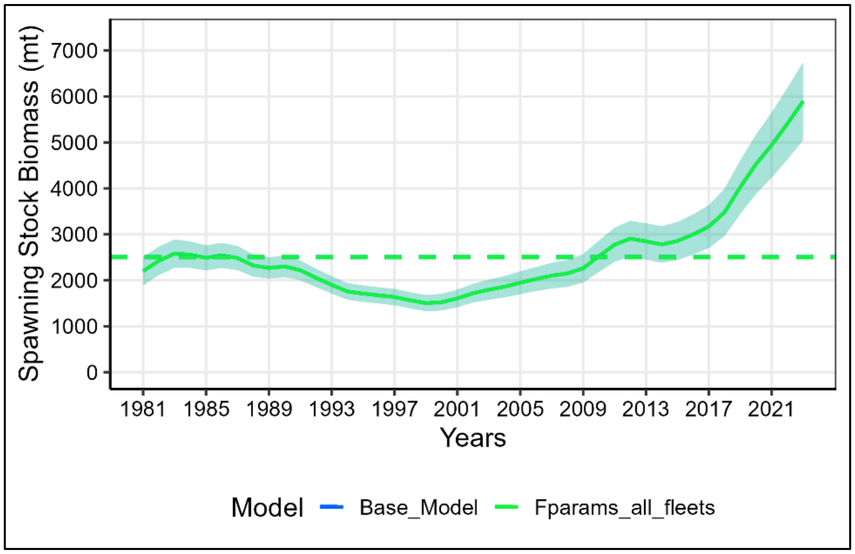


c)

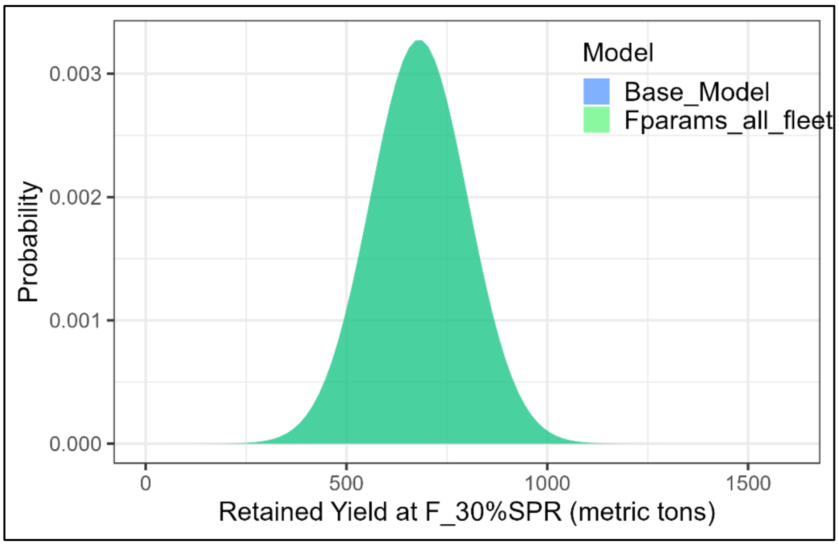
Figure 14. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with $75\%SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with the first 3 years of the SERFS index removed (2011-2013).



a)

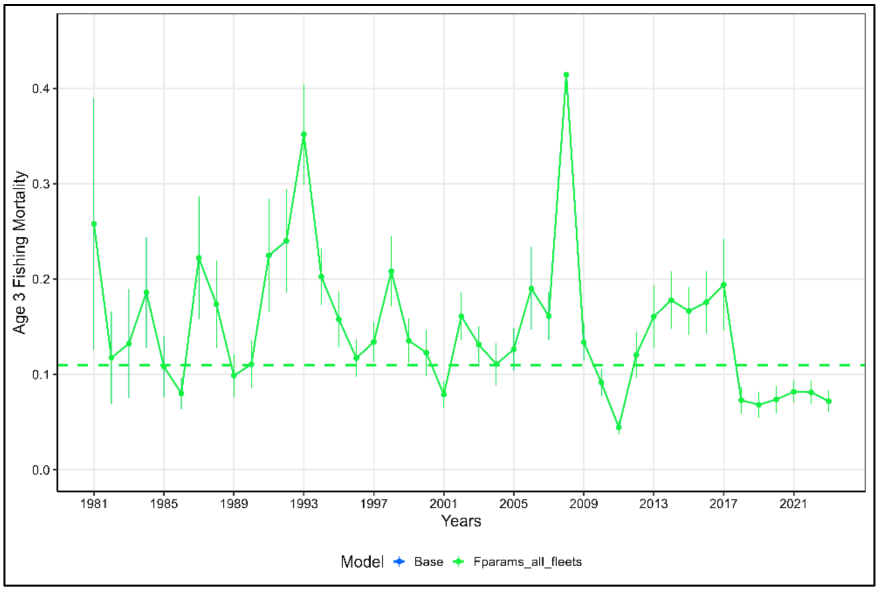


b)

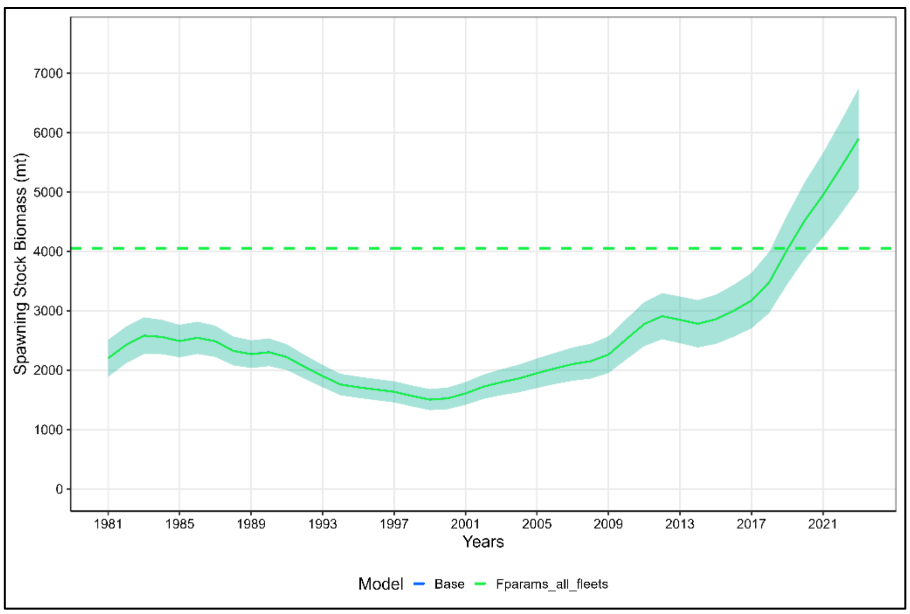


c)

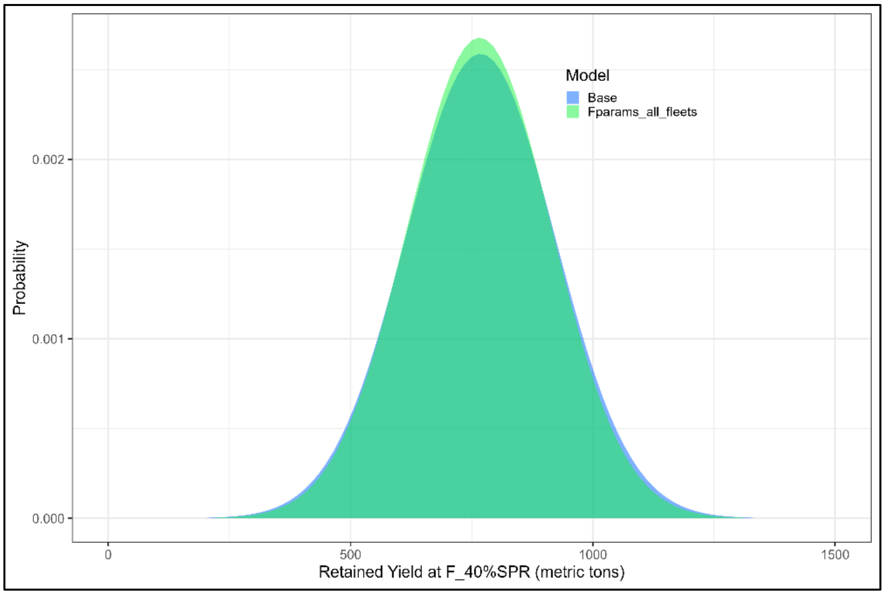
Figure 15. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with $75\%SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when fishing mortality rate (F) parameters were estimated for all fleets.


Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
Fparams_all_fleets

a)

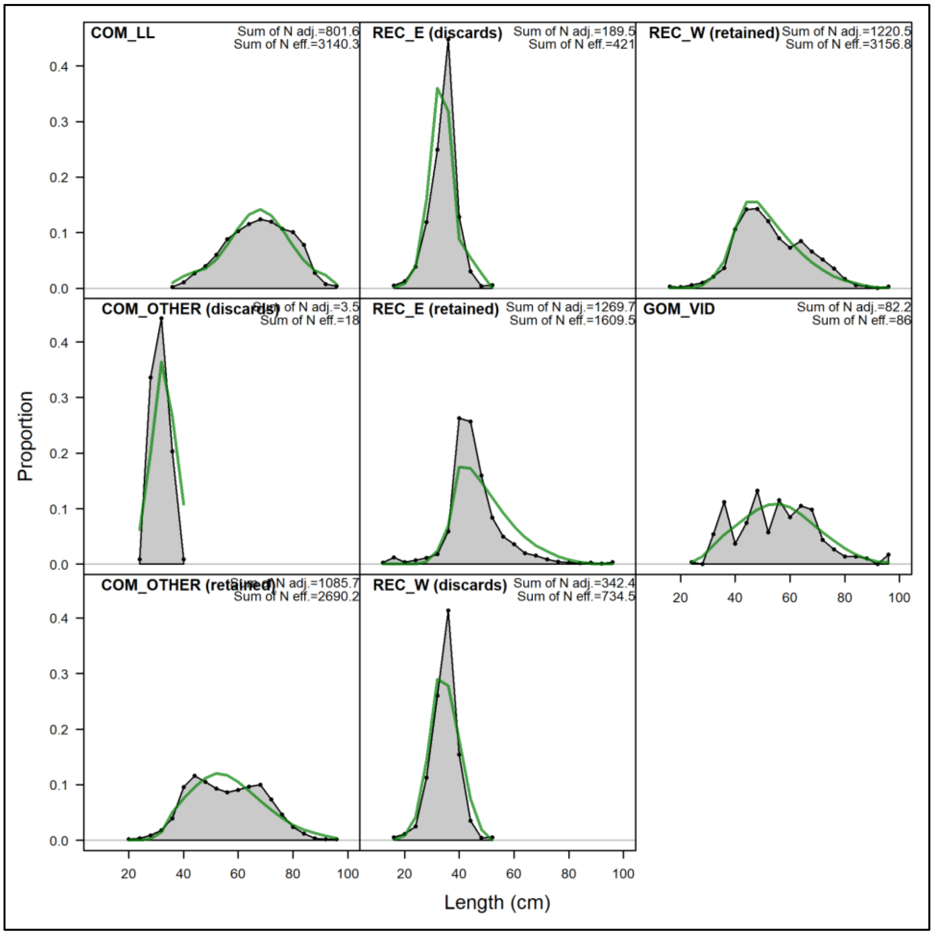

Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
Fparams_all_fleets

b)



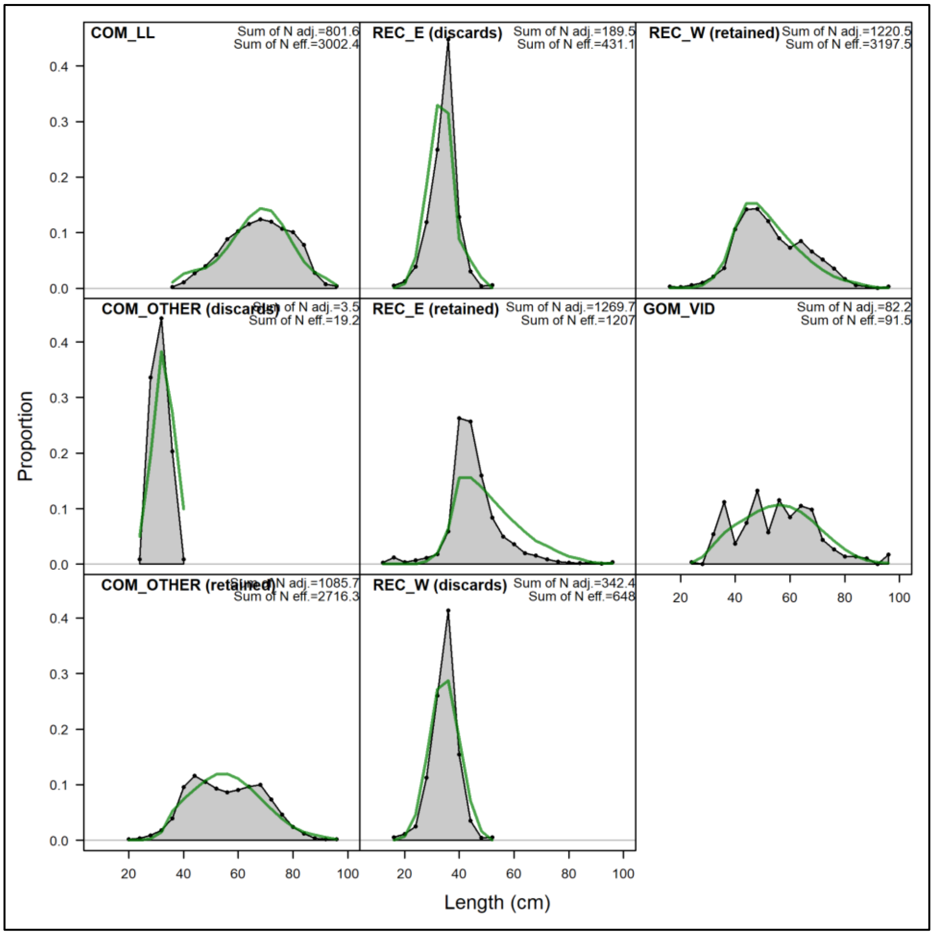
c)

Figure 16. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with $75\%SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when fishing mortality rate (F) parameters were estimated for all fleets.



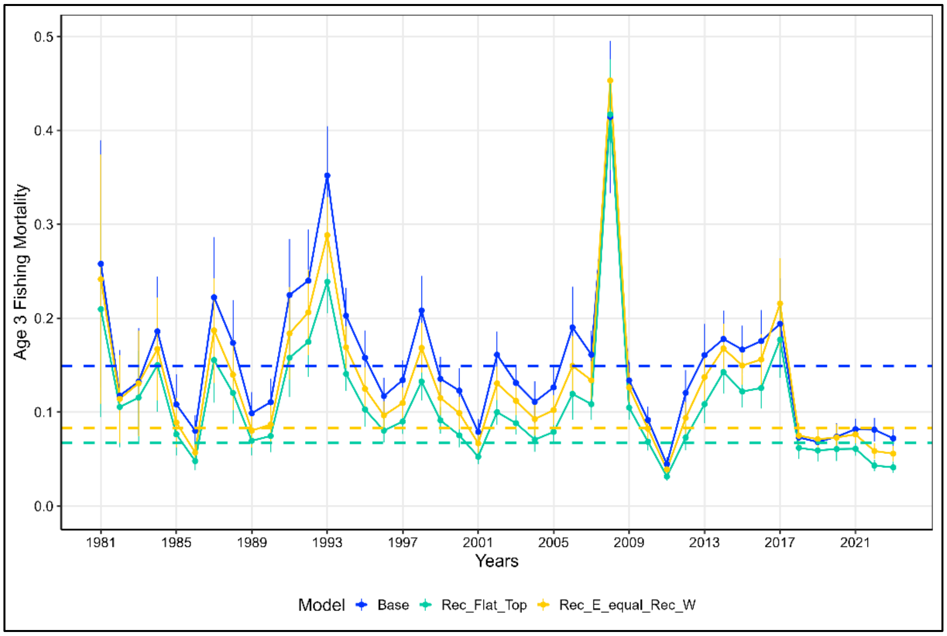
COM_LL
Sum of N adj.=801.6
Sum of N eff.=3140.3
REC_E (discards)
Sum of N adj.=189.5
Sum of N eff.=421
REC_W (retained)
Sum of N adj.=1220.5
Sum of N eff.=3156.8
COM_OTHER (discards)
Sum of N adj.=3.5
Sum of N eff.=18
REC_E (retained)
Sum of N adj.=1269.7
Sum of N eff.=1609.5
GOM_VID
Sum of N adj.=82.2
Sum of N eff.=86
COM_OTHER (retained)
Sum of N adj.=1085.7
Sum of N eff.=2690.2
REC_W (discards)
Sum of N adj.=342.4
Sum of N eff.=734.5
Proportion
Length (cm)

a)

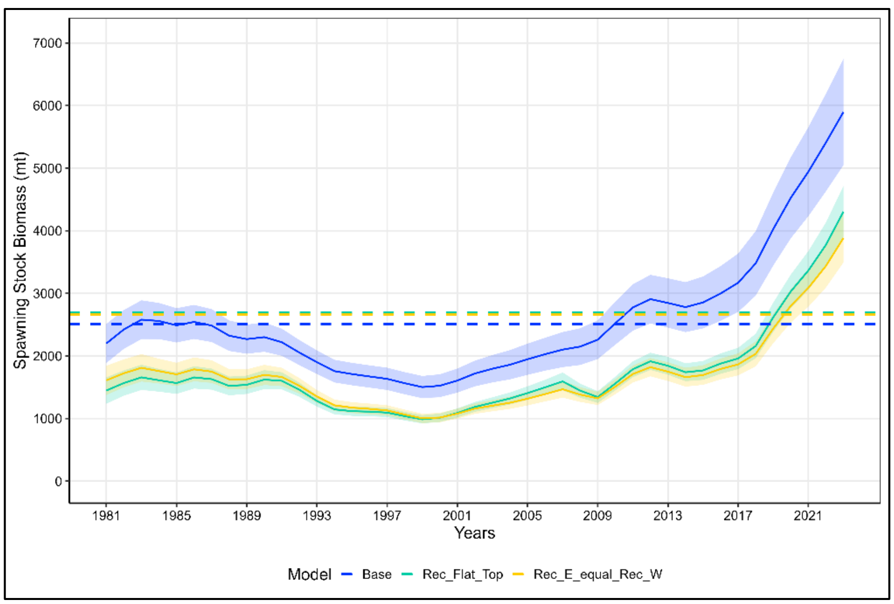


b)

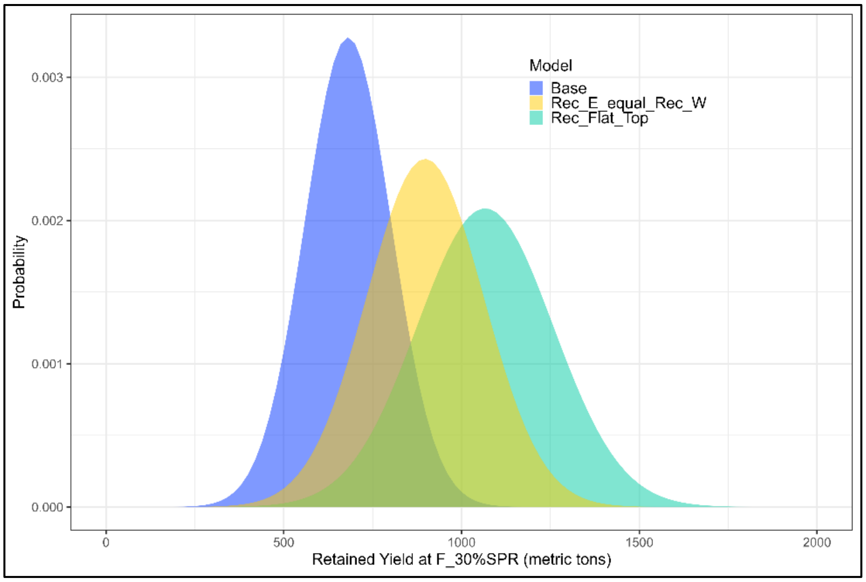
Figure 17. Comparison of the overall fits to the observed length compositions as estimated when either flat-top selectivity is assumed for the Rec West and Rec East fleets (a; model = "Rec Flat Top") or the Rec East selectivity is fixed at the Base Model estimates for Rec West (b; model="Rec E equal Rec W_Base").


Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
0.5
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
Rec_Flat_Top
Rec_E_equal_Rec_W

a)

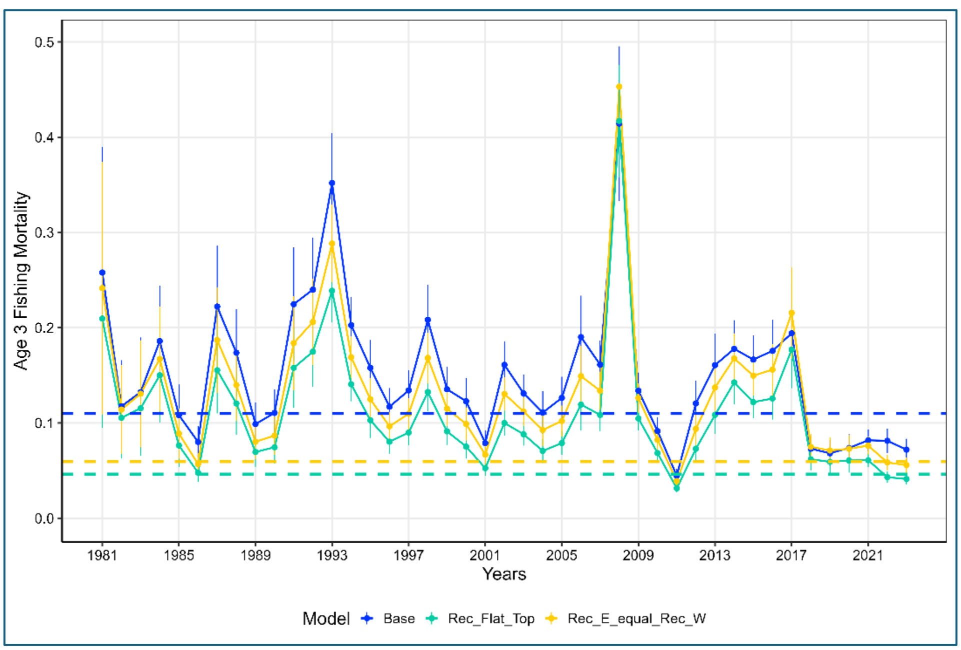

Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
Rec_Flat_Top
Rec_E_equal_Rec_W

b)

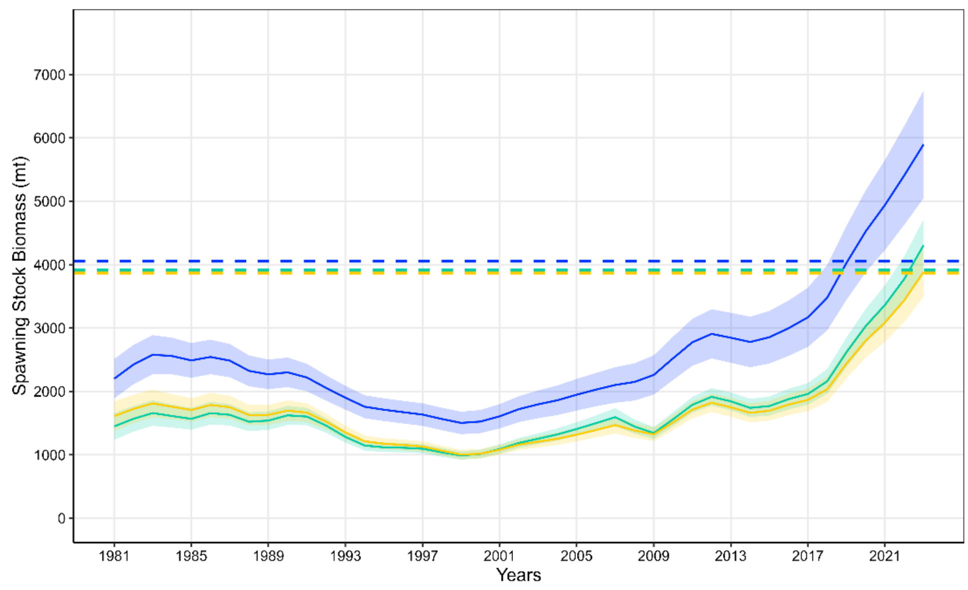


c)

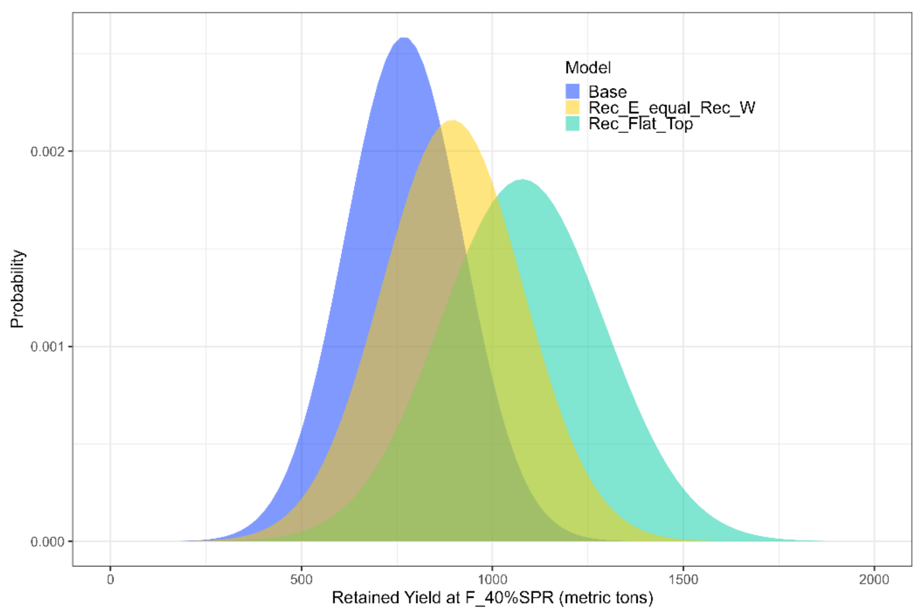
Figure 18. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with $75\%SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when either flat-top selectivity is assumed for the Rec West and Rec East fleets (model = "Rec Flat Top") or the Rec East selectivity is fixed at the Base Model estimates for Rec West (model="Rec E equal Rec W_Base").



a)



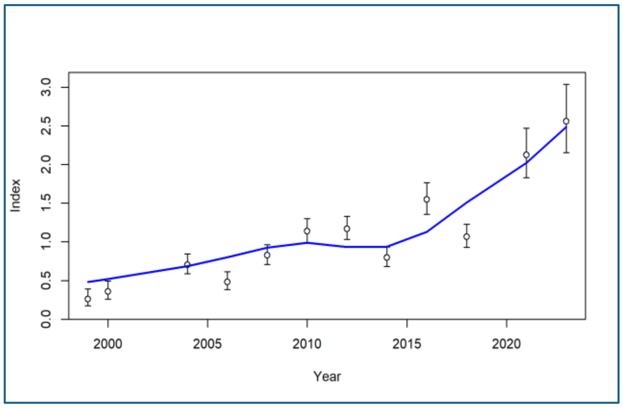
b)



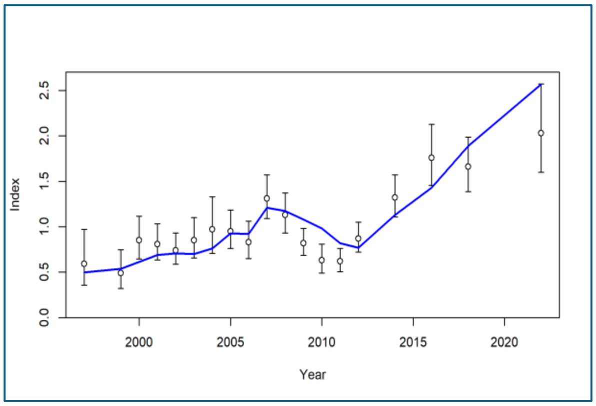
c)

Figure 19. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with $75\%SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when either flat-top selectivity is assumed for the Rec West and Rec East fleets (model = "Rec Flat Top") or the Rec East selectivity is fixed at the Base Model estimates for Rec West (model="Rec E equal Rec W_Base").

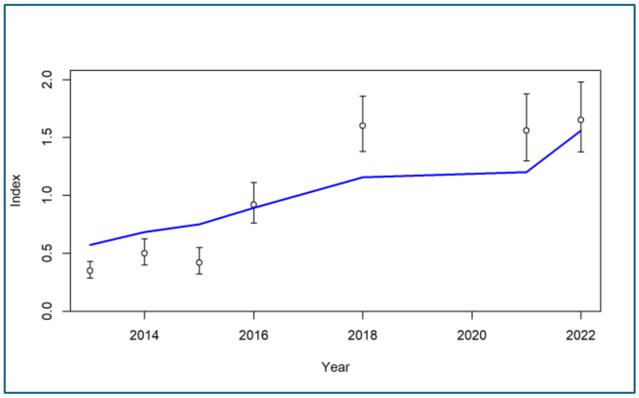
a) RVC Dry Tortugas Index



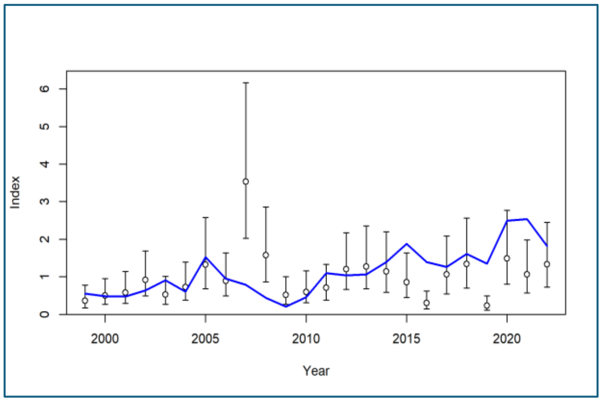
b) RVC FL Keys Index



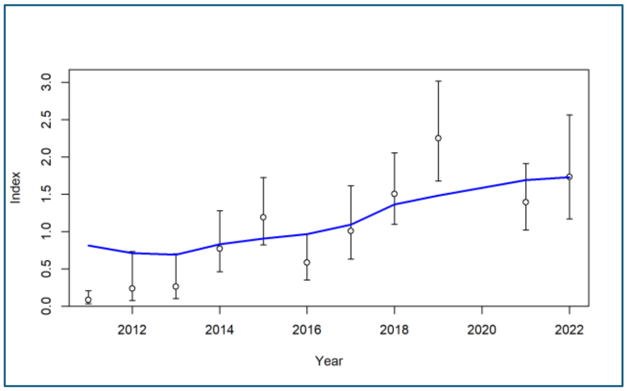
c) RVC SE FL Index



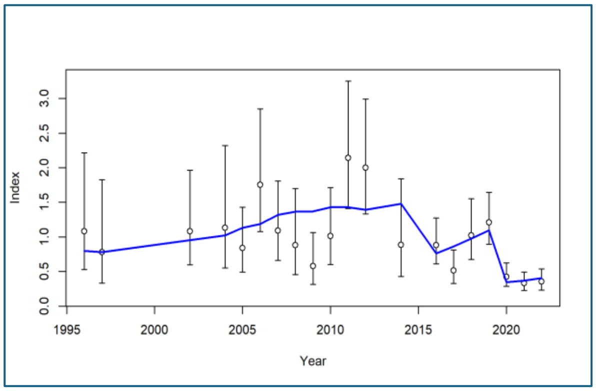
d) FIM YOY Index



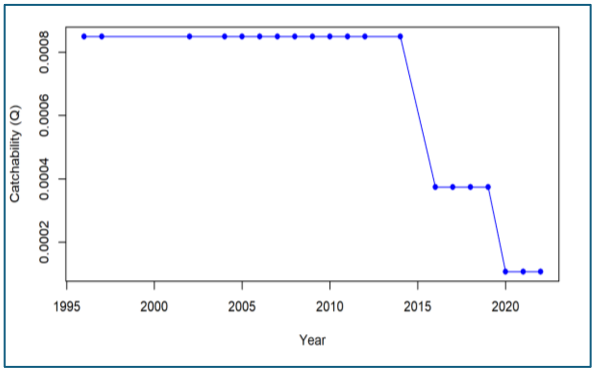
e) SERFS Video Index



f) Gulf Combined Video Index



g) Estimated Catchability for the Gulf Combined Video Index



h) Commercial Longline CPUE

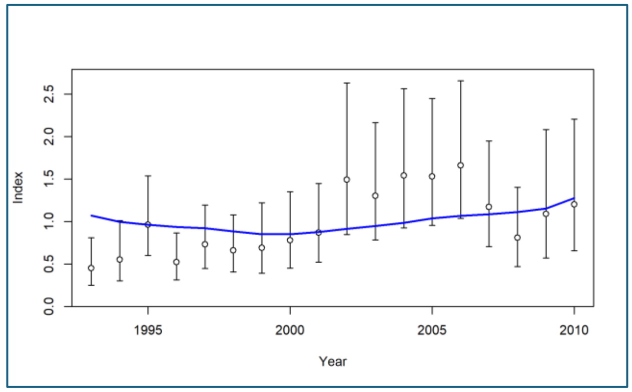
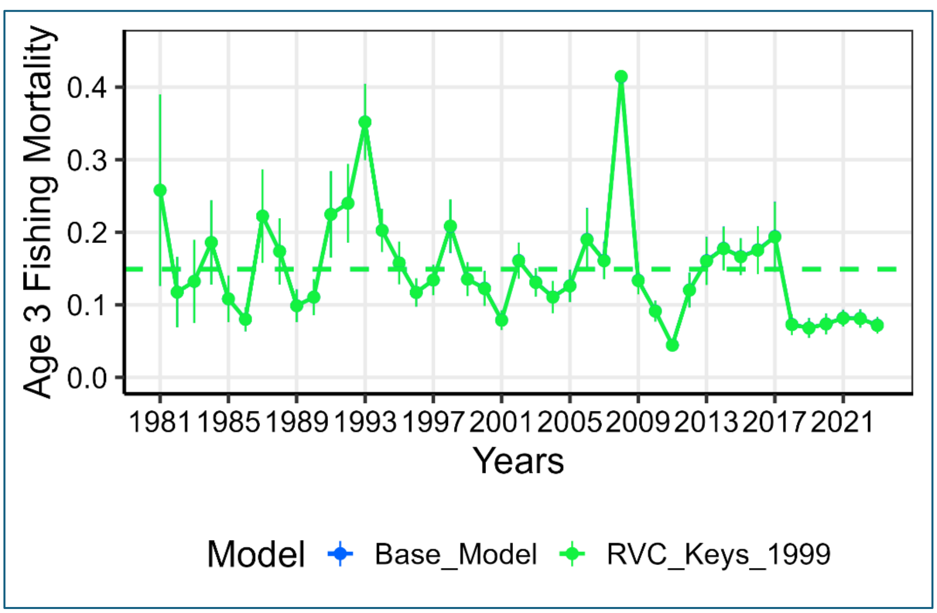
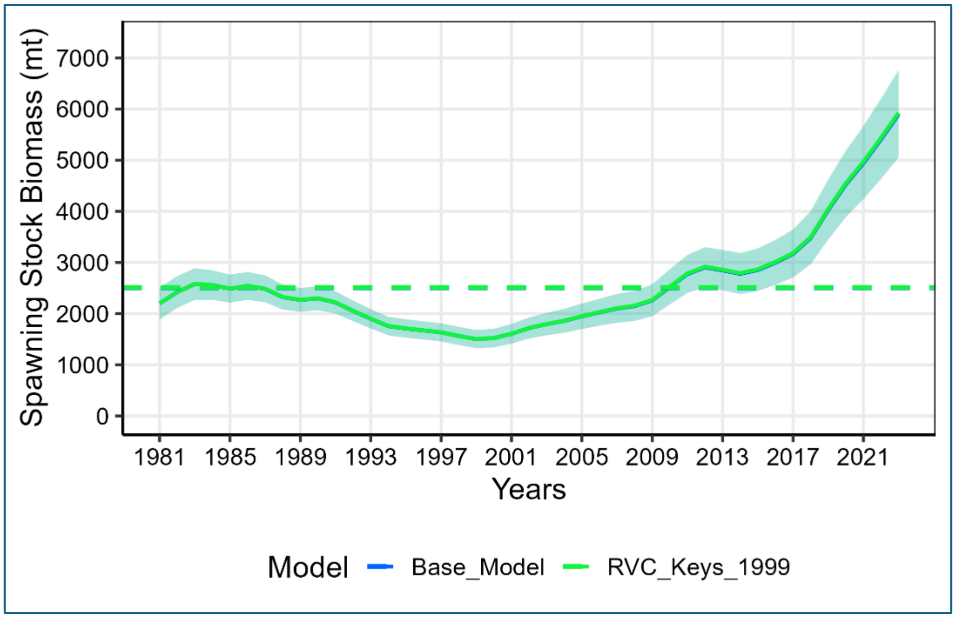


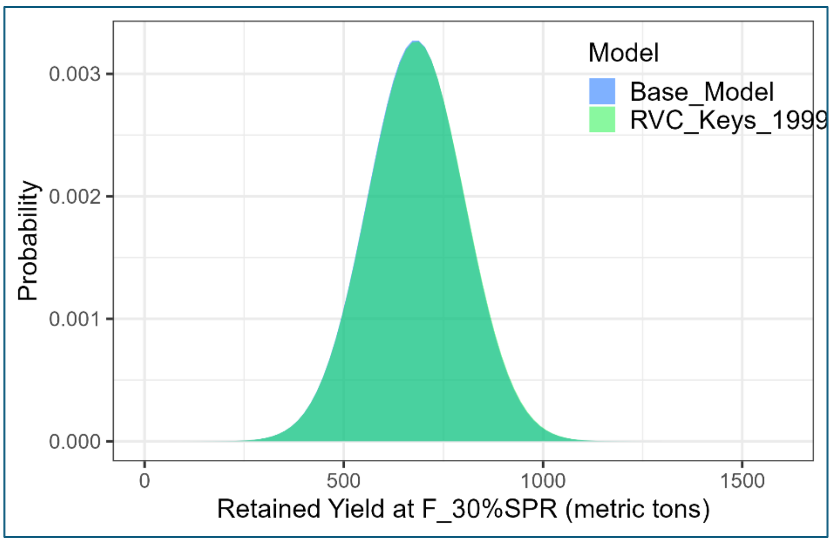
Figure 20. Fits to indices when the index value and related standard error in 1999 for the RVC FL Keys survey was included in the Base Model.



a)

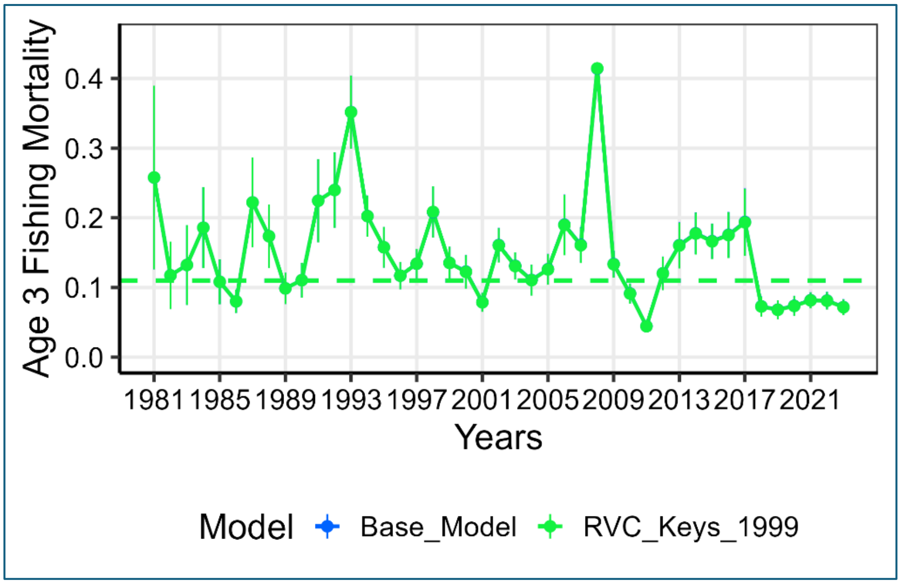


b)



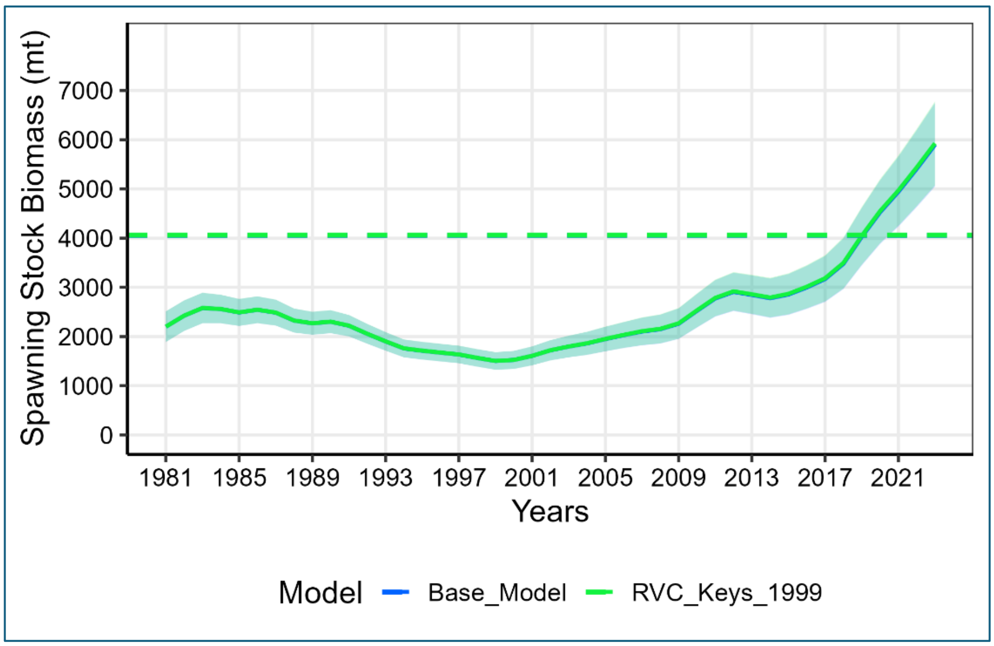
c)

Figure 21. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with $75\%SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with the inclusion of the RVC FL Keys index value and related standard error for 1999 ('RVC Keys 1999').



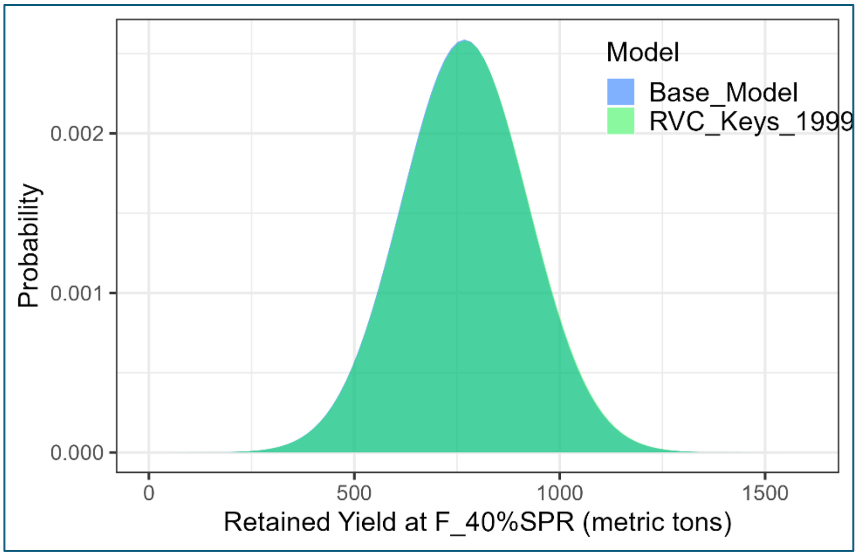
Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981 1985 1989 1993 1997 2001 2005 2009 2013 2017 2021
Years
Model Base_Model RVC_Keys_1999

a)



Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
1981 1985 1989 1993 1997 2001 2005 2009 2013 2017 2021
Years
Model Base_Model RVC_Keys_1999

b)



c)

Figure 22. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with 75%$SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with the inclusion of the RVC FL Keys index value and related standard error for 1999 ('RVC Keys 1999').