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

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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
Halie O'Farrell .... FWC/FWRI
Chris Swanson .... FWC/FWRI
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Ken Brennan .... SEFSC
Matt Campbell .... SEFSC
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Scott Crosson .... SEFSC
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Eric Fitzpatrick .... SEFSC
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Justin Lewis .... FWC
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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
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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:

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

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 $\text{Pauly}_{\text{nls-T}}$ 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 $Pauly_{nls\text{-}T}$ 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 $Pauly_{nls\text{-}T}$ 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 $Pauly_{nls\text{-}T}$ (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:

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

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 '$Pauly_{nls-T}$ 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*	$Pauly_{nls-T}$ 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.

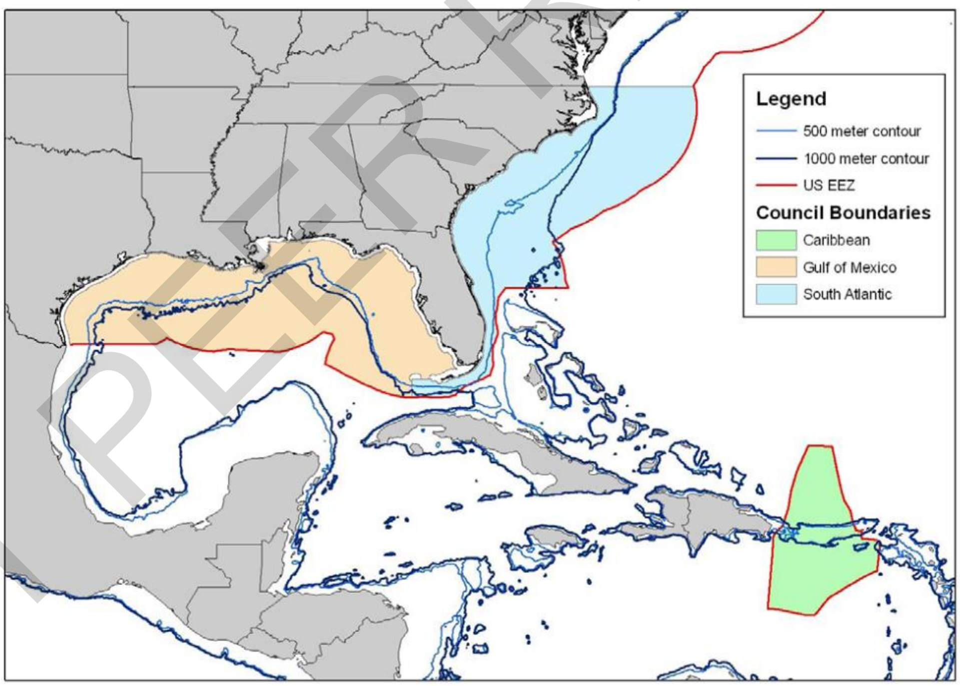

Figure 2.14.2. Jurisdictional boundaries in the Southeast Region for the South Atlantic Fishery Management Council, the Gulf of Mexico Fishery Management Council, and the Caribbean Fishery Management Council.

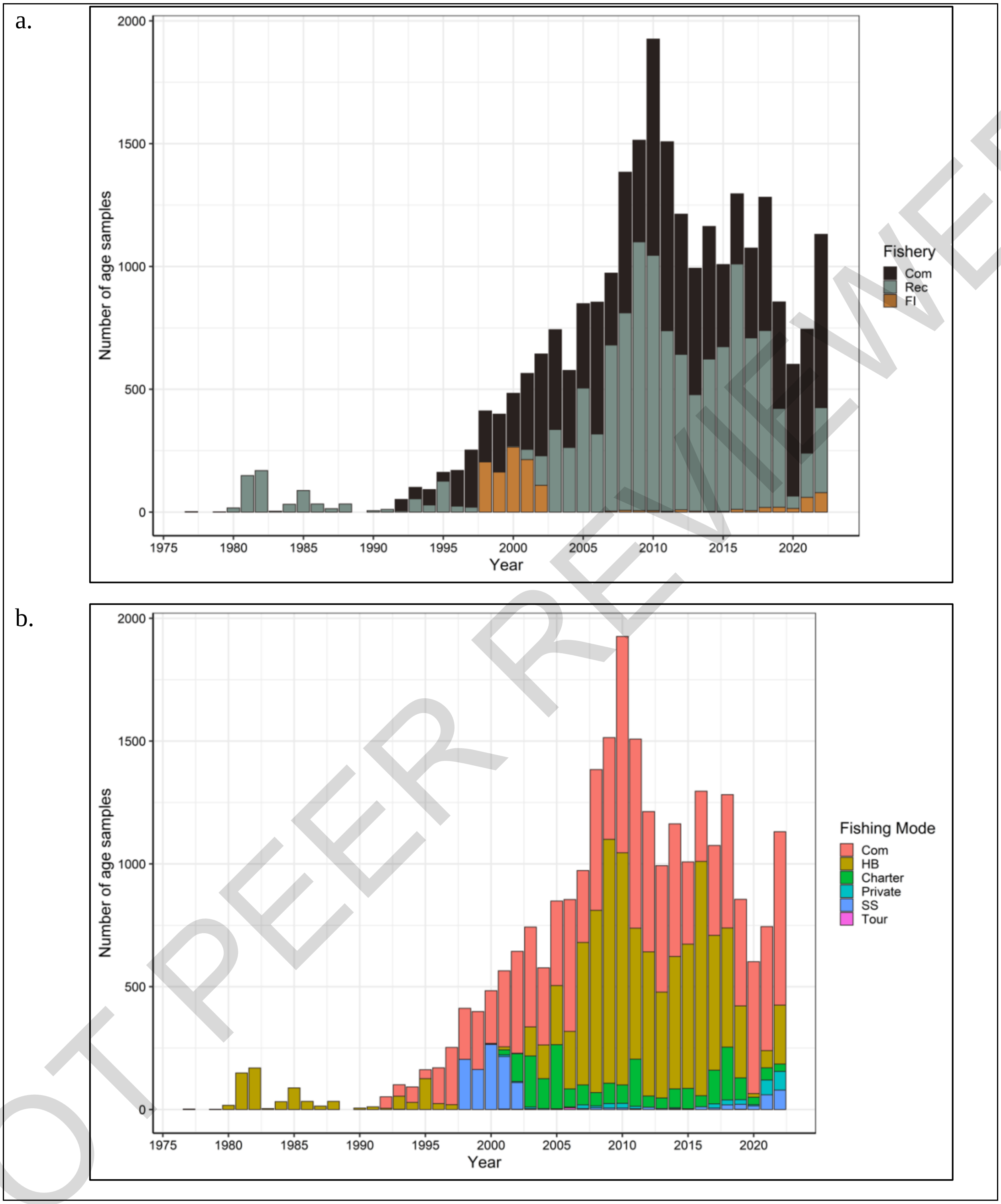

Figure 2.14.3. Number of Mutton Snapper age samples collected per year from the southeastern U.S. from 1977 – 2022. **(a)** Bar plots by commercial (Com), recreational (Rec), and fishery independent (FI) sectors and **(b)** by commercial (Com), recreational (Headboat [HB], Charter, Private, tournament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

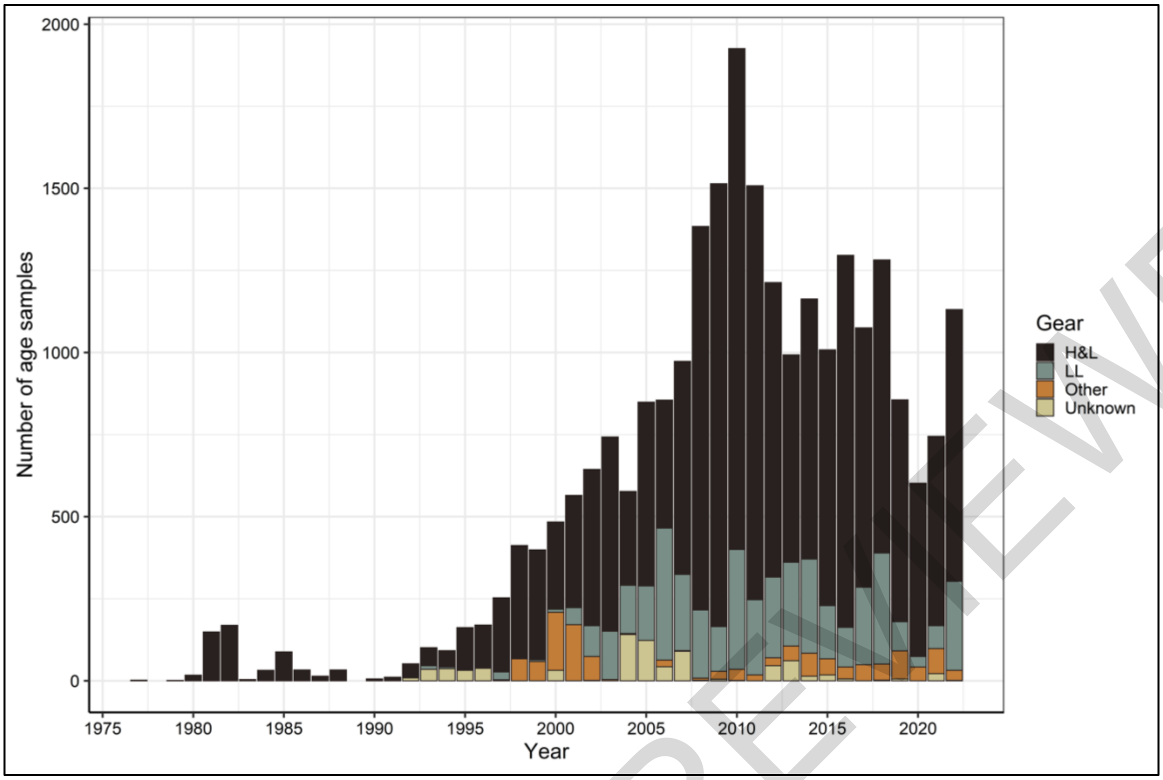

Figure 2.14.4. Number of Mutton Snapper age samples by hook and line (H&L), long line (LL), other, and unknown fishing gears collected from the southeastern U.S. from 1977 – 2022.

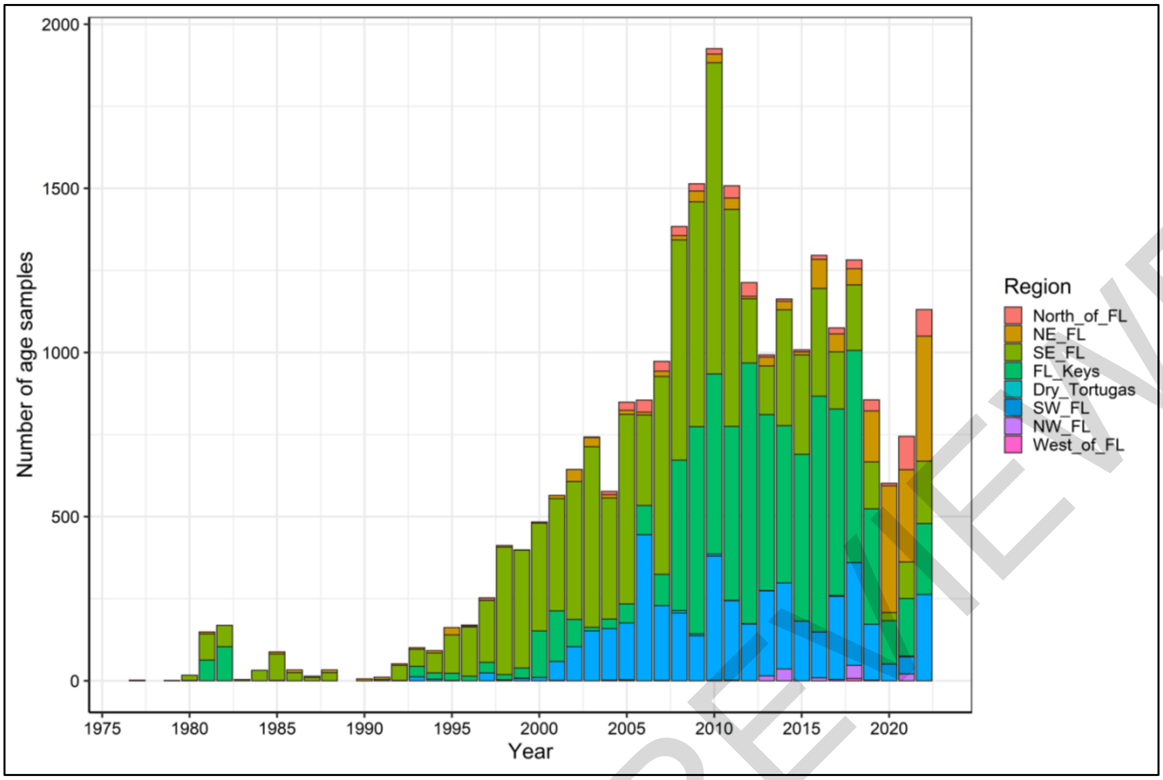

Figure 2.14.5. Number of Mutton Snapper age samples collected by region within the southeastern U.S. from 1977 – 2022.Regions are defined as North of Florida (North of FL), Northeast Florida (NE FL), Southeast Florida (SE FL), the Florida Keys (FL Keys), the Dry Tortugas (Dry Tortugas), Southwest Florida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

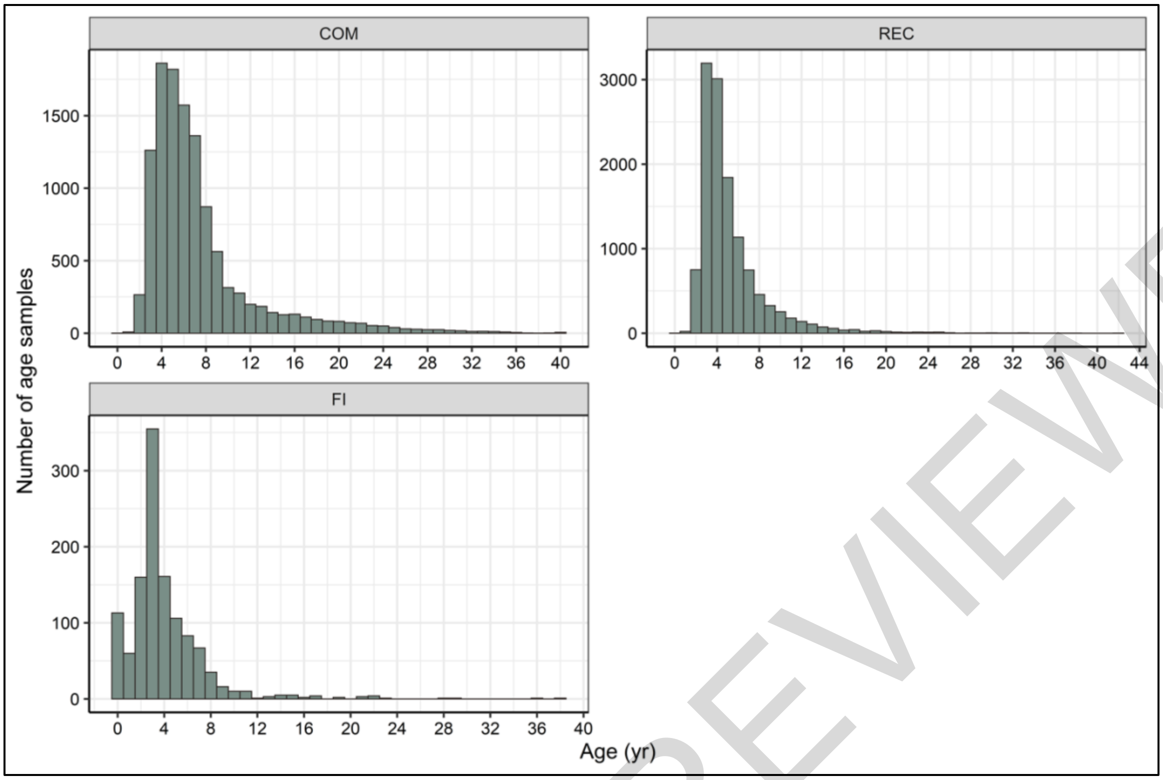

Figure 2.14.6. Histograms of Mutton Snapper age samples collected by commercial (COM), recreational (REC), and fishery independent (FI) sectors within the southeastern U.S. Bin increments are equal to 1 year.

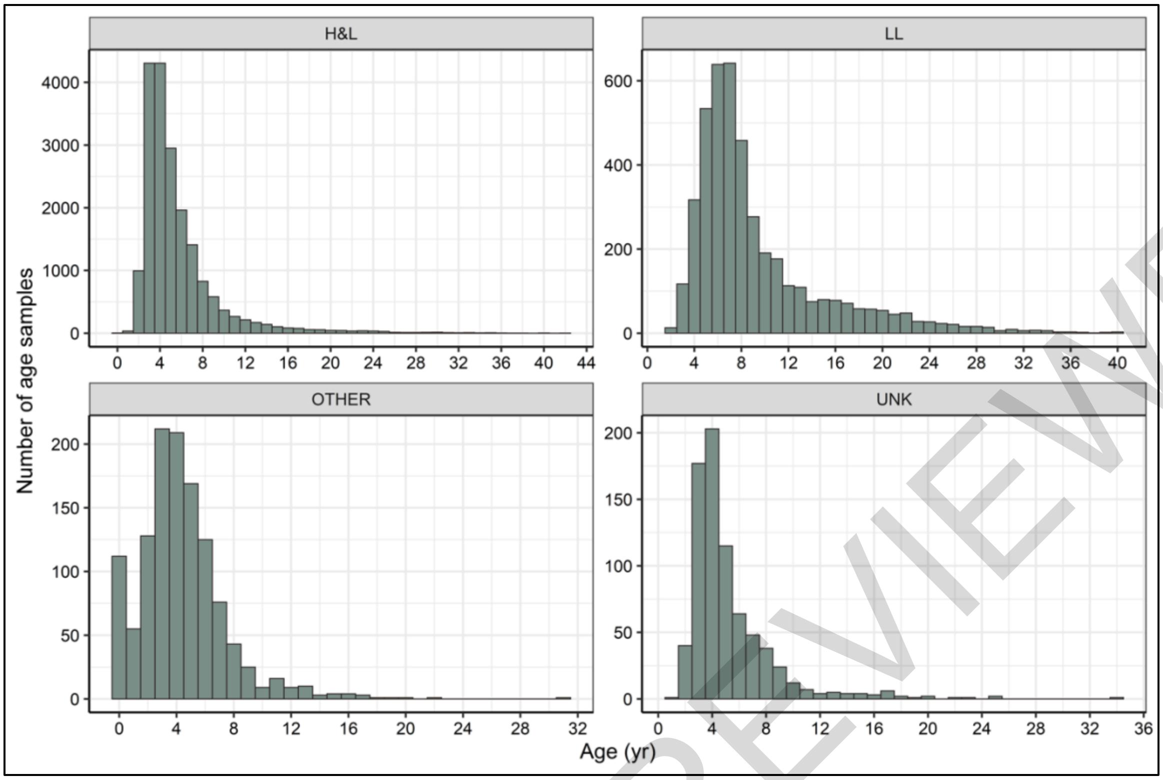

Figure 2.16.7. Histograms of southeastern U.S. Mutton Snapper age samples collected by gear from fishery-dependent and -independent data sources between 1977 – 2022. Bin increments are equal to 1 year.

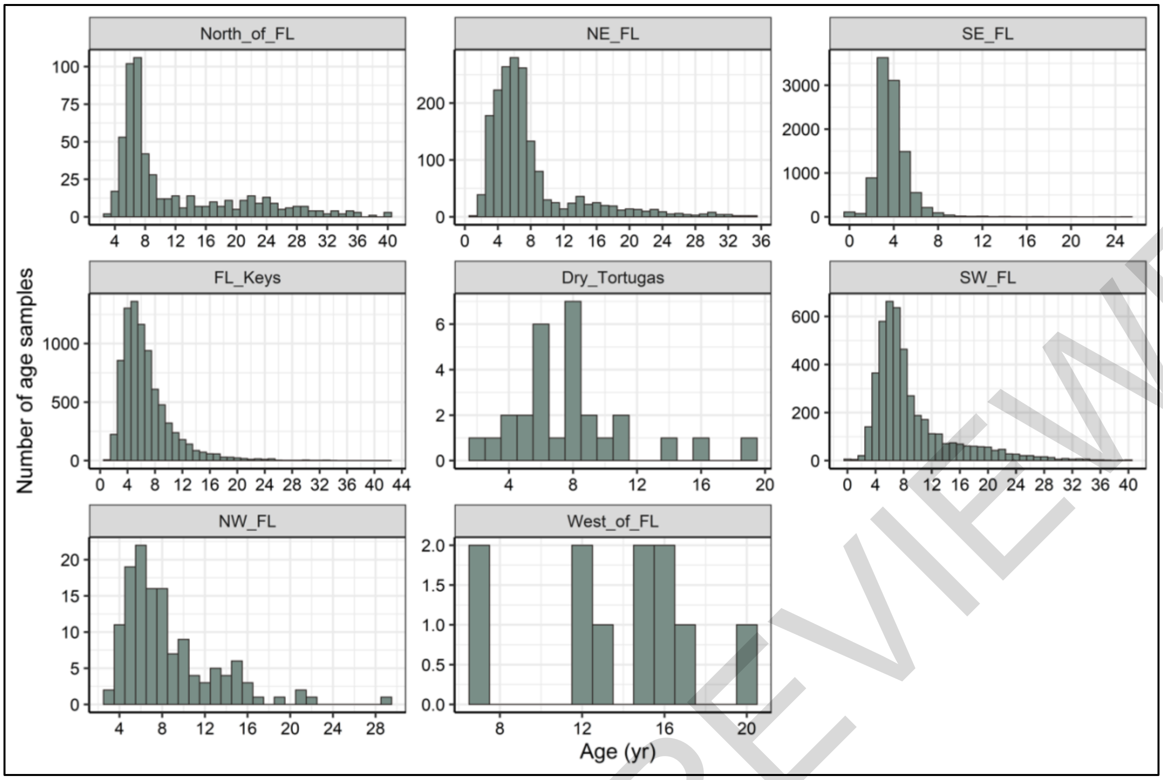

Figure 2.14.8. Histograms of Mutton Snapper age samples collected by region within the southeastern U.S. Regions are defined as North of Florida (North of FL), Northeast Florida (NE FL), Southeast Florida (SE FL), the Florida Keys (FL Keys), the Dry Tortugas (Dry Tortugas), Southwest Florida (SW FL),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

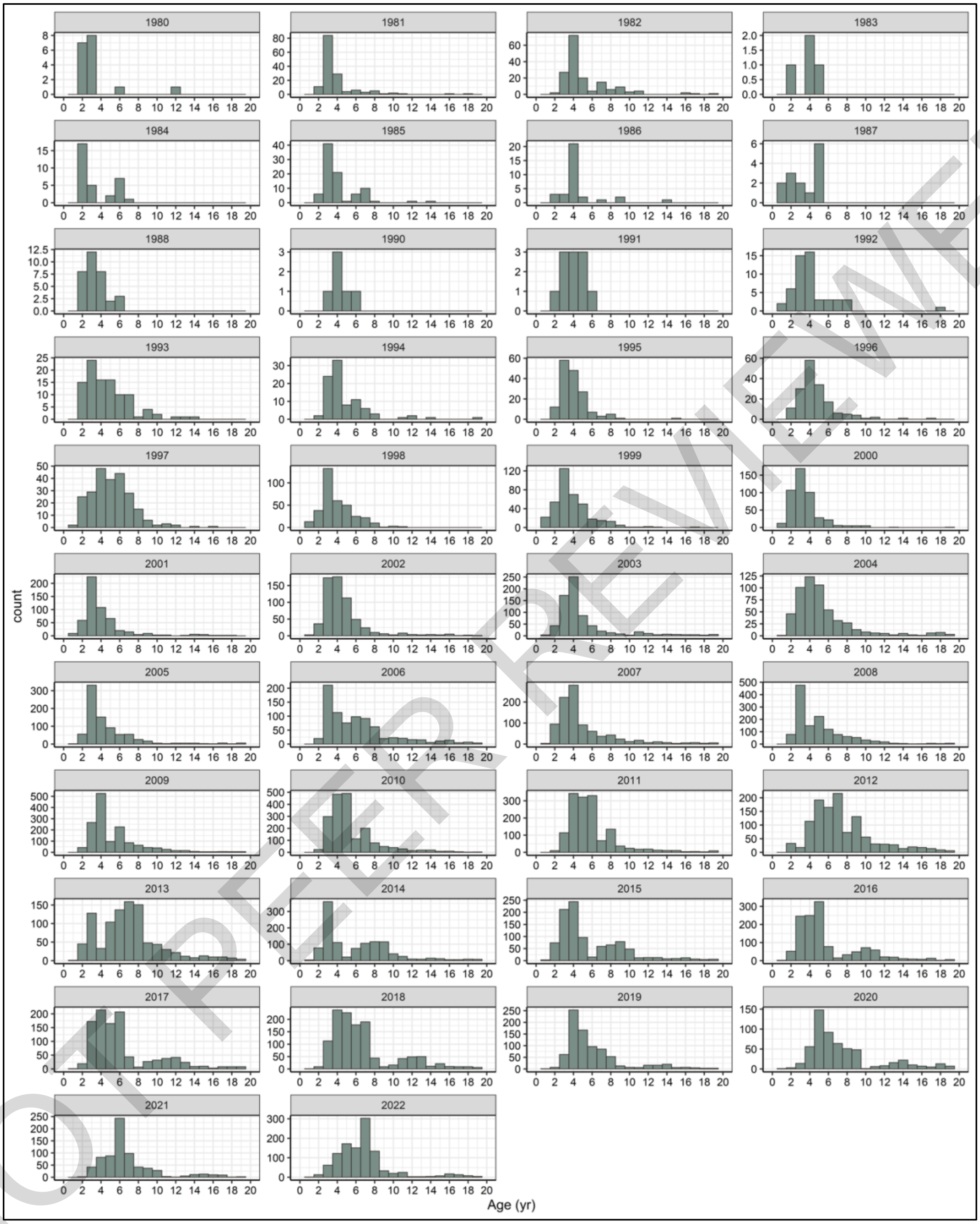

Figure 2.14.9. Histograms of Mutton Snapper age samples by calendar age (curtailed to ages 0 to 20 years) collected from the southeastern U.S. from 1980 – 2022. Bin increments are equal to 1 year.

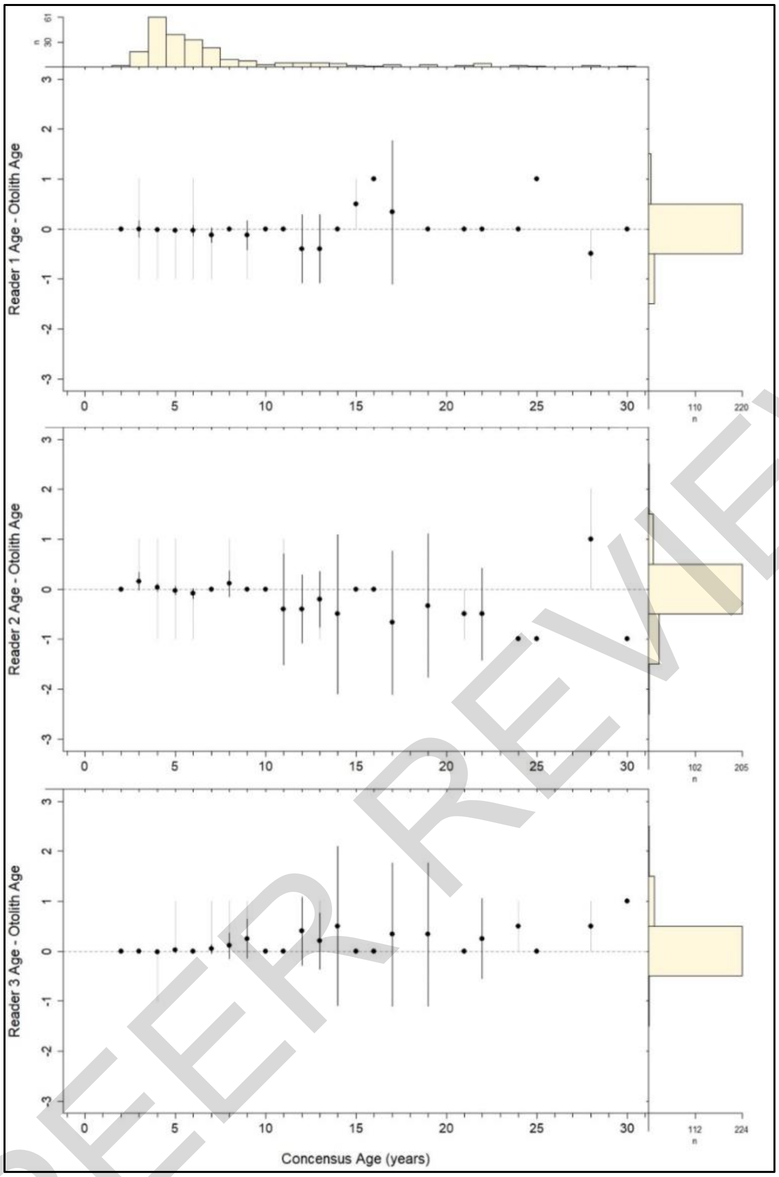

Figure 2.14.10. Age bias plots for the three primary FWRI ageing staff from quality control subsample (n=240). X-axis is consensus age, y-axis is agreement between reader and consensus age. The gray vertical lines of each point demonstrate the age estimation range by each reader, and the black vertical 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.

a.

b.

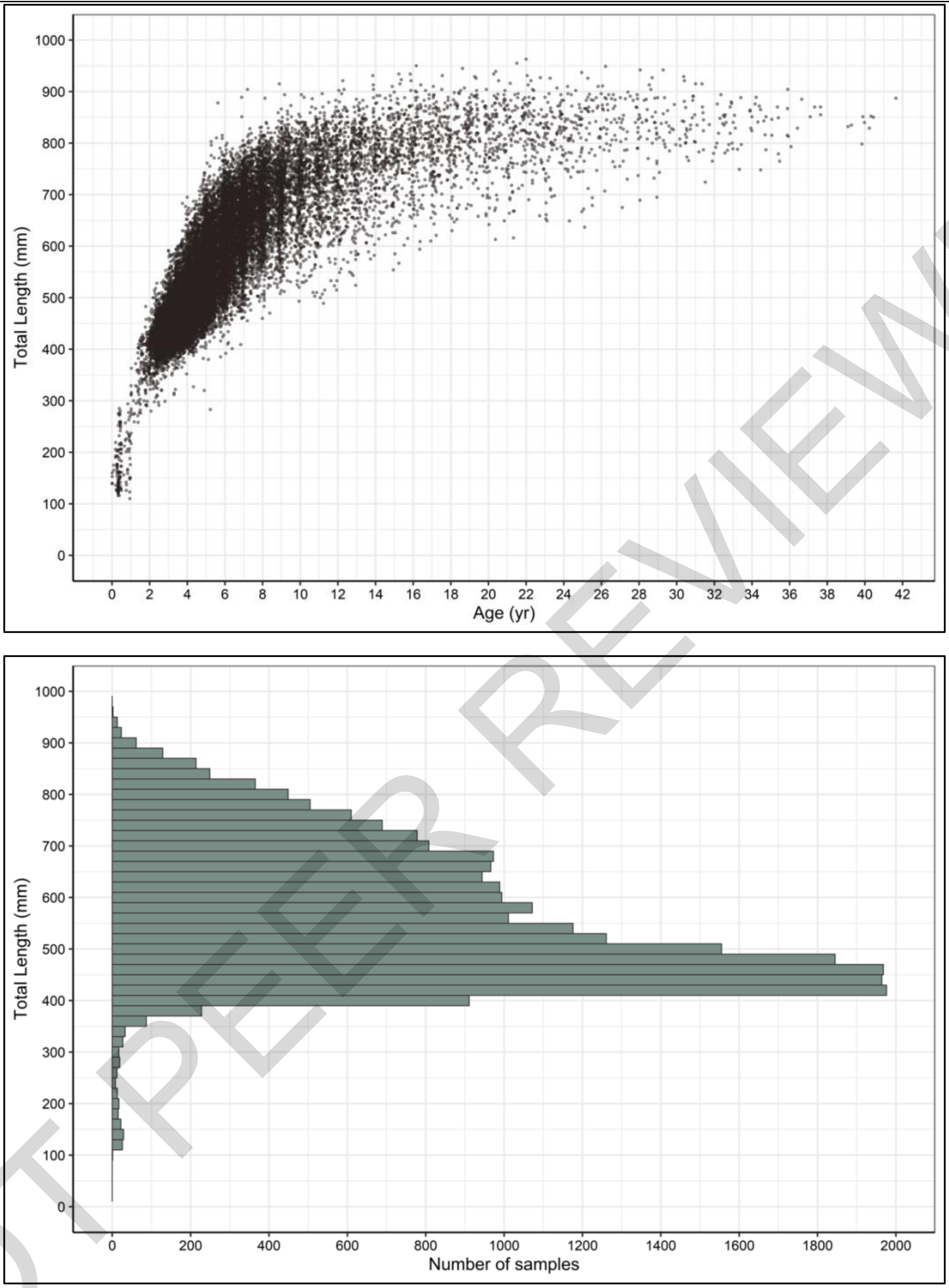

Figure 2.14.11. Southeastern U.S. Mutton Snapper collected from fishery-dependent and -independent data sources between 1977 – 2022. (**a**) Scatterplot of the length ('maximum' total length mm)-at-age (fractional, yr) and (**b**) histogram of the number of length samples in 20 mm bin increments.

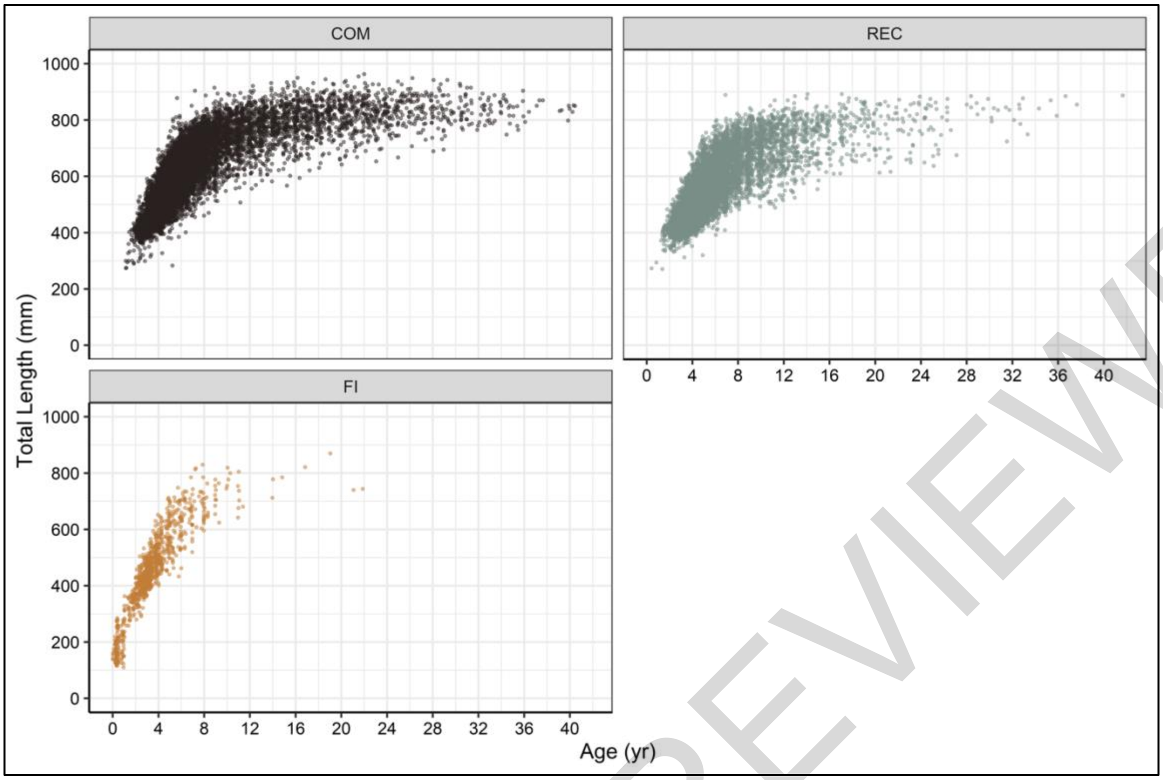

Figure 2.14.12. Southeastern U.S. Mutton Snapper length ('maximum' total length mm)-at-age (fractional, yr) by commercial (COM), recreational (REC), and fishery independent (FI) sectors between 1977 – 2022.

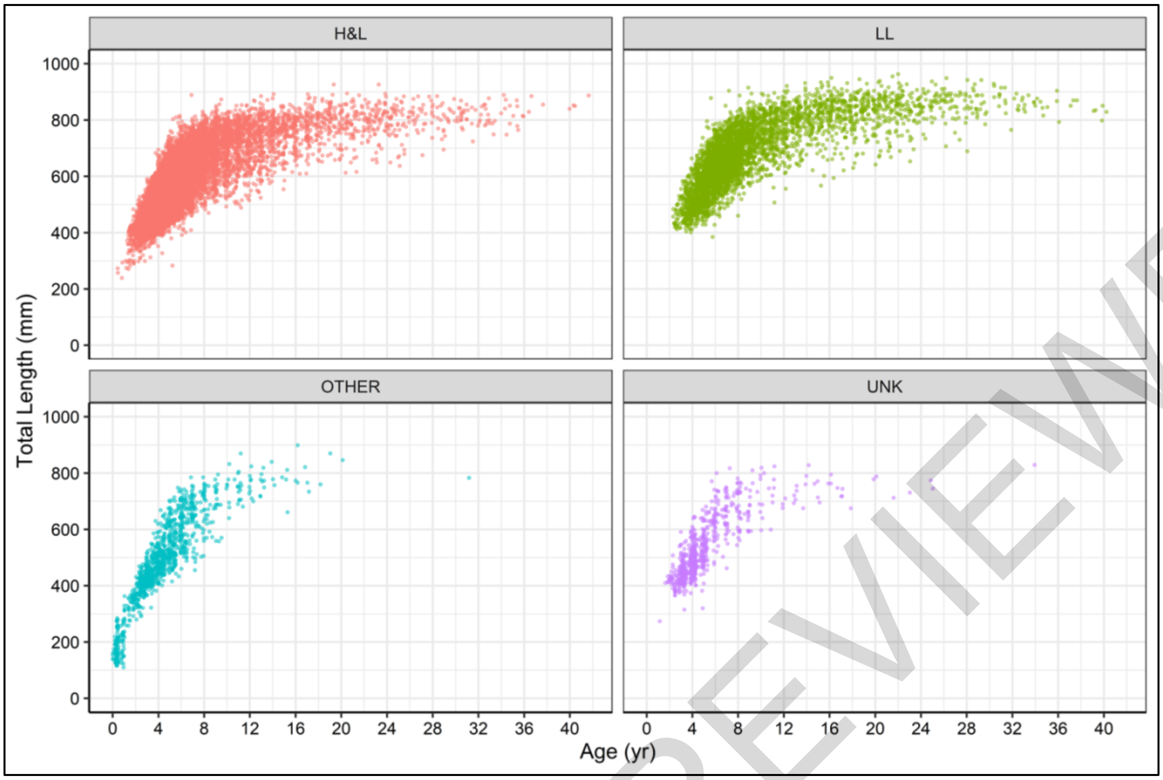

Figure 2.14.13. Southeastern U.S. Mutton Snapper length (‘maximum’ total length mm)-at-age (fractional, yr) by gear from fishery-dependent and -independent data sources between 1977 – 2022.

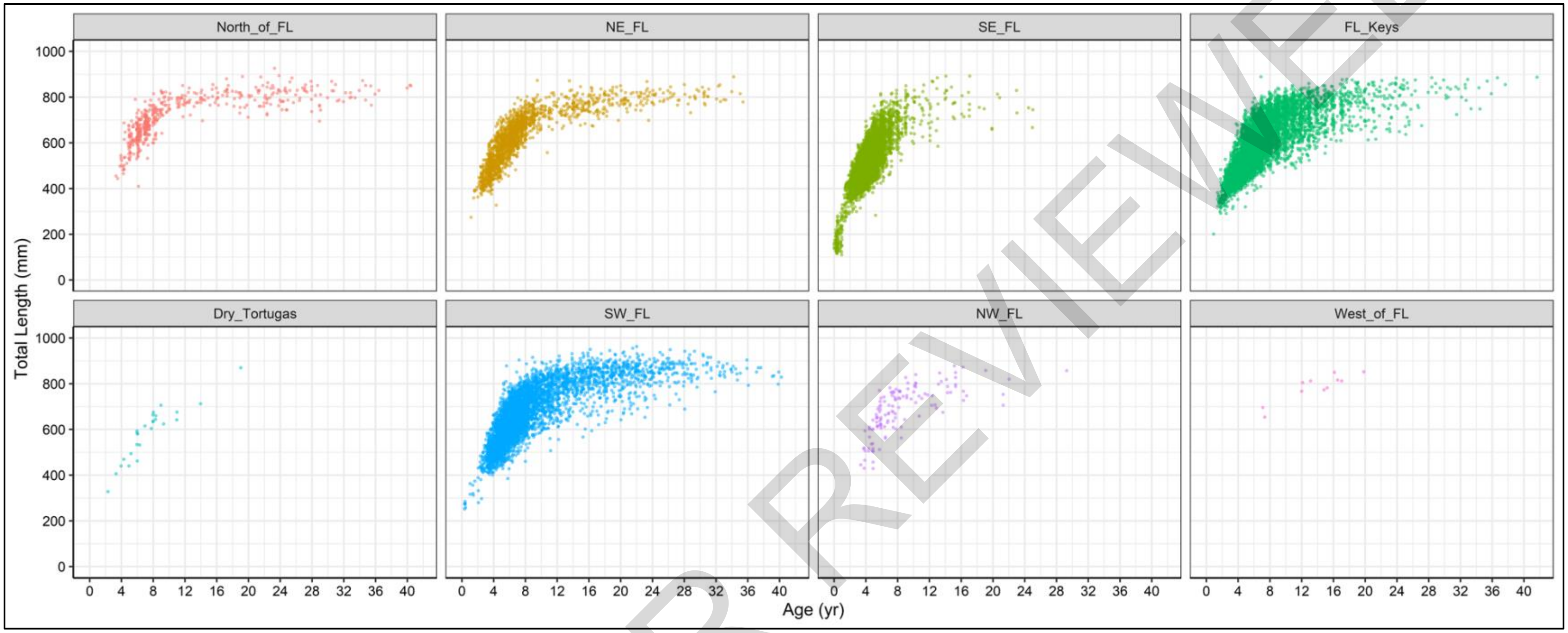

Figure 2.14.14. Southeastern U.S. Mutton Snapper length ('maximum' total length mm)-at-age (fractional, yr) by region between 1977 – 2022. Regions are defined as North of Florida (North of FL), Northeast Florida (NE FL), Southeast Florida (SE FL), the Florida Keys (FL Keys), the Dry Tortugas (Dry Tortugas),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

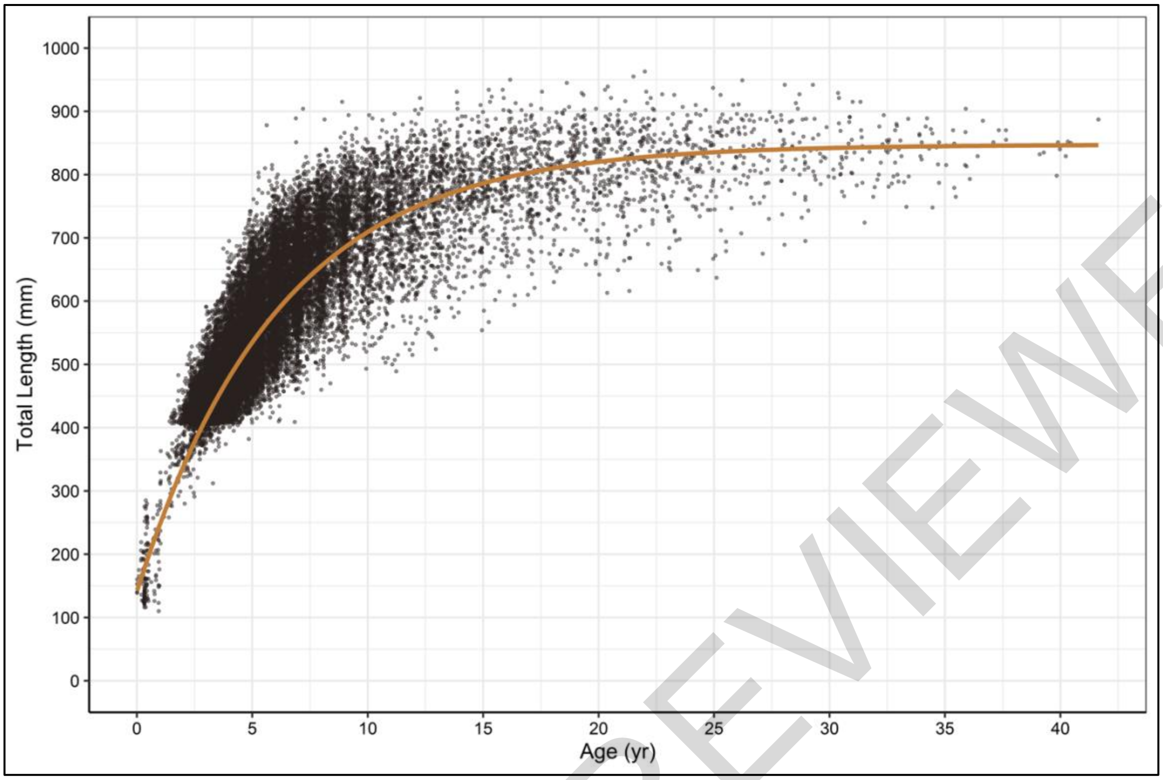

Figure 2.14.15. Size-truncated southeastern U.S. Mutton Snapper length ('maximum' total length mm)-at-age (fractional, yr) collected from fishery-dependent and -independent data sources between 1977 – 2022 (n = 24,234 otoliths). The dark orange line is the predicted length-at-age from the best fit size-truncated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

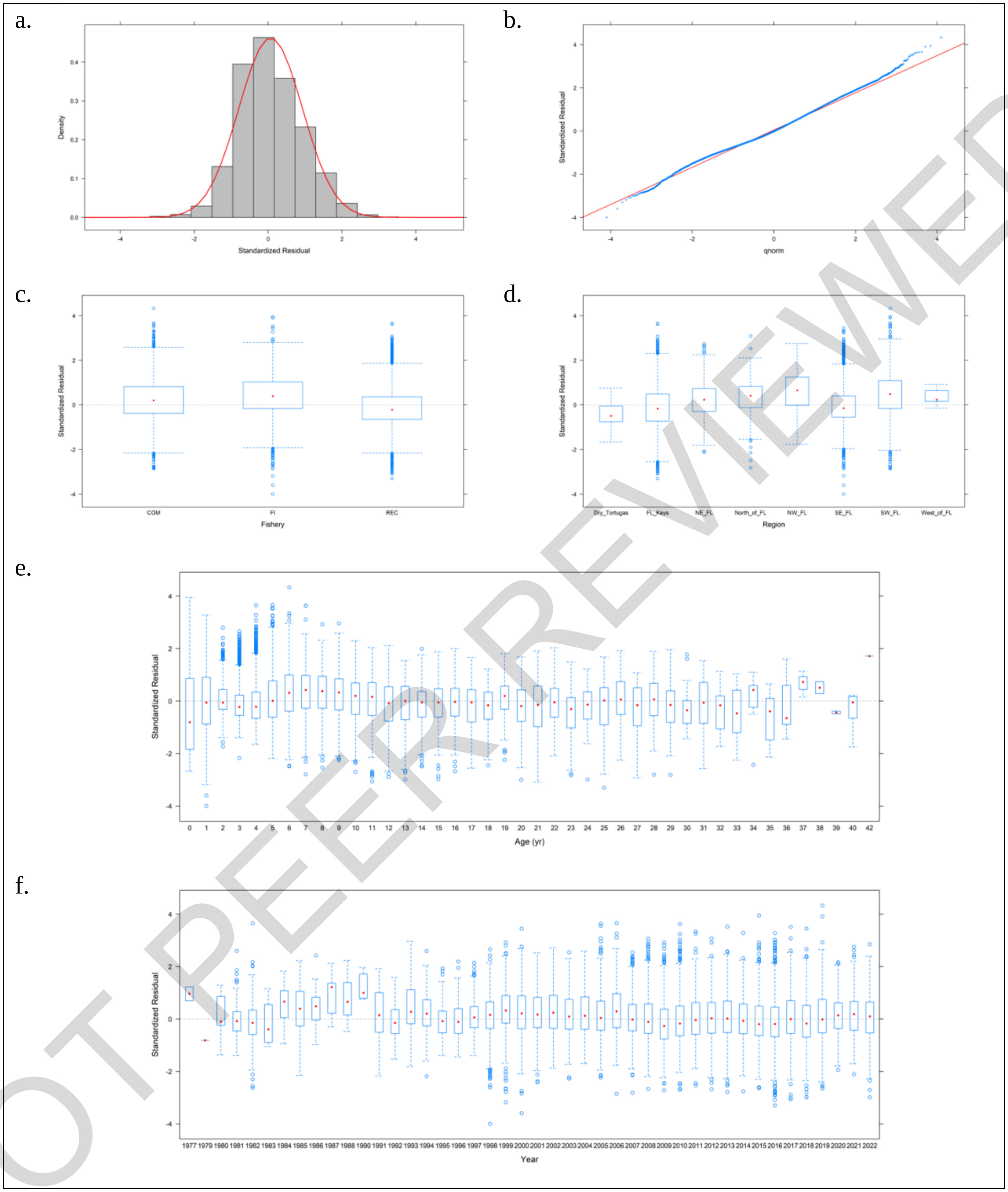

Figure 2.14.16. Standardized residual diagnostic plots for the size-truncated von Bertalanffy growth model applied to inverse-weighted data where CV was a linear function of age: a) density distribution, b) normal probability plot (quantiles vs standardized residuals), c) standardized residuals by fishery,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

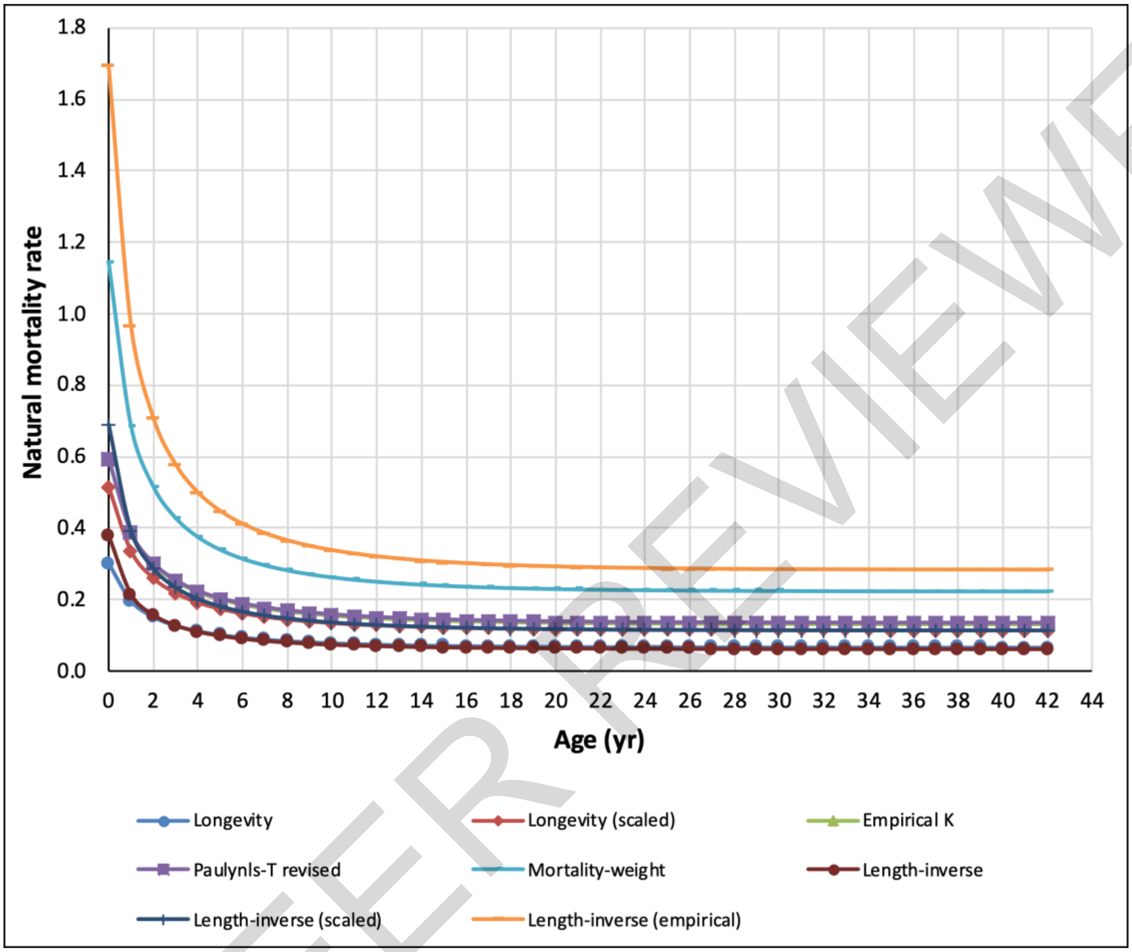

Figure 2.14.17. Natural mortality-at-age, *M(a)*, of Mutton Snapper with an observed maximum age of 42 years. 'Longevity', 'Empirical K', and the 'Pauly$_{nls\text{-}T}$ revised' estimates of *M(a)* are derived following Lorenzen (2000, 2005) using their respective constant *M* estimates (0.129, 0.253, 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. 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.

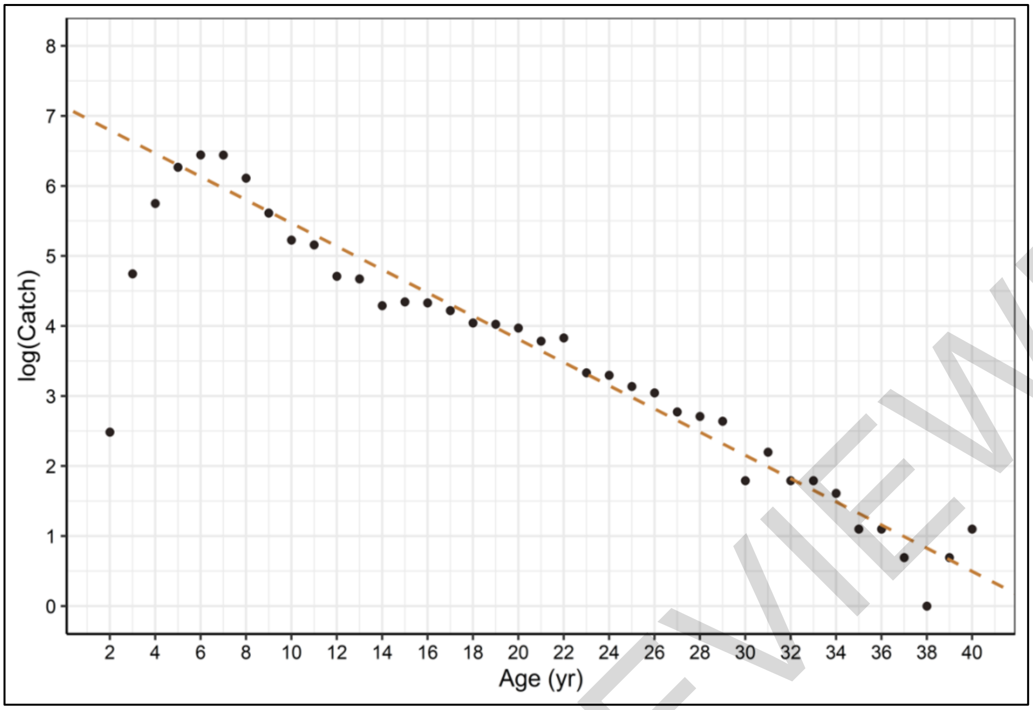

Figure 2.14.18. Commercial long line catch-at-age data (log transformed) of southeastern U.S. Mutton Snapper from 1992 – 2022 for catch curve analysis. The dashed line is the weighted linear regression fit to ages 6 – 40 whom are considered fully selected.

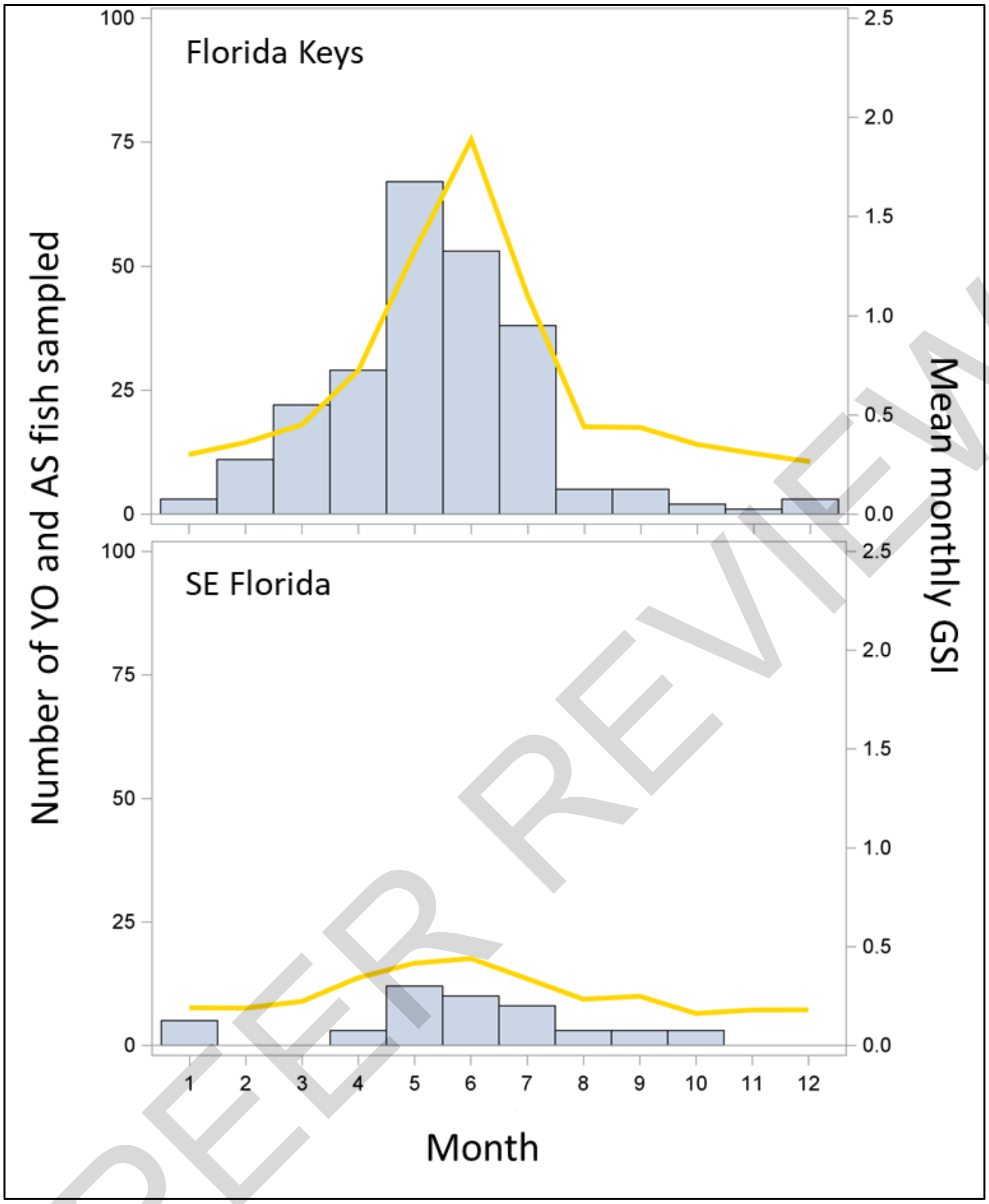

Figure 2.14.19. Female Mutton Snapper macroscopically staged as having yolked oocytes (macroscopic reproductive phase “YO”) occurred in all months in the Florida Keys and most months in southeast (SE) Florida. The number of YO females peaked in May, with GSI of all females peaking in June. GSI and number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

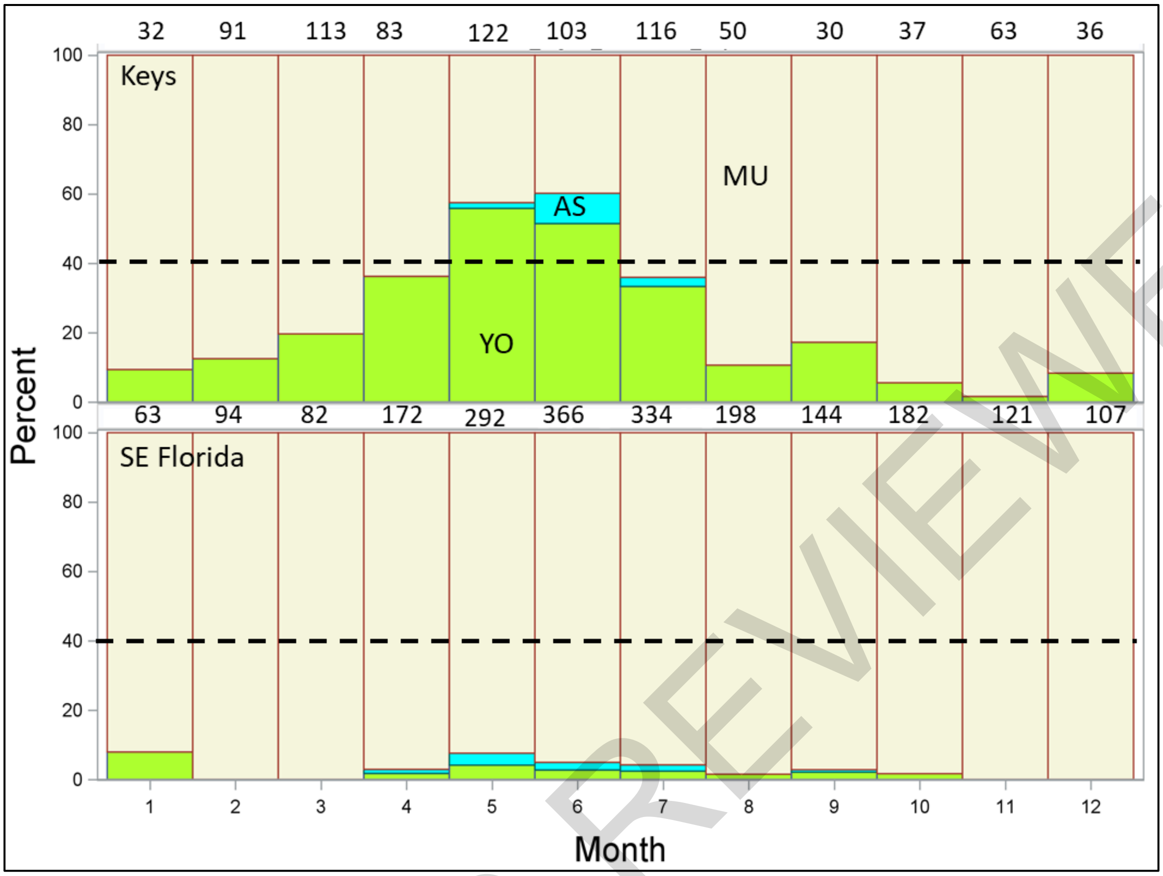

Figure 2.14.20. Monthly proportion of macroscopic phases (YO = yolked, AS = active spawner, MU = mature undeveloped) of Mutton Snapper. Peak spawning occurred in May and June when the proportion of spawning capable females (YO and AS) was > 40% (dashed reference line).

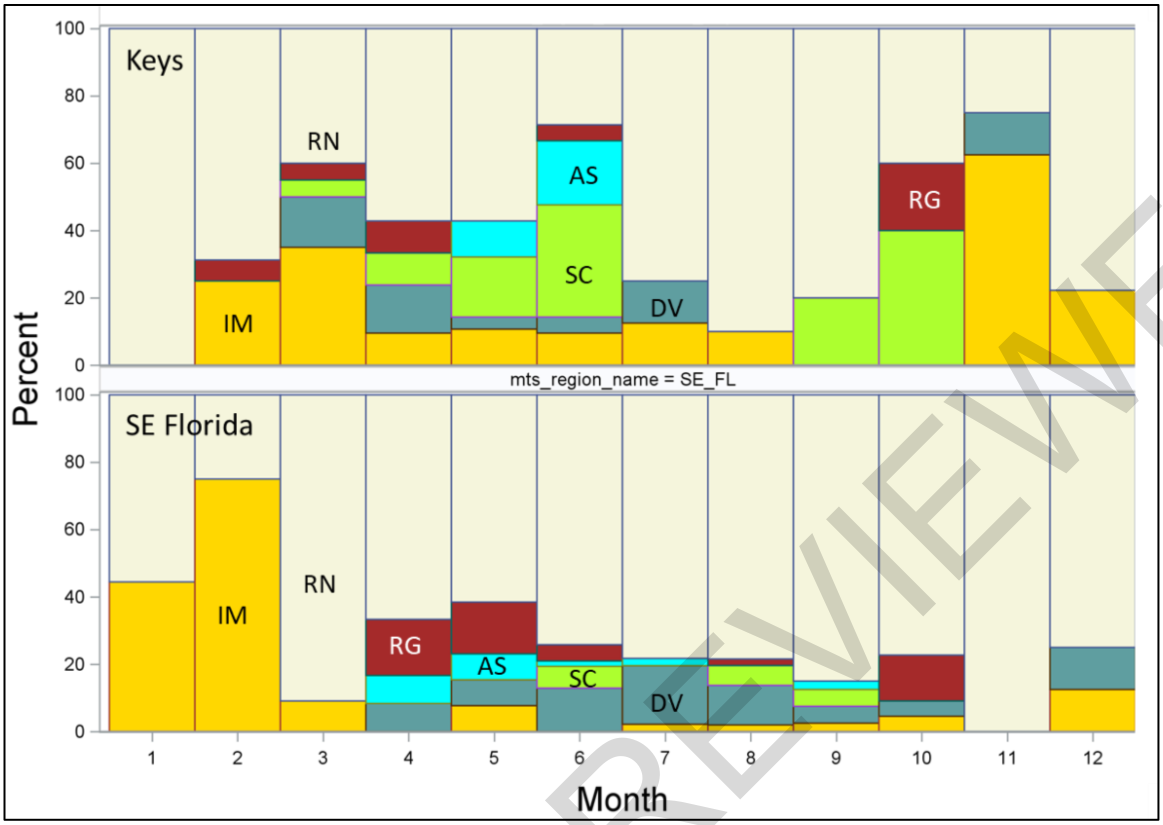

Figure 2.14.21. Frequency plot of monthly histological reproductive phases of Mutton Snapper by study area (Florida Keys (Keys): n = 156; southeast (SE) Florida, n = 294). IM = Immature, DV = Developing, SC = Spawning capable, AS = Active Spawner RG = Regressing, RN=regenerating.

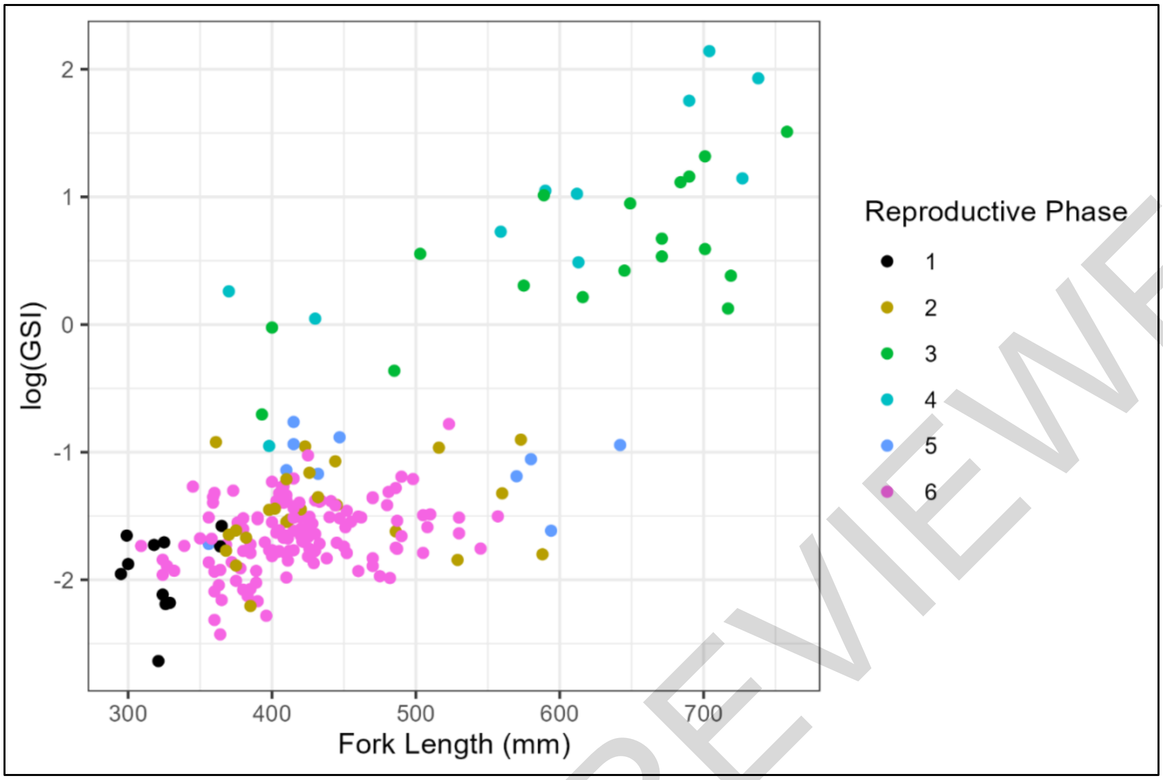

Figure 2.14.22. GSI in log space as a function of fork length for Mutton Snapper samples assessed via histology (n = 213), showing GSI cannot be used to distinguish immature (Reproductive Phase 1) individuals from mature, non-spawning individuals.

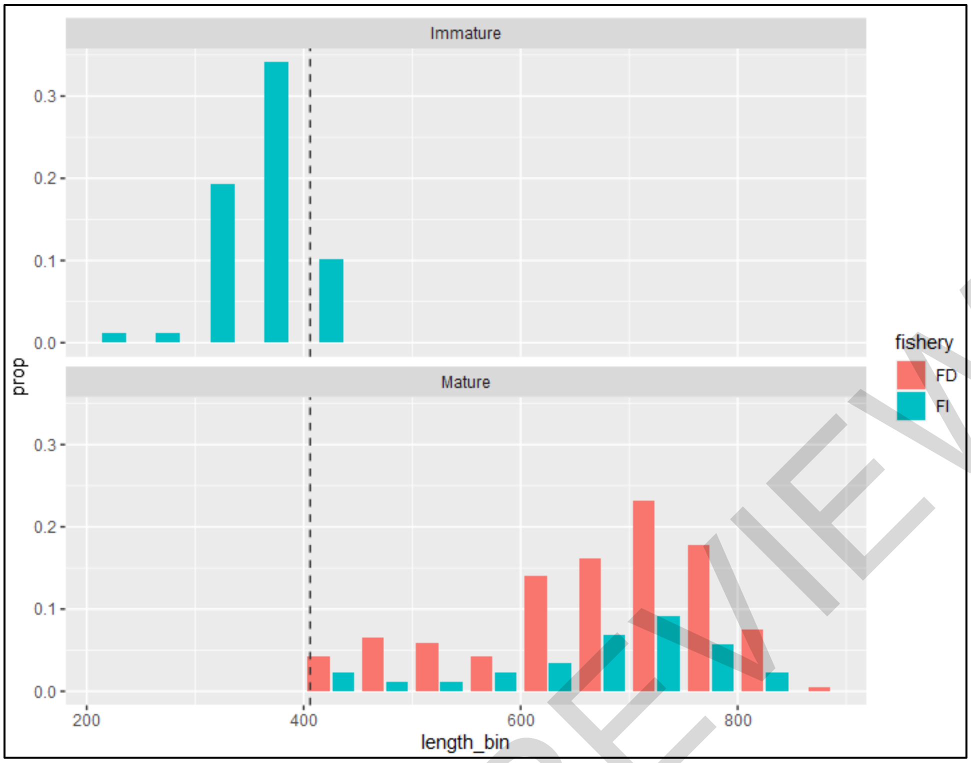

Figure 2.14.23. Length distribution (shown as proportions by fishery; FI = fishery-independent, FD = fishery-dependent) for the 274 female Mutton Snapper used in the recommended maturity-at-length model (All year, Histo and Macro spawning capable and actively spawning) for natural total length. All immature 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.

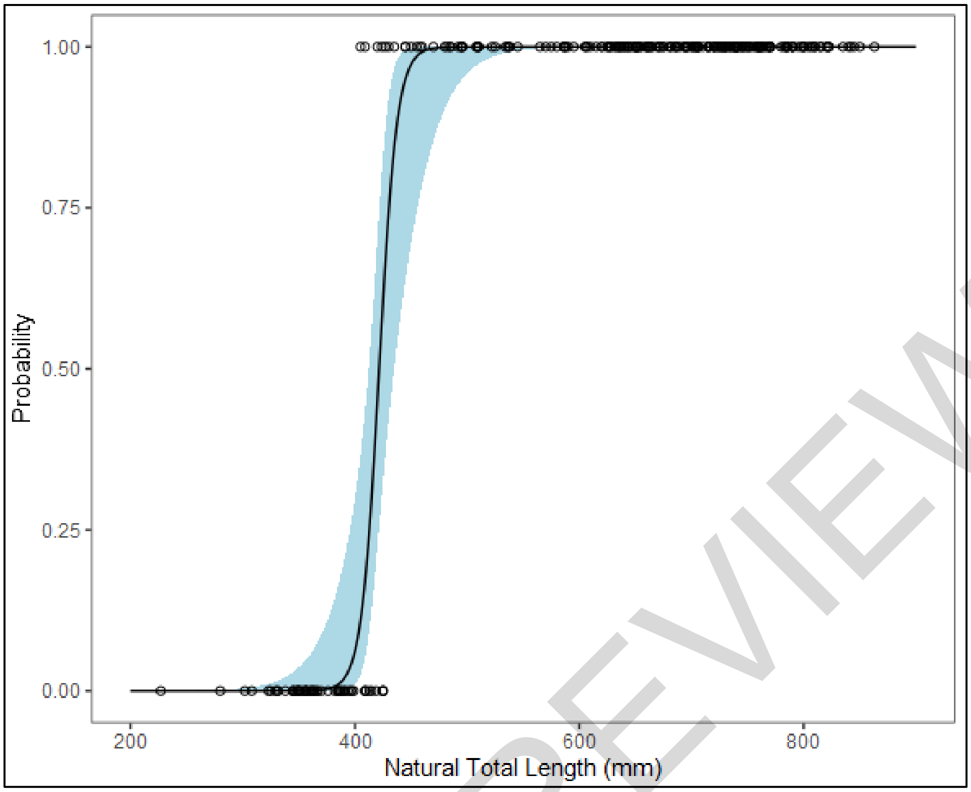

Figure 2.14.24. Observed (n = 274) and predicated fork length-at-maturity for Mutton Snapper with 95% confidence intervals for the model that included all sampling months and spawning capable or actively spawning females assigned through histology and macroscopic staging in the mature group. The estimated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

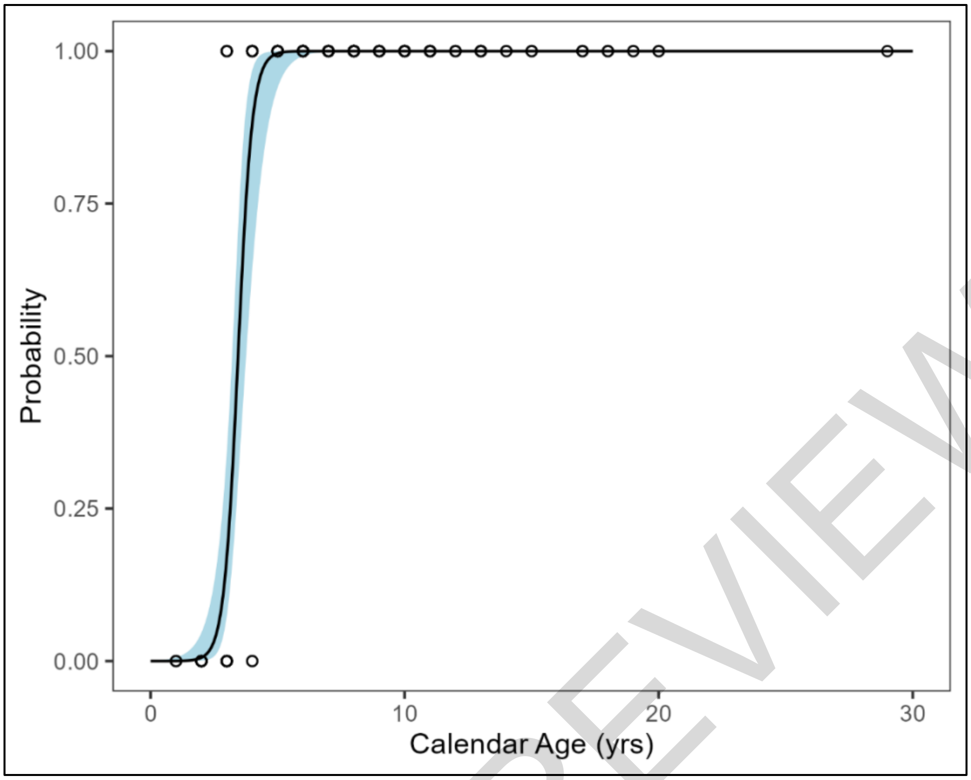

Figure 2.14.25. Observed (n = 240) and predicated age-at-maturity for Mutton Snapper with 95% confidence intervals for the model that included all sampling months and spawning capable or actively spawning females assigned through histology and macroscopic staging in the mature group. The estimated age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

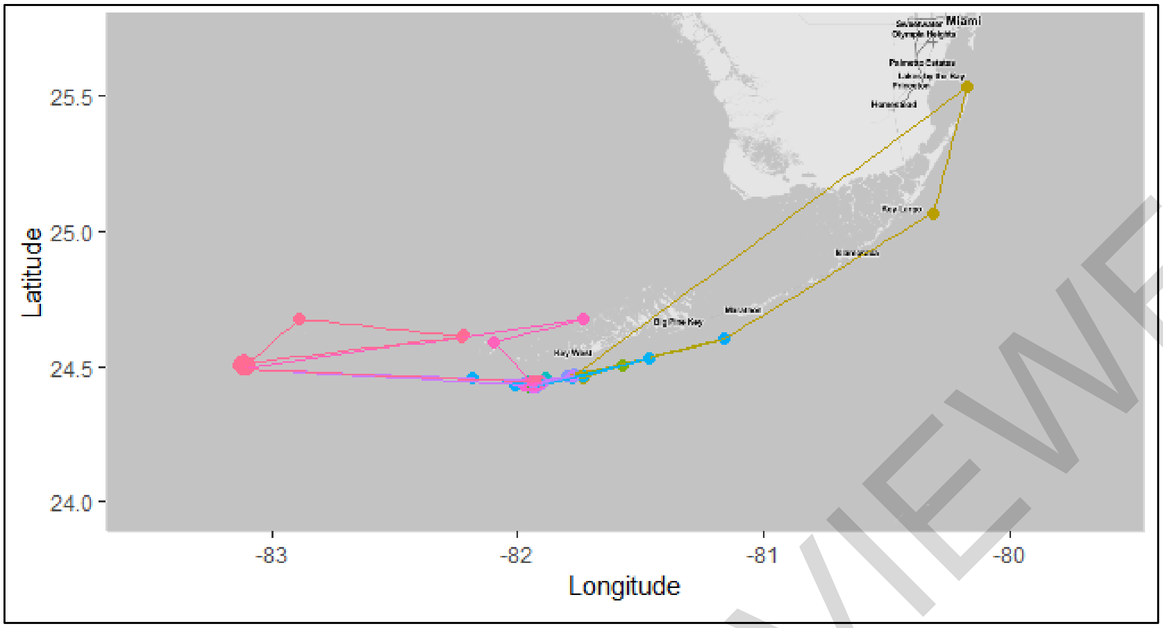

Figure 2.14.26. Total movement paths (April 2021 – May 2023) of Mutton Snapper tagged at Western Dry Rocks off Key West, FL. Colors represent different individuals, circles represent detections at acoustic receivers, and lines represent movement between detections.

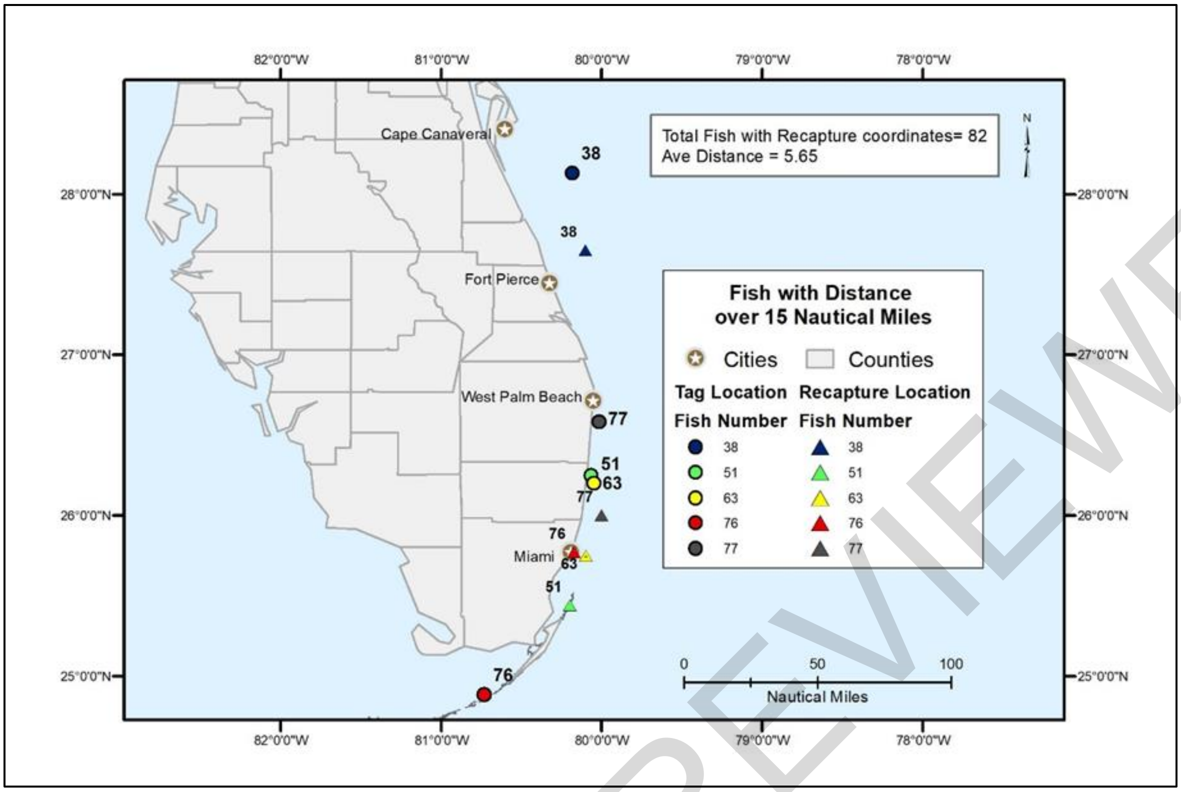

Figure 2.14.27. Mark-recapture locations of southeastern U.S. Mutton Snapper whose tagging and subsequent recapture locations were with more than 15 nautical miles.

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.

Discards

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

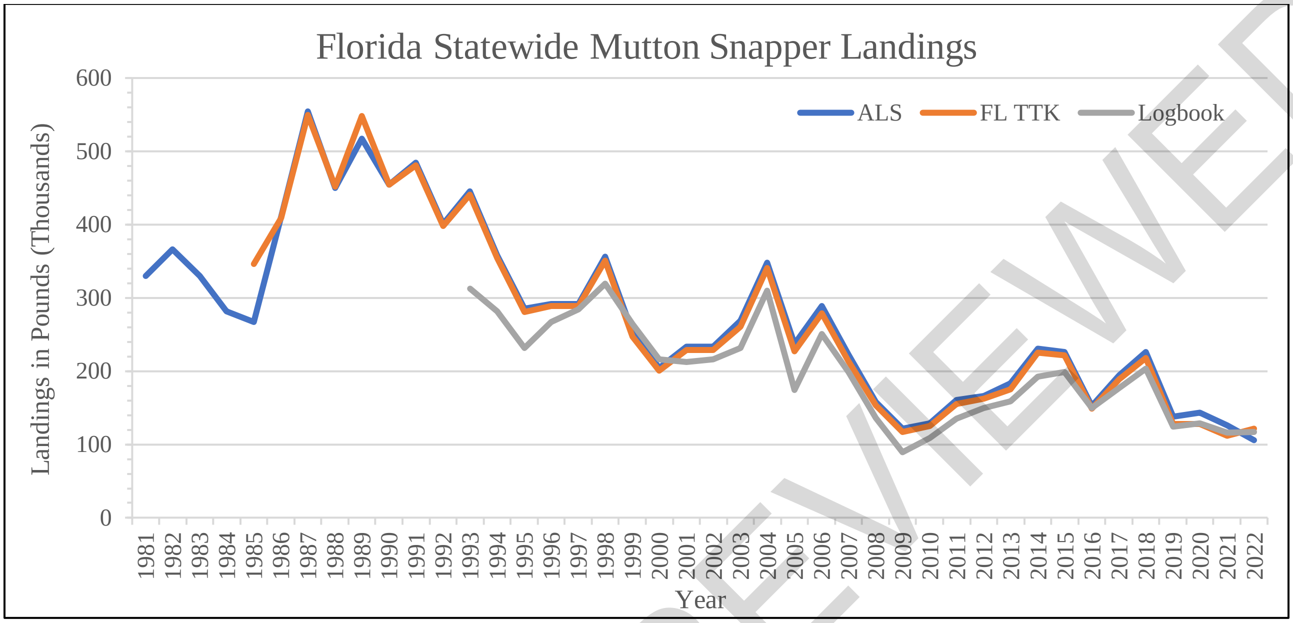


Figure 3.11.1 Comparison of total mutton snapper landings for Florida between the Accumulative Landings System (ALS), Florida Trip Ticket Program (FL TTK), and the Coastal Logbook Program (Logbook).

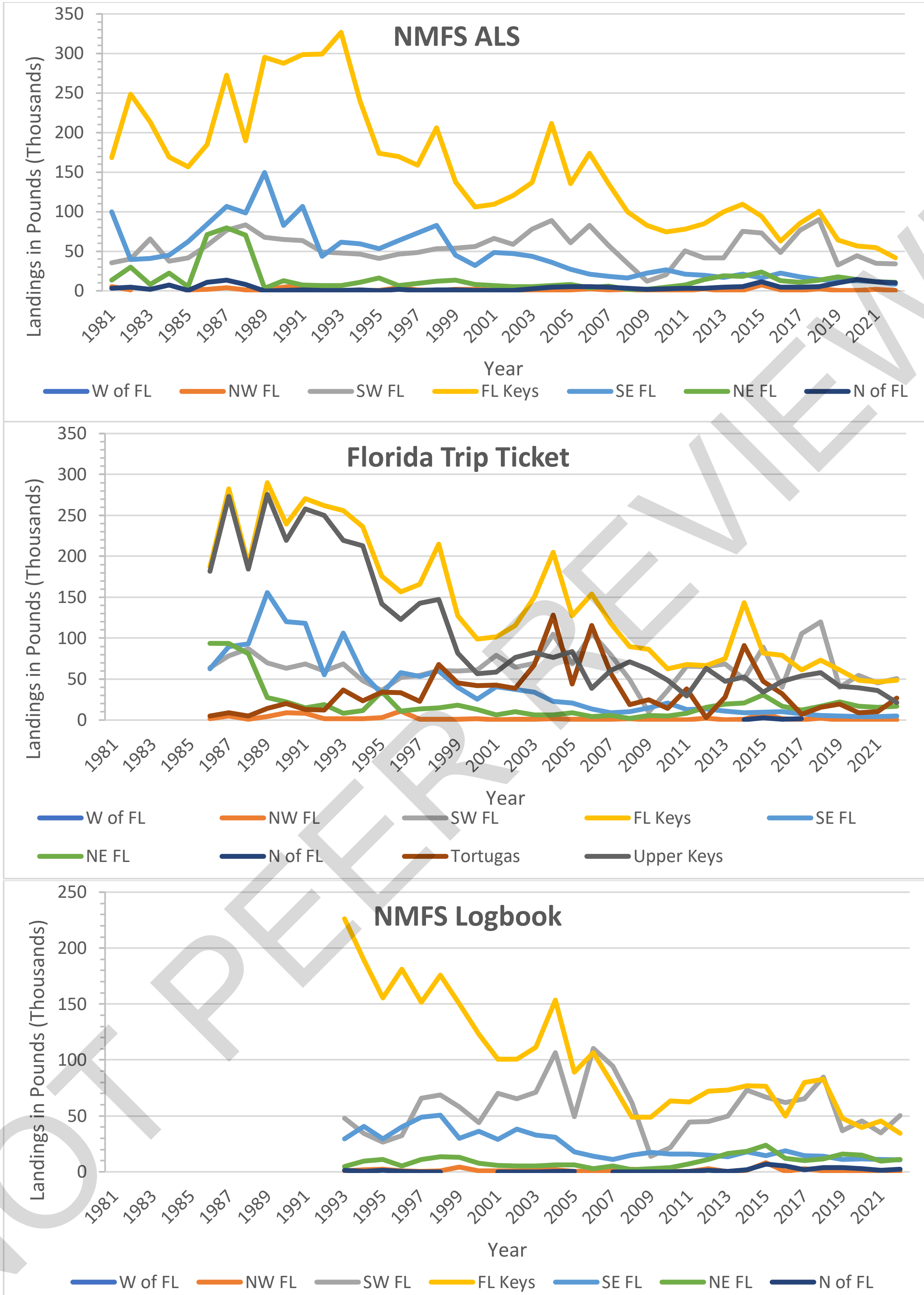
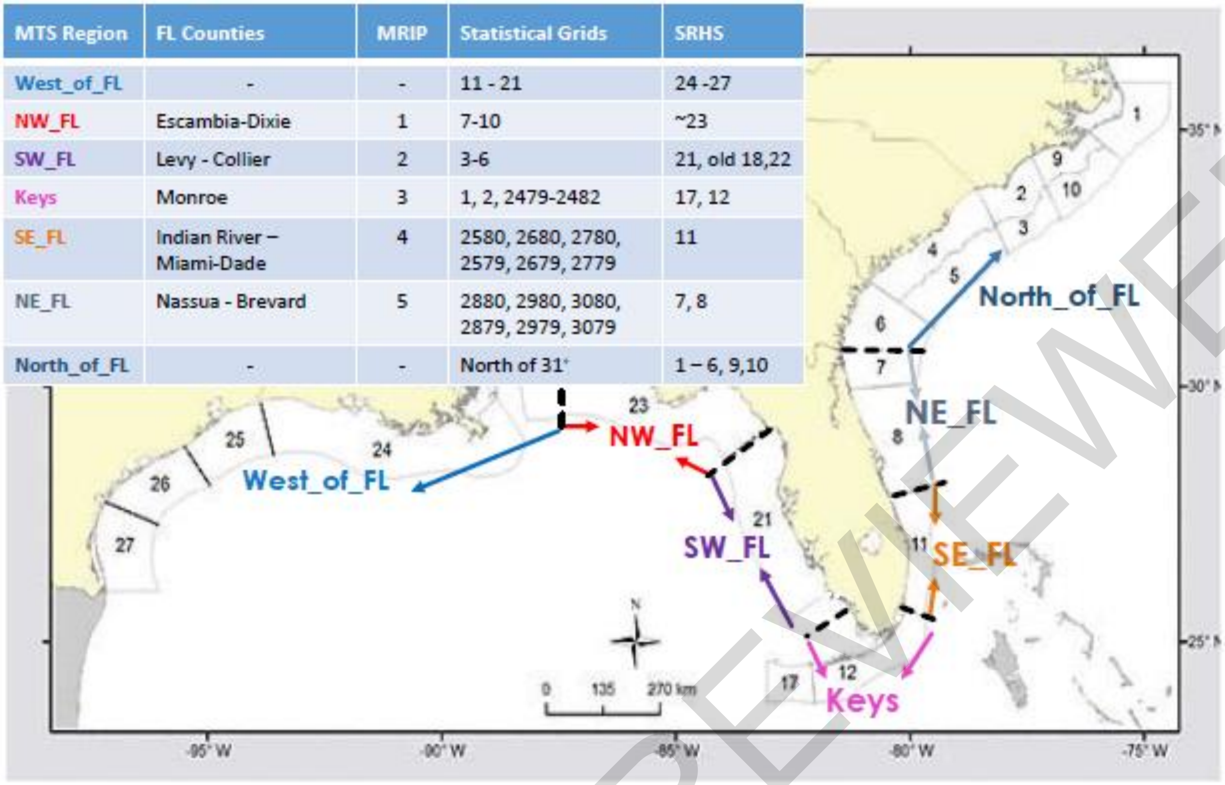
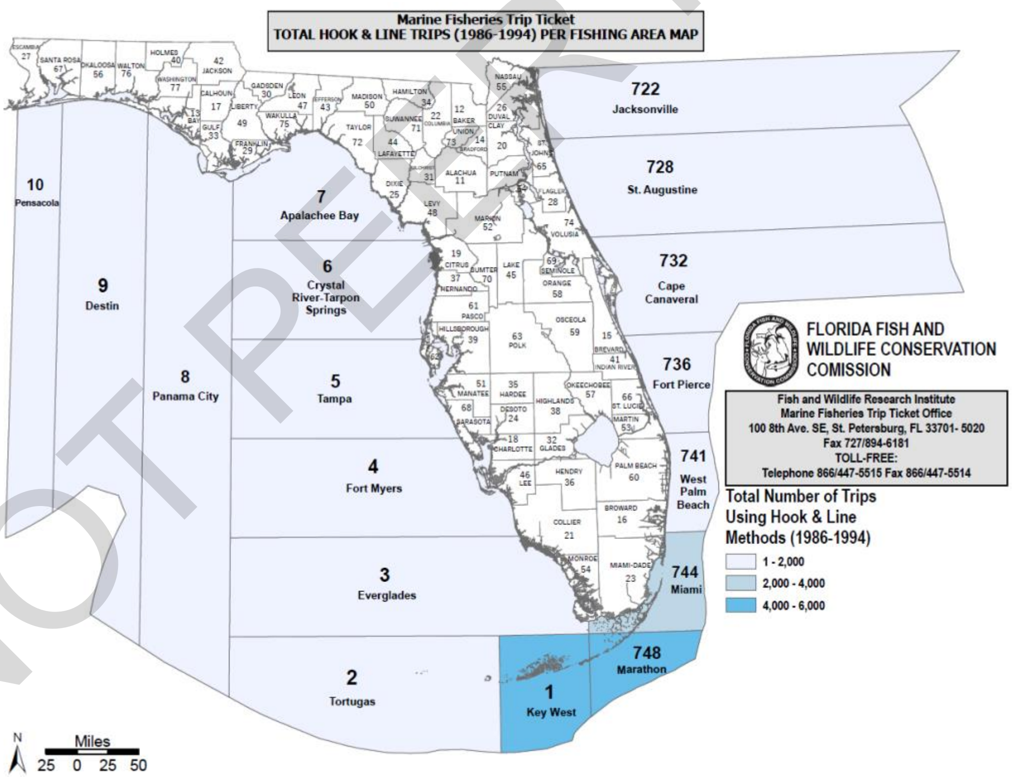


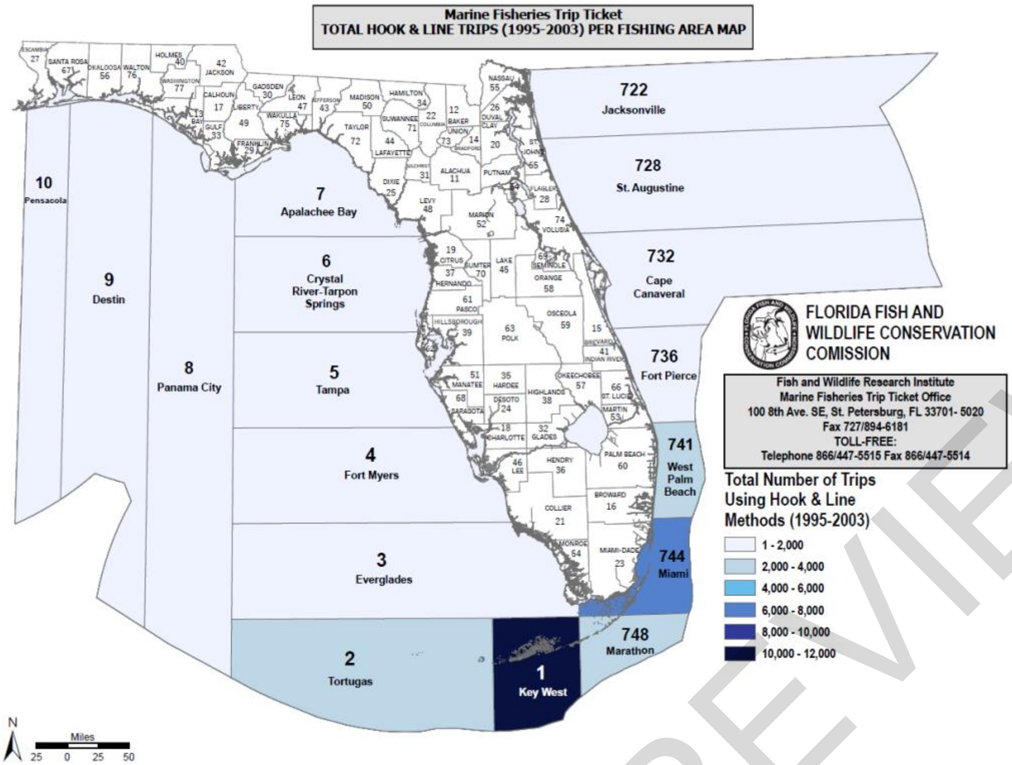
Figure 3.11.2 Mutton Snapper landings by region (West of FL, NW FL, SW FL, FL Keys, Tortugas*, SE FL, NW FL, and North of FL) for each source (ALS, FL TTK, and Logbook). *Tortugas was included in Florida data at the request of assessment staff.



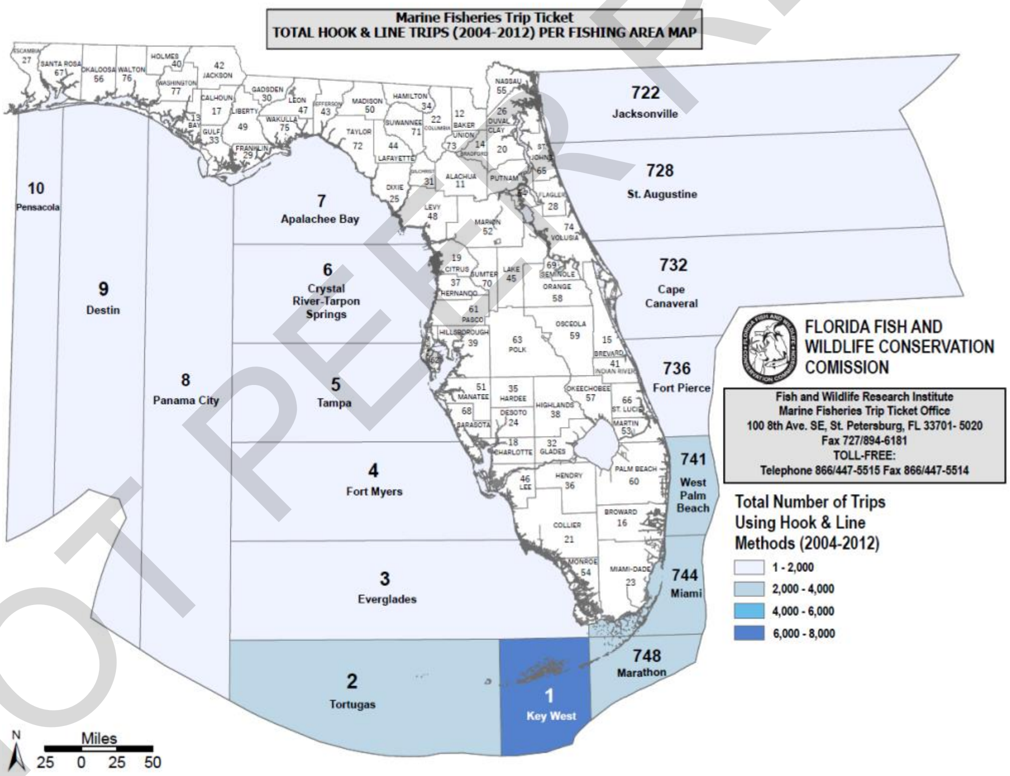
MTS Region	FL Counties	MRIP	Statistical Grids	SRHS
West_of_FL	-	-	11 - 21	24 -27
NW_FL	Escambia-Dixie	1	7-10	~23
SW_FL	Levy - Collier	2	3-6	21, old 18,22
Keys	Monroe	3	1, 2, 2479-2482	17, 12
SE_FL	Indian River – Miami-Dade	4	2580, 2680, 2780, 2579, 2679, 2779	11
NE_FL	Nassua - Brevard	5	2880, 2980, 3080, 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
FLORIDA FISH AND WILDLIFE CONSERVATION COMISSION
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
N
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
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 Hook & Line Methods (2004-2012)
1 - 2,000
2,000 - 4,000
4,000 - 6,000
6,000 - 8,000
N
Miles
25 0 25 50

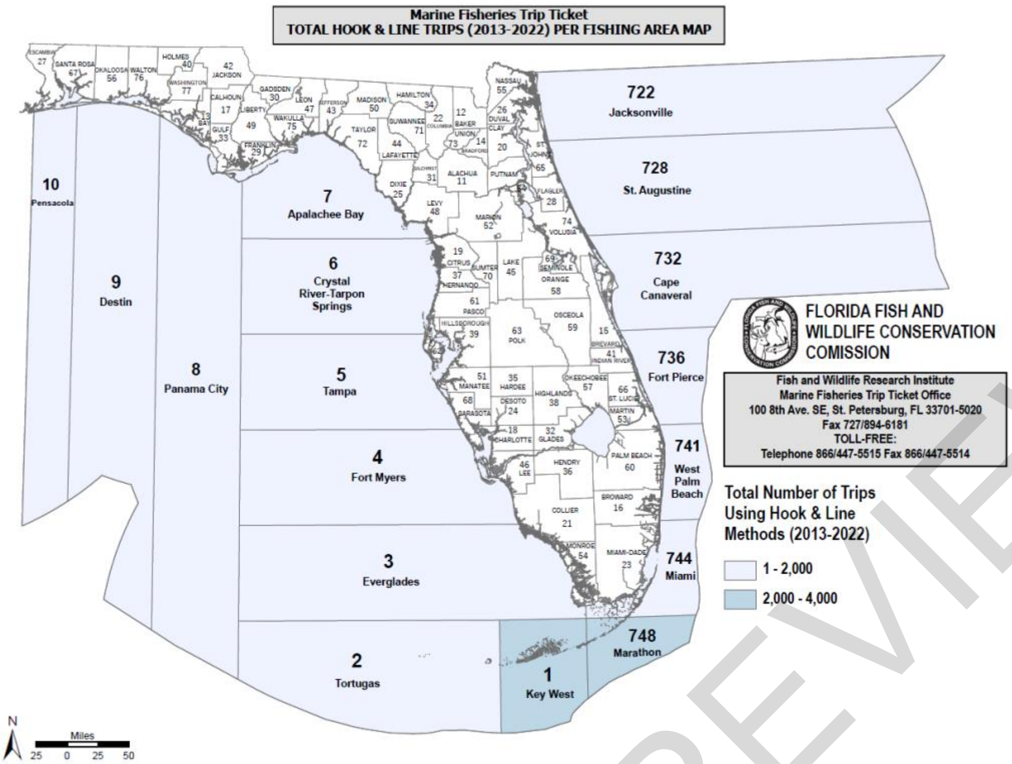
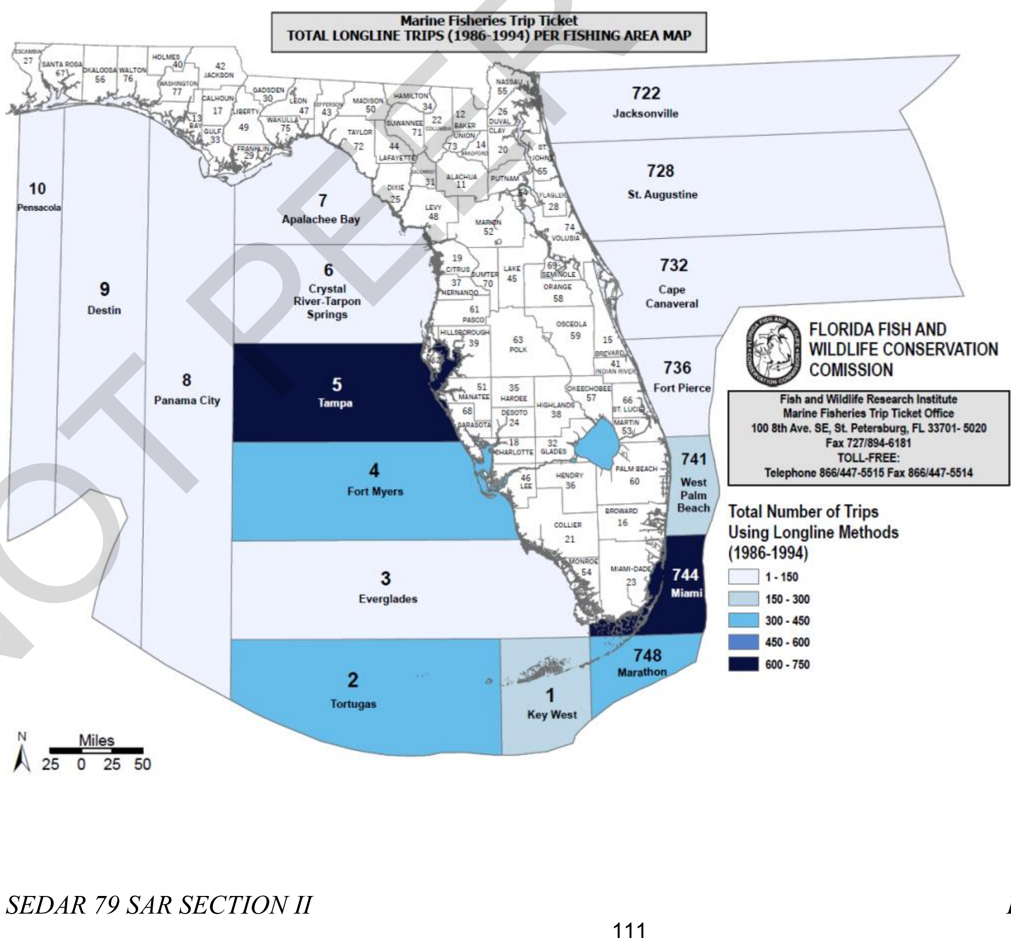
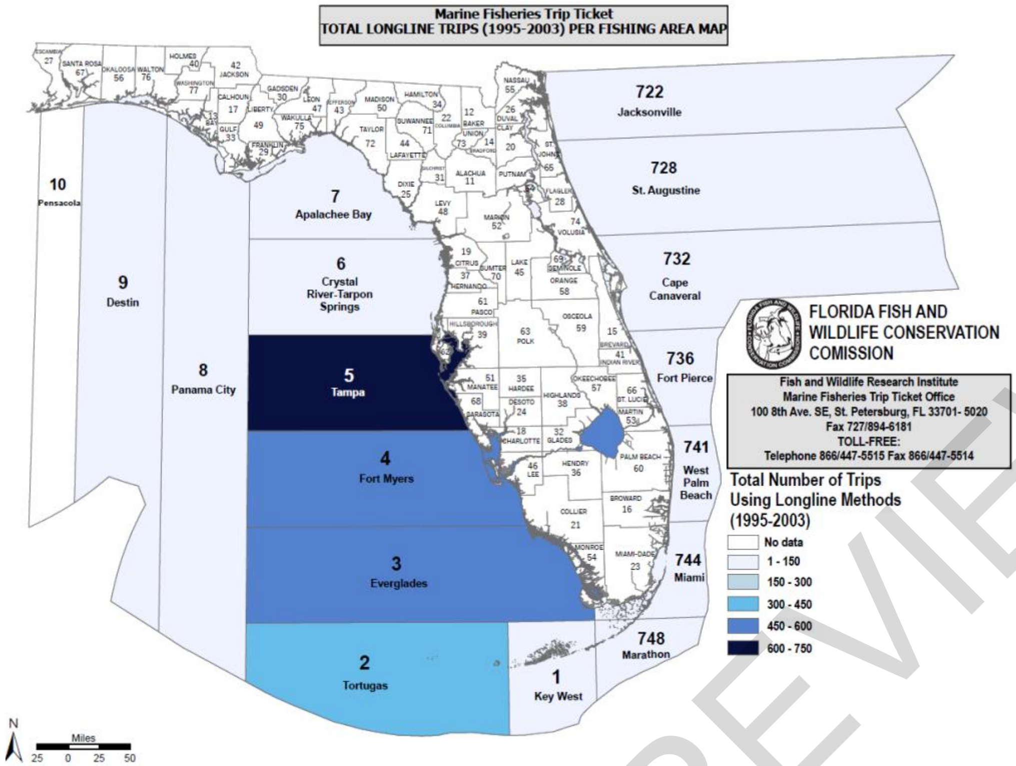


Figure 3.11.1A Total number of H&L trips landing Mutton Snapper, by statistical grid and year group (1986-1994, 1995-2003, 2004-2012, and 2013-2022), in Florida Trip Tickets.




Marine Fisheries Trip Ticket
TOTAL LONGLINE TRIPS (1995-2003) PER FISHING AREA MAP
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
722 Jacksonville
728 St. Augustine
732 Cape Canaveral
736 Fort Pierce
741 West Palm Beach
744 Miami
748 Marathon
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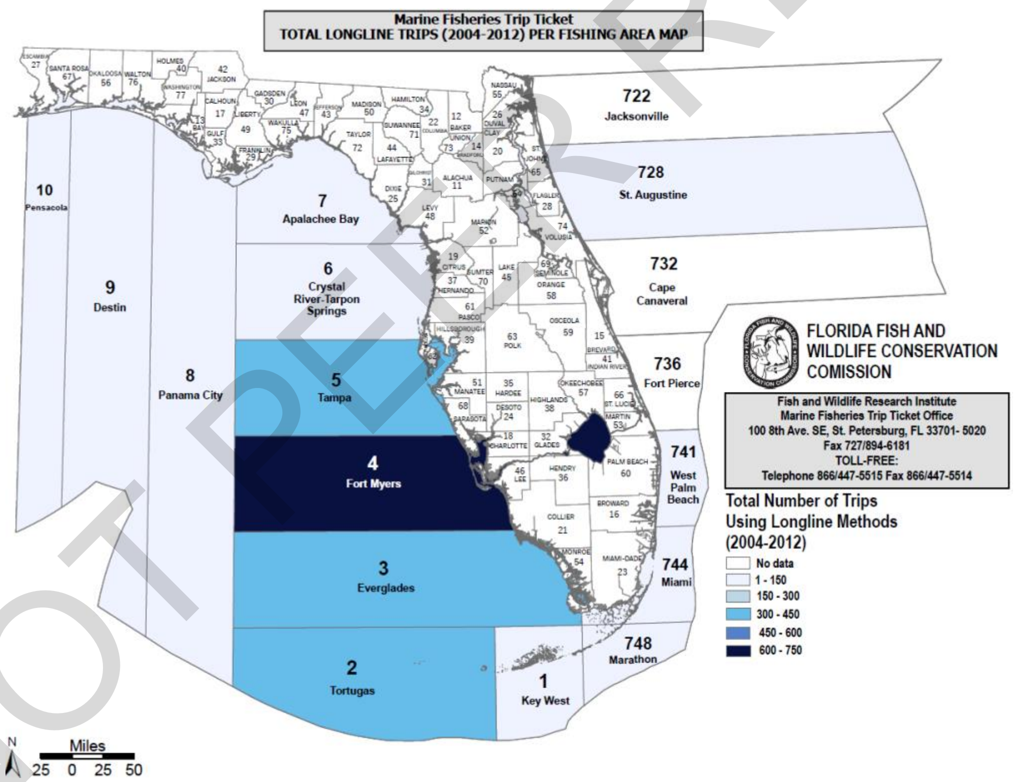
Fax 727/894-6181
TOLL-FREE:
Telephone 866/447-5515 Fax 866/447-5514
Total Number of Trips Using Longline Methods (1995-2003)
No data
1 - 150
150 - 300
300 - 450
450 - 600
600 - 750
N
Miles
25 0 25 50


Marine Fisheries Trip Ticket
TOTAL LONGLINE TRIPS (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
722 Jacksonville
728 St. Augustine
732 Cape Canaveral
736 Fort Pierce
741 West Palm Beach
744 Miami
748 Marathon
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TOLL-FREE:
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
N
Miles
25 0 25 50

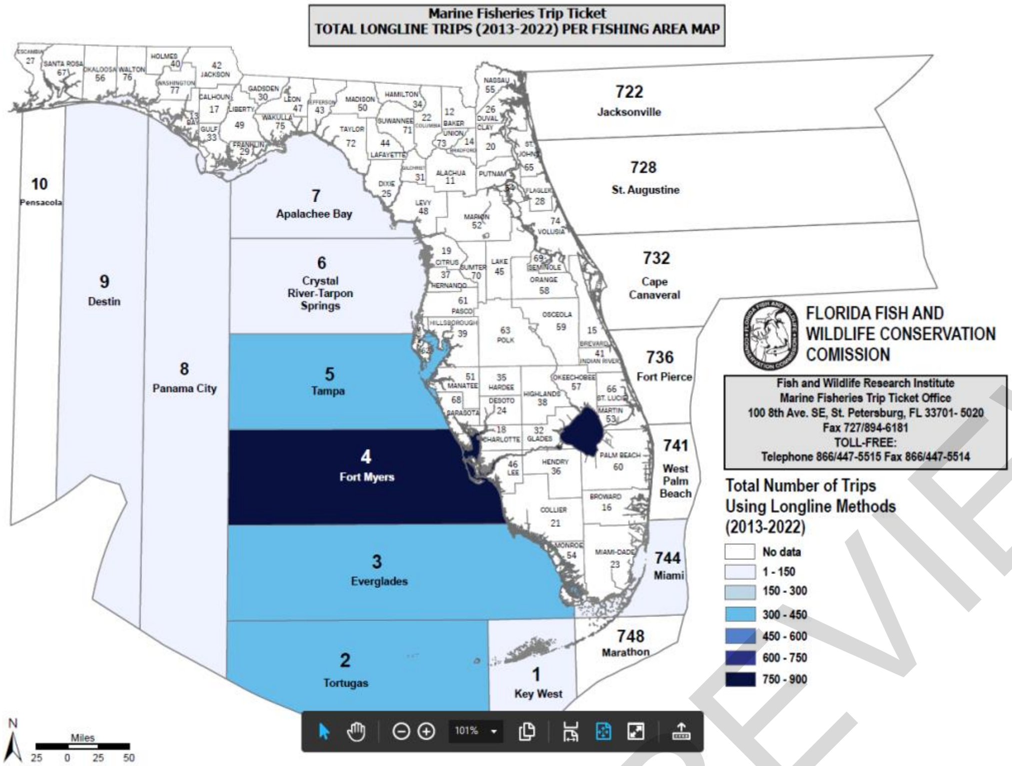
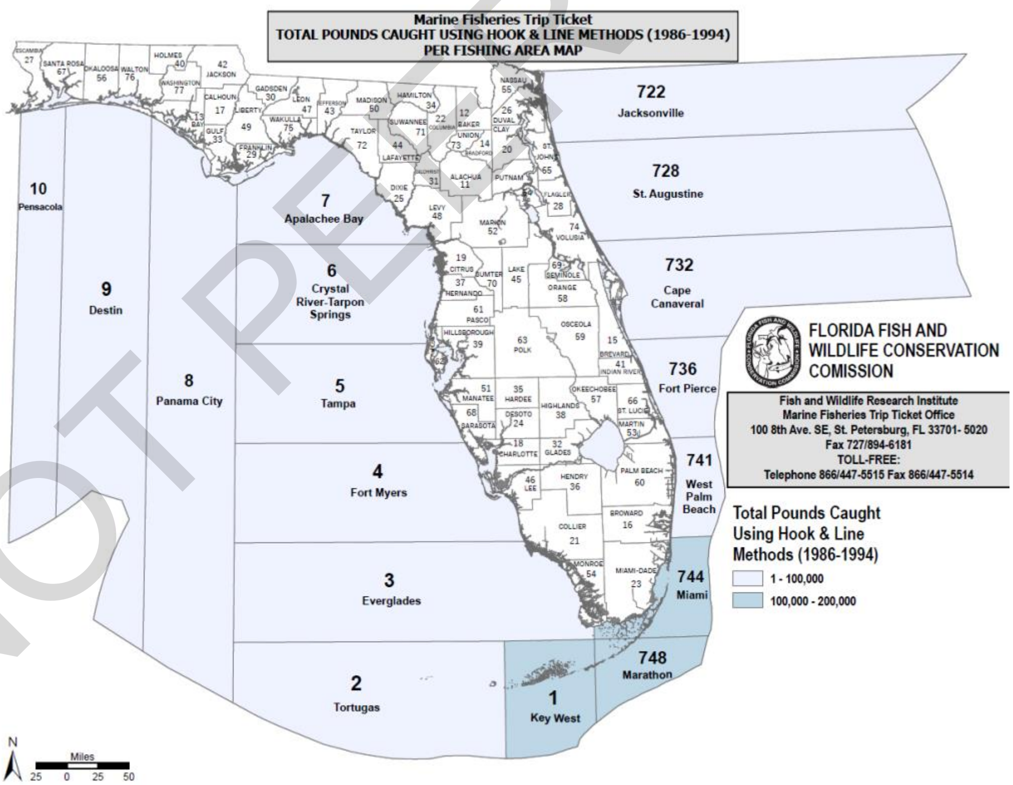
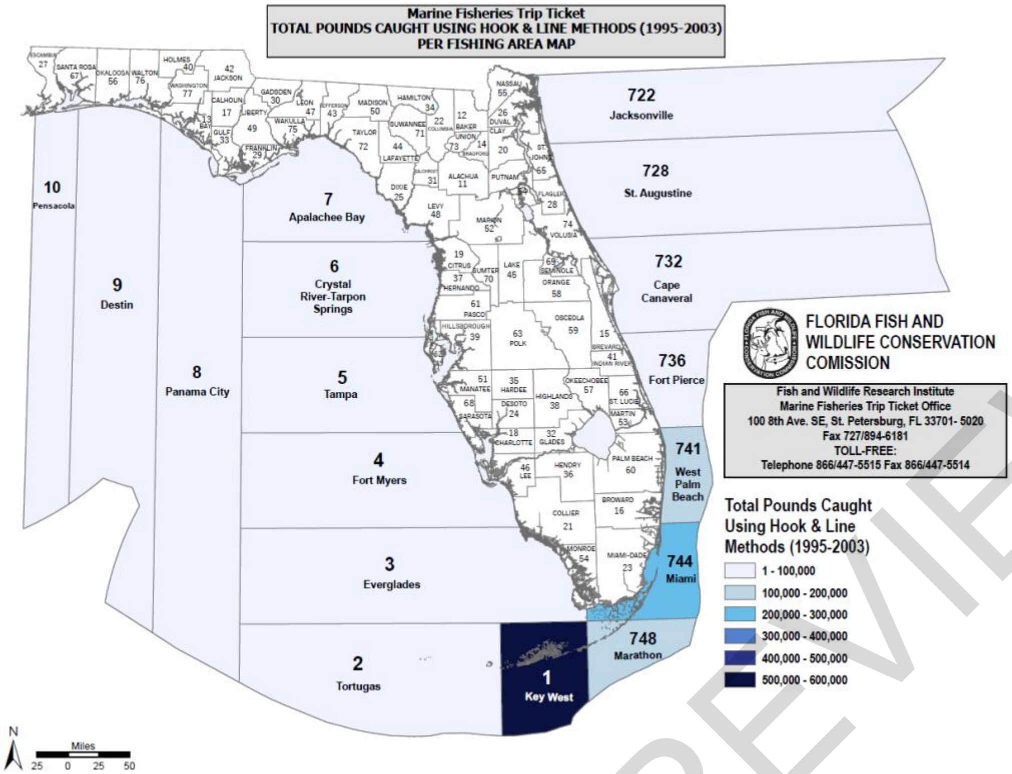


Figure 3.11.2B Total number of Longline trips landing Mutton Snapper, by statistical grid and year group (1986-1994, 1995-2003, 2004-2012, and 2013-2022), in Florida Trip Tickets.




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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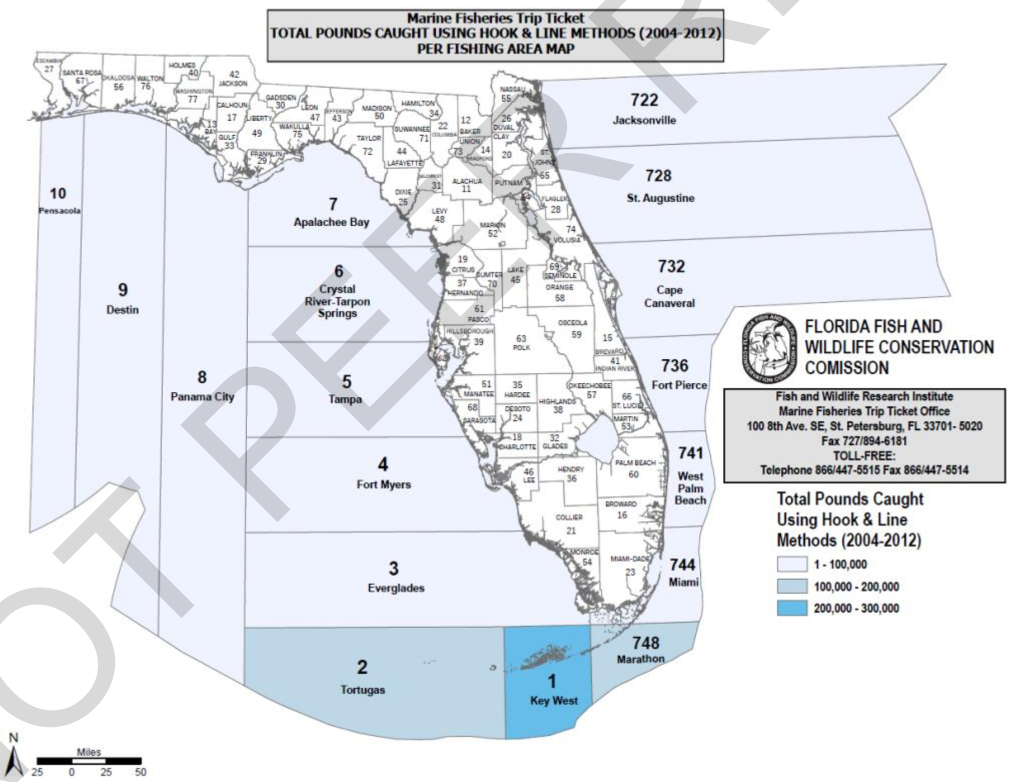
Fax 727/894-6181
TOLL-FREE:
Telephone 866/447-5515 Fax 866/447-5514
Total Pounds Caught Using Hook & Line Methods (1995-2003)
1 - 100,000
100,000 - 200,000
200,000 - 300,000
300,000 - 400,000
400,000 - 500,000
500,000 - 600,000
N
Miles
25 0 25 50


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
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8
Panama City
9
Destin
10
Pensacola
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TOLL-FREE:
Telephone 866/447-5515 Fax 866/447-5514
Total Pounds Caught Using Hook & Line Methods (2004-2012)
1 - 100,000
100,000 - 200,000
200,000 - 300,000
N
Miles
25 0 25 50

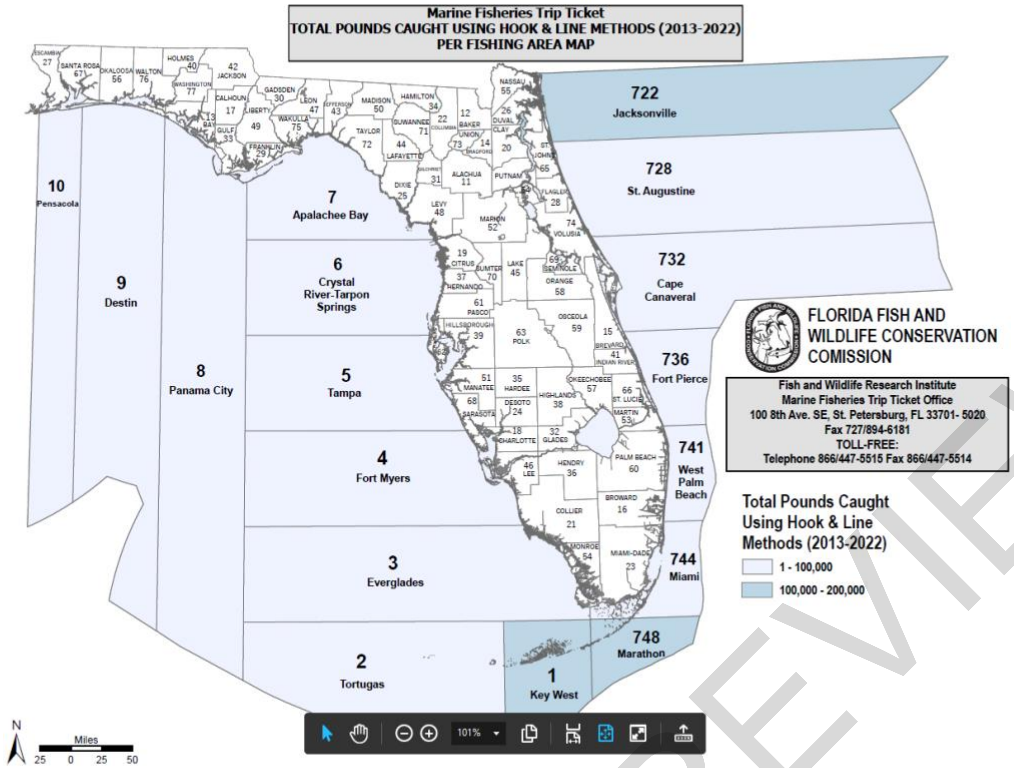
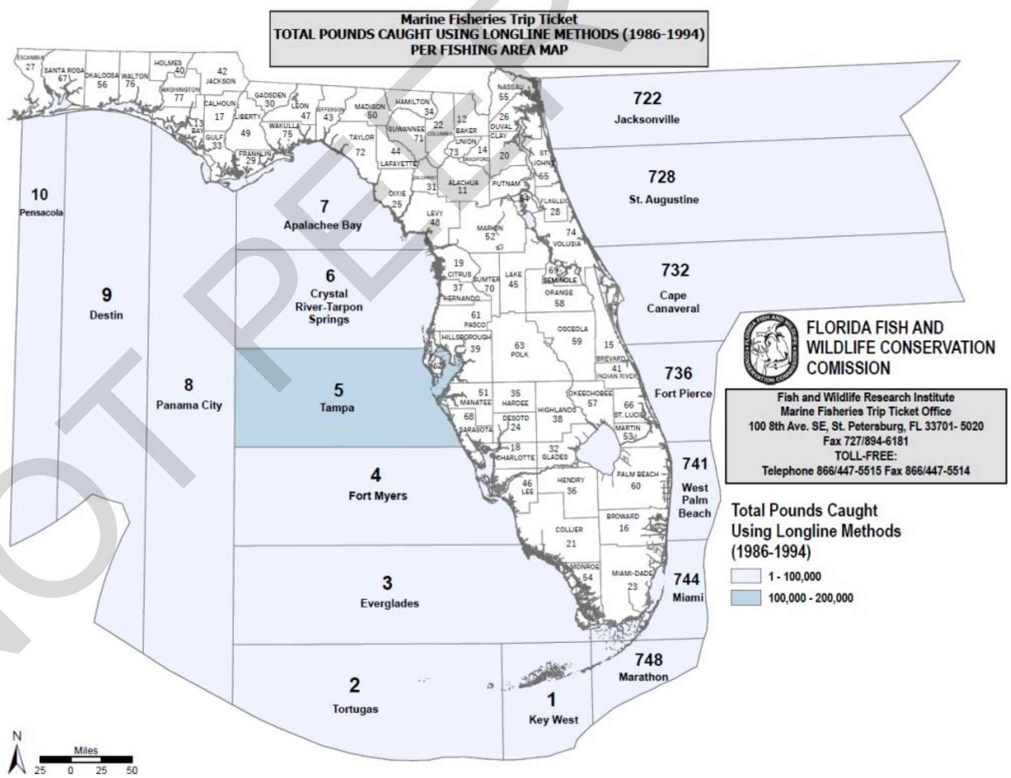
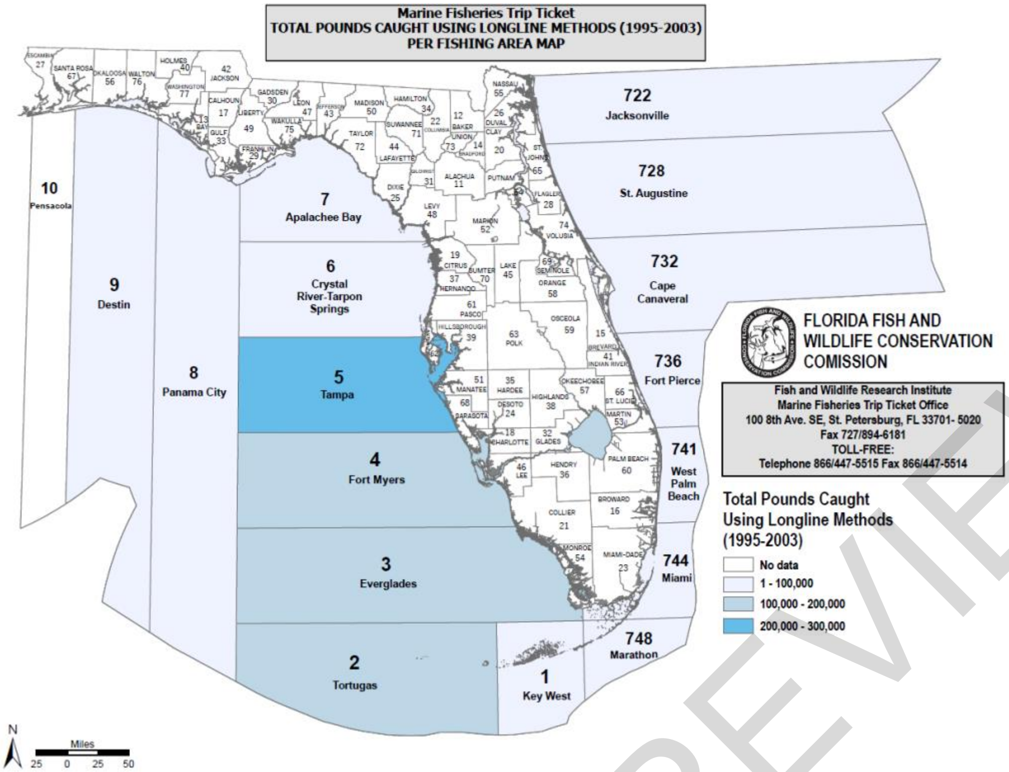


Figure 3.11.5A Total harvest of Mutton Snapper from H&L trips, by statistical grid and year group (1986-1994, 1995-2003, 2004-2012, and 2013-2022), in Florida Trip Tickets.





Marine Fisheries Trip Ticket
TOTAL POUNDS CAUGHT USING LONGLINE METHODS (1995-2003)
PER FISHING AREA MAP
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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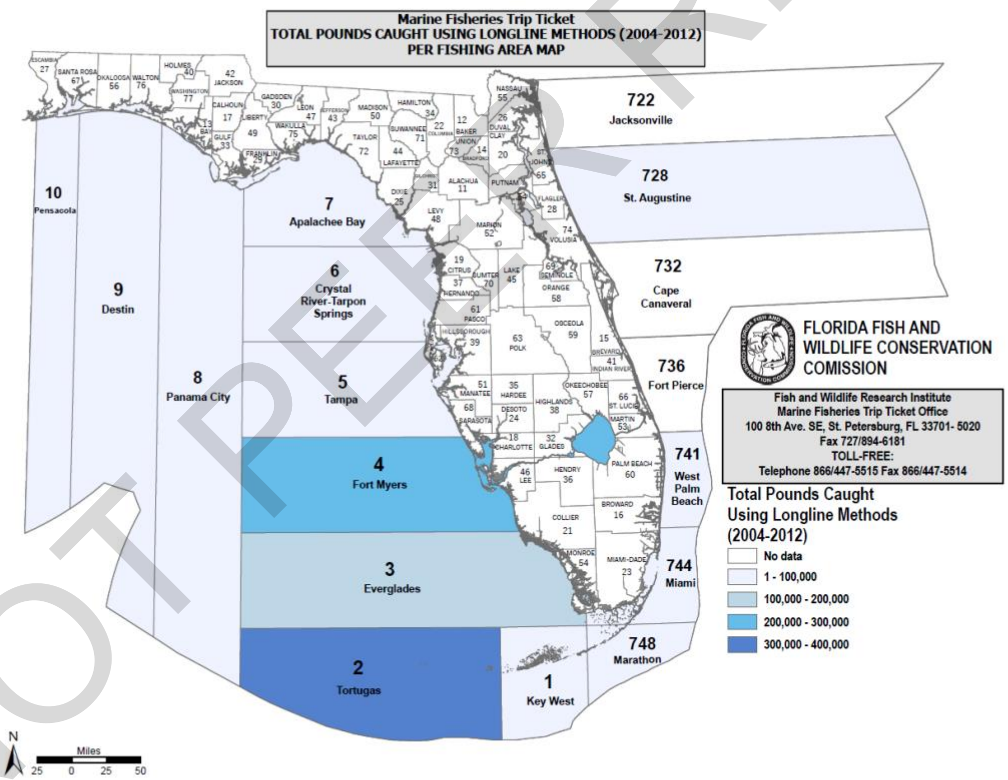
TOLL-FREE:
Telephone 866/447-5515 Fax 866/447-5514
Total Pounds Caught Using Longline Methods (1995-2003)
No data
1 - 100,000
100,000 - 200,000
200,000 - 300,000
N
Miles
25 0 25 50



Marine Fisheries Trip Ticket
TOTAL POUNDS CAUGHT USING LONGLINE METHODS (2004-2012)
PER FISHING AREA MAP
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 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

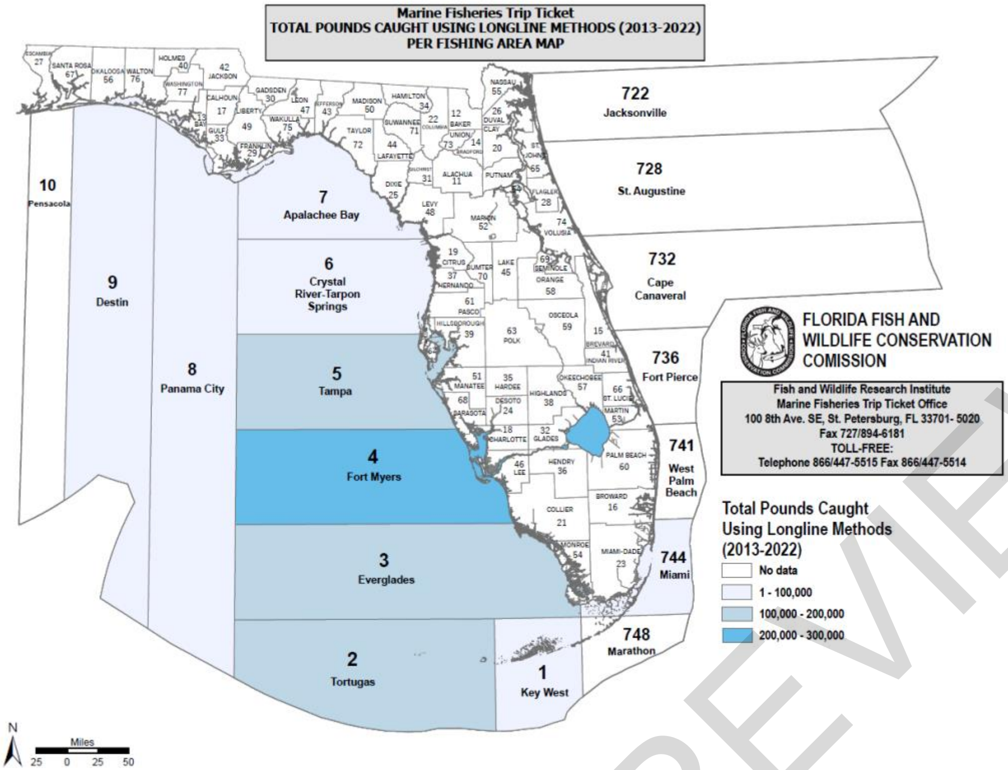


Figure 3.11.5B Total harvest of Mutton Snapper from Longline trips, by statistical grid and year group (1986-1994, 1995-2003, 2004-2012, and 2013-2022), in Florida Trip Tickets.

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

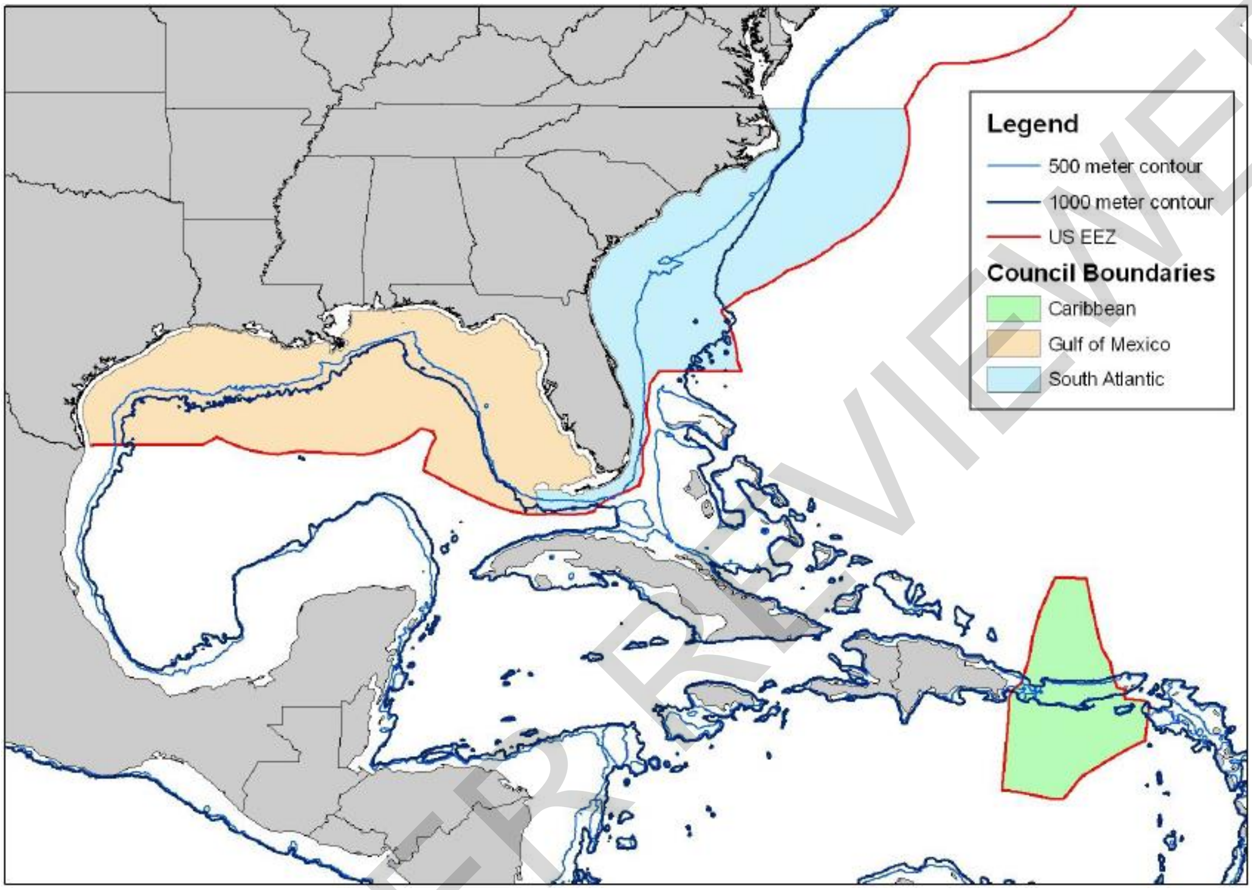
Provide recreational catch statistics through 2022, including both landings and discards in both pounds and number.

- 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

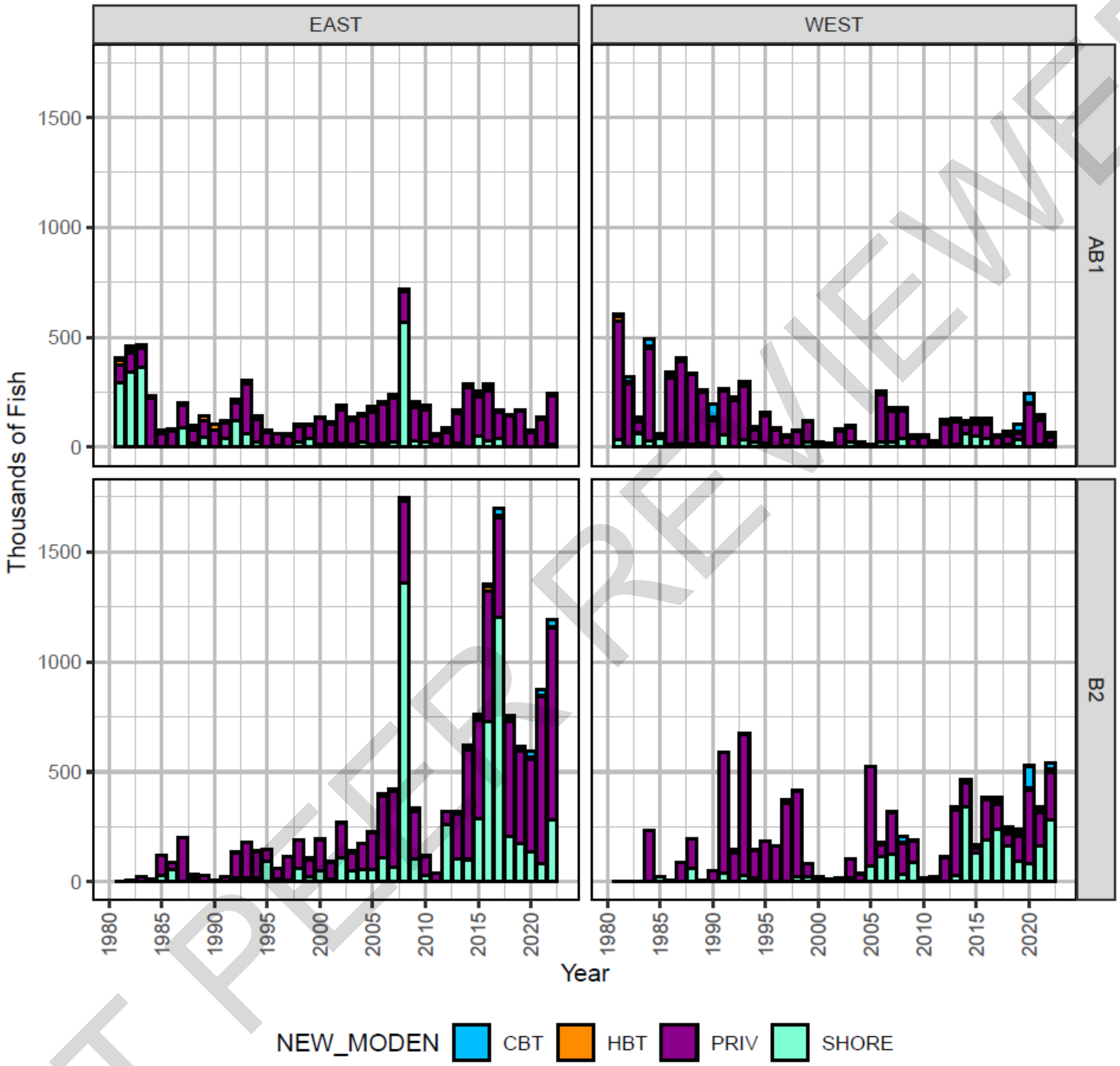

Figure 4.11.1. Annual Mutton Snapper landings (AB1) and discards (B2), in thousands of fish, by location and mode from 1981 to 2022 (MRIP, LACreel 2014+, TPWD). Note catch from the combined Private-Shore fishing mode in the LA Creel survey has been added to the Private mode. MRIP Headboat estimates are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

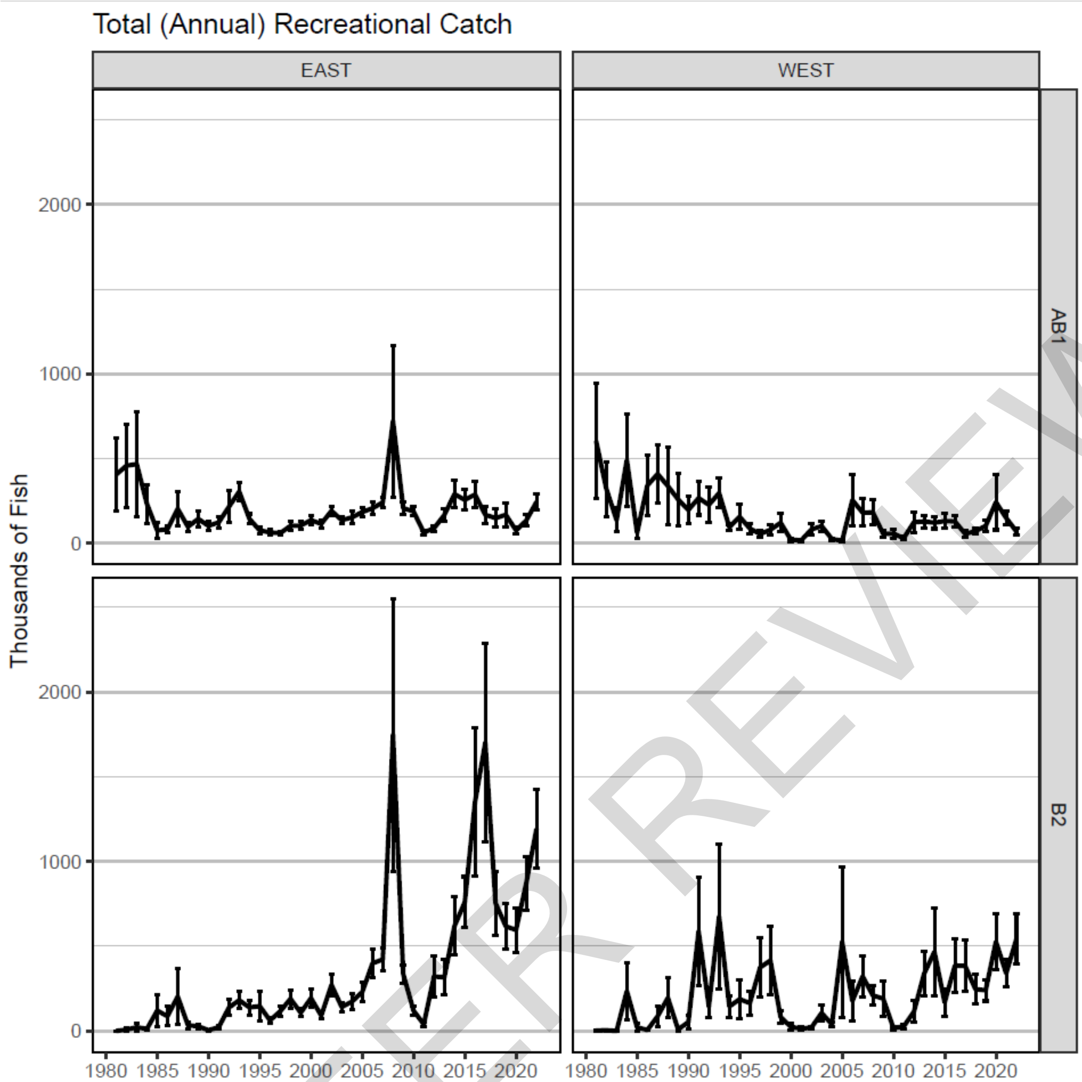

Figure 4.11.2. Mutton Snapper landings (AB1) and discards (B2), in numbers of fish, with associated coefficients of variation (CV; Dettloff et al. 2020) by year for all modes combined (MRIP, LACreel 2014+, TPWD, SRHS).

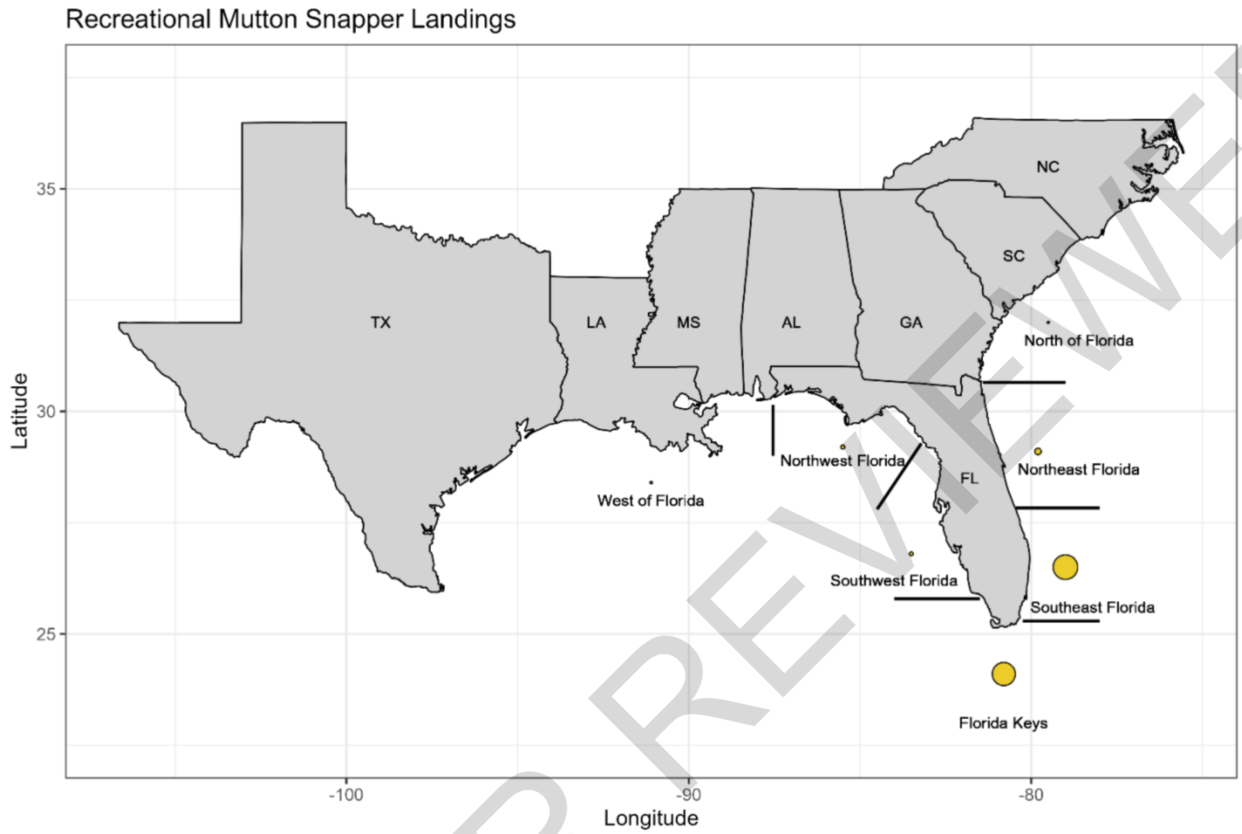

Figure 4.11.3. Distribution of total recreational landings (AB1), in thousands of fish, for Mutton Snapper by region. Estimates are combined across all surveys (MRIP, SRHS, TPWD, and LA Creel) and represent the average of 1981-2022 landings.

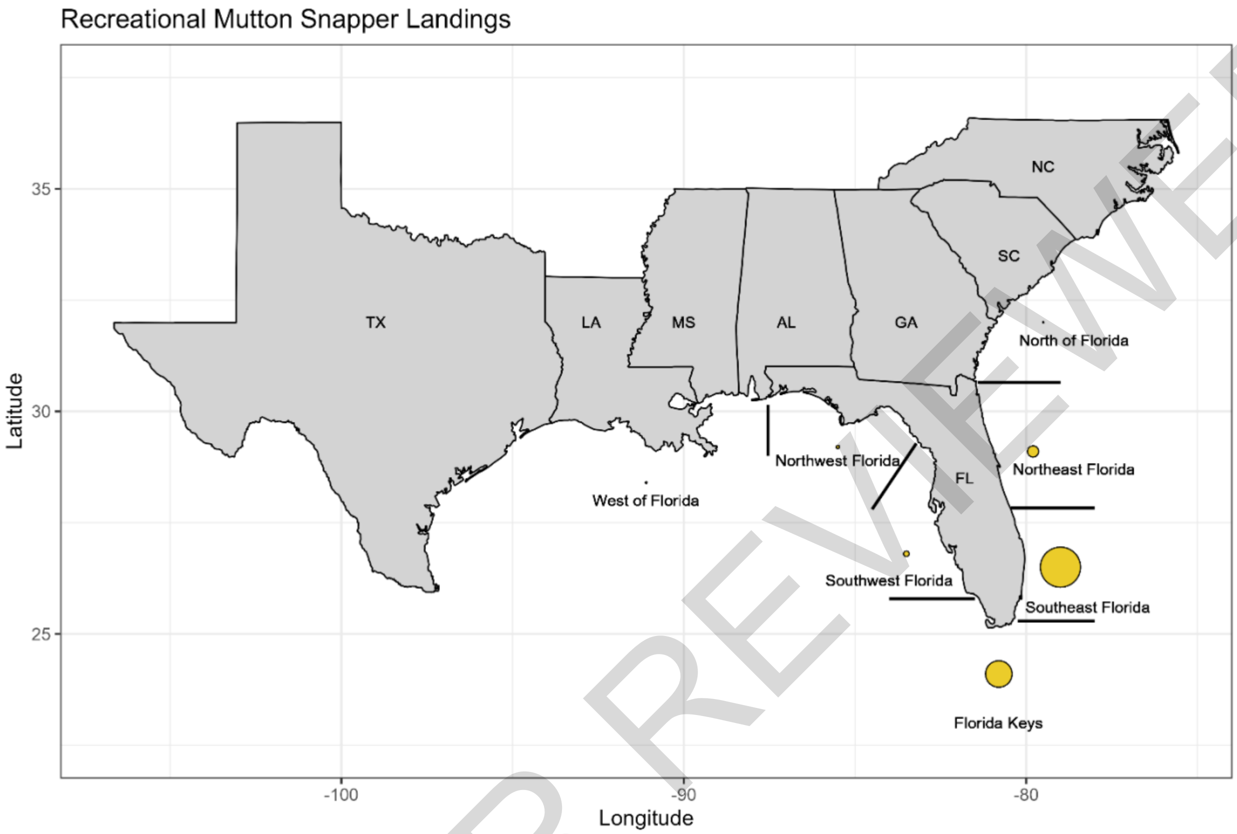

Figure 4.11.4. Distribution of total recreational releases (B2), in thousands of fish, for Mutton Snapper by region. Estimates are combined across all surveys (MRIP, SRHS, TPWD, and LA Creel) and represent the average of 2004-2022 releases.

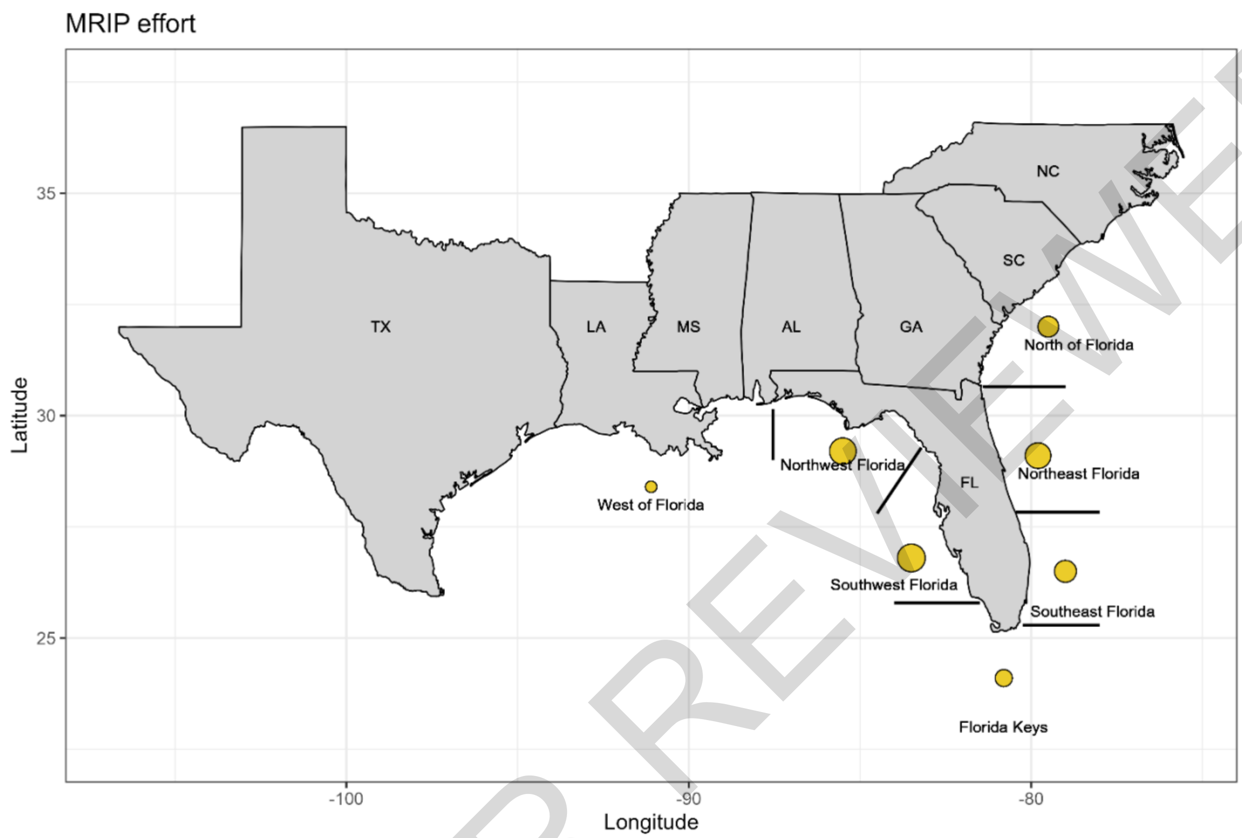

Figure 4.11.5. Distribution of private, charter, and shore mode fishing effort (MRIP, TPWD, and LA Creel) by region. Estimates are the average number of angler trips from 1981-2022.

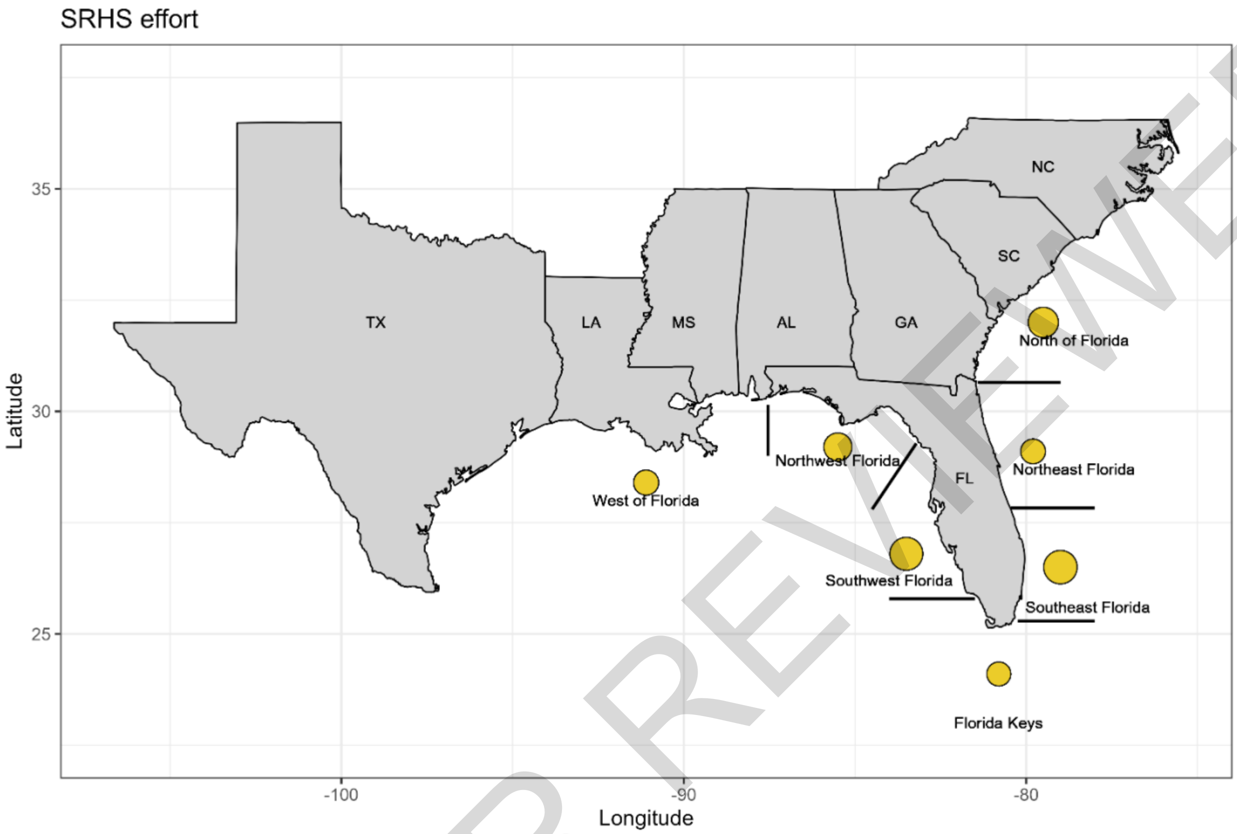

Figure 4.11.6. Distribution of headboat (SRHS) fishing effort by region. Estimates are the average number of angler days from 1986-2022.

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

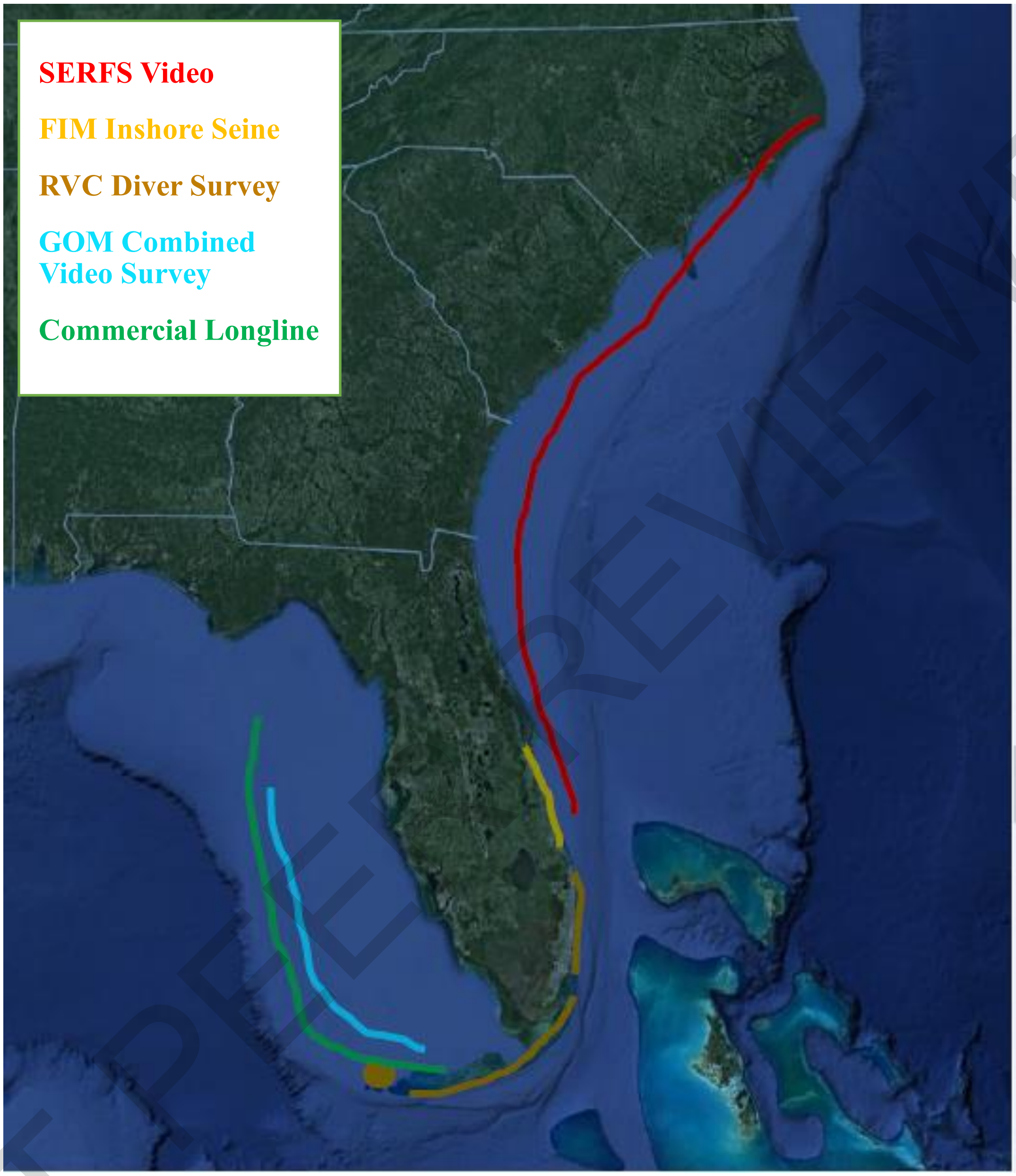

Figure 5.9.1 Spatial extent of indices found to be "Suitable and Recommended" for use in SEDAR 79.

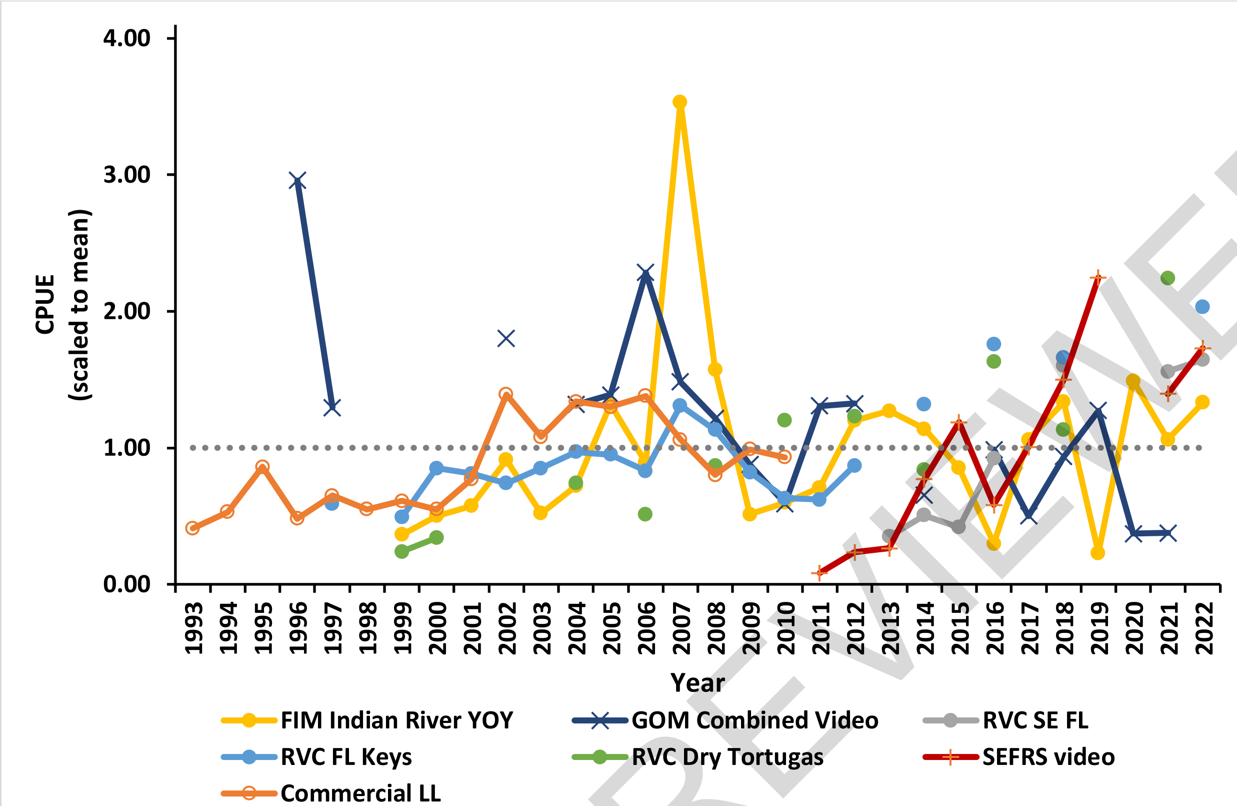

Figure 5.9.2. Relative indices of abundance found to be "Suitable and Recommended" for use in SEDAR 79.