# SEDAR 41 Stock Assessment report South Atlantic Gray Triggerfish

## SEDAR 41 Panel

SEDAR82-RD01

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Southeast Data, Assessment, and Review

# SEDAR 41
## Stock Assessment Report

# South Atlantic Gray Triggerfish

April 2016

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# SEDAR 41

## South Atlantic Gray Triggerfish

## SECTION I: Introduction

April 2016

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North Charleston, SC 29405

## Executive Summary

SEDAR 41 addressed the stock assessments for South Atlantic gray triggerfish and red snapper. The assessments consisted of four in-person workshops, as well as a series of webinars. Two Data Workshops (DW) were held in Charleston, SC, the first August 4-8, 2014 and the second August 4-6, 2015. The SEDAR 41 Assessment Process was conducted through a combination of an in-person workshop, held December 14-17, 2015 in Morehead City, NC, and a series of webinars held from October 2015 to February 2016. The Review Workshop (RW) took place March 15-18, 2016 in North Charleston, SC.

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

The final Stock Assessment Report (SAR) for South Atlantic Gray Triggerfish was disseminated to the public in April 2016. The Council's Scientific and Statistical Committee (SSC) will review the SAR for its stock. The SSCs are tasked with recommending whether assessments represent Best Available Science, whether the results presented in the SARs are useful for providing management advice, and developing fishing level recommendations for the Council. An SSC may request additional analyses be conducted or may use the information provided in the SAR as the basis for their fishing level recommendations (e.g. Overfishing Limit and Acceptable Biological Catch). The South Atlantic Fishery Management Council's SSC will review the assessment at its May 2016 meeting, followed by the Council receiving that information at its June 2016 meeting. Documentation on SSC recommendations is not part of the SEDAR process and is handled through each Council.

During the March 2016 RW, the RW Panel evaluated outputs and results from the Beaufort Assessment Model (BAM), the primary assessment model that implements a statistical catch-at-age framework; and a secondary, surplus-production model (ASPIC) used to help evaluate model uncertainty and provide a comparison of assessment results. Low contrast in Gray Triggerfish landings and indices of abundance caused ASPIC results to be considered non-informative by the RW. An error with the Southeast Reef Fish Survey (SERFS) chevron trap survey age composition data used in the base configuration of the BAM model was discovered during the RW. Based on the magnitude of changes to the data, results, and model diagnostics developed from the Assessment Workshop (AW) base model as well as concerns about overfitting the SERFS combined chevron trap and video (CVID) survey, the RW Panel felt that the proposed base model parameterization was inappropriate to provide information on Gray Triggerfish stock status or benchmarks. The RW Panel recommended that further modeling is needed to fit the corrected age data and to resolve the fit to the CVID survey.

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

- *Southeast Region Headboat Survey (SRHS) Data Evaluation*: After the 2014 DW, a working paper was submitted questioning the validity of data collected during the early years of the SRHS. The assessment was delayed in order to investigate these potential issues. Prior to the 2015 DW, the SEFSC did a comprehensive evaluation of the SRHS program that indicated no evidence of chronic, widespread misreporting, no evidence of an apparent temporal pattern in potentially misreported data, and minimal spatial patterns in potentially misreported data.
- *Marine Recreational Information Program (MRIP) Access Point Angler Intercept Survey (APAIS) adjustment:* Starting in wave 2 of 2013, the MRIP APAIS implemented a revised sampling design. To address this new survey design change, a Calibration Workshop was held in 2014. The final report recommended an additional calibration for catch estimates and recommended an interim 'simple ratio' method using 2013 data. SEDAR 41 was the first time this method was used in a South Atlantic SEDAR assessment.
- *Ageing*: Gray triggerfish dorsal spines are difficult to age and issues pertaining to ageing lead to the cessation of the SEDAR 32 Gray Triggerfish Stock Assessment in August 2013. Additional ageing workshops and webinars were held between the National Marine Fisheries Service Beaufort and South Carolina Department of Natural Resource ageing labs. Prior to the start of SEDAR 41, a decision was made that one lab would read all spine samples due to higher within laboratory reader consistency. The DW Panel also discussed using increments vs. calendar ages. Members of the Assessment Team noted that calendar ages were necessary for a catch at age model, so the DW Panel developed a set of criteria to convert increments to calendar ages.
- *Natural mortality*: Both the DW and AW panels had lengthy discussions about natural mortality. The final recommendation was to use the Charnov et al. (2013) age-varying natural mortality curve scaled to the Then et al. (2015) point estimate for those ages fully recruited to the fishery. SEDAR 41 was the first time the Then et al. (2015) estimator has been used in a South Atlantic SEDAR assessment.
- *Southeast Reef Fish Survey (SERFS) Chevron Trap and Video Indices – Independence and Selectivity:* The AW Panel recommended combining the trap and video indices into one index (CVID) since the data are collected from the same sampling platform (e.g. cameras are mounted on the traps). Age composition data were not available for the

video index, so the selectivity for the combined CVID index was informed by age composition of gray triggerfish caught in chevron traps.

- *Use of Fishery Independent (FI) and Fishery Dependent (FD) Indices*: The DW Panel recommended a series of FI and FD indices for use in the model. During model development, the AW Panel found there were conflicts between the FI and FD indices. The AW Panel recommended using only the FI index (CVID) in the base run. Sensitivity runs explored the effects of including both the FI and FD indices and only the FD indices.
- *Stock Recruitment Curve and Steepness:* Attempts were made to estimate steepness resulting in a value near its upper bound. Estimates of annual recruitment from the model were on the asymptotic portion of the stock-recruitment curve. The AW Panel decided to assume this asymptote represented an average recruitment by fixing steepness at 0.99, acknowledging this would require using spawning potential ratio (SPR) benchmarks to determine stock status rather than MSY-benchmarks.
- *Upweighting the CVID Index:* The AW Panel recommended upweighting the CVID index by a factor of 6 to ensure a good fit to the index. The RW Panel had concerns that this caused the model to 'overfit' the survey. The estimates of abundance at age in the first year of the assessment were the lowest in the assessment time series, despite being relatively early in the exploitation history. The low abundance estimates were produced, in part, by closely fitting to the first year of the CVID survey, which was the lowest in the survey time series. The RW Panel recommended further investigation was needed to resolve the model fit to the CVID survey.
- *SERFS Revised Chevron Trap Age Compositions:* An error with the chevron trap survey age composition data was discovered during the RW. The age compositions used at the AW were based on the number of annuli and the corrected data were based on calendar-year age. Revised age compositions were provided during the RW. The changes in estimates of age composition were substantial from 1991 to 2007, and less substantial from 2008-2014. The RW Panel recommended further modeling was needed to fit the corrected age data.

# I. Introduction

## 1. SEDAR Process Description

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

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

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

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

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

## 2. Management Overview

### 2.1 Fishery Management Plan and Amendments

The following summary describes only those management actions that likely affect gray triggerfish fisheries and harvest.

*Original Snapper Grouper Fishery Management Plan*

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

*SAFMC FMP Amendments affecting gray triggerfish*

| Description of Action | FMP/Amendment | Effective Date |
|---|---|---|
| -Gear limitations – poisons, explosives, fish traps, trawls.<br>-Designated modified habitats or artificial reefs as Special Management Zones (SMZs). | FMP (1983) | 08/31/83 |
| -Prohibited trawl gear to harvest fish south of Cape Hatteras, NC and north of Cape Canaveral, FL.<br>-Directed fishery defined as vessel with trawl gear and ≥200 lbs s-g on board.<br>-Established rebuttable assumption that vessel with s-g on board had harvested such fish in the exclusive economic zone (EEZ). | Amendment # 1 | 01/12/89 |
| -Prohibited gear: fish traps except black sea bass traps north of Cape Canaveral, FL; entanglement nets; longline gear inside 50 fathoms; bottom longlines to harvest wreckfish; powerheads and bangsticks in designated SMZs off S. Carolina. | Amendment # 4 | 01/01/92 |

| | | |
|---|---|---|
| -Required permits (commercial & for-hire) and specified data collection regulations.<br>-Established an assessment group and annual adjustment procedure (framework).<br>-No retention of snapper grouper spp. caught in other fisheries with gear prohibited in snapper grouper fishery if captured snapper grouper had no bag limit or harvest was prohibited. If had a bag limit, could retain only the bag limit. | | |
| -Required dealer, charter and headboat federal permits.<br>-Allowed sale under specified conditions.<br>-Specified allowable gear and made allowance for experimental gear.<br>-Allowed multi-gear trips in NC.<br>-Added localized overfishing to list of problems and objectives.<br>-Adjusted bag limit and crew specs. for charter and head boats. | Amendment # 7 | 01/23/95 |
| -Established program to limit initial eligibility for snapper grouper fishery: Must demonstrate landings of any species in the snapper grouper (SG) fishery management unit (FMU) in 1993, 1994, 1995 or 1996; and have held valid SG permit between 02/11/96 and 02/11/97.<br>-Granted transferable permit with unlimited landings if vessel landed ≥ 1,000 pounds (lbs) of snapper grouper species in any of the years<br>-Granted non-transferable permit with 225 lb trip limit to all other vessels.<br>-Modified problems, objectives, optimum yield (OY), and overfishing definitions.<br>-Allowed retention of snapper grouper species in excess of bag limit on permitted vessel with a single bait net or cast nets on board. | Amendment # 8 | 12/14/98 |
| -All snapper grouper without a bag limit: aggregate recreational bag limit 20 fish/person/day, excluding tomtate and blue runner. | Amendment # 9 | 2/24/99 |
| -Identified essential fish habitat | Amendment # 10 | 07/14/00 |

| | | |
|---|---|---|
| (EFH) and established habitat areas of particular concern (HAPC) for species in the snapper grouper FMU. | | |
| -Maximum sustainable yield (MSY) proxy = 40% static SPR.<br>-Overfishing level = F>F30% static SPR.<br>-Approved definitions for overfished and overfishing.<br>MSST = [(1-M) or 0.5 whichever is greater]*$B_{MSY}$.<br>MFMT = $F_{MSY}$ | Amendment # 11 | 12/02/99 |
| -Extended for an indefinite period the regulation prohibiting fishing for and possessing snapper grouper spp. within the *Oculina* Experimental Closed Area. | Amendment #13A (2003b) | 04/26/04 |
| -Established eight deepwater Type II marine protected areas (MPAs) to protect a portion of the population and habitat of long-lived deepwater snapper grouper species. Also protected known spawning areas of many snapper grouper species including gray triggerfish. | Amendment #14 (2007) | 2/12/09 |
| -Prohibit the sale of bag-limit caught snapper grouper species. | Amendment # 15B | 2/15/10 |
| -Captain and crew on for-hire trips cannot retain the bag limit of vermilion snapper and species within the 3-fish grouper aggregate.<br>-For vermilion snapper: directed com quota split Jan-June and July-Dec; reduce bag limit from 10 to 5 and a rec closed recreational season November through March. | Amendment # 16 | 7/29/09 |
| -Provide presentation of spatial information for EFH and EFH-HAPC designations under the Snapper Grouper FMP. | Amendment #19 (Comprehensive Ecosystem-Based Amendment 1) | 7/22/10 |
| -Required use of non-stainless steel circle hooks when fishing for snapper grouper species with hook-and-line gear north of 28 deg. N latitude in the South Atlantic EEZ. | Amendment #17A | 3/3/11 |
| -Establish acceptable biological catch (ABC) control rules, establish ABCs, sector allocations, annual catch limits (ACLs), and accountability measures (AMs) for | Amendment # 25 (Comprehensive ACL Amendment) | 4/16/12 |

| | | |
|---|---|---|
| species not undergoing overfishing.<br>- Gray triggerfish commercial ACL = 305,262 lb ww; recreational ACL = 367,303 lb ww.<br>- Commercial AM for gray triggerfish is inseason closure when ACL met; recreational AM is to reduce length of fishing season following ACL overage as needed.<br>-Remove some species from South Atlantic FMU and designate others as ecosystem component species. | | |
| - Designate the Deepwater MPAs as EFH-HAPCs.<br>- Limit harvest of snapper grouper species in SC SMZs to the bag limit. | Amendment #23 (Comprehensive Ecosystem-based Amendment 2) | 1/30/12 |
| -Modify the restriction on retention of bag limit quantities of vermilion snapper and species within the 3-fish grouper aggregate by captain and crew of for-hire vessels<br>-Minimize regulatory delay when adjustments to snapper grouper species' ABC, ACLs, and ACTs are needed as a result of new stock assessments.<br>-Increase the number of allowable crew members from three to four on dual-permitted vessels. | Amendment #27 | 1/27/14 |
| -Establish a 12-inch (30.5-cm) fork length (FL) minimum size limit for gray triggerfish in Federal waters off North Carolina, South Carolina, and Georgia for both the commercial and recreational sectors.<br>-Increase the minimum size limit for gray triggerfish off the east coast of Florida from 12 inches (30.5 cm), total length to 14 inches (35.6 cm), FL for both the commercial and recreational sectors.<br>-Establish a total ABC/ACL of 717,000 lbs ww (for gray triggerfish the SAFMC set the ACL = ABC) and set the commercial ACL to 312,325 lbs. ww and the recreational ACL to 404,675 lbs. ww. | Amendment #29 | TBD<br>As of March 5, 2015, the regulations have not been implemented. NMFS approved the amendment on February 20, 2015. Implementation is expected in April 2015. |

*SAFMC Regulatory Amendments affecting gray triggerfish*

| Description of Action | Amendment | Effective Date |
|---|---|---|
| -Prohibited fishing in SMZs except with hand-held hook-and-line and spearfishing gear. | Regulatory Amendment # 1 | 03/27/87 |
| -Established 2 artificial reefs off Ft. Pierce, FL as SMZs. | Regulatory Amendment # 2 | 03/30/89 |
| -Established artificial reef at Key Biscayne, FL as SMZ. | Regulatory Amendment # 3 | 11/02/90 |
| -Established 8 SMZs off S. Carolina, where only hand-held, hook-and-line gear and spearfishing (excluding powerheads) was allowed. | Regulatory Amendment # 5 | 07/31/93 |
| -Established actions which applied only to EEZ off Atlantic coast of FL: Bag limits – 5 hogfish/person/day (recreational only), 2 cubera snapper/person/day > 30" TL; 12" TL – gray triggerfish. | Regulatory Amendment # 6 | 05/22/95 |
| -Established 10 SMZs at artificial reefs off South Carolina. | Regulatory Amendment # 7 | 01/29/99 |
| -Established 12 SMZs at artificial reefs off Georgia; revised boundaries of 7 existing SMZs off Georgia to meet CG permit specs; restricted fishing in new and revised SMZs. | Regulatory Amendment # 8 | 11/15/00 |
| - Establish trip limits for vermilion snapper and gag, increase trip limit for greater amberjack, and reduce bag limit for black sea bass. | Regulatory Amendment # 9 | Bag limit: 6/22/11<br>Trip limits: 7/15/11 |
| -Revise the ABCs, ACLs (including sector ACLs), and ACTs implemented by the Comprehensive ACL Amendment (SAFMC 2011c). The revisions may prevent a disjunction between the established ACLs and the landings used to determine if AMs are triggered.<br>- Gray triggerfish commercial ACL = 272,880 lb ww; recreational ACL = 353,638 lb ww. | Regulatory Amendment # 13 | 7/17/13 |
| -Adjust ACLs for vermilion snapper and red porgy, and remove the 4-month recreational closure for vermilion snapper. | Regulatory Amendment # 18 | 9/5/13 |
| -Increase yellowtail snapper ACL.<br>-Remove measure that closes all shallow water groupers when the gag commercial ACL is met.<br>-Reduce gag commercial ACL. | Regulatory Amendment #15 | 9/12/13 |

| | | |
|---|---|---|
| -Increase commercial and recreational ACL for black sea bass.<br>-Establish November-April black sea bass pot prohibition. | Regulatory Amendment #19 | 9/23/13 (ACL)<br>10/23/13 (pots) |
| -Change start date of commercial and recreational fishing years for greater amberjack to March 1<br>-Change commercial fishing year for black sea bass to Jan 1-Dec 31<br>-Change recreational fishing year for black sea bass to April 30-March 31<br>-Establish 300 pound gw commercial trip limit for black sea bass using hook-and-line gear from Jan 1 to Apr 30. From May 1 to Dec 31, the trip limit is 1,000 pounds gw for hook-and-line gear and pot gear. NOTE: black sea bass pots prohibited annually from Nov 1 to April 30.<br>-Revise AMs for vermilion snapper and black sea bass (recreational)<br>-Reduce gag trip limit to 500 pounds gw when 75% of ACl is met | Regulatory Amendment # 14 | 12/8/14 |

### 2.2 Emergency and Interim Rules (if any)

**Emergency Rule effective 9/3/1999:** reopen the Amendment 8 Snapper Grouper Permit application process.

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

### 2.3 Secretarial Amendments (if any)

None

### 2.4 Control Date Notices (if any)

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

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

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

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

### 2.5 Management Program Specifications

**Table 2.5.1. General Management Information**

*South Atlantic*

| | |
|---|---|
| Species | Gray triggerfish |
| Management Unit | Southeastern US |
| Management Unit Definition | NC/VA border southward to the SAFMC/GMFMC boundary |
| Management Entity | South Atlantic Fishery Management Council |
| Management Contacts<br>SERO / Council | SAFMC: Myra Brouwer/Gregg Waugh<br>SERO: Jack McGovern |
| Current stock exploitation status | Unknown |
| Current stock biomass status | Unknown |

**Table 2.5.2 Management Parameters**

| Criteria | South Atlantic – Proposed (values from SEDAR 41) | | |
|---|---|---|---|
| | Definition | Base Run Values | Median of Base Run MCBs |
| MSST[1] | (1-M) $B_{MSY}$<br>0.5 $B_{MSY}$ | | |
| MFMT | $F_{MSY}$, if available; $F_{30\%\ SPR}$ proxy [2] | | |
| $F_{MSY}$ | $F_{MSY}$ | | |
| MSY | Yield at $F_{MSY}$, landings and discards, pounds and numbers | | |
| $B_{MSY}$[1] | Total or spawning stock, to be defined | | |
| $R_{MSY}$ | Recruits at MSY | | |
| F Target | 75% $F_{MSY}$ | | |
| Yield at $F_{TARGET}$ (equilibrium) | Landings and discards, pounds and numbers | | |
| M | Natural mortality, average across ages | | |
| Terminal F | Exploitation | | |

| | | | |
|---|---|---|---|
| Terminal Biomass[1] | Biomass | | |
| Exploitation Status | F/MFMT | | |
| Biomass Status[1] | B/MSST | | |
| | $B/B_{MSY}$ | | |
| Generation Time | | | |
| $T_{REBUILD}$ (if appropriate) | | | |

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

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

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

*NOTE: Because this is the first assessment of this stock, there are no existing values for management parameters. The default proxy for $F_{MSY}$ is F30%SPR.*

**Table 2.5.3. Stock Rebuilding Information**
N/A

**Table 2.5.4. General Projection Specifications**
Snapper Grouper Amendment 29 includes an action to modify the ABC and ACLs for gray triggerfish and change the minimum size limit for gray triggerfish. Projections should account for changes in selectivity due to regulation changes in Snapper Grouper Amendment 29.

Amendment 29 was submitted for Secretarial Review on October 14, 2014. NMFS approved the amendment on February 20, 2015. As of March 5, 2015, the regulations have not been implemented. Implementation is expected in April 2015. The amendment will specify a 12 inch FL minimum size limit for gray triggerfish in federal waters off of the NC, SC, and GA for both the recreational and commercial sectors; will specify 14 inch FL minimum size limit for gray triggerfish in federal waters off of the east coast of Florida for the commercial and recreational sectors; and will change the total ABC/ACL to 717,000 lbs ww (for gray triggerfish the SAFMC set the ACL = ABC) and set the commercial ACL to 312,325 lbs. ww and the recreational ACL to 404,675 lbs. ww.

*South Atlantic*

| Requested Information | Value |
|---|---|
| First Year of Management | Assume management begins in 2019. However, if stock neither overfished or |

| | |
|---|---|
| | overfishing, a projection with the revised ABC and OFL should be provided assuming that landings limits are changed in the 2017 fishing year. |
| Interim basis | ACL, if landings are within 10% of the ACL; average landings otherwise. |
| Projection Outputs | |
| Landings | Pounds and numbers |
| Discards | Pounds and numbers |
| Exploitation | F & Probability F>MFMT |
| Biomass (total or SSB, as appropriate) | B & Probability B>MSST<br>(and Prob. B>$B_{MSY}$ if under rebuilding plan) |
| Recruits | Number |

**Table 2.5.5. Base Run Projections Specifications. Long Term and Equilibrium conditions.**

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

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

**Table 2.5.6. P-star projections. Short term specifications for OFL and ABC recommendations. Additional P-star projections may be requested by the SSC once the ABC control rule is applied.**

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

**Table 2.5.7. Quota Calculation Details**

If the stock is managed by quota, please provide the following information.

| | |
|---|---|
| Current acceptable biological (ABC) | ABC = 626,518 pounds ww** |

| Value | |
|---|---|
| Commercial annual catch limit (ACL) | 272,880 pounds ww ** |
| Recreational ACL | 353,638 pounds ww** |
| Next Scheduled Quota Change | |
| Annual or averaged quota? | Annual |
| If averaged, number of years to average | n/a |
| Does the quota include bycatch/discard? | n/a* |

*The ACL values are "landings only" provided by SSC through their ABC control rule for data poor species. ACLs provided do not include discards.

**Snapper Grouper Amendment 29 will modify the ABC and ACLs for gray triggerfish to the following: ABC = 717,000 lbs ww, commercial ACL = 312,325 lbs. ww, and recreational ACL to 404,675 lbs. ww. Amendment 29 was submitted for Secretarial Review October 14, 2014. NMFS approved the amendment on February 20, 2015. As of March 5, 2015, the regulations have not been implemented. Implementation is expected in April 2015.

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

The South Atlantic SSC recommended the ABC in April 2011. The Council then set ABC=ACL through the Comprehensive ACL Amendment and established sector specific ACLs based on historical catch. Values were modified in July 2013 through Regulatory Amendment 13 to incorporate new information from the Marine Recreational Information Program. Below is the rationale provided for the SSC's recommendation of ABC (from the April 2011 SSC Report):

*Gray triggerfish was assessed through PDRP, with difficulty obtaining fits using multiple techniques, therefore effort data were uninformative.*
*MARMAP has a CPUE (see draft report). No age data yet. Trend in the fishery-independent index is relatively flat since 1999, while landings are showing an increasing trend. Some drop recently, in the last 3 years. MARMAP CPUE and landings track each other more consistently in the early period. MARMAP average lengths are generally increasing, but only slightly. No signs of concern in the FI info.*

*Is it possible landings are small relative to biomass?*

*Recent catch trend is increasing approaching 1998 peak. May be due to redirection of the fishery, but CPUE and mean length from FI does not indicate increases are of concern at this time.*
*Apply decision tree, condition 2 (third highest landings value for 1999-2008). ABC = 672,565 lbs.*
*Decision tied to fishing level that did not lead to decline in later years - unlike higher observed landings levels.*

*OFL unknown. Have biomass trend from MARMAP, exploratory assessment, PDRP, but not released at this point. Assessment planned for 2012.*

**Does the quota include bycatch/discard estimates? If so, what is the source of the bycatch/discard values? What are the bycatch/discard allowances?**

The SSC's recommended ABC was for landed catch only did not include estimates of discard and bycatch.

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

See excerpt above.

### 2.6 Regulatory Timeline

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

**Table 2.6.1. Annual Commercial Gray Triggerfish Regulatory Summary**

| Year | Fishing Year | Size Limit (only applies off the Atlantic coast of Florida) | Possession Limit | Open Date | Close Date | Other |
|---|---|---|---|---|---|---|
| 1993 | Calendar Year | none | none | January 1 | | |
| 1994 | Calendar Year | none | none | January 1 | | |
| 1995 | Calendar Year | 12” TL (began in May) | none | January 1 | | |
| 1996 | Calendar Year | 12” TL | none | January 1 | | |
| 1997 | Calendar Year | 12” TL | none | January 1 | | |
| 1998 | Calendar Year | 12” TL | none | January 1 | | |
| 1999 | Calendar Year | 12” TL | none | January 1 | | |
| 2000 | Calendar Year | 12” TL | none | January 1 | | |
| 2001 | Calendar Year | 12” TL | none | January 1 | | |
| 2002 | Calendar Year | 12” TL | none | January 1 | | |
| 2003 | Calendar Year | 12” TL | none | January 1 | | |
| 2004 | Calendar Year | 12” TL | none | January 1 | | |
| 2005 | Calendar Year | 12” TL | none | January 1 | | |
| 2006 | Calendar Year | 12” TL | none | January 1 | | |
| 2007 | Calendar Year | 12” TL | none | January 1 | | |
| 2008 | Calendar Year | 12” TL | none | January 1 | | |
| 2009 | Calendar Year | 12” TL | none | January 1 | | |
| 2010 | Calendar Year | 12” TL | none | January 1 | | |
| 2011 | Calendar Year | 12” TL | none | January 1 | | |
| 2012 | Calendar Year | 12” TL | none | January 1 | 9/11/12 | Re-opened 12/12/12 to 12/19/12 |
| 2013 | Calendar Year | 12” TL | none | January 1 | 7/7/13 | Re-opened 10/28/13 to 11/14/13 |
| 2014 | Calendar Year | 12” TL | none | January 1 | 5/12/14 | |

**Table 2.6.2. Annual Recreational Gray Triggerfish Regulatory Summary**

| Year | Fishing Year | Size Limit (only applies off the Atlantic coast of Florida) | Bag Limit | Open Date | Close Date | Other |
|---|---|---|---|---|---|---|
| 1993 | Calendar Year | none | none | January 1 | | |
| 1994 | Calendar Year | none | none | January 1 | | |
| 1995 | Calendar Year | 12" TL (began in May) | none | January 1 | | |
| 1996 | Calendar Year | 12" TL | none | January 1 | | |
| 1997 | Calendar Year | 12" TL | none | January 1 | | |
| 1998 | Calendar Year | 12" TL | none | January 1 | | |
| 1999 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit (effective in February) | January 1 | | |
| 2000 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2001 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2002 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2003 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2004 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2005 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2006 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2007 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2008 | Calendar Year | 12" TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2009 | Calendar Year | 12” TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2010 | Calendar Year | 12” TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2011 | Calendar Year | 12” TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2012 | Calendar Year | 12” TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | |
| 2013 | Calendar Year | 12” TL | Included in 20 fish aggregate snapper grouper limit | January 1 | | ACL exceeded by 6% |
| 2014 | Calendar Year | 12” TL | Included in 20 fish aggregate snapper grouper limit | January 1 | 11/26/14 | In-season closure due to exceeding ACL in previous year. 74% of ACL harvested in 2014 |

### 2.6.3 Closures due to Meeting Commercial Quota or Commercial/Recreational ACL

Commercial: 09/11/12; Re-opened 12/12/12 - 12/19/12; 07/07/13; Re-opened 10/28/13 – 11/14/13.

Recreational: 11/26/14. Closed when 74% of ACL was harvested because ACL exceeded by 6% in 2013.

**Table 7. State Regulatory History**

***North Carolina:***
There are currently no North Carolina state-specific regulations for gray triggerfish. North Carolina has complemented federal regulations for all snapper grouper species via proclamation authority since 1991. Between 1992 and 2005, species-specific regulations were added to the proclamation authority contained in rule 15A NCAC 03M .0506. In 2002, North Carolina adopted its Inter-Jurisdictional Fishery Management Plan (IJ FMP), which incorporates all ASMFC and council-managed species by reference, and adopts all federal regulations as minimum standards for management. In completing the 2008 update to the IJ FMP, all species-specific regulations were removed from rule 15A NCAC 03M .0506, and proclamation authority to implement changes in management was moved to rule 15A NCAC 03M .0512. Since this time, all snapper grouper regulations have been contained in a single proclamation, which is updated anytime an opening/closing of a particular species in the complex occurs, as well as any changes in allowable gear, required permits, etc. Beginning in 2015, commercial and recreational regulations are contained in separate proclamations. The most current Snapper Grouper proclamations (and all previous versions) can be found using this link: http://portal.ncdenr.org/web/mf/proclamations.

**15A NCAC 03M .0506 SNAPPER-GROUPER COMPLEX**
(a) In the Atlantic Ocean, it is unlawful for an individual fishing under a Recreational Commercial Gear License with seines, shrimp trawls, pots, trotlines or gill nets to take any species of the Snapper-Grouper complex.
(b) The species of the snapper-grouper complex listed in the South Atlantic Fishery Management Council Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region are hereby incorporated by reference and copies are available via the Federal Register posted on the Internet at www.safmc.net and at the Division of Marine Fisheries, P.O. Box 769, Morehead City, North Carolina 28557 at no cost.
*History Note: Authority G.S. 113-134; 113-182; 113-221; 143B-289.52;*
*Eff. January 1, 1991;*
*Amended Eff. April 1, 1997; March 1, 1996; September 1, 1991;*
*Temporary Amendment Eff. December 23, 1996;*
*Amended Eff. August 1, 1998; April 1, 1997;*

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

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

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

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

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

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

***South Carolina:***

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

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

As such, South Carolina gray triggerfish regulations are (and have been) pulled directly from the federal regulations as promulgated under Magnuson-Stevens Fishery Conservation and Management Act. There are no known separate gray triggerfish regulations that have been codified in the South Carolina Code.

***Georgia:***

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

***Florida:***

Florida Atlantic Gray Triggerfish Regulatory History

| Year | Size Limit | Possession Limit | Other Regulation Changes |
|---|---|---|---|
| 1995 | 12” TL | None | |
| 1996 | 12” TL | None | |
| 1997 | 12” TL | None | |
| 1998 | 12” TL | None | |
| 1999 | 12” TL | None | |
| 2000 | 12” TL | None | |
| 2001 | 12” TL | None | |
| 2002 | 12” TL | None | |
| 2003 | 12” TL | None | |
| 2004 | 12” TL | None | |
| 2005 | 12” TL | None | |
| 2006 | 12” FL | None | Change in the legal measurement from TL to FL |
| 2007 | 12” FL | None | |
| 2008 | 12” FL | None | |
| 2009 | 12” FL | None | |
| 2010 | 12” FL | None | |
| 2011 | 12” FL | None | |
| 2012 | 12” FL | None | |
| 2013 | 12” FL | None | |
| 2014 | 12” FL | None | |

**[1994]**

**REEF FISH, CH 46-14, F.A.C. (Effective March 1, 1994)**

- Establishes a minimum size limit of 12 inches for gray triggerfish, effective January 1, 1995

**[2006]**

**REEF FISH, CH 68B-14, F.A.C. (Effective July 1, 2006)**

- Provides that, for purposes of determining the legal size of reef fish species, "total length" means the straight line distance from the most forward point of the head with the mouth closed, to the farthest tip of the tail with the tail compressed or squeezed, while the fish is lying on its side
- Changes the legal measurement for gray triggerfish from total length to fork length

**References**
None provided.

## 3. Assessment History and Review

South Atlantic gray triggerfish has not been previously assessed under the SEDAR process. This stock has been assessed by catch curve analysis and resulting static spawning potential ratios (SPR) for the 1988, 1990, 1996, and 1999 fishing years (Staff 1991; Huntsman et al. 1992; Potts et al. 1998; Potts and Brennan 2001). Annual age composition estimates were derived from length composition data and age-length keys based on limited ageing data. Since age at maturity was unknown, it was assumed to be the average age to attain one-half asymptotic length. Additionally, estimated fishing mortality rates for the assessed years were conditional on assumed natural mortality rates ranging from 0.2 to 0.3. Estimated SPR values were 30%, 27%, 29%, and 62% for the 1988, 1990, 1996, and 1999 fishing years, respectively.

A subsequent assessment was conducted by students and staff of the NMFS RTR unit at Virginia Polytechnic Institute and State University (Broome et al. 2011). This effort also relied on catch-curve analyses but also attempted to fit an age aggregated surplus production model (ASPIC) to index and landings data from the late 1980's to 2009. The study yielded no conclusive findings as to the status of the stock and the authors suggested many of the same research recommendations as those highlighted in earlier assessments.

Broome, M., D. Claar, E. Hamman, T. Matthews, M. Salazar, K. Shugart-Schmidt, A. Tillman, M. Vincent, and J. Berkson. 2011. Exploratory assessment of four stocks in the U.S. South Atlantic: Bank sea bass (*Centropristis ocyurus*), Gray triggerfish (*Balistes capriscus*), Sand perch (*Diplectrum formosum*), and Tomtate (*Haemulon aurolineatum*). NOAA Technical Memorandum NMFS-SEFSC-617,133P.

Huntsman, G. R., J. C. Potts, R. Mays, R. L. Dixon, P. W. Willis, M. Burton, and B. W. Harvey. 1992. A stock assessment of the Snapper-Grouper Complex in the U.S. South Atlantic based on the fish caught in 1990. Report to the South Atlantic Fishery Management Council, One Southpark Circle, Suite 306, Charleston, SC 29407, 104p.

Potts, J. C., M. L. Burton, and C. S. Manooch III. 1998. Trends in catch data and estimated static SPR values for fifteen species of reef fish landed along the southeastern United States. Report to the South Atlantic Fishery Management Council, One Southpark Circle, Suite 306, Charleston, SC 29407. 45p.

Potts, J. C., and K. Brennan. 2001. Trends in catch data and estimated static SPR values for fifteen species of reef fish landed along the southeastern United States. Report to the South Atlantic Fishery Management Council, One Southpark Circle, Suite 306, Charleston, SC 29407. 41 p.

Staff of Beaufort Laboratory, Southeast Fisheries Science Center. 1991. South Atlantic snapper grouper assessment 1991. Report to the South Atlantic Fishery Management Council, One Southpark Circle, Suite 306, Charleston, SC 29407. 21 p., 4 Tables, 39 Figures.

## 4. Regional Maps

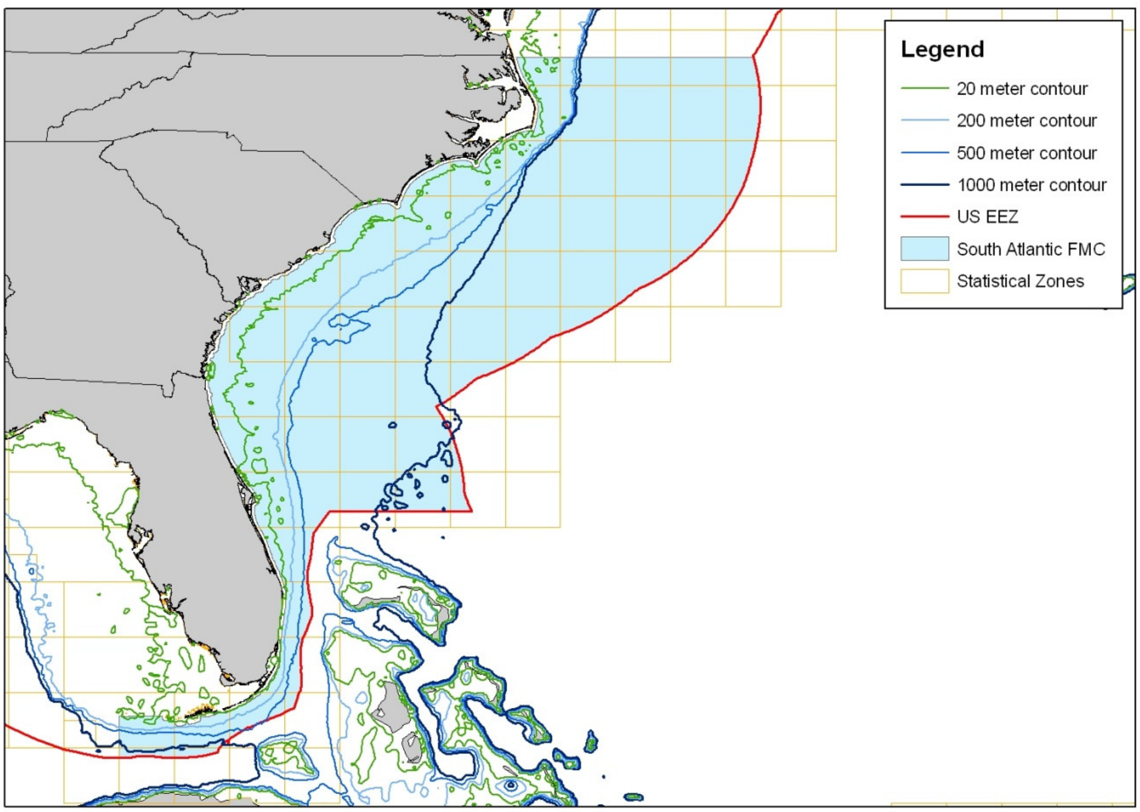


Figure 4.1: South Atlantic Fishery Management Council and EEZ boundaries.

## 5. SEDAR Abbreviations

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

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

# SEDAR

## Southeast Data, Assessment, and Review

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# SEDAR 41

## South Atlantic Gray Triggerfish

## SECTION II: Data Workshop Report

## September 15, 2015

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

# 1. Introduction

## 1.1 Workshop Time and Place

The initial SEDAR 41 Data Workshop (DW) was held August 4 – 8, 2014 in Charleston, South Carolina. A data scoping call was held May 28, 2014 and webinars were held July 2, 2014, August 15, 2014 September 11, 2014, and September 26, 2014.

A working paper submitted after the DW questioned the validity of data collected during the early years of the Southeast Region Headboat Survey (SRHS). The Data Workshop Panel discussed this issue on a post-DW webinar and recommended stopping the SEDAR 41 assessments for both species to investigate the headboat issues and delaying both assessments until the issues are resolved. The SAFMC and SEDAR Steering Committee were briefed on this recommendation in fall 2014. A new schedule was approved in December 2014 delaying the assessment approximately one year and the terminal year of the assessment was changed to 2014.

The second abbreviated DW was held August 4-6, 2015 in Charleston, SC. This workshop built on the work done at the 2014 DW, revisiting decisions only if new information or analyses were available. Otherwise datasets were updated with 2014 data using decisions from the 2014 DW. Two data webinars were held before the workshop on April 15 and July 1, 2015 and a post-DW webinar was held August 20, 2015.

Between the 2014 and 2015 DW's, the Southeast Fisheries Science Center conducted a headboat data evaluation and submitted a working paper (SEDAR41-DW46) for review at the 2015 DW.

## 1.2 Terms of Reference

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 growth, maturation, and fecundity by age, sex, or length as applicable.
   - Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling.
   - Evaluate, discuss, and characterize the sources of uncertainty, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].

3. Compare and contrast life history traits between the Gulf of Mexico and South Atlantic stocks.
4. Recommend discard mortality rates.
   - Review available research and published literature.
   - Consider research directed at these species as well as similar species from the SE and other areas.
   - Provide estimates of discard mortality rate by fishery, gear type, depth, and other feasible or appropriate strata.
   - Include thorough rationale for recommended discard mortality rates.
   - Provide justification for any recommendations that deviate from the range of discard mortality provided in the last benchmark or other prior assessment.
   - Evaluate, discuss, and characterize the sources of uncertainty, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].
5. Provide measures of population abundance that are appropriate for stock assessment.
   - Consider and discuss all available and relevant fishery dependent and independent data sources.
   - Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics.
   - Provide maps of fishery and survey coverage.
   - Develop fishery and survey CPUE indices by appropriate strata (e.g., age, size, area, and fishery) and include measures of precision and accuracy.
   - Discuss the degree to which available indices adequately represent fishery and population conditions.
   - Recommend which data sources adequately and reliably represent population abundance for use in assessment modeling.
   - Evaluate, discuss, and characterize the sources of uncertainty, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].
   - Complete the SEDAR index evaluation worksheet for each index considered.
   - Rank the available indices with regard to their reliability and adequacy for use in assessment modeling.
6. Provide commercial catch statistics, including both landings and discards in both pounds and number.

- Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear.
- Evaluate, discuss, and characterize the sources of uncertainty, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].
- Provide length and age distributions for both landings and discards if feasible.
- Provide maps of fishery effort and harvest by species and fishery sector or gear.

7. Provide recreational catch statistics, including both landings and discards in both pounds and number.
   - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear.
   - Evaluate, discuss, and characterize the sources of uncertainty, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].
   - Provide length and age distributions for both landings and discards if feasible.
   - Provide maps of fishery effort and harvest by species and fishery sector or gear.
8. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.
9. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines (Section II. of the SEDAR assessment report).

1. In providing ranges for uncertain or incomplete information, data workshop groups should consider and distinguish between those ranges and bounds that represent probable values (i.e., likely alternative states) to be included in structured uncertainty analyses, and those that represent extreme values to be considered in evaluating model performance through sensitivity analyses.

## 1.3 List of Participants

**2014 Data Workshop Panelists**

Nate Bacheler, SEFSC/NMFS
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David Wyanski, SCDNR

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

**2015 Data Workshop Panelists**

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

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*Participated in webinars but did not attend the data workshop.

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Ken Stump, Ocean Foundation
Byron White, SCDNR
Michelle Willis, SCDNR

## 1.4 List of Data Workshop Working Papers

South Atlantic red snapper and gray triggerfish data workshop document list. Working papers that were updated from the 2014 DW or were new for the 2015 DW are labeled as such.

| Document # | Title | Authors |
|---|---|---|
| | **Documents Prepared for the Data Workshop (DW)** | |
| SEDAR41-DW01 | **UPDATED:** Georgia Headboat Red Snapper Catch and Effort Data, 1983-2013 | Amick and Knowlton 2014 |
| SEDAR41-DW02 | **UPDATED:** Georgia Red Snapper Catch & Effort Collection during Mini-Seasons, 2012-2014 | Knowlton 2015 |
| SEDAR41-DW03 | Standardized video counts of Southeast U.S. Atlantic gray triggerfish (*Balistes capriscus*) from the Southeast Reef Fish Survey ****See SEDAR41-DW44 for index updated through 2014** | Purcell et al. 2014 |
| SEDAR41-DW04 | Standardized video counts of Southeast U.S. Atlantic red snapper (*Lutjanus campechanus*) from the Southeast Reef Fish Survey ****See SEDAR41-DW45 for index updated through 2014** | Purcell et al. 2014 |
| SEDAR41-DW05 | Gray Triggerfish Fishery-Independent Indices of Abundance in US South Atlantic Waters Based on | Ballenger et al. 2014 |

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| | a Chevron Trap Survey<br>****See SEDAR41-DW52 for index recommended from 2015 DW** | |
| SEDAR41-DW06 | Red Snapper Fishery-Independent Indices of Abundance in US South Atlantic Waters Based on a Chevron Trap Survey<br>****See SEDAR41-DW53 and SEDAR41-DW54 for index recommendations from 2015 DW** | Ballenger et al. 2014 |
| SEDAR41-DW07 | Age Truncation and Reproductive Resilience of Red Snapper (*Lutjanus campechanus*) Along the East Coast of Florida **(has since been published – see SEDAR41-RD57)** | Lowerre-Barbieri et al. 2014 |
| SEDAR41-DW08 | The utility of a hooked gear survey in developing a fisheries-independent index of abundance for red snapper along Florida's Atlantic coast | Guenther et al. 2014 |
| SEDAR41-DW09 | Size and age composition of red snapper, *Lutjanus campechanus*, collected in association with fishery-independent and fishery-dependent projects off of Florida's Atlantic coast during 2012 and 2013 | Switzer et al. 2014 |
| SEDAR41-DW10 | Overview of Florida's Cooperative East Coast Red Snapper Tagging Program, 2011-2013 | Brodie et al. 2014 |
| SEDAR41-DW11 | Habitat models for Gray Triggerfish collected in fishery-independent trap surveys off the southeastern United States | Muhling et al. 2014 |
| SEDAR41-DW12 | **UPDATED:** Preliminary standardized catch rates of Southeast US Atlantic red snapper (*Lutjanus campechanus*) from headboat logbook data | SFB-NMFS 2015 |
| SEDAR41-DW13 | **UPDATED:** Preliminary standardized catch rates of Southeast US Atlantic gray triggerfish (*Balistes capriscus*) from headboat logbook data | SFB-NMFS 2015 |
| SEDAR41-DW14 | **UPDATED:** Standardized catch rates of red snapper (*Lutjanus campechanus*) from headboat at-sea-observer data | SFB-NMFS 2015 |
| SEDAR41-DW15 | Standardized catch rates of gray triggerfish (*Balistes capriscus*) from headboat at-sea-observer data | SFB-NMFS 2014 |
| SEDAR41-DW16 | **UPDATED:** Report on Life History of South Atlantic Gray Triggerfish, *Balistes capriscus*, from Fishery-Independent Sources | Kolmos et al. 2015 |

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| SEDAR41-DW17 | **UPDATED:** Estimates of Historic Recreational Landings of Red Snapper in the South Atlantic Using the FHWAR Census Method | Brennan 2015 |
| SEDAR41-DW18 | **UPDATED**: South Carolina Red Snapper Catch and Biological Data Collection during Mini-Seasons, 2012-2014 | Dukes & Hiltz 2015 |
| SEDAR41-DW19 | **UPDATED**: Standardized catch rates of red snapper (*Lutjanus campechanus*) in the southeast U.S. from commercial logbook data | SFB-NMFS 2015 |
| SEDAR41-DW20 | **UPDATED**: Standardized catch rates of gray triggerfish (*Balistes capriscus*) in the southeast U.S. from commercial logbook data | SFB-NMFS 2015 |
| SEDAR41-DW21 | North Carolina Division of Marine Fisheries Red Snapper Carcass Collections, 2012-2013 | NCDMF 2014 |
| SEDAR41-DW22 | SEDAR 41 Red snapper stock assessment must utilize “direct” estimates of gear selectivity | Barile and Nelson 2014 |
| SEDAR41-DW23 | Atlantic Red Snapper (*Lutjanus campechanus*) Fishing History Timeline | Hudson 2014 |
| SEDAR41-DW24 | Atlantic Red Snapper (*Lutjanus campechanus*) Historical Fishing Pictures | Hudson 2014 |
| SEDAR41-DW25 | Historical For-Hire Fishing Vessels: South Atlantic Fishery Management Council, 1930’s to 1985 | Hudson 2014 |
| SEDAR41-DW26 | SEDAR 41 Atlantic Red Snapper and Gray Triggerfish Data Workshop Historical Photographs of For-Hire Vessels 1930’s to 1985 | Hudson 2014 |
| SEDAR41-DW27 | Red snapper mini season ad-hoc working group report | Red Snapper Mini Season Ad-hoc Group 2014 |
| SEDAR41-DW28 | Red Snapper *Lutjanus campechanus* in Gulf of Mexico versus southeast US Atlantic Ocean waters: gaps in knowledge and implications for management | Rindone et al. 2014 |
| SEDAR41-DW29 | Discards of red snapper (*Lutjanus campechanus*) for the headboat fishery in the US South Atlantic ****See SEDAR41-AW01 for updated HB discards WP** | FEB-NMFS 2014 |
| SEDAR41-DW30 | Discards of gray triggerfish (*Balistes capriscus*) for the headboat fishery in the US South Atlantic ****See SEDAR41-AW02 for updated HB** | FEB-NMFS 2014 |

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| | **discards WP** | |
| SEDAR41-DW31 | Red Snapper Preliminary Genetic Analysis Temporal Genetic Diversity Trends in the South Atlantic Bight | O'Donnell and Darden 2014 |
| SEDAR41-DW32 | SCDNR Charterboat Logbook Program Data, 1993-2013 | Hiltz 2014 |
| SEDAR41-DW33 | **UPDATED:** Size Distribution, Release Condition, and Estimated Discard Mortality of Red Snapper Observed in For-Hire Recreational Fisheries in the South Atlantic | Sauls et al. 2015 |
| SEDAR41-DW34 | **UPDATED:** Size Distribution, Release Condition, and Estimated Discard Mortality of Gray Triggerfish Observed in For-Hire Recreational Fisheries in the South Atlantic | Sauls et al. 2015 |
| SEDAR41-DW35 | **UPDATED:** Marine Resources Monitoring, Assessment and Prediction Program: Report on Atlantic Red Snapper, *Lutjanus campechanus*, Life History for the SEDAR 41 Data Workshop | White et al. 2014<br>Wyanski et al. 2015 |
| SEDAR41-DW36 | **UPDATED:** Discards of Red Snapper Calculated for Commercial Vessels with Federal Fishing Permits in the US South Atlantic | McCarthy 2015 |
| SEDAR41-DW37 | **UPDATED:** Calculated Discards of Gray Triggerfish from US South Atlantic Commercial Fishing Vessels | McCarthy 2015 |
| SEDAR41-DW38 | Historic catch of red snapper by headboats through historic photograph analysis | Gray et al. 2014 |
| SEDAR41-DW39 | Index report cards | Index Working Group 2014 |
| SEDAR41-DW40 | Problems with Headboat Index of Abundance Confounds Use in SEDAR 41 Red Snapper | Nelson et al. 2014 |
| SEDAR41-DW41 | Commercial Fishing Targeting Changes | Fex 2014 |
| SEDAR41-DW42 | **NEW:** South Atlantic Red Snapper (*Lutjanus campechanus*) monitoring in Florida: Revised recreational private boat mode estimates for 2012 and 2013 mini-seasons, and new private boat mode estimates for the 2014 mini-season | Sauls 2015 |
| SEDAR41-DW43 | **NEW:** Hook Selectivity in gray triggerfish observed in the for-hire fishery off the Atlantic coast of Florida | Gray and Sauls 2015 |
| SEDAR41-DW44 | **NEW:** Standardized video counts of Southeast | Ballew et al. 2015 |

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| | U.S. Atlantic gray triggerfish (*Balistes capriscus*) from the Southeast Reef Fish Survey | |
| SEDAR41-DW45 | **NEW:** Standardized video counts of Southeast U.S. Atlantic red snapper (*Lutjanus campechanus*) from the Southeast Reef Fish Survey | Ballew et al. 2015 |
| SEDAR41-DW46 | **NEW:** Headboat Data Evaluation | NMFS-SEFSC 2015 |
| SEDAR41-DW47 | **NEW:** Development of an ageing error matrix for U.S. gray triggerfish *(Balistes capriscus)* | SFB-NMFS 2015 |
| SEDAR41-DW48 | **NEW:** Development of an ageing error matrix for U.S. red snapper *(Lutjanus campechanus)* | SFB-NMFS 2015 |
| SEDAR41-DW49 | **NEW:** Estimates of reproductive activity in red snapper by size, season, and time of day with nonlinear models | Klibansky 2015 |
| SEDAR41-DW50 | **NEW:** Hook Selectivity in red snapper observed in the for-hire fishery off the Atlantic coast of Florida | Gray and Sauls 2015 |
| SEDAR41-DW51 | **NEW:** SERFS Chevron Trap Red Snapper Index of Abundance: An Investigation of the Utility of Historical (1990-2009) Chevron Trap Catch Data | Ballenger 2015 |
| SEDAR41-DW52 | **NEW:** Gray Triggerfish Fishery-Independent Index of Abundance in US South Atlantic Waters Based on a Chevron Trap Survey (1990-2014) | Ballenger and Smart 2015 |
| SEDAR41-DW53 | **NEW:** Red Snapper Fishery-Independent Index of Abundance in US South Atlantic Waters Based on a Chevron Trap Survey (2005-2014) | Ballenger and Smart 2015 |
| SEDAR41-DW54 | **NEW:** Red Snapper Fishery-Independent Index of Abundance in US South Atlantic Waters Based on a Chevron Trap Survey (2010-2014) | Ballenger and Smart 2015 |
| **Reference Documents** | | |
| SEDAR41-RD01 | List of documents and working papers for SEDAR 32 (South Atlantic Blueline Tilefish and Gray Triggerfish) – all documents available on the SEDAR website. | SEDAR 32 |
| SEDAR41-RD02 | List of documents and working papers for SEDAR 9 (Gulf of Mexico Gray Triggerfish, Greater Amberjack, and Vermilion Snapper) – all documents available on the SEDAR website. | SEDAR 9 |
| SEDAR41-RD03 | 2011 Gulf of Mexico Gray Triggerfish Update Assessment | SEDAR 2011 |
| SEDAR41-RD04 | List of documents and working papers for SEDAR | SEDAR 24 |

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| | 24 (South Atlantic red snapper) – all documents available on the SEDAR website. | |
| SEDAR41-RD05 | List of documents and working papers for SEDAR 31 (Gulf of Mexico red snapper) – all documents available on the SEDAR website. | SEDAR 31 |
| SEDAR41-RD06 | List of documents and working papers for SEDAR 15 (South Atlantic red snapper and greater amberjack) – all documents available on the SEDAR website. | SEDAR 15 |
| SEDAR41-RD07 | 2009 Gulf of Mexico red snapper update assessment | SEDAR 2009 |
| SEDAR41-RD08 | List of documents and working papers for SEDAR 7 (Gulf of Mexico red snapper) – all documents available on the SEDAR website. | SEDAR 7 |
| SEDAR41-RD09 | SEDAR 24 South Atlantic Red Snapper: management quantities and projections requested by the SSC and SERO | NMFS - Sustainable Fisheries Branch 2010 |
| SEDAR41-RD10 | Total removals of red snapper (*Lutjanus campechanus*) in 2012 from the US South Atlantic | NMFS - Sustainable Fisheries Branch 2013 |
| SEDAR41-RD11 | Amendment 17A to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | SAFMC 2010 |
| SEDAR41-RD12 | Amendment 28 to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | SAFMC 2013 |
| SEDAR41-RD13 | Total removals of red snapper (*Lutjanus campechanus*) in 2013 from the U.S. South Atlantic | NMFS - Sustainable Fisheries Branch 2014 |
| SEDAR41-RD14 | South Atlantic red snapper (*Lutjanus campechanus*) monitoring in Florida for the 2012 season | Sauls et al. 2013 |
| SEDAR41-RD15 | South Atlantic red snapper (*Lutjanus campechanus*) monitoring in Florida for the 2013 season | Sauls et al. 2014 |
| SEDAR41-RD16 | A directed study of the recreational red snapper fisheries in the Gulf of Mexico along the West Florida shelf | Sauls et al. 2014 |
| SEDAR41-RD17 | Using generalized linear models to estimate selectivity from short-term recoveries of tagged | Bacheler et al. 2009 |

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| | red drum *Sciaenops ocellatus*: Effects of gear, fate, and regulation period | |
| SEDAR41-RD18 | Direct estimates of gear selectivity from multiple tagging experiments | Myers and Hoenig 1997 |
| SEDAR41-RD19 | Examining the utility of alternative video monitoring metrics for indexing reef fish abundance | Schobernd et al. 2014 |
| SEDAR41-RD20 | An evaluation and power analysis of fishery independent reef fish sampling in the Gulf of Mexico and U.S. South Atlantic | Conn 2011 |
| SEDAR41-RD21 | Consultant's Report: Summary of the MRFSS/MRIP Calibration Workshop | Boreman 2012 |
| SEDAR41-RD22 | 2013 South Atlantic Red Snapper Annual Catch Limit and Season Length Projections | SERO 2013 |
| SEDAR41-RD23 | Southeast Reef Fish Survey Video Index Development Workshop | Bacheler and Carmichael 2014 |
| SEDAR41-RD24 | Observer Coverage of the 2010-2011 Gulf of Mexico Reef Fish Fishery | Scott-Denton and Williams |
| SEDAR41-RD25 | Circle Hook Requirements in the Gulf of Mexico: Application in Recreational Fisheries and Effectiveness for Conservation of Reef Fishes | Sauls and Ayala 2012 |
| SEDAR41-RD26 | GADNR Marine Sportfish Carcass Recovery Project | Harrell 2013 |
| SEDAR41-RD27 | Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States | Gulf and South Atlantic Fisheries Foundation 2008 |
| SEDAR41-RD28 | A Continuation of Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States | Gulf and South Atlantic Fisheries Foundation 2010 |
| SEDAR41-RD29 | Continuation of Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States | Gulf and South Atlantic Fisheries Foundation 2013 |
| SEDAR41-RD30 | Amendment 1 and Environmental Assessment and Regulatory Impact Review to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | SAFMC 1988 |
| SEDAR41-RD31 | Final Rule for Amendment 1 to the Fishery Management Plan for the Snapper Grouper | Federal Register 1989 |

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| | Fishery of the South Atlantic Region | |
| SEDAR41-RD32 | Population Structure and Genetic Diversity of Red Snapper (Lutjanus campechanus) in the U.S. South Atlantic and Connectivity with Red Snapper in the Gulf of Mexico | Gold and Portnoy 2013 |
| SEDAR41-RD33 | Oogenesis and fecundity type of Gulf of Mexico gray triggerfish reflects warm water environmental and parental care | Lang and fitz 2014 |
| SEDAR41-RD34 | Depth-related Distribution of Postjuvenile Red Snapper in Southeastern U.S. Atlantic Ocean Waters: Ontogenetic Patterns and Implications for Management | Mitchell et al. 2014 |
| SEDAR41-RD35 | Gray Triggerfish Age Workshop | Potts 2013 |
| SEDAR41-RD36 | Age, Growth, and Reproduction of Gray Triggerfish *Balistes capriscus* Off the Southeastern U.S. Atlantic Coast | Kelly 2014 |
| SEDAR41-RD37 | Assessment of Genetic Stock Structure of Gray Triggerfish (*Balistes capriscus*) in U.S. Waters of the Gulf of Mexico and South Atlantic Regions | Saillant and Antoni 2014 |
| SEDAR41-RD38 | Genetic Variation of Gray Triggerfish in U.S. Waters of the Gulf of Mexico and Western Atlantic Ocean as Inferred from Mitochondrial DNA Sequences | Antoni et al. 2011 |
| SEDAR41-RD39 | Characterization of the U.S. Gulf of Mexico and South Atlantic Penaeid and Rock Shrimp Fisheries Based on Observer Data | Scott-Denton et al. 2012 |
| SEDAR41-RD40 | Does hook type influence the catch rate, size, and injury of grouper in a North Carolina commercial fishery | Bacheler and Buckel 2004 |
| SEDAR41-RD41 | Fishes associated with North Carolina shelf-edge hardbottoms and initial assessment of a proposed marine protected area | Quattrini and Ross 2006 |
| SEDAR41-RD42 | Growth of grey triggerfish, *Balistes capriscus*, based on growth checks of the dorsal spine | Ofori-Danson 1989 |
| SEDAR41-RD43 | Age Validation and Growth of Gray Triggerfish, *Balistes capriscus*, In the Northern Gulf of Mexico | Fioramonti 2012 |
| SEDAR41-RD44 | A review of the biology and fishery for Gray Triggerfish, *Balistes capriscus*, in the Gulf of Mexico | Harper and McClellan 1997 |
| SEDAR41-RD45 | Stock structure of gray triggerfish, *Balistes* | Ingram 2001 |

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| | *capriscus*, on multiple spatial scales in the Gulf of Mexico | |
| SEDAR41-RD46 | Evaluation of the Efficacy of the Current Minimum Size Regulation for Selected Reef Fish Based on Release Mortality and Fish Physiology | Burns and Brown-Peterson 2008 |
| SEDAR41-RD47 | Population Structure of Red Snapper from the Gulf of Mexico as Inferred from Analysis of Mitochondrial DNA | Gold et al. 1997 |
| SEDAR41-RD48 | Successful Discrimination Using Otolith Microchemistry Among Samples of Red Snapper *Lutjanus campechanus* from Artificial Reefs and Samples of *L.campechanus* Taken from Nearby Oil and Gas Platforms | Nowling et al. 2011 |
| SEDAR41-RD49 | Population Structure and Variation in Red Snapper (Lutjanus campechanus) from the Gulf of Mexico and Atlantic Coast of Florida as Determined from Mitochondrial DNA Control Region Sequence | Garber et al. 2003 |
| SEDAR41-RD50 | Population assessment of the red snapper from the southeastern United States | Manooch et al. 1998 |
| SEDAR41-RD51 | Otolith Microchemical Fingerprints of Age-0 Red Snapper, *Lutjanus campechanus*, from the Northern Gulf of Mexico | Patterson et al. 1998 |
| SEDAR41-RD52 | Implications of reef fish movement from unreported artificial reef sites in the northern Gulf of Mexico | Addis et al. 2013 |
| SEDAR41-RD53 | Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species | Then et al. 2014 |
| SEDAR41-RD54 | Length selectivity of commercial fish traps assessed from in situ comparisons with stereo-video: Is there evidence of sampling bias? | Langlois et al. 2015 |
| SEDAR41-RD55 | MRIP Calibration Workshop II – Final Report | Carmichael and Van Vorhees (eds.) 2015 |
| SEDAR41-RD56 | Total Removals of red snapper (*Lutjanus campechanus*) in 2014 from the U.S. South Atlantic | SEFSC 2015 |
| SEDAR41-RD57 | Assessing reproductive resilience: an example with South Atlantic red snapper *Lutjanus campechanus* | Lowerre-Barbiere et al. 2015 |
| SEDAR41-RD58 | Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey | Smart et al. 2014 |

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| | and its partners | |
| SEDAR41-RD59 | MRIP Transition Plan for the Fishing Effort Survey | Atlantic and Gulf Subgroup of the MRIP Transition Team 2015 |

# 2. Life History

## 2.1 Overview (Group Membership, Leader, Issues)

The life history working group (LHWG) was tasked with reviewing the new data and analysis available (mostly as a result of adding the 2014 data) since the 2014 DW, and combining fishery dependent data compiled by the South East Fisheries Science Center Beaufort Laboratory (SEFSC, NOAA/NMFS-Beaufort) and fishery independent data compiled by South Carolina Department of Natural Resources (SCDNR). This combined data set could then be used for analysis of life history parameters for Gray Triggerfish. Note that the collaborative fishery-independent snapper grouper monitoring conducted by the Marine Resources Monitoring, Assessment and Prediction Program (MARMAP), the South East Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) (both housed at SC-DNR's Marine Resources Research Institute), and the South East Fishery-Independent Survey (SEFIS) (NMFS project housed at SEFSC, Beaufort, NC) are now collectively referred to as the South East Reef Fish Survey (SERFS). Data from all SERFS components were combined for analyses. The SEFSC data predominantly came from various fishery-dependent sources.

The LHWG reviewed the age data from the different labs, and discussed models that describe growth and reproduction most appropriately, the biological unit stock based on literature, estimates of natural mortality and selection of preferred estimate, migration and movements of Gray Triggerfish. Additionally, the LHWG provided a comparison between estimates/methods proposed for use in SEDAR 41 with estimates/methods used in Gulf of Mexico Gray Triggerfish assessments. The LHWG did not discuss or make recommendations for discard mortality during the 2015 DW as the development of estimates for discard mortality were discussed by an ad hoc working group formed prior to the 2014 DW.

**LHWG Membership for the Data Workshop in August 2014.**
**Panel members**
Marcel Reichert – SCDNR/SA-SSC (LH Working Group Leader)
David Wyanski SCDNR (Gray Triggerfish Subgroup Leader)
Walter Bubley - SCDNR
Chip Collier – SAFMC (Bycatch Mortality Subgroup Leader)
Michael Cooper – NMFS
Tanya Darden – SCDNR
Shelly Falk – SCDNR
Cameron Guenther – FWRI
Susan Lowerre-Barbieri – FWRI
Adam Lytton – SCDNR
Todd Kellison – NMFS
Amanda Kelly – SCDNR
Kevin Kolmos – SCDNR*

Jennifer Potts – NMFS
George Sedberry – NOAA/SSC
Byron White – SCDNR
Kevin Craig – SEFSC Assessment Staff
David Nelson – DW Panel member

* Denotes that Panel member was not at Data Workshop, but contributed to webinars, data collection, analyses, and report preparation.

**Observers**
Jessica Lewis - NMFS
Kevin Spanik – SCDNR
Michelle Willis – SCDNR

Note that the Observers played a very active role in the data compilation and analyses and their assistance was much appreciated by the Panel Members.

**LHWG Membership for the Data Workshop in August 2015.**
**Panel members**
Marcel Reichert – SCDNR/SA-SSC (LH Working Group Leader)
David Wyanski SCDNR (Gray Triggerfish Subgroup Leader)
Walter Bubley - SCDNR
Jennifer Potts – NMFS (red Snapper Subgroup Leader)
George Sedberry – NOAA/SSC
Nikolai Klibansky - SEFSC
Kevin Craig – SEFSC Assessment Staff
David Nelson – DW Panel member

Note that Panel members that participated in the 2014 DW, but were not present at the 2015 DW contributed to webinars and assisted with the compiling the data updates and analyses for the 2015 DW.

## 2.2 Review of Working Papers

**SEDAR41-DW16**
Report on Life History of South Atlantic Gray Triggerfish, *Balistes capriscus*, from Fishery-Independent Sources. Kolmos et al. 2014.

*Synopsis*

This document described aspects of Gray Triggerfish life history in South Atlantic waters, including length, weight and dorsal spine increment count ranges, age- and length-at-maturity, and sex ratio based largely on fishery-independent data collected by the MARMAP program, and, in recent years, the SEAMAP-SA and SEFIS programs.

*Critique*
SEDAR 41 Reference Document 16 was reviewed and deemed pertinent for the SEDAR process. While the first dorsal spine is a commonly used structure for ageing, validation studies (marginal increment analysis, etc.) are needed to increase confidence in age assignments. Studies to evaluate the effectiveness of alternative aging structures would also be useful. Representatives of the LHWG at SEDAR 41 were in strong agreement that due to the pelagic nature of juvenile Gray Triggerfish, increment age 0 fish are most-likely much closer to age 1 by the time they settle to hard bottom habitat and recruit to sampling gear, particularly the chevron trap. Members of the LHWG have made several recommendations for dealing with the uncertainty in this age class such as omitting them from analysis, using fractional ages, and fixing the $t_0$ parameter of the von Bertalanffy growth curve. Period-specific maturation analyses conducted in this study are important since it may show biological response to increased fishing pressure, as commercial and recreational fishermen have reported an increased desirability for Gray Triggerfish in recent years. Lack of histology samples in current spawning condition observed in this study may be due to lack of feeding due to bi-parental care behavior as noted, but it has also been suggested that spawning may occur in deeper waters and on shelf edges, where sampling gear may not be providing significant coverage. Continued observations from video cameras mounted on chevron traps may help to elucidate this uncertainty

**SEDAR41-DW34**
Size Distribution, Release Condition, and Estimated Discard Mortality of Gray Triggerfish Observed in For-Hire Recreational Fisheries in the South Atlantic. Sauls et al. 2014.

*Synopsis*
The working paper provides a description of the size distribution, hook type used, and release condition of Gray Triggerfish in the for-hire recreational fishery. The paper includes the time series and the geographic coverage of the data collected and methods used to develop the estimates from the at-sea observer program for the South Atlantic. The at-sea observer program started in 2004 for headboats in the South Atlantic and 2010 for charter boats in Florida. Florida has slightly different methodology than other states and collects more information on the observer trips than other states collect. This allowed for estimates of hook type usage, description of hooking location (to determine potentially lethal hooking), and description of condition of the discarded Gray Triggerfish.

*Critique*
The working paper is acceptable for use in the stock assessment. The paper provides needed information on the methods used to estimate the number and lengths of discarded fish. It also provided needed information on the impact of circle hooks to reduce discard mortality (potential lethal hooking events) and the condition of discarded Gray Triggerfish.

**SEDAR41-DW47**
Development of an ageing error matrix for U.S. gray triggerfish (*Balistes capriscus*)
Sustainable Fisheries Branch, National Marine Fisheries Service (contact: Eric Fitzpatrick)

*Synopsis*
The DW describes the age error matrix for use in the SEDAR41 assessment. This analysis was done after the 2014 DW and no update was needed for the 2015 DW.

*Critique*
The LHWG reviewed the data and analysis and agreed that the presented information should be used to characterize the uncertainty in age estimates based on the variability in age readings between readers and labs. Note that the additional information on the age determination process is provided in section 2.6 of this LHWG report.

## 2.3 Stock Definition and Description

Gray Triggerfish inhabit both natural and artificial reefs ranging from Nova Scotia to Argentina, including the Gulf of Mexico and off of Bermuda in the western Atlantic (Harper and McClellan, 1997; Fioramonti, 2012) and from Norway to the northwestern coast of Africa in the eastern Atlantic (Ofori-Danson 1989; Fioramonti 2012) (Figure 2.1). Genetic stock structure of Gray Triggerfish from the Gulf of Mexico and the western Atlantic was initially investigated by Antoni et al. (2011) using mitochondrial DNA sequences from samples along Texas, Louisiana, west coast Florida, east coast Florida, and South Carolina. Their results indicated homogeneity of genetic variants between the Gulf of Mexico and U.S. South Atlantic, but their sample sizes were low and the use of only one locus may not provide adequate resolution to reveal more subtle differences. The authors also noted that larvae and small juveniles utilize *Sargassum* spp. habitat for a few weeks to a few months, thus accounting for genetic mixing between the two bodies of water. Based on earlier studies and their own study, Simmons and Szedlmayer (2011) concluded that Gray Triggerfish spend 4-7 months in the pelagic zone before settlement to benthic substrate. Tagging studies indicate large juveniles and adults are highly sedentary (Ingram 2001). A follow-up study by Sallient and Antoni (2014 MARFIN Final Report) included additional markers (mtND4 and 17 microsatellites) and specimens (n=665) from six locations in the Gulf of Mexico and two U.S. South Atlantic locations ranging from south Texas to South Carolina. Similar to their prior study, analyses of both genetic data sets suggest genetic homogeneity throughout the U.S. sampling region which was consistent with large neighborhood sizes. Therefore, there appears to be no stock structure within the U.S. Atlantic, within the Gulf of Mexico, or between the U.S. Atlantic and Gulf of Mexico, indicating that Gray Triggerfish are demographically connected within U.S. waters.

Sallient and Antoni (2014) also evaluated genetic connectivity between the eastern and western Atlantic Gray Triggerfish populations using both mtND4 and 17 microsatellites. Interestingly, they detected high connectivity between U.S. and European (i.e. France) populations with West Africa populations representing a genetically distinct stock. The authors suggest the genetic uniqueness of the African Gray Triggerfish populations are likely the result of current pattern influence on larval dispersal. Additionally, they note the potential of a large portion of Gray Triggerfish along the western European coast to have originated from U.S. stocks – based on a lower abundance of Gray Triggerfish along the European coast in combination with a high European effective population size estimate which is similar in magnitude to U.S. stock estimates. The similar levels of genetic diversity, effective population size estimates, and allele frequency distributions support their proposal.

During the 2015 DW, no new information was available, therefore, single stock management of Gray Triggerfish along the U.S. Atlantic appears to be biologically appropriate. However, for purposes of this assessment, Gray Triggerfish stock definition is from the Florida Keys (Atlantic side) to as far north as landings are recorded.

***Recommendation***

The "South Atlantic" Gray Triggerfish stock be defined as the population occurring in the SAFMC jurisdiction in the Florida Keys in the south to as far north as landings are recorded.

## 2.4 Natural Mortality

Gray Triggerfish have various strategies for protection from predators during the larval/juvenile and adult stages of life, which can impact estimates of natural mortality. Gray Triggerfish are nest builders and briefly protect their nests until the eggs hatch (Bernardes and Dias 2001, Ofori-Danson 1990, MacKichan and Szedlmayer 2007, Simmons 2008). They spend most of their early life in *Sargassum* spp. (Fahay 1975, Dooley 1972, Bortone et al. 1977, Wells and Rooker 2004, Casazza and Ross 2008). These small fish may be vulnerable to pelagic predators feeding in and around the *Sargassum* spp. The fish is also vulnerable to predation during its transition to the demersal reefs. Gray Triggerfish are characterized by their tough skin and have been observed wedging themselves into rock crevices on the reef at night for protection (Allen 2000, Moyle and Cech 2003). The LHWG felt that a point estimate of M was inappropriate even though it had been used in a previous SEDAR assessment (SEDAR-9). Given these behavioral adaptations that afford extra protection at different life stages, the LHWG suggested the use of an age-varying estimate of natural mortality to better represent natural mortality in Gray Triggerfish.

Two methods for estimating age-dependent natural mortality using fitted von Bertalanffy growth models were discussed - Lorenzen (1996), a weight based estimator using length-weight conversions to provide values, and Charnov et al. (2013), using lengths directly from the growth model. Charnov et al. (2013) provides an equation which is an improvement to the empirical equation in Gislason et al. (2010), as well as meta-analyses of other estimators of M, including Lorenzen (1996). They also take into account various aspects of life history traits and habitat of a wide variety of exploited marine and brackish water fishes, leading the LHWG to recommend the Charnov et al. (2013) equation, which utilizes von Bertalanffy growth parameters $L_\infty$ and k, as the best initial estimate of M-at-age:

M = ((Length-at-age/$L_\infty$)^(-1.5))*k

To apply the Charnov et al. (2013) method, the von Bertalanffy growth model was fit as the population growth model, but with $t_0$ fixed at 0. The von Bertalanffy parameters used were:

$L_\infty$ = 443.91 mm
k = 0.50
fixed $t_0$ = 0

The Charnov model provided an age-specific estimate of natural mortality that ranged from 1.30 – 0.50 for fish aged 1 to 15, respectively (Table 2.1). Because cumulative survival after full recruitment into the fishery (age 4+) using the Charnov et al. (2013) method produced cumulative survival of 0.3% to the maximum age, which the LHWG believed to be a biologically realistic value, there was no need to scale the age-varying estimate to a point estimate for natural mortality (Table 2.1).

To obtain confidence intervals around the estimates for natural mortality in regards to the growth models, fractional calendar ages were binned to integers and a bootstrapping procedure was run on the length-at-age data with 1000 iterations for each age bin. Confidence intervals (CI = 95%) were obtained from the bootstrap output. The CI produced two new growth curves encompassing 95% probabilities around each age from the original modeled values. Natural mortality was then calculated for the two growth curves bracketing the original curve using the Charnov et al. (2013) calculation, thus producing an upper and lower bound for the M estimate for use in sensitivity analysis (Table 2.1).

***Recommendations***

1. The LHWG recommends using the unscaled-Charnov natural mortality curve.

2. Variance about the M curve will be investigated by bootstrapping each increment to produce a confidence interval (CI) from each age. The CI will be applied to the length-at-age values for each increment and the Charnov method will be run again on those values, producing an upper and lower limit for sensitivity analyses.

## 2.5 Discard Mortality

Note: Discard mortality estimates were developed during the 2014 DW. No new information or analyses were available, so discard mortality estimates were not revisited at the 2015 DW.

Discard Mortality Participants

| | |
|---|---|
| Zack Bowen | Jimmy Hull |
| Mark Brown | Robert Johnson |
| Chip Collier | David Nelson |
| Chris Conklin | Paul Nelson |
| Jack Cox | Beverly Sauls |
| Sonny Davis | Bill Shearin |
| Kenny Fex | Kate Siegfried |
| Rusty Hudson | Erik Williams |

A literature search was conducted for estimated discard mortality rates for Gray Triggerfish and very little new information has become available since SEDAR 32. SEDAR 32 reviewed four peer-reviewed papers and one final report; one of which was the basis for determining the discard mortality rate for SEDAR 9 and its 2011 update. Commercial and recreational discards were low for Gray Triggerfish in the Gulf of Mexico, and SEDAR 9 assumed a 0% mortality rate for both the commercial and recreational fisheries. However, estimates reviewed for this SEDAR ranged from <1% (Patterson et al., 2002) for fish captured via charter boat methods in 24 – 35m in the Gulf of Mexico to 93% (Stephen and Harris 2010) for fish captured via a commercial vessel fishing in 20 – 80m off South Carolina. An additional estimate of discard mortality rate was produced from a tagging study incorporating commercial, headboat, and research vessels fishing off Onslow Bay, NC, in 29 – 37m (Rudershausen et al., 2010). Although a direct discard mortality rate was not provided in the manuscript, the authors provided an estimated discard mortality rate of 15%, which is more than likely an underestimate (J. Buckel, personal communication).

Two additional studies provided information on possible discard fates. Ansley and Harris (1981) documented a 23% recapture rate for Gray Triggerfish found on artificial reefs and live bottom off Georgia, whereas Collins (1996) indicated a survival rate of 83% for Gray Triggerfish caught across three depth strata off the coast of South Carolina.

Two unpublished datasets were discussed during the SEDAR 32 data workshop. The commercial discard logbook dataset (SEDAR32-DW11) and fishery observer data from recreational hook-and-line headboat trips on the east coast of Florida (SEDAR32-DW14) provided fishery-dependent sources for estimates of discard mortality for Gray Triggerfish. The commercial logbook data indicated the majority of Gray Triggerfish discarded were released alive, indicating a low level of discard mortality (Table 2.2). If only those fish in the "all alive" category are considered, the maximum discard mortality rate for that dataset is 9% for both gears combined. If "majority alive" assumes 51% are discarded alive, the associated mortality rate, including "all alive" fish, would be 5%. The Florida headboat data (2005-2011) indicated 12% of discards observed at the surface were in fair to poor condition (includes dead and preyed upon discards).

The subgroup discussed the findings of each source of data. The SEDAR 9 rate of 0% was provided as a reference for what has been previously used in assessments; however, no one in the subgroup or at plenary had any confidence in a 0% discard mortality rate for this species. Two sources were determined to be non-informative (Patterson et al. 2002 and Ansley and Harris 1981) as they discussed tagging mortality/survival rates not necessarily discard mortality rates. The remaining references provide estimates of surface mortality for Gray Triggerfish and do not include sources of delayed mortality. The commercial discard logbook indicated a maximum mortality rate of 9%; however, that value will be lower as there is an unknown number of fish from the "majority alive" category that survive. The discard mortality rates estimated by the remaining studies ranged from a low of 12% (SEDAR32-DW14) to an extreme of 93% (Stephen and Harris, 2010). The large range in values resulted in continued discussion at the subgroup and plenary levels. The 93% estimate was considered an outlier. The estimate was five times greater than all other surface release estimates.

The subgroup discussed if we had additional information to change what was selected in the SEDAR 32 and decided to bracket the observed values with a range of 5% to 20% (Table 2.3), which would be used for sensitivities. At SEDAR 32, the midrange of the range was selected (12.5%) to avoid the asymmetrical distribution of discard mortality resulting from median and average being perpetuated through the model outputs.

The subgroup discussed if regulations for increased usage of circle hooks would have an impact on the discard mortality of Gray Triggerfish. Research on the impact of circle hooks indicated that Gray Triggerfish were rarely hooked in potentially lethal locations (Sauls and Ayala 2012). Therefore the subgroup recommended no change in discard mortality through time due to a regulation change in 2011 requiring circle hooks and dehooking devices.

There was some discussion on the effects of barotrauma to Gray Triggerfish. Triggerfish have a small mouth and stomach inversion was not seen as a symptom of barotrauma. When released, triggerfish typically swim down quickly. However, cloacal extrusion (anal prolapsed) and internal organ compression was discussed as a potential source of delayed mortality. More research is needed to determine the impact of barotrauma on Gray Triggerfish.

***Recommendation***

The plenary accepted the subgroups recommendation of discard mortality of 12.5% with a sensitivity interval ranging from 5 to 20% for all sectors.

## 2.6 Age

Age data were updated and reanalyzed for the 2015 DW. Age data from fishery-independent (FI) and fishery-dependent (FD) sources were analyzed to estimate various life history parameters. The combined data set included 17,679 aged fish. The age samples were collected from 1990-2014 in U.S. Atlantic waters. Fishery-independent data (n=8,417) were collected in 1991-2009 (MARMAP), and 2010-2014 (SERFS). The fishery dependent samples were collected by NMFS and state agency port agents covering the commercial and recreational fisheries. The samples were sent to NMFS-Beaufort (n=9,262) for processing and aging. NMFS-Beaufort samples contained 7,307 commercial samples; 225 from charter boats (most from FL: n=223 and NC: n=2); 1,708 from headboats; 7 from private boats; 1 from tournament; and 14 samples of unknown fishery.

All samples were assigned an increment count and margin code. Following the Gray Triggerfish Age Workshop in November 2013 (SEDAR41-DW16), the SEFSC and SCDNR spine readers felt uncomfortable assigning consistent edge codes for possible use in determining annual age. Thus, the margin codes only indicated a presence or an absence of the translucent zone (annulus) on the edge of the spine section. The LHWG originally recommended the use of increment counts as a proxy for age to be used in this assessment, but the assessment model assumes the use of age. Also, because this species exhibits early maturation, analysis using increment counts suggests that the fish is spawning before it is hatched. The LHWG explored other options for converting increment counts to calendar age. Analysts of the Gulf of Mexico SEDAR9 Update Assessment (2011) converted increment counts to age based the assumption of a July 1 birth date without regards of the width of the terminal increment (“edge type”) (pers. comm. Jeff Isley, NOAA, SEFSC, Miami Laboratory, Miami, FL). To calculate ages of all fish caught January through June, increment counts were bumped by one. For all fish caught July through December, increment counts were equal to age. These calculations were made with no information on timing of increment formation, margin type or size of the fish. Because the data available for the SEDAR41 assessment included marginal increment type, the LHWG investigated alternatives to determine how best to convert the increment counts to calendar age.

Converting increment counts to calendar ages is based on the timing of increment formation. During SEDAR32, the Gray Triggerfish age data contained higher level of margin, or edge, definition: 1= increment (translucent zone) on the margin; 2 = narrow opaque zone on margin, <1/3 of previous translucent zone; 3 = moderate translucent zone, 1/3 – 2/3 of previous translucent zone; and 4 = wide translucent margin, >2/3 of previous translucent zone. The data compiled by SEFSC suggested that the increment was forming in late spring to early summer with a peak in May and was fully formed by the end of June (Figure 2.2). The analysis of presence/absence of the increment on the margin included with the SEDAR41 data set suggests a similar pattern of peak formation of the increment in May and essentially complete by the end of June (Figure 2.3), though some increments were still on the margin in July - September. Based on this information, the following criteria to convert increment counts to calendar age for all fish aged 1+ is as follows:

- If fish landed January – June with no increment on the margin then calendar age = increment count +1;
- If fish landed January – June with an increment on the margin then calendar age = increment count;
- If fish landed July – December, regardless of margin type, calendar age = increment count.

The fish with no increments (increment count = 0) were looked at a differently when determining whether to bump the counts to 1 or not. Gray Triggerfish exhibit peak spawning in July and the juveniles spend the first part of life at the surface associated with *Sargassum* spp. Those observed juveniles in the S*argassum* spp. have been noted as being 75 – 100 mm FL. The juveniles then settle to hard-bottom habitat. We compared the lengths of fish with one increment on the margin caught in July – September to those with no increment caught in the same months (Figure 2.4). Based on the time of spawning, the size of the fish, and the fact that the fish with no increments were caught during bottom fishing with traps or hook and line, the LHWG made the following assumptions for converting increment counts to calendar ages:

- If fish was caught January – June, then calendar age was assumed to be 1;
- If the fish was caught July – September and the FL > 160mm, then calendar age = 1
- If the fish was caught July – September and the FL < 160mm, the calendar age = 0

***Recommendation***

Convert increment counts to calendar age based on above analysis and methods by SEDAR41 LHWG.

### 2.6.1 Age Workshop Results and Addressing the Issues that Arose from the SEDAR 32 for Gray Triggerfish

Issues pertaining to ageing Gray Triggerfish based on the first dorsal spine lead to the cessation of SEDAR 32 Gray Triggerfish Stock Assessment in August 2013. The two labs providing age data (NMFS-Beaufort and SCDNR) recognized a divergence in interpretation of increments on the spine sections, specifically SCDNR readers assigned older ages to the samples compared to NMFS-Beaufort readers. An aging workshop was held at the NMFS-Beaufort laboratory in November 2013 to assess and resolve issues regarding the interpretation of increment counts. As a result of the workshop, refined aging criteria were put in place for all involved readers (see SEDAR 41 – DW16 for more information). After the workshop, an additional calibration set was created. The results from the interpretation of increment counts from this calibration set indicated an improvement in the consistency of ages between the two labs. However, at this point, most of the inconsistency of ages between the two labs existed for the younger fish (i.e., age-1 and age-2 fish). As a result, the labs decided to re-examine a portion of those younger fish. The results indicated that the SCDNR readers assigned younger ages compared to the NMFS-Beaufort readers. This pattern was the opposite of the results occurring before the age workshop in November 2013. The data indicated that the readings within the NMFS-Beaufort lab were more consistent than for readings within the SCDNR laboratory. After two more exchanges of age samples and a series of webinars to resolve this issue, a decision was made by all parties involved as well as the SEFSC Directorate that Beaufort staff would read all fishery-independent spine samples for SEDAR 41 Gray Triggerfish Stock Assessment. This decision was based on the higher within-laboratory reader consistency at NMFS-Beaufort. In addition, a series of refined ageing criteria were established. These fishery-independent readings would be done in addition to the fishery-dependent samples the Beaufort laboratory was responsible for. All Gray Triggerfish age readers from NMFS-Beaufort and SCDNR agreed that the data set brought forth by the SEFSC would constitute the best available Gray Triggerfish age data for SEDAR 41.

Staff at the SCDNR laboratory decided to re-age all fishery-independent samples using the established criteria to investigate if the original issues persisted as there was some indication that readers may have overcompensated (counted as increments) for features discussed during the series of webinars. During the data workshop these increment counts were compared to the NMFS-Beaufort increment counts. The overall APE between the labs was 11.7% (mean coefficient of variation was 16.53). In addition, the perfect agreement was 51%, with an agreement within 1 increment of 87%, and an agreement within 2 increments of 97%. The working group agreed that these were good results given the complex nature of the spine structure. However, a certain degree of bias persisted, with SCDNR assigning younger ages to various older fish, but note that the sample sizes for 6+ fish are small. As increment formation has not been validated, the LHWG recommended a validation study to refine and improve age determination in Gray Triggerfish (see research recommendations).

### 2.6.2 Age Reader Precision and Ageing Error Matrix

The ageing error matrix was provided after the 2014 DW (see SEDAR41-DW47) and reviewed during the 2015 DW (see above). A total of 1,383 spine samples from both NMFS-Beaufort and SCDNR were read by the two primary age readers at the NMFS-Beaufort Lab. The average percent error (APE) was 7.5% between the two readers. That APE is deemed very good considering that both the South Atlantic and Gulf of Mexico gray triggerfish age readers agreed that an APE<15% would constitute good consistency. A bias plot of paired age readings suggests no bias by one reader's data over the other's in age determination. All ages provided for SEDAR41 assessment were from the two age readers at the NMFS-Beaufort Lab.

***Recommendation***

The age error matrix as provided in the WP should be used to characterize the uncertainty in the age estimates as a result of the variability in age reading between readers.

#### 2.6.3 Max Age

The 2014 age data did not yield older fish and the maximum age remains 15 years based on the oldest fish in the combined data base. The spine of this fish had 15 increments and was collected in 2011 in NC using a commercial hand line, but no sex information is available. Note that the combined data contained 55 fish with 10+ increments in the spines.

***Recommendation***

Use 15 as the maximum age for Gray Triggerfish in the South Atlantic.

## 2.7 Growth

The LHWG discussed several issues including whether to model growth with a correction for the minimum size-limit bias effect in fishery-dependent data using the model coding developed by Diaz et al. (2004) based on McGarvey and Fowler (2002), inversely weighting the von Bertalanffy growth model by sample size at each age, or to use sex-specific growth curves. For this assessment, fractional age was used to model growth of Gray Triggerfish. The fractional age was computed based on the following equation and using July as month of peak spawning:

$A_F = A_C + [(M_C – M_S)/12]$;
Where
$A_F$ = fractional age,
$A_C$ = calendar age,
$M_C$ = month of capture, and
$M_S$ = month of peak spawning.

Growth parameters were evaluated for the overall population and for fishery-dependent samples only (Table 2.4). Estimated von Bertalanffy (VB) growth parameters included $L_\infty$ (the asymptotic fish length, mm FL), k (VB growth parameter), and $t_0$ (theoretical age in yrs at length = 0). The von Bertalanffy growth model for the population was fitted to a robust data set comprised of all fishery-independent and fishery-dependent samples (combined data set), inversely weighted to allow best model fit of the largest, oldest fish, and Díaz-corrected for the Florida samples subject to the 12 inch FL minimum-size limit, and assuming constant standard deviation (sigma), which gave the best model fits (Figure 2.5). The resulting parameter values were $L_\infty = 453$, $k = 0.34$, and $t_0 = -0.98$. The von Bertalanffy growth model was run on all fishery-dependent aged samples to estimate of the size at age of Gray Triggerfish landed in the fisheries of the U.S. South Atlantic (Figure 2.6). The parameter estimates were allowed to be freely estimated, but inversely weighted by sample size at age (Table 2.4).

Sexual dimorphism often occurs in other fishes, leading to an initial investigation into the potential of dimorphic growth in Gray Triggerfish. Using the aged specimens for which sex also was determined, we compared male and female mean fork length at age (Figure 2.7) and found males to be larger at age compared to females. Due to this difference, the estimates of spawning biomass should be based on the female growth only (Figure 2.8). To be consistent with the overall population growth model, the sex specific growth models were run using inverse weighting.

***Recommendations***

1. Pool all data for population growth model.
2. The LHWG recommends using the inverse-weighted von Bertalanffy growth model with Diaz-correction applied to the fish landed in Florida subject to the 12 inch minimum fork length, for the full data set to represent population growth.
3. The LHWG recommends using the inversely-weighted von Bertalanffy growth model with parameters freely estimated applied to fishery-dependent data to represent size-at-age of fishery samples. This model is not meant to represent the biology of the population.
4. The growth models showed significant differences between sexes. Therefore, the LWHG recommends using the female only growth model for spawning biomass calculations.

## 2.8 Reproduction

### 2.8.1 General Reproductive Strategy

Gray Triggerfish do not change sex during their lifetime (gonochoristic). This fish species exhibits a relatively unusual mating strategy compared to other reef fish species in the snapper-grouper complex. Harem-like reproductive behavior has been observed in which males construct demersal nests and perform courtship behaviors (e.g., change in color and circling females) to attract multiple females with which to mate (Simmons and Szedlemayer 2012). Simmons and Szedlmayer (2012) showed evidence that Gray Triggerfish in the Gulf of Mexico preferred substrate composed primarily (67%) of fine sand for nest building, with nests located a mean distance of 8.7 m (+ 0.4 SE) from artificial reef structures. It is not thought that there is high competition for this spawning habitat in the South Atlantic Bight because the natural reefs are surrounded by primarily sandy substrate (Struhsaker 1969). After fertilization, parental care of the demersal eggs has been observed for both sexes. Typically, a female stays inside the nest and guards the eggs while the male guards the territory surrounding the nests. These behaviors continue until the eggs hatch, which occurs within 24-48 hours after fertilization (Simmons and Szedlemayer 2011). During the early life stages, pelagic larvae and juvenile Triggerfish are associated with *Sargassum* spp. (Dooley 1972, Bortone et al. 1977,Wells and Rooker 2004, Casazza and Ross 2008). Simmons and Szedlmayer (2011) studied juvenile settlement of Gray Triggerfish to artificial reef sites in the northern Gulf of Mexico from 2003-2007. Peak recruitment of age-0 Gray Triggerfish occurred during September to December. Based on diver surveys in which fish size was estimated in 25-mm size classes, the smallest recruits to benthic reefs during September and October were 25-50 mm FL and the largest were 126-150 mm FL. These largest recruits are similar to the size (FL) of the largest individuals collected in surface waters in earlier studies (167 mm in Dooley 1972, 106 mm in Bortone et al. 1977, 137 mm in Wells and Rooker 2004, 145 mm in Casazza and Ross 2008).

The gonads of male Triggerfishes are unique in their structure and function. Across most fish species, the general form and function of the male and female gonads are similar, in that they consist of two lobes that are posteriorly attached and release the gametes via oviduct (female) or spermatic duct (male). In Gray triggerfish, the accessory glands are used to store spermatozoa before spawning. Histological examination of both the testes and accessory glands is needed to assign the most accurate reproductive state to males.

The histological criteria to assess reproductive state in Gray Triggerfish were finalized during the Age and Reproduction workshops described by Kolmos et al. (2013, SEDAR32-DW03 and 2014, SEDAR41-DW16). SCDNR-MARMAP provided the only histological data (n=9,619) for this assessment based on primarily (92%) fishery-independent specimens collected during 1983 and 1991-2013; most specimens were caught off South Carolina (59%) and Georgia (25%) (Table 2.5). Sex was macroscopically assigned for additional 531 fishery-dependent specimens provided by NMFS-Beaufort. Age-related results presented in this section were based on calendar age. Information on sex ratio, sexual maturity, spawning seasonality, and spawning frequency are based on the most accurate technique (histology) utilized to assess reproductive condition in fishes (Figure 2.9).

### 2.8.2 Sexual Maturity

Sexual maturity analyses were done using data collected through 2013 as no additional sexual maturity information was collected/available from 2014. As a result, the analyses and recommendations presented at the 2014 DW (see below) were recommended for use in the assessment. Age-based maturity analyses were done using calendar age, whereas length-based maturity analyses were done using FL (mm). Predicted values of size and age at maturity (1 cm size bins) were estimated using the Logistic model (proportion mature = 1 - 1/(1 + exp(a+b*FL)), as it provided the best fit by Akaike's Information Criterion. The smallest mature female was 142 mm FL and the youngest was age 1, while the largest immature female was 297 mm FL and the oldest was age 4 (Tables 2.6 and 2.7). The female size-at-maturity model estimated a length at 50% maturity ($L_{50}$) of 177 mm FL. Age-at-maturity modeled by logistic equation generated an $A_{50}$ of 0.167 years which is biologically unrealistic (Table 2.8). Maturity analysis was re-evaluated by the LHWG and after further panel discussion and webinars, the recommendation was made to use the predicted proportion mature for females while setting Age 0 fish to 0% mature. Mature gonads were present in 0% of females at age 0, 80% at age 1, 96% at age 2, 99% at age 3, and 100% at age >3 (Table 2.7). The smallest mature male was 164 mm FL, while the largest immature male was 292 mm FL (Table 2.8 and 2.9). The predicted size of males and at 50% maturity was 179 mm FL (Table 2.9). Mature gonads were present in 80% of males at age 1, 96% at age 2, 99% at age 3, 100% at age >3 (Table 2.9). There were no maturity data for age 0 males.

### 2.8.3 Sex Ratio

Sexual dimorphism has been documented for Gray Triggerfish, with mature males attaining larger sizes than mature females (Ingram 2001, MacKichan and Szedlmayer 2007, Moore 2001, Simmons 2008, Kelly 2014). As additional information collected in 2014 sex was available, the LHWG updated the information presented at the 2014 DW. However, the resulting 2015 DW recommendation did not differ from that presented in 2014. The LHWG recommended combining fishery-dependent and fishery-independent data sets based on similarities in age and length-specific sex ratio. The proportion of females (0.543) is greater than would be expected if the population sex ratio was 1:1 (Chi-squared = 73.87; $p < 0.0001$), but the significant result is likely the result of a large dataset and has no biological significance (Table 2.11); restricting this analysis to Ages 1-6 yielded the same result (Chi-squared = 52.83; $p < 0.0001$). The proportion of females was relatively constant at Ages 1-6, but an increasing trend was evident at older ages (Figure 2.10). With respect to size, the proportion of females was relatively constant at sizes $\leq$ 35 cm FL, but a decreasing trend was evident at 36-50 cm FL (Figure 2.11). Specimens > 50 cm FL were almost exclusively males, reflecting the sexual dimorphism characteristic of the species. Although analyses revealed an overall sex ratio favoring females and trends related to age and size, we do not believe there is strong evidence for using a sex-specific stock assessment model.

***Recommendation:***

Overall sex ratio in the population is 1:1, however age-specific sex ratio results are needed to estimate total egg production.

### 2.8.4 Spawning Seasonality

Spawning seasonality analyses were done using data collected through 2013 as no additional information was collected/available from 2014. As a result, the analyses and recommendations presented at the 2014 DW (see below) were recommended for use in the assessment. Observed spawning seasonality for female Gray Triggerfish using data from SERFS is shown in Figure 2.12. Based on the occurrence of specimens with imminent (migratory nucleus or hydrated oocytes) or recent (postovulatory complexes) indicators of spawning, the beginning and end of the spawning season were defined as the earliest (April 10$^{th}$) and latest (September 29$^{th}$) date that any of these specimens were collected in any year, respectively. Note that only two spawning females have been captured in April (n=78 adult females) and only four in September (n=893 adult females) during the history of SERFS sampling; in addition, no spawning females have been captured after August 28$^{th}$ (n=1,088 adult females). Therefore, we concluded that a more conservative estimate of beginning and end dates was warranted.

The spawning season for Gray Triggerfish has been described as occurring in late spring and summer months for the U.S. South Atlantic (Moore 2001, Kelly 2014) and the Gulf of Mexico (Hood and Johnson 1997, Ingram 2001), which is very similar to the results of the current analysis.

***Recommendation***

Move the onset of the spawning season to May 5$^{th}$ and end date to August 28$^{th}$. Duration of the spawning season for the population is therefore estimated to be 116 days.

### 2.8.5 Spawning Frequency/Fecundity Proxy (Females)

Spawning frequency and fecundity estimates analyses were done using data collected through 2013 as no additional information was collected/available from 2014. As a result, the analyses and recommendations presented at the 2014 DW (see below) were recommended for use in the assessment. Because the terminology associated with spawning frequency can be confusing, we define terms here. Spawning fraction measures the proportion of mature females spawning daily (Hunter and Macewicz 1985; Murua et al. 2003). Spawning interval refers to the time period between spawning events and at the population level is estimated as the reciprocal of the spawning fraction. Spawning frequency refers to the number of spawning events within a spawning season and is calculated by dividing the number of days within this spawning season by the spawning interval. These definitions follow Lowerre-Barbieri et al. (2011).

SERFS histological data from fishery-independent sampling, mostly with chevron traps, were used to estimate spawning frequency. Sampling with chevron traps was limited to daylight hours. Female Gray Triggerfish appear to spawn at night, as oocyte maturation occurs primarily during the morning (Figure 2.13). Because Gray Triggerfish are nest builders, females tend to stay inside or near the nests (Simmons and Szedlmayer 2012) and are thus not as likely to enter traps; therefore, the occurrence of specimens with indicators of imminent (migratory nucleus or hydrated oocytes) or recent (postovulatory complexes) spawning is low compared to other reproductive states noted in histological samples. In the SERFS data, the proportion of female Gray Triggerfish from chevron trap catches with indicators of spawning among specimens with vitellogenic oocytes (but no atresia) ranged from 0.03 in May to 0.12 in July; monthly sample sizes pooled over years ranged from 5 in April to 612 in July (Kelly, 2014). The inverse of the average proportion (0.10) corresponded to the occurrence of a spawning event approximately every 10 days.

To evaluate the level of reproductive activity in the population over the spawning season, an analysis was run to calculate the proportion of spawners among all adult females (active + inactive); this analysis accounts for the occurrence of skipped spawning and variation in spawning season duration related to size/age. The results showed that the overall proportion of spawners increased with age, ranging from 0.009 at Age 1 to 0.074 at Ages 6+ (Table 2.11).

An equation relating batch fecundity to fork length from a Gulf of Mexico study was selected because fecundity has not been investigated in the portion of the population along the Atlantic coast of the U.S. Use of this equation is appropriate, given the apparent lack of stock structure in U.S. waters. In the study by Lang and Fitzhugh (2014; SEDAR41-RD33), batch fecundity (BF) in 65 specimens ranged from 0.34 to 2.0 million eggs and was significantly related to fork length (FL): BF=8703*FL – 1,776,483 ($r^2$=0.56; range of FL=266-386 mm).

***Recommendations***

The LHWG recommended use of: 1) the total egg production (TEP) method of estimating stock reproductive potential; the equation by age class is: TEP = proportion female x proportion mature x # of batches x batch fecundity. Given that spawning fraction is relatively consistent for Ages 6+, data were pooled to estimate spawning fraction (0.074) and subsequently the # of egg batches (7) per fish per spawning season. Use the equation from Lang and Fitzhugh (2014, SEDAR41-RD33) to estimate batch fecundity based on fork length.

## 2.9 Movements and Migrations

Studies of movements and migrations in Gray Triggerfish are rare, but some information is available from the known life history of this species, and general reef fish tagging work. Since the 2014 DW review of the available literature, no new information became available and the 2014 LHWG recommendations did not change. The early life history of this species includes demersal eggs that are spawned in nests that are constructed and guarded by males, with females protecting the eggs (Simmons and Szedlmayer 2012). Eggs hatch into a pelagic larva (Richards and Lindeman 1987). Once hatched, juveniles are associated with epipelagic seaweeds and debris, including floating *Sargassum* spp. Juveniles spend the first few months of their lives in the pelagic environment before settling back to the benthic environment (Casazza and Ross 2008, Simmons and Szedlmayer 2012,). Adults are considered to be sedentary and display territorial behavior (Ingram 2001, Simmons and Szedlmayer 2012).

Rudershausen et al. (2010) opportunistically tagged Gray Triggerfish (n=332; 190-530 mm TL) in Onslow Bay, NC during a discard mortality study of Black Sea Bass (*Centropristis striata*). Although the authors did not report exact recapture locations, they have been able to infer general locations of recaptures from where specific fisherman fish (Buckel, personal communication, 5 August 2014). Of 29 recaptures, 24 were caught close to their release location in Onslow Bay. There have been no reports of recaptures of triggerfish from that study outside of Onslow Bay.

In a large (n = 3,109, 12 species) tagging study on artificial reefs in the Gulf of Mexico, Gray Triggerfish had the highest percentage of recaptures made at tagging reefs (54.5%) and showed the least movement among 12 tagged species (Addis et al. 2013). During the study, a hurricane passed over the study area, thus adding an unplanned factor to movement analyses. Neither fish size, reef depth, time free, and hurricane exposure significantly affected Gray Triggerfish movement (Addis et al. 2013). Gray Triggerfish displayed the lowest movement of the 12 species, with a mean (SD) dispersion rate of 55.9 (30.5) m per day for individuals not exposed to a hurricane and 69.6 (17.8) m per day for individuals exposed to the hurricane, which may have cause some individuals to move farther off the reef. Five recaptured Gray Triggerfish were free for longer than a year, and all were recaptured at tagging sites. Four Gray Triggerfish were recaptured multiple times during tagging events. Mean (SD) distance moved among recaptures with reported recapture location was 8.8 (3.1) km (n = 47 of 267).

Pelagic juveniles may disperse great distances with surface currents, and appearance of small Gray Triggerfish is an annual occurrence in Irish waters in late summer. Many of these reports are of dead stranded specimens (Quigley et al. 1993), indicating that they are expatriated from warmer regions to the Irish coast. Juvenile Gray Triggerfish are a dominant member of the *Sargassum* spp. ichthyofauna (Wells and Rooker 2004; Casazza and Ross 2008). It is likely that they are widely dispersed by the currents that disperse *Sargassum* spp. in the North Atlantic. Genetic analysis indicates no population structure between the east and west North Atlantic, perhaps mediated by drift of pelagic juveniles (Antoni et al. 2011).

Small Gray Triggerfish are common in shallow water in the South Atlantic and the population is generally distributed across the shelf; however, spawning occurs predominantly at the shelf-edge reef (55 m) (Sedberry et al. 2006, Schobernd and Sedberry 2009). This may represent ontogenetic movement into deeper water.

One unknown aspect of Gray Triggerfish spawning behavior is whether fish return to particular reef sites for spawning. Other species of triggerfish including the Red-toothed Triggerfish and Yellowmargin Triggerfish move to particular spawning grounds (Fricke 1980, Gladstone 1994) and may return to the same site repeatedly. Simmons and Szedlemeyer (2012) observed the same dominant male at one reef site on four different surveys, and its continued presence along with new females suggested that harem spawning behaviors were related to specific spawning grounds as observed in other triggerfishes (Fricke 1980, Gladstone 1994).

## 2.10 Meristics and Conversion Factors

Due the large data set, the addition of the 2014 was unlikely to change the conversion factors and the SEDAR41 panel recommended to use the conversions presented at the 2014 DW. Data for the length-length and whole weight (g) – length (mm) regressions were pulled from the Southeast Region Headboat Survey (Atlantic portion only), South East Reef Fish Survey (SCDNR, MARMAP and SEFIS), and MRIP data bases. Fork length was agreed upon to be the length type used in the assessment. When total length was measured by the fishery-independent survey, the max TL was taken including the caudal filaments. Linear regressions were run to convert total length and standard length to fork length (Table 2.12 and Figure 2.14). Log transformed whole weight and length regressions were run for all three length types. The regression equations were then converted to power equations which included ½ mean squared error (MSE) to account for the transformation bias (Table 2.12). Regression parameters are included in Table 2.12 and Figure 2.14 illustrates the scatter plot of data points with obvious outliers excluded.

## 2.11 Recommendations for Alternative Parameter Estimates and Comparison of Recommended Parameter Choices Between South Atlantic and Gulf of Mexico

Note that alternative parameter estimates and approaches recommended by the LHWG are listed under the various chapters discussing the analyses and parameter choices.

An overview of comparison of parameter choices recommended by the SEDAR 41 LH WG and those used in previous GoM assessments for Gray Triggerfish are given in Table 2.13. As the parameter choice is not always straight forward, the LH WG recommends reviewing the appropriate section of the stock assessment reports for details of the parameter choices.

## 2.12 Itemized list of Tasks for Completion Following Workshop

- Updating the LHWG report.
- Completing comparison of parameters and approaches between the South Atlantic and Gulf of Mexico.

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## 2.14 Tables

**Table 2.1**

Age-varying natural mortality estimates for Gray Triggerfish using the method developed by Charnov et al. (2013). The variance around natural mortality is expressed as a lower and upper boundary encompassing 95% probability of the original value.

| Age | Charnov | Lower | Upper |
|---|---|---|---|
| 1 | 1.305 | 1.274 | 1.337 |
| 2 | 0.830 | 0.821 | 0.838 |
| 3 | 0.666 | 0.662 | 0.670 |
| 4 | 0.591 | 0.588 | 0.594 |
| 5 | 0.552 | 0.549 | 0.555 |
| 6 | 0.531 | 0.526 | 0.535 |
| 7 | 0.518 | 0.512 | 0.524 |
| 8 | 0.511 | 0.501 | 0.521 |
| 9 | 0.507 | 0.489 | 0.525 |
| 10 | 0.504 | 0.477 | 0.533 |
| 11 | 0.502 | 0.455 | 0.558 |
| 12 | 0.501 | 0.454 | 0.557 |
| 13 | 0.501 | 0.477 | 0.527 |
| 14 | 0.501 | 0.415 | 0.620 |
| 15 | 0.500 | | |
| **Cumulative survival (Age 4+)** | 0.003 | 0.004 | 0.002 |

**Table 2.2**

Reported discard dispositions Gray Triggerfish from commercial logbooks from SEDAR 32. Totals of 'kept as bait' were excluded from this table. N fish is the total number of fish discarded. Totals may not sum to 100 percent due to data confidentiality constraints.

| Species | Gear | All Dead | Majority Dead | All Alive | Majority Alive | Unable to Determine | Not Reported | N fish |
|---|---|---|---|---|---|---|---|---|
| Gray Triggerfish | Vertical Line | | | 89.00% | 10.40% | | | 3,388 |
| | Trap | | | 93.40% | 6.20% | | | 2,033 |
| | Combined Gears | | | 90.65% | 8.82% | | | 5,421 |

**Table 2.3**

Reported discard mortality estimates for Gray Triggerfish by study.

| Source | Mortality Estimate |
|---|---|
| SEDAR 32-DW14 | 12 |
| SEDAR 32- DW11 | 12 |
| Rudershausen et al. (2010) | 15 |
| Collins (1994) | 17 |
| Stephen and Harris (2010) | 93 |
| Patterson et al. (2002) SEDAR 9 | 0 |

**Table 2.4**

Von Bertalanffy growth model parameters for the population, females only, and fishery-dependent. N: sample size, Length in mm fork length.

| Source | N | Linf | StDev | K | StDev | $t_0$ | StDev |
|---|---|---|---|---|---|---|---|
| **Population** | **17,508** | **453.17** | **23.29** | **0.34** | **0.12** | **-0.98** | **0.66** |
| **Population- Females** | **4,907** | **409.88** | **27.74** | **0.36** | **0.15** | **-1.01** | **0.74** |
| **Fishery-Dependent, both sexes** | **9,090** | **474.41** | **39.07** | **0.21** | **0.15** | **-3.73** | **8.32** |

**Table 2.5**

Gray Triggerfish Samples with reproductive data by year and state. Note that 92% of the data were from fishery-independent surveys.

| Year | FL | GA | SC | NC |
|---|---|---|---|---|
| 1990 | 0 | 0 | 0 | 0 |
| 1991 | 0 | 0 | 145 | 0 |
| 1992 | 1 | 6 | 188 | 2 |
| 1993 | 1 | 99 | 193 | 3 |
| 1994 | 0 | 146 | 298 | 0 |
| 1995 | 8 | 245 | 281 | 0 |
| 1996 | 1 | 90 | 719 | 29 |
| 1997 | 35 | 130 | 641 | 10 |
| 1998 | 34 | 109 | 344 | 19 |
| 1999 | 20 | 11 | 155 | 3 |
| 2000 | 10 | 49 | 187 | 19 |
| 2001 | 0 | 45 | 185 | 13 |
| 2002 | 74 | 111 | 132 | 15 |
| 2003 | 26 | 4 | 36 | 1 |
| 2004 | 1 | 16 | 165 | 20 |
| 2005 | 7 | 134 | 187 | 17 |
| 2006 | 7 | 26 | 121 | 5 |
| 2007 | 8 | 152 | 116 | 21 |
| 2008 | 3 | 133 | 172 | 1 |
| 2009 | 6 | 96 | 87 | 65 |
| 2010 | 11 | 117 | 82 | 10 |
| 2011 | 41 | 124 | 217 | 9 |
| 2012 | 174 | 125 | 163 | 42 |
| 2013 | 235 | 222 | 265 | 318 |
| **Total** | **703** | **2190** | **5079** | **622** |

**Table 2.6**

Female Gray Triggerfish Fork Length (FL in cm) at maturity. Obs. Mature= proportion mature in observations. Pred. Mat. is predicted proportion mature at size estimated with a Logistic model (=1-1/(1+exp(a+b*FL)) with a= -9.8 and b=0.055). $FL_{50}$ = 177 mm.

| FL | Immature | Mature | Total | Obs. Mature | Pred. Mat. |
|---|---|---|---|---|---|
| 8 | 2 | 0 | 2 | 0 | 0.005 |
| 9 | 0 | 0 | 0 | NA | 0.008 |
| 10 | 4 | 0 | 4 | 0 | 0.014 |
| 11 | 2 | 0 | 2 | 0 | 0.024 |
| 12 | 1 | 0 | 1 | 0 | 0.041 |
| 13 | 3 | 0 | 3 | 0 | 0.069 |
| 14 | 8 | 1 | 9 | 0.111 | 0.114 |
| 15 | 10 | 1 | 11 | 0.091 | 0.183 |
| 16 | 17 | 3 | 20 | 0.150 | 0.280 |
| 17 | 18 | 15 | 33 | 0.455 | 0.404 |
| 18 | 13 | 24 | 37 | 0.649 | 0.541 |
| 19 | 13 | 30 | 43 | 0.698 | 0.672 |
| 20 | 12 | 46 | 58 | 0.793 | 0.781 |
| 21 | 6 | 46 | 52 | 0.885 | 0.861 |
| 22 | 10 | 79 | 89 | 0.888 | 0.915 |
| 23 | 5 | 72 | 77 | 0.935 | 0.949 |
| 24 | 7 | 119 | 126 | 0.944 | 0.970 |
| 25 | 0 | 127 | 127 | 1 | 0.983 |
| 26 | 1 | 182 | 183 | 0.995 | 0.990 |
| 27 | 1 | 137 | 138 | 0.993 | 0.994 |
| 28 | 1 | 244 | 245 | 0.996 | 0.997 |
| 29 | 1 | 208 | 209 | 0.995 | 0.998 |
| 30 | 1 | 342 | 343 | 0.997 | 0.999 |
| 31 | 0 | 271 | 271 | 1 | 0.999 |
| 32 | 0 | 333 | 333 | 1 | 1 |
| 33 | 0 | 270 | 270 | 1 | 1 |
| 34 | 0 | 316 | 316 | 1 | 1 |
| 35 | 0 | 277 | 277 | 1 | 1 |
| 36 | 0 | 310 | 310 | 1 | 1 |
| 37 | 0 | 217 | 217 | 1 | 1 |
| 38 | 0 | 214 | 214 | 1 | 1 |
| 39 | 0 | 143 | 143 | 1 | 1 |
| 40 | 0 | 134 | 134 | 1 | 1 |
| 41 | 0 | 76 | 76 | 1 | 1 |
| 42 | 0 | 46 | 46 | 1 | 1 |
| 43 | 0 | 21 | 21 | 1 | 1 |
| 44 | 0 | 16 | 16 | 1 | 1 |
| 45 | 0 | 8 | 8 | 1 | 1 |
| 46 | 0 | 7 | 7 | 1 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 47 | 0 | 4 | 4 | 1 | 1 |
| 48 | 0 | 1 | 1 | 1 | 1 |
| 49 | 0 | 2 | 2 | 1 | 1 |
| 50 | 0 | 1 | 1 | 1 | 1 |
| 51 | 0 | 0 | 0 | NA | 1 |
| 52 | 0 | 0 | 0 | NA | 1 |
| 53 | 0 | 0 | 0 | NA | 1 |
| 54 | 0 | 0 | 0 | NA | 1 |
| 55 | 0 | 0 | 0 | NA | 1 |
| 56 | 0 | 1 | 1 | 1 | 1 |

**Table 2.7**

Female Gray Triggerfish age-at-maturity (N = 4,134). Predicted proportion mature at age estimated with the Logistic model (= 1 - 1/(1 + exp(a+b*age))), except at Age 0. *Age 0 female predicted proportion mature set to 0. $Age_{50}$ = 0.167 yr.

| Calendar Age (yr) | # Immature | # Mature | # Total | Observed Proportion Mature | Predicted Proportion Mature |
|---|---|---|---|---|---|
| **0** | 2 | 0 | 2 | 0 | 0* |
| **1** | 60 | 244 | 304 | 0.803 | 0.803 |
| **2** | 35 | 800 | 835 | 0.958 | 0.956 |
| **3** | 9 | 1168 | 1177 | 0.992 | 0.992 |
| **4** | 3 | 911 | 914 | 0.997 | 0.998 |
| **5** | 0 | 505 | 505 | 1 | 1 |
| **6** | 0 | 197 | 197 | 1 | 1 |
| **7** | 0 | 114 | 114 | 1 | 1 |
| **8** | 0 | 53 | 53 | 1 | 1 |
| **9** | 0 | 22 | 22 | 1 | 1 |
| **10** | 0 | 5 | 5 | 1 | 1 |
| **11** | 0 | 5 | 5 | 1 | 1 |
| **12** | 0 | 1 | 1 | 1 | 1 |

| Parameters | a | SE | b | SE |
|---|---|---|---|---|
| Estimates | -0.28 | 0.244 | 1.684 | 0.137 |

**Table 2.8**

Male Gray Triggerfish Fork Length (FL in cm) at maturity. Obs. Mature= proportion mature in observations. Pred. Mat. is predicted proportion mature at length estimated with the Logistic model (=1-1/(1+exp(a+b*FL)) with a= -8.4 and b=0.047). $FL_{50}$ = 179 mm.

| FL | Immatur | Mature | Total | Obs. Mature | Pred. Mat. |
|---|---|---|---|---|---|
| 13 | 1 | 0 | 1 | 0 | 0.090 |
| 14 | 3 | 0 | 3 | 0 | 0.136 |
| 15 | 6 | 0 | 6 | 0 | 0.202 |
| 16 | 8 | 2 | 10 | 0.2 | 0.287 |
| 17 | 16 | 6 | 22 | 0.273 | 0.392 |
| 18 | 14 | 20 | 34 | 0.588 | 0.507 |
| 19 | 18 | 27 | 45 | 0.600 | 0.622 |
| 20 | 14 | 43 | 57 | 0.754 | 0.724 |
| 21 | 6 | 41 | 47 | 0.872 | 0.807 |
| 22 | 7 | 71 | 78 | 0.910 | 0.870 |
| 23 | 2 | 50 | 52 | 0.962 | 0.914 |
| 24 | 6 | 85 | 91 | 0.934 | 0.945 |
| 25 | 6 | 73 | 79 | 0.924 | 0.965 |
| 26 | 3 | 77 | 80 | 0.963 | 0.978 |
| 27 | 2 | 93 | 95 | 0.979 | 0.986 |
| 28 | 2 | 117 | 119 | 0.983 | 0.991 |
| 29 | 2 | 115 | 117 | 0.983 | 0.994 |
| 30 | 0 | 165 | 165 | 1 | 0.996 |
| 31 | 0 | 146 | 146 | 1 | 0.998 |
| 32 | 0 | 182 | 182 | 1 | 0.999 |
| 33 | 0 | 187 | 187 | 1 | 0.999 |
| 34 | 0 | 272 | 272 | 1 | 0.999 |
| 35 | 0 | 162 | 162 | 1 | 1 |
| 36 | 0 | 277 | 277 | 1 | 1 |
| 37 | 0 | 192 | 192 | 1 | 1 |
| 38 | 0 | 217 | 217 | 1 | 1 |
| 39 | 0 | 144 | 144 | 1 | 1 |
| 40 | 0 | 201 | 201 | 1 | 1 |
| 41 | 0 | 151 | 151 | 1 | 1 |
| 42 | 0 | 181 | 181 | 1 | 1 |
| 43 | 0 | 93 | 93 | 1 | 1 |
| 44 | 0 | 97 | 97 | 1 | 1 |
| 45 | 0 | 76 | 76 | 1 | 1 |
| 46 | 0 | 50 | 50 | 1 | 1 |
| 47 | 0 | 27 | 27 | 1 | 1 |
| 48 | 0 | 27 | 27 | 1 | 1 |
| 49 | 0 | 10 | 10 | 1 | 1 |
| 50 | 0 | 11 | 11 | 1 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 51 | 0 | 3 | 3 | 1 | 1 |
| 52 | 0 | 4 | 4 | 1 | 1 |
| 53 | 0 | 3 | 3 | 1 | 1 |
| 54 | 0 | 1 | 1 | 1 | 1 |
| 55 | 0 | 0 | 0 | NA | 1 |
| 56 | 0 | 0 | 0 | NA | 1 |
| 57 | 0 | 0 | 0 | NA | 1 |
| 58 | 0 | 1 | 1 | 1 | 1 |

**Table 2.9**

Male Gray Triggerfish age at maturity (N=3,437). Predicted proportion mature at age estimated with the Logistic model (= 1 - 1/(1 + exp(a+b*age))), except at Age 0. $Age_{50}$ = 0.155 yr.

| Cal. Age | # Immature | # Mature | # Total | Observed Proportion Mature | Predicted Proportion Mature |
|---|---|---|---|---|---|
| 1 | 46 | 195 | 241 | 0.809 | 0.802 |
| 2 | 36 | 658 | 694 | 0.948 | 0.955 |
| 3 | 5 | 949 | 954 | 0.995 | 0.991 |
| 4 | 1 | 783 | 784 | 0.999 | 0.998 |
| 5 | 1 | 479 | 480 | 0.998 | 1.000 |
| 6 | 0 | 159 | 159 | 1.000 | 1.000 |
| 7 | 0 | 83 | 83 | 1.000 | 1.000 |
| 8 | 0 | 29 | 29 | 1.000 | 1.000 |
| 9 | 0 | 10 | 10 | 1.000 | 1.000 |
| 10 | 0 | 3 | 3 | 1.000 | 1.000 |

| Parameters | a | SE | b | SE |
|---|---|---|---|---|
| Estimates | -0.26 | 0.270 | 1.660 | 0.150 |

**Table 2.10**

Sex ratio in Gray Triggerfish population. Overall dataset includes fishery-independent and fishery-dependent data. SERFS: South East Reef Fish Survey (fishery-independent).

| | Ratio: Female:Male | # Male | # Female | Proportion Female | Chi-squared | P-value |
|---|---|---|---|---|---|---|
| **Overall** | 1.19 | 4,643 | 5,509 | 0.543 | 73.87 | <0.0001 |
| **SERFS** | 1.200 | 3,765 | 4,520 | 0.546 | 68.80 | <0.0001 |

**Table 2.11**

Spawning fraction in Gray Triggerfish captured in chevron traps by the SERFS during 1991-2013. *The duration of oocyte maturation (OM) and postovulatory complexes (POC) is estimated to be ~30 hr (6 hr for OM with no hydration + 24 hr for POC ), based on Fitzhugh et al. (1993) and Fitzhugh et al. (2012; SEDAR31-DW07). Spawning season duration = 1st and last occurrence of spawners during May - Aug. # batches = (Prop. Spawners/30 hr*24 hr day$^{-1}$) * spawning season duration in days.

| Calendar Age (yr) | # adult females | Prop. Spawners (OM, POC; ~24 h) * | Avg. Spawning Interval (d) | Est. Spawning Season Duration (d) | # Batches/ind.fish by Age |
|---|---|---|---|---|---|
| 1 | 181 | 0.009 | 113 | 8 | 0.1 |
| 2 | 625 | 0.024 | 41 | 87 | 2.1 |
| 3 | 904 | 0.032 | 31 | 104 | 3.3 |
| 4 | 672 | 0.055 | 18 | 79 | 4.3 |
| 5 | 371 | 0.058 | 17 | 102 | 5.9 |
| 6 | 134 | | | 75 | 7.6 |
| 7 | 82 | | | 115 | 6.7 |
| 8 | 36 | | | 0 | 0.0 |
| 9 | 13 | | | | 0.0 |
| 10 | 3 | | | | 0.0 |
| 11 | 3 | | | 0 | 0.0 |
| 12 | 1 | | | | 0.0 |
| | | | | | |
| 6+ | 272 | 0.074 | 14 | 95 | 7.0 |

**Table 2.12 (A + B)**

**A**

Gray Triggerfish length – length conversion equations based on linear regression analysis. Total length is max. TL including filaments.

| Equation | Units | n | $R^2$ | SE | Range |
|---|---|---|---|---|---|
| FL = 25.58 + 0.80*TL | mm | 10,127 | 0.97 | 0.57, 0.00 | TL: 76 -691 |
| FL = 16.61 + 1.14*SL | mm | 10,175 | 0.98 | 0.42, 0.00 | SL: 59 - 505 |
| TL = -18.27 + 1.21*FL | mm | 10,127 | 0.97 | 0.75, 0.00 | FL: 75 - 578 |
| TL = 1.73 + 1.38*SL | mm | 10,137 | 0.95 | 0.86, 0.00 | SL: 59 - 525 |
| SL = -9.62 + 0.86*FL | mm | 10,175 | 0.98 | 0.38, 0.00 | FL: 75 - 578 |
| SL = 12.12 + 0.69*TL | mm | 10,137 | 0.95 | 0.60, 0.00 | TL: 76 - 691 |

**B**

Gray Triggerfish length-weight conversions based on linear regressions of ln transformed whole weight (W in g) and lengths (FL, TL, or SL in mm), and resulting power equation. Total length is max. TL including filaments.

| Variables | a (SE) | b (SE) | MSE | n | $R^2$ | Range | Power Equation |
|---|---|---|---|---|---|---|---|
| W - FL | -10.51 (0.02) | 2.97 (0.00) | 0.02 | 36,573 | 0.94 | W: 75 – 620 | $W = 2.75*10^{-5}\ FL^{2.97}$ |
| W – TL | -9.53 (0.03) | 2.74 (0.01) | 0.02 | 10,068 | 0.96 | W: 76 – 691 | $W = 7.37*10^{-5}\ TL^{2.74}$ |
| W - SL | -9.04 (0.02) | 2.81 (0.00) | 0.01 | 10,118 | 0.98 | W: 59 - 505 | $W = 1.12*10^{-4}\ SL^{2.81}$ |
| FL - W | 3.68 (0.00) | 0.32 (0.00) | 0.00 | 36,573 | 0.94 | FL: 11 - 6200 | $FL = 39.65\ W^{0.32}$ |

**Table 2.13**

Comparison of LH DW parameter recommendations for SEDAR 41 (SA) and those used in the GoM in previous SEDAR assessments.

| Parameter | SEDAR 41 | GOM value | SEDAR 9 SAR page # | GOM value | SEDAR 9 SAR page # | Notes |
|---|---|---|---|---|---|---|
| M | age varying, unscaled. 1.30 for age 1 to 0.50 for age 15 | fixed value=0.27 | 88 | Unchanged from SEDAR 9 | 29 | |
| Linf | 453 | Various - by state-specific fishery (e.g., Alabama recreational) | 53 | | | |
| k | 0.34 | see above | 53 | | | |
| t0 | -0.98 | See above | 53 | | | |
| Linf | | | | 423.4 | 29 | Continuity model |
| k | | | | 0.4269 | 29 | Continuity model |
| t0 | | | | 0.6292 | 29 | Continuity model |
| Linf | | | | 904.9 | 29 | Update and value added models |
| k | | | | 0.0742 | 29 | Update and value added models |
| t0 | | | | 2.3833 | 29 | Update and value added models |
| | | | | | | |
| Maximum age | 15 | 16 or 10 | 55-56 & 185 | 16 | 20 | |
| Age | spines - fractional calendar age | spines - increments | | increments | | |
| | | | | | | |
| Sex ratio | 1:1 | ? | ? | ? | ? | |
| | | | | | | |
| Fecundity | total egg production by age using length/egg production equation from GOM | 170,289e0.3159x, where x = age | 88 | Unchanged from SEDAR 9 | 29 | |
| Fecundity | | Mean total annual fecundity = 17,071,634 eggs/yr (± 2,010,787). | 185 & 20 (for MTAF) | Schedule unchanged from SEDAR 9; no info on MTAF | 224 | |
| Age at maturity | Females 80% at age 1, 96% at age 2, 100% age 3+; males: 80% age 1, 96% age 2, 96=9% age 3, 100% age 4+ | ? | ? | ? | ? | |
| Length at Maturity | Female L50=177mm FL; males L50=179 mm FL | | | | | |
| Maturity schedule | | 0.875 at age 1, 1.0 at age 2 and older | 185 | Unchanged from SEDAR 9 | 224 | |
| Spawning seasonality | April-September | May-August | 185 | May-August | 224 | |
| Spawning frequency | once every 10 days | Interval between spawnings 3.7 days (± 0.6). # spawnings 24.3 (± 4.1) per yr. | 20 | ? | ? | |
| | | | | | | |
| | | | | | | |
| Discard mortality - commercial | 12.50% | 0 ("extremely low") | 87 | Unchanged from SEDAR 9 | 24 | recr. fleets were ignored because of extremely low release mortality, |
| Discard mortality - for-hire | 12.50% | 0 (for headboat) | 142 | Unchanged from SEDAR 9 | 24 | |
| Discard mortality - private | 12.50% | 0 ("extremely low") | 87 | | | |
| All sectors | 12.50% | | | | | |

## 2.15 Figures

**Figure 2.1.**

Computer Generated Native Distribution Map for *Balistes capriscus* (Gray Triggerfish) (modeled future range map based on IPCC A2 emissions scenario). www.aquamaps.org, version of Aug. 2013. Web. Accessed 5 Aug. 2014.

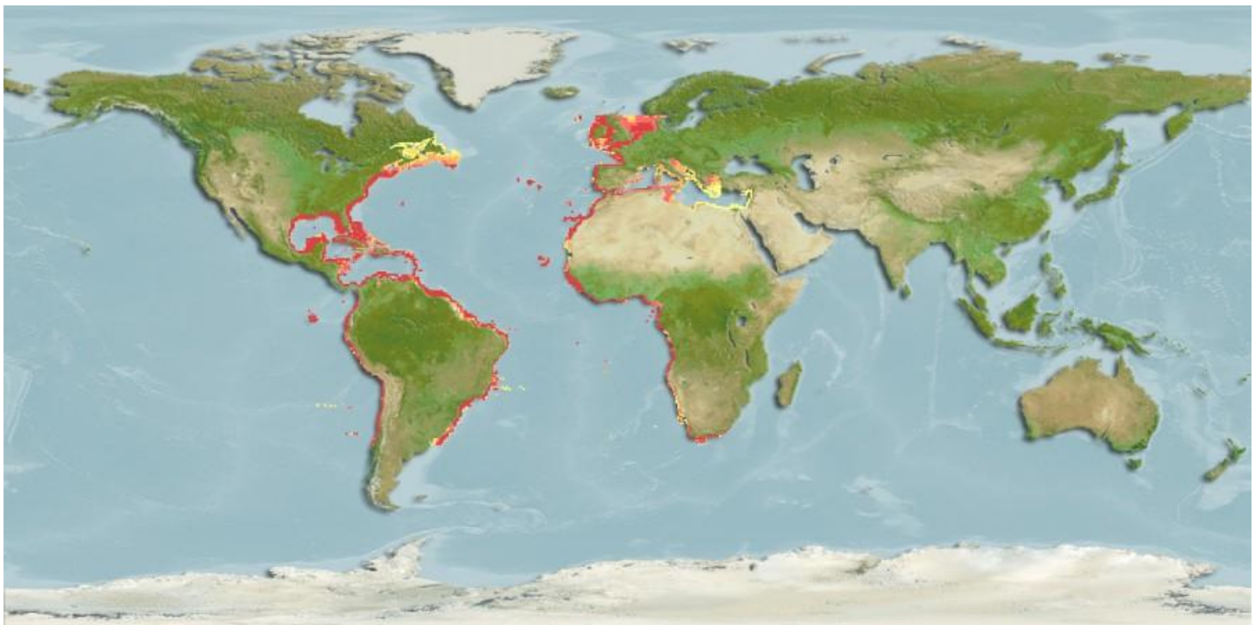


**Figure 2.2**

Monthly margin analysis from SEFSC SEDAR32 data when all margin codes were applied. These data were used in SEDAR32 to form the basis of converting increment counts to calendar age. Essentially all increments were formed by the end of June.

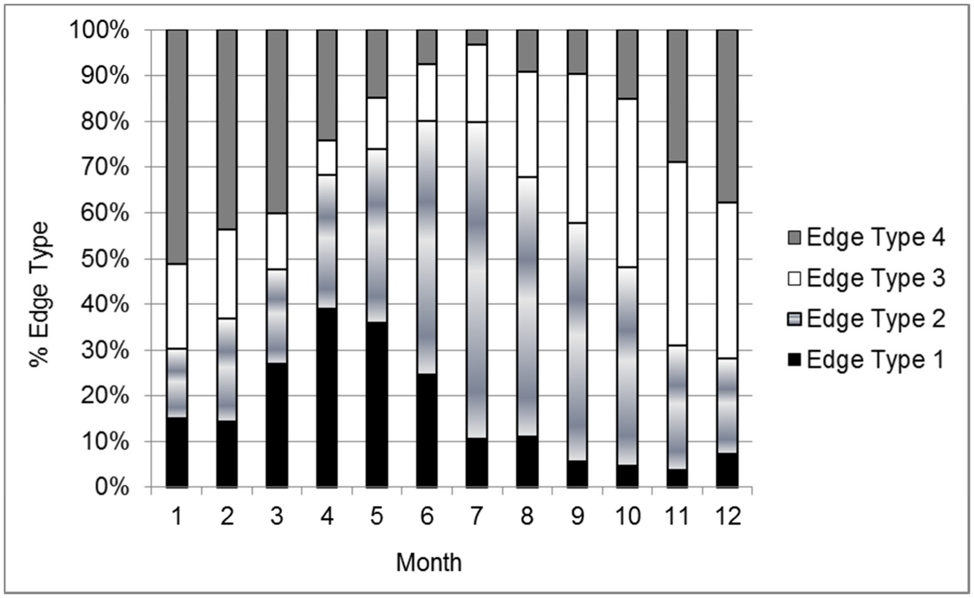



**Figure 2.3**

Monthly margin analysis of Gray Triggerfish as the presence or absence of the increment (translucent zone) on the margin of the spine from SEDAR41 age data set.

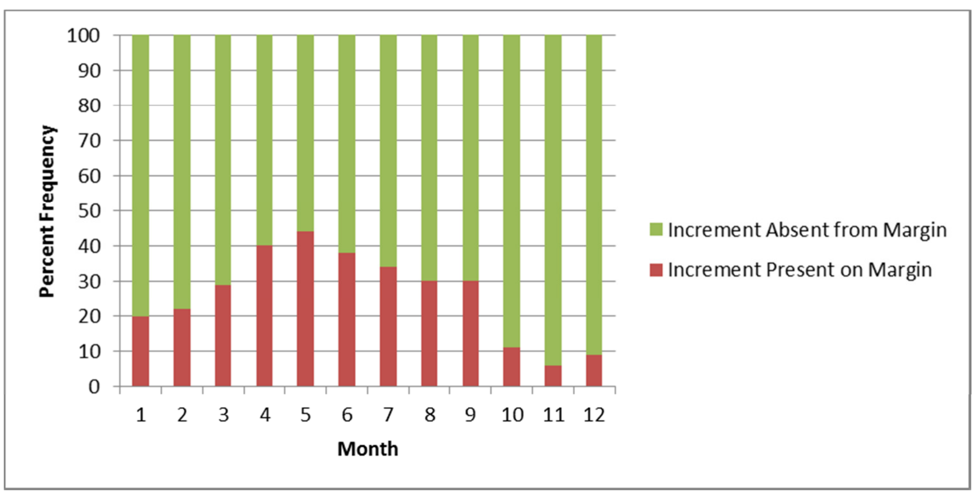


**Figure 2.4.**
Length frequency (1 cm FL bins) histograms of increment-0 Gray Triggerfish compared to increment-1 fish with increment on the margin.

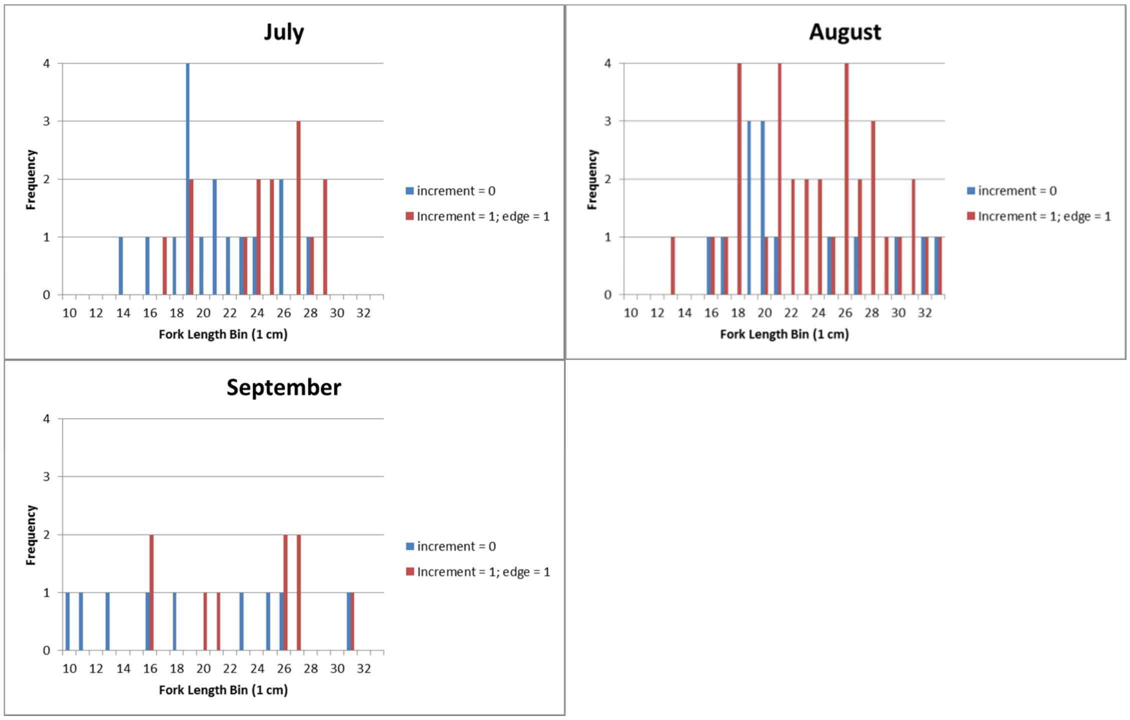


**Figure 2.5**

Size at age and modeled growth for Gray Triggerfish using combined fishery-dependent and fishery-independent data. Length (y-axis) is in mm fork length. The open red diamonds are size at age from collection not under any size limits. The black open circles are Florida samples subjected to the 12 inch FL minimum-size limit and for which the Díaz-correction was applied. Growth was modeled using the Von Bertalanffy (VB) growth model inversely-weighted by sample size at calendar age.

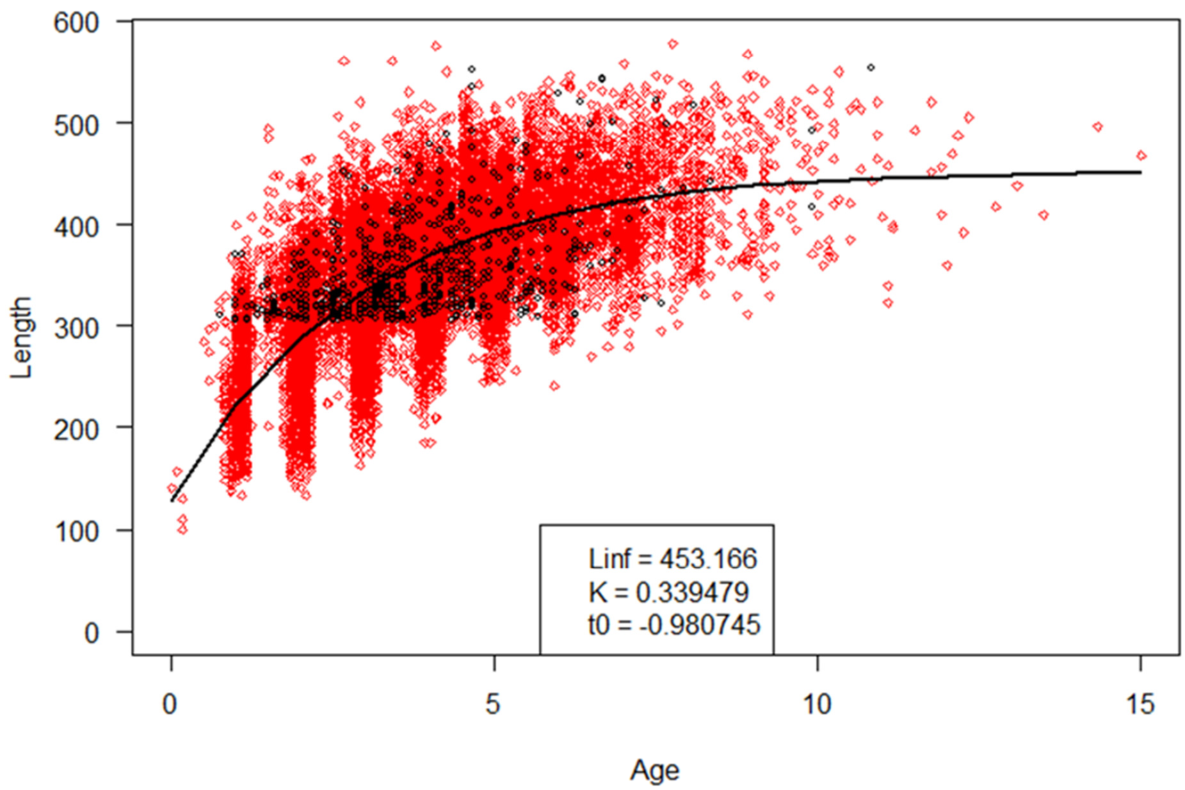


**Figure 2.6**

Size at age and modeled growth for Gray Triggerfish as landed in the fisheries of the U.S. South Atlantic. Growth was modeled using the Von Bertalanffy (VB) growth model inversely-weighted by sample size at calendar age.

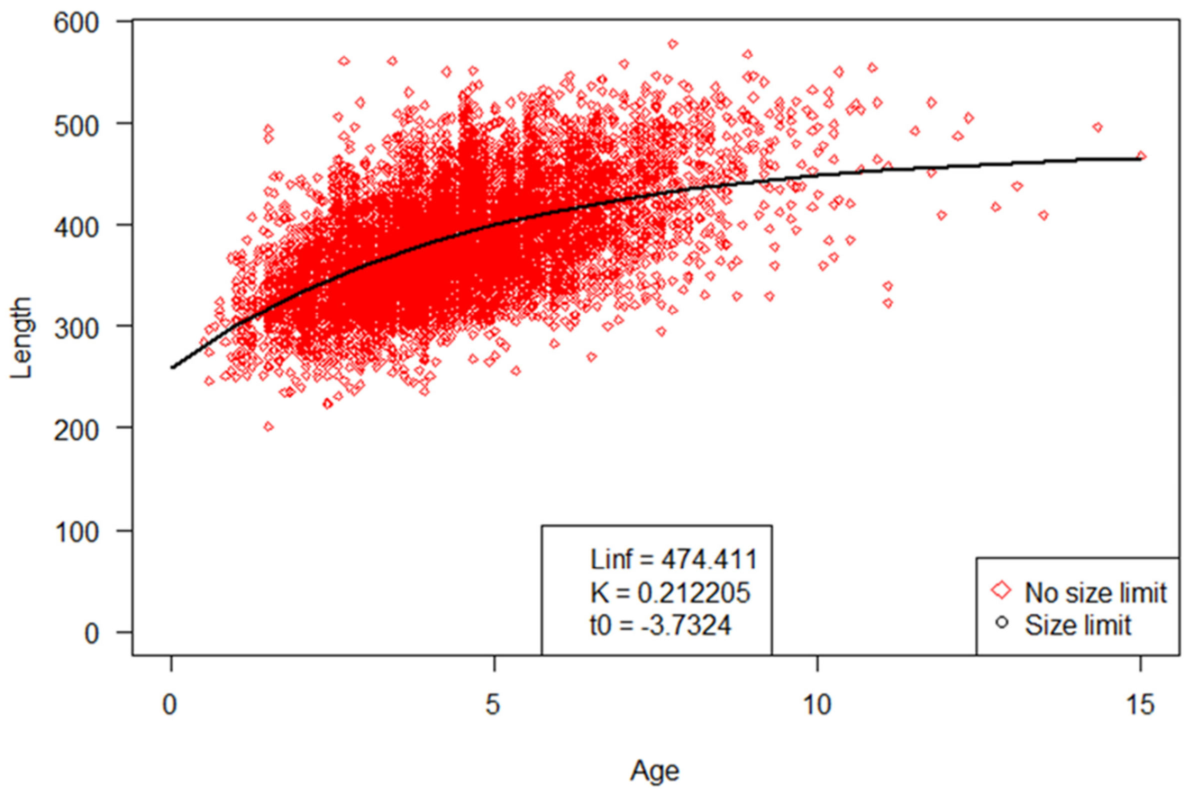


**Figure 2.7**

Mean fork length (mm) at calendar age of Gray Triggerfish males and females. Indication of dimorphic growth after onset of maturity.

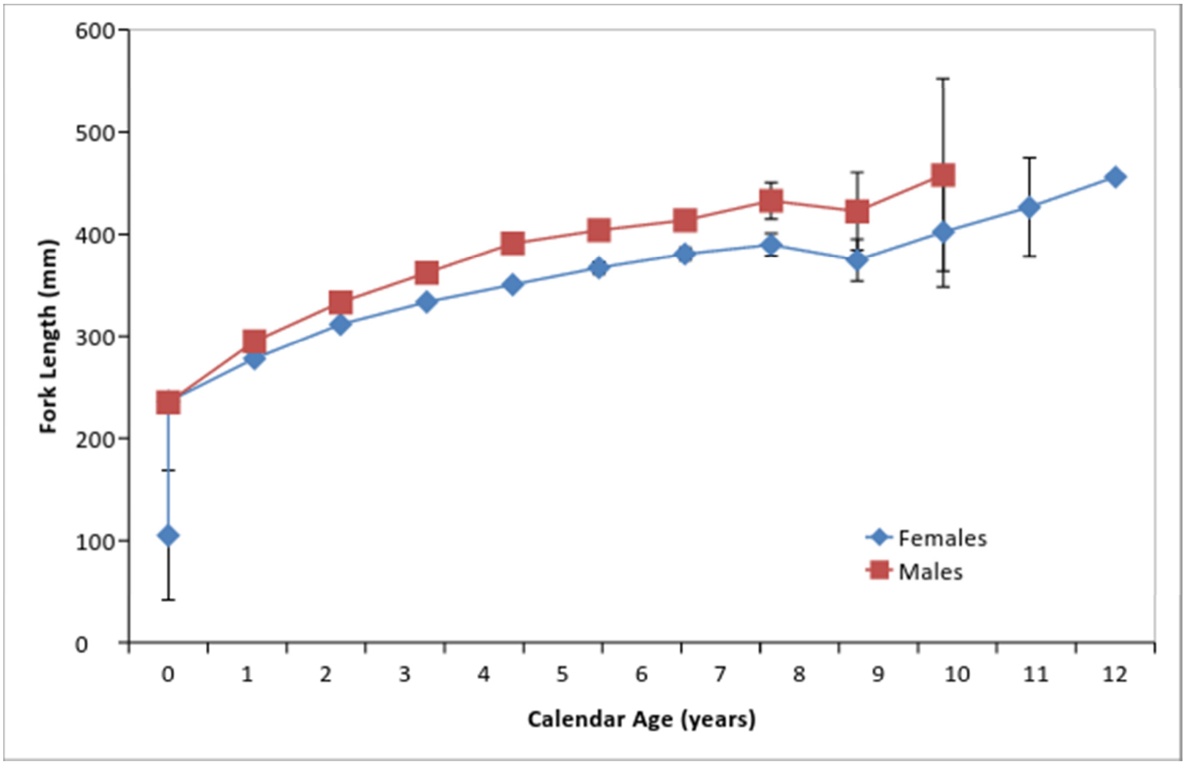


**Figure 2.8**

Size at fractional age and modeled growth for female Gray Triggerfish Length (y-axis) is in mm fork length. The open red diamonds are size at age from collection not under any size limits. The black open circles are Florida samples subjected to the 12 inch FL minimum-size limit and for which the Díaz-correction was applied. Growth was modeled using the Von Bertalanffy (VB) growth model and inversely weighted data.

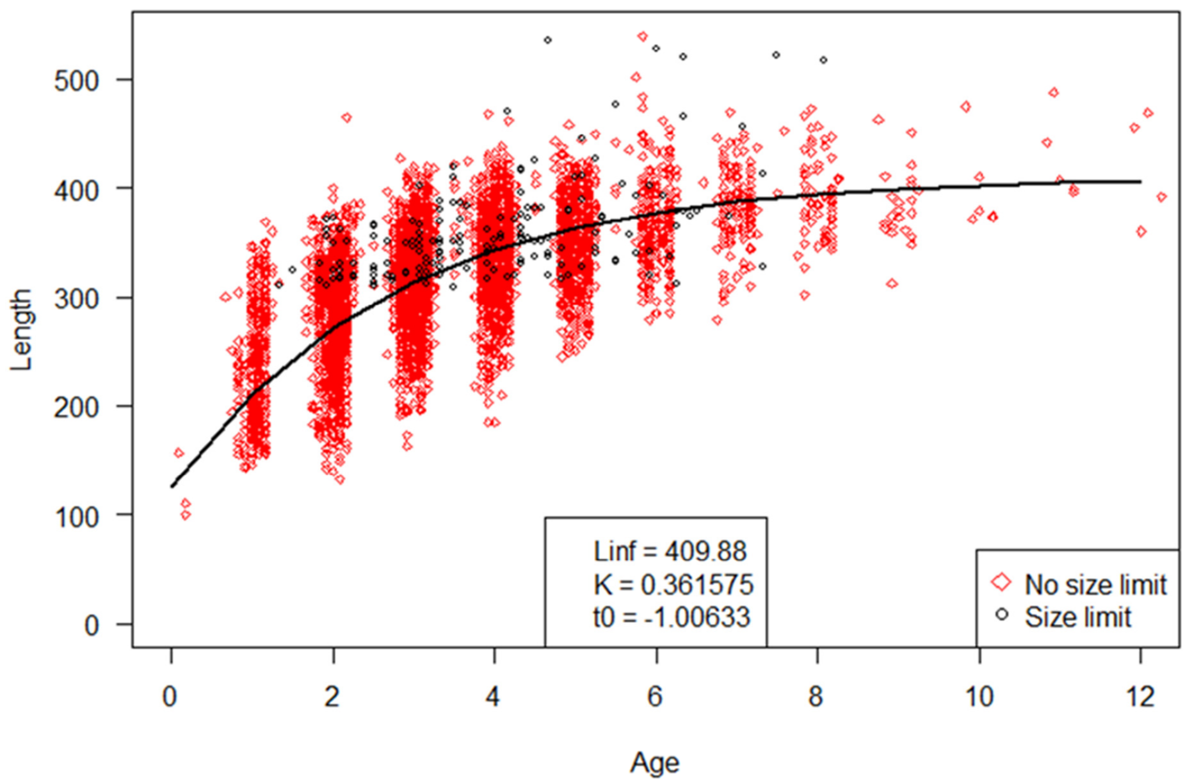


**Figure 2.9.**

QA/QC of histological data from female Gray Triggerfish collected by SERFS . CAO = cortical alveolar oocytes; Def. mature = definitely mature (developing, spawning capable, and regressing reproductive phases).

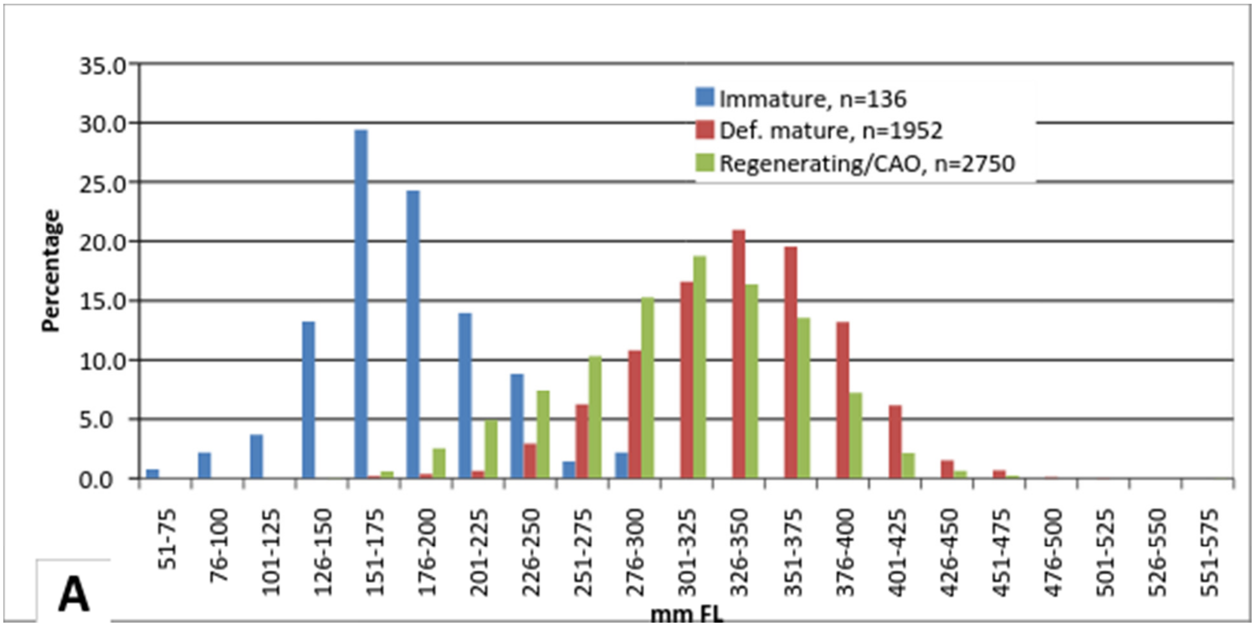


**Figure 2.10**

Sex ratio by calendar age (Cal Age in years) for adult Gray Triggerfish collected by SERFS.

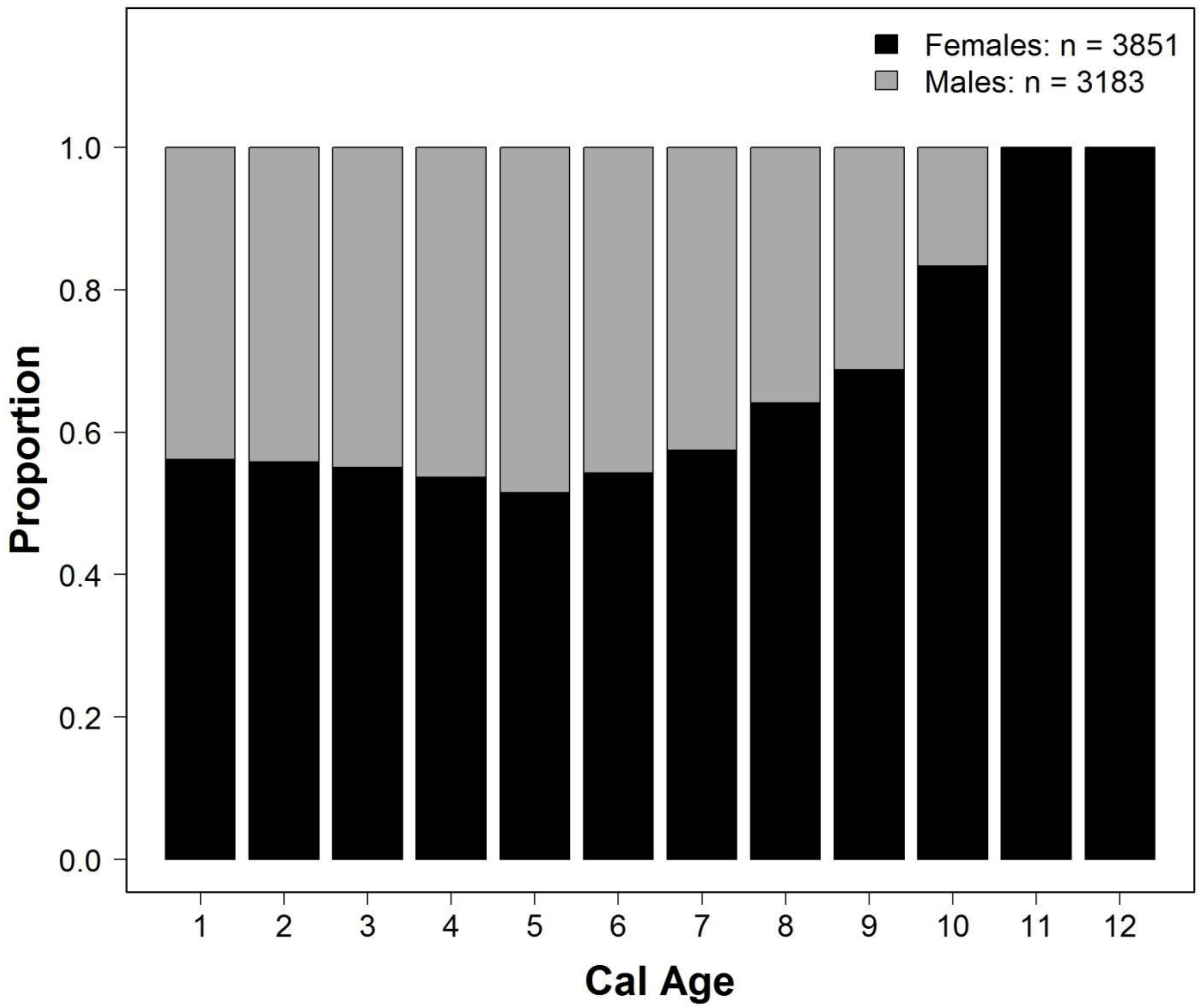


**Figure 2.11**

Sex ratio by fork length (cm) for adult Gray Triggerfish collected by SERFS. Gray=male (n=3,851), black=female (n=3,183).

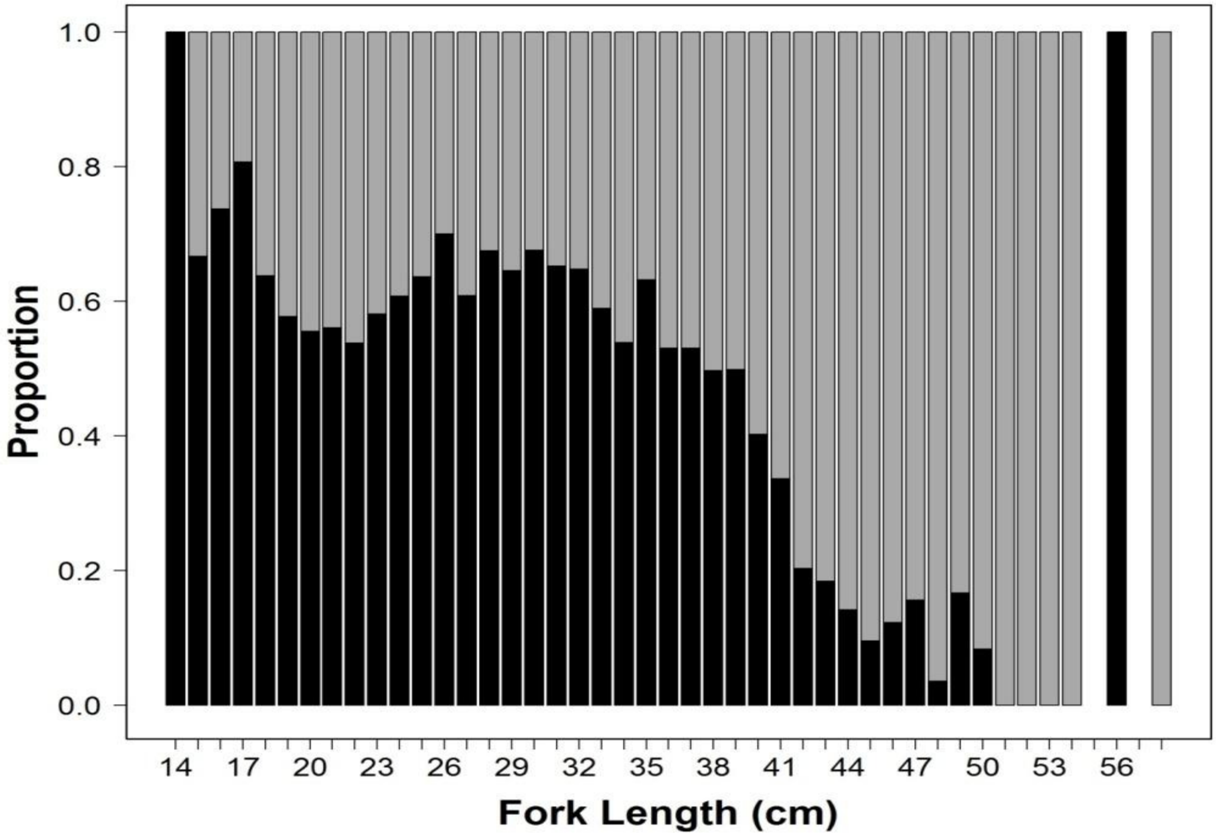


**Figure 2.12**

Spawning seasonality in female Gray Triggerfish collected by SERFS. CAO= cortical alveolar oocytes, Yolked= Yolked oocytes, MNO= migratory nucleus oocytes, POF= postovulatory follicle (=postovulatory complexes).

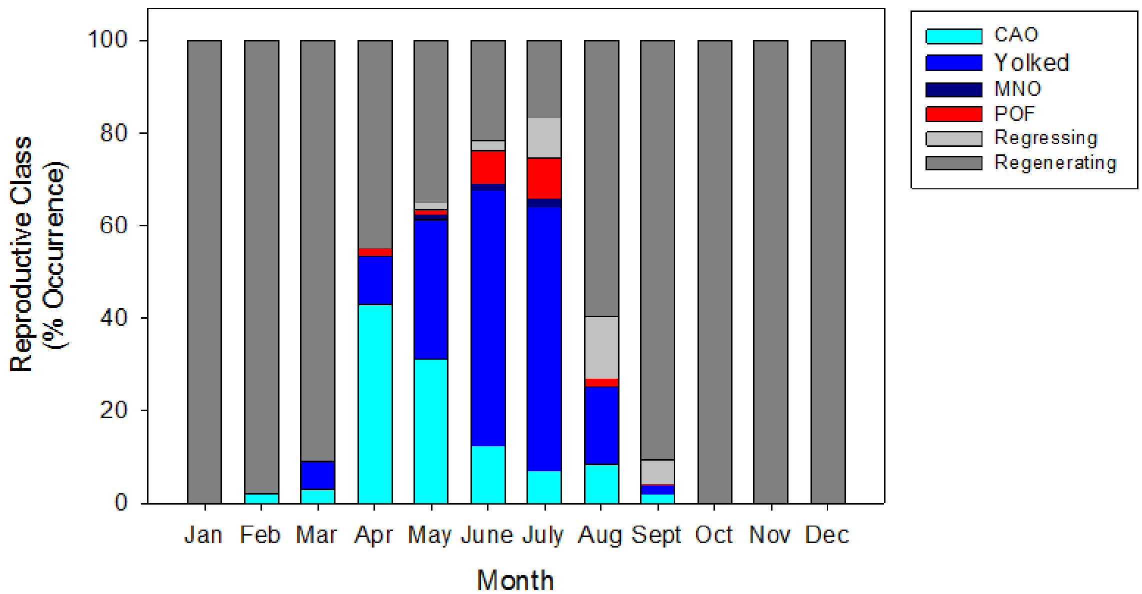


**Figure 2.13**

Time of day of spawning in Gray Triggerfish collected by SERFS during fishery-independent sampling during 1991-2011. All specimens had indicators of imminent or recent spawning. EST=Eastern Standard Time; POF=postovulatory follicle, equivalent to postovulatory complex (POC); 5 h EST=5:00 to 5:59. The number above each bar indicate the sample size for each time interval with n is the total sample size.

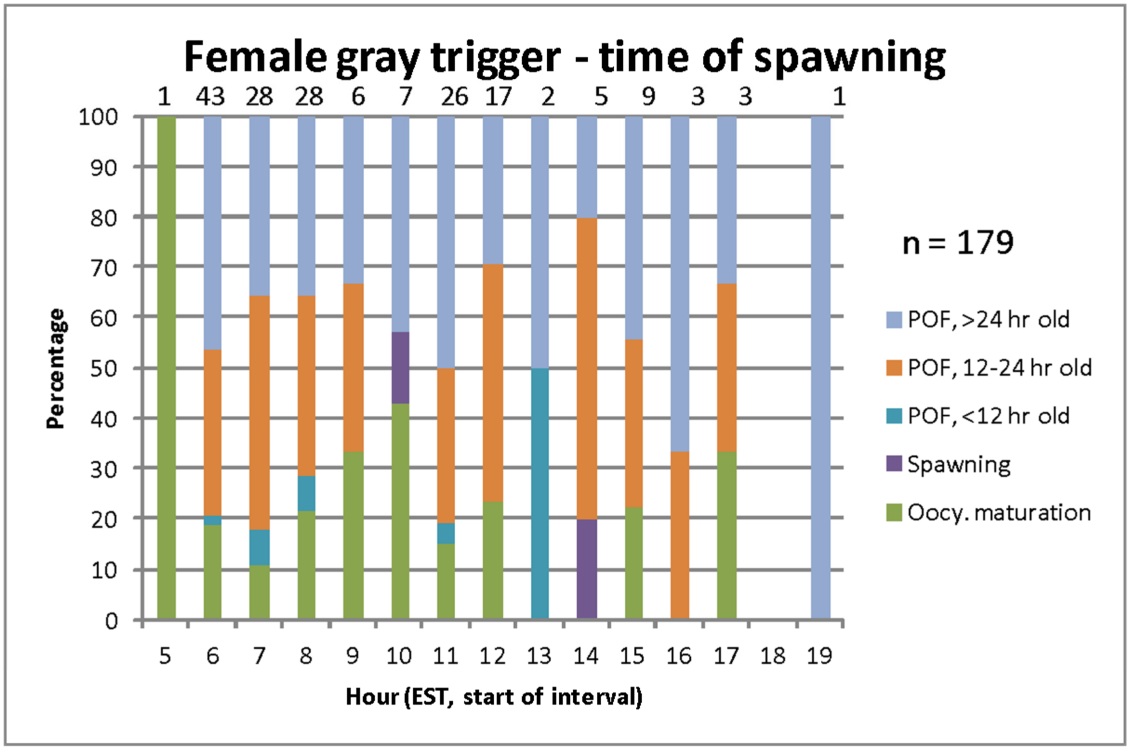
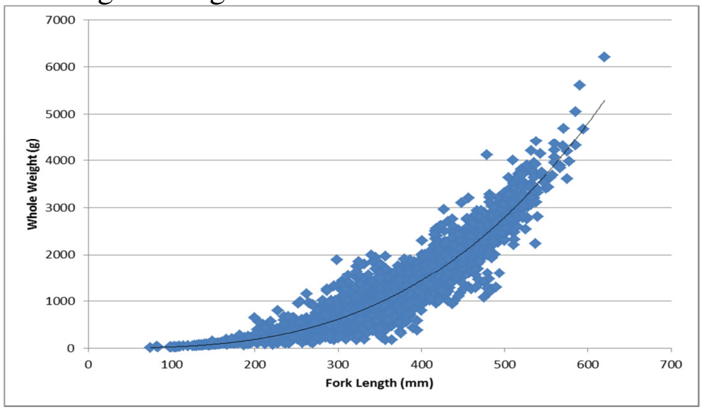
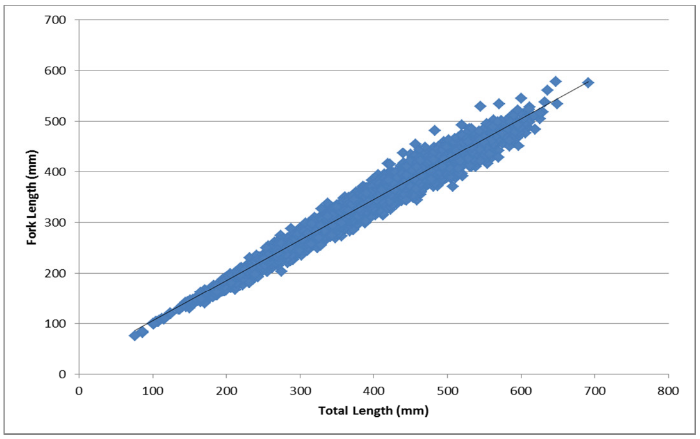
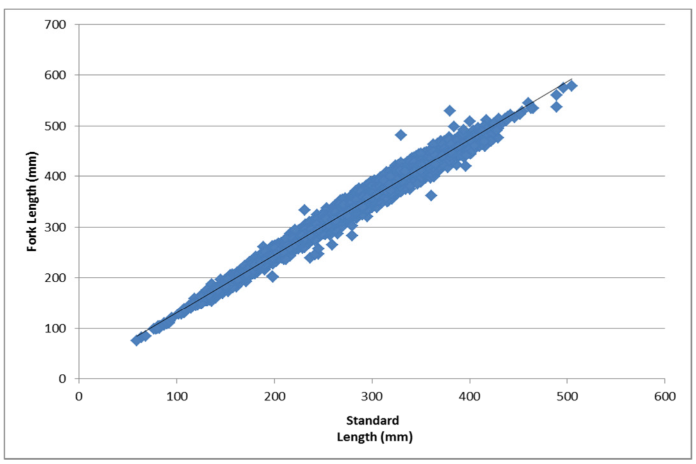


**Figure 2.14.**
Gray Triggerfish: Scatter Plots of raw data used in conversion equations. Whole weight – length and length – length.



# 3. Commercial Fishery Statistics

## 3.1 Overview

Commercial landings for the US South Atlantic gray triggerfish stock were developed by gear (handlines and other) in whole weight pounds for the period 1950–2014 based on federal and state databases. Corresponding landings in numbers were based on mean weights estimated from the Trip Interview Program (TIP) by year, state, and gear.

Commercial discards were calculated from vessels fishing in the US South Atlantic using data from Coastal Fisheries Logbook Program (CFLP) from 1993–2014.

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

### 3.1.1 Commercial Workgroup Participants

| | | |
|---|---|---|
| Julie DeFilippi | Workgroup co-leader/ Data Provider | ACCSP |
| Kevin McCarthy | Workgroup co-leader/ Data Provider | SEFSC Miami |
| Joe Myers | Rapporteur/Data Provider | ACCSP |
| Steve Brown* | Data provider | FL FWC |
| Julie Califf | Data provider | GA DNR |
| Amy Dukes | Data provider | SC DNR |
| Kenny Fex | Commercial | NC/Snapper-Grouper AP |
| Stephanie McInerny* | Data provider | NC DMF |
| David Nelson | Commercial | FL |
| Larry Beerkircher* | Data provider | SEFSC Miami |
| ***2014 Only Workshop*** | | |
| Neil Baertlein | Workgroup leader | SEFSC Miami |
| Zach Bowen | Commercial | GA/SAFMC |
| Chris Conklin | Commercial | SC/SAFMC |
| Jack Cox | Commercial | NC/SAFMC |
| Refik Orhun* | Data provider | SEFSC Miami |

*Did not attend workshop

### 3.1.2 Issues Discussed at the Data Workshop

Most methodologies remained consistent with those of SEDAR 32. Issues discussed included stock boundaries, gear groupings, and the apportioning of unclassified triggerfish. For discards, the workgroup discussed the potential of false 'no discard' reports from the CFLP discard logbook.

New issues discussed included the addition of 2012-2014 data and uncertainty. The largest impact was for that of discard estimation. Beginning in 2012, gray triggerfish experienced closed seasons due to Annual Catch Limits (ACLs) being met. To account for the open and closed seasons, discard rates were calculated for 2012-2014. A 2002 through 2011 mean discard rate was maintained for all other years. Uncertainty, while previously provided, had not been incorporated and concern over the presented numbers was raised. After consultation with the assessment biologists, the group devised updated methodologies for uncertainty which are presented in detail in 3.3.4.

## 3.2 Review of Working Papers

**SEDAR41-RD39:** This report discussed data from 2007-2010 collected by an observer program tasked to characterize the shrimp fisheries in the US Gulf of Mexico and South Atlantic. Data for the South Atlantic penaeid and rock shrimp fisheries are available back to 2008. No data were collected to species for gray triggerfish for this time period. Observer trips prior to 2008 were said to be biased and possibly not representative.

*Review and final decisions determined during 2014 workshop.*

## 3.3 Commercial Landings

***DW ToR #6****: Provide commercial catch statistics, including both landings and discards in both pounds and number. Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear. Evaluate, discuss, and characterize the sources of uncertainty, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models. Provide length and age distributions for both landings and discards if feasible. Provide maps of fishery effort and harvest by species and fishery sector or gear.*

Commercial landings of gray triggerfish were compiled from 1950 through 2014 for the US South Atlantic. Sources for landings included the Florida Fish and Wildlife Conservation Commission trip ticket program (FWC), South Carolina Department of Natural Resources (SCDNR), North Carolina Division of Marine Fisheries (NCDMF), and the Atlantic Coastal Cooperative Statistics Program (ACCSP). Further discussion of how landings were compiled from the above sources can be found in section 3.3.4. Detailed descriptions of historical federal and state data collections can be found in Appendix A.

### 3.3.1 Commercial Gears Considered

The workgroup investigated reported gears landing gray triggerfish from various data sources (ACCSP, CFLP, FWC, SCDNR, & NCDMF) and determined that the primary gear was some type of handline. It was the workgroup's recommendation to then categorize landings into two gear groups: handline and other. A list of gears included in the handline category can be found in Table 3.1.

**Decision 1:** The workgroup suggested two gear groupings to characterize the gray triggerfish fishery (handlines and other). Handlines, which include hook and line, electric/hydraulic bandit reels, and trolling, make up 94.2% of the landings by weight.

*This decision was approved by the plenary.*

### 3.3.2 Stock Boundaries

***DW ToR #1**: Review stock structure and unit stock definitions and consider whether changes are required.*

Landings of triggerfish can be found as far north as Massachusetts and most landings along the Atlantic coast are reported as unclassified. While unclassified triggerfish landings can be apportioned to species using commercial landings proportions attained from other commercial data sources (i.e. TIP, CFLP), no such commercial data exist for the Mid and North Atlantic regions. The workgroup discussed the possibility of using the North Carolina species proportions for all landings north of North Carolina. However the workgroup felt this would be inaccurate as the species composition among triggerfish (namely gray, queen, and ocean triggers) is different among states (see Figure 3.1). The workgroup also considered using proportions developed for the recreational sector, but did not feel they were representative of the commercial sector as fishing methods and areas can be quite different between sectors. The workgroup felt the best approach was to assume 100% of northern triggerfish landings be gray triggerfish. Representatives from the northern states were contacted and indicated the majority or all of their landings of triggerfish were gray triggerfish. As the proportion of triggerfish in NC ranges from 95%-100%, it was the workgroup's recommendation to assign 100% of the triggerfish landings as gray triggerfish north of North Carolina.

**Decision 2:** Because unclassified triggerfish landings north of NC cannot be apportioned by species, the workgroup recommended including those landings with the assumption that 100% are gray triggerfish.

*This decision was approved by the plenary.*

The Commercial Workgroup considered the southern boundary and determined that US 1 in Monroe County, FL would be used as the dividing line between the South Atlantic and Gulf of Mexico stocks. From 1986–2014, logbook proportions were used to divide landings in Monroe County. Prior to 1986, only the east coast of Monroe County will be included. These decisions are based on the granularity of the data available.

**Decision 3:** The Workgroup recommends using the east coast of FL and the SA jurisdiction of the FL keys as the southern boundary of the Atlantic gray triggerfish stock.

*This decision was approved by the plenary.*

Maps of the Atlantic stock area and specific areas in FL can be found in Figures 3.3 and 3.4.

### 3.3.3 Misidentification and Unclassified Triggerfish

Most landings of triggerfish from the Atlantic are reported as unclassified. Based on data from CFLP and TIP, the large majority of triggerfish landed in the South Atlantic are gray triggerfish. Unclassified landings should be proportioned out to determine gray triggerfish landings by year, state, and gear. Species proportions for NC were provided by TIP from 1983 – 2014 by year and gear. Low sample sizes for triggerfish in 1983 made the proportion for NC unreliable so an average proportion across years (1984-2011) will be used for any year prior to 1984. Species proportions for SC, GA, and FL will come from CFLP. The taxonomic level of the TIP data for SC wasn't detailed enough to calculate appropriate proportions for this species. A longer time series for GA is available in the logbook data. Low sample sizes for triggerfish from TIP caused FL proportions to be unrepresentative of the fishery.

**Decision 4:** The Workgroup recommends applying proportions to all unclassified landings to account for gray triggerfish.

*This decision was approved by the plenary.*

### 3.3.4 Commercial Landings by Gear and State

Statistics on commercial landings (1950 to present) for all species on the Atlantic coast are maintained in the Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse.

The Data Warehouse is an online database of fisheries dependent data provided by the ACCSP state and federal partners. Data sources and collection methods are illustrated by state in Figure 3.5. The Data Warehouse was queried in August 2015 for all triggerfish landings (annual summaries by gear category) for 1950–2014 from Florida (east coast including Monroe County) through Maine (ACCSP, 2015). Data are presented using the gear categories as determined at the Data Workshop. The specific ACCSP gears in each category are listed in Table 3.1. Commercial landings in pounds (whole weight) were developed based on methodologies for gear as defined by the Workgroup for each state as available by gear for 1950–2014.

**Decision 5**: The Workgroup recommends providing all available data from 1950–2014.

*This decision was approved by the plenary.*

Florida

Comparisons were made between Florida's commercial trip ticket data (1986-2014) to the NMFS general canvas (1976-1996) and logbook data (1992-2014). All three datasets were very similar in landings trends and level of landings reported for matching years. It was decided to use the landings from the Florida trip ticket data over the general canvas and logbook since general canvas data are Florida trip ticket data since 1997, and trip ticket data were more complete and are of a longer time series than the logbook data. Two issues arose with regard to gray triggerfish landings from Florida South Atlantic waters. First, until June of 2013, all trip ticket reports of triggerfish species were reported as unclassified triggerfish (this was also the case with the general canvas data). Secondly was how to separate South Atlantic from Gulf of Mexico landings in Monroe County (Florida Keys). While gray triggerfish landings in Monroe County were not large compared to the rest of Florida, it was estimated from the NMFS logbook data that the amount of South Atlantic gray triggerfish landed in Monroe county was as much as 9% in a given year. It was decided to use the NMFS logbook data to proportion out South Atlantic gray triggerfish from the unclassified triggerfish in the trip ticket data since the logbook data are reported to species back to 1992, and since it was believed that fisher reported area fished data were generally more accurate than area fished data reported by dealers. Additionally, it was decided to use NMFS logbook data to apportion landings by gear in the trip ticket data. While both programs collected gear by trip over the same time series (since 1992), the workgroup decided that gear reported by fisher would generally be more accurate than dealer reported gears.

The amount of South Atlantic gray triggerfish by year in the Florida trip ticket data was determined by calculating the proportion of Monroe County South Atlantic gray triggerfish separately from the rest of South Atlantic Florida in the logbook data for years 1993-2014. This was done by dividing the amount of SA gray triggerfish into total triggerfish landings for both Monroe and non-Monroe SA Florida, then applying those proportions to the corresponding years for Monroe County and the non-Monroe SA Florida triggerfish landings from the trip ticket data. An average proportion for both SA Monroe County and non-Monroe SA Florida was calculated from the combined 1993-2014 logbook data and applied to corresponding total triggerfish landings in the trip ticket data from 1986-1992. SA Monroe County and non-Monroe SA landings were then combined into total SA gray triggerfish landings in the Florida trip ticket data. NMFS logbook data were then used to calculate proportions of Florida SA gray triggerfish harvest by gear. This was done by dividing landings for each gear into total Florida SA landings, then applying those proportions to the Florida trip ticket SA landings by year from 1993-2014. The average proportion of logbook landings over all years by gear was then applied to trip ticket landings from 1986-1992.

One additional issue with triggerfish landings in SA Florida was how the fish were graded. Historically, Florida has used the original NMFS conversion factor of 1.04 and accepted all reports of triggerfish as gutted. However, industry representatives and commercial fish house samples all indicated that most fish were landed in whole condition accept for a portion of the Florida East coast that encompassed the region from New Smyrna Beach to Cape Canaveral (Volusia, Indian River and Brevard counties). The workgroup agreed that landings from this region would be treated as gutted while the rest of SA Florida would be treated as whole fish landings. Final landings are in whole (live) pounds.

**Decision 6**: The Workgroup recommends using 1993-2014 logbook data to apportion Florida landings prior to 1993.

*This decision was approved by the plenary.*

Georgia

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

South Carolina

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

SCDNR provided landings data for unclassified triggerfish from 1978 – 2014. Data from 1978 – 2003 were collected in monthly totals through collaborative efforts by SCDNR and the NMFS Cooperative Statistics Program and all data were correlated and confirmed with the ACCSP data warehouse. Data provided from 2004 – 2014 were more comprehensive because SCDNR instituted a mandatory Trip Ticket Program in late 2003. All landings data are provided by year and approved gear type.

Triggerfish were landed whole, therefore no conversions were necessary, and all landing through this time period were associated with gears used. Landings data for triggerfish were partitioned by gear/gear combinations. Gear combinations recommended by the Commercial Workgroup for Gray Triggerfish were Handline and Other.

Between the years 1978 to 2014, the vast majority of landings were assigned to unclassified triggerfish. In order to proportion these landing to Gray Triggerfish, two data sources were examined; TIP and Commercial logbook. TIP sampling data were determined to be biased as sampling efforts in SC were target-based, with only having targets set forth for Gray Triggerfish. Commercial logbook data, collected from 1993 – 2014 was determined to be a viable dataset to calculate a proportion percentage. The average proportion for years 1993 to 2011 by gear was calculated and applied to the unclassified triggerfish landings provided by SCDNR data by year and gear for years 1978 to 1992. Years 2012 and 2013 were not used in this average proportion because during each of those years, the Allowable Catch Limit (ACL) was reached and commercial fishing for Gray Triggerfish was closed. Years 1993 to 2013 was proportioned by the corresponding yearly calculated proportion percentage from the commercial logbook data. Mean weights by year and gear provided by TIP were used to convert pounds to numbers of fish.

North Carolina

NCDMF provided landings data from 1978–2014. Data from 1978–1993 were provided by the NMFS Cooperative Statistics Program and are also stored in the NCDMF database; data from 1994–2014 were provided by the NC Trip Ticket Program. Up to three gears can be listed on a trip ticket therefore, landings were analyzed to look at gear combinations and no gear reassignments were deemed necessary for this species. Data from NCDMF is also stored in the ACCSP data warehouse. Data were provided by NCDMF to capture all three gears and would contain the most recent edits to the data.

All landings of triggerfish from NC are unclassified; therefore, proportions from the Trip Interview Program (TIP) were used to determine the proportion of gray triggerfish from the unclassified landings. TIP proportions are provided by year, state, and gear for 1983–2014.

Gear groupings provided by Beerkircher for triggerfish were Handline and Other and match the gear groupings recommended by the Commercial Workgroup. Average proportions by gear were used for years before 1984 and for any year in the other gear group where a proportion was not available. The proportion from 1983 was not used due to low sample size.

The majority of triggerfish landed in NC are whole so a conversion from gutted to whole weight was not necessary for this species. Final landings in pounds were calculated by multiplying the unclassified triggerfish landings by the gray triggerfish proportion by year, state, and gear. Mean weights from 1983–2014 by state and gear provided by TIP were used to convert pounds to numbers of fish. Average mean weights were used for years before 1984. The mean weight for 1983 was not used due to low sample size and an uncharacteristically high mean weight.

Virginia through Massachusetts

All northern landings have been provided by ACCSP. 100% of triggerfish landings were assumed to be gray triggerfish. There are relatively few landings of triggerfish north of North Carolina which can be seen in north/south comparison in Figure 3.2. Annual mean weights from North Carolina were used to estimate numbers of fish.

Combined State Results

Landings for Florida through Massachusetts by gear category are presented in pounds whole weight (Table 3.2; Figure 3.6) and numbers of fish (Table 3.3; Figure 3.7). Handlines are the dominant gear and account for 94.2% of the total landings for the period of 1950–2014.

A consistent gray triggerfish fishery began in the mid-1970s and steadily grew through the 1980s to just under 100,000 pounds annually. A dramatic increase in landings began in 1990 and peaked in 1994 at almost a half million pounds. Several commercial fishermen on the panel noted that this is about when gray triggerfish became more heavily targeted and switched from longline to bandit gear. Beginning in 1998, landings fell to below 200,000 pounds in 2004 and rose again to almost a half million pounds again by 2011. Possible reasons for this large dip in landings included the reduction of snapper grouper permits in 1998. Other possible explanations include shifts in effort. Several fishers from North Carolina and Florida recalled switching to vermilion snapper and shark fishing.

**Decision 7:** The Workgroup made the following decisions for reporting commercial landings:

- Landings should be reported as whole weight in pounds and number of fish
- Final landings data would come from the following sources:
  - VA-North: 1950-2014 (ACCSP)
  - NC: 1950-1993 (ACCSP)

| | | |
|---|---|---|
| | | 1994-2014 (NCDMF) |
| o | SC: | 1950-1979 (ACCSP) |
| | | 1980-2014 (SCDNR) |
| o | GA: | 1950-2014 (ACCSP) |
| o | FL: | 1950-1985 (ACCSP) |
| | | 1986-2014 (FL FWC) |

*This decision was approved by the plenary.*

<u>Whole vs. Gutted Weight</u>
Gray triggerfish in the South Atlantic are typically landed in whole weight; however, it was discovered that some fishermen in FL land triggerfish in gutted condition. For this analysis, landings in NC, SC, and GA were reported as is in whole weight. Based on input from fishermen, FL landings from Volusia, Indian River, and Brevard counties would be considered gutted and would be converted to whole weight using the FL conversion factor of 1.04.

**Decision 8:** The Commercial Workgroup will provide gray triggerfish landings in pounds whole weight.

*This decision was approved by the plenary.*

<u>Confidentiality Issues</u>
Landings of gray triggerfish were pooled across states by gear to meet the rule of 3 and ensure confidential landings were not presented in this report. Landings by state and gear will be provided to the data compiler for use in the assessment.

<u>Uncertainty</u> (2015 data workshop)
The commercial workgroup estimated uncertainty in commercial fishery landings, after consultation with assessment biologists, by modifying the methodology used in SEDAR 24 (p.64) for red snapper.

> Relative CVs were developed by year and state based upon method of data collection. For the earliest years annual landings summaries were collected at the state level and therefore a CV of 0.5 was produced. As data collections improved in each of these states, CVs become smaller, with the eventual CV of 0.1 for each state.

The new estimates of uncertainty are not coefficients of variation, but are estimates of possible reporting error; i.e., represent the range in actual commercial landings relative to the reported landings.

In making these uncertainty estimates, two assumptions were made:

1. *Landings may be underreported during all years; however, underreporting was likely highest during early years of the time series and were more accurate in recent years.* This assumption was based upon the following information and data workshop expert testimony: during the period 1950 (beginning of landings time series) to 1961 landings were summarized annually by state and likely did not include landings from small scale dealers. In the years 1962-1977 landings data were collected annually, but under a more all-inclusive program (General Canvass). Monthly landings summaries were collected during the period 1978 to the beginning of trip ticket data collection (starting dates vary among states). The most recent landings data, collected through state trip ticket programs, were assumed to be most reliable and inclusive of all gray triggerfish commercial landings.
2. *Landings may be overestimated during the years 1950-1977 because triggerfish landings were not species specific. The proportion of gray triggerfish to other triggerfish species was believed to be unchanged over the time period 1950-present, therefore yearly estimates of gray triggerfish to other triggerfish proportions represent samples of the true proportions.* Unclassified triggerfish landings were apportioned into species specific landings using reported (commercial coastal logbook data) or observed (TIP data) species proportions. That process may have resulted in an overestimate of the true landings of gray triggerfish because the true proportion of gray triggerfish may have been overestimated.

During workgroup discussions it was recognized that using the levels of landings uncertainty recommended during SEDAR 24 (40-50% uncertainty) would poorly inform the assessment model of landings during the early years of the time series (1950-1977). The group agreed, based upon expert opinion, that an upper bound ½ that recommended during SEDAR 24 (i.e., 25% greater landings during 1950-1961, 20% during 1962-1977, 10% during the period 1978 until implementation of state trip ticket programs (varies by state). See Table 3.5 for state specific upper bounds.

A lower bound for commercial landings was based upon variance in estimates of the proportion of gray triggerfish landings to landings of other triggerfish species. If the proportion of gray triggerfish landings to other triggerfish landings has been constant, then yearly estimates of those proportions using coastal logbook or TIP data represent multiple samples of the true species proportions. The workgroup recommended using the standard deviation of the gray triggerfish proportions across years to calculate a lower bound for gray triggerfish landings. A lower bound will be set as the estimated landings minus the pounds equal to one standard deviation of the proportion of gray triggerfish landings to other triggerfish species landings. Those calculations will be done separately by state. This decision was based upon expert opinion. State-specific standard deviations in gray triggerfish proportions are provided in Table 3.5.

**Decision 9**: The Workgroup recommends estimating landings uncertainty based on modified SEDAR 24 recommendations for a landings upper bound and a lower bound set as the estimated landings minus one standard deviation of the proportion of gray triggerfish landings to other triggerfish species landings.

*This decision was approved by the plenary.*

### 3.3.5 Converting Landings in Weight to Landings in Numbers

The weight in pounds for each handline length sample was calculated, as was the mean weight by state, gear and year. Where the sample size was less than 30 fish, the mean across all years, 1983-2014, was used (Table 3.4). Since other gear length samples and landings are minimal no mean weights were produced for other gear. Handline weights have therefore been used as a proxy. For landings prior to 1983, mean weights were applied for each state as they were when the sample size was fewer than 30. To convert northern, Virginia through Maine, landings to numbers the overall mean weight from North Carolina was used. The landings in pounds whole weight (Table 3.2 and Figure 3.6) were then divided by the mean weight for each year to derive landings in numbers (Table 3.3 and Figure 3.7).

## 3.4 Commercial Discards

### 3.4.1 Directed Fishery Discards

***2015 updated analyses***

Calculations of the total number of gray triggerfish discarded or kept as bait/eaten from the commercial fishery were updated to include data from 2014. Methods were otherwise unaltered from those recommended during the initial SEDAR41 data workshop in August 2014. Updated calculated discards and calculated totals of fish kept for bait or eaten are provided in Tables 3.6 and 3.7. Very minor differences in calculated discards and number of fish kept for bait/eaten between the 2014 data workshop and the 2015 workshop were likely due to inclusion of an additional year of data when calculating the mean discard or kept rates. Use of mean rates across years was necessary due to small sample sizes of reported gray triggerfish discards and reported kept for bait gray triggerfish. In addition, updates or edits to the discard logbook and/or coastal logbook data sets would result in minor changes in the number of calculated discards (McCarthy, K., 2015).

***2014 analyses***

Methods used to calculate commercial discards are described in document SEDAR41-DW37. Available data useful for calculating discards included self-reported discard rates and gear-specific effort from the commercial fishery. Gray triggerfish discards were calculated using vertical line (handline and electric/hydraulic "bandit" gear) and trap gear data. Reports of gray triggerfish discards from vessels fishing other gears included only one percent of all discarded gray triggerfish for the period 2002-2013.

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 2002-2013. Rates were calculated separately for vertical line and trap gears. Those discard rates were then multiplied by the yearly gear-specific total fishing effort (vertical line: total hook-hours fished; trap: total number of traps fished) reported to the coastal logbook program. Effort data were available for the period 1993-2013. Discards were calculated separately for those fish reported as discarded and those that were reported as "kept as bait or eaten".

The above methods were modified during the data workshop to account for differences in discard rates during the 2012 and 2013 open and closed gray triggerfish fishing seasons. The mean discard rate for the years 2002-2011 was used in the calculation of yearly discards during the period 1993-2011. Calculations of discards during the 2012-13 open fishing seasons used the mean discard rate during the open seasons of those years. Similarly, calculation of closed season discards (2012-13) was made using the mean of the discard rates reported during 2012 and 2013 closed seasons. Discard rates were multiplied by the appropriate year and season total effort reported to the coastal logbook program. Calculation of the annual number of gray triggerfish reported as "kept as bait/eaten" followed the methods described for discard calculation.

An increase in the number of reports of "no discards" (of any species) may have resulted in underreporting of commercial discards. To address the issue of discard underreporting in both discard calculation methods described above, data included in discard rate calculations were filtered to remove records from vessels that never reported discards of any species during a year. In addition, data from vertical line vessels that reported more than 17 trips without reporting discards of any species (17=the mean number of reported trips prior to the first trip with reported discard plus two standard deviations of that mean) or more than 3 trips (mean plus two standard deviations) without a report of discards in the trap fishery. Those data filters were recommendations of the SEDAR32 data workshop. Including data from those fishers that habitually reported no discards would have resulted in discard rates that were erroneously low. Trips targeting mackerel are unlikely to have discards of gray triggerfish, therefore, trips that reported only landings of mackerel species were excluded from this analysis. Additional data filters included the removal of clearly erroneous data (values of gear-specific effort data beyond the 99.9 percentile of the data). Discard logbook data with multiple gears fished on a trip were also excluded because discards could not be unambiguously attributed to a particular gear. That data filtering step was not necessary when summing total effort from the logbook data because reported effort data was gear-specific.

During all years, the number of calculated discards of both gears combined was less than 9,000 fish except during one year/filtering combination. The high number (relative to other years) of gray triggerfish reported as "kept as bait/eaten" during the 2012 and 2013 closed commercial fishing seasons may have been retained under recreational bag limits. The recreational fishery remained open throughout 2012 and 2013.

**Decision 10:** The Workgroup accepts the discard estimates of gray triggerfish for 1992-2013 as developed in working paper S41DW37 and revised during the data workshop to account for differences in discard rates during open and closed gray triggerfish fishing seasons.

*This decision was approved by the plenary.*

During 1992 only 20% of vessels in Florida were required to report to the logbook program and the SEDAR32 data workshop recommendation was to limit the discard calculations to the period 1993-2013. The SEDAR41 commercial working group and Data Workshop panel also recommended beginning the commercial discard time series in 1993.

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 gray triggerfish and other species. An effort was made to minimize that potential error by removing data from vessels that never reported discards of any species during a year. In addition, data from vertical line vessels that reported more than 17 trips 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) or more than 3 trips (mean plus two standard deviations) without a report of discards in the trap fishery 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 total commercial discards provided in SEDAR41-DW37 may represent a minimum estimate of the number of gray triggerfish discarded from the commercial fishery. 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 gray triggerfish discards. This decision was approved in plenary session of the Data Workshop.

### 3.4.2 Shrimp Bycatch

The possibility of constructing gray triggerfish bycatch estimates from the south Atlantic shrimp fishery was investigated. Beginning in 2008, a mandatory observer program was put in place to sample trips in the penaeid and rock shrimp fisheries. The observer sampling protocol however does not require gray triggerfish to be recorded at the species level, but instead are lumped into a general finfish category. Prior to 2008, gray triggerfish had been recorded to the species level on species characterization trips. Between 1997 and 2013, only 46 gray triggerfish were reported. Of the 46 fish, 44 were reported on 6 of 18 species characterization trips between 2001 and 2003. The other 2 fish were reported on 2 of 243 species characterization trips between 2005 and 2007. This disparity in triggerfish observed between the 2001-2003 and 2005-2007 time periods is likely attributed to the differences in shrimp fisheries sampled. The 2001-2003 trips were largely off the eastern coast of Florida and likely rock shrimp trips. The latter time period predominately sampled trips to the north in the penaeid fishery. These limited data may suggest that there is minimal gray triggerfish bycatch in the rock shrimp fishery and little to none in the penaeid fishery. Anecdotal evidence supplied by several fishermen at the workshop support this. One fisher recalled rarely seeing gray trigger while shrimping between Florida's Cape Canaveral and Brunswick, Georgia dating back to the 1950's. It is also important to note these species characterization trips were voluntary and may not be representative of the penaeid and/or rock shrimp fleets (Scott 2014). It is with these limited data and potential sampling biases that we recommend not modelling shrimp bycatch.

**Decision 11:** Bycatch from the shrimp fishery will not be constructed due to insufficient data and potential sampling bias.

*This decision was approved by the plenary.*

*Review and final decisions determined during 2014 workshop.*

## 3.5 Commercial Effort

The distribution of directed commercial effort in trips by year was compiled from the Coastal Fisheries Logbook Program (CFLP) for 1993-2013 and supplied here for informational purposes. These data are presented in Figure 3.8. The distribution of harvest by statistical grid, as reported to the CFLP, is a displayed in Figure 3.9. Figure 3.10 shows a distribution of harvest by depth and latitude.

*Review and final decisions determined during 2014 workshop. This was not updated in 2015.*

## 3.6 Biological Sampling

Length Samples

Commercial length data were available from the SEFSC Trip Interview Program for all years, 1983 to 2014. 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 insure that the contents agree with the master data tables.

REGIONS other than South Atlantic are filtered out. Data were assigned as South Atlantic samples via a hierarchal procedure. If area fished was in the interview's effort information (e.g. usually derived from captain), this information was used. If the Captain's information was not available, but area fished was provided in the interview's landings information (e.g. derived from the dealer's records/trip tickets), 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 (e.g., all records not previously resolved that landed in NC, SC, or GA were assumed to be south Atlantic samples, and all records not previously resolved that landed in FL's east coast counties (Dade county northward) were also assumed to be south Atlantic samples).

IS_DISABLED='Y' TRIPS are filtered out. TIP allows errant data to exist in the database until such time as the issue can be resolved. TIP also allows testing trips in the production database. These only make up 0.2 % of all south Atlantic TIP interviews. It is unlikely that BSD would import these records and that agents would send age structures from errant trips. Agents cannot disable trips, only system and database administrators can.

FISHING_MODE<>'COMMERCIAL' are filtered out. TIP is meant to be a commercial representative sampling program, however the TIP database has been used to house recreational, scientific, experimental, etc. data collections. Non-commercial trips make up 14% of south Atlantic TIP interviews.

BIAS_TYPE<>'NO BIAS KNOWN' are filtered out. In the past, samplers where asked to record if they felt the trip was representative, or biased for some particular reason. Trips with a bias indicated make up 1.9% of south Atlantic TIP interviews.

INTERVIEW_TYPE='TRIP_SURVEY' are filtered out. An interview type coded Trip Survey means that the sampling was taken from the aggregated landings of more than one trip (this could involve a single vessel but multiple trips, or multiple vessels). In these cases, if the sampler knew that the gear type and/or area fished varied among the trips included in the trip survey, historical practice was to assign area fished and gear type to what the sampler believed characterized the “majority” of the catch (and therefore in theory the majority of the sampled specimens). Since area fished and gear type cannot be conclusively identified for a trip survey, then if these variables are necessary for the assessment, they should be filtered out. It should be noted that this filter disproportionately affects the lengths available from South Carolina samples in the 1980’s and early 1990’s. For example, in the south Atlantic data overall trip survey lengths are about 2% of the data, but for South Carolina trip survey lengths account for 41% of the length data. Filtering out these records results in zero lengths for South Carolina in the years 1985, 1986, 1987, 1989, 1990, 1992, and 1995.

GEAR TYPE: Will be determined by the first gear type listed in the trip record. The assumption is that if a trip uses multiple gear types, a single gear type is the primary type used, and is listed by the sampler first. Where a gear type was not obtained via an interview, then the gear information from the dealer was used.

**OBSERVATION-SPECIFIC FILTERING:**

SAMPLE_RANDOM=NO are filtered out. Samples coded as ‘NO” for this variable are assume to have some type of sampling issue; the sample was selected by a non-random or targeted method. These observations may not be representative of the trip’s catch and should not be used. For triggerfish, non-random samples are 1% of the observations.

CONDITION_TYPE=’GUTTED-HEAD OFF’ were removed as length collection should be impossible if the fish was in such condition. Null values for condition type were left in, as it was historically standard practice by many samplers to only record a condition when a weight was taken, also many samplers seemed to operate under the impression that leaving this value as null meant the fish was in standard industry condition (for red snapper and triggerfish, this means the head is left on). Only 30 records were affected by this filter.

LENGTH1_MM= NULL or 0 will be filtered out. A very small number of observations in TIP do not have length data. Unreasonable lengths were filtered including 22 lengths <=63 mm were deleted as unreasonably small and two lengths of 3410 and 3606 mm were deleted as unreasonably large, leaving the length range as 146 mm to 1270 mm.

<u>Age Samples</u>
Most of the age structures were obtained from TIP port agents and ageing analyst coordinated with TIP data collection experts to obtain consistency in filtering data. Ageing analysts contacted state sampling representatives to determine if increased sampling outside the TIP program in recent years were biased in any way.

### 3.6.1 Sampling Intensity

Length samples
Gear-specific summaries of the quantity and quality of the length data show that the majority of the length data available for gray triggerfish are from the handline fishery (Table 3.8). All other gears are characterized by relatively poor annual sample sizes, coverage, and variability in the mean length and weight across gears. Annual sample sizes of lengths and number of trips sampled are summarized in Tables 3.9 and 3.10, respectively, by gear and state for gray triggerfish in the U.S. South Atlantic from the TIP database for 1983-2014. The state-specific sample sizes are inadequate to weight samples for any of the gears. Even the most abundant gear, handline, has no length samples for many year/state combinations. A value of zero cannot be weighted and small sample sizes cause spikes in a composition for areas with average or greater landings. A comparison of the relative number of fish sampled across states to the relative landings across states is shown in Figure 3.11. Overall, North Carolina is relatively over-sampled for most of the time period, South Carolina has only one fish sampled prior to 2005, Georgia has no samples prior to 1995 and then fluctuates relative to landings through 2005. After 2005 there are no Georgia samples with the exception of 2013. Florida has only one year with samples prior to 1992 and then is sampled proportional to landings with some variability and a few under sampled years. The absence of samples and years with limited samples by state precludes state-specific weighting methods for most years. Weighting at a coarser scale assumes similar length distributions across regions but makes the annual compositions more comparable. Combining North Carolina with South Carolina and Georgia with Florida gives adequate samples for both regions from 1995 to present. The regional relationship between handline length samples and landings is shown in Figure 3.12. Prior to 1995, all samples are from North Carolina. The “other” gear includes sporadic sampling by states and very different gear types (e.g. longline and trawl).

Age samples
Annual sample sizes for commercial handline and other gears by state are given in Tables 3.11 and 3.12. Almost all ages are from North Carolina and South Carolina with the exception of a few years with samples from Florida.

### 3.6.2 Length/Age Distribution

Length distributions - Landings
All gray triggerfish lengths were converted to FL in mm using the formula provided by the SEDAR 41 Life History Workgroup and binned into one centimeter groups with a floor of 0.6 cm and a ceiling of 0.5 cm. The length data and landings data were divided into handline and other gears. Unweighted gray triggerfish handline annual length compositions are provided in

the SEDAR 41 data workbook and shown in Figure 3.13 . No gray triggerfish discard length data were available from the commercial observer program.

Age distributions – Landings
Calendar ages were determined by ageing experts and provided to commercial composition analysts for summary. Unweighted gray triggerfish handline annual age compositions are provided in the SEDAR 41 data workbook and shown in Figure 3.14.

### 3.6.3 Adequacy for Characterizing Catch

Length samples
The TIP sample sizes for the development length distributions appear to be adequate for the commercial handline. Overall there is more uncertainty that the handline length distribution prior to 1991 characterizes coastwide landings due to the lack of coverage in the Georgia/Florida region. However, North Carolina accounts for over 50% of the coastwide landings on average. When combined regionally with South Carolina, the Carolinas account for approximately 70% of the landings on average. The size distribution would have to be drastically different in the Georgia/Florida region to impact the weighted length distribution.

Length samples from the other gears were limited. Development of any length distributions from other gears would be uninformative due to the lack of spatial and temporal coverage and the disparity in mean length for the different gears (Table 3.8). The other category represents only 8% of the overall landings and assuming they are represented by the handline length compositions would very minimally increase the uncertainty of an assessment.

Age samples
Handline ages are missing for Georgia and Florida for most years. The samples are adequate from 2004 to present for development of annual age compositions. The 2002 samples consist of only 8 fish from 2 trips. The lack of coverage in Georgia and Florida may not be problematic since the Carolinas account for the majority of the landings. Weighting age compositions by length compositions can correct for bias in sampling age structures from the overall sample as well as region-specific differences.

**Decision 12:** The Workgroup recommends only development of a handline length distribution which should be weighted regionally (Car and GFL). Years with limited trips or very limited spatial coverage should not be used to characterize catch (1983). The workgroup recommends development of annual handline age compositions weighted by the annual handline length compositions. Years with limited trips or very limited spatial coverage should not be used to characterize catch (2002).

## 3.7 Comments on Adequacy of Data for Assessment Analyses

Landings

The workgroup feels the landings data for assessment analyses are adequate. There is a clear landings history for the available time series. Commercial landings of triggerfish were relatively unsubstantial prior to the 1970s, so it is likely that any gray triggerfish landings made prior to 1950 were negligible. There was an issue concerning species identification. All landings were reported to their respective states as unclassified triggerfish. Additional commercial data sources such as the Trip Interview Program (TIP) and the Coastal Fisheries Logbook Program (CFLP) were needed to apportion the landings to species. There were no commercial data available north of North Carolina to develop proportions to apply to the relatively small amount of unclassified triggerfish landings in the north. These landings were subsequently dropped. There was a slight issue in regards to landing condition. It was initially thought that all gray triggerfish landings were in whole weight. However, in consulting with industry representatives and port agents in Florida, South Carolina, and North Carolina, it was found that a segment of the commercial fleet landed triggerfish gutted, while the rest of the fleet landed them whole. To address the gutted landings, landings from several counties in Florida were considered gutted and were converted to whole pounds.

Discards

Discard calculations are less adequate as there may be issues concerning the quality of self-reported data, especially where 'no discard' reports are concerned. While it is generally accepted that a trip without discards, of any kind, can and will happen, there is high level of uncertainty in the accuracy of 'no discard' reports. There has been an increase in the number of 'no discard' reports over the past ten years; from roughly 30% to 60% of all discard reports. It is likely that some fishers may simply report 'no discards' to satisfy their reporting requirements. However, due to the relatively low discard rate for this particular species, the inclusion, or exclusion, of all 'no discard' reports has little impact on the overall take of gray triggerfish.

Length and age samples

Length and age samples from the handline fishery are adequate for assessment analyses. The increased uncertainty for years with limited coverage could be modeled by reducing the weighting factor (typically trip sample size) by the proportion landings represented by missing states or regions (e.g. an annual trip sample size of 40 for both regions with no samples from one region that has 20% of the landings would be reduced to a sample size of 32).

## 3.8 Literature Cited

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## 3.9 Research Recommendations

Landings

- Require species level reporting in state trip ticket programs. Some states in process of instituting species level reporting for all species.
- Improve gear and effort data collections.

Discard

- Investigate the validity and magnitude of “no discard” trips. This may include fisher interviews throughout the region.
- Examine potential impacts of “no discard” trips on estimated discards.
- Improve discard logbook data collections via program expansion or more detailed reporting (e.g. more detailed logbook, electronic reporting)
- Establish an observer program that is representative of the fisheries in the South Atlantic.

Biosampling

- Standardize TIP sampling protocol to get representative samples at the species level.
- Standardize TIP data extraction.
- Establish an observer program that is representative of the fisheries in the South Atlantic.
- Increase untargeted sampling in NE and Mid-Atlantic observer programs.
- Increase untargeted dockside sampling in NE and Mid-Atlantic.

## 3.10 Tables

**Table 3.1** Specific ACCSP gears in each gear category for gray triggerfish commercial landings.

| HAND LINE GEAR | | | | |
|---|---|---|---|---|
| *GEAR_CODE* | *GEAR_NAME* | *TYPE_CODE* | *TYPE_NAME* | *SEDAR 41 CATEGORY* |
| 300 | HOOK AND LINE | 007 | HOOK AND LINE | HAND LINE |
| 301 | HOOK AND LINE, MANUAL | 007 | HOOK AND LINE | HAND LINE |
| 302 | HOOK AND LINE, ELECTRIC | 007 | HOOK AND LINE | HAND LINE |
| 303 | ELECTRIC/HYDRAULIC, BANDIT REELS | 007 | HOOK AND LINE | HAND LINE |
| 320 | TROLL LINES | 007 | HOOK AND LINE | HAND LINE |
| 700 | HAND LINE | 013 | HAND LINE | HAND LINE |
| 701 | TROLL AND HAND LINES CMB | 013 | HAND LINE | HAND LINE |
| ***ALL OTHER GEARS ARE GROUPED AS OTHER** | | | | |

**Table 3.2** Gray triggerfish landings, in whole weight pounds, by gear.

| Year | Hand Line | Other |
|---|---|---|
| 1950 | 911 | 62 |
| 1951 | 1,077 | 73 |
| 1952 | 497 | 34 |
| 1953 | 83 | 6 |
| 1954 | 2,567 | 174 |
| 1955 | 2,567 | 174 |
| 1956 | 911 | 62 |
| 1957 | 2,981 | 202 |
| 1958 | 1,822 | 124 |
| 1959 | 2,319 | 157 |
| 1960 | 2,236 | 152 |
| 1961 | 2,485 | 169 |
| 1962 | 9,110 | 618 |
| 1963 | 5,715 | 388 |
| 1964 | 3,975 | 270 |
| 1965 | 1,859 | 126 |
| 1966 | 1,398 | 95 |
| 1967 | 2,899 | 197 |
| 1968 | 2,733 | 185 |
| 1969 | 1,325 | 90 |
| 1970 | 2,014 | 137 |
| 1971 | 4,389 | 298 |
| 1972 | 7,702 | 523 |
| 1973 | 8,199 | 556 |
| 1974 | 14,905 | 1,012 |
| 1975 | 28,987 | 1,967 |
| 1976 | 17,972 | 1,220 |
| 1977 | 17,144 | 1,163 |
| 1978 | 38,556 | 1,734 |
| 1979 | 40,829 | 1,497 |
| 1980 | 50,665 | 3,094 |
| 1981 | 72,559 | 6,542 |
| 1982 | 95,505 | 1,376 |
| 1983 | 65,991 | 3,317 |
| 1984 | 69,772 | 3,210 |
| 1985 | 65,743 | 1,894 |
| 1986 | 67,702 | 1,447 |
| 1987 | 73,192 | 1,392 |
| 1988 | 75,804 | 3,530 |
| 1989 | 92,779 | 3,074 |
| 1990 | 178,186 | 15,334 |
| 1991 | 242,062 | 27,810 |
| 1992 | 252,900 | 8,378 |
| 1993 | 318,540 | 8,231 |
| 1994 | 392,457 | 15,235 |

| | | |
|---|---|---|
| 1995 | 462,496 | 23,031 |
| 1996 | 400,659 | 38,368 |
| 1997 | 502,613 | 30,691 |
| 1998 | 407,144 | 14,821 |
| 1999 | 262,200 | 15,053 |
| 2000 | 187,546 | 7,236 |
| 2001 | 206,355 | 7,268 |
| 2002 | 183,964 | 18,557 |
| 2003 | 178,692 | 11,735 |
| 2004 | 232,680 | 18,174 |
| 2005 | 265,519 | 9,134 |
| 2006 | 229,416 | 10,493 |
| 2007 | 307,137 | 14,482 |
| 2008 | 306,569 | 12,130 |
| 2009 | 339,784 | 28,837 |
| 2010 | 423,670 | 28,336 |
| 2011 | 465,088 | 32,635 |
| 2012 | 265,078 | 41,793 |
| 2013 | 300,483 | 30,771 |
| 2014 | 262,448 | 12,156 |

**Table 3.3** Gray triggerfish landings, in numbers of fish, by gear.

| Year | Hand Line | Other |
|---|---|---|
| 1950 | 314 | 21 |
| 1951 | 371 | 25 |
| 1952 | 171 | 12 |
| 1953 | 29 | 2 |
| 1954 | 884 | 60 |
| 1955 | 884 | 60 |
| 1956 | 314 | 21 |
| 1957 | 1,027 | 70 |
| 1958 | 627 | 43 |
| 1959 | 799 | 54 |
| 1960 | 770 | 52 |
| 1961 | 856 | 58 |
| 1962 | 3,137 | 213 |
| 1963 | 1,968 | 134 |
| 1964 | 1,369 | 93 |
| 1965 | 640 | 43 |
| 1966 | 482 | 33 |
| 1967 | 998 | 68 |
| 1968 | 941 | 64 |
| 1969 | 456 | 31 |
| 1970 | 694 | 47 |
| 1971 | 1,512 | 103 |
| 1972 | 2,653 | 180 |
| 1973 | 2,824 | 192 |
| 1974 | 5,133 | 348 |
| 1975 | 9,983 | 677 |
| 1976 | 6,189 | 420 |
| 1977 | 5,904 | 401 |
| 1978 | 13,359 | 592 |
| 1979 | 13,920 | 515 |
| 1980 | 16,818 | 1,021 |
| 1981 | 24,296 | 2,245 |
| 1982 | 31,602 | 509 |
| 1983 | 22,008 | 1,122 |
| 1984 | 20,563 | 843 |
| 1985 | 18,438 | 514 |
| 1986 | 18,362 | 515 |
| 1987 | 19,292 | 479 |
| 1988 | 22,230 | 1,073 |
| 1989 | 29,390 | 1,049 |
| 1990 | 57,557 | 5,301 |
| 1991 | 82,418 | 9,627 |
| 1992 | 88,013 | 3,026 |
| 1993 | 103,742 | 2,666 |
| 1994 | 132,045 | 5,103 |

| | | |
|---|---|---|
| **1995** | 159,870 | 7,873 |
| **1996** | 152,106 | 17,251 |
| **1997** | 193,885 | 11,867 |
| **1998** | 157,898 | 5,940 |
| **1999** | 91,941 | 5,295 |
| **2000** | 69,016 | 2,623 |
| **2001** | 76,319 | 2,765 |
| **2002** | 69,581 | 7,102 |
| **2003** | 66,046 | 4,385 |
| **2004** | 92,784 | 7,451 |
| **2005** | 102,197 | 3,554 |
| **2006** | 81,994 | 3,734 |
| **2007** | 103,846 | 4,819 |
| **2008** | 102,915 | 3,982 |
| **2009** | 123,278 | 10,528 |
| **2010** | 141,223 | 9,509 |
| **2011** | 154,680 | 10,646 |
| **2012** | 85,082 | 12,679 |
| **2013** | 98,585 | 9,760 |
| **2014** | 82,053 | 3,713 |

**Table 3.4** Mean weights in pounds whole weight for gray triggerfish used for developing landings in numbers by year, state and gear.

| Year | NC | SC | GA | FL | VA North |
|---|---|---|---|---|---|
| 1950-1982 | 3.1777 | 2.8168 | 2.5467 | 2.9037 | 3.1777 |
| 1983 | 3.1777 | 2.8168 | 2.5467 | 2.9037 | 3.1777 |
| 1984 | 4.6608 | 2.8168 | 2.5467 | 2.9037 | 4.6608 |
| 1985 | 4.5857 | 2.8168 | 2.5467 | 3.4128 | 4.5857 |
| 1986 | 4.7626 | 2.8168 | 2.5467 | 2.9037 | 4.7626 |
| 1987 | 4.6127 | 2.8168 | 2.5467 | 2.9037 | 4.6127 |
| 1988 | 3.9061 | 2.8168 | 2.5467 | 2.9037 | 3.9061 |
| 1989 | 3.7210 | 2.8168 | 2.5467 | 2.9037 | 3.7210 |
| 1990 | 3.4531 | 2.8168 | 2.5467 | 2.9037 | 3.4531 |
| 1991 | 3.0217 | 2.8168 | 2.5467 | 2.9037 | 3.0217 |
| 1992 | 3.0436 | 2.8168 | 2.5467 | 2.6833 | 3.0436 |
| 1993 | 3.0799 | 2.8168 | 2.5467 | 3.5170 | 3.0799 |
| 1994 | 2.9147 | 2.8168 | 2.5467 | 3.5904 | 2.9147 |
| 1995 | 2.8950 | 2.8168 | 1.9731 | 3.2730 | 2.8950 |
| 1996 | 2.6040 | 2.8168 | 1.8946 | 2.8537 | 2.6040 |
| 1997 | 2.5944 | 2.8168 | 1.9708 | 2.4950 | 2.5944 |
| 1998 | 2.5309 | 2.8168 | 2.5467 | 2.3693 | 2.5309 |
| 1999 | 2.8080 | 2.8168 | 3.1697 | 2.9388 | 2.8080 |
| 2000 | 2.8257 | 2.8168 | 2.4804 | 2.2140 | 2.8257 |
| 2001 | 2.6716 | 2.8168 | 2.6041 | 2.4168 | 2.6716 |
| 2002 | 2.6324 | 2.8168 | 2.5215 | 2.5015 | 2.6324 |
| 2003 | 2.6763 | 2.8168 | 2.8807 | 2.5393 | 2.6763 |
| 2004 | 2.5536 | 2.8168 | 2.5007 | 1.9224 | 2.5536 |
| 2005 | 2.6705 | 2.6510 | 2.9504 | 2.1551 | 2.6705 |
| 2006 | 2.7507 | 2.8949 | 2.5467 | 2.9164 | 2.7507 |
| 2007 | 2.9593 | 2.8439 | 2.5467 | 3.3593 | 2.9593 |
| 2008 | 2.9052 | 2.9751 | 2.5467 | 3.6669 | 2.9052 |
| 2009 | 2.7016 | 2.8753 | 2.5467 | 2.8920 | 2.7016 |
| 2010 | 3.0523 | 2.8366 | 2.5467 | 3.1742 | 3.0523 |
| 2011 | 3.1149 | 2.8036 | 2.5467 | 3.0907 | 3.1149 |
| 2012 | 3.3716 | 2.7311 | 2.5467 | 3.1380 | 3.3716 |
| 2013 | 3.1970 | 2.7394 | 3.0675 | 3.0544 | 3.1970 |
| 2014 | 3.2310 | 2.8168 | 2.5467 | 3.5138 | 3.2310 |

**Table 3.5** Commercial landings uncertainty upper and lower bounds by year and state. Note that there is no lower bound for VA North data as all landings are assumed to be 100% gray triggerfish.

| Year Range | VA North | NC | GA | SC | FL |
|---|---|---|---|---|---|
| 1950-1961 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| 1962-1977 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| 1978-1985 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| 1986-1989 | 0.2 | 0.1 | 0.1 | 0.1 | 0.05 |
| 1990-1993 | 0.1 | 0.1 | 0.1 | 0.1 | 0.05 |
| 1994-2001 | 0.1 | 0.05 | 0.1 | 0.1 | 0.05 |
| 2002-2003 | 0.1 | 0.05 | 0.05 | 0.1 | 0.05 |
| 2004-present | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Lower bound | NA | 0.05 | 0.13 | 0.12 | 0.09 |

**Table 3.6** Yearly a) vertical and b) trap discards of gray triggerfish from US South Atlantic commercial fisheries. Discards calculated separately for open and closed seasons. Data filters described in the text. Discard rate for the period 1993-2011 was the single rate calculated using combined 2002-2011 data. Open season 2012-14 discard rate was calculated using combined open season 2012-14 data. Closed season 2012-14 discard rate was calculated using combined closed season 2012-14 data. Trips (discards) = trips reporting to the discard logbook program and were summed as defined above (i.e., 2002-2011, 2012-14 open season, 2012-14 closed season). Trips (total effort) = number of trips reporting to the coastal logbook program. Vertical line effort = hook hours fished, trap effort = number of traps fished. Discards are reported as number of fish.

a)

| Year | Season | Trips (discards) | Trips (total effort) | Discard Rate | Discard Rate CV | Total Effort | Calculated Discards |
|---|---|---|---|---|---|---|---|
| | Vertical line | | | | | | |
| 1993 | Open | 18,612 | 11,846 | 0.0021 | 11.70 | 1,331,155 | 2,812 |
| 1994 | Open | 18,612 | 14,446 | 0.0021 | 11.70 | 1,680,269 | 3,549 |
| 1995 | Open | 18,612 | 14,468 | 0.0021 | 11.70 | 1,676,441 | 3,541 |
| 1996 | Open | 18,612 | 15,395 | 0.0021 | 11.70 | 1,647,052 | 3,479 |
| 1997 | Open | 18,612 | 17,642 | 0.0021 | 11.70 | 1,778,302 | 3,757 |
| 1998 | Open | 18,612 | 15,865 | 0.0021 | 11.70 | 1,280,813 | 2,706 |
| 1999 | Open | 18,612 | 14,462 | 0.0021 | 11.70 | 1,079,870 | 2,281 |
| 2000 | Open | 18,612 | 13,298 | 0.0021 | 11.70 | 1,155,724 | 2,441 |
| 2001 | Open | 18,612 | 13,927 | 0.0021 | 11.70 | 1,202,087 | 2,539 |
| 2002 | Open | 18,612 | 14,575 | 0.0021 | 11.70 | 1,156,630 | 2,443 |
| 2003 | Open | 18,612 | 14,062 | 0.0021 | 11.70 | 982,399 | 2,075 |
| 2004 | Open | 18,612 | 13,178 | 0.0021 | 11.70 | 874,447 | 1,847 |
| 2005 | Open | 18,612 | 11,843 | 0.0021 | 11.70 | 807,361 | 1,705 |
| 2006 | Open | 18,612 | 11,654 | 0.0021 | 11.70 | 880,385 | 1,860 |
| 2007 | Open | 18,612 | 12,801 | 0.0021 | 11.70 | 946,780 | 2,000 |
| 2008 | Open | 18,612 | 13,036 | 0.0021 | 11.70 | 962,163 | 2,033 |
| 2009 | Open | 18,612 | 14,352 | 0.0021 | 11.70 | 1,007,193 | 2,128 |
| 2010 | Open | 18,612 | 12,769 | 0.0021 | 11.70 | 819,205 | 1,731 |
| 2011 | Open | 18,612 | 13,093 | 0.0021 | 11.70 | 784,566 | 1,657 |
| 2012 | Open | 7,599 | 9,814 | 0.0067 | 11.97 | 576,915 | 3,848 |
| 2013 | Open | 7,599 | 7,273 | 0.0067 | 11.97 | 427,868 | 2,854 |
| 2014 | Open | 7,599 | 5,661 | 0.0067 | 11.97 | 313,762 | 2,093 |
| 2012 | Closed | 1,774 | 2,526 | 0.0277 | 7.71 | 124,835 | 3,460 |
| 2013 | Closed | 1,774 | 4,728 | 0.0277 | 7.71 | 323,090 | 8,955 |
| 2014 | Closed | 1,774 | 8,425 | 0.0277 | 7.71 | 455,476 | 12,624 |

b)

| Year | Season | Trips (discards) | Trips (total effort) | Discard Rate | Discard Rate CV | Total Effort | Calculated Discards |
|---|---|---|---|---|---|---|---|
| | Trap | | | | | | |
| 1993 | Open | 895 | 1,023 | 0.05239 | 4.55 | 43,311 | 2,269 |
| 1994 | Open | 895 | 1,195 | 0.05239 | 4.55 | 59,745 | 3,130 |
| 1995 | Open | 895 | 1,032 | 0.05239 | 4.55 | 55,765 | 2,921 |
| 1996 | Open | 895 | 1,168 | 0.05239 | 4.55 | 59,422 | 3,113 |
| 1997 | Open | 895 | 1,353 | 0.05239 | 4.55 | 62,406 | 3,269 |
| 1998 | Open | 895 | 1,201 | 0.05239 | 4.55 | 53,588 | 2,807 |
| 1999 | Open | 895 | 1,075 | 0.05239 | 4.55 | 49,538 | 2,595 |
| 2000 | Open | 895 | 829 | 0.05239 | 4.55 | 37,859 | 1,983 |
| 2001 | Open | 895 | 1,096 | 0.05239 | 4.55 | 43,626 | 2,286 |
| 2002 | Open | 895 | 826 | 0.05239 | 4.55 | 35,942 | 1,883 |
| 2003 | Open | 895 | 783 | 0.05239 | 4.55 | 31,505 | 1,651 |
| 2004 | Open | 895 | 820 | 0.05239 | 4.55 | 31,221 | 1,636 |
| 2005 | Open | 895 | 596 | 0.05239 | 4.55 | 24,787 | 1,299 |
| 2006 | Open | 895 | 786 | 0.05239 | 4.55 | 32,018 | 1,677 |
| 2007 | Open | 895 | 616 | 0.05239 | 4.55 | 26,389 | 1,382 |
| 2008 | Open | 895 | 561 | 0.05239 | 4.55 | 18,820 | 986 |
| 2009 | Open | 895 | 772 | 0.05239 | 4.55 | 28,804 | 1,509 |
| 2010 | Open | 895 | 404 | 0.05239 | 4.55 | 15,561 | 815 |
| 2011 | Open | 895 | 237 | 0.05239 | 4.55 | 6,986 | 366 |
| 2012 | Open | 283 | 257 | 0.07818 | 3.68 | 6,787 | 531 |
| 2013 | Open | 283 | 134 | 0.07818 | 3.68 | 3,342 | 261 |
| 2014 | Open | 283 | 59 | 0.07818 | 3.68 | 1,451 | 113 |
| 2012 | Closed | 154 | 67 | 0.14180 | 4.01 | 1,948 | 276 |
| 2013 | Closed | 154 | 233 | 0.14180 | 4.01 | 6,002 | 851 |
| 2014 | Closed | 154 | 203 | 0.14180 | 4.01 | 4,993 | 708 |

**Table 3.7** Yearly gray triggerfish discards reported as "kept for bait" from the US South Atlantic commercial vertical line fishery; calculated separately for open and closed seasons. Data filters described in the text. Kept rate for the period 1993-2011 was the single rate calculated using combined 2002-2011 data. Open season 2012-14 kept rate was calculated using combined open season 2012-14 data. Closed season 2012-14 kept rate was calculated using combined closed season 2012-14 data. Trips (discards) = trips reporting to the discard logbook program and were summed as defined above (i.e., 2002-2011, 2012-14 open season, 2012-14 closed season). Trips (total effort) = number of trips reporting to the coastal logbook program. Vertical line effort = hook hours fished. Calculated kept fish are reported as number of fish. No gray triggerfish were reported as kept for bait or eaten from the commercial trap fishery.

| Year | Season | Trips (discards) | Trips (total effort) | Kept for Bait Rate | Kept for Bait Rate CV | Total Effort | Calculated Kept Fish |
|---|---|---|---|---|---|---|---|
| Vertical line | | | | | | | |
| 1993 | Open | 18,612 | 11,846 | 0.000138 | 29.5 | 1,331,155 | 184 |
| 1994 | Open | 18,612 | 14,446 | 0.000138 | 29.5 | 1,680,269 | 232 |
| 1995 | Open | 18,612 | 14,468 | 0.000138 | 29.5 | 1,676,441 | 231 |
| 1996 | Open | 18,612 | 15,395 | 0.000138 | 29.5 | 1,647,052 | 227 |
| 1997 | Open | 18,612 | 17,642 | 0.000138 | 29.5 | 1,778,302 | 245 |
| 1998 | Open | 18,612 | 15,865 | 0.000138 | 29.5 | 1,280,813 | 177 |
| 1999 | Open | 18,612 | 14,462 | 0.000138 | 29.5 | 1,079,870 | 149 |
| 2000 | Open | 18,612 | 13,298 | 0.000138 | 29.5 | 1,155,724 | 160 |
| 2001 | Open | 18,612 | 13,927 | 0.000138 | 29.5 | 1,202,087 | 166 |
| 2002 | Open | 18,612 | 14,575 | 0.000138 | 29.5 | 1,156,630 | 160 |
| 2003 | Open | 18,612 | 14,062 | 0.000138 | 29.5 | 982,399 | 136 |
| 2004 | Open | 18,612 | 13,178 | 0.000138 | 29.5 | 874,447 | 121 |
| 2005 | Open | 18,612 | 11,843 | 0.000138 | 29.5 | 807,361 | 111 |
| 2006 | Open | 18,612 | 11,654 | 0.000138 | 29.5 | 880,385 | 122 |
| 2007 | Open | 18,612 | 12,801 | 0.000138 | 29.5 | 946,780 | 131 |
| 2008 | Open | 18,612 | 13,036 | 0.000138 | 29.5 | 962,163 | 133 |
| 2009 | Open | 18,612 | 14,352 | 0.000138 | 29.5 | 1,007,193 | 139 |
| 2010 | Open | 18,612 | 12,769 | 0.000138 | 29.5 | 819,205 | 113 |
| 2011 | Open | 18,612 | 13,093 | 0.000138 | 29.5 | 784,566 | 108 |
| 2012 | Open | 7,599 | 9,814 | 0.000264 | 37.8 | 576,915 | 152 |
| 2013 | Open | 7,599 | 7,273 | 0.000264 | 37.8 | 427,868 | 113 |
| 2014 | Open | 7,599 | 5,661 | 0.000264 | 37.8 | 313,762 | 83 |
| 2012 | Closed | 1,774 | 2,526 | 0.003515 | 13.2 | 124,835 | 439 |
| 2013 | Closed | 1,774 | 4,728 | 0.003515 | 13.2 | 323,090 | 1,136 |
| 2014 | Closed | 1,774 | 8,425 | 0.003515 | 13.2 | 455,476 | 1,601 |

**Table 3.8** Gear-specific relative percentage of length samples , total number of years with samples (Years), the number of years with 30 or more fish measured (Years>30 (31 Total)), the proportion of years with only one state contributing to the annual length samples (Years1state), mean total length in millimeters (meanTLmm), and mean weight in pounds (meanWt_lb).

| Gear | Length samples | Years | Years>30 (32 Total) | Years 1 state | meanTLmm | meanWt_lb |
|---|---|---|---|---|---|---|
| Lines | 95.9% | 32 | 31 | 0.22 | 386 | 2.92 |
| Pots | 1.9% | 17 | 11 | 0.47 | 323 | 1.72 |
| Diving | 1.0% | 17 | 7 | 0.71 | 390 | 3.00 |
| Longline | 0.4% | 12 | 2 | 0.75 | 433 | 4.11 |
| Trawl | 0.3% | 2 | 2 | 1.00 | 362 | 2.41 |
| other | 0.6% | 19 | 1 | 0.74 | 355 | 2.27 |

**Table 3.9** Number of gray triggerfish sampled for lengths by gear (handline, other) and state from the U.S. South Atlantic TIP database, 1983-2014.

| | Handline | | | | Other | | | |
|---|---|---|---|---|---|---|---|---|
| Year | NC | SC | GA | FL | NC | SC | GA | FL |
| 1983 | 13 | | | | | | | |
| 1984 | 282 | | | | 2 | 2 | | |
| 1985 | 533 | | | 117 | 13 | | 6 | |
| 1986 | 201 | | 2 | 6 | | | | |
| 1987 | 409 | | | | 3 | | | |
| 1988 | 212 | | | | 30 | 32 | | |
| 1989 | 339 | | | | | | | |
| 1990 | 650 | | | | 10 | | | |
| 1991 | 572 | | | | 89 | | | 20 |
| 1992 | 424 | | | 63 | 17 | | | 1 |
| 1993 | 825 | | | 282 | 33 | | | 10 |
| 1994 | 1311 | | | 169 | 31 | | | 12 |
| 1995 | 2172 | | 287 | 672 | | | | 8 |
| 1996 | 969 | | 152 | 668 | | | | 12 |
| 1997 | 355 | | 290 | 261 | | | | 15 |
| 1998 | 886 | | 13 | 439 | | | | 51 |
| 1999 | 1108 | | 263 | 451 | 9 | | | 61 |
| 2000 | 1690 | | 309 | 566 | 1 | | | 40 |
| 2001 | 1465 | 1 | 271 | 283 | | | | 35 |
| 2002 | 828 | | 400 | 201 | 128 | | | 6 |
| 2003 | 1448 | | 463 | 319 | 91 | | | 75 |
| 2004 | 2633 | | 763 | 82 | 29 | | | |
| 2005 | 2261 | 62 | 310 | 45 | 117 | | | |
| 2006 | 1926 | 458 | | 322 | | 9 | | 10 |
| 2007 | 1122 | 630 | | 378 | 68 | 3 | | 22 |
| 2008 | 1120 | 408 | | 55 | 61 | 15 | | 3 |
| 2009 | 962 | 673 | | 196 | 73 | 85 | | 10 |
| 2010 | 1109 | 369 | | 969 | 57 | | | 61 |
| 2011 | 1226 | 263 | | 1673 | 32 | 4 | | 23 |
| 2012 | 924 | 115 | | 953 | 19 | | | 76 |
| 2013 | 676 | 132 | 55 | 731 | 5 | 3 | | 96 |
| 2014 | 374 | | | 32 | 25 | | | 26 |

**Table 3.10** Number of trips sampled for gray triggerfish lengths by gear (handline, other) and state from the U.S. South Atlantic TIP database, 1983-2014.

| | Handline | | | | Other | | | |
|---|---|---|---|---|---|---|---|---|
| Year | NC | SC | GA | FL | NC | SC | GA | FL |
| 1983 | 9 | | | | 1 | 1 | | |
| 1984 | 42 | | | | 3 | | 1 | |
| 1985 | 48 | | | 13 | 1 | | | |
| 1986 | 33 | | 1 | 1 | 5 | 1 | | |
| 1987 | 46 | | | | 3 | | | |
| 1988 | 32 | | | | 8 | | | 1 |
| 1989 | 38 | | | | 2 | | | 1 |
| 1990 | 38 | | | | 2 | | | 5 |
| 1991 | 36 | | | | 2 | | | 1 |
| 1992 | 28 | | | 6 | | | | 5 |
| 1993 | 53 | | | 24 | | | | 3 |
| 1994 | 55 | | | 11 | | | | 4 |
| 1995 | 73 | | 14 | 49 | | | | 5 |
| 1996 | 37 | | 10 | 31 | 1 | | | 9 |
| 1997 | 14 | | 8 | 29 | 1 | | | 5 |
| 1998 | 34 | | 2 | 29 | | | | 9 |
| 1999 | 51 | | 12 | 32 | 61 | | | 4 |
| 2000 | 88 | | 10 | 56 | 48 | | | 10 |
| 2001 | 70 | 1 | 13 | 53 | 1 | | | |
| 2002 | 60 | | 11 | 22 | 3 | | | |
| 2003 | 45 | | 11 | 22 | | 4 | | 4 |
| 2004 | 112 | | 17 | 19 | 9 | 1 | | 4 |
| 2005 | 109 | 9 | 5 | 13 | 17 | 5 | | 1 |
| 2006 | 124 | 64 | | 32 | 17 | 6 | | 4 |
| 2007 | 160 | 87 | | 38 | 14 | | | 9 |
| 2008 | 192 | 68 | | 9 | 6 | 1 | | 5 |
| 2009 | 157 | 67 | | 18 | 5 | | | 4 |
| 2010 | 178 | 52 | | 39 | 1 | 1 | | 13 |
| 2011 | 171 | 53 | | 73 | 5 | | | 8 |
| 2012 | 133 | 22 | | 47 | 19 | | | 76 |
| 2013 | 76 | 32 | 1 | 39 | 5 | 3 | | 96 |
| 2014 | 45 | | | 6 | 25 | | | 26 |

**Table 3.11** Number of fish sampled for gray triggerfish ages by gear (handline, other) and state from the U.S. South Atlantic commercial fishery.

| | Handline | | | Other | | |
|---|---|---|---|---|---|---|
| Year | NC | SC | FL | NC | SC | FL |
| 2002 | | | 8 | | | |
| 2004 | 188 | | 3 | | | |
| 2005 | 386 | | | | | |
| 2006 | 327 | 136 | | | 4 | |
| 2007 | 478 | 203 | | 15 | | |
| 2008 | 653 | 83 | | 23 | 5 | |
| 2009 | 616 | 70 | | 32 | 22 | |
| 2010 | 668 | 297 | | 27 | | |
| 2011 | 1022 | 215 | | 29 | 5 | |
| 2012 | 744 | 12 | | 4 | | |
| 2013 | 466 | 97 | 2 | 4 | | |
| 2014 | 354 | 35 | 42 | 25 | | 7 |

**Table 3.12** Number of trips sampled for gray triggerfish ages by gear (handline, other including diving) and state from the U.S. South Atlantic commercial fishery.

| | Handline | | | Other | | |
|---|---|---|---|---|---|---|
| Year | NC | SC | FL | NC | SC | FL |
| 2002 | | | 2 | | | |
| 2004 | 25 | | 1 | | | |
| 2005 | 47 | | | | | |
| 2006 | 53 | 33 | | | 2 | |
| 2007 | 138 | 58 | | 4 | | |
| 2008 | 173 | 32 | | 10 | 2 | |
| 2009 | 155 | 25 | | 10 | 5 | |
| 2010 | 164 | 51 | | 11 | | |
| 2011 | 164 | 47 | | 6 | 2 | |
| 2012 | 108 | 2 | | 1 | | |
| 2013 | 70 | 27 | 2 | 1 | | |
| 2014 | 50 | 13 | 6 | 5 | | 2 |

## 3.11 Figures

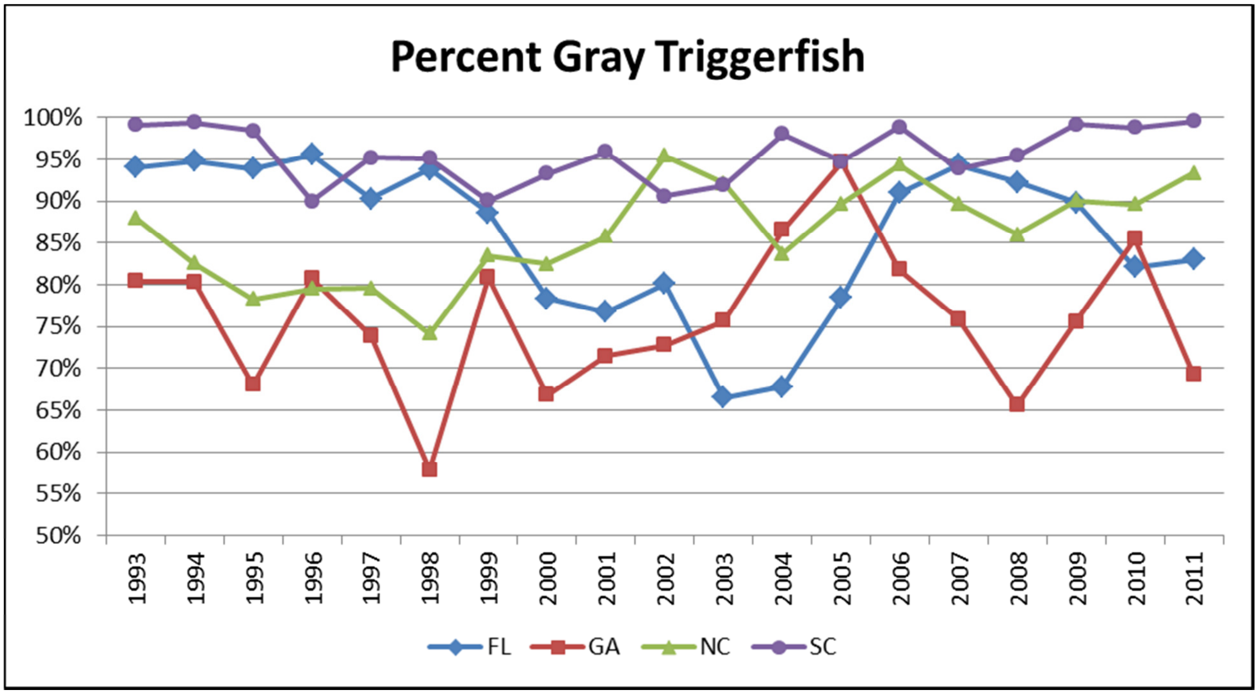


**Figure 3.1** Percentage gray triggerfish of total triggerfish landings (gray, queen, and ocean) as reported to the CFLP.

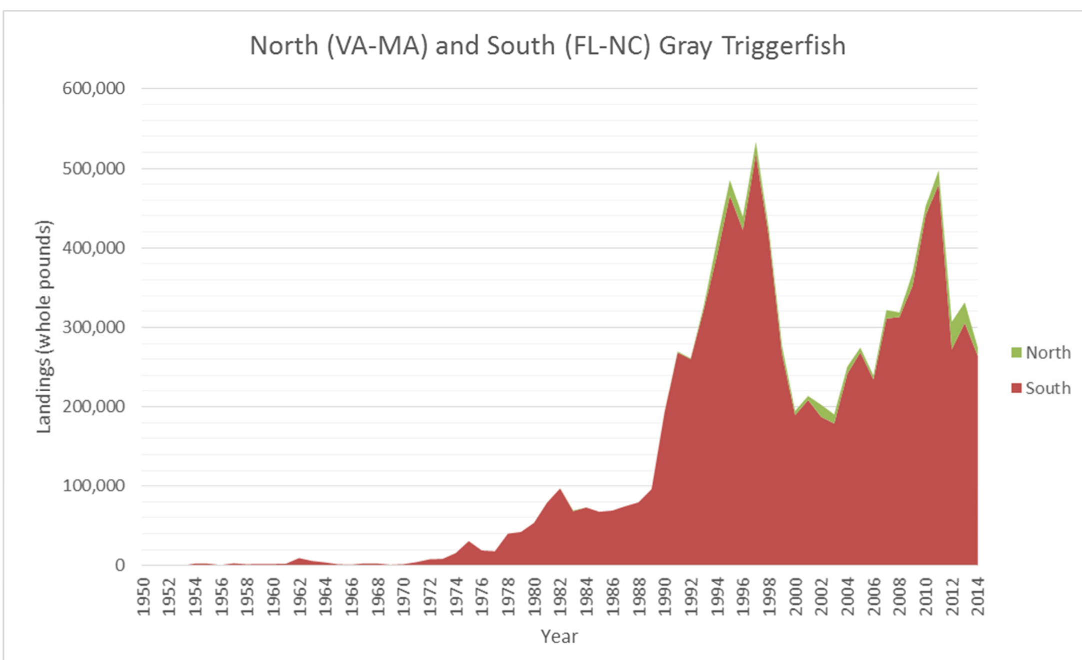


**Figure 3.2** Comparison of total triggerfish landings between the South (FL to NC) and the North (VA to ME). Weights shown here are pre-apportioned weights and possess landings of all triggerfish species.

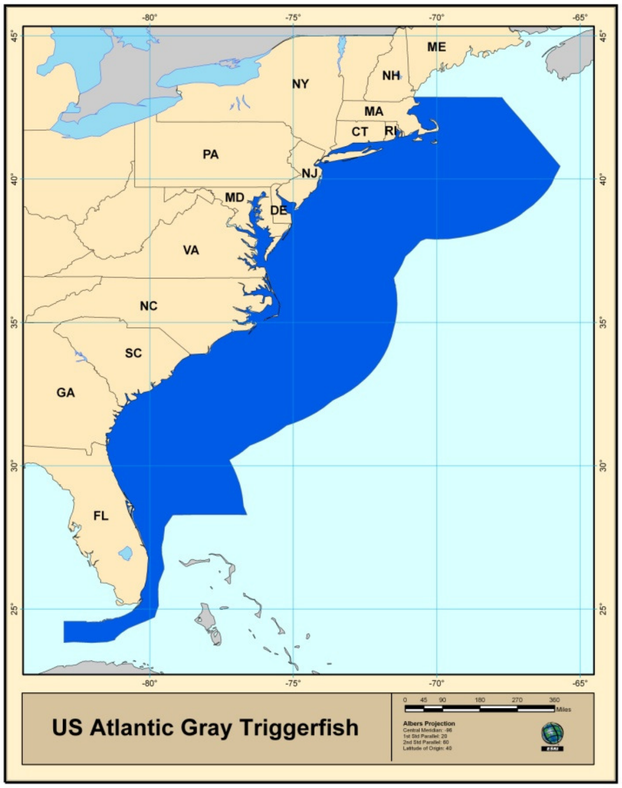


**Figure 3.3** Region of gray triggerfish landings.

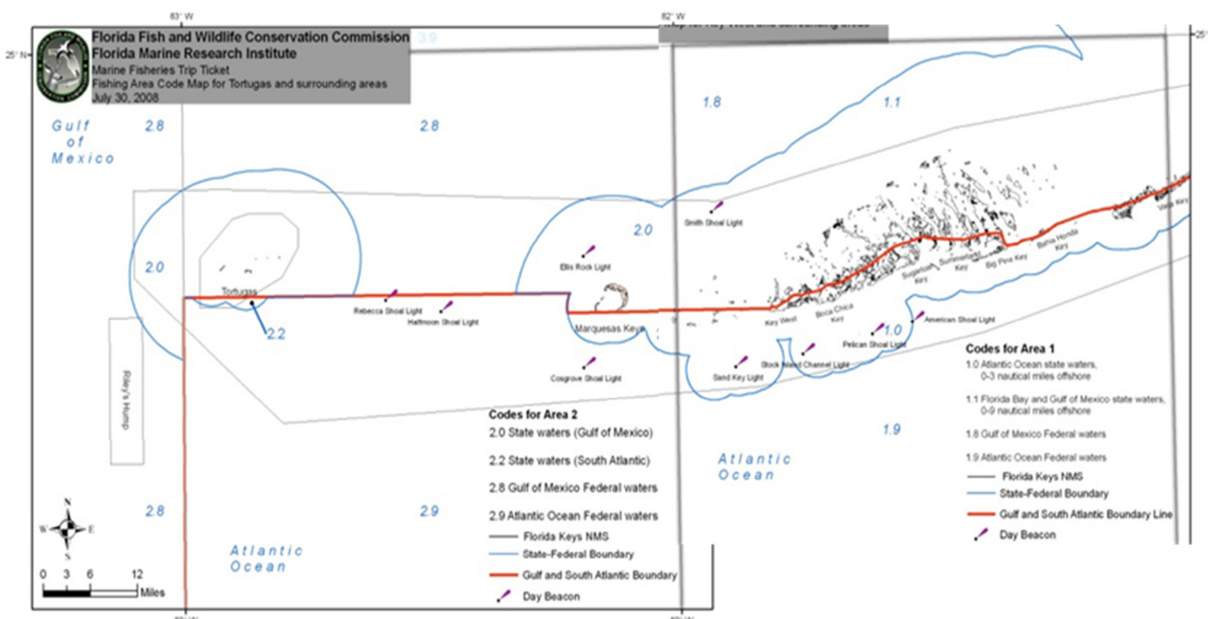


**Figure 3.4** Close-up of the southern boundary as defined by the Gulf of Mexico/South Atlantic Council boundary.

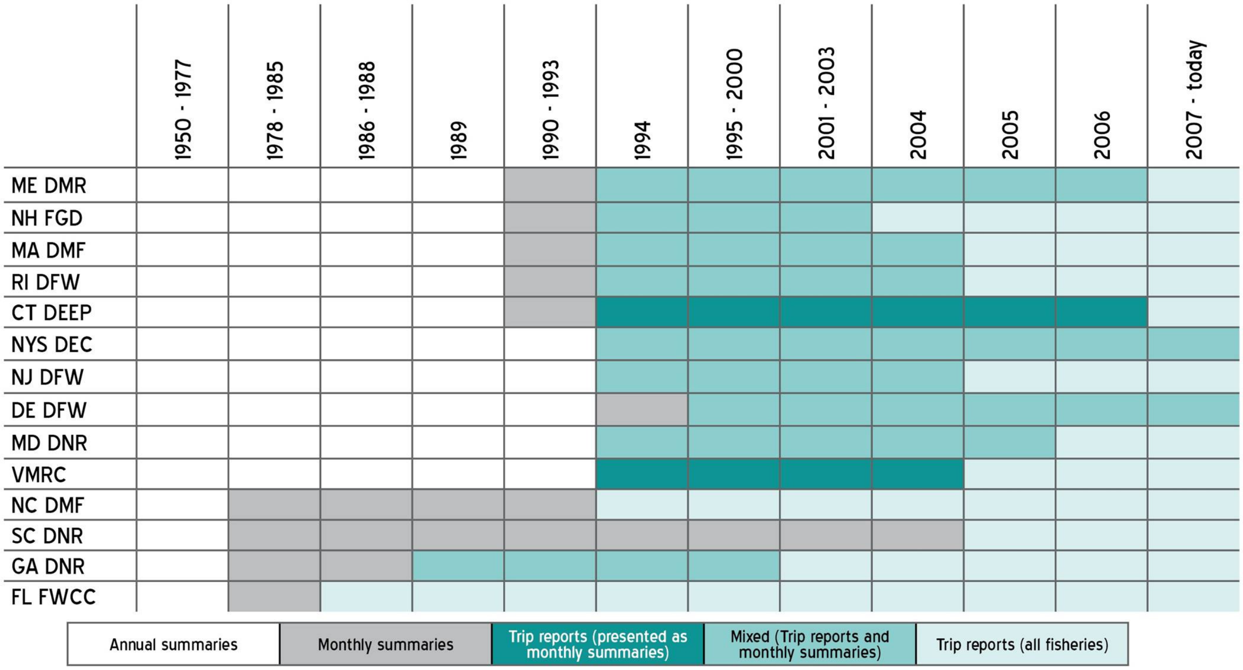


**Figure 3.5** Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse – data sources and collection methods by state. Early summaries provided by NMFS.

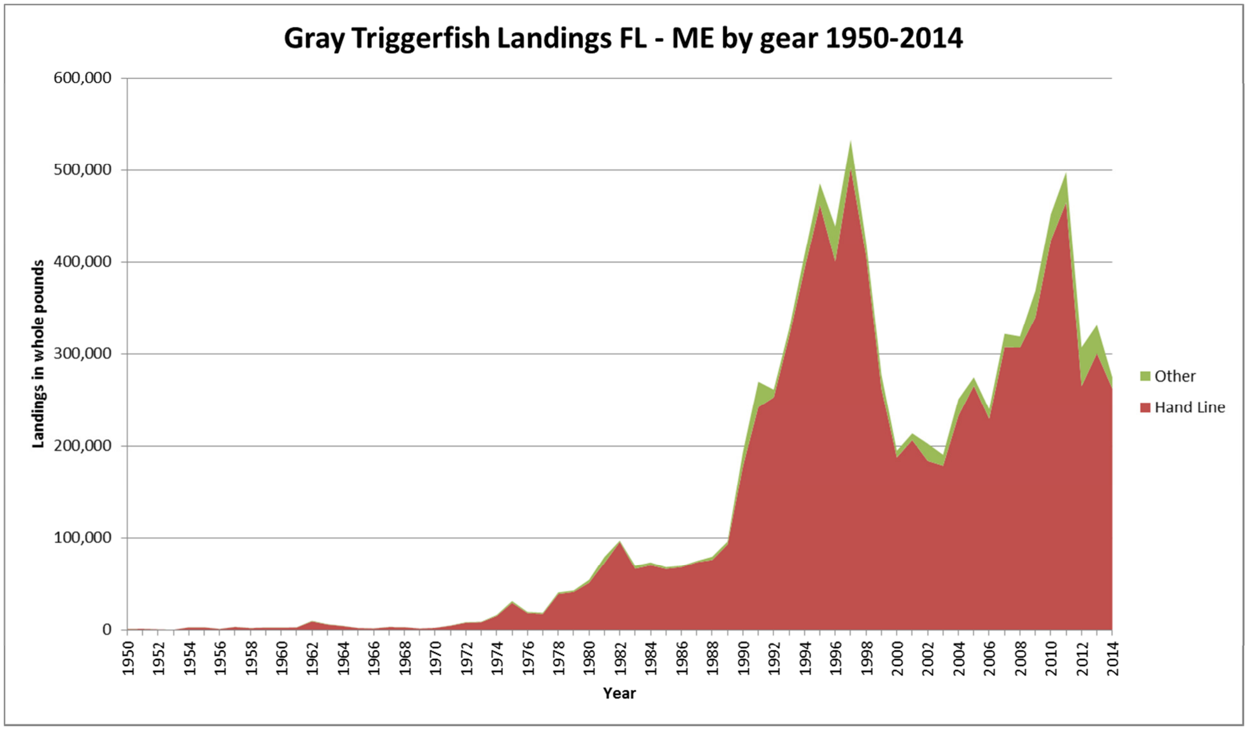


**Figure 3.6** Gray triggerfish landings, in whole weight pounds, by gear.

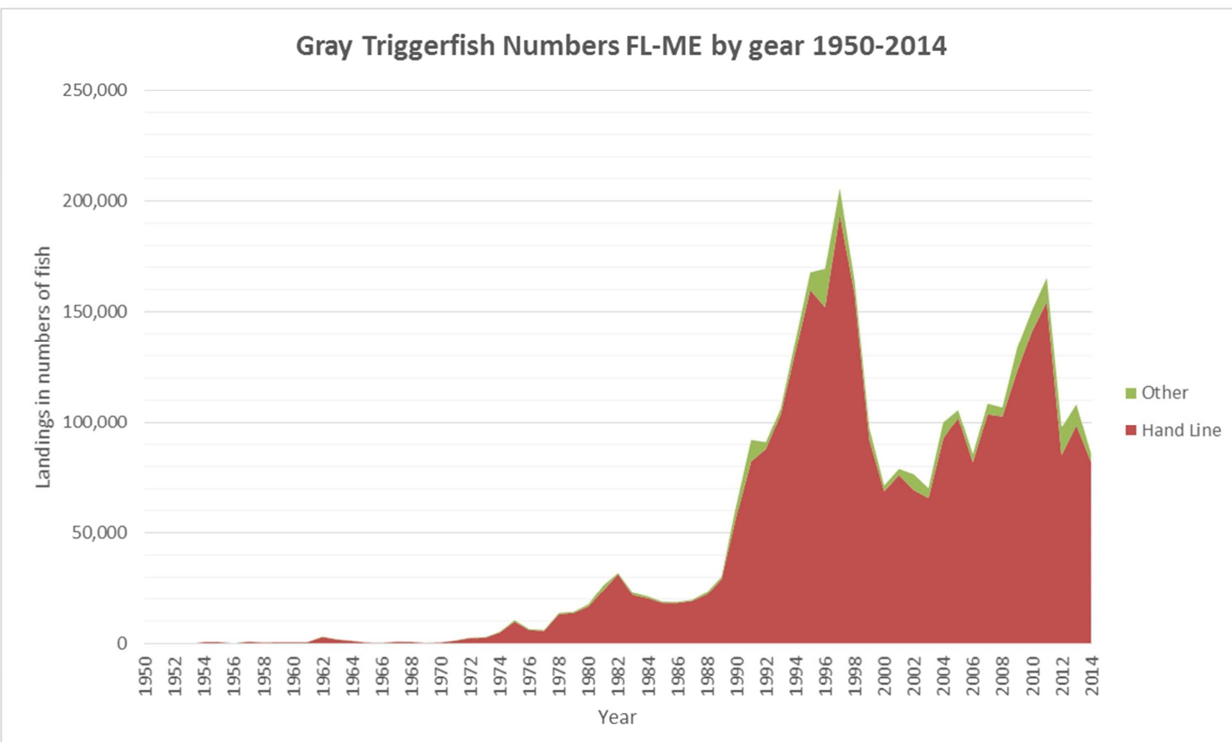


**Figure 3.7** Gray triggerfish landings, in numbers of fish, by gear.

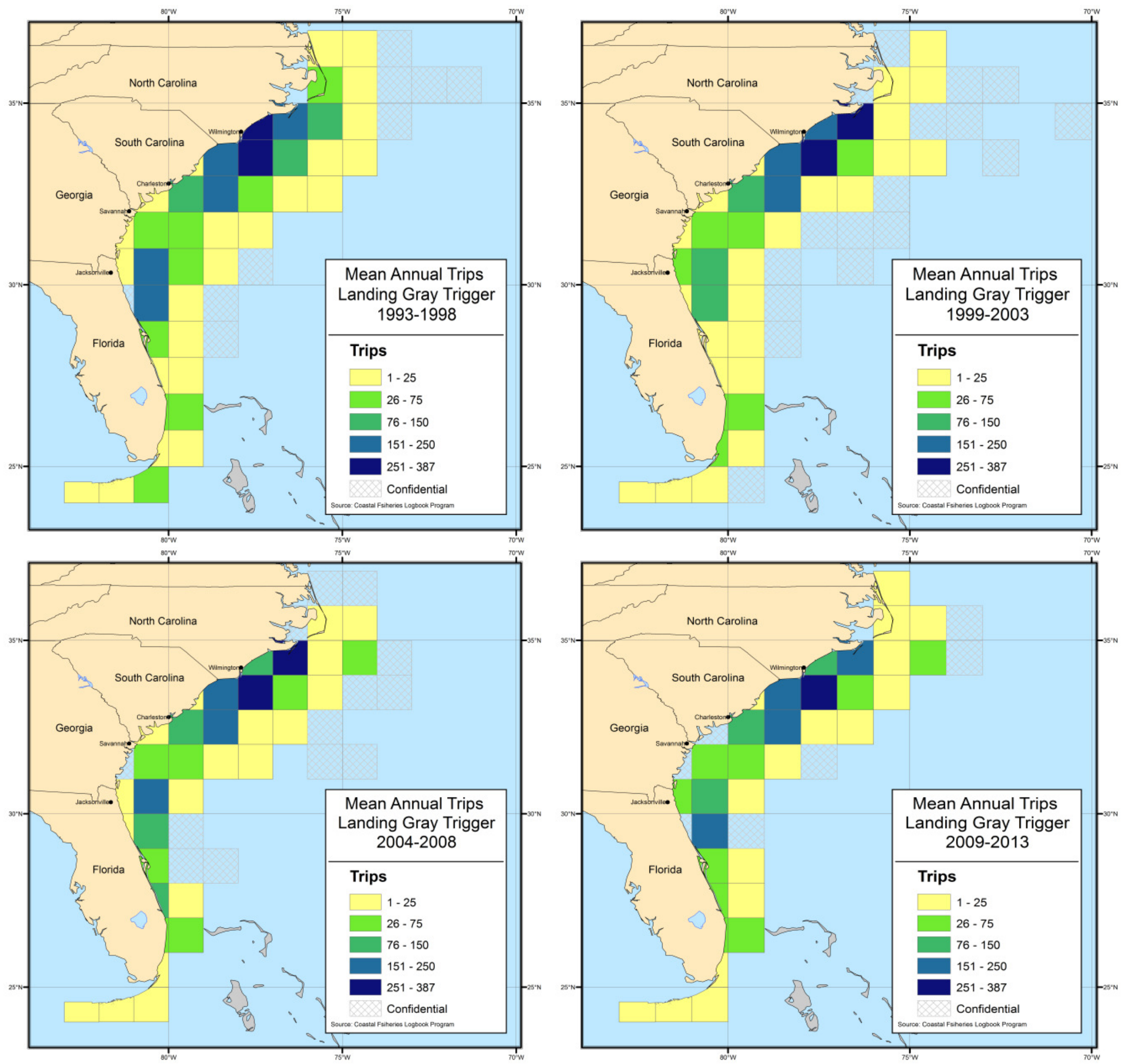


**Figure 3.8** Average number of trips landing gray triggerfish, by statistical grid, in the U.S. South Atlantic as reported to the CFLP.

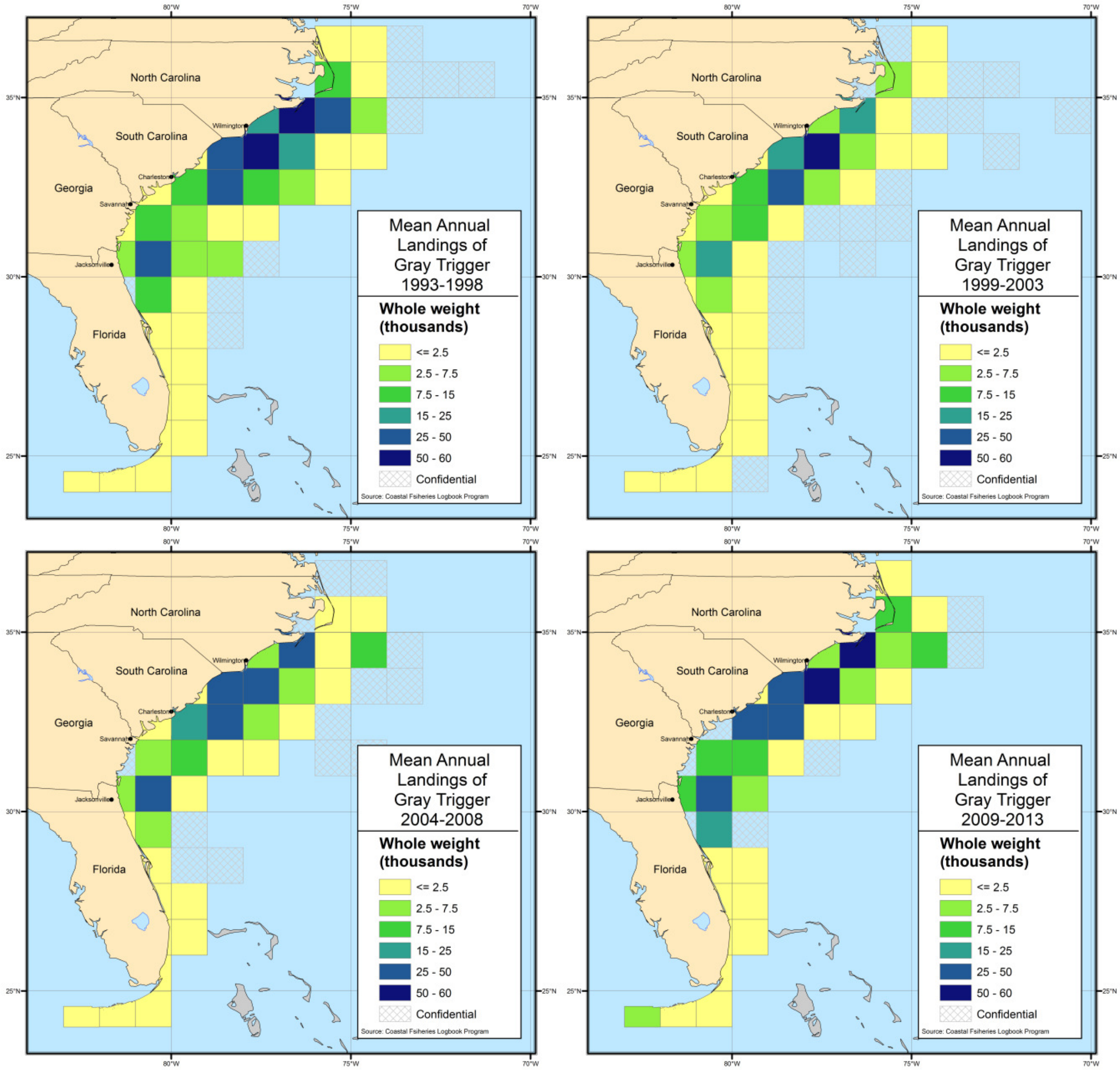


**Figure 3.9** Average annual harvest of gray triggerfish, by statistical grid, in the U.S. South Atlantic as reported to the CFLP.

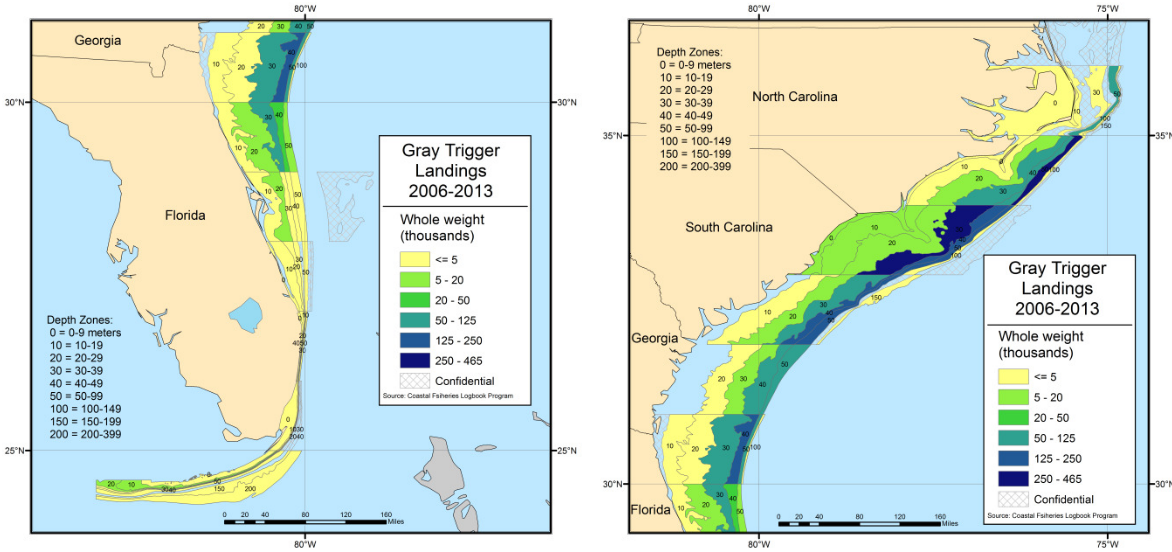


**Figure 3.10** Total harvest of gray triggerfish by depth and degrees latitude in the U.S. South Atlantic as reported to the CFLP.

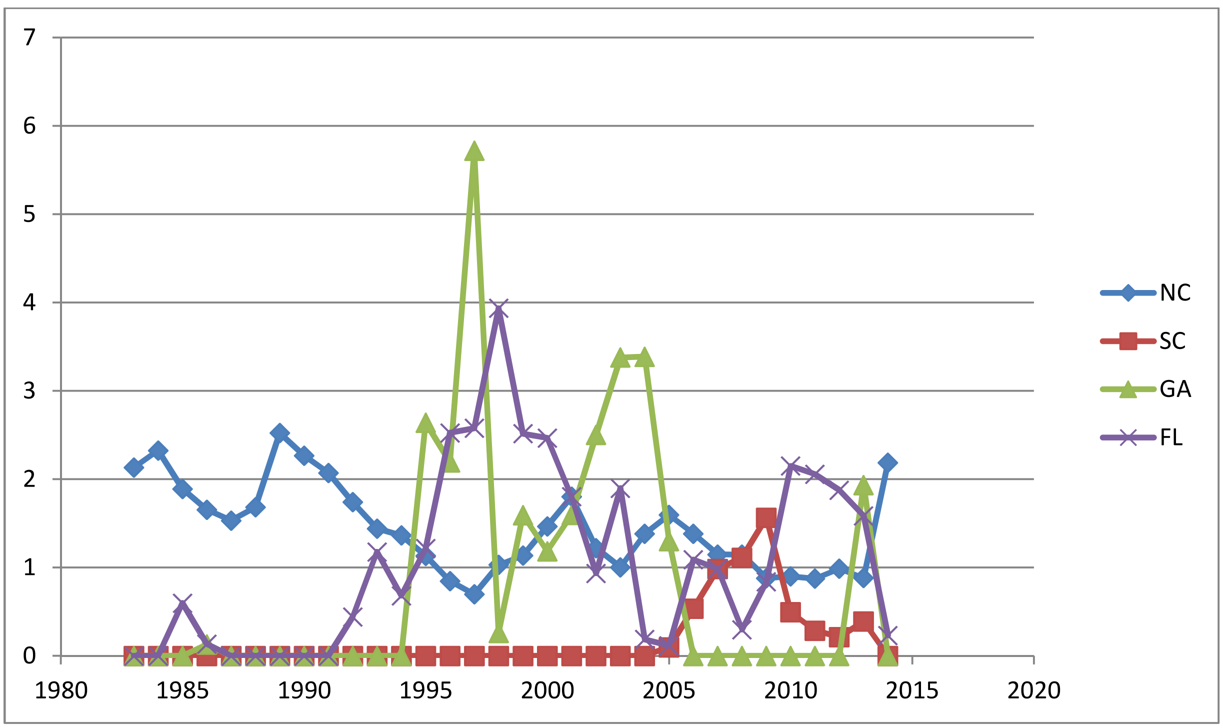


**Figure 3.11** Relative comparison of sampled fish to landings in pounds (e.g. if all fish measured are from one state that has 25% of the landings the value would be 4; if 25% of fish sampled are from one state and 25% of the landings are from that state, the value would be 1).

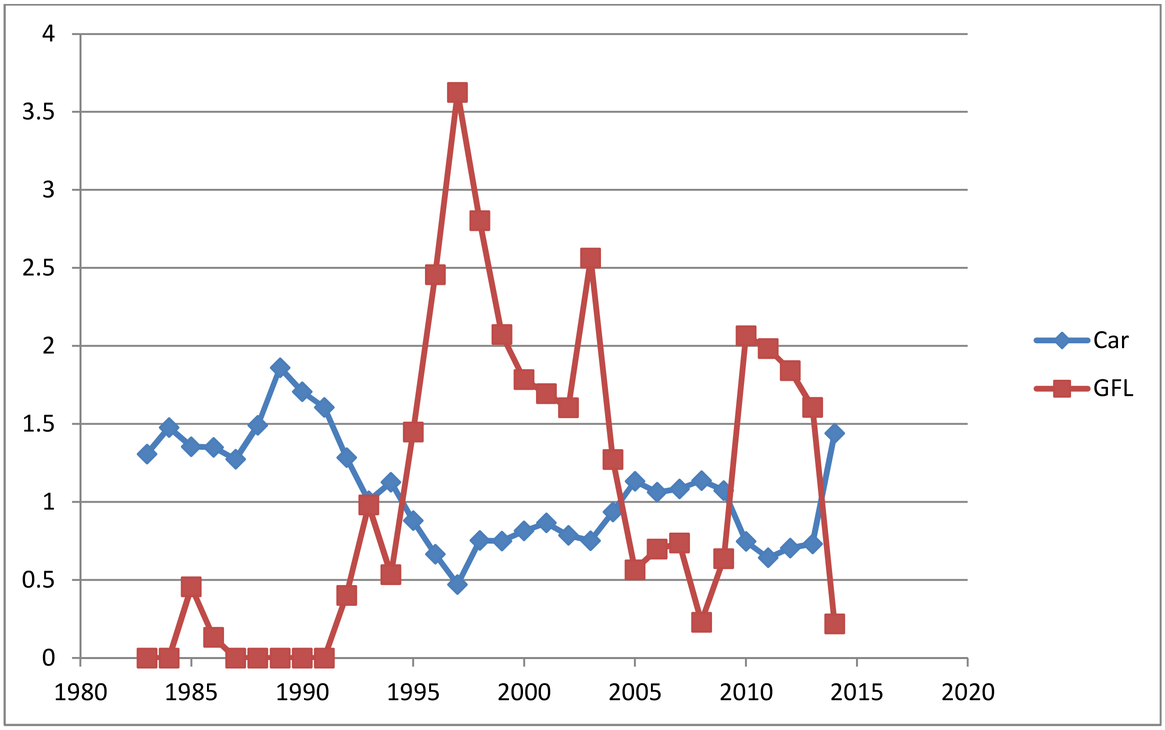


**Figure 3.12** Relative comparison of sampled fish to landings in pounds by region (a value of 1 means the fish were sampled proportional to landings).

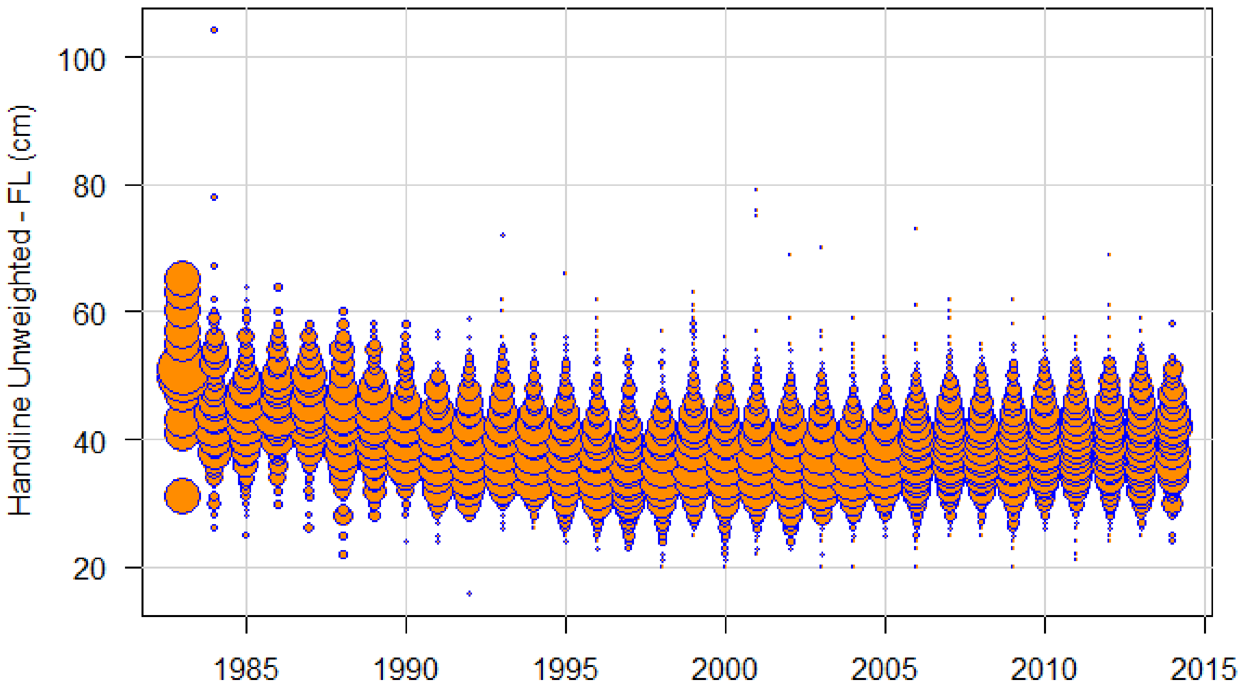


**Figure 3.13** Gray triggerfish nominal handline length compositions (area of bubble relative to annual proportion at length in 1 cm bins).

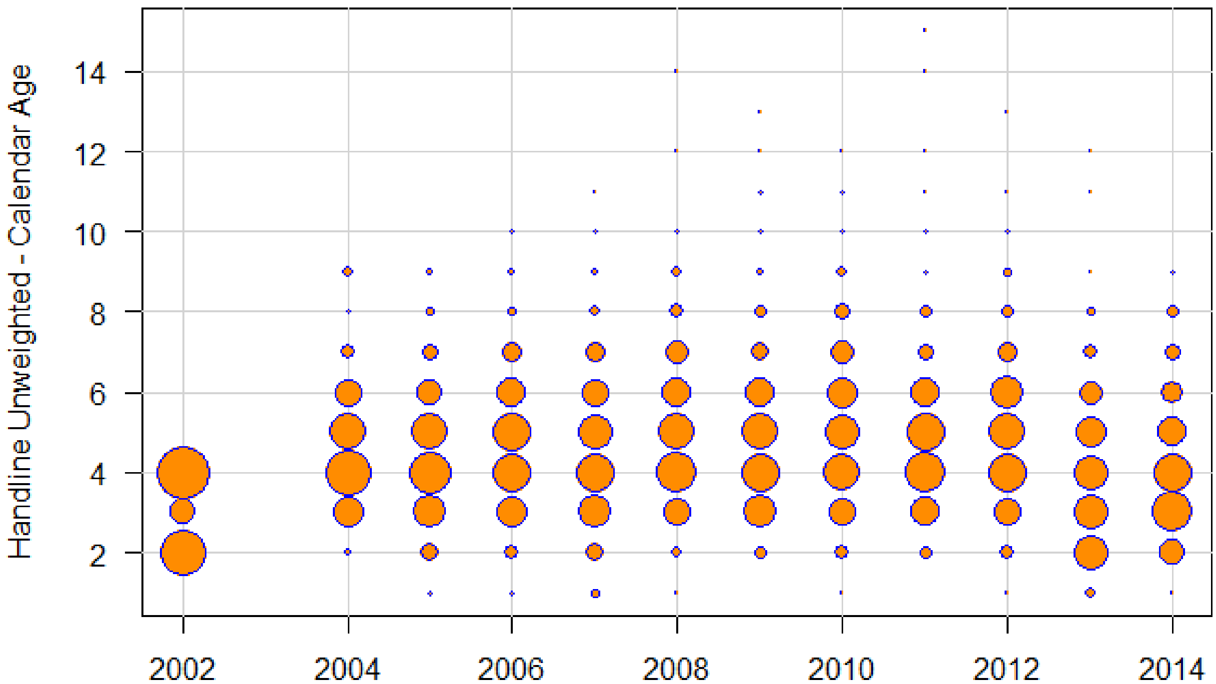


**Figure 3.14** Gray triggerfish nominal age composition to a maximum calendar age of 15 years (area of bubble relative to annual proportion at calendar age).

# Appendix A

**NMFS SECPR Accumulated Landings System (ALS)**

Information on the quantity and value of seafood products caught by fishermen in the U.S. has been collected starting in the late 1800s (inaugural year is species dependent). Fairly serious collection activity began in the 1920s. The data set maintained by the Southeast Fisheries Science Center (SEFSC) in the SECPR database management system is a continuous dataset that begins in 1962.

In addition to the quantity and value, information on the gear used to catch the fish, the area where the fishing occurred and the distance from shore are also recorded. Because the quantity and value data are collected from seafood dealers, the information on gear and fishing location are estimated and added to the data by data collection specialists. In some states, this ancillary data are not available.

Commercial landings statistics have been collected and processed by various organizations during the 1962-to-present period that the SECPR data set covers. During the 16 years from 1962 through 1978, these data were collected by port agents employed by the Federal government and stationed at major fishing ports in the southeast. The program was run from the Headquarters Office of the Bureau of Commercial Fisheries in Washington DC until 1970. After 1970 it was run by the newly created National Marine Fisheries Service, which had replaced the Bureau of Commercial Fisheries. Data collection procedures were established by Headquarters and the data were submitted to Washington for processing and computer storage. In 1978, the responsibility for collection and processing were transferred to the SEFSC.

In the early 1980s, the NMFS and the state fishery agencies within the Southeast began to develop a cooperative program for the collection and processing of commercial fisheries statistics. With the exception of two counties, one in Mississippi and one in Alabama, all of the general canvass statistics are collected by the fishery agency in the respective state and provided to the SEFSC under a comprehensive Cooperative Statistics Program (CSP).

The purpose of this documentation is to describe the current collection and processing procedures that are employed for the commercial fisheries statistics maintained in the SECPR database.

1960 - Late 1980s
=================

Although the data processing and database management responsibility were transferred from the Headquarters in Washington DC to the SEFSC during this period, the data collection procedures remained essentially the same. Trained data collection personnel, referred to as fishery reporting specialists or port agents, were stationed at major fishing ports throughout the Southeast Region. The data collection procedures for commercial landings included two parts.

The primary task for the port agents was to visit all seafood dealers or fish houses within their assigned areas at least once a month to record the pounds and value for each species or product type that were purchased or handled by the dealer or fish house. The agents summed the landings and value data and submitted these data in monthly reports to their area supervisors. All of the monthly data were submitted in essentially the same form.

The second task was to estimate the quantity of fish that were caught by specific types of gear and the location of the fishing activity. Port agents provided this gear/area information for all of the landings data that they collected. The objective was to have gear and area information assigned to all monthly commercial landings data.

There are two problems with the commercial fishery statistics that were collected from seafood dealers. First, dealers do not always record the specific species that are caught and second, fish or shellfish are not always purchased at the same location where they are unloaded, i.e., landed. Dealers have always recorded fishery products in ways that meet their needs, which sometimes make it ambiguous for scientific uses. Although the port agents can readily identify individual species, they usually were not at the fish house when fish were being unloaded and thus, could not observe and identify the fish.

The second problem is to identify where the fish were landed from the information recorded by the dealers on their sales receipts. The NMFS standard for fisheries statistics is to associate commercial statistics with the location where the product was first unloaded, i.e., landed, at a shore-based facility. Because some products are unloaded at a dock or fish house and purchased and transported to another dealer, the actual 'landing' location may not be apparent from the dealers' sales receipts. Historically, communications between individual port agents and the area supervisors were the primary source of information that was available to identify the actual unloading location.

Cooperative Statistics Program
==============================
In the early 1980s, it became apparent that the collection of commercial fisheries statistics was an activity that was conducted by both the Federal government and individual state fishery agencies. Plans and negotiations were initiated to develop a program that would provide the fisheries statistics that are needed for management by both Federal and state agencies. By the mid-1980s, formal cooperative agreements had been signed between the NMFS/SEFSC and each of the eight coastal states in the southeast, Puerto Rico and the US Virgin Islands.

Initially, the data collection procedures that were used by the states under the cooperative agreements were essentially the same as the historical NMFS procedures. As the states developed their data collection programs, many of them promulgated legislation that authorized their fishery agencies to collect fishery statistics. Many of the state statutes include mandatory data submission by seafood dealers.

Because the data collection procedures (regulations) are different for each state, the type and detail of data varies throughout the Region. The commercial landings database maintained in SECPR contains a standard set of data that is consistent for all states in the Region.

A description of the data collection procedures and associated data submission requirements for each state follows.

Florida
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Prior to 1986, commercial landings statistics were collected by a combination of monthly mail submissions and port agent visits. These procedures provided quantity and value, but did not provide information on gear, area or distance from shore. Because of the large number of dealers, port agents were not able to provide the gear, area and distance information for monthly data. This information, however, is provided for annual summaries of the quantity and value and known as the Florida Annual Canvas data (see below).

Beginning in 1986, mandatory reporting by all seafood dealers was implemented by the State of Florida. The State requires that a report (ticket) be completed and submitted to the State for every trip. Dealers have to report the type of gear as well as the quantity (pounds) purchased for each species. Information on the area of catch can also be provided on the tickets for individual trips. As of 1986 the ALS system relies solely on the Florida trip ticket data to create the ALS landings data for all species other than shrimp.

Georgia
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Prior to 1977, the National Marine Fisheries Service collected commercial landings data Georgia. From 1977 to 2001 state port agents visited dealers and docks to collect the information on a regular basis. Compliance was mandatory for the fishing industry. To collect more timely and accurate data, Georgia initiated a trip ticket program in 1999, but the program was not fully implemented to allow complete coverage until 2001. All sales of seafood products landed in Georgia must be recorded on a trip ticket at the time of the sale. Both the seafood dealer and the seafood harvester are responsible for insuring the ticket is completed in full.

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

South Carolina began collecting TIP length frequencies in 1983 as part of the Cooperative Statistics Program. Target species and length quotas were supplied by NMFS and sampling targets were established for monthly commercial trips by gear sampling was set to collect those species with associated length frequencies. In 2005, SCDNR began collecting age structures (otoliths and spines) in addition to length frequencies, using ACCSP funding to supplement CSP funding. Typically for every four fish measured a single age structure was collected. This sampling periodicity was changed in 2010 to collect both a length and age structure from every fish intercepted as a recommendation from the SEFSC.

North Carolina
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The National Marine Fisheries Service prior to 1978 collected commercial landings data for North Carolina. Port agents would conduct monthly surveys of the state's major commercial seafood dealers to determine the commercial landings for the state. Starting in 1978, the North Carolina Division of Marine Fisheries entered into a cooperative program with the National Marine Fisheries Service to maintain the monthly surveys of North Carolina's major commercial seafood dealers and to obtain data from more dealers.

The North Carolina Division of Marine Fisheries Trip Ticket Program (NCTTP) began on 1 January 1994. The NCTTP was initiated due to a decrease in cooperation in reporting under the voluntary NMFS/North Carolina Cooperative Statistics Program in place prior to 1994, as well as an increase in demand for complete and accurate trip-level commercial harvest statistics by fisheries managers. The detailed data obtained through the NCTTP allows for the calculation of effort (i.e. trips, licenses, participants, vessels) in a given fishery that was not available prior to 1994 and provides a much more detailed record of North Carolina's seafood harvest.

**NMFS SECPR Annual Canvas Data for Florida**

The Florida Annual Data files from 1976–1996 represent annual landings by county (from dealer reports) which are broken out on a percentage estimate by species, gear, area of capture, and distance from shore. These estimates are submitted by Port agents, which were assigned responsibility for the particular county, from interviews and discussions from dealers and fishermen collected throughout the year. The estimates are processed against the annual landings totals by county on a percentage basis to create the estimated proportions of catch by the gear, area and distance from shore. The sum of percentages for a given Year, State, County, Species combination will equal 100.

Area of capture considerations: ALS is considered to be a commercial landings database which reports where the marine resource was landed. With the advent of some State trip ticket programs as the data source the definition is more loosely applied. As such one cannot assume reports from the ALS by State or county will accurately inform you of Gulf vs. South Atlantic vs. Foreign catch. To make that determination you must consider the area of capture.

# 4. Recreational Fishery Statistics

## 4.1 Overview

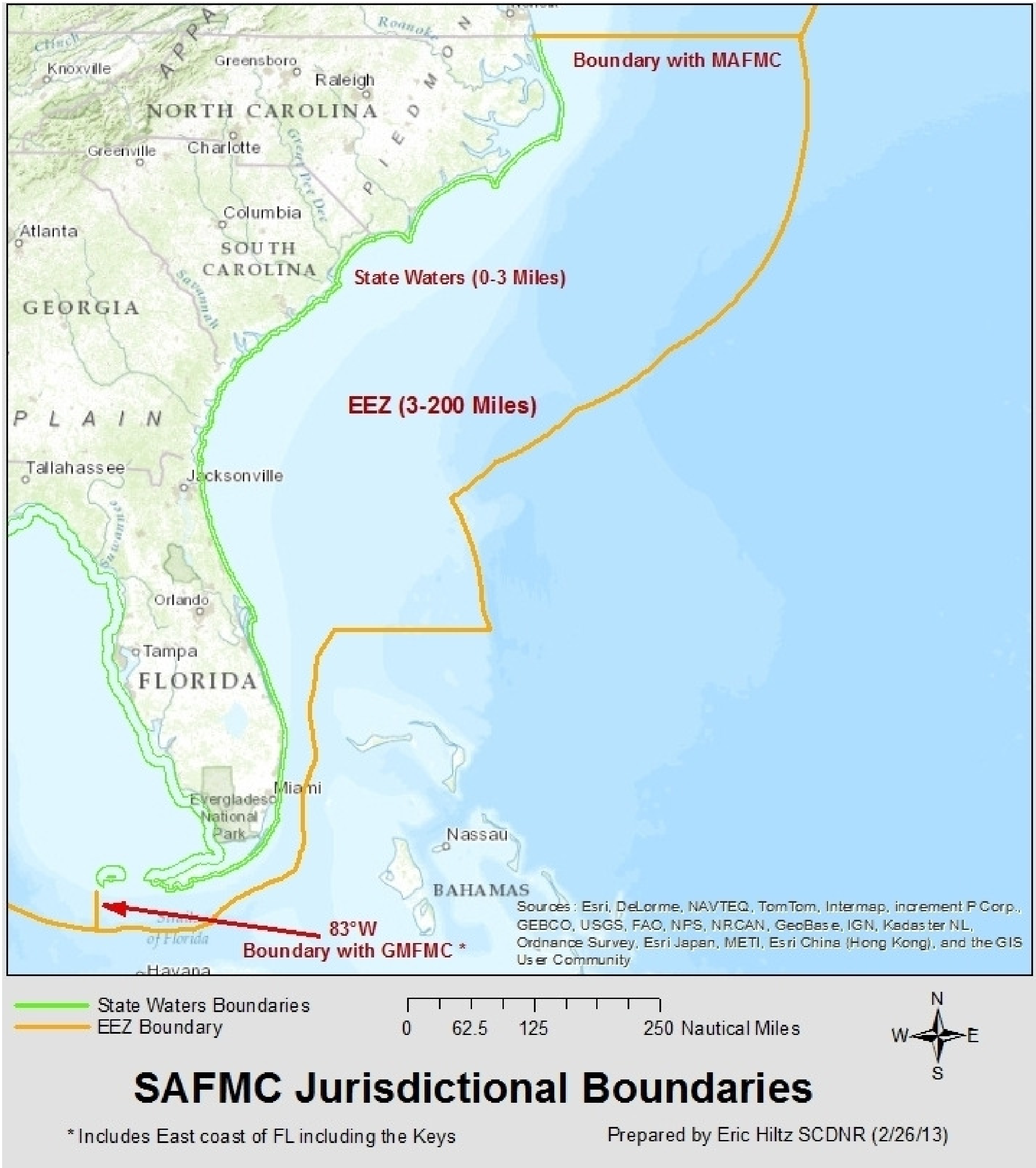
### 4.1.1 Recreational Working Group (RWG) Membership

Members- Ken Brennan (Leader, NMFS Beaufort, NC), Mark Brown (SAFMC Appointee/Industry rep SC), Kelly Fitzpatrick (NMFS Beaufort, NC), Dawn Franco (GADNR), Eric Hiltz (SCDNR), Rusty Hudson (SAFMC Appointee\ Industry rep FL) Robert Johnson (SAFMC Appointee\ Industry rep FL), Mike Larkin (NMFS SEFSC), Vivian Matter (NMFS SEFSC), Beverly Sauls (FWC, FL), Bill Shearin (SAFMC Appointee\ Industry rep GA), Erik Williams (NMFS Beaufort, NC) and Chris Wilson (NCDNR).

### 4.1.2 Issues

1) Allocation of Monroe county catches to the Atlantic or the Gulf of Mexico: may vary by data source depending on differing spatial resolutions of the datasets.
2) Headboat logbook forms did not include gray triggerfish on a universal form until 1984.
3) Headboat estimated landings start in 1974 for NC and SC, 1977 in GA\NEFL and 1981 in SEFL. Estimating gray triggerfish headboat landings from 1974 to1980 (date dependent on region) for periods of partial geographic coverage in the SRHS.
4) Headboat discards. Data are available from the SRHS since 2004. Review whether they are reliable for use, and determine if there are other sources of data prior to 2004 that could be used as a proxy to estimate headboat discards.
5) Calibration of Marine Recreational Fisheries Statistics Survey (MRFSS) to Marine Recreational Information Program (MRIP) 1981-2003.
6) Charter boat landings: MRFSS charter survey methods changed in 2003 in East Florida and in 2004 for Georgia and north.
7) Combined charter boat/headboat landings, 1981-1985: Official headboat landings are available from the SRHS. Therefore, the headboat component of the MRFSS combined charter boat/headboat mode must be parsed out.
8) Usefulness of historical data sources to generate estimates of landings prior to 1981.
9) Determine percentage of unidentified triggerfish catch estimates in the MRFSS/MRIP data that are gray triggerfish.
10) MRIP APAIS adjustment: change in survey protocols starting in 2013.

### 4.1.3 South Atlantic Fishery Management Council Jurisdictional Boundaries



## 4.2 Review of Working Papers

**SEDAR41-DW24,** *Atlantic Red Snapper (Lutjanus campechanus) and Gray Triggerfish (Balistes capriscus) Historical Fishing Pictures Summary Hudson, R 2014.*
Southeastern Fisheries Association- East Coast Fisheries Section provides the SEDAR 41 data workshop (DW) a cache of historical deep sea for-hire fishing pictures accurately dated during the 1950's to the 1970's. This collection is from the Ponce de Leon Inlet and Greater Daytona Beach region in Volusia County, Florida. The historical professional photographs are significant as they demonstrate, visually, the for-hire recreational landings of Atlantic Red snapper and Gray triggerfish by day, month and year for this region.

**SEDAR41-DW25,** *Atlantic Red Snapper (Lutjanus campechanus) and Gray Triggerfish (Balistes capriscus) Index of For-Hire Vessels from the SAFMC region Hudson, R 2014.*
Southeastern Fisheries Association- East Coast Fisheries Section provides the SEDAR 41 data workshop (DW) an index of for-hire vessels from the South Atlantic Fishery Management Council (SAFMC) region that mostly participated in the fisheries for Atlantic Red snapper and Gray triggerfish.

**SEDAR41-DW26,** *Atlantic Red Snapper (Lutjanus campechanus) and Gray Triggerfish (Balistes capriscus) Photographic and Other Evidence of For-Hire Vessels in the SAFMC region Hudson, R 2014.*
Southeastern Fisheries Association- East Coast Fisheries Section provides the SEDAR 41 data workshop (DW) photographic and other evidence of for-hire vessels from the South Atlantic Fishery Management Council (SAFMC) region that mostly participated in the fisheries for Atlantic Red snapper and Gray Triggerfish.

**SEDAR41-DW30,** *Discards of gray triggerfish (Balistes capriscus) for the headboat fishery in the US South Atlantic, Fitzpatrick, K 2014 .*
The Southeast Region Headboat Survey (SRHS) was modified in 2004 to collect self-reported discards for each reported trip. These self-reported data are currently not validated within the SRHS. The SRHS discard rates were compared to the MRFSS/MRIP At-Sea Observer program discard rates for validation purposes and to determine whether the SRHS discard estimates should be used for a full or partial time series (2004-2013). Discard estimates prior to 2004 are calculated using a proxy method. For gray triggerfish the MRFSS/MRIP CH, MRFSS/MRIP PR, and MRFSS/MRIP CH:SRHS discard ratio methods were evaluated as proxy methods for calculating discards from the headboat fishery.

**SEDAR41-DW34,** *Size Distribution, Release Condition, and Estimated Discard Mortality of Gray Triggerfish Observed in For-Hire Recreational Fisheries in the South Atlantic, Sauls, B., C. Wilson and K. Fitzpatrick 2014.*

Since 2004, trained fishery observers have been employed on randomly selected headboat fishing trips to observe angler fishing activity and collect detailed information on discarded fish. In addition, observers were employed on charter vessels on the Atlantic coast of Florida in 2013. This paper summarizes the number of sampled trips by state, generates sample weights, and plots weighted length frequencies for all observed gray triggerfish (both harvested and discarded) from headboats. Additional data collected in Florida on hook type, fishing depth, and release condition of observed discards is also synthesized.

**SEDAR41-DW43,** *Hook selectivity in gray triggerfish observed in the for-hire fishery off the Atlantic coast of Florida, Gray, A. and B. Sauls.*
Summarizes an analysis to determine how hook size and hook type might influence the size of fish caught despite regional differences in fishing techniques. Data were collected within the for-hire fishery after the circle hook requirement was implemented in northeast Florida; however, there were enough observations of gray triggerfish caught on both hook types in all regions to offer some insight into potential changes in selectivity since circle hooks were required.

## 4.3 Recreational Landings

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

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

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

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

The MRFSS/MRIP design incorporates three complementary survey methods for estimating catch and effort. Catch data are collected through angler interviews during dockside intercept surveys of recreational fishing trips after they have been completed. Effort data are collected using two telephone surveys. The Coastal Household Telephone Survey (CHTS) uses random digit dialing of coastal households to obtain detailed information about the previous two months of recreational fishing trips from the anglers. The weekly For-Hire Survey was implemented in the South Atlantic in the 2000's and interviews charterboat operators (captains or owners) to obtain the trip information with only one-week recall period. Effort estimates from the two telephone surveys are aggregated to produce total effort estimates by wave. Catch rates from dockside intercept surveys are combined with estimates of effort from telephone interviews to estimate total landings and discards by wave, mode, and area fished (inland, state, and federal waters). Catch estimates from early years of the survey are highly variable with high proportional standard errors (PSE's), and sample size in the dockside intercept portion have been increased over time to improve precision of catch estimates. Full survey documentation and ongoing efforts to review and improve survey methods are available at: http://www.st.nmfs.noaa.gov/recreational-fisheries/MRIP/program-evolution.

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

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

*Calibration of traditional MRFSS charter boat estimates*
Conversion factors have been estimated to calibrate the traditional MRFSS charterboat estimates with the FHS for 1986-2003 in the South Atlantic (SEDAR16-DW-15, 2008) and for 1981-2003 in the mid-Atlantic (SEDAR17-Data Workshop Report, 2008). 1986-2003 South Atlantic calibration factors were updated in 2011 (SEDAR25-Data Workshop Report, 2011). The relationship between the old charterboat method estimates of angler trips and the FHS estimates of angler trips was used to estimate the conversion factors. Since these factors are based on effort, they can be applied to all species' landings. In the Gulf of Mexico and the South Atlantic, the period of 1981-1985 could not be calibrated with the same ratios developed for 1986+ because in the earlier 1981-1985 time period, MRFSS considered charterboat and headboat as a single combined mode. Thus, in order to properly calibrate the estimates from 1981-1985, headboat data from the Southeast Region Head-boat Survey (SRHS) were included in the analysis. To calibrate the MRFSS combined charterboat and headboat mode effort estimates in 1981-1985, conversion factors were estimated using 1986-1990 effort estimates from both modes, in equivalent effort units, an angler trip (SEDAR28-DW-12). These calibration factors were applied to the charterboat estimates and are tabulated in Table 4.10.1.

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

*MRIP weighted estimates, APAIS changes, and the calibration of MRFSS estimates*
The Marine Recreational Information Program (MRIP) was developed to generate more accurate recreational catch rates by re-designing the MRFSS sampling protocol to address potential biases including port activity and time of day. Revised catch and effort estimates from 2004 to 2012, based on MRIP's improved estimation methodology, were released on January 25, 2012. For estimates prior to 2004, an MRIP Calibration Workshop was held in 2012, and the Consultant's Report recommended that MRFSS estimates prior to 2004 be calibrated to the new MRIP

estimation method (Boreman, 2012) using a method developed by a special MRFSS/MRIP Calibration Ad-hoc Working Group following the Calibration Workshop (Salz et al. 2012).

Starting in 2013, wave 2, the MRIP Access Point Angler Intercept Survey (APAIS) implemented a “revised sampling design that includes an updated sampling frame; eliminates interviewer latitude in selecting interviewing sites; establishes discrete sampling periods of fixed duration, including nighttime sampling; and requires interviewers to collect detailed information about the number of completed boat and angler fishing trips during the sampling period” (MRIP Implementation Plan 2011). To address this new survey design change, a second Calibration Workshop was held in 2014 and the final report from that workshop recommended an additional calibration for catch estimates (Carmichael and Van Vorhees 2015). The recommended interim calibration approach, found in Appendix 2 of the report, uses the ratio of the catch estimated in 2013 using the entire sampling period for the new MRIP APAIS design, versus catch estimated in 2013 using only during peak sampling periods in the old MRFSS survey design. Gray triggerfish catch for all years prior to 2013 was re-estimated using this ratio, based on a single year of data from the new APAIS design (2013), for each sub-region, state, and mode combination with all waves and areas combined. Tables 4.10.2 and 4.10.3 show the differences between the Atlantic gray triggerfish MRIP APAIS landing and discard estimates and the MRIP estimates for the time period 2004-2012.

As new MRIP APAIS estimates are available for a portion of the recreational time series that the MRFSS covers, conversion factors between the MRFSS estimates and the MRIP APAIS estimates were developed in order to maintain one consistent time series for the recreational catch estimates. Ratio estimators, based on the ratios of the means, were developed for Atlantic gray triggerfish to hind-cast catch and variance estimates by fishing mode. In order to apply the charter boat ratio estimator back in time to 1981, charter boat landings were isolated from the combined charter boat /headboat mode for 1981-1985. The MRFSS to MRIP APAIS calibration process is the same as the original MRFSS to MRIP adjustment that has been used since 2012, which is detailed in SEDAR31-DW25 and SEDAR32-DW02. Table 4.10.4 shows the ratio estimators used in the calibration. Figure 4.11.2 shows the MRIP versus MRIP APAIS adjusted estimates for Atlantic gray triggerfish from 1981 to 2014.

*Unidentified triggerfish estimates*
Catch estimates of unidentified triggerfish (Balistidae family) are present in the MRFSS/MRIP dataset. In SEDAR 9 (Gulf of Mexico gray triggerfish) all the unidentified Balistidae landings were considered gray triggerfish. In the Atlantic, however, ocean triggerfish and queen triggerfish make up a larger percentage of the total landings from the Balistidae family. The RWG analyzed the proportion of identified gray triggerfish to ocean triggerfish and queen triggerfish (excluding shore mode for the later species) in order to determine the proportion of the unidentified landings are actually gray triggerfish (Figure 4.11.3). Southeast Region

Headboat Survey and TIP data were also analyze for comparison. The RWG recommends using the average ratio from the MRIP dataset from 2000 to 2011 of 0.94 to allocate the unidentified triggerfish to gray triggerfish. The RWG felt that there is more confidence in the later time frame in the species identification.

*Monroe County*

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

Although Monroe county estimates can be separated using these processes, they cannot be partitioned into those from the Atlantic Ocean and those from the Gulf of Mexico. Gray triggerfish is a reef associated species and Monroe county catches are most likely from the Atlantic side of the Keys. SEDAR 9 (Gulf of Mexico gray triggerfish) included Monroe county landings; however, these landings were low and will have a limited effect if they are excluded from the Gulf stock in the future. Therefore, the recreational workgroup decided to allocate the Monroe county landings to the Atlantic in SEDAR 41.

*Calculating landings estimates in weight*

The MRFSS and the MRIP surveys use different methodologies to estimate landings in weight. To apply a consistent methodology over the entire recreational time series, the Southeast Fisheries Science Center (SEFSC) implemented a method for calculating average weights for the MRIP (and MRIP adjusted) landings. This method is detailed in SEDAR32-DW-02. The length-weight equation developed by the Life History Working Group (W=2.75E-5*(L^2.97)) was used to convert gray triggerfish sample lengths into weights, when no weight was recorded. W is whole weight in grams and L is fork length in millimeters.

*1981, wave 1*

MRFSS began in 1981, wave 2. In the east coast of Florida and Monroe County, FL, catch for 1981 wave 1 was estimated by determining the proportion of catch in wave 1 to catch in all other waves for 1982-1984 by fishing mode and area. These proportions were then used to estimate wave 1 in 1981 from the estimated catches in other waves of that year. This methodology is consistent with past SEDARs (e.g. SEDAR 28 Spanish mackerel and cobia).

*Variances*

Variances are provided by MRFSS/MRIP for their recreational catch estimates. Variances are adjusted to take into account the variance of the conversion factor when an adjustment to the estimate has been made (FHS and MRIP conversions). However, the variance estimates of the charter and headboat modes in 1981-1985 are missing. This is due to the MRIP calibration procedure, which requires the combined charter/headboat mode to be split in order to apply the MRIP adjustment to the charter mode back to 1981. In addition, variance estimates are not available for weight estimates generated through the SEFSC method described above.

MRIP landings in numbers of fish and in whole weight in pounds are presented in Table 4.10.5. CVs associated with estimated landings in numbers are also shown. Atlantic gray triggerfish estimates include all Atlantic coast states from Monroe County, FL north through Maine Headboat landings estimates from VA and north are included in the MRIP estimates, while landings estimates from south of VA are included in the SRHS estimates.

### 4.3.2 Southeast Region Headboat Survey (SRHS)

*Introduction*

The Southeast Region Headboat Survey estimates landings and effort for headboats in the South Atlantic and Gulf of Mexico. The Headboat Survey began in 1972 in North Carolina and South Carolina. In 1976 the survey was expanded to northeast Florida (Nassau-Indian River counties) and Georgia, followed by southeast Florida (St. Lucie-Monroe counties) in 1978. Due to headboat area definitions and confidentiality issues, Georgia and East Florida data must be combined. The SRHS began in the Gulf of Mexico in 1986 and extends from Naples, FL to South Padre Island, TX. The South Atlantic and Gulf of Mexico Headboat Surveys generally include 70-80 vessels participating in each region annually.

The Headboat Survey incorporates two components for estimating catch and effort. 1) Biological information: size of the fish landed are collected by port samplers during dockside sampling, where fish are measured to the nearest mm and weighed to the nearest 0.01 kg. These data are used to generate mean weights for all species by area and month. Port samplers also collect otoliths and spines for ageing studies during dockside sampling events. 2) Information about total catch and effort are collected via a logbook form that is filled out by vessel personnel for individual trips. These logbooks are summarized by vessel to generate estimated landings by species, area, and time strata. Most recently, the SRHS implemented electronic logbook reporting in the South Atlantic and Gulf of Mexico as of Jan 1, 2013. Headboat personnel are now required to report trip information via a website or mobile application.

The headboat logbook form was changed several times during the early years of the Headboat Survey. In the case of gray triggerfish, the logbook form used in North Carolina and South

Carolina included triggerfish starting in 1974, but did not specifically list gray triggerfish until 1984. The logbook form for Georgia and Florida included gray triggerfish in 1980. The Headboat Survey did not have a universal logbook form that included gray triggerfish for all areas until 1984. Dockside sampling records were reviewed for the years when only triggerfish were listed on the form and it was demonstrated that nearly all reported triggerfish were gray triggerfish for North Carolina and South Carolina. Based on this information the headboat logbook data was used for the time period it was available (1974-2013) in SEDAR32. This was also supported in SEDAR 41(1974-2014).

In the early years of the SRHS, there was only partial geographic coverage in the South Atlantic. Landings are available in NC and SC beginning in 1974. Landings are not available for GA/NEFL from 1974-1975 or SEFL from 1974-1980. Estimates for these areas/time periods can be calculated from several methods using the ratio of NC and SC landings from 1974-1980 for periods of partial coverage. For GA/NEFL a five year ratio is calculated by dividing the total landings for NEFL (1976-1978) by NC and SC combined total landings (1976-1978). This ratio is then multiplied to the 1974 and1975 combined total landings for NC and SC, resulting in the total landings for NEFL for 1974 and 1975. The same approach was used to calculate landings for SEFL 1974-1980 by using the total landings from 1981- 1985. This same method and landings were accepted for use in SEDAR 32 and was also supported in SEDAR 41.

*Catch Estimates*
Final SRHS landings estimates are shown in Table 4.10.6 by year and state (Figure 4.11.4). SRHS areas 1-17 are included in the gray triggerfish stock.

*Characterizing sources of uncertainty*
Variances estimates are not currently available for the SRHS catch estimates. Further research is required to develop a suitable method to calculate variance. The RWG included this as a research recommendation.

### 4.3.3 Historic Recreational Landings

*Introduction*
The historic recreational landings time period is defined as pre-1981 for the charter boat, headboat, private boat, and shore fishing modes, which represents the start of the Marine Recreational Fisheries Statistics Survey (MRFSS) and availability of landings estimates for gray triggerfish.

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

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

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

*Salt Water Angler Surveys (SWAS)*

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

*Anderson, 1965*

The RWG discussed the Anderson study as a possible source of information for historical gray triggerfish landings. The study area designated as the Cape Canaveral area included Brevard and Volusia counties in Florida. The recreational data was obtained from field surveys from February to October, 1963 and was further limited to the southern portion of the study area. The RWG considered this spatially and temporally limiting for possibly expanding estimated landings prior to 1981.

*FHWAR census method*

The FHWAR method (SEDAR41-DW17) was used in SEDAR 28 to reconstruct landings back to 1950s. The RWG considered using this same method for gray triggerfish, but determined that in order for this method to be applicable, evidence should show that these fish were desirable and harvested by anglers historically. After reviewing numerous black and white photos from the east coast of Florida charter boat and headboat fishery (courtesy of R. Hudson) back to the early 1950's, it was apparent that gray triggerfish did appear in the catch. Personal communications with other captains in the RWG indicated that gray triggerfish became more desirable as a food fish in the late 1970s and early 1980s throughout the South Atlantic.

*Issue:* Available historical gray triggerfish landings prior to 1981.

*Option 1:* Use available recreational time series for the MRFSS\MRIP 1981to 2014 (APAIS adjusted) and headboat estimates 1974 - 2014.

*Option 2:* Use FHWAR census method to estimate gray triggerfish landing 1955-1980 in the NE-FLE (Maine – Florida Keys). Use interpolation to complete time series.

**Decision:** *Option 2.*

Option #2 approved. Use FHWAR census method to estimate gray triggerfish recreational landing 1955-1980 in the NE-FLE, Table 4.10.7. Use interpolation to complete time series. Historic and contemporary recreational landings (1955-2014) are presented in Table 4.10.8 and Figure 4.11.5.

#### 4.3.4 Potential Sources for Additional Landings Data

*SCDNR Charter boat Logbook Program Data, 1993 – 2014*
The Recreational Fisheries Working Group discussed the possibility of replacing the MRIP charter mode estimates for South Carolina from 1993 to 2014 with the SCDNR Charter boat Logbook Program estimates. The SCDNR Charter boat Logbook Program is a mandatory logbook program and is a complete census. However, the data is self-reported and no field validation is done on catch or effort. SCDNR charter boat logbook data were compared with MRIP charter mode estimates (Figure 4.11.6). The Recreational Fisheries Working Group recommended not replacing the MRIP charter boat estimates with the SCDNR Charter boat Logbook Program estimates for 1993 – 2014. The MRIP estimates represent a longer time series and switching from the MRIP dataset (1981 – 1992) to the SCDNR Charter boat logbook dataset (1993-2014) would artificially reduce the total catch potentially due to the change in methodology that would not necessarily be indicative of a change in the gray triggerfish population which could affect the stock assessment model. Concern was also expressed about replacing the MRIP dataset with the SCDNR Charter boat logbook dataset because the data would only be replaced for one state (SC) and one mode (charter). Additionally since MRFSS/MRIP estimates are currently used to monitor annual catch limits (ACL's), the group thought it would be appropriate to use these estimates for the recreational landings data.

### 4.4 Recreational Discards

Total recreational discards are summarized below by survey. A map and figures summarizing the total recreational gray triggerfish discards are included in Figure 4.11.7.

#### 4.4.1 MRFSS/MRIP Discards

Discarded live fish are reported by the anglers interviewed by the MRIP/MRFSS. Consequently, neither the identity nor the quantities reported are verified. Lengths and weights of discarded fish are not sampled or estimated by the MRFSS/MRIP.

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

MRIP discards in numbers of fish and associated CVs by are presented in Table 4.10.9. Atlantic gray triggerfish estimates include all Atlantic coast states from Monroe County, FL north through Maine. Headboat discard estimates from VA and north are included in the MRIP estimates, while discard estimates from south of VA are included in the SRHS estimates.

### 4.4.2 Headboat At-Sea Observer Survey Discards

An observer survey of the recreational headboat fishery was launched in NC and SC in 2004 and in GA and FL in 2005 to collect more detailed information on recreational headboat catch, particularly for discarded fish. Headboat vessels are randomly selected throughout the year in each state, and the east coast of Florida is further stratified into northern and southern sample regions. Biologist's board selected vessels with permission from the captain and observe anglers as they fish on the recreational trip. Data collected include number and species of fish landed and discarded, size of landed and discarded fish, and the release condition of discarded fish (FL only) Data are also collected on the length of the trip, area fished (inland, state, and federal waters) and, in Florida, the minimum and maximum depth fished. In the Florida Keys (sub-region 3) some vessels that run trips that span more than 24 hours are also sampled to collect information on trips that fish farther offshore and for longer durations, primarily in the vicinity of the Dry Tortugas. The gray triggerfish discard data from the MRFSS At-Sea Observer Headboat program and the Southeast Region Headboat Survey (SRHS) logbook were compared (SEDAR 41-DW_30, 2014). Based on the results of these comparisons, it was determined that due to low coverage rates (1-2% coverage by state) the MRFSS At-Sea Observer Headboat discard data did not adequately characterize a sporadic headboat fishery such as gray triggerfish. Therefore, the MRFSS At-Sea Observer data was not recommended for use in this assessment.

### 4.4.3 Headboat Logbook Discards

The Southeast Region Headboat Survey logbook form was modified in 2004 to include a category to collect self-reported discards for each reported trip. This category is described on the form as the number of fish by species released alive and number released dead. Port agents instructed each captain on criteria for determining the condition of discarded fish. A fish is considered "released alive" if it is able to swim away on its own. If the fish floats off or is obviously dead or unable to swim, it is considered "released dead". As of Jan 1, 2013 the SRHS began collecting logbook data electronically. Changes to the trip report were also made at this time, one of which removed the condition category for discards i.e., released alive vs. released dead. The new form now collects only the total number of fish released regardless of condition.

These self-reported data are currently not validated within the Headboat Survey and were compared to the MRFSS At-Sea Observer Headboat program. Due to low coverage rates, the observer discard data did not adequately characterize the gray triggerfish headboat fishery. It was determined that the logbook discard data would be used from 2004-2014 (SEDAR 41-

DW_30, 2015). The RWG concluded that a proxy should be used to estimate the headboat gray triggerfish discards for previous years. The RWG considered the following three possible data sources to be used as a proxy for estimated headboat discards for 1981-2003 (Figure 4.11.8).

- MRIP CH discard ratio proxy method 1981-2003.
- MRIP CH:SRHS discard ratio proxy method 1981-2003 (SEDAR 28-Assessment Workshop Report, 2012).
- SRHS dockside sample discard ratio proxy method (1981-2003).

*Issue: Proxy for estimated headboat discards from 1981-2003.*

Option 1: Apply the MRIP charter boat discards:landings ratio to estimated headboat landings in order to estimate headboat discards from 1981-2003; use a 5 year mean discards:landings ratio to estimated headboat landings in order to estimate headboat discards from 1974-1980.

Option 2: Calculate a ratio of the mean ratio of SRHS discards:landings (2004-2013) to the mean ratio of MRIP CH discards:landings (2004-2013). Apply this ratio to the yearly MRIP charter boat discards:landings ratio (1981-2003) in order to estimate the yearly SRHS discards:landings ratio (1981-2003). This ratio is then applied to the SRHS landings (1981-2003) in order to estimate headboat discards (1981-2003). Use a 5 year (1981-1985) mean discards:landings ratio to estimated headboat landings in order to estimate headboat discards from 1974-1980.

Option 3: SRHS Dockside sample method: From the SRHS dockside samples calculate the mean ratio of fish less than 12in TL (1976-1980) and subtract from that the mean ratio of fish less than 12in TL (1981-1994) (if negative assume the proportion of discards is equal to the proportion of fish <12in TL in the dockside sample); apply that to the SRHS landings (1981-2003) to get the number of fish <12in TL discarded (1984-2003). Calculate the mean ratio of fish 12in TL (1981-1994) and subtract from that the mean ratio of fish less 12in TL (1995-2003) (if negative assume the proportion of discards is equal to the proportion of fish <12in TL in the dockside sample); apply that to the SRHS landings (1995-2003) to estimate the number of fish 12in TL discarded (1995-2003).

**Decision:** Option 2. The MRIP CH:SRHS discard ratio method follows the same pattern as the SRHS in 2006-2009 and is closer to the SRHS discard rate in terms of magnitude in all years but 2010-2012. The MRIP SRHS: CH ratio method also captures trends in desirability of gray triggerfish, which changed significantly in the mid-1980s. Final discard estimates from the SRHS are shown in Table 4.10.10 by year and state and in Figure 4.11.9. The increase in discards during later years is most likely driven by discards from FL after size limit regulation was introduced in 1995.

## 4.5 Biological Sampling

### 4.5.1 Sampling Intensity Length/Age/Weight

Length samples from recreational landings were obtained from the Marine Recreational Fisheries Statistics Survey, Southeast Region Headboat Survey and South Carolina State Finfish Survey.

Any existing total length measurements without an associated fork length measurement were converted to fork length using the following equation derived for the combined South Atlantic stock by the Life History Working Group at the SEDAR 41 data workshop:

$FL = 25.58 + 0.80TL$ ($R2 = 0.97$)

*MRFSS/MRIP Biological Sampling*

The MRFSS/MRIP angler intercept survey includes the sampling of fish lengths from the harvested (landed, whole condition) catch. Up to 15 of each species landed per angler interviewed are measured to the nearest mm along a center line (defined as tip of snout to center of tail along a straight line, not curved over body). In those fish with a forked tail, this measure would typically be referred to as a fork length, and in those fish that do not have a forked tail it would typically be referred to as a total length with the exception of some fishes that have a single, or few, caudal fin rays that extend further. Weights are typically collected for the same fish measured although weights are not preferred when time is constrained. Aging structures and other biological samples are not collected during MRFSS/MRIP assignments because of concerns over the introduction of bias to survey data collection.

The number of gray triggerfish measured in the Atlantic (ME to FLE, including the Keys) from MRFSS/MRIP by year, mode, and state are summarized in Table 4.10.11. The number of angler trips with measured gray triggerfish in the Atlantic (ME to FLE, including the Keys) from MRFSS/MRIP by year, mode, and state are summarized in Table 4.10.12.

*Headboat Survey Biological Sampling*

Lengths were collected from 1972 to 2013 by headboat dockside samplers. From 1972 to 1975, only North Carolina and South Carolina were sampled whereas Georgia and northeast Florida were sampled beginning in 1976. The Southeast Region Headboat Survey conducted dockside sampling for the entire range of Atlantic waters along the southeast portion of the US from the NC-VA border through the Florida Keys beginning in 1978. Weights are typically collected for the same fish measured during dockside sampling. Also, biological samples (scales, otoliths, spines, stomachs and gonads) are collected routinely and processed for aging, diet studies, and maturity studies.

Annual numbers of gray triggerfish measured for length in the headboat fleet and the number of trips from which gray triggerfish were measured are summarized in Table 4.10.13. Dockside mean weights for the headboat fishery are tabulated for 1972-2013 in Table 4.10.14.

*SCDNR State Finfish Survey (SFS)*
Gray triggerfish lengths were collected through the SCDNR State Finfish Survey (SFS) from 1988 to 2012. Starting in 2013 SCDNR took over MRIP sampling responsibilities in SC. Because of this, the SFS survey was terminated except for January and February sampling. No grey triggerfish were sampled during those months in 2013 and 2014. The SFS collects finfish intercept data in South Carolina through a non-random intercept survey at public boat landings along the SC coast. The survey focuses on known productive sample sites, targets primarily private boat mode, and is conducted year-round (January- December) using a questionnaire and interview procedure similar to the intercept portion of the MRIP. From 1988 through March 2009 mid-line lengths were measured and from April 2009 to 2012 total lengths were measured. From 1988 to 2012 SFS personnel collected 220 gray triggerfish lengths. The Recreational Fisheries Working Group recommended the SCDNR SFS length data for all modes be used to supplement the MRFSS/MRIP length data for length compositions.

Summarized length data from 1988 – 2012 can be found in Table 4.10.15.

*Aging data*
The number of gray triggerfish aged from the recreational fishery and the number of trips with aged gray triggerfish by year, state, and mode is summarized in Table 4.10.16. The number of trips provided is a combination of angler and vessel trips.

## 4.6 Recreational Effort

Total recreational effort is summarized below by survey. Effort is summarized for all marine fishing by mode, regardless of what was caught. A map and figures summarizing MRFSS/MRIP effort in angler trips are included in Figure 4.11.10. A map and figures summarizing SRHS effort in angler days are included in Figure 4.11.11.

### 4.6.1 MRFSS/MRIP Effort

Effort estimates for the recreational fishery survey are produced via telephone surveys of both anglers (private/rental boats and shore fishers) and for-hire boat operators (charterboat anglers, and in early years, party or charter anglers). The methods have changed during the full time series (see section 4.3 for descriptions of survey method changes and adjustments to survey estimates for uniform time-series of catch estimates). An angler-trip is defined as a single day of fishing by a single angler in the specified mode, not to exceed 24 hours. MRFSS effort estimates are presented from 1981 to 2003. MRIP effort estimates are presented starting in 2004. Angler trip estimates are tabulated in Table 4.10.17 by year and mode, including all Atlantic coast states from Monroe County, FL north through Maine

### 4.6.2 Headboat Effort

Catch and effort data are reported on logbooks provided to all headboats in the survey. These forms are completed by the captain or designated crew member after each trip and represent the total number and weight of all the species kept, along with the total number of fish discarded for each species. Data on effort are provided as number of anglers on a given trip. Numbers of anglers are standardized, depending on the type of trip (length in hours), by converting number of anglers to "angler days" (e.g., 40 anglers on a half-day trip would yield 40 * 0.5 = 20 angler days). Angler days are summed by month for individual vessels. Each month, port agents collect these logbook trip reports and check for accuracy and completeness. Although reporting via the logbooks is mandatory, compliance is not 100% and is variable by location. To account for non-reporting, a correction factor is developed based on sampler observations, angler numbers from office books and all available information. This information is used to provide estimates of total catch (expanded or corrected for non-reporting) by month and area, along with estimates of effort.

Estimated headboat angler days have decreased in the South Atlantic in recent years (Table 4.10.18). The most obvious factor which impacted the headboat fishery in the Atlantic was the high price of fuel. This coupled with the economic down turn starting in 2008 resulted in a marked decline in angler days in the South Atlantic headboat fishery. Reports from industry staff, captains\owners, and port agents indicated fuel prices, the economy and fishing regulations are the factors that most affected the amount of trips, number of passengers, and overall fishing effort. However, estimated angler days have risen in recent years (2012-2013).

## 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:

- Landings, as adjusted, appear to be adequate for the time period covered.
- Size data appear to adequately represent the landed catch for the recreational sector.

## 4.8 Itemized List of Tasks for Completion Following Workshop

The length and age distributions will be prepared and discussed in a working paper for the Assessment Workshop.

## 4.9 Literature Cited

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## 4.10 Tables

**Table 4.10.1** Atlantic MRFSS charterboat conversion factors and standard errors (in parentheses).

a) Apply to 1981-1985 charterboat/headboat mode in the South Atlantic and Gulf of Mexico.

| | WAVE | | | | | |
|---|---|---|---|---|---|---|
| STATE | 1 | 2 | 3 | 4 | 5 | 6 |
| NC | - | 2.151 (0.12) | 2.294 (0.12) | 1.444 (0.12) | 1.763 (0.12) | 0.857 (0.12) |
| SC | - | 1.035 (0.04) | 1.085 (0.04) | 1.437 (0.04) | 0.891 (0.04) | 0.750 (0.04) |
| GFE | 0.845 (0.02) | 0.951 (0.02) | 0.985 (0.02) | 1.016 (0.02) | 0.811 (0.02) | 0.696 (0.02) |
| AFW | 0.883 (0.03) | 0.883 (0.03) | 1.104 (0.05) | 1.104 (0.05) | 0.883 (0.03) | 0.883 (0.03) |
| MS | 1.155 (0.11) | 1.155 (0.11) | 2.245 (0.11) | 2.245 (0.11) | 1.155 (0.11) | 1.155 (0.11) |
| LA | 0.962 (0.09) | 0.962 (0.09) | 2.260 (0.13) | 2.260 (0.13) | 0.962 (0.09) | 0.962 (0.09) |

b) Apply to 1986- 2002 charterboat mode in FLE

| | WAVE | | | | | |
|---|---|---|---|---|---|---|
| Area | 1 | 2 | 3 | 4 | 5 | 6 |
| Inshore | 1.600 (0.65) | 2.786 (0.65) | 2.201 (0.65) | 2.894 (0.65) | 1.630 (0.65) | 2.386 (0.65) |
| Ocean | 0.664 (0.10) | 0.852 (0.10) | 0.828 (0.10) | 1.006 (0.10) | 0.478 (0.10) | 0.549 (0.10) |

c) Apply to 1986- 2003 charterboat mode in GA and SC

| | WAVE | | | | | |
|---|---|---|---|---|---|---|
| Area | 1 | 2 | 3 | 4 | 5 | 6 |
| Inshore | - | 1.635 (0.90) | 3.100 (0.90) | 2.092 (0.90) | 0.931 (0.90) | 0.757 (0.90) |
| Ocean | - | 0.939 (0.36) | 1.272 (0.33) | 2.161 (0.32) | 0.835 (0.33) | 0.638 (0.36) |

d) Apply to 1986- 2003 charterboat mode in NC

| | WAVE | | | | | |
|---|---|---|---|---|---|---|
| Area | 1 | 2 | 3 | 4 | 5 | 6 |
| Inshore | - | 11.850 (3.48) | 10.026 (2.63) | 6.616(2.84) | 3.766 (2.84) | 9.415 (3.11) |
| Ocean | - | 2.188 (0.58) | 2.504 (0.58) | 1.565 (0.60) | 2.102 (0.60) | 0.661 (0.60) |

e) Apply to 1981- 2003 charterboat/headboat mode in the mid-Atlantic
*originally only said to apply to 1986-2003 data, but the cbt/hbt combined mode in sub_reg=5 was consistent from 1981-2003 and there is no HBS data providing headboat estimates in this sub-region.

| | WAVE | | | | | |
|---|---|---|---|---|---|---|
| STATE | 1 | 2 | 3 | 4 | 5 | 6 |
| NY | - | 1.187 (0.48) | 2.048 (0.54) | 2.665 (0.48) | 1.210 (0.51) | 0.617 (0.48) |
| NJ | - | 1.289 (0.36) | 1.179 (0.34) | 1.644 (0.34) | 0.809 (0.34) | 1.115 (0.36) |
| DE/MD | - | 1.294 (0.52) | 1.599 (0.54) | 1.930 (0.54) | 0.861 (0.52) | 1.171 (0.56) |
| VA | - | 0.770 (0.25) | 0.680 (0.21) | 0.761 (0.21) | 0.324 (0.22) | 0.313 (0.22) |

**Table 4.10.2.** Gray triggerfish MRIP vs MRIP APAIS estimates of landings (number of fish) for the Atlantic (sub-regions 4- 6) 2004-2012. See accompanying graph below table which includes the ratio of the MRIP APAIS to MRIP discards (value on right axis).

| year | MRIP ab1 | MRIP CV_ab1 | MRIP APAIS ab1 | MRIP APAIS CV_ab1 |
|---|---|---|---|---|
| 2004 | 190,069 | 0.22 | 217,963 | 0.41 |
| 2005 | 117,252 | 0.18 | 207,746 | 0.36 |
| 2006 | 110,398 | 0.19 | 169,506 | 0.43 |
| 2007 | 258,461 | 0.15 | 308,856 | 0.21 |
| 2008 | 209,061 | 0.19 | 429,321 | 0.38 |
| 2009 | 262,504 | 0.16 | 497,253 | 0.31 |
| 2010 | 165,081 | 0.13 | 325,334 | 0.31 |
| 2011 | 105,881 | 0.17 | 167,214 | 0.31 |
| 2012 | 161,008 | 0.18 | 264,993 | 0.25 |

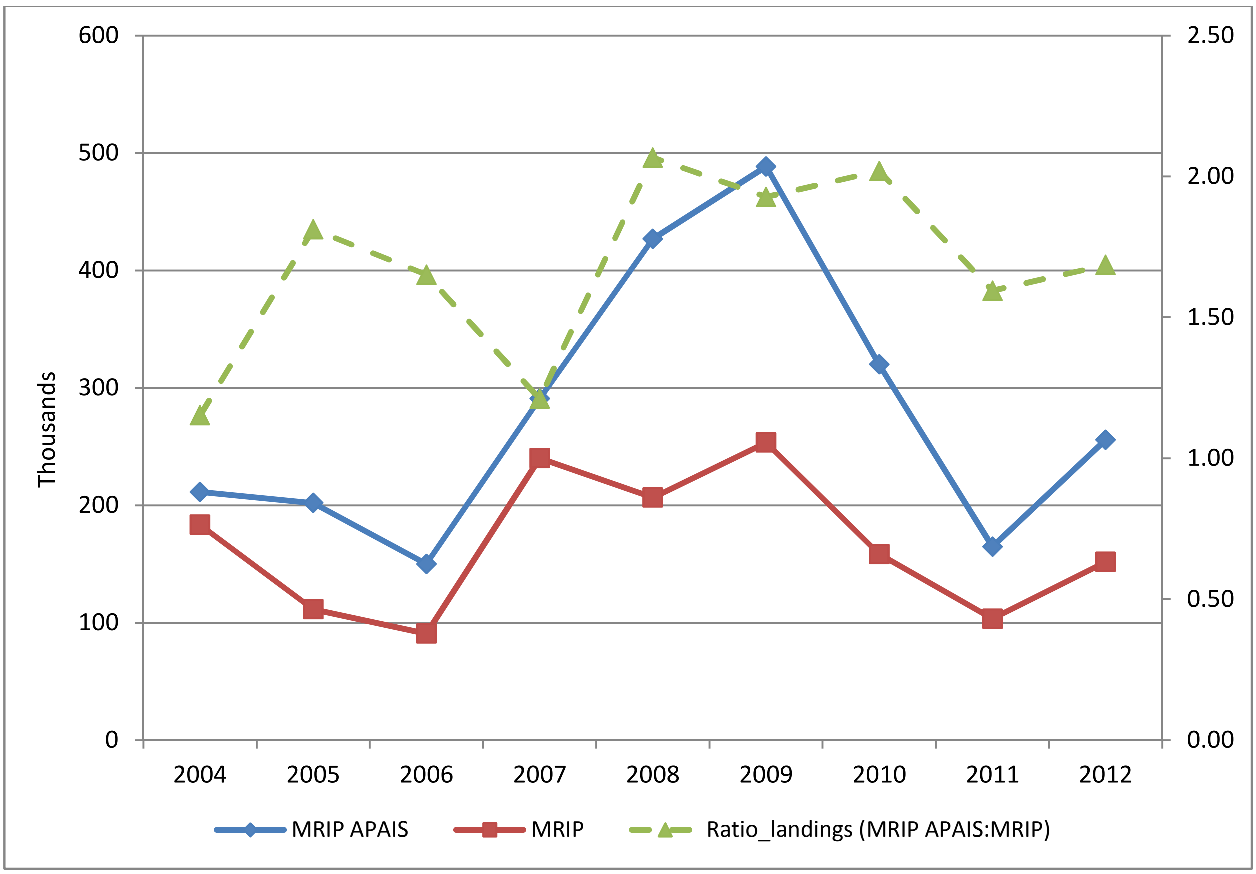


**Table 4.10.3.** Gray triggerfish MRIP vs MRIP APAIS estimates of discards (number of fish) for the Atlantic (sub-regions 4-6) 2004-2012. See accompanying graph below table which includes the ratio of the MRIP APAIS to MRIP discards (value on right axis).

| year | MRIP b2 | MRIP CV_b2 | MRIP APAIS b2 | MRIP APAIS CV_b2 |
|---|---|---|---|---|
| 2004 | 182,668 | 0.17 | 188,878 | 0.69 |
| 2005 | 168,625 | 0.16 | 183,398 | 0.24 |
| 2006 | 157,762 | 0.21 | 160,854 | 0.29 |
| 2007 | 261,010 | 0.18 | 273,363 | 0.33 |
| 2008 | 163,574 | 0.16 | 187,957 | 0.43 |
| 2009 | 225,065 | 0.33 | 257,785 | 0.37 |
| 2010 | 163,325 | 0.25 | 182,256 | 0.46 |
| 2011 | 71,123 | 0.20 | 76,327 | 0.41 |
| 2012 | 91,148 | 0.17 | 100,065 | 0.71 |

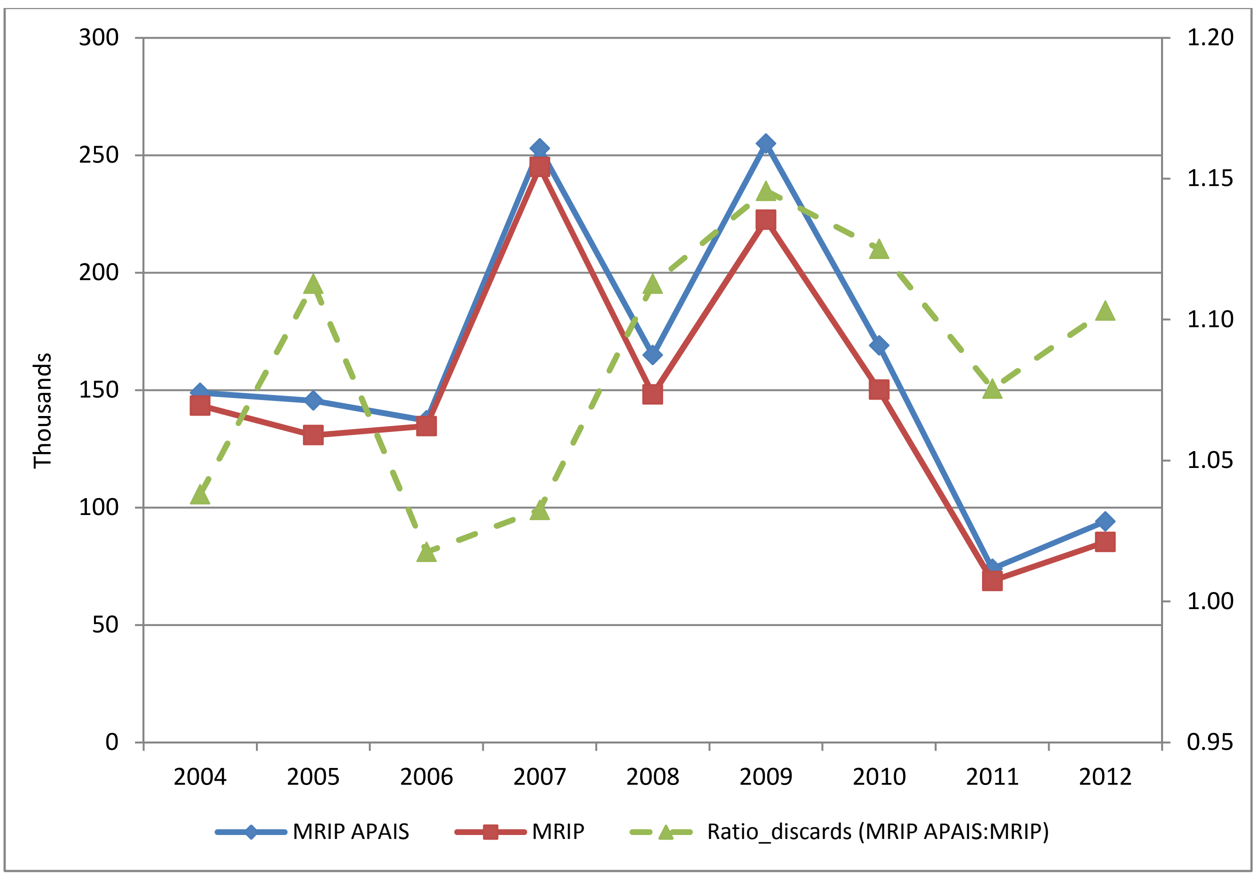


**Table 4.10.4.** Atlantic gray triggerfish ratio estimators for adjusting MRFSS numbers and variance estimates (AB1 and B2) to MRIP APAIS numbers and variances for 1981-2003. The variances of the numbers ratio estimators are also shown.

a) South Atlantic gray triggerfish

| | Numbers Ratio Estimator | | Variance Ratio Estimator | | Variance of Numbers Ratio Estimator | |
|---|---|---|---|---|---|---|
| MODE | AB1 | B2 | AB1 | B2 | AB1 | B2 |
| Charterboat | 0.925814 | 0.815523 | 2.479677 | 2.451844 | 0.006679 | 0.007349 |
| Private | 1.902458 | 0.94826 | 22.36285 | 4.251994 | 0.062316 | 0.004048 |
| Shore | 0.832073 | 0.89416 | 0.993057 | 1.645265 | 0.02224 | 0.030647 |

b) Mid-Atlantic gray triggerfish

| | Numbers Ratio Estimator | | Variance Ratio Estimator | | Variance of Numbers Ratio Estimator | |
|---|---|---|---|---|---|---|
| MODE | AB1 | B2 | AB1 | B2 | AB1 | B2 |
| Charterboat/Headboat | 0.975191 | 0.449072 | 4.954964 | 0.221942 | 0.017683 | 0.021459 |
| Private | 1.366588 | 1.176426 | 2.832694 | 5.981934 | 0.005066 | 0.02066 |
| Shore | 1.040934 | 0.928205 | 1.233836 | 0.819844 | 0.008656 | 0.009695 |

c) North Atlantic gray triggerfish

| | Numbers Ratio Estimator | | Variance Ratio Estimator | | Variance of Numbers Ratio Estimator | |
|---|---|---|---|---|---|---|
| MODE | AB1 | B2 | AB1 | B2 | AB1 | B2 |
| Charterboat/Headboat | 1.404506 | 1.492521 | 4.011636 | 2.227618 | 0.008434 | 9.89E-16 |
| Private | 1.206951 | 1.142514 | 1.981688 | 1.298391 | 0.162785 | 0.129633 |
| Shore | | 2.393295 | | 9.528698 | NA | 1.341624 |
| All | 1.252498 | 1.485517 | 2.138975 | 2.7197026 | 0.1175639 | 0.3659927 |

**Table 4.10.5.** Atlantic (ME-FL Keys) gray triggerfish landings (numbers of fish and whole weight in pounds) by year and mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). MRFSS estimates adjusted to MRIP APAIS estimates prior to 2013. CH and CH/HB mode adjusted for FHS conversion prior to 2004. CH/HB mode landings are from the Mid-Atlantic and North Atlantic (sub-regions 4 and 5) through 2003. After 2004 CH and HB modes are estimated separately in these sub-regions. *CVs for CH mode 1981-1985 are unavailable.

| | Estimated CH Landings | | | Estimated CH/HB Landings | | | Estimated HB Landings | | |
|---|---|---|---|---|---|---|---|---|---|
| YEAR | Number | CV* | Pounds | Number | CV | Pounds | Number | CV | Pounds |
| 1981 | 1,082 | | 2,400 | 0 | 0.00 | 0 | | | |
| 1982 | 12,617 | | 27,991 | 711 | 1.26 | 1,523 | | | |
| 1983 | 2,609 | | 5,817 | 3,896 | 2.06 | 8,348 | | | |
| 1984 | 10,468 | | 23,222 | 0 | 0.00 | 0 | | | |
| 1985 | 9,626 | | 21,504 | 5,605 | 2.02 | 12,008 | | | |
| 1986 | 750 | 0.80 | 1,663 | 5,270 | 1.51 | 11,291 | | | |
| 1987 | 1,834 | 0.62 | 4,070 | 4,374 | 2.21 | 9,370 | | | |
| 1988 | 4,584 | 0.66 | 10,170 | 0 | 0.00 | 0 | | | |
| 1989 | 4,926 | 0.78 | 12,104 | 14,556 | 1.01 | 41,624 | | | |
| 1990 | 3,984 | 0.41 | 10,848 | 2,531 | 0.99 | 5,423 | | | |
| 1991 | 6,950 | 0.36 | 17,316 | 29,910 | 0.85 | 73,424 | | | |
| 1992 | 22,833 | 0.26 | 60,255 | 2,947 | 1.05 | 6,313 | | | |
| 1993 | 22,915 | 0.41 | 42,101 | 28,230 | 1.00 | 46,405 | | | |
| 1994 | 42,451 | 0.29 | 97,991 | 4,694 | 1.01 | 10,056 | | | |
| 1995 | 33,519 | 0.36 | 68,911 | 4,956 | 1.24 | 10,618 | | | |
| 1996 | 47,865 | 0.42 | 114,121 | 3,095 | 1.00 | 6,676 | | | |
| 1997 | 52,957 | 0.46 | 109,121 | 107,929 | 1.01 | 237,961 | | | |
| 1998 | 11,764 | 0.42 | 31,090 | 2,427 | 1.13 | 5,447 | | | |
| 1999 | 24,844 | 0.36 | 61,704 | 3,389 | 1.04 | 7,261 | | | |
| 2000 | 7,273 | 0.64 | 15,490 | 3,382 | 1.22 | 7,246 | | | |
| 2001 | 13,041 | 0.44 | 28,556 | 2,603 | 0.99 | 5,577 | | | |
| 2002 | 26,541 | 0.40 | 63,153 | 21,196 | 0.71 | 45,877 | | | |
| 2003 | 26,649 | 0.45 | 56,969 | 3,640 | 0.86 | 7,798 | | | |
| 2004 | 33,656 | 0.39 | 64,495 | | | | 12,510 | 0.59 | 27,637 |
| 2005 | 14,376 | 0.97 | 28,099 | | | | 301 | 0.41 | 654 |
| 2006 | 17,178 | 0.47 | 38,384 | | | | 353 | 0.37 | 757 |
| 2007 | 75,522 | 0.38 | 150,030 | | | | 14,034 | 0.59 | 31,443 |
| 2008 | 19,979 | 0.62 | 52,356 | | | | 1,186 | 0.58 | 2,557 |
| 2009 | 31,331 | 0.25 | 68,350 | | | | 6,238 | 0.35 | 12,608 |
| 2010 | 40,902 | 0.29 | 87,549 | | | | 1,378 | 0.51 | 3,039 |
| 2011 | 30,320 | 0.41 | 64,182 | | | | 1,566 | 0.43 | 3,355 |
| 2012 | 50,965 | 0.31 | 136,253 | | | | 2,409 | 0.45 | 5,430 |
| 2013 | 60,558 | 0.18 | 127,056 | | | | 664 | 0.65 | 1,333 |
| 2014 | 46,335 | 0.16 | 104,858 | | | | 2,489 | 0.50 | 5,074 |

**Table 4.10.5 (continued).** Atlantic (ME-FL Keys) gray triggerfish landings (numbers of fish and whole weight in pounds) by year and mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). MRFSS estimates adjusted to MRIP APAIS estimates prior to 2013. CH and CH/HB mode adjusted for FHS conversion prior to 2004. CH/HB mode landings are from the Mid-Atlantic and North Atlantic (sub-regions 4 and 5) through 2003. After 2004 CH and HB modes are estimated separately in these sub-regions. *CVs for CH mode 1981-1985 are unavailable.

| | Estimated PR Landings | | | Estimated SH Landings | | | ALL MODES Landings | | |
|---|---|---|---|---|---|---|---|---|---|
| YEAR | Number | CV | Pounds | Number | CV | Pounds | Number | CV* | Pounds |
| 1981 | 70,104 | 1.13 | 149,269 | 1,392 | 2.15 | 2,632 | 71,496 | 1.11 | 151,900 |
| 1982 | 60,118 | 1.33 | 132,192 | 4,609 | 0.62 | 10,225 | 64,727 | 1.23 | 142,417 |
| 1983 | 93,199 | 1.16 | 206,110 | 10,276 | 0.78 | 22,235 | 103,475 | 1.05 | 228,345 |
| 1984 | 104,491 | 1.13 | 231,495 | 5,882 | 0.57 | 13,161 | 110,373 | 1.07 | 244,656 |
| 1985 | 152,521 | 1.51 | 338,331 | 691 | 1.00 | 1,534 | 153,212 | 1.51 | 339,864 |
| 1986 | 65,867 | 0.97 | 145,794 | 0 | 0.00 | 0 | 65,867 | 0.97 | 145,794 |
| 1987 | 108,858 | 0.96 | 239,585 | 11,652 | 0.74 | 24,962 | 120,509 | 0.87 | 264,547 |
| 1988 | 98,719 | 1.07 | 216,474 | 10,048 | 0.48 | 22,292 | 108,767 | 0.97 | 238,767 |
| 1989 | 370,059 | 1.40 | 950,457 | 5,163 | 0.63 | 13,772 | 375,222 | 1.39 | 964,229 |
| 1990 | 227,864 | 0.90 | 632,918 | 4,092 | 0.43 | 10,428 | 231,956 | 0.88 | 643,345 |
| 1991 | 235,572 | 0.71 | 584,767 | 41,366 | 1.11 | 105,332 | 276,937 | 0.63 | 690,100 |
| 1992 | 149,262 | 0.57 | 369,559 | 17,203 | 0.33 | 43,470 | 166,465 | 0.51 | 413,029 |
| 1993 | 190,154 | 0.62 | 333,390 | 27,626 | 0.38 | 46,555 | 217,779 | 0.54 | 379,945 |
| 1994 | 104,606 | 0.71 | 257,721 | 19,430 | 0.41 | 43,384 | 124,037 | 0.60 | 301,105 |
| 1995 | 100,859 | 0.81 | 204,716 | 8,799 | 0.40 | 17,951 | 109,658 | 0.74 | 222,667 |
| 1996 | 213,186 | 0.94 | 436,377 | 11,155 | 0.46 | 24,017 | 224,341 | 0.89 | 460,394 |
| 1997 | 120,575 | 1.19 | 245,209 | 9,527 | 0.57 | 21,047 | 130,101 | 1.10 | 266,256 |
| 1998 | 71,825 | 1.58 | 181,570 | 7,561 | 0.66 | 17,168 | 79,386 | 1.43 | 198,737 |
| 1999 | 83,933 | 0.94 | 188,528 | 577 | 1.00 | 1,243 | 84,509 | 0.93 | 189,772 |
| 2000 | 83,081 | 0.96 | 177,650 | 13,991 | 0.78 | 28,416 | 97,072 | 0.83 | 206,066 |
| 2001 | 107,100 | 1.01 | 245,120 | 3,263 | 0.78 | 7,201 | 110,362 | 0.98 | 252,321 |
| 2002 | 126,048 | 0.73 | 225,780 | 10,866 | 0.72 | 22,389 | 136,914 | 0.67 | 248,169 |
| 2003 | 133,926 | 0.88 | 263,488 | 6,553 | 0.55 | 14,713 | 140,479 | 0.84 | 278,202 |
| 2004 | 164,389 | 0.54 | 333,828 | 7,407 | 0.74 | 16,045 | 171,796 | 0.52 | 349,873 |
| 2005 | 171,576 | 0.42 | 349,504 | 21,493 | 0.76 | 46,340 | 193,069 | 0.38 | 395,844 |
| 2006 | 151,435 | 0.48 | 325,820 | 540 | 1.00 | 1,110 | 151,975 | 0.48 | 326,929 |
| 2007 | 214,642 | 0.27 | 435,777 | 4,657 | 1.10 | 9,880 | 219,300 | 0.26 | 445,657 |
| 2008 | 404,115 | 0.41 | 1,011,389 | 4,041 | 0.60 | 9,677 | 408,156 | 0.40 | 1,021,067 |
| 2009 | 411,732 | 0.37 | 880,435 | 47,950 | 0.50 | 92,811 | 459,683 | 0.34 | 973,245 |
| 2010 | 272,254 | 0.37 | 663,122 | 10,800 | 0.66 | 23,351 | 283,054 | 0.35 | 686,473 |
| 2011 | 131,508 | 0.38 | 329,861 | 3,820 | 0.72 | 8,877 | 135,328 | 0.37 | 338,738 |
| 2012 | 199,094 | 0.32 | 427,265 | 12,525 | 0.58 | 24,186 | 211,619 | 0.31 | 451,451 |
| 2013 | 99,577 | 0.19 | 202,770 | 6,018 | 0.31 | 13,338 | 105,595 | 0.18 | 216,108 |
| 2014 | 168,675 | 0.21 | 389,217 | 12,739 | 0.80 | 27,312 | 181,414 | 0.21 | 416,530 |

**Table 4.10.6.** Estimated headboat landings of gray triggerfish in the South Atlantic 1974-2014. Due to headboat area definitions and confidentiality issues, Georgia and East Florida landings must be combined.

| | Number | | | | Weight (lb) | | | | Avg |
|---|---|---|---|---|---|---|---|---|---|
| Year | NC | SC | GA/FLE | South Atlantic | NC | SC | GA/FLE | South Atlantic | Weight (lb) |
| 1974 | 10,575 | 16,516 | 35,883 | 62,974 | 58,242 | 73,736 | 92,264 | 224,241 | 3.56 |
| 1975 | 12,035 | 10,452 | 29,785 | 52,272 | 59,476 | 48,189 | 76,584 | 184,249 | 3.52 |
| 1976 | 8,153 | 8,543 | 16,020 | 32,716 | 41,835 | 36,625 | 42,144 | 120,604 | 3.69 |
| 1977 | 5,838 | 11,877 | 16,542 | 34,257 | 33,647 | 49,101 | 44,380 | 127,128 | 3.71 |
| 1978 | 8,163 | 5,886 | 22,947 | 36,996 | 40,523 | 24,546 | 57,769 | 122,838 | 3.32 |
| 1979 | 9,192 | 4,400 | 18,786 | 32,378 | 46,081 | 25,609 | 50,947 | 122,637 | 3.79 |
| 1980 | 3,939 | 7,450 | 10,343 | 21,732 | 20,721 | 37,814 | 26,331 | 84,866 | 3.91 |
| 1981 | 3,222 | 3,218 | 19,223 | 25,663 | 17,566 | 17,383 | 46,970 | 81,919 | 3.19 |
| 1982 | 4,678 | 6,531 | 18,295 | 29,504 | 24,341 | 27,163 | 45,844 | 97,348 | 3.30 |
| 1983 | 4,955 | 4,967 | 18,685 | 28,607 | 21,905 | 20,729 | 40,343 | 82,977 | 2.90 |
| 1984 | 7,676 | 3,622 | 15,598 | 26,896 | 34,149 | 13,973 | 39,348 | 87,470 | 3.25 |
| 1985 | 9,815 | 4,150 | 21,635 | 35,600 | 41,334 | 17,340 | 45,906 | 104,580 | 2.94 |
| 1986 | 6,628 | 4,526 | 17,217 | 28,371 | 24,701 | 18,530 | 36,706 | 79,937 | 2.82 |
| 1987 | 2,387 | 4,324 | 22,865 | 29,576 | 11,233 | 18,129 | 40,909 | 70,271 | 2.38 |
| 1988 | 1,743 | 3,629 | 29,554 | 34,926 | 6,438 | 13,288 | 50,094 | 69,820 | 2.00 |
| 1989 | 944 | 3,284 | 33,139 | 37,367 | 3,124 | 13,440 | 68,809 | 85,373 | 2.28 |
| 1990 | 11,213 | 3,838 | 56,653 | 71,704 | 30,785 | 11,087 | 73,802 | 115,674 | 1.61 |
| 1991 | 23,463 | 10,019 | 52,047 | 85,529 | 75,491 | 22,415 | 61,720 | 159,626 | 1.87 |
| 1992 | 41,965 | 19,775 | 29,993 | 91,733 | 88,438 | 42,702 | 39,181 | 170,321 | 1.86 |
| 1993 | 64,058 | 25,523 | 17,489 | 107,070 | 139,493 | 72,890 | 28,975 | 241,359 | 2.25 |
| 1994 | 48,995 | 24,697 | 16,695 | 90,387 | 106,604 | 54,638 | 28,722 | 189,964 | 2.10 |
| 1995 | 60,426 | 20,389 | 12,552 | 93,367 | 119,249 | 42,472 | 20,189 | 181,910 | 1.95 |
| 1996 | 55,476 | 24,989 | 9,489 | 89,954 | 100,070 | 44,651 | 18,960 | 163,682 | 1.82 |
| 1997 | 61,432 | 32,583 | 12,155 | 106,170 | 115,851 | 58,112 | 18,450 | 192,414 | 1.81 |
| 1998 | 36,535 | 20,258 | 9,064 | 65,857 | 81,121 | 38,768 | 14,839 | 134,727 | 2.05 |
| 1999 | 18,320 | 11,398 | 7,500 | 37,218 | 38,231 | 22,787 | 13,465 | 74,483 | 2.00 |
| 2000 | 15,683 | 10,671 | 7,738 | 34,092 | 28,519 | 21,196 | 12,760 | 62,475 | 1.83 |
| 2001 | 13,001 | 9,231 | 10,746 | 32,978 | 26,378 | 20,289 | 17,336 | 64,003 | 1.94 |
| 2002 | 30,061 | 11,710 | 15,859 | 57,630 | 52,742 | 22,011 | 23,586 | 98,340 | 1.71 |
| 2003 | 20,029 | 11,930 | 13,792 | 45,751 | 39,555 | 22,553 | 19,572 | 81,681 | 1.79 |
| 2004 | 31,908 | 12,733 | 33,432 | 78,073 | 71,596 | 25,396 | 52,483 | 149,475 | 1.91 |
| 2005 | 35,609 | 5,667 | 22,306 | 63,582 | 71,165 | 12,283 | 30,773 | 114,222 | 1.80 |
| 2006 | 19,931 | 8,781 | 14,439 | 43,151 | 41,841 | 18,832 | 21,851 | 82,524 | 1.91 |
| 2007 | 38,704 | 15,328 | 12,371 | 66,403 | 81,568 | 28,372 | 23,347 | 133,287 | 2.01 |
| 2008 | 22,879 | 7,292 | 14,587 | 44,758 | 45,451 | 15,329 | 29,845 | 90,625 | 2.02 |
| 2009 | 31,910 | 8,676 | 19,359 | 59,945 | 63,691 | 19,690 | 45,276 | 128,657 | 2.15 |
| 2010 | 30,153 | 13,345 | 25,309 | 68,807 | 61,614 | 31,569 | 59,379 | 152,561 | 2.22 |
| 2011 | 19,954 | 10,861 | 22,541 | 53,356 | 44,680 | 26,525 | 54,396 | 125,602 | 2.35 |
| 2012 | 19,325 | 7,388 | 22,383 | 49,096 | 42,891 | 17,729 | 55,789 | 116,409 | 2.37 |
| 2013 | 30,367 | 10,068 | 16,052 | 56,487 | 64,922 | 23,392 | 32,913 | 121,226 | 2.15 |
| 2014 | 26,468 | 9,072 | 17,568 | 53,108 | 56,196 | 21,733 | 35,343 | 113,273 | 2.13 |

*Use a 5 year average ratio of NC/SC for GA/NEFL 1974-1975 and SEFL 1974-1980**.**

**Table 4.10.7.** Estimated gray triggerfish historical recreational landings using the FHWAR census method, 1955-1980.

| Year | Total U.S. Saltwater Days | Adjusted Saltwater day NE-FLE | Avg CPUE MRFSS & SRHS 81-85 | Historic Catch (number) | CV |
|---|---|---|---|---|---|
| 1955 | 58,621,000 | 2,022,131 | 0.018 | 47,530 | 0.28 |
| 1960 | 80,602,000 | 2,952,867 | 0.018 | 65,353 | 0.28 |
| 1965 | 95,837,000 | 4,289,877 | 0.018 | 77,705 | 0.28 |
| 1970 | 113,694,000 | 4,415,509 | 0.018 | 92,184 | 0.28 |
| 1975 | 167,499,000 | 6,597,502 | 0.018 | 135,809 | 0.28 |
| 1980 | 164,040,000 | 6,969,725 | 0.018 | 133,005 | 0.28 |

**Table 4.10.8.** Historic recreational gray triggerfish landings (1955-2014); FHWAR method 1955-1980.

| Year | Number | Year | Number |
|---|---|---|---|
| 1955 | 47,530 | 1985 | 204,043 |
| 1956 | 51,095 | 1986 | 100,258 |
| 1957 | 54,659 | 1987 | 156,294 |
| 1958 | 58,224 | 1988 | 148,278 |
| 1959 | 61,788 | 1989 | 432,071 |
| 1960 | 65,353 | 1990 | 310,175 |
| 1961 | 67,823 | 1991 | 399,326 |
| 1962 | 70,294 | 1992 | 283,978 |
| 1963 | 72,764 | 1993 | 375,994 |
| 1964 | 75,235 | 1994 | 261,569 |
| 1965 | 77,705 | 1995 | 241,501 |
| 1966 | 80,601 | 1996 | 365,255 |
| 1967 | 83,497 | 1997 | 397,157 |
| 1968 | 86,392 | 1998 | 159,434 |
| 1969 | 89,288 | 1999 | 149,961 |
| 1970 | 92,184 | 2000 | 141,819 |
| 1971 | 100,782 | 2001 | 158,985 |
| 1972 | 109,585 | 2002 | 242,281 |
| 1973 | 118,389 | 2003 | 216,518 |
| 1974 | 127,193 | 2004 | 296,036 |
| 1975 | 136,202 | 2005 | 271,328 |
| 1976 | 137,739 | 2006 | 212,657 |
| 1977 | 139,276 | 2007 | 375,259 |
| 1978 | 140,812 | 2008 | 474,079 |
| 1979 | 142,349 | 2009 | 557,198 |
| 1980 | 143,886 | 2010 | 394,141 |
| 1981 | 98,241 | 2011 | 220,570 |
| 1982 | 107,559 | 2012 | 314,089 |
| 1983 | 138,587 | 2013 | 223,307 |
| 1984 | 147,737 | 2014 | 283,346 |

**Table 4.10.9.** MRIP Atlantic (ME-FL Keys) gray triggerfish discards (numbers of fish released alive) by year and mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). MRFSS estimates adjusted to MRIP APAIS estimates prior to 2013. CH and CH/HB mode adjusted for FHS conversion prior to 2004. CH/HB mode discards are from the Mid-Atlantic and North Atlantic (sub-regions 4 and 5) through 2003. After 2004 CH and HB modes are estimated separately in these sub-regions. *CVs for CH mode 1981-1985 are unavailable.

| | Estimated CH Discards | | Estimated CH/HB Discards | | Estimated HB Discards | | Estimated PR Discards | | Estimated SH Discards | | ALL MODES Discards | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | Number | CV* | Number | CV | Number | CV | Number | CV | Number | CV | Number | CV* |
| 1981 | 1,097 | | 0 | 0.00 | | | 24,048 | 1.37 | 1,053 | 1.27 | 26,199 | 1.26 |
| 1982 | 987 | | 0 | 0.00 | | | 6,847 | 6.05 | 5,639 | 0.99 | 13,473 | 3.10 |
| 1983 | 3,030 | | 0 | 0.00 | | | 35,047 | 1.88 | 17,831 | 0.58 | 55,908 | 1.19 |
| 1984 | 1,604 | | 0 | 0.00 | | | 28,618 | 3.93 | 0 | 0.00 | 30,222 | 3.72 |
| 1985 | 3,609 | | 223 | 0.59 | | | 41,276 | 1.49 | 3,980 | 0.94 | 49,087 | 1.25 |
| 1986 | 108 | 1.56 | 0 | 0.00 | | | 64,688 | 0.63 | 37,477 | 0.67 | 102,272 | 0.47 |
| 1987 | 0 | 0.00 | 0 | 0.00 | | | 77,207 | 0.48 | 2,134 | 0.91 | 79,341 | 0.47 |
| 1988 | 94 | 1.56 | 0 | 0.00 | | | 97,921 | 0.79 | 5,981 | 1.27 | 103,996 | 0.74 |
| 1989 | 245 | 1.66 | 0 | 0.00 | | | 193,961 | 0.38 | 77,575 | 0.83 | 271,781 | 0.36 |
| 1990 | 0 | 0.00 | 544 | 0.59 | | | 82,645 | 0.47 | 4,915 | 0.80 | 88,104 | 0.44 |
| 1991 | 1,461 | 1.30 | 1,629 | 0.45 | | | 206,076 | 0.30 | 106,214 | 0.58 | 315,380 | 0.28 |
| 1992 | 1,295 | 1.97 | 175 | 0.55 | | | 93,107 | 0.32 | 31,667 | 0.32 | 126,244 | 0.25 |
| 1993 | 0 | 0.00 | 465 | 1.49 | | | 73,252 | 0.67 | 8,818 | 0.53 | 82,535 | 0.60 |
| 1994 | 1,954 | 0.86 | 211 | 0.49 | | | 67,650 | 1.06 | 9,964 | 0.41 | 79,780 | 0.90 |
| 1995 | 2,412 | 0.91 | 372 | 0.49 | | | 97,260 | 1.68 | 6,362 | 0.56 | 106,406 | 1.53 |
| 1996 | 2,611 | 1.03 | 61 | 0.55 | | | 86,657 | 0.79 | 40,634 | 0.33 | 129,963 | 0.54 |
| 1997 | 14,420 | 1.47 | 1,861 | 0.55 | | | 81,870 | 0.37 | 7,571 | 0.59 | 105,722 | 0.35 |
| 1998 | 0 | 0.00 | 0 | 0.00 | | | 35,754 | 0.50 | 3,673 | 0.73 | 39,426 | 0.46 |
| 1999 | 7,257 | 0.53 | 250 | 0.55 | | | 51,665 | 0.63 | 4,803 | 0.55 | 63,974 | 0.52 |
| 2000 | 1,416 | 0.74 | 1,296 | 0.31 | | | 59,777 | 0.34 | 11,825 | 0.60 | 74,314 | 0.29 |
| 2001 | 5,509 | 0.43 | 87 | 0.50 | | | 68,106 | 0.38 | 9,370 | 0.55 | 83,072 | 0.32 |
| 2002 | 7,098 | 0.38 | 491 | 0.52 | | | 100,206 | 0.31 | 11,934 | 0.52 | 119,730 | 0.27 |
| 2003 | 4,697 | 0.33 | 0 | 0.00 | | | 148,212 | 0.33 | 8,787 | 0.51 | 161,696 | 0.31 |
| 2004 | 12,995 | 0.38 | | | 8 | 1.00 | 168,123 | 0.77 | 7,752 | 0.67 | 188,878 | 0.69 |
| 2005 | 12,127 | 0.52 | | | 0 | 0.00 | 156,340 | 0.27 | 14,931 | 0.60 | 183,398 | 0.24 |
| 2006 | 7,852 | 0.53 | | | 0 | 0.00 | 147,772 | 0.32 | 5,230 | 0.95 | 160,854 | 0.29 |
| 2007 | 15,941 | 0.37 | | | 0 | 0.00 | 246,607 | 0.36 | 10,816 | 0.62 | 273,363 | 0.33 |
| 2008 | 11,725 | 0.45 | | | 0 | 0.00 | 159,533 | 0.50 | 16,699 | 0.56 | 187,957 | 0.43 |
| 2009 | 12,574 | 1.53 | | | 587 | 0.54 | 216,646 | 0.43 | 27,977 | 0.52 | 257,785 | 0.37 |
| 2010 | 6,211 | 1.23 | | | 0 | 0.00 | 159,558 | 0.52 | 16,486 | 0.62 | 182,256 | 0.46 |
| 2011 | 6,838 | 2.14 | | | 51 | 1.00 | 65,971 | 0.41 | 3,468 | 0.99 | 76,327 | 0.41 |
| 2012 | 4,851 | 1.95 | | | 570 | 0.76 | 72,126 | 0.97 | 22,518 | 0.48 | 100,065 | 0.71 |
| 2013 | 15,443 | 0.24 | | | 95 | 1.08 | 139,333 | 0.27 | 7,209 | 0.23 | 162,080 | 0.24 |
| 2014 | 15,851 | 0.26 | | | 22 | 0.94 | 152,669 | 0.20 | 4,447 | 0.31 | 172,989 | 0.17 |

**Table 4.10.10.** Estimated South Atlantic gray triggerfish discards for SRHS by year and state. Due to headboat area definitions and confidentiality issues, Georgia and East Florida landings must be combined. 2004-2014 uses SRHS logbook discards. 1981-2003 HB mode uses MRIP CH:SRHS discard ratio proxy method. 1974-1980 uses mean MRIP CH:SRHS discard ratio (1981-1985).

| Year | NC | SC | GA/FLE | South Atlantic |
|---|---|---|---|---|
| 1974 | 225 | 35 | 10,629 | 10,889 |
| 1975 | 256 | 22 | 8,823 | 9,101 |
| 1976 | 173 | 18 | 4,746 | 4,937 |
| 1977 | 124 | 25 | 4,900 | 5,049 |
| 1978 | 174 | 12 | 6,797 | 6,984 |
| 1979 | 196 | 9 | 5,565 | 5,770 |
| 1980 | 84 | 16 | 3,064 | 3,163 |
| 1981 | - | - | 14,241 | 14,241 |
| 1982 | - | - | 1,291 | 1,291 |
| 1983 | - | - | 7,519 | 7,519 |
| 1984 | - | - | 1,454 | 1,454 |
| 1985 | 1,044 | 44 | 3,766 | 4,854 |
| 1986 | - | - | 6,533 | 6,533 |
| 1987 | - | - | - | - |
| 1988 | - | - | 1,320 | 1,320 |
| 1989 | - | - | 1,582 | 1,582 |
| 1990 | - | - | - | - |
| 1991 | - | 130 | - | 130 |
| 1992 | 27 | - | 361 | 388 |
| 1993 | - | - | - | - |
| 1994 | 191 | - | - | 191 |
| 1995 | 938 | - | - | 938 |
| 1996 | 222 | - | - | 222 |
| 1997 | - | 234 | 467 | 702 |
| 1998 | - | - | - | - |
| 1999 | 522 | 52 | 2,091 | 2,664 |
| 2000 | - | - | 3,360 | 3,360 |
| 2001 | - | 158 | 3,345 | 3,503 |
| 2002 | - | - | 6,032 | 6,032 |
| 2003 | - | - | 2,349 | 2,349 |
| 2004 | 60 | 226 | 1,681 | 1,967 |
| 2005 | 2 | 142 | 1,929 | 2,073 |
| 2006 | - | 125 | 2,776 | 2,901 |
| 2007 | 6 | 163 | 1,630 | 1,799 |
| 2008 | 56 | 164 | 10,500 | 10,720 |
| 2009 | 44 | 104 | 10,205 | 10,353 |
| 2010 | 5 | 33 | 19,321 | 19,359 |
| 2011 | 103 | 198 | 11,221 | 11,522 |
| 2012 | 4 | 8 | 12,640 | 12,652 |
| 2013 | 207 | 367 | 8,187 | 8,761 |
| 2014 | 284 | 300 | 11567 | 12151 |

**Table 4.10.11.** Number of gray triggerfish measured in the Atlantic (ME-FL Keys) in the MRFSS/MRIP charter fleet by year and state.

| | Charter | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **YEAR** | **FL Keys** | **FLE** | **GA** | **SC** | **NC** | **VA** | **MD** | **DE** | **NJ** | **NY** | **All** |
| 1981 | | | | | | | | | | | |
| 1982 | | | | | | | | | | | |
| 1983 | | | | 1 | | | | | | | 1 |
| 1984 | | | | 1 | | | | | | | 1 |
| 1985 | | | 1 | | | | | | | | 1 |
| 1986 | | 1 | | | | | | | | | 1 |
| 1987 | | | | 2 | | | | | | | 2 |
| 1988 | | | | 1 | 3 | | | | | | 4 |
| 1989 | 1 | 1 | | 3 | 13 | | | 1 | 1 | | 20 |
| 1990 | 2 | | | 1 | 13 | | | | 1 | | 17 |
| 1991 | 1 | 1 | | 1 | 9 | | | | | | 12 |
| 1992 | | | 3 | 2 | 25 | 1 | 1 | | | | 32 |
| 1993 | 2 | | 4 | 3 | 24 | | | | | | 33 |
| 1994 | 4 | | 10 | | 192 | | | | | | 206 |
| 1995 | 1 | 1 | 7 | 1 | 79 | 1 | | 1 | | | 91 |
| 1996 | | | 3 | 2 | 162 | 1 | | | | | 168 |
| 1997 | | 1 | 8 | | 57 | | | | 7 | | 73 |
| 1998 | 1 | 4 | 12 | 9 | 20 | | | | | | 46 |
| 1999 | 1 | 29 | 2 | 41 | 43 | 2 | | | | | 118 |
| 2000 | 5 | 10 | 1 | 13 | 1 | | | | | | 30 |
| 2001 | 3 | 31 | 7 | 37 | 21 | | | | 1 | | 100 |
| 2002 | 4 | 83 | 6 | 20 | 41 | 8 | | | | | 162 |
| 2003 | 5 | 86 | 47 | 1 | 43 | | | | | | 182 |
| 2004 | 4 | 137 | 71 | 39 | 13 | | | 1 | 4 | | 269 |
| 2005 | 2 | 72 | 28 | 1 | 19 | | | 15 | | | 137 |
| 2006 | | 35 | 42 | 9 | 17 | | | | | | 103 |
| 2007 | 3 | 55 | 67 | 1 | 47 | 1 | | 19 | 4 | | 197 |
| 2008 | 3 | 34 | 34 | 1 | 49 | 4 | | 14 | | 1 | 140 |
| 2009 | 2 | 52 | 51 | 9 | 43 | 1 | 1 | 47 | 1 | | 207 |
| 2010 | | 104 | 59 | 11 | 279 | 1 | | 14 | | | 468 |
| 2011 | 3 | 45 | 41 | | 282 | | | 5 | | | 376 |
| 2012 | 5 | 25 | 52 | 7 | 131 | | | 7 | 1 | | 228 |
| 2013 | 2 | 82 | 15 | | 324 | 7 | | 1 | | | 431 |
| 2014 | 4 | 157 | 7 | 3 | 170 | 1 | 7 | 15 | 2 | | 366 |

**Table 4.10.11 (continued).** Number of gray triggerfish measured in the Atlantic (ME-FL Keys) in the MRFSS/MRIP private mode by year and state.

| | Private | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | FL Keys | FLE | GA | SC | NC | VA | MD | DE | NJ | NY | CT | RI | MA | All |
| 1981 | | 6 | | | | | | | | | | | | 6 |
| 1982 | | 14 | | | | | | | | | | | | 14 |
| 1983 | | 8 | | | | | | | 2 | | | | | 10 |
| 1984 | 1 | 10 | | | | | | | | | 1 | | | 12 |
| 1985 | | 20 | 1 | | 1 | | | | | | | | | 22 |
| 1986 | | 16 | | | 2 | 10 | | 2 | | | | 1 | | 31 |
| 1987 | 2 | 11 | 1 | | 3 | 3 | | | | 10 | | | | 30 |
| 1988 | 4 | 15 | | | | | | | | 2 | | | | 21 |
| 1989 | 1 | 25 | | | 15 | 1 | 1 | | 1 | 14 | 1 | | | 59 |
| 1990 | 1 | 8 | 2 | | 12 | 6 | | 3 | 6 | 6 | 1 | | | 45 |
| 1991 | 4 | 7 | 1 | | 6 | 4 | 5 | 8 | | 8 | | 2 | | 45 |
| 1992 | 2 | 13 | | 7 | 6 | 8 | 2 | 4 | 2 | 1 | | | | 45 |
| 1993 | 2 | 12 | 1 | 2 | 37 | 29 | | 1 | | 5 | | 2 | | 91 |
| 1994 | 4 | 4 | | 1 | 37 | 2 | | 1 | | 3 | | 1 | 2 | 55 |
| 1995 | 2 | 8 | | | 2 | 2 | | | 6 | | | | | 20 |
| 1996 | | 3 | | 2 | 53 | 4 | | 7 | | 2 | | | 1 | 72 |
| 1997 | 9 | 5 | | | 22 | | | 15 | | 1 | | | | 52 |
| 1998 | | 5 | 1 | 2 | 4 | 2 | 1 | | 2 | | | 1 | | 18 |
| 1999 | 2 | 24 | | 14 | 9 | | | 1 | | | | | | 50 |
| 2000 | | 7 | | | 16 | 2 | | | | | | | | 25 |
| 2001 | | 11 | 1 | | 23 | 1 | | 6 | 3 | 2 | | | | 47 |
| 2002 | | 30 | | | 11 | 4 | 1 | 1 | 4 | | | | | 51 |
| 2003 | | 27 | | 1 | 1 | 1 | | 1 | 1 | | | 6 | | 38 |
| 2004 | | 14 | 2 | 2 | 4 | 2 | | 7 | 3 | 2 | | | | 36 |
| 2005 | | 20 | | | 1 | 21 | | 3 | 1 | 4 | | | | 50 |
| 2006 | | 41 | 2 | 1 | 4 | 1 | | 2 | | 1 | | | | 52 |
| 2007 | 3 | 53 | 6 | 1 | 5 | 10 | | 7 | 4 | 1 | | | 2 | 92 |
| 2008 | | 33 | 5 | | 14 | 7 | | 2 | | | | | | 61 |
| 2009 | 1 | 42 | | 3 | 15 | | 1 | 2 | 1 | | | | | 65 |
| 2010 | 1 | 50 | | | 46 | 1 | | 3 | 4 | 2 | | | | 107 |
| 2011 | | 39 | | 1 | 8 | | | | 1 | | | | | 49 |
| 2012 | | 45 | 3 | | 7 | 1 | | 3 | 1 | 3 | | | | 63 |
| 2013 | 1 | 44 | 3 | 3 | 13 | 2 | | 17 | | | | | | 83 |
| 2014 | 8 | 80 | 3 | 4 | 7 | | 9 | 7 | 6 | 1 | | | | 125 |

**Table 4.10.11 (continued).** Number of gray triggerfish measured in the Atlantic (ME-FL Keys) in the MRFSS/MRI headboat (sub-regions 4 and 5) and shore modes by year and state.

| | Headboat | | | | | | | | | Shore | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **YEAR** | **VA** | **MD** | **DE** | **NJ** | **NY** | **CT** | **RI** | **MA** | **All** | **Keys** | **FLE** | **NC** | **VA** | **MD** | **DE** | **NJ** | **NY** | **RI** | **All** |
| 1981 | | | | | | | | | | 1 | | | | | | | | | 1 |
| 1982 | | | | 1 | | | | | 1 | | 2 | | | | | | | | 2 |
| 1983 | | | | | | | | | | | 1 | | | | | | | | 1 |
| 1984 | | | | | | | | | | | 6 | | | | | | | | 6 |
| 1985 | 3 | | | | | | | | 3 | | 1 | | | | | | | | 1 |
| 1986 | 2 | | | | | | | | 2 | | | | | | | | | | |
| 1987 | | | | 2 | | | | | 2 | | | | | | | | 4 | | 4 |
| 1988 | | | | | | | | | | | 3 | | | | | | | | 3 |
| 1989 | 1 | 2 | 1 | 1 | 6 | | | | 11 | | | | | | | | 2 | | 2 |
| 1990 | | | 1 | | | | | | 1 | | | 4 | | | | | 2 | | 6 |
| 1991 | | 1 | | 10 | | | | | 11 | 2 | 1 | 1 | | | | | | | 4 |
| 1992 | | 1 | 1 | | | | | | 2 | | 1 | 7 | | | | | 2 | 1 | 11 |
| 1993 | 1 | | | 4 | | | | | 5 | | 1 | 33 | | | 2 | | 2 | | 38 |
| 1994 | 3 | | | | 2 | | | | 5 | | 1 | 2 | | 1 | | | 8 | | 12 |
| 1995 | 2 | | | | | | | | 2 | | 2 | 8 | | 1 | | | | | 11 |
| 1996 | 2 | | | 1 | | | | | 3 | | 1 | 2 | 1 | | | 2 | | 2 | 8 |
| 1997 | 1 | | | 13 | | | | | 14 | | | 1 | | 4 | | 1 | | | 6 |
| 1998 | | | | | | | | | | | | 6 | | | | | | | 6 |
| 1999 | | | 4 | 3 | | | | | 7 | | | | | | | | | | |
| 2000 | 1 | | | | | | | | 1 | | 1 | 1 | | | | 1 | | | 3 |
| 2001 | 5 | | | 2 | | | | | 7 | | 1 | | | | 1 | | | | 2 |
| 2002 | 8 | 1 | | 30 | | | | | 39 | | | | | | | | 3 | | 3 |
| 2003 | 1 | | 1 | | 6 | | | | 8 | | 1 | 6 | | | | | | | 7 |
| 2004 | | 4 | 1 | 9 | 5 | | | 2 | 21 | | | | 2 | | | | | | 2 |
| 2005 | 1 | 6 | | 1 | | | | | 8 | | 1 | 5 | | | 1 | | | | 7 |
| 2006 | 2 | 7 | 2 | | | | | | 11 | | 1 | | | | | | | | 1 |
| 2007 | 7 | 27 | 5 | 26 | 12 | | 1 | | 78 | | 4 | | | | 2 | | | | 6 |
| 2008 | 9 | | 1 | 3 | 2 | | | | 15 | | | | | | | | | | |
| 2009 | 16 | 46 | 1 | 23 | 2 | | 2 | | 90 | | | 8 | | 1 | 1 | 5 | 4 | | 19 |
| 2010 | | 4 | 1 | 1 | 4 | | | 1 | 11 | | 1 | 3 | | | | | 1 | | 5 |
| 2011 | 4 | 2 | 3 | 8 | 2 | | | | 19 | | 1 | | | | | | | | 1 |
| 2012 | 6 | 1 | 19 | 4 | 2 | | | | 32 | | 1 | | | | | 2 | | | 3 |
| 2013 | 1 | 2 | 2 | 1 | | 1 | | | 7 | 2 | | 3 | | | 1 | 1 | | 2 | 9 |
| 2014 | | 9 | 23 | 2 | 5 | | | | 39 | | | 1 | | | | 1 | 1 | 3 | 6 |

**Table 4.10.12.** Number of angler trips with measured gray triggerfish in the Atlantic (ME-FL Keys) in the MRFSS/MRIP charter fleet by year and state.

| | Charter | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **YEAR** | **FL Keys** | **FLE** | **GA** | **SC** | **NC** | **VA** | **MD** | **DE** | **NJ** | **NY** | **All** |
| 1981 | | | | | | | | | | | |
| 1982 | | | | | | | | | | | |
| 1983 | | | | 1 | | | | | | | 1 |
| 1984 | | | | 1 | | | | | | | 1 |
| 1985 | | | 1 | | | | | | | | 1 |
| 1986 | | 1 | | | | | | | | | 1 |
| 1987 | | | | 2 | | | | | | | 2 |
| 1988 | | | | 1 | 2 | | | | | | 3 |
| 1989 | 1 | 1 | | 3 | 3 | | | 1 | 1 | | 10 |
| 1990 | 2 | | | 1 | 8 | | | | 1 | | 12 |
| 1991 | 1 | 1 | | 1 | 8 | | | | | | 11 |
| 1992 | | | 2 | 1 | 16 | 1 | 1 | | | | 21 |
| 1993 | 1 | | 4 | 1 | 9 | | | | | | 15 |
| 1994 | 1 | | 8 | | 28 | | | | | | 37 |
| 1995 | 1 | 1 | 3 | 1 | 20 | 1 | | 1 | | | 28 |
| 1996 | | | 3 | 2 | 16 | 1 | | | | | 22 |
| 1997 | | 1 | 8 | | 11 | | | | 1 | | 21 |
| 1998 | 1 | 2 | 5 | 4 | 4 | | | | | | 16 |
| 1999 | 1 | 11 | 2 | 13 | 8 | 1 | | | | | 36 |
| 2000 | 4 | 4 | 1 | 5 | 1 | | | | | | 15 |
| 2001 | 3 | 19 | 4 | 6 | 9 | | | | 1 | | 42 |
| 2002 | 4 | 41 | 4 | 5 | 13 | 2 | | | | | 69 |
| 2003 | 4 | 41 | 17 | 1 | 8 | | | | | | 71 |
| 2004 | 2 | 43 | 17 | 16 | 7 | | | 1 | 1 | | 87 |
| 2005 | 2 | 27 | 14 | 1 | 5 | | | 2 | | | 51 |
| 2006 | | 20 | 13 | 5 | 5 | | | | | | 43 |
| 2007 | 2 | 23 | 17 | 1 | 8 | 1 | | 6 | 2 | | 60 |
| 2008 | 2 | 23 | 10 | 1 | 14 | 3 | | 3 | | 1 | 57 |
| 2009 | 2 | 23 | 12 | 3 | 11 | 1 | 1 | 13 | 1 | | 67 |
| 2010 | | 38 | 15 | 4 | 25 | 1 | | 4 | | | 87 |
| 2011 | 2 | 12 | 7 | | 22 | | | 3 | | | 46 |
| 2012 | 4 | 15 | 9 | 2 | 28 | | | 7 | 1 | | 66 |
| 2013 | 2 | 20 | 1 | | 20 | 1 | | 1 | | | 45 |
| 2014 | 4 | 62 | 4 | 1 | 25 | 1 | 1 | 1 | 2 | | 101 |

**Table 4.10.12 (continued).** Number of angler trips with measured gray triggerfish in the Atlantic (ME-FL Keys) in the MRFSS/MRIP private mode by year and state.

| | Private | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **YEAR** | **FL Keys** | **FLE** | **GA** | **SC** | **NC** | **VA** | **MD** | **DE** | **NJ** | **NY** | **CT** | **RI** | **MA** | **All** |
| 1981 | | 5 | | | | | | | | | | | | 5 |
| 1982 | | 5 | | | | | | | | | | | | 5 |
| 1983 | | 3 | | | | | | | 1 | | | | | 4 |
| 1984 | 1 | 4 | | | | | | | | | 1 | | | 6 |
| 1985 | | 11 | 1 | | 1 | | | | | | | | | 13 |
| 1986 | | 12 | | | 2 | 6 | | 1 | | | | 1 | | 22 |
| 1987 | 2 | 8 | 1 | | 3 | 1 | | | | 1 | | | | 16 |
| 1988 | 2 | 13 | | | | | | | | 2 | | | | 17 |
| 1989 | 1 | 15 | | | 7 | 1 | 1 | | 1 | 6 | 1 | | | 33 |
| 1990 | 1 | 4 | 1 | | 4 | 3 | | 2 | 2 | 4 | 1 | | | 22 |
| 1991 | 3 | 5 | 1 | | 3 | 1 | 2 | 3 | | 5 | | 2 | | 25 |
| 1992 | 1 | 9 | | 6 | 3 | 3 | 1 | 3 | 1 | 1 | | | | 28 |
| 1993 | 1 | 10 | 1 | 2 | 10 | 6 | | 1 | | 4 | | 2 | | 37 |
| 1994 | 3 | 4 | | 1 | 8 | 1 | | 1 | | 3 | | 1 | 1 | 23 |
| 1995 | 2 | 5 | | | 1 | 2 | | | 6 | | | | | 16 |
| 1996 | | 3 | | 2 | 11 | 4 | | 5 | | 2 | | | 1 | 28 |
| 1997 | 3 | 4 | | | 6 | | | 2 | | 1 | | | | 16 |
| 1998 | | 5 | 1 | 1 | 2 | 2 | 1 | | 1 | | | 1 | | 14 |
| 1999 | 2 | 19 | | 2 | 5 | | | 1 | | | | | | 29 |
| 2000 | | 5 | | | 5 | 2 | | | | | | | | 12 |
| 2001 | | 8 | 1 | | 3 | 1 | | 5 | 2 | 2 | | | | 22 |
| 2002 | | 16 | | | 6 | 2 | 1 | 1 | 4 | | | | | 30 |
| 2003 | | 15 | | 1 | 1 | 1 | | 1 | 1 | | | 1 | | 21 |
| 2004 | | 12 | 1 | 2 | 4 | 2 | | 2 | 1 | 1 | | | | 25 |
| 2005 | | 15 | | | 1 | 2 | | 2 | 1 | 1 | | | | 22 |
| 2006 | | 32 | 2 | 1 | 1 | 1 | | 2 | | 1 | | | | 40 |
| 2007 | 2 | 21 | 2 | 1 | 2 | 7 | | 4 | 3 | 1 | | | 1 | 44 |
| 2008 | | 24 | 2 | | 5 | 5 | | 2 | | | | | | 38 |
| 2009 | 1 | 32 | | 3 | 7 | | 1 | 1 | 1 | | | | | 46 |
| 2010 | 1 | 27 | | | 11 | 1 | | 3 | 3 | 2 | | | | 48 |
| 2011 | | 20 | | 1 | 6 | | | | 1 | | | | | 28 |
| 2012 | | 22 | 1 | | 4 | 1 | | 2 | 1 | 2 | | | | 33 |
| 2013 | 1 | 32 | 2 | 3 | 5 | 2 | | 13 | | | | | | 58 |
| 2014 | 5 | 40 | 2 | 3 | 3 | | 1 | 3 | 5 | 1 | | | | 63 |

**Table 4.10.12 (continued).** Number of angler trips with measured gray triggerfish in the Atlantic (ME-FL Keys) in the MRFSS/MRIP headboat (sub-regions 4 and 5) and shore modes by year and state.

| | Headboat | | | | | | | | | Shore | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | VA | MD | DE | NJ | NY | CT | RI | MA | All | Keys | FLE | NC | VA | MD | DE | NJ | NY | RI | All |
| 1981 | | | | | | | | | | 1 | | | | | | | | | 1 |
| 1982 | | | | 1 | | | | | 1 | | 2 | | | | | | | | 2 |
| 1983 | | | | | | | | | | | 1 | | | | | | | | 1 |
| 1984 | | | | | | | | | | | 3 | | | | | | | | 3 |
| 1985 | 2 | | | | | | | | 2 | | 1 | | | | | | | | 1 |
| 1986 | 2 | | | | | | | | 2 | | | | | | | | | | |
| 1987 | | | | 1 | | | | | 1 | | | | | | | | 2 | | 2 |
| 1988 | | | | | | | | | | | 3 | | | | | | | | 3 |
| 1989 | 1 | 2 | 1 | 1 | 5 | | | | 10 | | | | | | | | 2 | | 2 |
| 1990 | | | 1 | | | | | | 1 | | | 2 | | | | | 2 | | 4 |
| 1991 | | 1 | | 8 | | | | | 9 | 2 | 1 | 1 | | | | | | | 4 |
| 1992 | | 1 | 1 | | | | | | 2 | | 1 | 4 | | | | | 1 | 1 | 7 |
| 1993 | 1 | | | 3 | | | | | 4 | | 1 | 3 | | | 1 | | 1 | | 6 |
| 1994 | 3 | | | | 2 | | | | 5 | | 1 | 1 | | 1 | | | 5 | | 8 |
| 1995 | 2 | | | | | | | | 2 | | 1 | 4 | | 1 | | | | | 6 |
| 1996 | 2 | | | 1 | | | | | 3 | | 1 | 2 | 1 | | | 2 | | 1 | 7 |
| 1997 | 1 | | | 10 | | | | | 11 | | | 1 | | 2 | | 1 | | | 4 |
| 1998 | | | | | | | | | | | | 2 | | | | | | | 2 |
| 1999 | | | 1 | 3 | | | | | 4 | | | | | | | | | | |
| 2000 | 1 | | | | | | | | 1 | | 1 | 1 | | | | 1 | | | 3 |
| 2001 | 5 | | | 2 | | | | | 7 | | 1 | | | | 1 | | | | 2 |
| 2002 | 7 | 1 | | 15 | | | | | 23 | | | | | | | | 1 | | 1 |
| 2003 | 1 | | 1 | | 6 | | | | 8 | | 1 | 2 | | | | | | | 3 |
| 2004 | | 4 | 1 | 6 | 4 | | | 2 | 17 | | | | 1 | | | | | | 1 |
| 2005 | 1 | 5 | | 1 | | | | | 7 | | 1 | 1 | | | 1 | | | | 3 |
| 2006 | 2 | 6 | 2 | | | | | | 10 | | 1 | | | | | | | | 1 |
| 2007 | 7 | 23 | 2 | 16 | 8 | | 1 | | 57 | | 4 | | | | 1 | | | | 5 |
| 2008 | 6 | | 1 | 3 | 2 | | | | 12 | | | | | | | | | | |
| 2009 | 15 | 17 | 1 | 18 | 2 | | 2 | | 55 | | | 4 | | 1 | 1 | 1 | 1 | | 8 |
| 2010 | | 4 | 1 | 1 | 3 | | | 1 | 10 | | 1 | 2 | | | | | 1 | | 4 |
| 2011 | 3 | 2 | 3 | 7 | 2 | | | | 17 | | 1 | | | | | | | | 1 |
| 2012 | 5 | 1 | 11 | 4 | 2 | | | | 23 | | 1 | | | | | 2 | | | 3 |
| 2013 | 1 | 2 | 2 | 1 | | 1 | | | 7 | 1 | | 3 | | | 1 | 1 | | 1 | 7 |
| 2014 | | 9 | 17 | 2 | 3 | | | | 31 | | | 1 | | | | 1 | 1 | 2 | 5 |

**Table 4.10.13.** Number of gray triggerfish measured and number of trips with measured gray triggerfish in the SRHS by year and state, 1972-2014.

| | Fish(N) | | | | Trips(N) | | | |
|---|---|---|---|---|---|---|---|---|
| Year | NC | SC | GA/FLE | South Atlantic | NC | SC | GA/FLE | South Atlantic |
| 1972 | 48 | 64 | | 112 | 29 | 31 | | 60 |
| 1973 | 91 | 5 | | 96 | 47 | 3 | | 50 |
| 1974 | 77 | 221 | | 298 | 42 | 64 | | 106 |
| 1975 | 193 | 184 | | 377 | 67 | 74 | | 141 |
| 1976 | 149 | 191 | 82 | 422 | 67 | 79 | 33 | 179 |
| 1977 | 81 | 300 | 76 | 457 | 46 | 83 | 50 | 179 |
| 1978 | 200 | 148 | 249 | 597 | 52 | 38 | 135 | 225 |
| 1979 | 171 | 32 | 147 | 350 | 36 | 19 | 86 | 141 |
| 1980 | 136 | 94 | 197 | 427 | 40 | 28 | 112 | 180 |
| 1981 | 35 | 39 | 402 | 476 | 19 | 20 | 193 | 232 |
| 1982 | 121 | 100 | 329 | 550 | 43 | 52 | 146 | 241 |
| 1983 | 227 | 103 | 645 | 975 | 72 | 54 | 291 | 417 |
| 1984 | 143 | 184 | 524 | 851 | 58 | 85 | 275 | 418 |
| 1985 | 301 | 95 | 567 | 963 | 77 | 41 | 312 | 430 |
| 1986 | 290 | 83 | 346 | 719 | 76 | 45 | 215 | 336 |
| 1987 | 174 | 75 | 303 | 552 | 64 | 49 | 173 | 286 |
| 1988 | 103 | 75 | 253 | 431 | 40 | 44 | 144 | 228 |
| 1989 | 91 | 53 | 552 | 696 | 26 | 34 | 192 | 252 |
| 1990 | 207 | 32 | 554 | 793 | 42 | 26 | 183 | 251 |
| 1991 | 158 | 63 | 365 | 586 | 40 | 30 | 117 | 187 |
| 1992 | 190 | 270 | 278 | 738 | 44 | 81 | 116 | 241 |
| 1993 | 280 | 310 | 217 | 807 | 49 | 94 | 122 | 265 |
| 1994 | 300 | 468 | 257 | 1,025 | 48 | 92 | 99 | 239 |
| 1995 | 329 | 332 | 207 | 868 | 56 | 90 | 101 | 247 |
| 1996 | 507 | 411 | 103 | 1,021 | 70 | 76 | 43 | 189 |
| 1997 | 632 | 608 | 314 | 1,554 | 78 | 89 | 134 | 301 |
| 1998 | 261 | 290 | 403 | 954 | 72 | 77 | 199 | 348 |
| 1999 | 210 | 176 | 321 | 707 | 58 | 48 | 155 | 261 |
| 2000 | 126 | 76 | 214 | 416 | 47 | 30 | 110 | 187 |
| 2001 | 144 | | 345 | 489 | 53 | | 147 | 200 |
| 2002 | 139 | 139 | 301 | 579 | 35 | 45 | 145 | 225 |
| 2003 | 184 | 179 | 598 | 961 | 40 | 72 | 186 | 298 |
| 2004 | 227 | 51 | 970 | 1,248 | 40 | 22 | 249 | 311 |
| 2005 | 200 | 9 | 739 | 948 | 47 | 7 | 199 | 253 |
| 2006 | 82 | 86 | 592 | 760 | 32 | 46 | 184 | 262 |
| 2007 | 90 | 140 | 687 | 917 | 41 | 61 | 180 | 282 |
| 2008 | 151 | 119 | 385 | 655 | 38 | 30 | 118 | 186 |
| 2009 | 174 | 97 | 566 | 837 | 45 | 31 | 183 | 259 |
| 2010 | 341 | 109 | 863 | 1,313 | 65 | 32 | 228 | 325 |
| 2011 | 172 | 83 | 813 | 1,068 | 57 | 22 | 231 | 310 |
| 2012 | 561 | 34 | 638 | 1,233 | 75 | 12 | 203 | 290 |
| 2013 | 1,540 | 121 | 855 | 2,516 | 87 | 28 | 279 | 394 |
| 2014 | 799 | 76 | 785 | 1,660 | 69 | 20 | 274 | 363 |

**Table 4.10.14.** Mean weight (kg) of gray triggerfish measured in the SRHS by year and state, 1972-2014.

| | NC | | | | SC | | | | GA/FLE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | N | Mean (kg) | Min (kg) | Max (kg) | N | Mean (kg) | Min (kg) | Max (kg) | N | Mean (kg) | Min (kg) | Max (kg) |
| 1972 | 48 | 2.18 | 0.86 | 3.86 | 64 | 2.19 | 1.00 | 3.45 | | | | |
| 1973 | 91 | 2.18 | 0.82 | 4.54 | 5 | 2.09 | 1.32 | 3.09 | | | | |
| 1974 | 77 | 2.50 | 1.00 | 4.68 | 221 | 2.03 | 0.77 | 4.77 | | | | |
| 1975 | 193 | 2.19 | 0.73 | 4.36 | 184 | 2.10 | 0.02 | 4.04 | | | | |
| 1976 | 149 | 2.24 | 0.23 | 4.22 | 191 | 2.08 | 0.41 | 3.68 | 82 | 1.06 | 0.09 | 4.45 |
| 1977 | 81 | 2.50 | 0.50 | 4.50 | 300 | 1.87 | 0.27 | 4.22 | 76 | 1.58 | 0.45 | 4.43 |
| 1978 | 200 | 2.22 | 0.05 | 4.33 | 148 | 1.89 | 0.18 | 3.80 | 249 | 1.25 | 0.18 | 4.06 |
| 1979 | 171 | 2.30 | 0.85 | 5.00 | 32 | 2.36 | 1.05 | 4.15 | 147 | 1.13 | 0.24 | 3.75 |
| 1980 | 136 | 2.35 | 0.27 | 4.05 | 94 | 2.34 | 1.15 | 5.00 | 197 | 1.29 | 0.14 | 7.11 |
| 1981 | 35 | 2.65 | 0.17 | 4.43 | 39 | 2.14 | 0.72 | 3.90 | 402 | 1.10 | 0.12 | 4.01 |
| 1982 | 121 | 2.30 | 0.94 | 4.09 | 100 | 1.88 | 0.47 | 4.80 | 329 | 1.17 | 0.25 | 4.70 |
| 1983 | 227 | 2.03 | 0.40 | 4.65 | 103 | 1.91 | 0.40 | 5.15 | 645 | 0.97 | 0.19 | 4.80 |
| 1984 | 143 | 1.89 | 0.16 | 4.75 | 184 | 1.70 | 0.43 | 5.13 | 524 | 1.18 | 0.20 | 5.31 |
| 1985 | 301 | 1.92 | 0.25 | 4.90 | 95 | 1.77 | 0.26 | 4.90 | 567 | 0.93 | 0.20 | 10.70 |
| 1986 | 290 | 1.81 | 0.12 | 4.05 | 83 | 1.87 | 0.55 | 4.70 | 346 | 0.91 | 0.20 | 4.70 |
| 1987 | 174 | 2.20 | 0.43 | 5.03 | 75 | 1.90 | 0.54 | 4.60 | 303 | 0.83 | 0.12 | 4.00 |
| 1988 | 103 | 1.63 | 0.02 | 8.36 | 75 | 1.51 | 0.39 | 3.00 | 253 | 0.82 | 0.16 | 7.00 |
| 1989 | 91 | 1.57 | 0.40 | 3.64 | 53 | 1.80 | 0.38 | 6.20 | 552 | 0.77 | 0.07 | 6.10 |
| 1990 | 207 | 1.25 | 0.21 | 3.46 | 32 | 1.23 | 0.62 | 2.36 | 554 | 0.72 | 0.09 | 3.11 |
| 1991 | 158 | 1.47 | 0.02 | 8.83 | 63 | 1.00 | 0.33 | 2.03 | 365 | 0.67 | 0.16 | 2.77 |
| 1992 | 190 | 1.03 | 0.32 | 3.30 | 270 | 0.95 | 0.14 | 2.66 | 278 | 0.67 | 0.10 | 3.32 |
| 1993 | 280 | 0.97 | 0.11 | 3.96 | 310 | 1.01 | 0.32 | 4.36 | 217 | 0.78 | 0.18 | 3.30 |
| 1994 | 300 | 0.99 | 0.26 | 3.41 | 468 | 0.91 | 0.18 | 3.32 | 257 | 0.88 | 0.10 | 7.26 |
| 1995 | 329 | 0.91 | 0.22 | 2.54 | 332 | 0.90 | 0.21 | 2.23 | 207 | 0.76 | 0.18 | 4.22 |
| 1996 | 507 | 0.84 | 0.10 | 4.69 | 411 | 0.80 | 0.07 | 3.84 | 103 | 0.94 | 0.37 | 2.96 |
| 1997 | 632 | 0.87 | 0.33 | 3.68 | 608 | 0.80 | 0.02 | 3.02 | 314 | 0.75 | 0.19 | 4.50 |
| 1998 | 261 | 1.06 | 0.35 | 3.69 | 290 | 0.86 | 0.20 | 1.69 | 403 | 0.72 | 0.18 | 3.89 |
| 1999 | 210 | 0.99 | 0.30 | 3.05 | 176 | 0.92 | 0.34 | 2.03 | 321 | 0.79 | 0.23 | 3.64 |
| 2000 | 126 | 0.84 | 0.27 | 1.84 | 76 | 0.91 | 0.34 | 2.00 | 214 | 0.75 | 0.24 | 2.61 |
| 2001 | 144 | 0.94 | 0.28 | 2.00 | | | | | 345 | 0.69 | 0.21 | 4.03 |
| 2002 | 139 | 0.89 | 0.30 | 2.68 | 139 | 0.87 | 0.23 | 2.50 | 301 | 0.73 | 0.12 | 2.67 |
| 2003 | 184 | 0.92 | 0.37 | 2.93 | 179 | 0.85 | 0.24 | 3.05 | 598 | 0.64 | 0.16 | 2.96 |
| 2004 | 227 | 1.04 | 0.19 | 3.96 | 51 | 0.85 | 0.31 | 2.39 | 970 | 0.66 | 0.26 | 2.06 |
| 2005 | 200 | 0.91 | 0.12 | 2.25 | 9 | 1.08 | 0.60 | 2.12 | 739 | 0.61 | 0.22 | 3.93 |
| 2006 | 82 | 0.96 | 0.18 | 2.44 | 86 | 1.02 | 0.11 | 3.72 | 592 | 0.68 | 0.33 | 3.08 |
| 2007 | 90 | 0.96 | 0.33 | 5.67 | 140 | 0.90 | 0.31 | 2.13 | 687 | 0.85 | 0.33 | 3.64 |
| 2008 | 151 | 0.95 | 0.35 | 2.06 | 119 | 0.96 | 0.40 | 1.61 | 385 | 0.91 | 0.23 | 2.60 |
| 2009 | 174 | 0.94 | 0.36 | 9.80 | 97 | 0.97 | 0.34 | 2.38 | 566 | 1.02 | 0.40 | 3.41 |
| 2010 | 341 | 0.89 | 0.24 | 2.77 | 109 | 1.04 | 0.25 | 2.46 | 863 | 1.05 | 0.42 | 3.17 |
| 2011 | 172 | 1.05 | 0.25 | 2.27 | 83 | 0.98 | 0.41 | 2.24 | 813 | 1.10 | 0.15 | 3.46 |
| 2012 | 561 | 1.03 | 0.23 | 8.60 | 34 | 0.95 | 0.47 | 1.88 | 638 | 1.14 | 0.32 | 5.70 |
| 2013 | 1,540 | 0.96 | 0.21 | 2.38 | 121 | 1.06 | 0.43 | 3.28 | 855 | 0.99 | 0.24 | 3.11 |
| 2014 | 799 | 0.98 | 0.34 | 2.43 | 76 | 1.03 | 0.41 | 2.68 | 785 | 1.01 | 0.39 | 3.26 |

**Table 4.10.15.** SCDNR State Finfish Survey number of gray triggerfish measured (total and by mode), mean length, standard deviation of length, and minimum and maximum size range (all modes combined). No length measurements were recorded during 1994, 1995, 1997 and 2012. Total length measurements from 2009-2011 were converted to fork length using the following equation developed at the SEDAR 41 data workshop: FL = 25.58 + 0.80TL ($R^2$ = 0.97).

| Year | Number of Gray Triggerfish Measured | Number of fish measured by mode | | Mean FL(mm) | StDev FL(mm) | Minimum FL(mm) | Maximum FL(mm) |
|---|---|---|---|---|---|---|---|
| | | Charter | Private | | | | |
| 1991 | 3 | | 3 | 346 | 33.40658618 | 310 | 376 |
| 1992 | 7 | | 7 | 286.7142857 | 6.237368187 | 279 | 295 |
| 1993 | 1 | | 1 | 286 | | 286 | 286 |
| 1994 | | | | | | | |
| 1995 | | | | | | | |
| 1996 | 4 | | 4 | 301.5 | 42.4931367 | 255 | 340 |
| 1997 | | | | | | | |
| 1998 | 2 | | 2 | 328 | 4.242640687 | 325 | 331 |
| 1999 | 20 | 6 | 14 | 339.15 | 47.22652578 | 232 | 434 |
| 2000 | 5 | 3 | 2 | 317 | 46.33033563 | 268 | 374 |
| 2001 | 2 | | 2 | 269 | 11.3137085 | 261 | 277 |
| 2002 | 53 | | 53 | 316.490566 | 49.29995422 | 153 | 453 |
| 2003 | 14 | | 14 | 341.9285714 | 45.38631492 | 275 | 415 |
| 2004 | 75 | | 75 | 340.2933333 | 60.81513266 | 230 | 485 |
| 2005 | 4 | | 4 | 288.5 | 7.325753659 | 281 | 298 |
| 2006 | 3 | | 3 | 318.3333333 | 92.11044096 | 255 | 424 |
| 2007 | 1 | | 1 | 326 | | 326 | 326 |
| 2008 | 3 | | 3 | 328.3333333 | 18.50225212 | 310 | 347 |
| 2009 | 12 | | 12 | 295.7133333 | 34.26753919 | 243.98 | 338.38 |
| 2010 | 10 | | 10 | 309.18 | 29.12959549 | 271.98 | 359.18 |
| 2011 | 1 | | 1 | 313.58 | | 313.58 | 313.58 |

**Table 4.10.16.** Number of gray triggerfish aged and number of trips with aged gray triggerfish in the recreational fishery by year, state and mode.

| | Fish(N) | | | | | Trips(N)* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Charter | | Headboat | | Private | Charter | | Headboat | | Private | Fish | Trips |
| Year | FL | NC | FL | NC/SC/GA | FL | FL | NC | FL | NC/SC/GA | FL | (N) | (N)* |
| 1990 | - | - | 18 | - | - | - | - | 10 | - | - | 18 | 10 |
| 1991 | - | - | 5 | 37 | - | - | - | 3 | 21 | - | 42 | 24 |
| 1994 | - | - | 1 | - | - | - | - | 1 | - | - | 1 | 1 |
| 1997 | - | - | 2 | - | - | - | - | 2 | - | - | 2 | 2 |
| 2001 | - | - | - | - | 2 | - | - | - | - | 1 | 2 | 1 |
| 2002 | 5 | - | - | - | - | 4 | - | - | - | - | 5 | 4 |
| 2003 | 5 | - | 37 | - | 1 | 3 | - | 20 | - | 1 | 43 | 24 |
| 2004 | 47 | - | 9 | - | 4 | 18 | - | 4 | - | 2 | 60 | 24 |
| 2005 | 90 | - | 67 | 1 | - | 35 | - | 18 | 1 | - | 158 | 54 |
| 2006 | 28 | - | 63 | 20 | - | 9 | - | 12 | 18 | - | 111 | 39 |
| 2007 | 10 | - | 7 | 62 | - | 1 | - | 3 | 44 | - | 79 | 48 |
| 2008 | 3 | - | 3 | 18 | - | 2 | - | 3 | 10 | - | 24 | 15 |
| 2009 | 1 | - | 2 | 29 | - | 1 | - | 2 | 28 | - | 32 | 31 |
| 2010 | 1 | - | - | 97 | - | 1 | - | - | 55 | - | 98 | 56 |
| 2011 | 1 | - | 1 | 60 | - | 1 | - | 1 | 35 | - | 62 | 37 |
| 2012 | - | - | 22 | 101 | - | - | - | 10 | 25 | - | 123 | 35 |
| 2013 | 4 | 1 | 73 | 416 | - | 4 | 1 | 47 | 82 | - | 494 | 134 |
| 2014 | 28 | 1 | 238 | 319 | - | 8 | 1 | 108 | 79 | - | 586 | 196 |

*Trips (N) is a combination of angler and vessel trips

**Table 4.10.17**. Atlantic (ME-FLE) estimated number of angler trips for charter boat mode, headboat mode, and charter boat/headboat mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). CH and CH/HB mode adjusted for FHS conversion prior to 2004. CH/HB mode estimates are from the Mid-Atlantic and North Atlantic (sub-regions 4 and 5) from 1981-2003. After 2004 CH and HB modes are estimated separately in sub-regions 4 and 5. MRFSS headboat effort from the South Atlantic has been separated from the combined Cbt/Hbt mode and removed. MRFSS/MRIP effort from the Florida Keys is included. *CVs for CH mode 1981-1985 are unavailable.

| | Estimated CH Angler Trips | | Estimated CH/HB Angler Trips | | Estimated HB Angler Trips | |
|---|---|---|---|---|---|---|
| YEAR | Trips | CV* | Trips | CV | Trips | CV |
| 1981 | 702,010 | | 5,127,985 | 0.07 | | |
| 1982 | 766,866 | | 6,448,699 | 0.16 | | |
| 1983 | 1,334,693 | | 5,695,547 | 0.08 | | |
| 1984 | 858,441 | | 3,947,943 | 0.09 | | |
| 1985 | 1,000,384 | | 5,152,262 | 0.16 | | |
| 1986 | 1,128,589 | 0.15 | 4,808,719 | 0.08 | | |
| 1987 | 816,316 | 0.14 | 3,517,564 | 0.08 | | |
| 1988 | 1,078,777 | 0.11 | 2,892,058 | 0.07 | | |
| 1989 | 864,145 | 0.12 | 2,400,947 | 0.07 | | |
| 1990 | 596,793 | 0.10 | 2,531,303 | 0.06 | | |
| 1991 | 684,455 | 0.08 | 2,993,819 | 0.07 | | |
| 1992 | 764,014 | 0.08 | 2,071,191 | 0.07 | | |
| 1993 | 1,056,635 | 0.07 | 3,666,103 | 0.07 | | |
| 1994 | 1,267,497 | 0.06 | 3,198,441 | 0.07 | | |
| 1995 | 1,507,150 | 0.06 | 2,986,512 | 0.07 | | |
| 1996 | 1,560,075 | 0.06 | 2,080,684 | 0.07 | | |
| 1997 | 1,596,206 | 0.06 | 2,680,613 | 0.07 | | |
| 1998 | 1,229,179 | 0.06 | 1,680,101 | 0.07 | | |
| 1999 | 1,000,898 | 0.07 | 1,535,047 | 0.07 | | |
| 2000 | 797,740 | 0.08 | 1,987,412 | 0.06 | | |
| 2001 | 833,305 | 0.08 | 2,216,717 | 0.06 | | |
| 2002 | 807,064 | 0.07 | 1,660,987 | 0.06 | | |
| 2003 | 777,444 | 0.08 | 2,026,445 | 0.06 | | |
| 2004 | 1,426,898 | 0.04 | | | 674,070 | 0.08 |
| 2005 | 1,662,619 | 0.07 | | | 616,961 | 0.04 |
| 2006 | 1,491,721 | 0.04 | | | 886,331 | 0.03 |
| 2007 | 1,917,784 | 0.03 | | | 937,197 | 0.04 |
| 2008 | 1,398,972 | 0.03 | | | 814,575 | 0.02 |
| 2009 | 1,330,537 | 0.03 | | | 774,156 | 0.01 |
| 2010 | 1,126,273 | 0.03 | | | 562,826 | 0.01 |
| 2011 | 1,334,364 | 0.02 | | | 596,969 | 0.01 |
| 2012 | 1,235,797 | 0.02 | | | 589,288 | 0.02 |
| 2013 | 1,445,643 | 0.04 | | | 952,322 | 0.02 |
| 2014 | 1,550,067 | | | | 808,707 | |

**Table 4.10.17 (continued).** Atlantic (ME-FLE) estimated number of angler trips for private/rental boat mode and shore mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). MRFSS/MRIP effort from the Florida Keys is included.

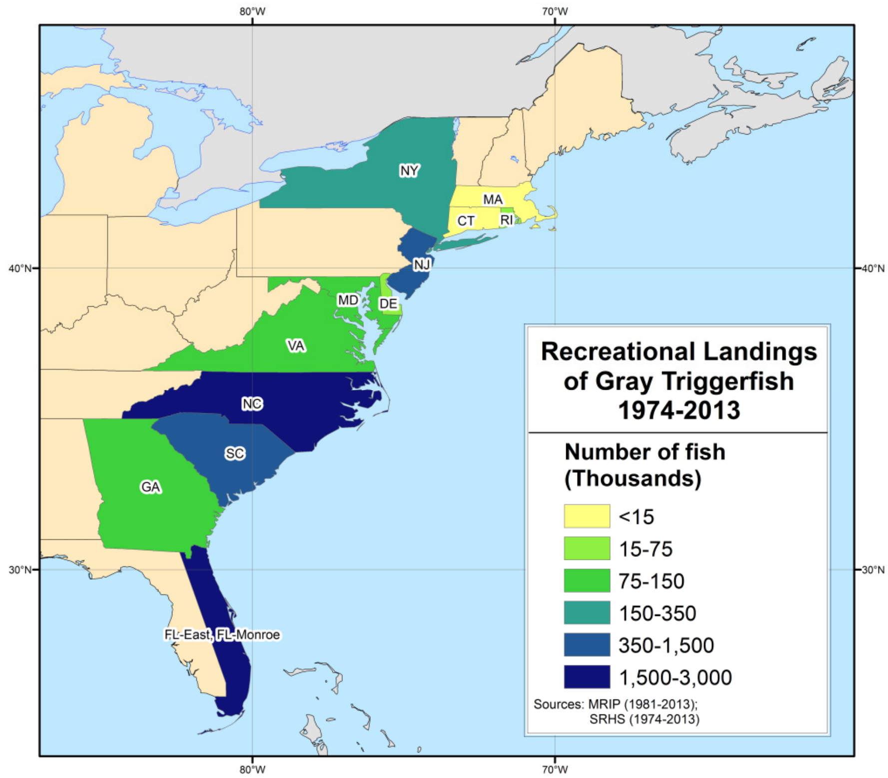
| | Estimated PR Angler Trips | | Estimated SH Angler Trips | | ALL MODES Angler Trips | |
|---|---|---|---|---|---|---|
| YEAR | Trips | CV | Trips | CV | Trips | CV |
| 1981 | 13,684,143 | 0.09 | 13,119,148 | 0.06 | 32,633,286 | 0.05 |
| 1982 | 14,281,195 | 0.04 | 16,820,621 | 0.06 | 38,317,382 | 0.04 |
| 1983 | 17,522,441 | 0.04 | 20,179,678 | 0.07 | 44,732,358 | 0.04 |
| 1984 | 18,146,102 | 0.04 | 17,480,861 | 0.05 | 40,433,347 | 0.03 |
| 1985 | 16,877,411 | 0.04 | 15,911,284 | 0.05 | 38,941,340 | 0.03 |
| 1986 | 20,669,710 | 0.03 | 16,561,685 | 0.04 | 43,168,703 | 0.02 |
| 1987 | 20,507,255 | 0.02 | 15,772,932 | 0.04 | 40,614,067 | 0.02 |
| 1988 | 20,279,058 | 0.02 | 16,877,695 | 0.03 | 41,127,588 | 0.02 |
| 1989 | 17,359,378 | 0.02 | 14,891,530 | 0.04 | 35,515,999 | 0.02 |
| 1990 | 17,663,168 | 0.02 | 13,573,672 | 0.03 | 34,364,937 | 0.02 |
| 1991 | 20,419,927 | 0.02 | 19,321,279 | 0.03 | 43,419,480 | 0.02 |
| 1992 | 17,783,844 | 0.02 | 16,477,154 | 0.02 | 37,096,203 | 0.02 |
| 1993 | 19,497,811 | 0.02 | 17,375,976 | 0.02 | 41,596,525 | 0.02 |
| 1994 | 21,118,885 | 0.02 | 19,639,094 | 0.02 | 45,223,917 | 0.01 |
| 1995 | 19,777,894 | 0.02 | 19,560,606 | 0.02 | 43,832,161 | 0.01 |
| 1996 | 20,117,710 | 0.02 | 18,928,861 | 0.02 | 42,687,330 | 0.01 |
| 1997 | 22,329,740 | 0.02 | 19,544,728 | 0.02 | 46,151,288 | 0.01 |
| 1998 | 19,895,505 | 0.02 | 17,066,719 | 0.02 | 39,871,505 | 0.02 |
| 1999 | 18,471,997 | 0.02 | 15,309,658 | 0.03 | 36,317,601 | 0.02 |
| 2000 | 25,550,773 | 0.02 | 21,314,273 | 0.02 | 49,650,198 | 0.01 |
| 2001 | 26,707,144 | 0.02 | 23,690,798 | 0.02 | 53,447,964 | 0.01 |
| 2002 | 22,509,418 | 0.02 | 19,134,357 | 0.02 | 44,111,826 | 0.01 |
| 2003 | 26,064,529 | 0.02 | 22,316,012 | 0.02 | 51,184,430 | 0.01 |
| 2004 | 26,257,681 | 0.02 | 21,287,755 | 0.03 | 49,646,405 | 0.02 |
| 2005 | 27,156,157 | 0.02 | 22,239,376 | 0.03 | 51,675,112 | 0.02 |
| 2006 | 26,730,425 | 0.02 | 22,794,602 | 0.03 | 51,903,079 | 0.02 |
| 2007 | 29,432,245 | 0.02 | 22,231,673 | 0.03 | 54,518,899 | 0.02 |
| 2008 | 28,216,819 | 0.02 | 22,559,871 | 0.03 | 52,990,238 | 0.02 |
| 2009 | 22,373,114 | 0.02 | 19,017,595 | 0.03 | 43,495,403 | 0.02 |
| 2010 | 23,244,450 | 0.02 | 18,502,636 | 0.03 | 43,436,185 | 0.02 |
| 2011 | 20,569,565 | 0.02 | 17,721,130 | 0.03 | 40,222,029 | 0.02 |
| 2012 | 20,066,105 | 0.02 | 17,338,228 | 0.03 | 39,229,418 | 0.02 |
| 2013 | 18,985,186 | 0.03 | 17,130,730 | 0.03 | 38,513,881 | 0.02 |
| 2014 | 19,592,794 | | 18,182,768 | | 40,134,336 | |

**Table 4.10.18.** South Atlantic headboat estimated angler days by year and state, 1981-2014.

| Year | NC | SC | GA/FLE | South Atlantic |
|---|---|---|---|---|
| 1981 | 19,374 | 59,030 | 298,883 | 377,287 |
| 1982 | 26,939 | 67,539 | 293,133 | 387,611 |
| 1983 | 23,830 | 65,733 | 277,863 | 367,426 |
| 1984 | 28,865 | 67,314 | 288,994 | 385,173 |
| 1985 | 31,384 | 66,001 | 280,845 | 378,230 |
| 1986 | 31,187 | 67,227 | 317,058 | 415,472 |
| 1987 | 35,261 | 78,806 | 333,041 | 447,108 |
| 1988 | 42,421 | 76,468 | 301,775 | 420,664 |
| 1989 | 38,678 | 62,708 | 316,864 | 418,250 |
| 1990 | 43,240 | 57,151 | 322,895 | 423,286 |
| 1991 | 40,936 | 67,982 | 280,022 | 388,940 |
| 1992 | 41,176 | 61,790 | 264,523 | 367,489 |
| 1993 | 42,786 | 64,457 | 236,973 | 344,216 |
| 1994 | 36,691 | 63,231 | 242,781 | 342,703 |
| 1995 | 40,295 | 61,739 | 210,714 | 312,748 |
| 1996 | 35,142 | 54,929 | 199,857 | 289,928 |
| 1997 | 37,189 | 60,150 | 173,273 | 270,612 |
| 1998 | 37,399 | 61,342 | 155,341 | 254,082 |
| 1999 | 31,596 | 55,499 | 164,052 | 251,147 |
| 2000 | 31,351 | 40,291 | 182,249 | 253,891 |
| 2001 | 31,779 | 49,265 | 163,389 | 244,433 |
| 2002 | 27,601 | 42,467 | 151,546 | 221,614 |
| 2003 | 22,998 | 36,556 | 145,011 | 204,565 |
| 2004 | 27,255 | 48,763 | 175,400 | 251,418 |
| 2005 | 31,573 | 34,036 | 172,839 | 238,448 |
| 2006 | 25,736 | 56,074 | 175,522 | 257,332 |
| 2007 | 29,002 | 60,729 | 157,150 | 246,881 |
| 2008 | 17,158 | 47,287 | 123,943 | 188,388 |
| 2009 | 19,468 | 40,919 | 136,420 | 196,807 |
| 2010 | 21,071 | 44,951 | 123,662 | 189,684 |
| 2011 | 18,457 | 44,645 | 132,492 | 195,594 |
| 2012 | 20,766 | 41,003 | 147,699 | 209,468 |
| 2013 | 20,547 | 40,963 | 165,679 | 227,189 |
| 2014 | 22,691 | 42,025 | 195,890 | 260,606 |

## 4.11 Figures

a) **Gray Triggerfish Landings by State 1974-2013**




b) **Gray Triggerfish Landings by State and Year 1974-2014**

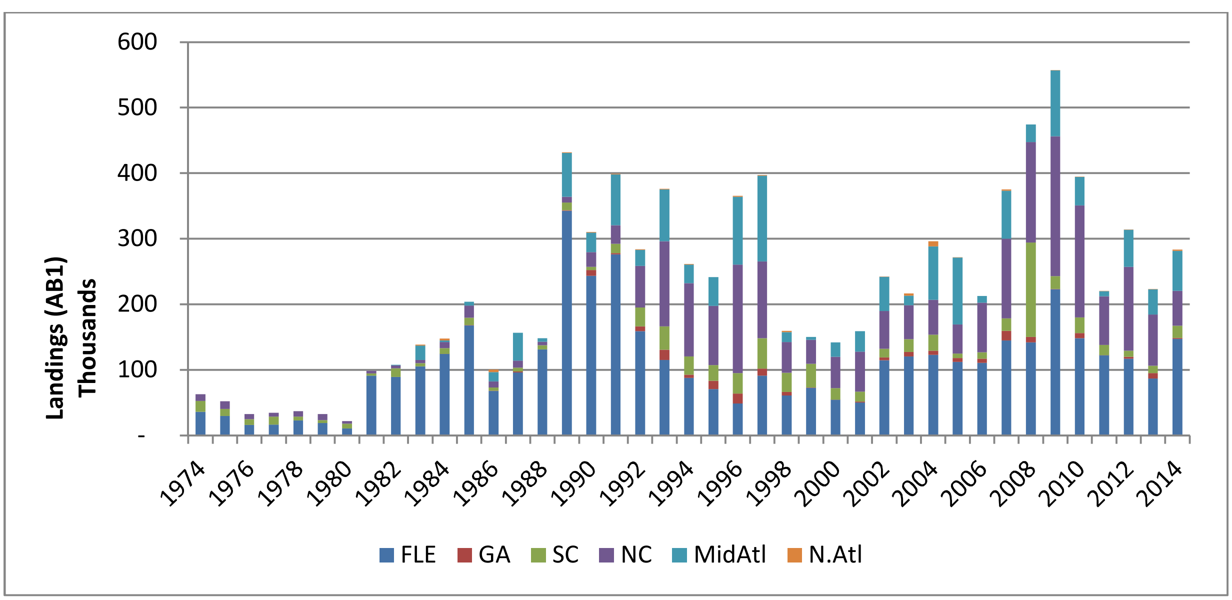
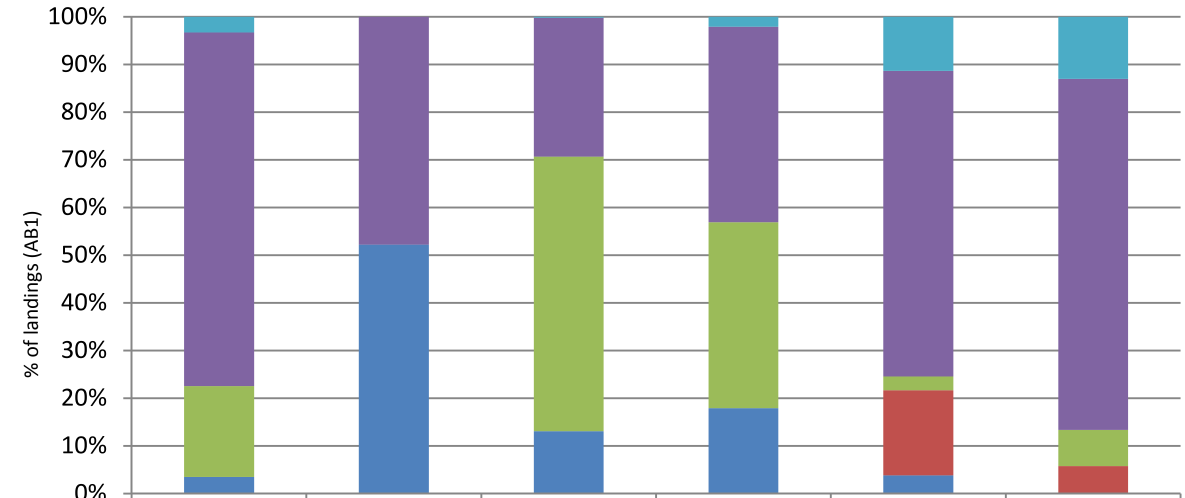



**Figure 4.11.1.** Estimated number of Atlantic gray triggerfish landings from MRFSS/MRIP (1981-2014) and SRHS (1974-2014) by state (a), by state and year (b), and by state and mode (c). East Florida landings include the Florida Keys. North Atlantic states include CT through ME. Mid-Atlantic states include VA through NY. SRHS landings for GA and FLE are grouped and shown in FLE due to vessel confidentiality issues.

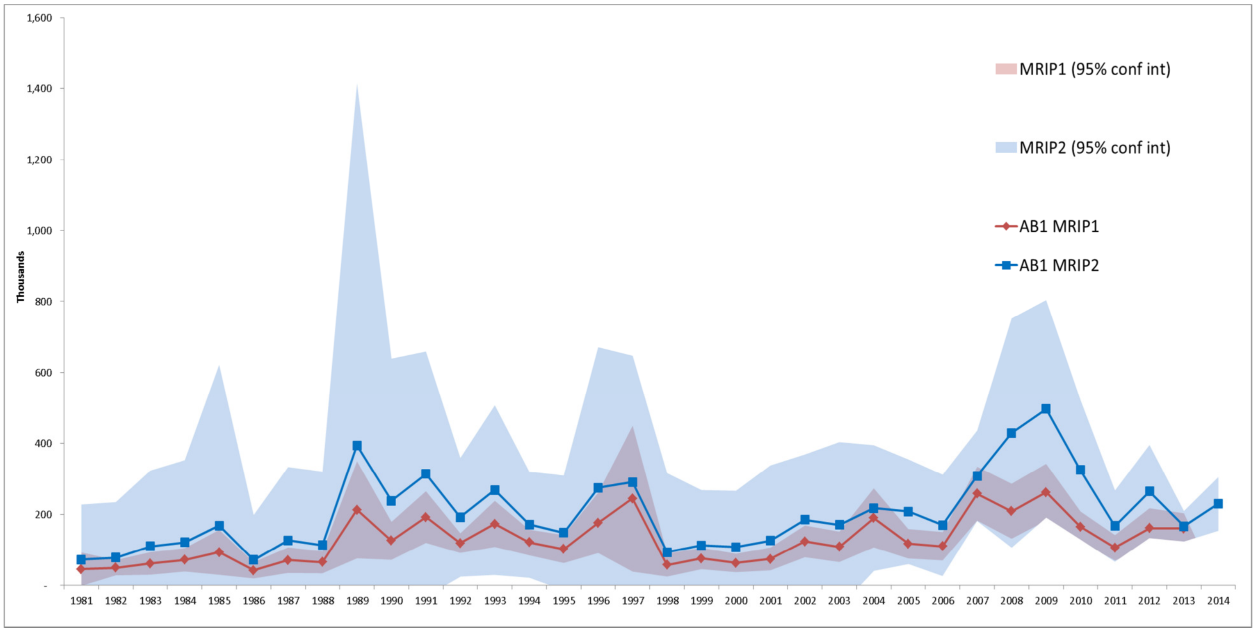
c) **Gray Triggerfish Landings by State and Mode 1974-2014**




| Landings (AB1) | FLE | GA | SC | NC | MidAtl | N.Atl |
|---|---|---|---|---|---|---|
| Shore | 147,444 | 0 | 1,923 | 48,609 | 161,154 | 4,580 |
| Priv | 3,265,667 | 76,910 | 227,440 | 955,621 | 909,530 | 25,757 |
| Hbt | 838,636 | 0 | 449,597 | 907,808 | 40,470 | 2,659 |
| Cbt/Hbt | 0 | 0 | 0 | 0 | 253,395 | 1,946 |
| Cbt | 154,732 | 84,104 | 102,437 | 417,413 | 54,437 | 83 |

**Figure 4.11.1 (continued).** Estimated number of Atlantic gray triggerfish landings from MRFSS/MRIP (1981-2014) and SRHS (1974-2014) by state (a), by state and year (b), and by state and mode (c). East Florida landings include the Florida Keys. North Atlantic states include CT through ME. Mid-Atlantic states include VA through NY. SRHS landings for GA and FLE are grouped and shown in FLE due to vessel confidentiality issues (continued).

a) AB1 (number of fish) landed




b) B2 (number of fish) discarded alive

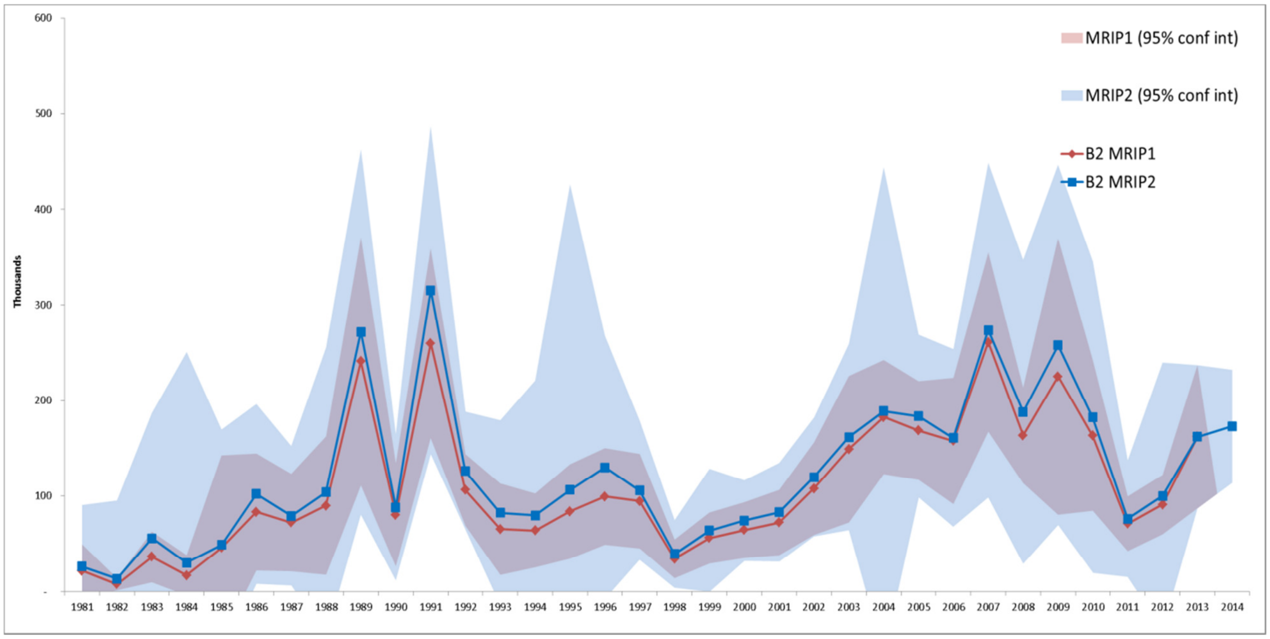



**Figure 4.11. 2.** MRIP estimates versus MRIP APAIS adjusted estimates for Atlantic gray triggerfish 1981-2014. 95% confidence intervals are included.

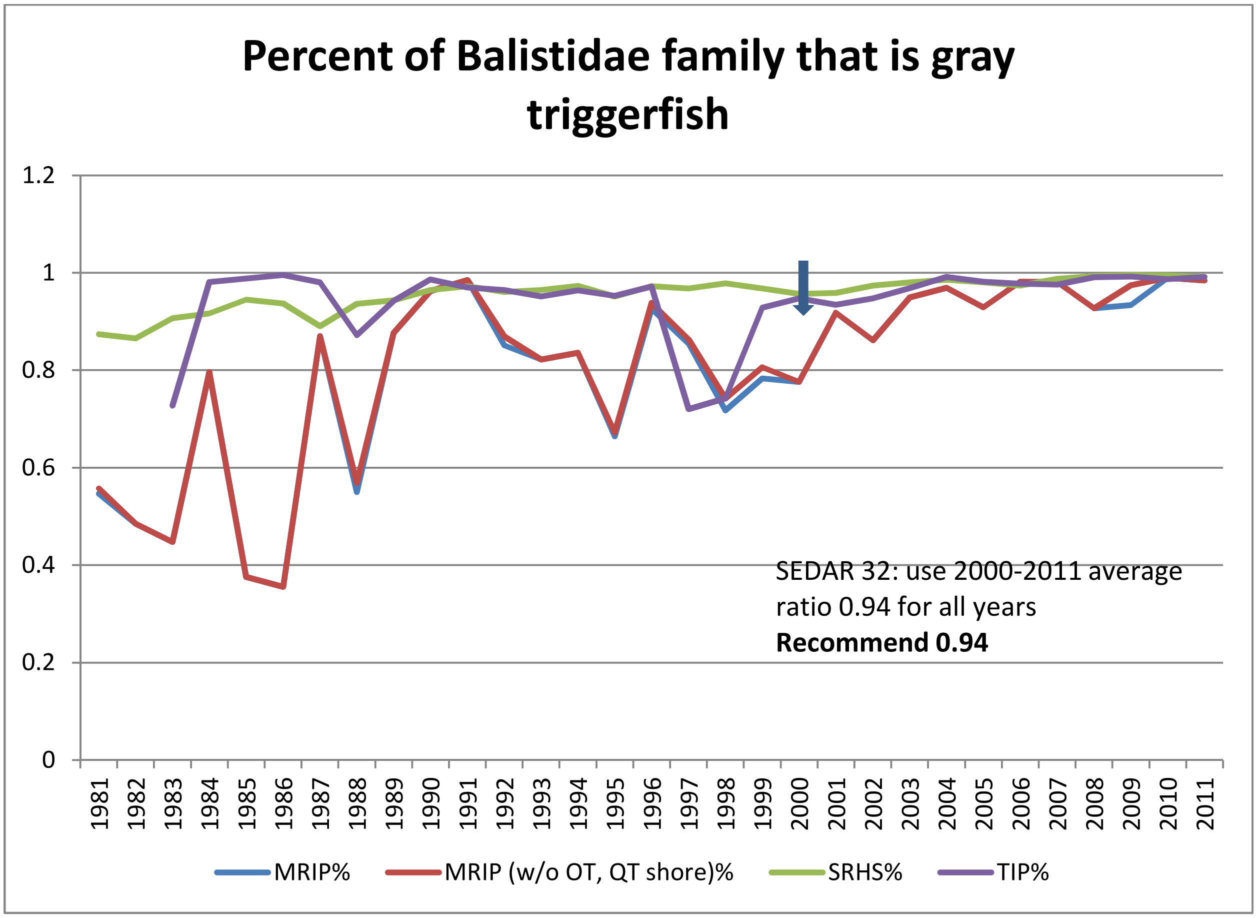



**Figure 4.11.3.** Proportion of identified Balistidae family landings that is gray triggerfish in MRFSS/MRIP, SRHS, and TIP (1981-2011).

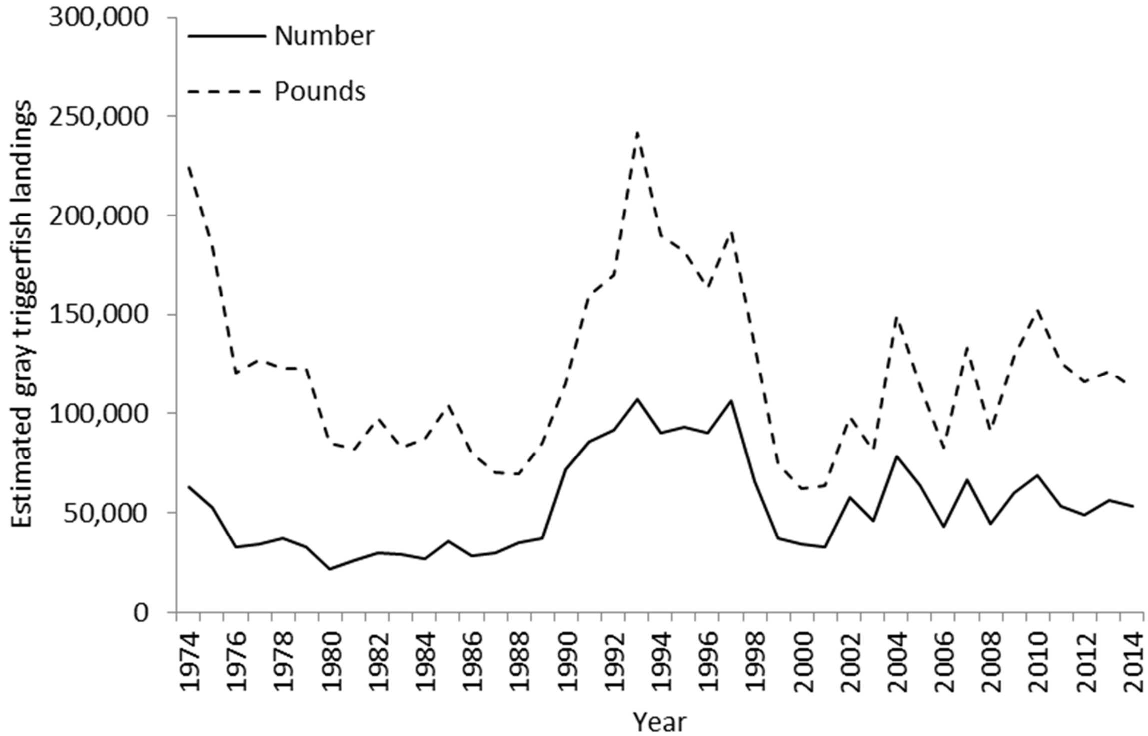



**Figure 4.11.4.** South Atlantic estimated gray triggerfish landings (number and pounds) for the headboat fishery, 1974-2014.

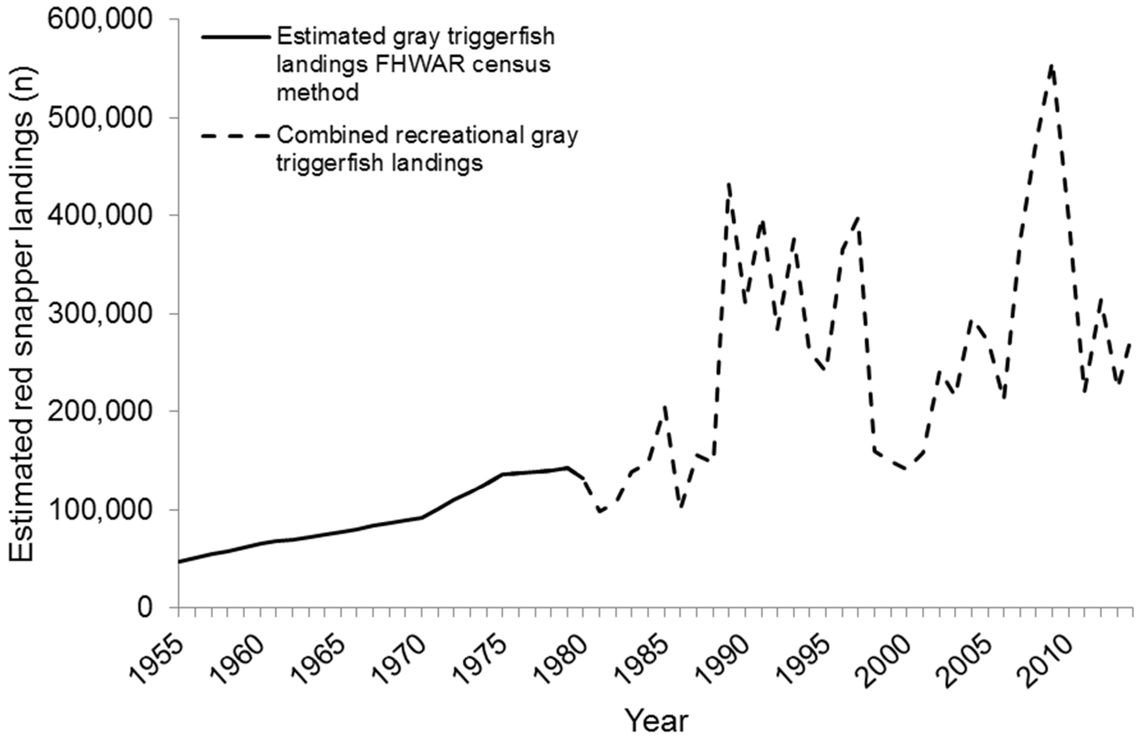



**Figure 4.11.5.** Historic and contemporary recreational gray triggerfish landings using the FHWAR method 1955-1980 and combined MRIP (APAIS adjusted) and SRHS 1981-2014.

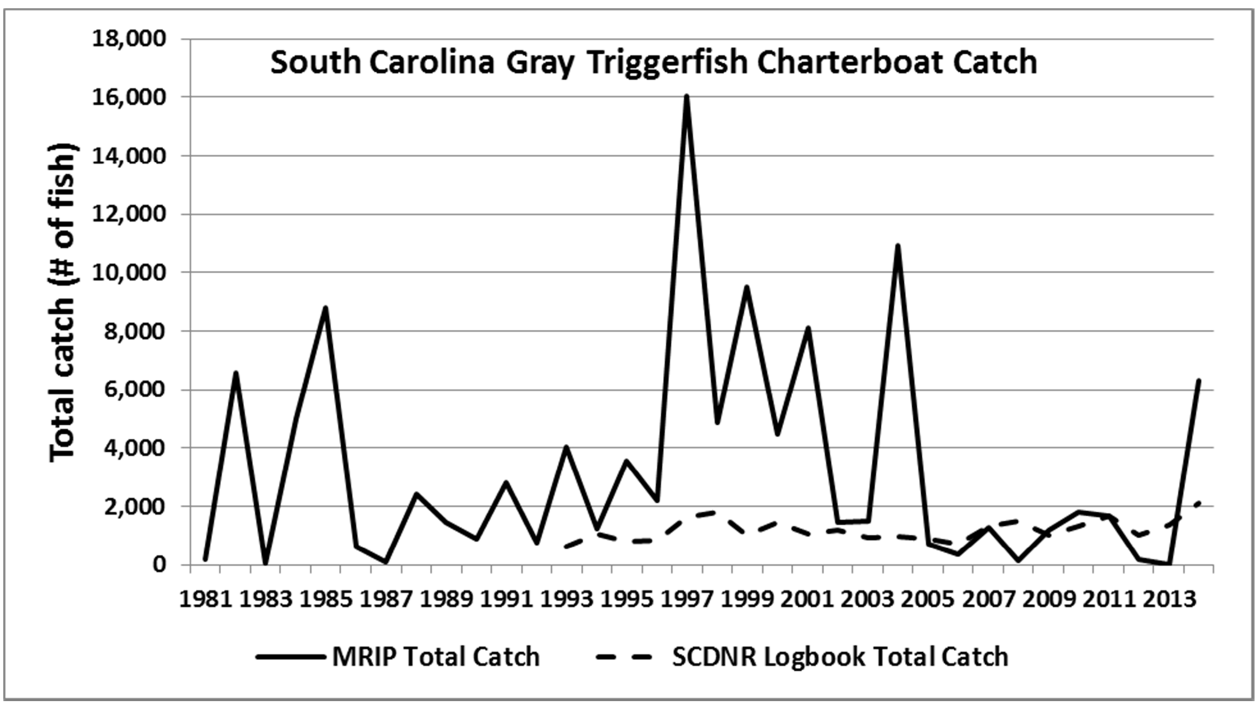
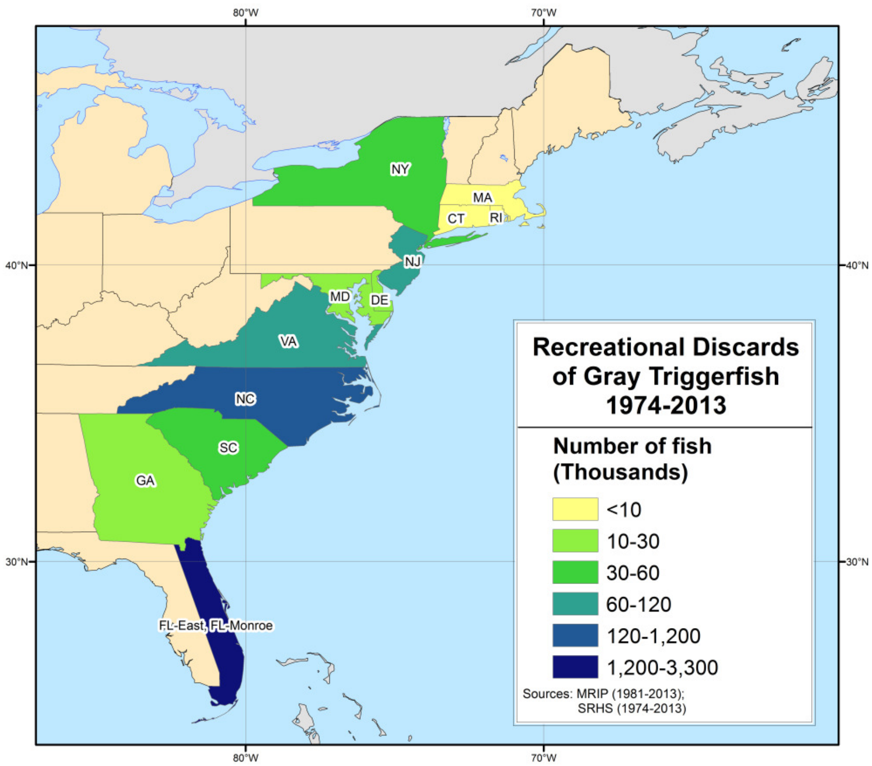



**Figure 4.11.6.** Comparison of SC total gray triggerfish catch (a+b1+b2) from MRIP charter mode and SCDNR charter boat logbook program, 1993-2014. Triggerfish are not reported to species in the SCDNR charter boat logbook program, however, the majority of triggerfish catches are thought to be gray triggerfish.

a) **Gray Triggerfish Discards by State 1974-2013**




b) **Gray Triggerfish Discards by State and Year 1974-2014**

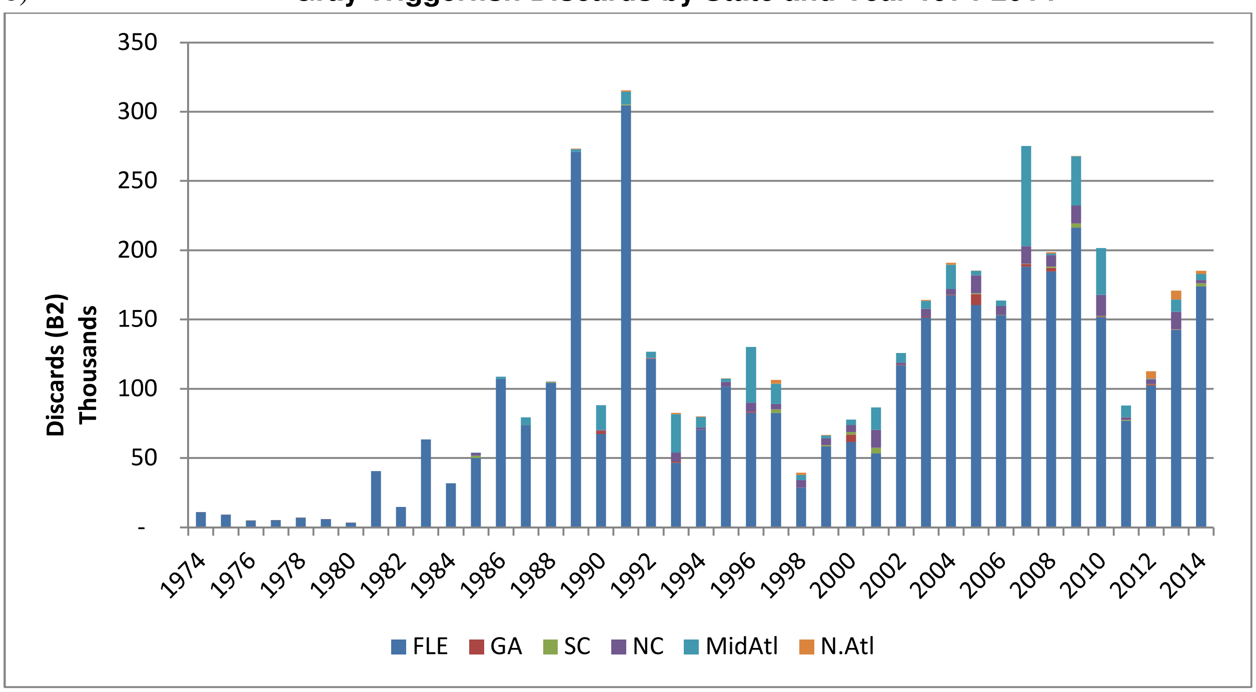
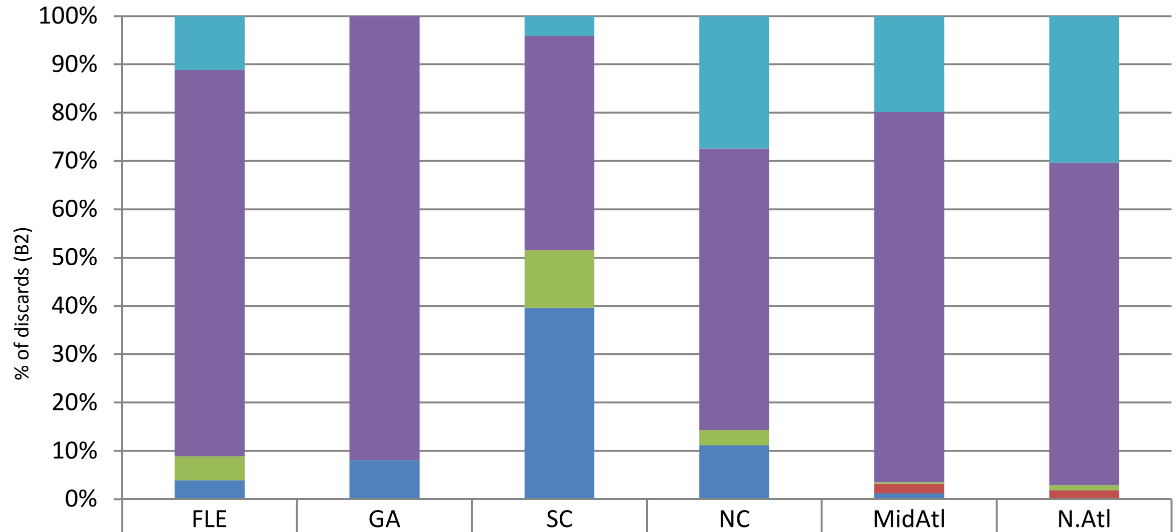



**Figure 4.11.7.** Estimated number of Atlantic gray triggerfish discards from MRFSS/MRIP (1981-2014) and SRHS (1974-2014) by state (a), by state and year (b), and by state and mode (c). East Florida discards include the Florida Keys. North Atlantic states include CT through ME. Mid-Atlantic states include VA through NY. SRHS discards for GA and FLE are grouped and shown in FLE due to vessel confidentiality issues.

c) **Gray Triggerfish Discards by State and Mode 1974-2014**




| Discards (B2) | FLE | GA | SC | NC | MidAtl | N.Atl |
|---|---|---|---|---|---|---|
| Shore | 432,941 | 0 | 901 | 42,403 | 71,776 | 7,719 |
| Priv | 3,090,019 | 22,698 | 9,693 | 90,186 | 276,955 | 16,976 |
| Hbt | 191,893 | 0 | 2,586 | 4,946 | 1,056 | 276 |
| Cbt/Hbt | 0 | 0 | 0 | 0 | 7,201 | 465 |
| Cbt | 151,083 | 2,006 | 8,661 | 17,220 | 4,339 | 3 |

**Figure 4.11.7 (continued).** Estimated number of Atlantic gray triggerfish discards from MRFSS/MRIP (1981-2014) and SRHS (1974-2014) by state (a), by state and year (b), and by state and mode (c). East Florida discards include the Florida Keys. North Atlantic states include CT through ME. Mid-Atlantic states include VA through NY. SRHS discards for GA and FLE are grouped and shown in FLE due to vessel confidentiality issues (continued).

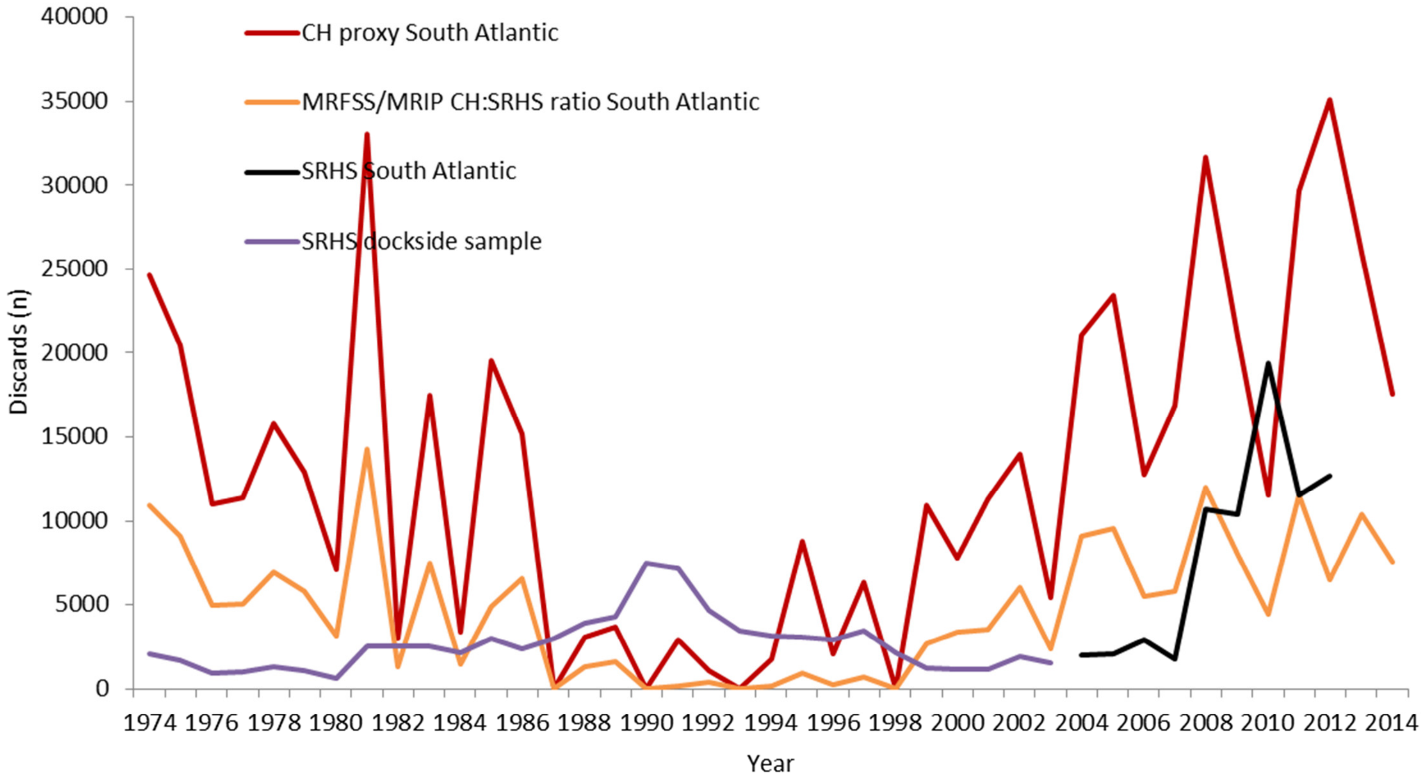



**Figure 4.11.8.** MRIP CH (1981-2014), MRIP PR (1981-2014), MRIP CH:SRHS discard ratio methods (1981-2014), SRHS dockside sample (1981-2003), and SRHS discard ratios (2004-2014)

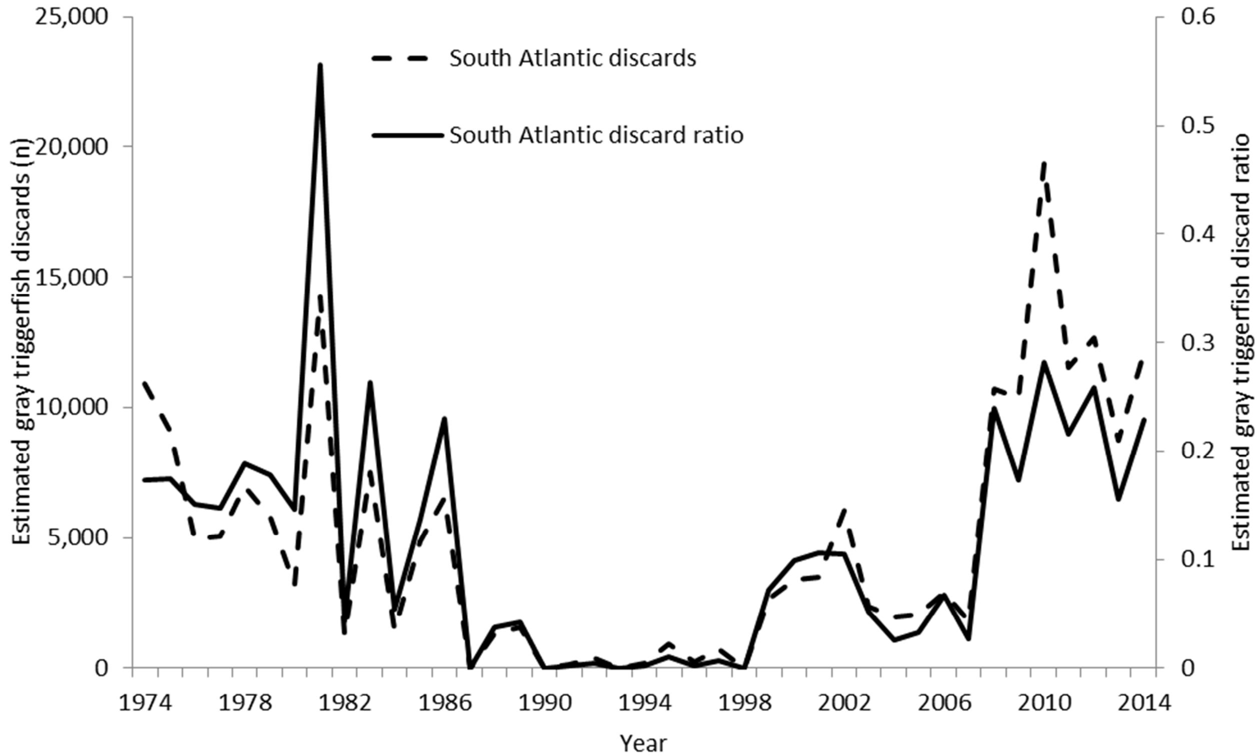
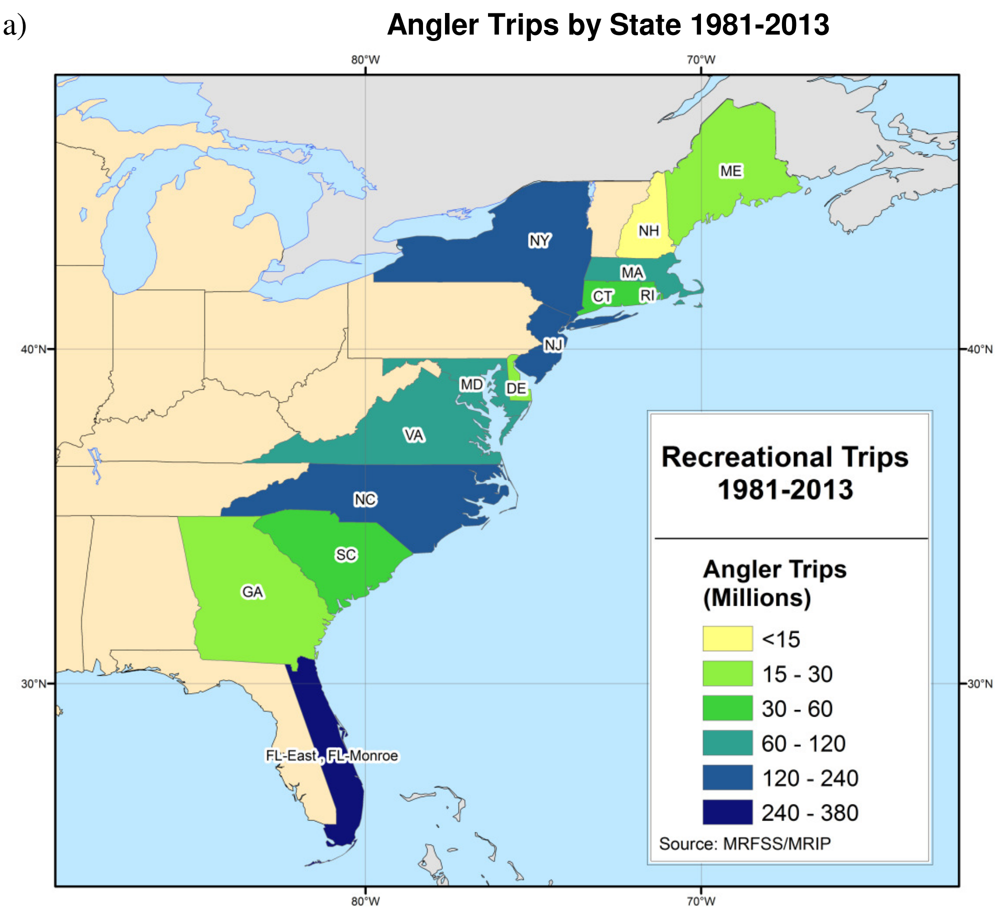



**Figure 4.11.9.** South Atlantic estimated gray triggerfish discards and discard ratio for the headboat fishery (MRIP CH:SRHS proxy method mean ratio (1981-1985) 1974-1980; MRIP CH:SRHS proxy method 1981-2003; SRHS 2004-2014).

a)




b)

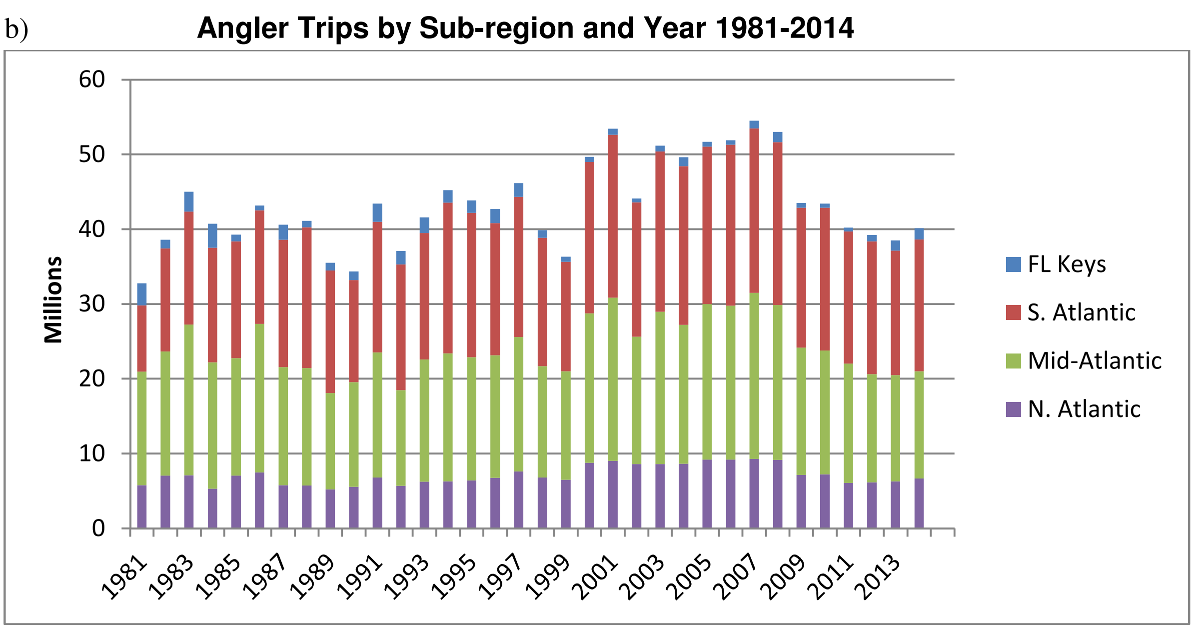
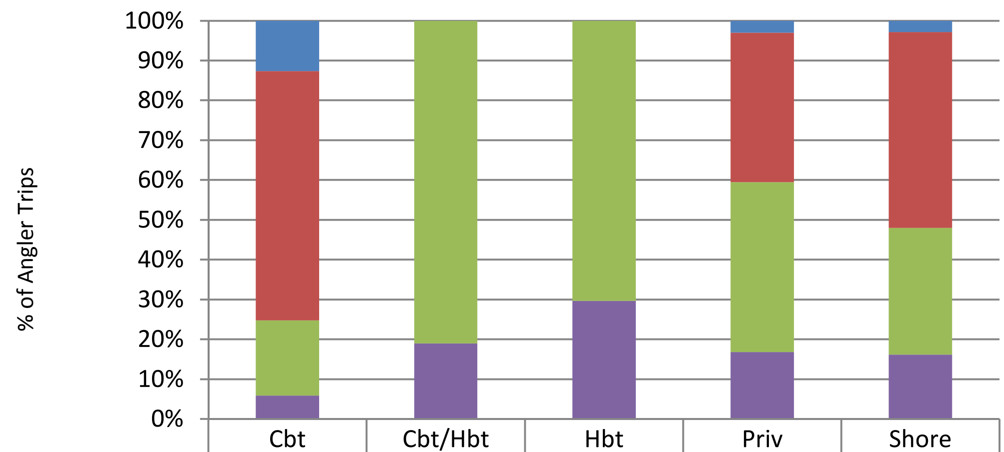



**Figure 4.11.10.** Atlantic estimated number of angler trips from MRFSS/MRIP (1981-2014) by state (a), by sub-region and year (b), and by sub-region and mode (c). MRFSS/MRIP data from ME to FLE, including the Florida Keys. North Atlantic states include CT through ME. Mid-Atlantic states include VA through NY. South Atlantic states include FLE through NC. MRFSS/MRIP headboat effort has been removed from the South Atlantic.

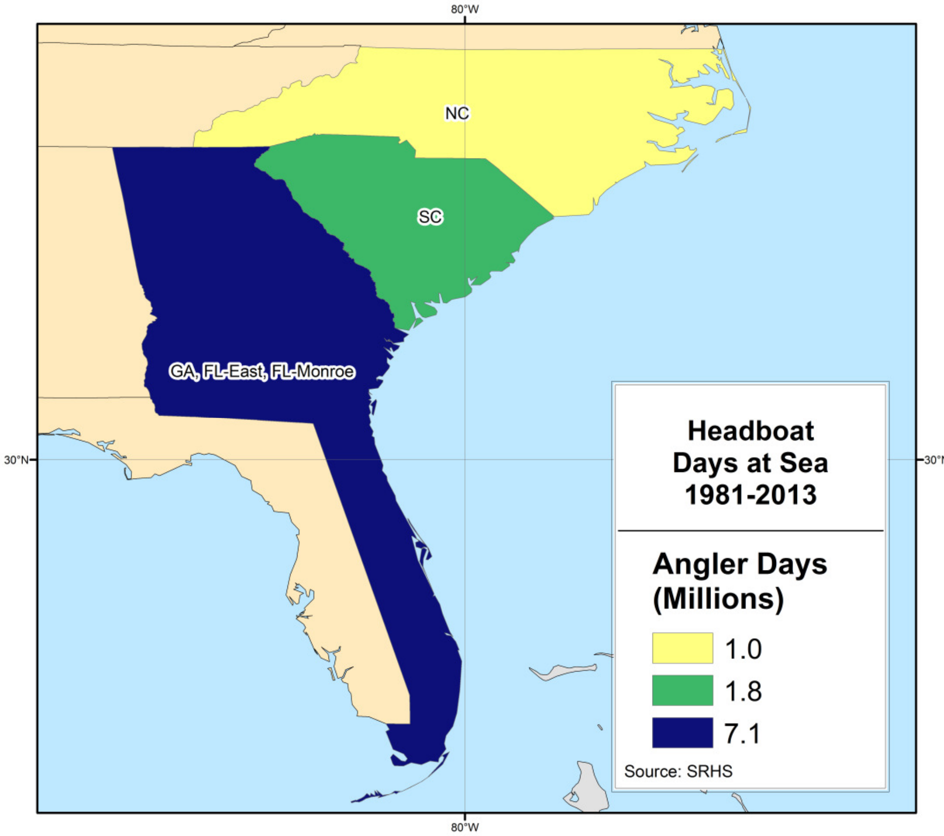
c) **Angler Trips by Sub-region and Mode 1981-2014**




| | Cbt | Cbt/Hbt | Hbt | Priv | Shore |
|---|---|---|---|---|---|
| FL Keys | 4,919,376 | | | 21,795,252 | 18,060,532 |
| S. Atlantic | 24,390,483 | | | 269,941,788 | 309,437,646 |
| Mid-Atlantic | 7,349,626 | 59,425,341 | 5,774,378 | 307,466,380 | 200,513,967 |
| N.Atlantic | 2,289,864 | 13,881,760 | 2,439,026 | 120,656,163 | 101,862,840 |

**Figure 4.11.10 (continued).** Atlantic estimated number of angler trips from MRFSS/MRIP (1981-2014) by state (a), by sub-region and year (b), and by sub-region and mode (c). MRFSS/MRIP data from ME to FLE, including the Florida Keys. North Atlantic states include CT through ME. Mid-Atlantic states include VA through NY. South Atlantic states include FLE through NC. MRFSS/MRIP headboat effort has been removed from the South Atlantic.

a) **Angler Days by State 1981-2013**




b) **Angler Days by State and Year 1981-2014**

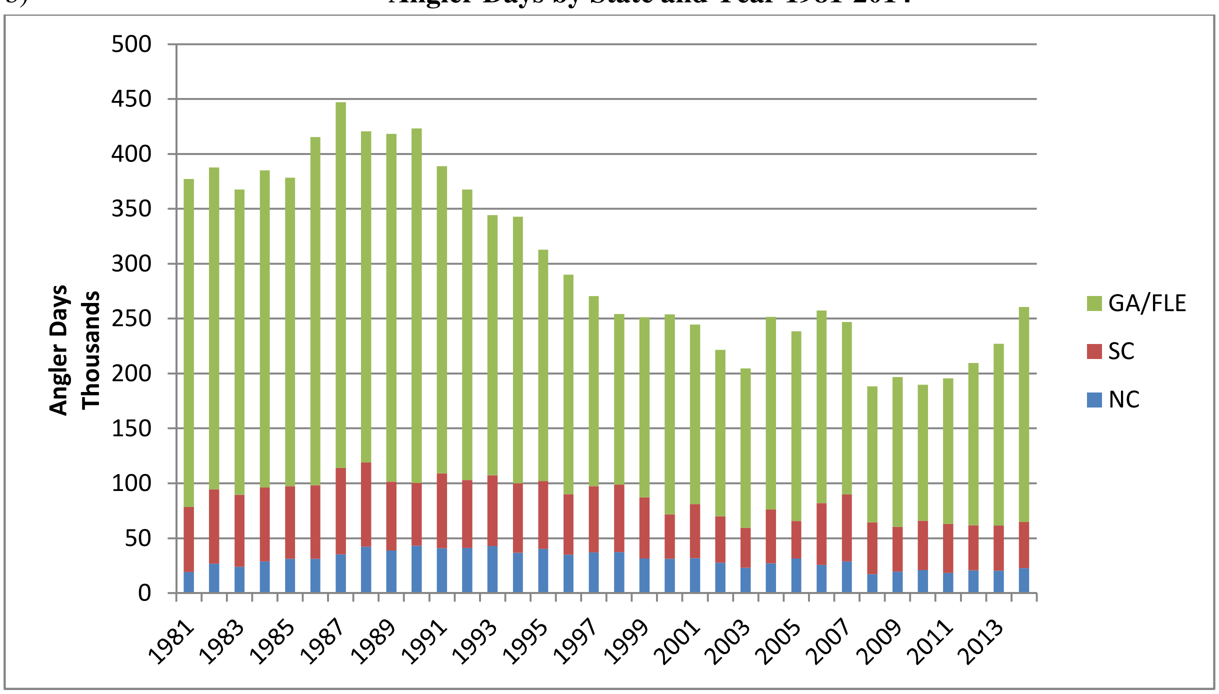



**Figure 4.11.11.** South Atlantic estimated number of headboat angler days from SRHS (1981-2014) by state (a) and by state and year (b). Due to confidentiality concerns, effort from Georgia has been grouped together with East Florida. SRHS data from NC to FLE, including Atlantic side of the Florida Keys.

# 5. Measures of Population Abundance

## 5.1 Overview

Seven fishery independent data sets were considered for use as an index of abundance (Table 5.1). During the data webinar prior to the DW, five of these datasets were discarded because of small sample sizes or limited geographic extent. Two fishery independent data sets were retained for further consideration at the DW: SERFS chevron traps and SERFS video survey.

Five fishery dependent data sets were considered for use as an index of abundance (Table 5.1). During the data webinars, four were recommended for further consideration at the DW. Ultimately, the DW recommended three of these fishery dependent indices for potential use in the assessment model: recreational headboat, general recreational sampled by MRFSS, and commercial handline.

In total, the DW recommended two fishery independent indices (SERFS chevron traps and video survey) and three fishery dependent indices (recreational headboat, MRFSS, and commercial handline) for potential use in the gray triggerfish stock assessment. These indices are listed in Table 5.1, with pros and cons of each in Table 5.2.

**Group membership**

Membership of this DW Index Working Group (IWG) included Nate Bacheler, Joey Ballenger, Nicholas Ballew, Peter Barile, Russ Brodie, Rob Cheshire, Kevin Craig, Eric Fitzpatrick, Kevin Purcell, Christina Schobernd, Kyle Shertzer (chair), Katie Siegfried, Tracy Smart, Ted Switzer, and Erik Williams. Several other DW panelists and observers contributed to the IWG discussions throughout the DW1 and DW2 workshops.

## 5.2 Review of Working Papers

The relevant working papers describing index construction were presented to the IWG. In most cases, the IWG recommended modifications to the initial modeling attempts, such that data treatments and/or model specifications were updated during the DW. Final working papers reflect decisions made during the DW, using addenda if necessary. In addition to working papers on index construction, the IWG also discussed any working papers available at the DW that were relevant to indices of abundance, namely SEDAR41-DW08, SEDAR41-DW11, and SEDAR41-DW46. SEDAR41-DW08 describes a pilot program for data collection using hook gear, SEDAR41-DW11 describes habitat models for gray triggerfish, and SEDAR41-DW46 describes evaluation of the headboat data set.

The index working papers provide information on sample sizes, diagnostics of model fits, and in some cases, maps of catch and effort. A summary of each index is provided below.

## 5.3 Fishery Independent Indices

Until 2009, virtually all fishery independent sampling of reef fishes in southeast U.S. Atlantic waters was conducted by the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program. In 2009, the Southeast Area Monitoring and Assessment Program – South Atlantic (SEAMAP-SA) program joined the chevron trap survey through their Reef Fish Complement. In 2010, the Southeast Fisheries Independent Survey (SEFIS) was created and joined the chevron trap survey. The partner-led survey is now referred to as the Southeast Reef Fish Survey (SERFS). With the advent of the partner programs, sampling coverage in the region has expanded, primarily in Florida. SERFS now samples between Cape Hatteras, North Carolina and St. Lucie Inlet, Florida, and it targets a sampling universe of approximately 3,000 sites of hard-bottom habitats between approximately 15 and 100 meters deep.

### 5.3.1 Chevron Trap

#### *5.3.1.1 Methods, Gears, and Coverage*

Chevron traps were baited with whole and cut Clupeids and deployed at stations randomly selected by computer from a database of live bottom stations on the continental shelf and shelf edge and soaked for approximately 90 minutes.

An index of abundance was developed by standardizing catch (number of gray triggerfish caught) using a zero-inflated negative binomial model (SEDAR41-DW52; Zuur et al. 2009). Effort (trap soak minutes) was included as an offset in the regression. Analyses were computed using the *pscl* library in R (Jackman 2008; Zeileis et al 2008; R Development Core Team 2014). Model covariates were treated as continuous variables and included sampling characteristics and environmental data.

#### *5.3.1.2 Sampling Intensity and Time Series*

Chevron traps were deployed from 1990 through 2014, ranging from 269 to 1465 traps per year meeting the depth criteria for this analysis. The spatial coverage of the survey has adequately covered the center of distribution of gray triggerfish in the region and percent positives were high enough to develop an index of abundance for the full time series. The annual number of traps (collections) used to compute the index is shown in Table 5.3.

#### *5.3.1.3 Size/Age Data*

The ages of gray triggerfish collected by chevron traps (1990-2014) ranged from 0 to 12 years (median = 3, mean = 3.23, n= 10,432). Age composition data are available for estimating the selectivity of this gear.

#### *5.3.1.4 Catch Rates*

Standardized catch rates are shown in Table 5.3 and in Figure 5.1. The units on catch rates are in numbers of fish. Effort was modeled as an offset, rather than as the denominator in the response variable.

#### *5.3.1.5 Uncertainty and Measures of Precision*

Measures of precision were computed using a bootstrap procedure (Efron and Tibshirani 1994), in which sampling events were drawn at random (by year) with replacement. The CVs are shown in Table 5.3.

#### *5.3.1.6 Comments on Adequacy for Assessment*

This index was considered to be adequate for the assessment. The dataset has good spatial coverage relative to the range of gray triggerfish and percent positives were high enough to create a meaningful index. Because the chevron trap index is fishery independent and has accompanying selectivity information (lengths and ages), it was considered by the IWG to be the highest ranking sources of information on trends in population abundance.

Several issues were addressed or discussed. During DW1, models included covariates as categorical variables. For DW2, models applied the zero-inflated negative binomial but included covariates as continuous variables using polynomials and backward selection by Bayesian Information Criterion. The polynomial approach was ultimately adopted. One topic discussed by the group, but not explicitly addressed, was the non-independence between chevron traps and the video survey; this topic was identified for future research.

### 5.3.2 Video Survey

#### *5.3.2.1 Methods, Gears, and Coverage*

In 2010 the SERFS program began attaching video cameras to a limited number of chevron traps (Georgia and Florida only), with cameras being attached to all traps beginning in 2011 as a standard component of the sampling program. An index of abundance for gray triggerfish was developed based on these videos using a zero-inflated negative binomial modeling approach (SEDAR41-DW44, Zuur *et al*. 2009). All data manipulation and analyses were conducted using R (R Development Core Team 2014). Modeling was executed using the *zeroinfl* function in the *pscl* package (Jackman 2008; Zeileis et al. 2008).

#### *5.3.2.2 Sampling Intensity and Time Series*

The video index time series consists of only 4 years (2011-2014). The IWG recognized differences in sampling in 2010 (more limited spatial coverage, different camera), and because video sampling in that year encompassed a limited amount of the gray triggerfish range, the group ultimately thought that 2010 should be excluded from the gray triggerfish index. This decision was in agreement with the recommendations of the Video Index Development Panel, a special working group convened in the spring of 2014 to guide and recommend a set of best practices for the development of a video indices based on SERFS data in the south Atlantic (SEDAR41-RD23).

A total of 4697 videos were considered for development of the gray triggerfish index. Of those, 454 were removed based on modeling considerations (SEDAR41-DW44), leaving a total of 4243 videos for index construction. These data span a wide latitudinal and depth range, covering a substantial region of the south Atlantic coastal shelf (SEDAR41-DW44, Figure 2). Detailed information on the depth, latitudinal, and seasonal distribution of sampling can be found in the index working paper (SEDAR41-DW44, Table 2).

#### *5.3.2.3 Size/Age Data*

As currently implemented, the size and age composition of populations sampled with the SERFS video survey gear are unknown, and therefore selectivity of the gear cannot be estimated from data. However, in a different system, Langlois et al. (2015) compared length compositions of snappers and groupers caught in traps to those observed on video cameras, and found those length compositions to be quite similar. Based on that, the IWG recommended applying selectivity of chevron traps to the video gear, in one of two ways: 1) if chevron trap selectivity is flat-topped, the video gear selectivity should mirror that of the chevron traps, or 2) if chevron trap selectivity is dome-shaped, the video gear selectivity should mirror only the ascending portion and then assume flat-topped selectivity. This recommendation was based on the expectation that the video survey gear should be flat-topped, because there is no known reason why larger (older) individuals would be less observable on video than smaller (younger) individuals. The IWG recognized the need for age/size compositions of the video survey, and recommended future research to remedy this limitation.

#### *5.3.2.4 Catch Rates*

Annual standardized index values for gray triggerfish, including CVs, are presented in Table 5.4 and in Figure 5.2.

#### *5.3.2.5 Uncertainty and Measures of Precision*

Using a bootstrap procedure with 1000 replicates, confidence intervals of 2.5% and 97.5% were calculated for each year of the survey (Figure 5.2), as were CVs (Table 5.4).

#### *5.3.2.6 Comments on Adequacy for Assessment*

The gray triggerfish video index (2011-2014) was recommended for use in the assessment. The resulting index was ranked second of the two fishery independent sources based on the absence of information concerning the age composition of the video sampling gear. Non-independence between the video survey and chevron traps was discussed and identified as a topic for future research.

## 5.4 Fishery Dependent Indices

In general, indices from fishery independent data are believed to represent abundance more accurately than those from fishery dependent data. This is because fishery dependent indices can be strongly affected by factors other than abundance, such as management regulations on the focal or other species, shifts in targeting, changes in fishing efficiency (technology creep), and density dependent catchabililty (hyperdepletion or hyperstability). The standardization procedures attempt to account for some of these issues to the extent possible.

### 5.4.1 Recreational Headboat Index

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

Headboats in the south Atlantic are sampled from North Carolina to the Florida Keys (Figure 5.3). Data have been collected since 1972, but logbook reporting did not start until 1973. In addition, only North Carolina and South Carolina were included in the earlier years of the data set. In 1976, data were collected from North Carolina, South Carolina, Georgia, and northern Florida, and starting in 1978, data were collected from southern Florida.

Variables reported in the data set include year, month, day, area, location, trip type, number of anglers, species, catch, and vessel identification. Biological data and discard data were recorded for some trips in some years.

The IWG discussed the starting and ending years for this index:

- Although data were reported throughout the 1980s, the CPUE during that time period was considered unreliable as a measure of abundance. This was due to increases in desirability to keep gray triggerfish throughout the 1980s, and the fact that the headboat logbooks contained no information on discards during that period.
- Many regulatory changes of snapper-grouper species were implemented in 1992, and they may have affected targeting of gray triggerfish. In addition, a 12-inch size limit was

implemented in 1995 in state and federal waters off the east coast of Florida. For this reason, the index was computed starting in 1995.

- Similarly, regulatory changes in 2010 on other species (implementation of ACLs, red snapper closure) increased the desirability of gray triggerfish. This likely resulted in increased targeting and catchability, and therefore the terminal year of the index was set to 2009. It was noted that fishery independent indices extend through 2014.

#### *5.4.1.1 Methods of Estimation*

**Data Filtering**

The headboat data and programmatic evaluation (SEDAR41-46) found a small percentage of logbook reports to be extreme outliers. Those values were likely erroneous and were removed from the data set prior to deriving the index.

Trips to be included in the computation of the index need to be determined based on effective effort for gray triggerfish. This may not be straightforward, because some trips caught gray triggerfish only incidentally, and some trips likely directed effort at gray triggerfish unsuccessfully. Given that direct information on species targeted is not available, effective effort must be inferred.

To determine which trips should be used to compute the index, the method of Stephens and MacCall (2004) was applied. The Stephens and MacCall method uses multiple logistic regression to estimate a probability for each trip that the focal species was caught, given other species caught on that trip. Species compositions differ across the south Atlantic; thus, the method was applied separately for two different regions: north (areas 2-10) and south (areas 11, 12, and 17) (Shertzer *et al.* 2009). To avoid rare species, the number of species in each analysis was limited to those species that occurred in 1% or more of trips. The most general model therefore included all species in the snapper-grouper complex which occurred in 1% or more of trips as main effects, excluding red porgy. Red porgy was removed because of regulations (closure followed by strict bag limits), which could erroneously remove trips likely to have caught gray triggerfish in recent years. A backward stepwise AIC procedure (Venables and Ripley 1997) was then used to perform further selection among possible species as predictor variables. In this procedure, a generalized linear model with Bernoulli response was used to relate presence/absence of gray triggerfish in headboat trips to presence/absence of other species.

**Model Description**

*Response and explanatory variables*

The response variable, catch per unit effort (CPUE), has units of fish/angler and was calculated as the number of gray triggerfish caught divided by the number of anglers. All explanatory (predictor) variables were modeled as categorical, rather than as continuous.

*Years* – 1995-2009

*Area* – Areas were pooled into regions of North Carolina (NC=2,3,9,10), South Carolina (SC=4,5), Georgia and North Florida (GNFL=6,7,8), and south Florida (sFL=11,12,17).

*Season* – The seasons were defined as winter (January, February, March), spring (April, May, June), summer (July, August, September) and fall (October, November, December).

*Party* – Five categories for the number of anglers on a boat were considered in the standardization process. The categories included: ≤20 anglers, 21-40 anglers, 41-60 anglers, 61-80 anglers, and >80 anglers. The minimum number of anglers per vessel was set at 6, which excluded the lower 0.5% of trips. These trips were excluded because they were possibly misreported and likely don't reflect the behavior of headboats in general.

*Trip Type* – Trip types of half and full day trips were included in the analysis. Three-quarter day trips were pooled with half-day trips (<10%). Multi-day trips were removed because most were in Florida and likely targeting deepwater species for some portion of the trip.

**Standardization**

CPUE was modeled using the delta-glm approach (Lo *et al*. 1992; Dick 2004; Maunder and Punt 2004). In particular, fits of lognormal and gamma models were compared for positive CPUE. Also, the combination of predictor variables was examined to best explain CPUE patterns (both for positive CPUE and the Bernoulli submodels). All analyses were performed in the R programming language (R Development Core Team 2014), with much of the code adapted from Dick (2004).

*Bernoulli submodel.* One component of the delta-GLM is a logistic regression model that attempts to explain the probability of either catching or not catching gray triggerfish on a particular trip. First, a model was fit with all main effects to determine which effects should remain in the binomial component of the delta-GLM. Stepwise AIC (Venables and Ripley1997) with a backward selection algorithm was then used to eliminate those that did not improve model fit. In this case, the stepwise AIC procedure did not remove any predictor variables. No concerning patterns were apparent in the quantile residuals (Dunn and Smyth 1996).

*Positive CPUE submodel.* To determine predictor variables important for describing positive CPUE, the positive portion of the model was fitted with all main effects using both the lognormal and gamma distributions. Stepwise AIC (Venables and Ripley1997) with a backward selection algorithm was then used to eliminate those that did not improve model fit. In this case, no predictor variables were removed for either error distribution.

Both submodels (Bernoulli and either lognormal or gamma) were then combined, and the models were compared using AIC. In this case, the delta-lognormal distribution performed best and was therefore used in the final model. No concerning patterns were apparent in standard diagnostic plots of residuals.

#### *5.4.1.2 Sampling Intensity*

The resulting data set contained more than 38,000 trips across all years with approximately 54–75% of those trips having positive catches of gray triggerfish. Annual numbers of trips used to compute the index are shown in Table 5.5.

#### *5.4.1.3 Size/Age Data*

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

#### *5.4.1.4 Catch Rates*

Standardized catch rates and associated error bars are shown in Figure 5.4, and tabulated in Table 5.5. The units on catch rates were number of fish landed per angler.

#### *5.4.1.5 Uncertainty and Measures of Precision*

Measures of precision were computed using the bootstrap procedure. Annual CVs of catch rates are tabulated in Table 5.5.

#### *5.4.1.6 Comments on Adequacy for Assessment*

The index of abundance created from the headboat data was considered by the IWG to be adequate for use in the assessment. The data cover a wide geographic range relative to most of the stock, and logbooks are intended to represent a census of the headboats. The data set has an adequately large sample size and has a long enough time series to provide potentially meaningful information for the assessment. For the duration of the index, sampling was consistent over time, and some of the data were verified by port samplers and observers.

After DW1, industry representatives questioned the headboat data set, in particular the “veracity of data reported by the fishery” prior to 1992 (SEDAR41-DW40). The DW panel recognized the importance of those concerns, and recommended that the assessment be paused until the headboat data set could be thoroughly evaluated. That evaluation (SEDAR41-DW46) was conducted and available to inform DW2. It found “no evidence of chronic misreporting by vessels, no evidence of apparent temporal trends in potentially misreported data, and minimal spatial trends in potentially misreported data." The evaluation did identify a small percentage of obviously erroneous data that were corrected or removed from the data base, and it recommended that standard data filtering techniques be applied when developing indices of abundance. Such techniques were applied for SEDAR41, and the DW2 index working group thought there was sufficient justification to recommend the headboat index for use in the assessment.

The primary caveat concerning this index was that it was derived from fishery dependent data. Headboat effort generally targets snapper-grouper species and not necessarily the focal species, which should minimize changes in catchability relative to fishery dependent indices that target more effectively. Nonetheless, as regulations have tightened on other co-occurring species, triggerfish have become increasingly targeted, particularly in recent years.

### 5.4.2 Marine Recreational Fisheries Statistics Survey (MRFSS)

The MRFSS access-point angler intercept survey is conducted at public marine fishing access points to collect data on the individual catch of fishers, including species identification, total number and disposition of each species, and length and weight measurements of retained fish, as well as information about the fishing trip and the angler's fishing behavior. Data query and analysis were conducted by ACCSP scientists for the SEDAR32 data workshop.

#### *5.4.2.1 Methods of Estimation*

Gray triggerfish is not typically listed as targeted by recreational fishers, and as a result the standard trip selection methodology employed by MRFSS (i.e. prim1 and prim2) to identify gray triggerfish trips results in data containing almost no zero trips. Preliminary analyses reported in the working paper (SEDAR32-DW06) were based on a lognormal GLM approach on positive trip data. The models and resulting standardized index were not very informative. ACCSP staff suggested using the Jaccard alternative trip-selection method to identify additional trips and increase the number of zero trips.

The Jaccard approach adds trips that do not report gray triggerfish catches but did report catches for other species identified as being highly associated with gray triggerfish. The approach calculates Jaccard coefficients measuring the degree of association between gray triggerfish and all other species. Coefficients are calculated on a species presence-absence matrix and, in this sense, the approach is similar to the Stephens and MacCall (2004) trip-selection approach. However, the Jaccard approach can be appealing because it retains all trips that caught the focal species. The formula for the Jaccard coefficient used to measure the strength of species associations is defined as,

$$S_j = \frac{a}{a+b+c}$$

where a = number of trips where triggerfish and species j were caught, b = number of trips where triggerfish was caught but not species j, and c = number of trips where species j was caught but not triggerfish

Gray triggerfish MRFSS data were subset to include only the private/rental and charter fishing modes, ocean <3 and ocean >3 fishing areas, and hook-and-line gear type. The six MRFSS wave levels were binned into three aggregate "seasonal" levels. In addition, the data were subset to include only Florida (east coast), Georgia, and North Carolina because non-zero gray triggerfish catches were too uncommon in South Carolina and more northern states. Trip data from Georgia and North Carolina were aggregated to increase the number of positive trips in this state group. For SEDAR32, the index was computed for 1993-2011, because only those years contained sufficient trip data then for all factor levels. For SEDAR41, the index developed for SEDAR-32 was truncated to the years 1993-2009, because of snapper-grouper regulatory changes that occurred in 2010 and likely led to increased targeting of gray triggerfish.

Jaccard-based trip selection was conducted on Florida and the Georgia-North Carolina groups separately. Thus, trip selection was based on species associations within each state group. Species identified as being highly associated with gray triggerfish in Florida were yellowtail snapper, white grunt, mutton snapper, vermilion snapper, sand tilefish, and red grouper (listed in descending order of association). Highly associated species in Georgia-North Carolina were vermilion snapper, white grunt, red porgy, red snapper, gag, and scamp (again, listed in descending order). These species agree favorably with those identified through other methods of multivariate analysis, such as cluster analysis (Shertzer and Williams 2008).

The increased number of trips, and in particular the number of zero trips, allowed calculation of a standardized recreational index using the delta log-normal approach. The delta-lognormal approach was used because it incorporates both catch numbers from positive trips and the percentage of trips catching the species of interest (Lo *et al* 1992; Dick 2004; Maunder and Punt 2004). The distribution of gray trigger ln(CPUE) data was described well by the normal distribution. Factors were selected for inclusion in the lognormal positive trip GLM using forward selection based on reductions in deviance for each component. The factors considered included state, wave, area fished, and mode. A factor was included in the model if it reduced residual deviance by 5% or more. The year factor was included in all model runs. The final positive trips model included year, wave, area, and mode, and the final proportion-positive model included year, wave, and state. Note that the wave and state factors used in these models reflect the aggregated groups described above.

#### *5.4.2.2 Sampling Intensity*
More than 12,000 angler-trips, 1993–2011, were included in the analysis. The proportion of positive trips among factors and factor levels varied between 25% and 35%. Annual sample sizes used to compute the index are shown in Table 5.6.

#### *5.4.2.3 Size/Age Data*
The sizes/ages represented in this index should be the similar to those of landings from the corresponding fleet (See section 4 of the DW report). However, this index also includes discards, which presumably occurred primarily off Florida as result of the 12-inch size limit in that location.

#### *5.4.2.4 Catch Rates*
Standardized catch rates and associated error bars are shown in Figure 5.5 and are tabulated in Table 5.6. The units on catch rates were number of fish caught per angler-hour. Caught fish included MRFSS type A (available to samplers) and type B (unavailable to samplers but reported by fishers; includes discards).

#### *5.4.2.5 Uncertainty and Measures of Precision*
Measures of precision were computed using the delta method described by Lo *et al*. (1992). Annual CVs of catch rates are tabulated in Table 5.6.

#### *5.4.2.6 Comments on Adequacy for Assessment*
The dataset has good spatial coverage relative to the range of gray triggerfish. The index included discards and is a sufficiently long time series to be informative for the assessment. While the index created from MRFSS is based on fishery dependent data and MRFSS has had some sampling design problems, the recommendation was to consider this index for use in the assessment.

Although the index was computed starting in 1993, the assessment might justifiably start the index in 1995, when size-limit regulations were implemented off the coast of Florida. Furthermore, the SEDAR41 IWG recommended ending this index in 2009, because of snapper-grouper regulatory changes in 2010 that likely led to increased targeting of gray triggerfish. This recommendation was consistent across all fishery dependent indices.

### 5.4.3 Commercial Handline Index
Landings and fishing effort of commercial vessels operating in the southeast U.S. Atlantic have been monitored by the NMFS Southeast Fisheries Science Center through the Coastal Fisheries

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

Catch per unit effort (CPUE) from the logbooks was used to develop an index of abundance for gray triggerfish landed with vertical lines (manual handline and electric reel), the dominant gear for this gray triggerfish stock. The time series used for construction of the index spanned 1993–2009, when all vessels with federal snapper-grouper permits were required to submit logbooks on each fishing trip. Discussions among the IWG and commercial fishermen at the SEDAR 41 DW revealed targeting changes for gray triggerfish related to the 2010 closure of red snapper and other species (e.g., shallow-water grouper closures). Fishermen indicated that they avoided red snapper since the closure and were targeting other species including gray triggerfish. For this reason the catch rate for gray triggerfish extends only through 2009.

#### *5.4.3.1 Methods of Estimation*

**Data Treatment**

For each fishing trip, the CFLP database included a unique trip identifier, the landing date, fishing gear deployed, areas fished, number of days at sea, number of crew, gear-specific fishing effort, species caught, and weight of the landings. Fishing effort data available for vertical line gear included number of lines fished, hours fished, and number of hooks per line. For this southeast U.S. Atlantic stock, areas used in analysis were those between 24 and 37 degrees latitude, inclusive of the boundaries (Figure 5.6).

Data were restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip. Reporting delays beyond 45 days likely resulted in less reliable effort data (landings data may be reliable even with lengthy reporting delays if trip ticket reports were referenced by the reporting fisher). Also excluded were records reporting multiple gears fished, which prevents designating catch and effort to specific gears. Therefore, only those trips that reported one gear fished were included in the analyses. Where trips reported multiple areas, the first area reported was used in the analysis. Only the latitude from the area designated was used in the analysis assuming most trips with multiple areas fished were moving across the shelf rather than north and south.

Clear outliers (>99.5 percentile) in the data were also excluded from the analyses. These outliers were identified for all snapper/grouper trip manual handlines as records reporting more than 6 lines fished, 8 hooks per line fished, 10 days at sea, 5 crew members or 100 hours fished;

outliers were identified for electric reels as records reporting more than 6 lines fished, 10 hooks per line fished, 12 days at sea, 5 crew members or 137 hours fished. Trips reporting fewer than 4 hours fished for both gears were removed. Positive gray triggerfish trips reporting greater than 12 pounds/hook-hr were excluded for both gears.

To determine which trips should be used to compute the index, the method of Stephens and MacCall (2004) was applied. The Stephens and MacCall method uses multiple logistic regression to estimate a probability for each trip that the focal species was caught, given other species caught on that trip. Species compositions differ across the south Atlantic; thus, the method was applied separately for areas north and south of Cape Canaveral , which has been identified as a zoogeographical boundary (Shertzer et al. 2009). Cape Canaveral falls in the middle of the one degree commercial sampling grid and was assigned to the south with the split at 29 degrees. To avoid rare species, the number of species in each analysis was limited to those species that occurred in 1% or more of trips. The most general model therefore included all species in the snapper-grouper complex which occurred in 1% or more of trips as main effects, excluding red porgy. Red porgy was removed because of regulations (closure followed by strict bag limits), which could erroneously remove trips likely to have caught gray triggerfish in recent years. A backward stepwise AIC procedure (Venables and Ripley 1997) was then used to perform further selection among possible species as predictor variables. In this procedure, a generalized linear model with Bernoulli response was used to relate presence/absence of gray triggerfish in commercial trips to presence/absence of other species. An alternative generalized linear model with Bernoulli response related the catch in pounds of other species to the presence/absence of gray triggerfish. Although the alternative method theoretically may be more efficient at identifying species associations, the IWG rejected the method due to concerns that the increase in trip limits in recent years may bias the results.

**Model Description**

*Response and explanatory variables*

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

CPUE = pounds of gray triggerfish/hook-hour

where hook-hours is the product of number of lines fished, number of hooks per line, and total hours fished. Explanatory variables, all categorical, are described below. The explanatory variables were year, month, area, crew size, and days at sea, each described below:

*Years* – Year was necessarily included, as standardized catch rates by year are the desired outcome. Years modeled were 1993–2009.

*Season* – The seasons were defined as winter (January, February, March), spring (April, May, June), summer (July, August, September) and fall (October, November, December).

*Lat* – Location is reported as latitude and longitude in one degree increments centered at the middle (e.g., CFLP lat=28 is centered at 28.5 degrees). The few trips with latitude reported north of 34 degrees and south of 24 degrees were pooled into the 34 and 24 degree bins, respectively (Figure 5.6).

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

*Days at sea* – Days at sea (sea days) was pooled into three levels: one or two days, three or four days, and five or more days.

**Standardization**

CPUE was modeled using the delta-glm approach (Lo et al. 1992; Dick 2004; Maunder and Punt 2004). In particular, fits of lognormal and gamma models were compared for positive CPUE. Also, the combination of predictor variables was examined to best explain CPUE patterns (both for positive CPUE and the Bernoulli submodels). All analyses were performed in the R programming language (R Development Core Team 2014), with much of the code adapted from Dick (2004).

*Bernoulli submodel*. One component of the delta-GLM is a logistic regression model that attempts to explain the probability of either catching or not catching gray triggerfish on a particular trip. First, a model was fitted with all main effects to determine which effects should remain in the binomial component of the delta-GLM. Stepwise AIC (Venables and Ripley1997) with a backward selection algorithm was then used to eliminate those that did not improve model fit. In this case, the stepwise AIC procedure did not remove any predictor variables. No concerning patterns were apparent in the quantile residuals (Dunn and Smyth 1996).

*Positive CPUE submodel*. To determine predictor variables important for describing positive CPUE, the positive portion of the model was fitted with all main effects using both the lognormal and gamma distributions. Stepwise AIC (Venables and Ripley1997) with a backward selection algorithm was then used to eliminate those that did not improve model fit. In this application, the lognormal distribution outperformed the gamma distribution.

Both submodels (Bernoulli and lognormal) were then combined into a single delta-lognormal model (1993-2009), with all predictors used for both submodels. No concerning patterns were apparent in standard diagnostic plots of residuals.

##### *5.4.3.2 Sampling Intensity*
Annual numbers of trips used to compute the index is typically greater than 1000, as shown in Table 5.7.

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

##### *5.4.3.4 Catch Rates*
Standardized catch rates and associated error bars are shown in Figure 5.7 and are tabulated in Table 5.7. The units on catch rates were pounds of fish landed per hook-hour.

##### *5.4.3.5 Uncertainty and Measures of Precision*
Estimates of variance were based on 1000 bootstrap runs where trips were chosen randomly with replacement (Efron and Tibshirani 1994). Annual CVs of catch rates are tabulated in Table 5.7.

##### *5.4.3.6 Comments on Adequacy for Assessment*
The index of abundance created from the commercial logbook data was considered by the IWG to be adequate for use in the assessment. The data cover a wide geographic range relative to that of the stock, and logbooks represent a census of the fleet. The data set has an adequately large sample size and has a long enough time series to provide potentially meaningful information for the assessment. The primary caveat concerning this index was that it was derived from fishery dependent data. Although the index was computed starting in 1993, the assessment might justifiably start the index in 1995, when size-limit regulations were implemented off the coast of Florida.

#### 5.4.4 Other Fishery Dependent Data Sources Considered During the DW
Several data sources were discussed during the pre-DW webinar for the potential to support indices of abundance, and some of these were discarded based on initial summaries of data. One data source was recommended during the webinar for further consideration, but was subsequently not recommended by the DW for use in the assessment: headboat at-sea observer data (Tables 5.1, 5.2).

The IWG recognized the potential utility of the headboat at-sea observer data set for some stocks. However, the IWG did not recommend it for use in this assessment, primarily because this fleet is already represented by the headboat index, which was preferred. The IWG considered starting the at-sea observer index in 2010 when the headboat index ends, but was concerned about changes in catchability after 2010 and recognized the availability of two fishery independent indices in recent years. Instead, the at-sea observer index was used in this assessment for comparison to other recreational indices. For years of overlap (2005-2009), it tracked favorably with the headboat index (Pearson correlation = 0.90) and with the MRFSS index (Pearson correlation = 0.97). This comparison increased confidence that recreational indices were all influenced by the same underlying driver(s), presumably abundance.

## 5.5 Consensus Recommendations and Survey Evaluations

The DW recommended two fishery independent (chevron traps and videos) and three fishery dependent indices (headboat, MRFSS, commercial handline) for potential use in the gray triggerfish stock assessment. Pearson correlations and significance values (p-values) between indices are presented in Table 5.8. All recommended indices and their CVs are in Table 5.9, and the indices are compared graphically in Figure 5.8.

The IWG discussed relative ranking of the ability of each index to represent true population abundance. Based on these discussions, the indices recommended for the assessment were ranked as follows, with pros and cons of each listed in Table 5.2.

1. Chevron traps
2. Video
3. Headboat index
4. Commercial handline index
5. MRFSS

Note that these rankings were made during the DW and are based solely on *a priori* information about each index. Therefore, the rankings should be considered preliminary, as they do not benefit from viewing indices for consistency with other data sets (e.g., age composition data). The assessment panel, with all data in hand, will be in a better position to judge the indices for use in the assessment.

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## 5.7 Tables

**Table 5.1.** Table of the data sources considered for indices of abundance.

| Fishery Type | Data Source | Area | Yrs | Units | Standardization Method | Issues | Use? |
|---|---|---|---|---|---|---|---|
| Recreational | Headboat | NC-FL | 1995-2009 | N kept/ angler | Delta-GLM | Fishery dependent, self reported | Yes |
| Recreational | MRFSS | NC-FL | 1993-2009 | N caught/ angler-hr | Delta-GLM | Fishery dependent. Potential bias in intercepts. | Yes |
| Recreational | Headboat-at-sea-observer | NC-FL | 2005-2009 | N caught/ angler | Delta-GLM | Fishery dependent. Samples same fleet as headboat. | No |
| Recreational | SCDNR charterboat logbook | SC | 1993-2013 | N caught/ angler-hr | Delta-GLM | Limited geographic coverage; fleet included in MRFSS index; does not identify triggerfish to species | No |
| Commercial | Commercial logbook handline | NC-FL | 1993-2009 | lb kept/ hook-hour | Delta-GLM | Fishery dependent, self reported | Yes |
| Independent | SERFS: chevron trap | NC-FL | 1990-2014 | N caught | Zero inflated negative binomial | Expanded spatial coverage through time | Yes |
| Independent | SERFS: video survey | NC-FL | 2011-2014 | N observed | Zero inflated negative binomial | Ages/sizes unknown | Yes |
| Independent | SEAMAP trawl survey | SC | | | | Few samples | No |
| Independent | MARMAP: blackfish trap | Mostly SC | 1981-1987 | | | Few samples | No |
| Independent | MARMAP: Florida trap | Mostly SC | 1981-1987 | | | Few samples | No |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Independent | MARMAP: Short-bottom longline | | | | | Few samples | No |
| Independent | MARMAP: Kali pole | | | | | Few samples | No |

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

<u>Fishery independent index</u>
SERFS Chevron Trap Index (*Recommended for use*)
Pros:

- Fishery independent random hard bottom survey
- Adequate regional coverage
- Standardized sampling techniques
- All fish caught are aged and measured

Cons:

- Short time series

SERFS Video Index (*Recommended for use*)
Pros:

- Fishery independent random hard bottom survey
- Adequate regional coverage
- Standardized sampling techniques
- Relatively high detection probabilities
- Likely to be less selective than capture gears

Cons:

- Short time series
- Ages/sizes observed are unknown

<u>Fishery dependent indices</u>
Recreational Headboat (*Recommended for use*)
Pros:

- Complete census
- Covers the entire management area
- Some data are verified by port samplers and observers
- Large sample size
- Strongly correlated with headboat at-sea-observer index
- Generally non-targeted for focal species, which should minimize changes in catchability relative to fishery dependent indices that target specific species

Cons:

- Fishery dependent (i.e., potentially affected by regulations, targeting, hyperdepletion, hyperstability)
- Little information on discard rates, particularly before mid-2000s
- Catchability may vary over time or with abundance
- Effective effort is difficult to identify

General recreational (MRFSS) (*Recommended for use*)
Pros:

- Intercept data by port samplers
- Spans the management area
- Includes estimates of discards

Cons:

- Fishery dependent (i.e., potentially affected by regulations, targeting, hyperdepletion, hyperstability)
- Catchability may vary over time or with abundance
- Potential bias in trips intercepted
- High variability
- Effective effort is difficult to identify

Commercial Logbook – Handline (*Recommended for use*)
Pros:

- Complete census
- Covers the entire management area
- Large sample size

Cons:

- Fishery dependent (i.e., potentially affected by regulations, targeting, hyperdepletion, hyperstability)
- Data are self-reported and largely unverified
- Catchability may vary over time or with abundance
- Landings could be cross-referenced with other data sources, but effective effort difficult to identify
- No information on discard rates
- Potential shifts in species targeted; commercial fishermen more skillful than general recreational fishermen at targeting focal species

Headboat at-sea observer index (*Not recommended for use*)
Pros:

- Observer program
- Good discard data (provides amount of discards and length frequency)
- Random sampling design
- Broad spatial coverage

Cons:

- Fishery dependent (i.e., potentially affected by regulations, targeting, hyperdepletion, hyperstability)

- Relatively short time series
- Information overlaps with headboat index
- Coverage of fleet is ~2%, but varies across states

SCDNR Charterboat *(Not recommended for use)*

Pros:

- Census

Cons:

- Fishery dependent (i.e., potentially affected by regulations, targeting, hyperdepletion, hyperstability)
- South Carolina only, limited geographic coverage relative to south Atlantic
- Information overlaps with MRFSS index
- No field validation

**Table 5.3** The number of trapping events (N), standardized index, and CV for the gray triggerfish index computed from SERFS chevron traps.

| Year | N | Standardized index | CV |
|---|---|---|---|
| 1990 | 305 | 0.25 | 0.20 |
| 1991 | 267 | 1.08 | 0.12 |
| 1992 | 288 | 0.85 | 0.16 |
| 1993 | 395 | 0.79 | 0.11 |
| 1994 | 396 | 1.03 | 0.10 |
| 1995 | 333 | 1.35 | 0.10 |
| 1996 | 376 | 1.62 | 0.10 |
| 1997 | 394 | 1.47 | 0.11 |
| 1998 | 445 | 1.75 | 0.13 |
| 1999 | 216 | 0.73 | 0.17 |
| 2000 | 292 | 0.62 | 0.19 |
| 2001 | 245 | 0.87 | 0.13 |
| 2002 | 244 | 1.53 | 0.15 |
| 2003 | 225 | 0.80 | 0.25 |
| 2004 | 290 | 1.28 | 0.14 |
| 2005 | 303 | 0.75 | 0.13 |
| 2006 | 292 | 0.53 | 0.15 |
| 2007 | 336 | 0.94 | 0.15 |
| 2008 | 303 | 0.88 | 0.15 |
| 2009 | 398 | 0.68 | 0.15 |
| 2010 | 703 | 0.65 | 0.13 |
| 2011 | 688 | 0.82 | 0.11 |
| 2012 | 1151 | 1.02 | 0.09 |
| 2013 | 1354 | 1.25 | 0.08 |
| 2014 | 1465 | 1.49 | 0.08 |

**Table 5.4** The nominal index (*SumCount*), number of trapping events (N), proportion positive, standardized index, and CV for the gray triggerfish index computed from the SERFS video survey.

| Year | Relative nominal *SumCount* | N | Proportion positive | Standardized index | CV |
|---|---|---|---|---|---|
| **2011** | 0.97 | 575 | 0.320 | 0.88 | 0.12 |
| **2012** | 0.94 | 1075 | 0.300 | 1.07 | 0.11 |
| **2013** | 1.08 | 1219 | 0.308 | 1.14 | 0.09 |
| **2014** | 1.01 | 1374 | 0.345 | 0.91 | 0.10 |

**Table 5.5** The number of trips (N), nominal CPUE, relative nominal CPUE, standardized index, and CV for gray triggerfish from headboat logbook data.

| Year | N | Nominal CPUE | Relative nominal | Standardized CPUE | CV |
|---|---|---|---|---|---|
| 1995 | 3275 | 0.39 | 1.08 | 0.88 | 0.04 |
| 1996 | 2431 | 0.57 | 1.61 | 0.94 | 0.04 |
| 1997 | 1925 | 0.54 | 1.51 | 1.22 | 0.04 |
| 1998 | 3033 | 0.44 | 1.23 | 1.00 | 0.03 |
| 1999 | 2648 | 0.32 | 0.89 | 0.87 | 0.03 |
| 2000 | 2602 | 0.28 | 0.79 | 0.59 | 0.04 |
| 2001 | 2591 | 0.20 | 0.56 | 0.60 | 0.04 |
| 2002 | 2183 | 0.34 | 0.96 | 0.73 | 0.04 |
| 2003 | 1806 | 0.42 | 1.17 | 0.93 | 0.04 |
| 2004 | 2306 | 0.47 | 1.31 | 1.52 | 0.03 |
| 2005 | 2100 | 0.30 | 0.84 | 1.19 | 0.04 |
| 2006 | 2137 | 0.25 | 0.71 | 0.97 | 0.04 |
| 2007 | 2243 | 0.32 | 0.89 | 1.11 | 0.03 |
| 2008 | 3215 | 0.24 | 0.68 | 1.06 | 0.03 |
| 2009 | 4049 | 0.27 | 0.75 | 1.40 | 0.03 |

**Table 5.6.** The number of angler-trips (N), proportion positive, nominal CPUE, standardized index, and CV for gray triggerfish from MRFSS data.

| Year | N | Proportion N positive | Relative Nominal CPUE | Standardized index | CV |
|---|---|---|---|---|---|
| 1993 | 453 | 0.21 | 0.53 | 0.55 | 0.13 |
| 1994 | 494 | 0.25 | 1.06 | 0.70 | 0.15 |
| 1995 | 411 | 0.23 | 0.70 | 0.71 | 0.15 |
| 1996 | 395 | 0.25 | 1.12 | 0.94 | 0.14 |
| 1997 | 354 | 0.34 | 1.17 | 1.38 | 0.14 |
| 1998 | 443 | 0.21 | 0.67 | 0.74 | 0.12 |
| 1999 | 662 | 0.22 | 0.73 | 0.84 | 0.14 |
| 2000 | 722 | 0.13 | 0.47 | 0.48 | 0.12 |
| 2001 | 729 | 0.23 | 0.59 | 0.71 | 0.10 |
| 2002 | 960 | 0.30 | 1.06 | 1.05 | 0.09 |
| 2003 | 966 | 0.31 | 1.12 | 1.09 | 0.08 |
| 2004 | 1093 | 0.34 | 1.58 | 1.61 | 0.09 |
| 2005 | 829 | 0.32 | 1.02 | 1.16 | 0.09 |
| 2006 | 922 | 0.27 | 0.89 | 0.89 | 0.09 |
| 2007 | 863 | 0.34 | 1.17 | 1.28 | 0.10 |
| 2008 | 818 | 0.30 | 0.90 | 0.96 | 0.10 |
| 2009 | 740 | 0.37 | 1.73 | 1.32 | 0.09 |

**Table 5.7.** The number of trips (N), nominal CPUE, relative nominal CPUE, standardized index, and CV for gray triggerfish from commercial logbook data (handlines).

| Year | N | Nominal CPUE | Relative nominal | Standardized CPUE | CV |
|---|---|---|---|---|---|
| 1993 | 770 | 0.41 | 0.62 | 0.76 | 0.07 |
| 1994 | 1281 | 0.64 | 0.97 | 0.89 | 0.05 |
| 1995 | 1479 | 0.62 | 0.93 | 1.01 | 0.05 |
| 1996 | 1167 | 0.76 | 1.14 | 1.04 | 0.05 |
| 1997 | 1593 | 0.93 | 1.40 | 1.53 | 0.04 |
| 1998 | 1427 | 1.06 | 1.59 | 1.38 | 0.05 |
| 1999 | 1415 | 0.79 | 1.19 | 1.06 | 0.05 |
| 2000 | 1348 | 0.47 | 0.71 | 0.76 | 0.05 |
| 2001 | 1582 | 0.42 | 0.64 | 0.69 | 0.05 |
| 2002 | 1714 | 0.46 | 0.69 | 0.66 | 0.05 |
| 2003 | 1352 | 0.62 | 0.93 | 0.75 | 0.06 |
| 2004 | 1233 | 0.77 | 1.15 | 1.14 | 0.05 |
| 2005 | 1296 | 0.74 | 1.12 | 1.24 | 0.05 |
| 2006 | 1219 | 0.72 | 1.08 | 0.99 | 0.05 |
| 2007 | 1453 | 0.63 | 0.95 | 1.00 | 0.05 |
| 2008 | 1369 | 0.62 | 0.94 | 0.98 | 0.05 |
| 2009 | 1052 | 0.64 | 0.97 | 1.13 | 0.05 |

**Table 5.8.** Pearson correlation values for indices recommended for use. P-values (in parentheses) represent the probability of obtaining the Pearson value under the null hypothesis of correlation=0. CVT=chevron traps.

| | Headboat | CVT | Video | Commercial | MRFSS |
|---|---|---|---|---|---|
| Headboat | 1.000 | | | | |
| CVT | 0.073 (0.795) | 1.000 | | | |
| Video | - | 0.120 (0.880) | 1.000 | | |
| Commercial | 0.663 (007) | - | - | 1.000 | |
| MRFSS | 0.862 (0.000) | - | - | 0.476 (0.054) | 1.000 |

**Table 5.9.** Gray triggerfish standardized indices of abundance and annual CVs recommended for potential use in the stock assessment. CVT=chevron traps, HB=headboats, and Comm=commercial handline. Each index is scaled to its mean.

| | **Standardized indices** | | | | | **CVs** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | HB | CVT | Video | Comm | MRFSS | HB | CVT | Video | Comm | MRFSS |
| 1990 | | 0.25 | | | | | 0.20 | | | |
| 1991 | | 1.08 | | | | | 0.12 | | | |
| 1992 | | 0.85 | | | | | 0.16 | | | |
| 1993 | | 0.79 | | 0.76 | 0.55 | | 0.11 | | 0.07 | 0.13 |
| 1994 | | 1.03 | | 0.89 | 0.70 | | 0.10 | | 0.05 | 0.15 |
| 1995 | 0.88 | 1.35 | | 1.01 | 0.71 | 0.04 | 0.10 | | 0.05 | 0.15 |
| 1996 | 0.94 | 1.62 | | 1.04 | 0.94 | 0.04 | 0.10 | | 0.05 | 0.14 |
| 1997 | 1.22 | 1.47 | | 1.53 | 1.38 | 0.04 | 0.11 | | 0.04 | 0.14 |
| 1998 | 1.00 | 1.75 | | 1.38 | 0.74 | 0.03 | 0.13 | | 0.05 | 0.12 |
| 1999 | 0.87 | 0.73 | | 1.06 | 0.84 | 0.03 | 0.17 | | 0.05 | 0.14 |
| 2000 | 0.59 | 0.62 | | 0.76 | 0.48 | 0.04 | 0.19 | | 0.05 | 0.12 |
| 2001 | 0.60 | 0.87 | | 0.69 | 0.71 | 0.04 | 0.13 | | 0.05 | 0.10 |
| 2002 | 0.73 | 1.53 | | 0.66 | 1.05 | 0.04 | 0.15 | | 0.05 | 0.09 |
| 2003 | 0.93 | 0.80 | | 0.75 | 1.09 | 0.04 | 0.25 | | 0.06 | 0.08 |
| 2004 | 1.52 | 1.28 | | 1.14 | 1.61 | 0.03 | 0.14 | | 0.05 | 0.09 |
| 2005 | 1.19 | 0.75 | | 1.24 | 1.16 | 0.04 | 0.13 | | 0.05 | 0.09 |
| 2006 | 0.97 | 0.53 | | 0.99 | 0.89 | 0.04 | 0.15 | | 0.05 | 0.09 |
| 2007 | 1.11 | 0.94 | | 1.00 | 1.28 | 0.03 | 0.15 | | 0.05 | 0.10 |
| 2008 | 1.06 | 0.88 | | 0.98 | 0.96 | 0.03 | 0.15 | | 0.05 | 0.10 |
| 2009 | 1.40 | 0.68 | | 1.13 | 1.32 | 0.03 | 0.15 | | 0.05 | 0.09 |
| 2010 | | 0.65 | | | | | 0.13 | | | |
| 2011 | | 0.82 | 0.88 | | | | 0.11 | 0.12 | | |
| 2012 | | 1.02 | 1.07 | | | | 0.09 | 0.11 | | |
| 2013 | | 1.25 | 1.14 | | | | 0.08 | 0.09 | | |
| 2014 | | 1.49 | 0.91 | | | | 0.08 | 0.10 | | |

## 5.8 Figures

**Figure 5.1.** The nominal (red dots) and standardized index (solid black line) for gray triggerfish computed from SERFS chevron traps. Gray shaded area represents 95% confidence interval as estimated from 6,000 bootstraps.

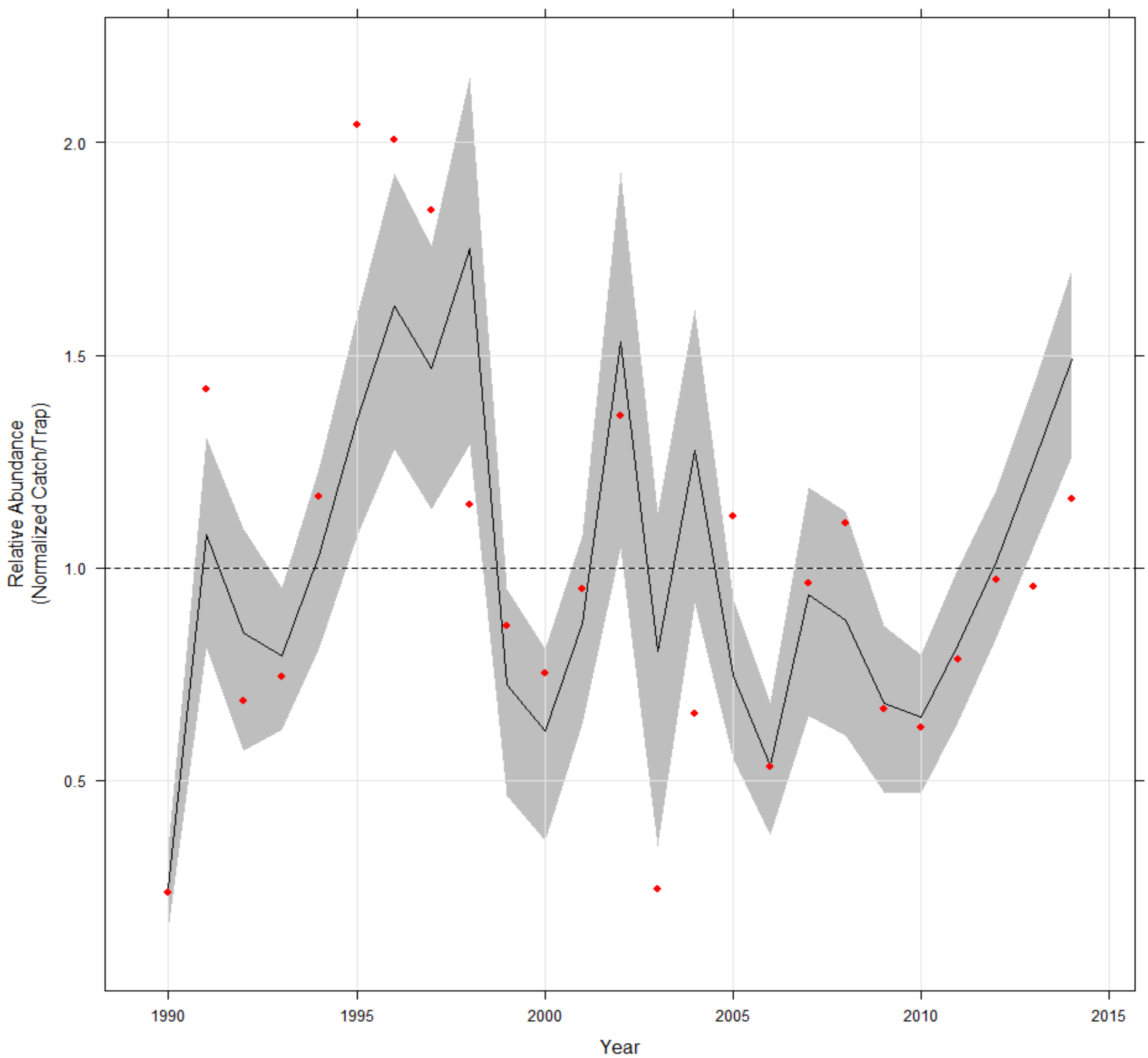


**Figure 5.2.** The nominal and standardized index for gray triggerfish computed from the SERFS video survey.

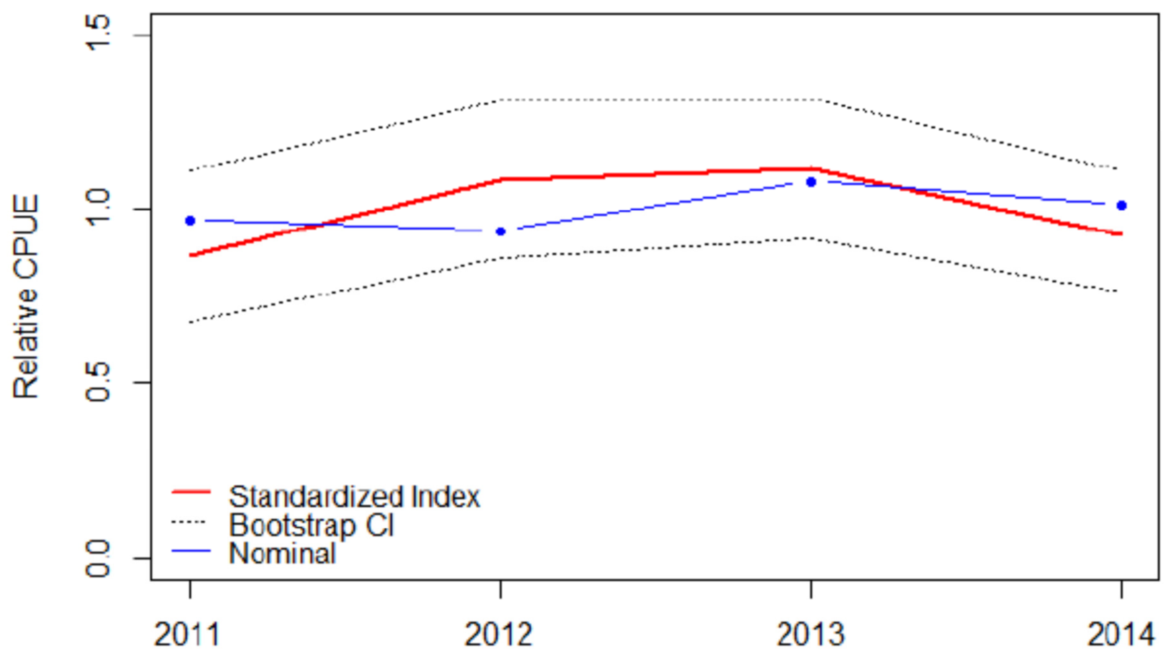


**Figure 5.3.** Map of headboat sampling area definitions. For analysis, areas were pooled as described in the text.

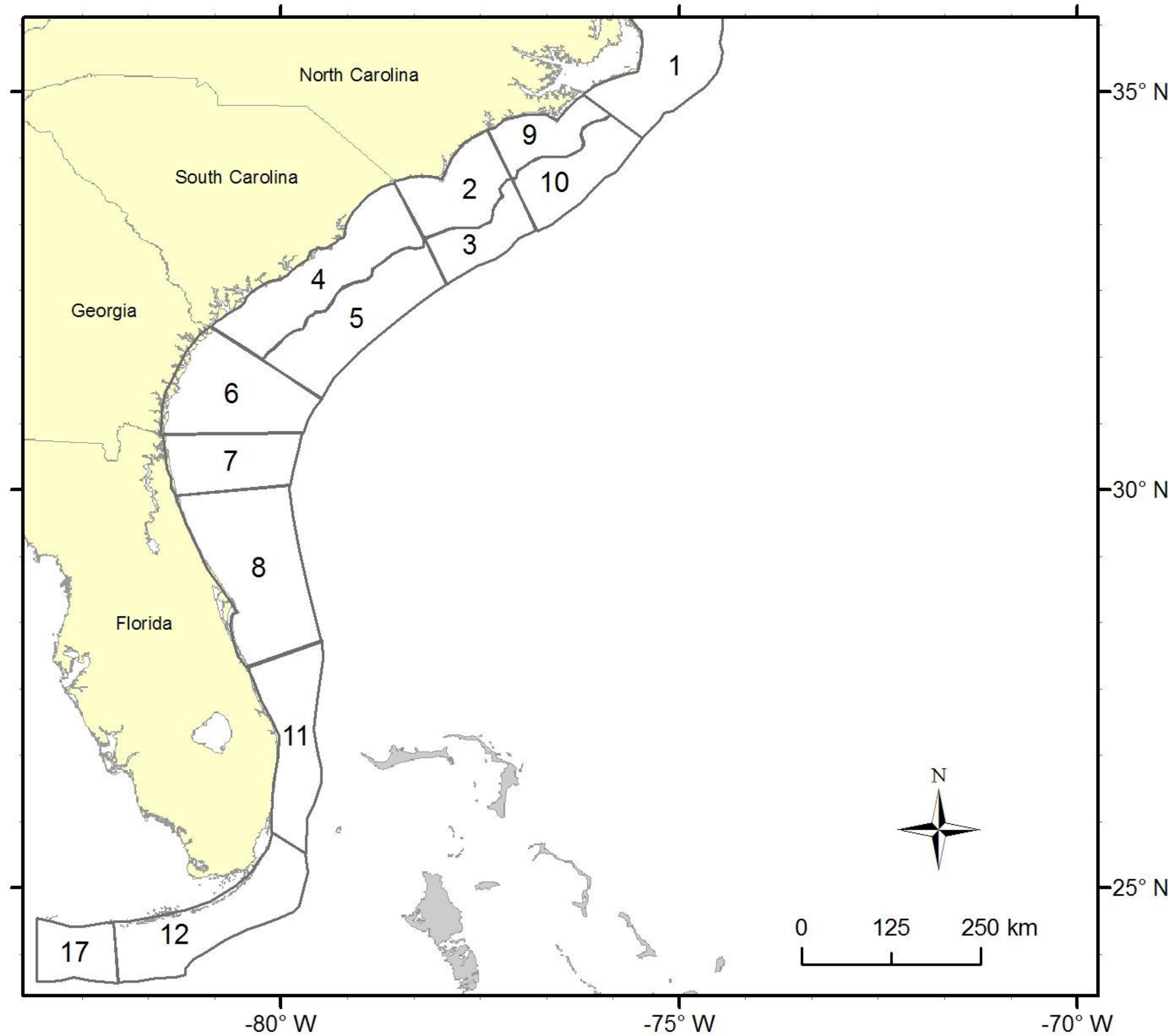


**Figure 5.4.** The nominal and standardized index for gray triggerfish computed from headboat data. Error bars represent approximate 95% confidence intervals.

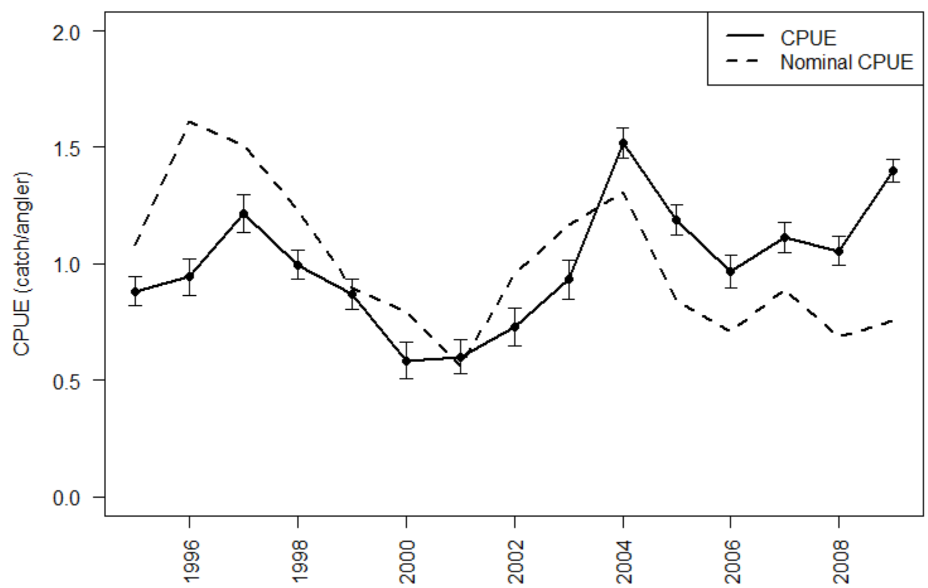


**Figure 5.5.** The nominal and standardized index for gray triggerfish computed from MRFSS data. Error bars (dashed) represent approximate 95% confidence intervals.

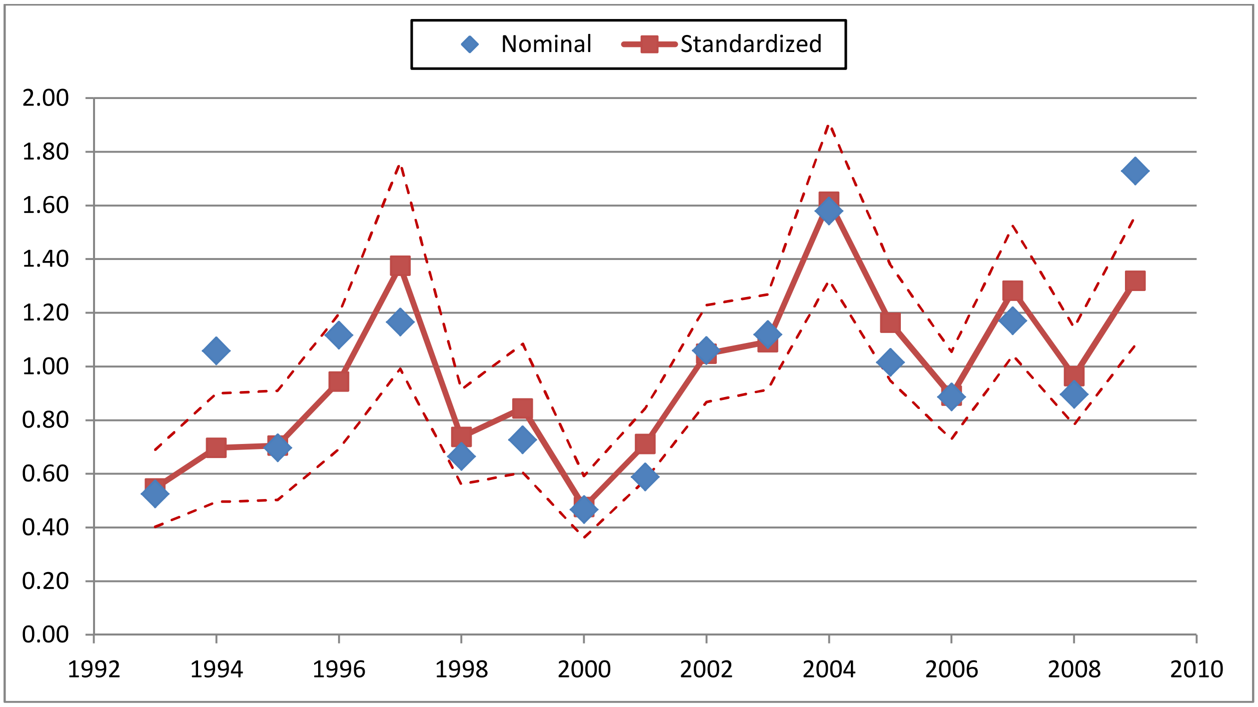


**Figure 5.6.** Latitude reported in the Coastal Fisheries Logbook Program (CFLP, commercial logbooks). Area is recorded in degrees where the first two digits signify degrees latitude, second two degrees longitude. Only latitude was used in this analysis.

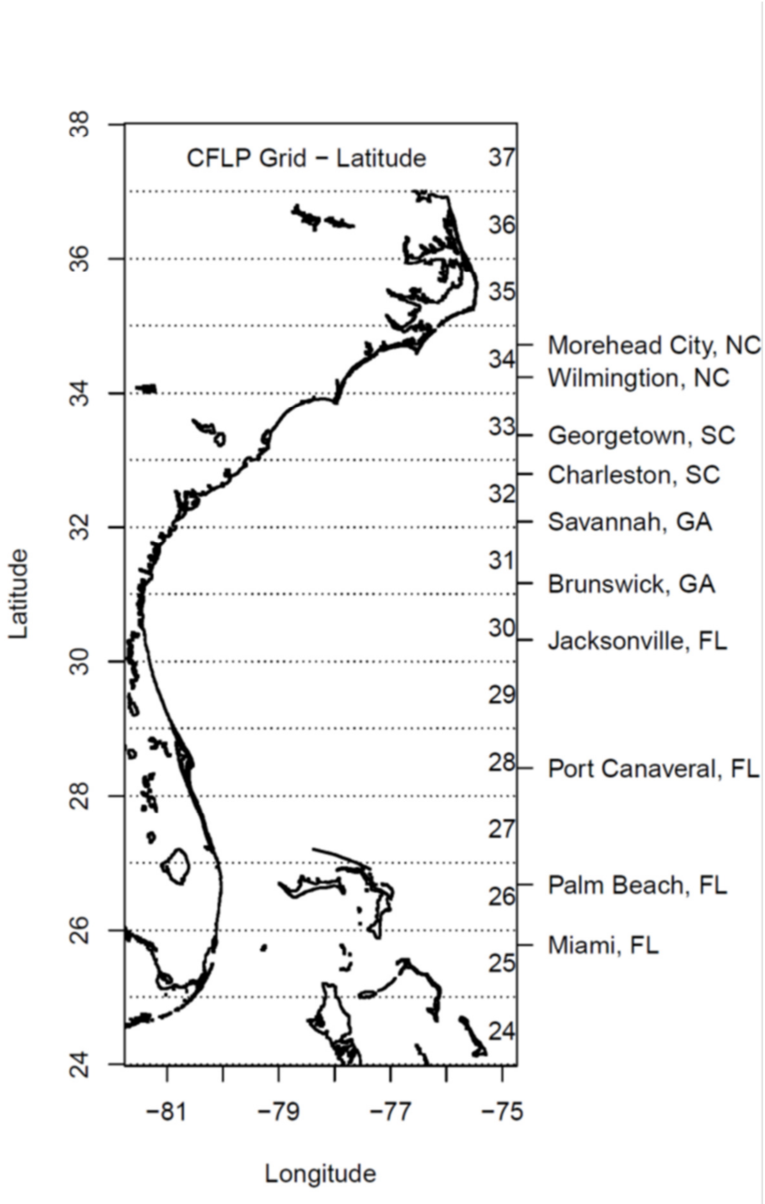


**Figure 5.7.** The nominal and standardized index for gray triggerfish computed from commercial logbook handline data, 1993–2009. Error bars represent approximate 95% confidence intervals. The nominal (Nominal CPUE), Standardized Stephens and MacCall approach approved for use in SEDAR 41 (SandM.CPUE), SEDAR 32 positive-only (SEDAR 32 Pos CPUE), and SEDAR 41 positive-only (SEDAR 41 Pos CPUE) runs are shown.

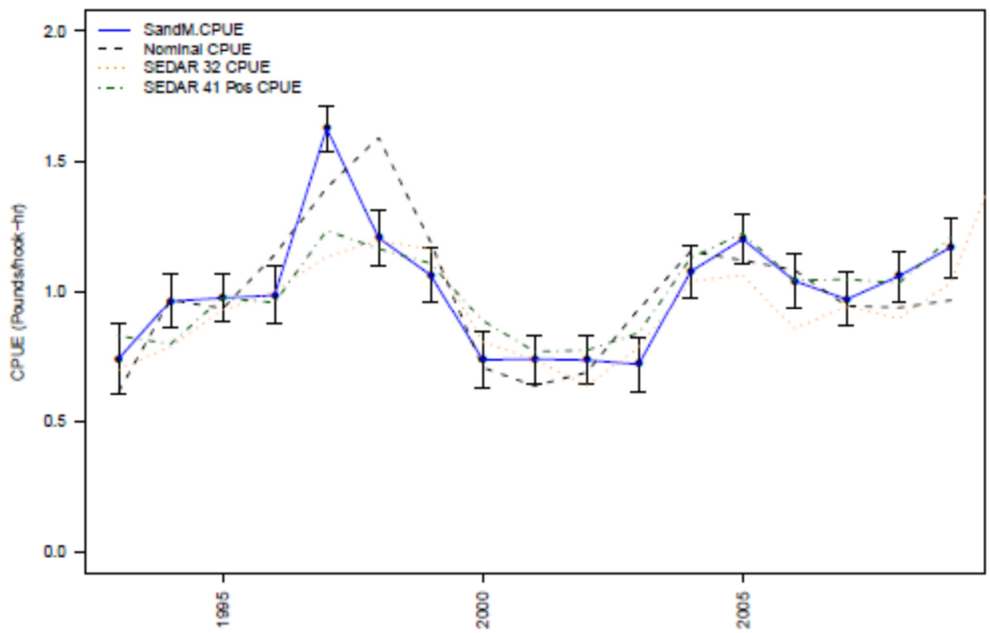
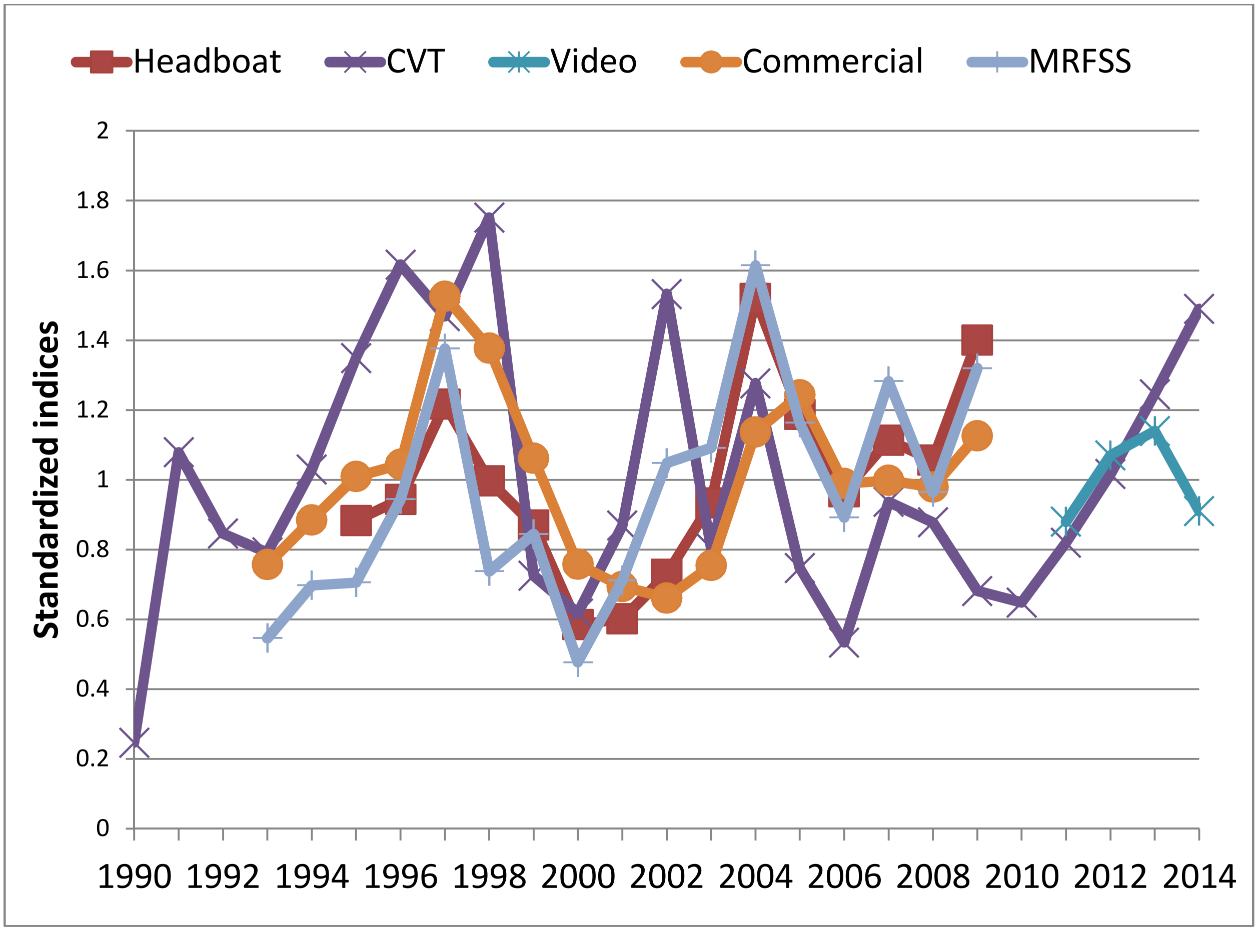


**Figure 5.8.** All indices (scaled to their respective means) recommended for potential use in the gray triggerfish stock assessment. CVT=Chevron traps.



# 6. Analytical Approach

The data gathered during the data workshop, and in efforts subsequent to the workshop, are sufficient to consider the use of both a statistical catch-age model and a surplus production model. Data provided include the following: age and length composition of the catches, age and growth relationships, complete landings and a recommended set of indices of abundance. The Beaufort Assessment Model (BAM) will be used for the age-structured modeling, and for a simpler counterpart, the ASPIC model will be used.

# 7. Research Recommendations

## 7.1 Life History

- More research on gray triggerfish movements and migrations in Atlantic waters is needed. Available data and the results of studies in the Gulf of Mexico indicate high site fidelity, but that tropical storms may cause greater than normal movement that might help dispersal to depleted areas. This needs to be confirmed in the South Atlantic. Additional acoustic and traditional tagging is needed on known spawning locations to document spawning migrations or aggregations, and return of fish to non-spawning areas.
- Age validation study that should include edge type and the potential for using various age structures for use in assessment. This should include the logistical feasibility of using these alternative structures for routine sampling and processing.
- Early life history is largely unknown. E.g. size and age at settlement and length of the pelagic stage.
- Estimates of delayed bycatch mortality are needed. This should include the effect of cloacal protrusion as a result of barotrauma.
- Tagging studies are needed to define spawning locations (only shelf edge or not) and, movement, the results of which could be used to help inform fishing mortality and natural mortality.
- Impact of climate change on mortality and recruitment.
- Research on spawning behavior/nesting and how it impacts survivorship and stock productivity.
- Determine fecundity type and estimate annual fecundity in Atlantic waters.
- Alternative methods of reproductive output. The methods described in Klibansky's SEDAR41-DW49 may provide a more accurate estimate of reproductive output than previously used. Further investigation into this modeling effort and use for future assessments should be investigated.
- Duration of spawning indicators. The definition of spawning indicators has received significant discussion recently. As this has significant implications for the estimates of reproductive output, further research is needed to define consistent criteria for spawning indicators in finfish.

- Investigate gray triggerfish competition for nests. The presence of competition for nest space may affect, among other things, the spawning success (reproductive output) and the choice of a spawner recruit relationship. Further investigation into the nesting behavior of gray triggerfish is needed to provide information to address these issues.

## 7.2 Commercial

**Landings**

- Require species level reporting in state trip ticket programs. Some states in process of instituting species level reporting for all species.
- Improve gear and effort data collections.

**Discards**

- Investigate the validity and magnitude of "no discard" trips. This may include fisher interviews throughout the region.
- Examine potential impacts of "no discard" trips on estimated discards.
- Improve discard logbook data collections via program expansion or more detailed reporting (e.g. more detailed logbook, electronic reporting)
- Establish an observer program that is representative of the fisheries in the South Atlantic.

**Biosampling**

- Standardize TIP sampling protocol to get representative samples at the species level.
- Standardize TIP data extraction.
- Establish an observer program that is representative of the fisheries in the South Atlantic.
- Increase untargeted sampling in NE and Mid-Atlantic observer programs.
- Increase untargeted dockside sampling in NE and Mid-Atlantic.

## 7.3 Recreational

- Complete analysis of available historic photos for trends in CPUE and mean size of landed Red Snapper and Gray Triggerfish for pre-1981 time period. (Ultimately all species).
- Formally archive data and photos for all other SEDAR target species.
- For Hire Survey (FHS) should collect additional variables (e.g. depth fished).
- Increasing sample sizes for at-sea headboat observers (i.e. number of trips sampled).
- Compute variance estimate for headboat landings.
- Mandatory logbooks for all federally permitted for-hire vessels.

## 7.4 Indices

- Compare existing methods and/or develop new methods to define effective effort in fishery dependent data.
- Estimate selectivity of video gear in the SERFS.
  - Tagging, stereo cameras
- For video reading, evaluate methods to score water clarity and habitat.
- Evaluate effect of (non) independence between chevron traps and videos, including methods to combine the indices.
- Continue exploring the use of continuous predictor variables (e.g., splines or polynomials) for ZIP and ZINB standardization models.
- Headboat at-sea observer program needs depth data from all states (not just FL) and increased coverage overall.
- SCDNR charterboat logbook program should be replicated by other states.
- Develop fishery independent hook-gear index (S41-DW08).

# SEDAR

## Southeast Data, Assessment, and Review

# SEDAR 41

## South Atlantic Gray Triggerfish

## SECTION III: Assessment Workshop Report

## February 2016


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

**Table of Contents**

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# 1. Introduction

## 1.1 Workshop Time and Place

The SEDAR 41 Assessment Process was conducted through a combination of an in-person workshop and series of webinars held from October 2015 to February 2016. The in-person workshop was held December 14-17, 2015 in Morehead City, NC. The workshop was originally scheduled for November 2015, but was delayed approximately one month to ensure a preliminary base run would be available at the beginning of the workshop. Six assessment webinars were held, three pre-workshop and three post-workshop, on the following dates: November 2, November 17 and December 1, 2015 and January 11, January 27, and February 17, 2016.

## 1.2 Terms of Reference

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

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

3. Provide estimates of stock population parameters, including:
   - Fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as necessary to describe the population.
   - Appropriate measures of precision for parameter estimates.

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

5. Provide estimates of yield and productivity.
   - Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.

6. Provide estimates of population benchmarks or management criteria consistent with the available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.
   - Evaluate existing or proposed management criteria as specified in the management summary.
   - Recommend proxy values when necessary.

7. Provide declarations of stock status relative to management benchmarks, or alternative data poor approaches if necessary.

8. Provide uncertainty distributions of proposed reference points and stock status metrics that provides the values indicated in the management specifications. Include probability density functions for biological reference point estimates and population metrics (e.g. biomass and exploitation) used to evaluate stock status.

9. Project future stock conditions (biomass, abundance, and exploitation; including probability density functions) and develop rebuilding schedules if warranted; include estimated generation time. Develop stock projections for the following circumstances, in accordance with the guidance on management needs provided in the management history:
   A) If stock is overfished:
      F=0, F=current, F=Fmsy, Ftarget
      F=Frebuild (max exploitation that rebuilds in the greatest allowed time)
      Fixed landings equal to the ABC
   B) If stock is overfishing
      F=Fcurrent, F=Fmsy, F=Ftarget, Fixed landings equal to the ABC
   C) If stock is neither overfished nor overfishing
      F=Fcurrent, F=Fmsy, F=Ftarget, Fixed landings equal to the ABC
   D) If data-limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice.
   E) Gray triggerfish projections should account for changes in selectivity that may result from actions in Snapper Grouper Amendment 29.

10. Compare and contrast productivity measures and assessment assumptions between the Gulf of Mexico and South Atlantic stocks.

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

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

## 1.3 List of Participants

**ASSESSMENT PANELISTS**
Kevin Craig - Lead Analyst Gray Triggerfish, SEFSC Beaufort
Kate Siegfried – Lead Analyst Red Snapper, SEFSC Beaufort
Rob Cheshire, SEFSC Beaufort
Eric Fitzpatrick, SEFSC Beaufort
Nikolai Klibansky, SEFSC Beaufort
Kyle Shertzer, SEFSC Beaufort
Erik Williams, SEFSC Beaufort
Joey Ballenger, SCDNR
Luiz Barbieri, FL FWCC / SSC
Peter Barile, SFA
Jeff Buckel, NC State / SSC
Marcel Reichert, SCDNR / SSC
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**APPOINTED OBSERVERS**
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Rusty Hudson, FL
Robert Johnson, FL
David Nelson, FL

**APPOINTED COUNCIL REPRESENTATIVES**
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Mark Brown, SAFMC
Chris Conklin, SAFMC

**COUNCIL AND AGENCY STAFF**
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Julie O'Dell, SEDAR / SAFMC
John Carmichael, SEDAR / SAFMC
Chip Collier, SAFMC
Mike Errigo, SAFMC
Nick Farmer, SERO
Mike Larkin, SERO

**WORKSHOP ATTENDEES**

Nate Bacheler, SEFSC Beaufort
Ken Brennan, SEFSC Beaufort
David Bush, NCFA
Michelle Duval, NCDMF / SAFMC
Kelly Fitzpatrick, SEFSC Beaufort
Jared Flowers, NCDMF
Laura Lee, NCDMF
Genny Nesslage, UMCES
Amy Schueller, SEFSC Beaufort / SSC
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Mike Wilberg, UMCES / CBC

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Lora Clarke, PEW
Roy Crabtree, SERO
Michelle Duval, NCDMF / SAFMC
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Dawn Franco, GADNR
Jimmy Hull, SFA
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Kathy Knowlton, GADNR
Laura, Lee, NCDMF / SSC
Jean-Jacques Maguire, Science Center for Marine Fisheries – Quebec
Anne Markwith, NCDMF
Mike Nelson, FL fisherman
Paul Nelson, FL fisherman
George Sedberry, NOAA / SSC
Tom Sminkey, NOAA
Karolyn Stillman, SEFSC Beaufort
Yuying Zhang, FL International University

## 1.4 Document List

SEDAR 41 assessment working paper and reference document list.

| Document # | Title | Authors |
|---|---|---|
| **Documents Prepared for the Assessment Workshop** | | |
| SEDAR41-AW01 | Addendum to SEDAR41-DW29: Discards of red snapper (*Lutjanus campechanus*) for the headboat fishery in the US South Atlantic | FEB-NMFS 2015 |
| SEDAR41-AW02 | Addendum to SEDAR41-DW30: Discards of gray triggerfish (*Balistes capriscus*) for the headboat fishery in the US South Atlantic | FEB-NMFS 2015 |
| SEDAR41-AW03 | South Atlantic U.S. red snapper (*Lutjanus campechanus*) age and length composition from the recreational fisheries | FEB-NMFS 2015 |
| SEDAR41-AW04 | South Atlantic U.S. gray triggerfish (*Balistes capriscus*) age and length composition from the recreational fisheries | FEB-NMFS 2015 |
| SEDAR41-AW05 | Commercial age and length composition weightings for Atlantic Red Snapper (*Lutjanus campechanus*) | SFB-NMFS 2015 |
| SEDAR41-AW06 | Commercial age and length composition weightings for Atlantic Gray Triggerfish (*Balistes capriscus*) | SFB-NMFS 2015 |
| SEDAR41-AW07 | Addendum to SEDAR41-DW17: Estimates of Historic Recreational Landings of Red Snapper in the South Atlantic Using the FHWAR Census Method | Brennan 2015 |
| SEDAR41-AW08 | South Atlantic U.S. red snapper (*Lutjanus campechanus*) catch curve analysis | SFB-NMFS 2015 |
| **Reference Documents** | | |
| SEDAR41-RD01 | List of documents and working papers for SEDAR 32 (South Atlantic Blueline Tilefish and Gray Triggerfish) – all documents available on the SEDAR website. | SEDAR 32 |
| SEDAR41-RD02 | List of documents and working papers for SEDAR 9 (Gulf of Mexico Gray Triggerfish, Greater Amberjack, and Vermilion Snapper) – all documents available on the SEDAR website. | SEDAR 9 |
| SEDAR41-RD03 | 2011 Gulf of Mexico Gray Triggerfish Update Assessment | SEDAR 2011 |

| | | |
|---|---|---|
| SEDAR41-RD04 | List of documents and working papers for SEDAR 24 (South Atlantic red snapper) – all documents available on the SEDAR website. | SEDAR 24 |
| SEDAR41-RD05 | List of documents and working papers for SEDAR 31 (Gulf of Mexico red snapper) – all documents available on the SEDAR website. | SEDAR 31 |
| SEDAR41-RD06 | List of documents and working papers for SEDAR 15 (South Atlantic red snapper and greater amberjack) – all documents available on the SEDAR website. | SEDAR 15 |
| SEDAR41-RD07 | 2009 Gulf of Mexico red snapper update assessment | SEDAR 2009 |
| SEDAR41-RD08 | List of documents and working papers for SEDAR 7 (Gulf of Mexico red snapper) – all documents available on the SEDAR website. | SEDAR 7 |
| SEDAR41-RD09 | SEDAR 24 South Atlantic Red Snapper: management quantities and projections requested by the SSC and SERO | NMFS - Sustainable Fisheries Branch 2010 |
| SEDAR41-RD10 | Total removals of red snapper (*Lutjanus campechanus*) in 2012 from the US South Atlantic | NMFS - Sustainable Fisheries Branch 2013 |
| SEDAR41-RD11 | Amendment 17A to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | SAFMC 2010 |
| SEDAR41-RD12 | Amendment 28 to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | SAFMC 2013 |
| SEDAR41-RD13 | Total removals of red snapper (*Lutjanus campechanus*) in 2013 from the U.S. South Atlantic | NMFS - Sustainable Fisheries Branch 2014 |
| SEDAR41-RD14 | South Atlantic red snapper (*Lutjanus campechanus*) monitoring in Florida for the 2012 season | Sauls et al. 2013 |
| SEDAR41-RD15 | South Atlantic red snapper (*Lutjanus campechanus*) monitoring in Florida for the 2013 season | Sauls et al. 2014 |
| SEDAR41-RD16 | A directed study of the recreational red snapper fisheries in the Gulf of Mexico along the West Florida shelf | Sauls et al. 2014 |
| SEDAR41-RD17 | Using generalized linear models to estimate | Bacheler et al. 2009 |

| | | |
|---|---|---|
| | selectivity from short-term recoveries of tagged red drum *Sciaenops ocellatus*: Effects of gear, fate, and regulation period | |
| SEDAR41-RD18 | Direct estimates of gear selectivity from multiple tagging experiments | Myers and Hoenig 1997 |
| SEDAR41-RD19 | Examining the utility of alternative video monitoring metrics for indexing reef fish abundance | Schobernd et al. 2014 |
| SEDAR41-RD20 | An evaluation and power analysis of fishery independent reef fish sampling in the Gulf of Mexico and U.S. South Atlantic | Conn 2011 |
| SEDAR41-RD21 | Consultant's Report: Summary of the MRFSS/MRIP Calibration Workshop | Boreman 2012 |
| SEDAR41-RD22 | 2013 South Atlantic Red Snapper Annual Catch Limit and Season Length Projections | SERO 2013 |
| SEDAR41-RD23 | Southeast Reef Fish Survey Video Index Development Workshop | Bacheler and Carmichael 2014 |
| SEDAR41-RD24 | Observer Coverage of the 2010-2011 Gulf of Mexico Reef Fish Fishery | Scott-Denton and Williams |
| SEDAR41-RD25 | Circle Hook Requirements in the Gulf of Mexico: Application in Recreational Fisheries and Effectiveness for Conservation of Reef Fishes | Sauls and Ayala 2012 |
| SEDAR41-RD26 | GADNR Marine Sportfish Carcass Recovery Project | Harrell 2013 |
| SEDAR41-RD27 | Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States | Gulf and South Atlantic Fisheries Foundation 2008 |
| SEDAR41-RD28 | A Continuation of Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States | Gulf and South Atlantic Fisheries Foundation 2010 |
| SEDAR41-RD29 | Continuation of Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States | Gulf and South Atlantic Fisheries Foundation 2013 |
| SEDAR41-RD30 | Amendment 1 and Environmental Assessment and Regulatory Impact Review to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | SAFMC 1988 |
| SEDAR41-RD31 | Final Rule for Amendment 1 to the Fishery | Federal Register |

| | | |
|---|---|---|
| | Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | 1989 |
| SEDAR41-RD32 | Population Structure and Genetic Diversity of Red Snapper (Lutjanus campechanus) in the U.S. South Atlantic and Connectivity with Red Snapper in the Gulf of Mexico | Gold and Portnoy 2013 |
| SEDAR41-RD33 | Oogenesis and fecundity type of Gulf of Mexico gray triggerfish reflects warm water environmental and parental care | Lang and Fitzhugh 2014 |
| SEDAR41-RD34 | Depth-related Distribution of Postjuvenile Red Snapper in Southeastern U.S. Atlantic Ocean Waters: Ontogenetic Patterns and Implications for Management | Mitchell et al. 2014 |
| SEDAR41-RD35 | Gray Triggerfish Age Workshop | Potts 2013 |
| SEDAR41-RD36 | Age, Growth, and Reproduction of Gray Triggerfish *Balistes capriscus* Off the Southeastern U.S. Atlantic Coast | Kelly 2014 |
| SEDAR41-RD37 | Assessment of Genetic Stock Structure of Gray Triggerfish (*Balistes capriscus*) in U.S. Waters of the Gulf of Mexico and South Atlantic Regions | Saillant and Antoni 2014 |
| SEDAR41-RD38 | Genetic Variation of Gray Triggerfish in U.S. Waters of the Gulf of Mexico and Western Atlantic Ocean as Inferred from Mitochondrial DNA Sequences | Antoni et al. 2011 |
| SEDAR41-RD39 | Characterization of the U.S. Gulf of Mexico and South Atlantic Penaeid and Rock Shrimp Fisheries Based on Observer Data | Scott-Denton et al. 2012 |
| SEDAR41-RD40 | Does hook type influence the catch rate, size, and injury of grouper in a North Carolina commercial fishery | Bacheler and Buckel 2004 |
| SEDAR41-RD41 | Fishes associated with North Carolina shelf-edge hardbottoms and initial assessment of a proposed marine protected area | Quattrini and Ross 2006 |
| SEDAR41-RD42 | Growth of grey triggerfish, *Balistes capriscus*, based on growth checks of the dorsal spine | Ofori-Danson 1989 |
| SEDAR41-RD43 | Age Validation and Growth of Gray Triggerfish, *Balistes capriscus*, In the Northern Gulf of Mexico | Fioramonti 2012 |
| SEDAR41-RD44 | A review of the biology and fishery for Gray Triggerfish, *Balistes capriscus*, in the Gulf of Mexico | Harper and McClellan 1997 |

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| SEDAR41-RD45 | Stock structure of gray triggerfish, *Balistes capriscus*, on multiple spatial scales in the Gulf of Mexico | Ingram 2001 |
| SEDAR41-RD46 | Evaluation of the Efficacy of the Current Minimum Size Regulation for Selected Reef Fish Based on Release Mortality and Fish Physiology | Burns and Brown-Peterson 2008 |
| SEDAR41-RD47 | Population Structure of Red Snapper from the Gulf of Mexico as Inferred from Analysis of Mitochondrial DNA | Gold et al. 1997 |
| SEDAR41-RD48 | Successful Discrimination Using Otolith Microchemistry Among Samples of Red Snapper *Lutjanus campechanus* from Artificial Reefs and Samples of *L.campechanus* Taken from Nearby Oil and Gas Platforms | Nowling et al. 2011 |
| SEDAR41-RD49 | Population Structure and Variation in Red Snapper (Lutjanus campechanus) from the Gulf of Mexico and Atlantic Coast of Florida as Determined from Mitochondrial DNA Control Region Sequence | Garber et al. 2003 |
| SEDAR41-RD50 | Population assessment of the red snapper from the southeastern United States | Manooch et al. 1998 |
| SEDAR41-RD51 | Otolith Microchemical Fingerprints of Age-0 Red Snapper, *Lutjanus campechanus*, from the Northern Gulf of Mexico | Patterson et al. 1998 |
| SEDAR41-RD52 | Implications of reef fish movement from unreported artificial reef sites in the northern Gulf of Mexico | Addis et al. 2013 |
| SEDAR41-RD53 | Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species | Then et al. 2014 |
| SEDAR41-RD54 | Length selectivity of commercial fish traps assessed from in situ comparisons with stereo-video: Is there evidence of sampling bias? | Langlois et al. 2015 |
| SEDAR41-RD55 | MRIP Calibration Workshop II – Final Report | Carmichael and Van Vorhees (eds.) 2015 |
| SEDAR41-RD56 | Total Removals of red snapper (*Lutjanus campechanus*) in 2014 from the U.S. South Atlantic | SEFSC 2015 |
| SEDAR41-RD57 | Assessing reproductive resilience: an example with South Atlantic red snapper *Lutjanus campechanus* | Lowerre-Barbiere et al. 2015 |
| SEDAR41-RD58 | Overview of sampling gears and standard | Smart et al. 2014 |

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| | protocols used by the Southeast Reef Fish Survey and its partners | |
| SEDAR41-RD59 | MRIP Transition Plan for the Fishing Effort Survey | Atlantic and Gulf Subgroup of the MRIP Transition Team 2015 |
| SEDAR41-RD60 | Technical documentation of the Beaufort Assessment Model (BAM) | Williams and Shertzer 2015 |
| SEDAR41-RD61 | Stock Assessment of Red Snapper in the Gulf of Mexico 1872-2013, with Provisional 2014 Landings: SEDAR Update Assessment | Cass-Calay et al. 2015 |
| SEDAR41-RD62 | Excerpt from the December 2013 SAFMC SEDAR Committee Minutes (pages 11-21 where SEDAR 41 ToR were discussed) | SAFMC SEDAR Committee |
| SEDAR41-RD63 | Population structure of red snapper (*Lutjanus campechanus)* in U.S. waters of the western Atlantic Ocean and the northeastern Gulf of Mexico | Hollenbeck et al. 2015 |
| SEDAR41-RD64 | SEDAR31-AW04: The Effect of Hook Type on Red Snapper Catch | Saul and Walter 2013 |
| SEDAR41-RD65 | SEDAR31-AW12: Estimation of hook selectivity on red snapper (*Lutjanus campechanus*) during a fishery independent survey of natural reefs in the Gulf of Mexico | Pollack et al. 2013 |
| SEDAR41-RD66 | Effect of Circle Hook Size on Reef Fish Catch Rates, Species Composition, and Selectivity in the Northern Gulf of Mexico Recreational Fishery | Patterson et al. 2012 |
| SEDAR41-RD67 | Effect of trawling on juvenile red snapper (*Lutjanus campechanus*) habitat selection and life history parameters | Wells et al. 2008 |
| SEDAR41-RD68 | SEDAR24-AW05: Selectivity of red snapper in the southeast U.S. Atlantic: dome-shaped or flat topped? | SFB-SEFSC 2010 |
| SEDAR41-RD69 | Hierarchical analysis of multiple noisy abundance indices | Conn 2010 |
| SEDAR41-RD70 | Data weighting in statistical fisheries stock assessment models | Francis 2011 |
| SEDAR41-RD71 | Corrigendum to Francis 2011 paper | Francis |
| SEDAR41-RD72 | Quantifying annual variation in catchability for commercial and research fishing | Francis et al. 2003 |
| SEDAR41-RD73 | Evolutionary assembly rules for fish life histories | Charnov et al. 2012 |

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| SEDAR41-RD74 | User's Guide for ASPIC Suite, version 7: A Stock-Production Model Incorporating Covariates and auxiliary programs | Prager 2015 |
| SEDAR41-RD75 | Standing and Special Reef Fish SSC, September 2015 Meeting Summary (see pages 4-7 for SEDAR 43 review) | Gulf of Mexico Standing and Special Reef Fish SSC |
| SEDAR41-RD76 | Standing and Special Reef Fish SSC, January 2016 Meeting Summary (see pages 2-7 for SEDAR 43 review) | Gulf of Mexico Standing and Special Reef Fish SSC |
| SEDAR41-RD77 | SEDAR 43 Gulf of Mexico Gray Triggerfish Stock Assessment Report | SEDAR 43 |

## 1.5 Statements Addressing Each Term of Reference

The following are the terms of reference with a statement explaining how each was addressed in the assessment report.

**Assessment Workshop Terms of Reference**

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

   *Data are summarized in the DW report and updates to data are described in section 2 of the AW report.*

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

   *A catch-age model (BAM) and a surplus production model (ASPIC) are described in section 3 of the AW report. The BAM was considered most reliable for providing management advice. Input data are documented in the DW report and in section 2 of the AW report. Model assumptions and equations of BAM are documented in Williams and Shertzer (2015) and those of ASPIC in Prager (2005).*

3. Provide estimates of stock population parameters, including:
   - Fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, and other parameters as necessary to describe the population.

- Appropriate measures of precision for parameter estimates.

*These estimates and measures of precision are described in section 3 of the AW report.*

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

   *Measures of uncertainty are described in section 3 of the AW report.*

5. Provide estimates of yield and productivity.
   - Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.

   *These estimates are provided in section 3 of the AW report.*

6. Provide estimates of population benchmarks or management criteria consistent with the available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.
   - Evaluate existing or proposed management criteria as specified in the management summary.
   - Recommend proxy values when necessary.

   *Estimated management benchmarks and alternatives are provided in section 3 of the AW report.*

7. Provide declarations of stock status relative to management benchmarks, or alternative data poor approaches if necessary.

   *Estimates of stock status are provided in section 3 of the AW report.*

8. Provide uncertainty distributions of proposed reference points and stock status metrics that provides the values indicated in the management specifications. Include probability

density functions for biological reference point estimates and population metrics (e.g. biomass and exploitation) used to evaluate stock status.

*Probabilistic analyses are described in section 3 of the AW report.*

9. Project future stock conditions (biomass, abundance, and exploitation; including probability density functions) and develop rebuilding schedules if warranted; include estimated generation time. Develop stock projections for the following circumstances, in accordance with the guidance on management needs provided in the management history:
    F) If stock is overfished:
    F=0, F=current, F=Fmsy, Ftarget
    F=Frebuild (max exploitation that rebuilds in the greatest allowed time)
    Fixed landings equal to the ABC
    G) If stock is overfishing
    F=Fcurrent, F=Fmsy, F=Ftarget, Fixed landings equal to the ABC
    H) If stock is neither overfished nor overfishing
    F=Fcurrent, F=Fmsy, F=Ftarget, Fixed landings equal to the ABC
    I) If data-limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice.
    J) Gray triggerfish projections should account for changes in selectivity that may result from actions in Snapper Grouper Amendment 29.

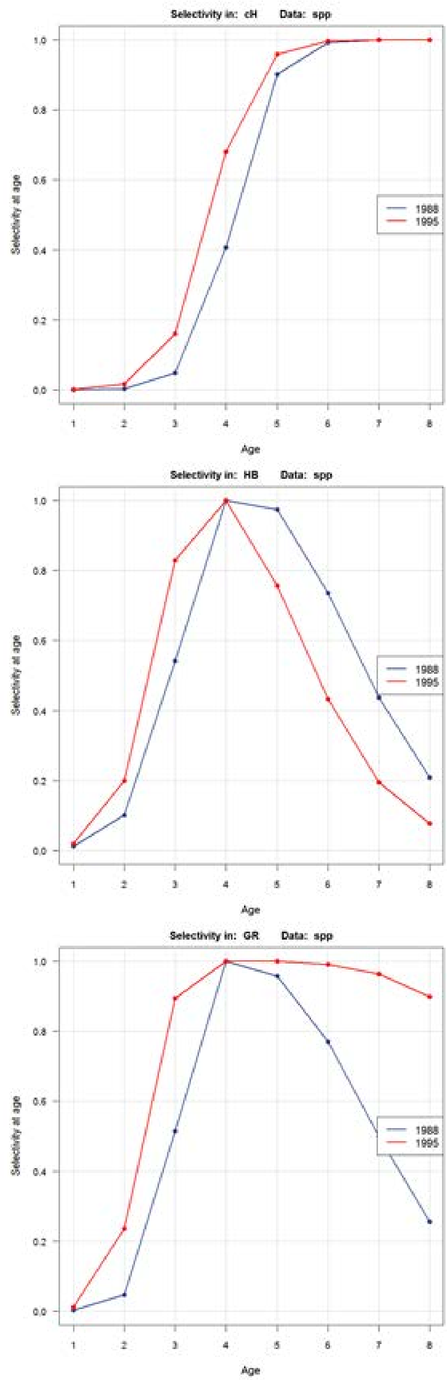
*Projections are described in section 3 of the AW report.*
*With respect to E) above, Amendment 29 specifies a 12 inch minimum fork length size limit to be in effect in federal waters off NC, SC, and GA for both the recreational and commercial sectors, and a 14 inch minimum fork length size limit to be in effect off the east coast of FL for both the recreational and commercial sectors. Both size limits went into effect in July 2015, the first year of the 10 year projection period*

*In the case of Gray Triggerfish, analysis of length and age compositions before and after the existing size limits that went into effect off Florida in 1995 (12 inch minimum total length) and 2006 (change to 12 inch minimum fork length) found no evidence of a shift to larger, older fish after the size limit took effect (RW working paper). In fact, there was a slight shift to younger fish after the size limit. This was evident in the shift in selectivity pattern to younger fish in the sensitivity analysis of the effects of blocking around these regulatory changes (See sensitivity S26 and S27 in the assessment report, Figure below).*

*The estimated A50 for the effort-weighted selectivity curve used in the projections is approximately age 3. The proposed size limit (12 inches FL) corresponds to an age 2 Gray Triggerfish. This would suggest a shift in selectivity to smaller, younger Gray Triggerfish under the size limit, the opposite of the intended effect of the regulation.*

*Any change in selectivity would affect the benchmarks used to gauge stock status. While it is possible to compute new benchmarks relevant to a projection scenario given assumptions about selectivity, doing so would divorce the projection from the assessment itself. Similarly, because the assessment model for Gray Triggerfish assumes a unit stock, there is no basis for incorporating spatial variation in management regulations.*

*Discussion with fishermen at the AW panel indicated there is little desire to retain Gray Triggerfish below the size limits proposed here. Given the lack of evidence that existing size limits have had a discernable effect on selectivity and the fact that the majority of Gray Triggerfish harvested are already larger than the proposed size limit, there appears to be little basis or need to formally account for the size limit in quantitative projections of Gray Triggerfish stock dynamics at this time.*


Selectivity in: cH Data: spp
Selectivity at age
Age
1988
1995
Selectivity in: HB Data: spp
Selectivity at age
Age
1988
1995
Selectivity in: GR Data: spp
Selectivity at age
Age
1988
1995

10. Compare and contrast productivity measures and assessment assumptions between the Gulf of Mexico and South Atlantic stocks.

    *The table addressing this ToR is found in Section 9.*

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

*Research recommendations are described in section 3 of the AW report.*

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

*This report was prepared within the specified time frame.*

# 2 Data Review and Update

The input data for this assessment are described below, with focus on modifications from the SEDAR41 DW.

## 2.1 Data Review

In this benchmark assessment, the Beaufort assessment model (BAM) was fitted to data sources developed during the SEDAR 41 DW with some modifications and additions.

**Model input compiled during the DW**

- Life history: Life history meristics, population and fishery growth curves, maturity, proportion female, number of batches at age, size-dependent batch fecundity, discard mortality, natural mortality
- Landings and discards: Commercial handline landings and discards, headboat landings and discards, recreational landings and discards
- Indices of abundance: Commercial handline, headboat, general recreational, SERFS chevron trap, SERFS video

**Model input modified or developed after the DW**

- Life history: Growth curves for the fishery and the SERFS trap survey, age–dependent natural mortality, maturity, age–dependent batch number
- Discards: impute values with zero discards for headboat survey
- Indices of abundance: Fishery–independent indices combined (Chevron trap and Video)
- Length compositions: Commercial handline, Headboat, Recreational
- Age compositions: Commercial handline, Headboat, Recreational, Chevron trap

## 2.2 Data Update

### 2.2.1 Life History

Estimates of the von Bertalanffy growth parameters were provided by the DW for the population as a whole and for converting fishery landings from age to length. An additional von Bertalanffy curve was generated from the SERFS chevron trap length and age data. This was used to fit the length compositions from the fishery independent survey. Age-specific mortality was updated due to an error in the original calculation which assumed the $t_0$ value was 0 prior to developing the age dependent mortality vector. Life-history information is summarized in Tables 1 and 2.

### 2.2.2 Landings and Discards

The recreational fleet structure to be modeled was decided after the DW. The general recreational fleet comprises the charterboat and private boat fleets, while the headboat fleet was modeled separately. The decision was made to separate headboat from the other recreational fishing modes because age compositions were available for the headboat fleet but not the general recreational fleet. Discard length compositions were available for the headboat fleet as well. Discards from the headboat fleet were zero in three years, which the panel considered unlikely, and so these values were replaced with an average from the previous year to the following year (including the zero year). Total removals as used in the assessment are in Table 3.

#### 2.2.3 Indices of Abundance

The DW provided separate SERFS chevron trap and video indices. However, because the data are collected from the same sampling platforms (i.e., cameras mounted on the chevron traps), the two indices are not independent measures of abundance. Therefore, the panel decided to combine the two using the Conn (2010) method for combining indices. All indices and their corresponding CVs are shown in Table 4, and Figure 1 shows the indices as recommended by the data workshop plotted with the new combined trap-video index for comparison. Fishery dependent indices of abundance were assumed to have CVs of 0.2 rather than the much smaller CVs generated from the index standardization, which is consistent with Francis (2003).

#### 2.2.4 Length Compositions

Length compositions for all data sources were developed in 3-cm bins over the range 15–69 cm (labeled at bin center). All lengths below and above the minimum and maximum bins were pooled. The commercial handline, general recreational and headboat lengths were weighted by the region and landings (SEDAR41-AW05 2015). For inclusion, length compositions in any given year had to meet the sample size criteria of $nfish > 30$ and $ntrips \geq 10$ (Table 5).

#### 2.2.5 Age Compositions

For age composition data, the upper range was pooled at 8 years old because of the low proportion of fish above this age and the small amount of variation in growth and natural mortality beyond this age. The age compositions were weighted by the length compositions to address bias in selection of fish to be aged. For inclusion, age compositions in any given year had to meet the sample size criteria of $nfish > 10$ and $ntrips \geq 10$ (Table 5).

#### 2.2.6 Additional Data Considerations

Size limits were in place beginning in 1995 (12 inch minimum total length size limit), and changed in 2006 (12 inch minimum fork length size limit). However, these size limit regulations applied only to water off of Florida. The panel examined size composition data and determined that there was little evidence to support selectivity time blocks. Data available for this update assessment are summarized in Tables 1–5.

## 3 Stock Assessment Methods

### 3.1 Overview

The primary model discussed for Gray Triggerfish during the Assessment Workshop (AW) was a statistical catch-age model implemented using the Beaufort Assessment Model (BAM) software (Williams and Shertzer 2015). BAM applies a statistical catch-age formulation implemented with the AD Model Builder software (Fournier et al. 2012). BAM is referred to as an integrated analysis because it has the capacity to include multiple data sources characterizing the population dynamics, inlcuding removals, age and length compositions, and indices of abundance, into a single modeling framework. An age-aggregated surplus production model (ASPIC) and catch curve analysis, both of which use subsets of the available data and require several simplifying assumptions, were used as supplementary analyses. An age-structured surplus production model was also investigated. In essence, a statistical catch-age model simulates a population forward in time while including fishing processes (Quinn and Deriso 1999; Shertzer et al. 2008). Quantities to be estimated are systematically varied until characteristics of the simulated population match available data on the real population. Statistical catch-age models share many attributes with ADAPT-style tuned and untuned VPAs. The model is similar in structure to Stock Synthesis (Methot 1989; 2009). Versions of BAM have been used in previous SEDAR assessments of reef fishes in the U.S. South Atlantic, such as Red Porgy, Black Sea Bass, Snowy Grouper, Gag Grouper, Greater Amberjack, Red Grouper, Vermilion Snapper, and Red Snapper. Abbreviations used herein are defined in Appendix A.

### 3.2 Data Sources

The catch-age model included data from commercial and recreational fisheries that caught Gray Triggerfish in U.S. South Atlantic waters as well as a fishery independent chevron trap-video survey (SERFS). The model was fitted to removals from three fleets over the period 1988-2014: the commercial handline fleet (hook-and-line), the general recreational fleet (charterboat and private boat modes), and the headboat fleet. Limited commercial landings (less than 5%) from other gears (e.g., traps, trawls) were pooled with commercial handlines. In addition, commercial handline discards were pooled with commercial landings because discards were low (less than 1% of commercial landings) and no data on size or age compositions of commercial discards were available to estimate discard selectivity. Landings and discards were modeled separately for the general recreational and headboat fleets. The headboat landings estimates were developed from the South Atlantic Regional Headboat Survey and the general recreational landings were developed from the private recreational and charterboat modes of the Marine Recreational Information Program (MRIP). Removals were modeled as number of fish for recreational fleets and as pounds whole weight for the commercial fleet. Discard removals assumed the discard mortality rate provided by the Data Workshop ($\delta = 0.125$).

In addition to annual removals, the model was fit to data on age composition, length composition, and an index of abundance. Age compositions were available for the commercial handline fleet (2004-2014), the headboat fleet (1990-1991, 2003, 2005-2014) and the SERFS chevron trap survey (1991-2014). Length compositions were available for the commercial handline fleet (1988-2014), the general recreational fleet (1989-2014), the headboat fleet (1988-2014), and from the SERFS chevron trap survey (1990-2014). In addition, length compositions were available for headboat discards (2005-2014). The model was also fit to a combined chevron trap-video index from the SERFS fishery-independent survey (CVID). Data used in the model are tabulated in §2 of this report.

### 3.3 Model Configuration

The assessment time period was 1988–2014. 1988 was chosen as the start year of the assessment because landings were limited and limited information was available on discards prior to this year. Gray Triggerfish were historically considered an undesirable species and were not heavily exploited prior to the 1980s. Based on discussions with fishermen and panelists at the AW, 1988 was determined to be a year after which changes in desirability of Gray Triggerfish stabilized. In addition, age composition and length composition data were available during this time to inform the initialization of the model. Model structure and equations of the BAM are detailed in (Williams and Shertzer 2015) along with AD Model Builder code for implementation. A general description of the assessment model follows:

### 3.4 Stock dynamics

In the assessment model, new biomass was acquired through growth and recruitment, while abundance of existing cohorts experienced exponential decay from fishing and natural mortality. The population was assumed closed to immigration and emigration. The model included age classes $1 - 8^{+}$, where the oldest age class $8^{+}$ allowed for the accumulation of fish (i.e., plus group). Maximum reported age of Gray Triggerfish in the South Atlantic is 15 years. The age to start the plus group (8) was chosen based on inspection of age composition data and where estimates of life history characteristics (i.e., size-at-age and age-based natural mortality) approached an asymptote.

### 3.5 Initialization

Initial (1988) abundance at age was computed in the model assuming an equilibrium age structure based on expected recruitment and an initial, age-specific total mortality rate. The initial recruitment in 1988 was assumed to be the expected value from the spawner-recruit curve. The initial mortality rate was the sum of natural mortality and fishing mortality. The equilibrium age structure was computed for ages $1 - 8^{+}$ and deviations were estimated around this age structure. Fishing mortality was the product of an initial fishing rate ($F_{init}$) and catch-weighted average selectivity. The initial fishing rate was estimated using a weak prior (CV=0.5) centered on $F_{\text{init}} = 0.05$. This was based on the assumption of the AW panel that Gray Triggerfish were lightly exploited prior to the 1980s.

### 3.6 Natural mortality rate

The natural mortality rate ($M$) was assumed constant over time, but decreasing with age. The form of $M$ as a function of age was based on Charnov et al. (2013). The Charnov et al. (2013) approach inversely relates the natural mortality at age to mean weight at age $W_a$ by the power function:

$$M = aW_a^b \tag{1}$$

As in previous SEDAR assessments, the age-dependent estimates of $M_a$ were re-scaled to provide the same fraction of fish surviving from age 4 (age of full selection) through the oldest observed age (15 yr) as would occur with constant $M = 0.41$, as recommended by the DW. This approach using cumulative mortality is consistent with the findings of Then et al. (2014).

### 3.7 Growth

Mean size at age of the population (total length, TL) was modeled with the von Bertalanffy equation, and weight at age (whole weight, WW) was modeled as a function of total length (Figure 2, Table 2). Parameters describing populaton growth and meristic conversions (TL-WW) were estimated by the DW and were treated as input to the assessment model. The von Bertalanffy parameter estimates from the DW were $L_{\infty} = 453.2$ mm, $k = 0.34$, $t_0 = -0.98$ yr, and $CV = 0.107$. Mean length at age of the fishery landings was modeled using a second von Bertalanffy growth curve. This growth curve was used to match landings from all commercial and recreational fleets because length at age was similar across fisheries. A third von Bertalanffy growth curve was used to match the length compositions from the SERFS fishery independent chevron trap survey. Starting values and associated CVs for parameters of these latter two growth curves were provided by the DW, and the model was allowed to estimate the parameters assuming a normal distribution of size at age with a CV also estimated by the assessment model.

### 3.8 Female maturity and sex ratio

Female maturity was modeled with a logistic function. Parameters for this model and a vector of maturity at age were provided by the DW and treated as input to the assessment model (Table 2). The sex ratio was assumed to be 50:50, as recommended by the DW.

### 3.9 Spawning stock

Spawning biomass was modeled as population fecundity (number of eggs) at the time of peak spawning. Population fecundity was the product of proportion of mature females at age, age-specific number of batches in a spawning season, and size-dependent batch fecundity. Estimates of age-dependent batch number and size-dependent batch fecundity were provided by the DW. For Gray Triggerfish, peak spawning was considered to occur at the end of May.

### 3.10 Recruitment

Expected recruitment of age-1 fish was predicted from spawning biomass using the Beverton–Holt spawner-recruit model. Steepness, $h$, is a key parameter of this model but could not be estimated for Gray Triggerfish. In this assessment, attempts to estimate steepness hit an upper bound (1.0). Likelihood profiling indicated that steepness was likely above about 0.5 but showed no clear minimum. Estimates of annual recruitment for Gray Triggerfish from the model were on the asymptotic portion of the stock-recruitment curve. Therefore, the AW Panel decided to assume this asymptote represented an average annual recruitment by fixing steepness at $h = 0.99$. Annual lognormal deviations in recruitment were assumed to occur around this average for the years 1988-2014. These deviations were constrained to sum to 1.0. Because composition data were available through the terminal year of the assessment and indicated some selection for age-1 fish, the AW panel agreed that this was a reasonable period over which to estimate recruitment deviations. The effects of alternative periods over which to estimate recruitment deviations was assessed via sensitivity analysis.

### 3.11 Landings and Discards

Time series of removals from three fleets were modeled over the 1988-2014 assessment period: the commercial handline fleet, the general recreational fleet, and the headboat fleet. Landings for each fleet over the assessment period were provided by the DW. Commercial discards were a small proportion (less than 1%) of commercial landings and, therefore, were pooled as commercial handline removals after applying a discard mortality rate of 0.125, as recommended by the DW. Headboat discards were also a small proportion of headboat landings, but length compositions of headboat discards were available to inform selectivity, and so headboat landings and discards were modeled separately. General recreational discards were assumed to have the same selectivity as for headboat discards. The same discard mortality rate was assumed for all fleets and for the entire assessment period ($\delta = 0.125$). Removals were modeled with the Baranov catch equation (Baranov 1918) and were fitted in either units of weight (1000 lb whole weight, commercial) or numbers (1000 fish, recreational).

### 3.12 Fishing Mortality

For each time series of removals, the assessment model estimated a separate full fishing mortality rate ($F$). Age-specific rates were then computed as the product of full $F$ and selectivity at age. The across-fleet annual $F$ was represented by apical $F$, computed as the maximum of $F$ at age summed across fleets.

### 3.13 Selectivities

Selectivity curves applied to landings and CPUE series were estimated using a parametric approach. This approach applies plausible structure on the shape of the curves and achieves greater parsimony than occurs with unique parameters for each age. Selectivity of removals from the commercial handline fleet and the fishery-independent CPUE series of abundance from the SERFS chevron trap-video survey were modeled as flat-topped using separate two-parameter logistic functions. These two data series contained the oldest reported Gray Triggerfish (ages 12-15). Recreationally landed fish were typically younger and smaller than commercially landed fish. Discussions with the AW panel indicated this was likely because recreationally landed fish are typically harvested from shallower water, and Gray Triggerfish show a pattern of increasing size with depth (Smart et al. 2016). Analysis of length composition data indicated that the smallest fish were harvested by the headboat fleet, which typically operates in shallow water, while the largest fish were harvested by the commercial handline fleet. Length compositions of the general recreational fleet were intermediate. Catch curve analysis was consistent with the hypothesis that older fish are more vulnerable to the commercial handline fleet than to recreational fleets. Therefore, separate four-parameter double logistic functions characterizing the ascending portion of the selectivity curve and the descending portion of the curve (dome-shaped selectivity) were assumed for the headboat and general recreational fleets. Assumptions about the form of selectivity functions was evaluated via sensitivity analysis.

Limited age data were available from the general recreational fleet. Moderate samples sizes were available in 2004 (18 trip, 47 fish) and 2005 (35 fish, 90 trips). However, these ages were exclusively from the charterboat mode and taken only off of Florida. This limited age data was in conflict with the general recreational length compositions which extended over the entire assessment period and represented both the private and charterboat modes of the general recreation fleet. As a result, the AW panel recommended removing these limited age compositions. A sensitivity analysis was done by fitting to a pooled general recreational age composition (weighted by the number of trips in the two years) and excluding the general recreational length compositions.

Selectivity of discards were estimated, assuming that discards consisted primarily of undersized fish, as was suggested by discard length compositions from the headboat fleet. Headboat discard selectivity was modeled as a three parameters logistic exponential function (dome-shaped selectivity). Discards from the general recreational fleet were assumed to have the same selectivity as the headboat fleet because no corresponding length or age composition data were available. The shape of the selectivity function (dome-shaped vs. flat-topped) of recreational discards was evaluated via sensitivity analysis.

Age and length composition data are critical for estimating selectivity parameters, and ideally a model would have sufficient composition data from each fleet over time to estimate distinct selectivities in each period of regulation. Age composition data for the modeled fleets were available from 1991-1993, 2003, and 2005-2014 for the headboat fleet, but sample sizes were limited (fewer than 50 fish annually) until the last two years of the assessment period (more than 100 fish annually). Age compositions were available from the commercial handline fleet beginning in 2004 with sample size increasing in 2007 (more than 100 fish). Length compositions were available for all fleets beginning in 1988 or 1989 and for headboat discards beginning in 2005 (fewer than 50 fish annually).

Regulatory changes relevant to Gray Triggerfish only applied to particular fisheries or particular regions within the stock area. Gray Triggerfish were included in an aggregate snapper-grouper bag limit in 1999 but this regulation only applied to the recreational sector of the fishery. A 12 inch total length minimum size limit was implemented in waters off Florida in 1995. This length limit was changed to 12 inch fork length in Florida waters in 2006. Analysis of length composition data and the limited age composition data before and after these regulations did not provide evidence of shifts in length and age to larger, older fish, as would be expected under a minimum length limit. Discussions with the AW panel indicated most harvested Gray Triggerfish were above these minimum length limits, and, thus, the regulations likely had minimal effects on selectivities of the fleets. Therefore, the AW panel recommended assuming constant selectivity over time for the recreational and commercial fleets. The effect of time-varying selectivity was evaluations via sensitivity analysis by estimating separate selectivities within each of these regulatory time periods.

### 3.14 Indices of abundance

The model was fit to a combined fishery independent trap-video index of relative abundance (CVID index, 1990–2014). Three fishery dependent indices were also considered by the AW panel: a headboat index (1995-2009), a general recreational index (1993-2009), and a commercial handline index (1993-2009). While the two recreational indices showed good agreement, they were in conflict with the commercial index for portions of the time series. In addition, all three fishery dependent indices were in conflict with the fishery independent index. Discussions with the fishermen and the AW panel indicated likely changes in targeting of Gray Triggerfish over the assessment period. As a result, the AW panel recommended including only the fishery independent trap-video index (CVID index).

The trap index extends from 1990-2014 and video was added to the trap survey in 2011. Because the trap and video indices were developed from the same survey and sampling design, they are not independent measures of population abundance. For Gray Triggerfish, the two indices were in strong agreement for three of the four years for which the video index was computed (2011-2014, Figure 1). The two indices diverged in the terminal year of the assessment. As a result, the AW panel recommended combining the two indices using an averaging method described in Conn (2010). The predicted trap-video index was conditional on selectivity of the trap survey and was computed from abundance at the midpoint of the year. The effects of including the fishery dependent indices and separating the trap and video indices were evaluated via sensitivity analysis.

### 3.15 Catchability

In the BAM, catchability scales indices of relative abundance to the estimated population abundance. For the base model, the AW Panel recommended a time-invariant catchability. The effect of time-varying catchability was evaluated via sensitivity analysis.

### 3.16 Biological reference points

Biological reference points (benchmarks) were calculated based on the fishing rate that would allow a stock to attain 30% of the maximum spawning potential which would have been obtained in the absence of fishing mortality. $F_{30\%}$ was considered a proxy for $F_{msy}$ and computed benchmarks were those corresponding to $F_{30\%}$. The quantities $\mathrm{SSB}_{\mathrm{F30\%}}$, $B_{\mathrm{F30\%}}$, and $L_{\mathrm{F30\%}}$ were estimated as proxies for MSY-related quantities (Gabriel and Mace 1999). In this assessment, spawning stock measures total eggs of the mature stock. These benchmarks are conditional on the estimated selectivity functions and the relative contributions of each fleet's fishing mortality. The selectivity pattern used here was the effort-weighted selectivities at age, with effort from each fleet estimated as the full $F$ averaged over the last three years of the assessment.

### 3.17 Fitting criterion

The fitting criterion was a penalized likelihood approach in which observed removals (landings and discards) were fit closely, and observed composition data and abundance indices were fit to the degree that they were compatible. Removals and index data were fit using lognormal likelihoods. Length and age composition data were fit using robust multinomial likelihoods (Francis 2011). In addition, a lognormal likelihood was applied to the deviations from average recruitment.

The model includes the capability for each component of the likelihood to be weighted by user-supplied values (for instance, to give more influence to desired data sources). For data components, these weights were applied by either adjusting CVs (lognormal components) or adjusting effective sample sizes (multinomial components). In this application to Gray Triggerfish, CVs of landings and discards (in arithmetic space) were assumed equal to 0.05, to achieve a close fit to these time series yet allowing some imprecision. In practice, the small CVs are a matter of computational convenience, as they help achieve the desired result of close fits to the landings, while avoiding having to solve the Baranov equation iteratively (which is complex when there are multiple fisheries). Weights on other data components (indices, age/length compositions) were adjusted iteratively, starting from initial weights as follows. The initial CV of the index was set equal to the values estimated by the Conn (2010) method used to combine the trap and video indices, which modified CVs derived from the GLM standardization conducted at the DW. Effective sample sizes of the multinomial components were assumed equal to the number of trips sampled annually, rather than the number of fish measured, reflecting the belief that the basic sampling unit occurs at the level of trip. These initial weights were then adjusted until standard deviations of normalized residuals were near 1.0 (Francis 2011).

After iterative reweighting, the fishery independent trap-video index (CVID) was not fit well by the model, particularly in the latter half of the time series. In accordance with the principle that abundance data should be given primacy (Francis 2011), the AW panel reviewed several runs with alternative increases in the weight applied to the index (range 2X to 10X the iteratively reweighted value). These alternative increases in the index weight were evaluated relative to the increase in fit to the index and the decrease in fit to other data sources. The AW panel recommended upweighting the index 6-fold relative to the value based on iterative reweighting. Weights less than this amount did not capture the major trends in the index, while higher weights compromised the fit to other data sources, while providing only modest increases in fit to the index. A range of index weights was included in the sensitivity and uncertainty analyses.

The compound objective function also included several penalties or prior distributions applied to maintain parameter values near reasonable values, and to prevent the optimization routine from drifting into parameter space with negligible gradient in the likelihood. Normal priors were applied to parameters defining the fishery landings and fishery independent growth curves, selectivities, the initialization ($F_{\text{init}}$), and $\sigma_R$. Priors on growth curves were based on the uncertainty in initial parameter estimates provided by the DW. For $\sigma_R$, the prior mean (0.6) and standard deviation (0.25) were based on Beddington and Cooke (1983) and Mertz and Myers (1996).

### 3.18 Configuration of base run

The base run was configured as described above with data provided by the DW. Uncertainty in parameter estimates and management quantities was evaluated through sensitivity analysis and a Monte Carlo-Bootstrap approach (described below).

### 3.19 Sensitivity analyses

Sensitivity of the model results to key model inputs and assumptions was examined through sensitivity analyses. A 5-year retrospective analysis was also conducted to investigate potential bias in model outputs. These model runs vary from the base run as follows:

- S1: Low natural mortality (scaled to 5th percentile of bootstrapped tmax estimator)
- S2: High natural mortality (scaled to 95th percentile of bootstrapped tmax estimator)
- S3: Low natural mortality (scaled to growth-based estimator $M = 0.27$)
- S4: Constant natural mortality ($M = 0.41$)
- S5: Constant natural mortality ($M = 0.27$)

- S6: Age-independent number of batches
- S7: Lower bound for age-specific number of batches (5th percentile of bootstrap estimates)
- S8: Upper bound for age-specific number of batches (95th percentile of bootstrap estimates)
- S9: Ricker stock recruitment curve
- S10: Steepness $h = 0.46$
- S11: Steepness $h = 0.84$
- S12: Estimate recruitment deviations beginning in 1993
- S13: Estimate recruitment deviations beginning in 1998
- S14: Estimate recruitment deviations beginning in 2003
- S15: Estimate recruitment deviations beginning in 2008
- S16: Estimate recruitment deviations beginning in 2013
- S17: Low discard mortality probability (all fisheries $\delta = 0.05$)
- S18: High discard mortality probability (all fisheries $\delta = 0.20$)
- S19: Low initial $F = 0.01$
- S20: High initial $F = 0.1$
- S21: Higher initial $F = 0.2$
- S22: Random walk (RW) catchability on trap index
- S23: All selectivities logistic
- S24: All selectivities dome-shaped
- S25: Fit to general recreational pooled age composition
- S26: Selectivity block around 1995 Florida length limit
- S27: Selectivity blocks around 1995 and 2006 Florida length limits
- S28: Selectivity block around 1999 aggregate snapper-grouper bag limit
- S29: Include all fishery-independent and fishery-dependent indices
- S30: Include fishery-dependent indices only
- S31: Separate video (VID) and trap (CVT) indices rather than a single index (CVID)
- S32: Separate video (VID) and trap (CVT) index with video upweighted
- S33: All likelihood weights set to 1
- S34: Likelihood weights based on iterative reweighting
- S35: Upweight CVID index 2X from iterative reweighting
- S36: Upweight CVID index 4X from iterative reweighting
- S37: Upweight CVID index 8X from iterative reweighting
- S38: Upweight CVID index 10X from iterative reweighting
- S39: Ageing error matrix included
- Retrospectives:
- R1: Data through 2013
- R2: Data through 2012

- R3: Data through 2011
- R4: Data through 2010
- R5: Data through 2009

### 3.20 Parameters Estimated

The model estimated annual fishing mortality rates of each fleet, selectivity parameters, catchability coefficients associated with indices, parameters of the spawner-recruit model (except steepness), annual recruitment deviations, and growth parameters for converting age to mean length of the fishery landings and the fishery independent trap-video index.

### 3.21 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of $F$, as were equilibrium landings and spawning biomass. Equilibrium landings and discards were also computed as functions of biomass $B$, which itself is a function of $F$. As in computation of benchmarks (described in §3.22), per recruit and equilibrium analyses applied the most recent selectivity patterns averaged across fleets, weighted by each fleet's $F$ from the last three years of the assessment (2012–2014).

### 3.22 Benchmark/Reference Point Methods

In this assessment of Gray Triggerfish, the quantities $F_{30\%}$, $\text{SSB}_{\text{F30\%}}$, $B_{\text{F30\%}}$, and $L_{\text{F30\%}}$ were estimated as proxies for MSY-based quantities. Steepness was not estimable, so the stock-recruit relationship was not used to identify a maximum yield. Instead, steepness was fixed at 0.99 in order to assume an average level of recruitment while estimating deviations around the mean. $F_{30\%}$ was used here to generate fishing benchmarks. However, because the stock-recruitment relationship was not estimated, some assumptions are required in order to generate biomass benchmarks. On average, expected recruitment is higher than that estimated directly from the spawner-recruit curve because of lognormal deviation in recruitment. Thus, in this assessment, the method of benchmark estimation accounted for lognormal deviation by including a bias correction in equilibrium recruitment. The bias correction ($\varsigma$) was computed from the variance ($\sigma_R^2$) of recruitment deviation in log space: $\varsigma = \exp(\sigma_R^2/2)$. Then, equilibrium recruitment ($R_{eq}$) associated with any $F$ is,

$$R_{eq} = \frac{R_0 \left[\varsigma 0.8 h \Phi_F - 0.2(1-h)\right]}{(h-0.2)\Phi_F} \tag{2}$$

where $R_0$ is virgin recruitment, $h$ is steepness which is fixed in this assessment, and $\Phi_F = \phi_F/\phi_0$ is spawning potential ratio given growth, maturity, and total mortality at age (including natural and fishing mortality rates). Because steepness is fixed at 0.99, $R_{eq}$ as a function of $F$ is approximately a straight line. The $R_{eq}$ and mortality schedule imply an equilibrium age structure and an average sustainable yield (ASY). The estimate of $L_{\text{F30\%}}$ is the ASY corresponding to $F_{30\%}$. The estimate of $\text{SSB}_{\text{F30\%}}$ follows from the corresponding equilibrium age structure, as does the estimate of discard mortalities $D_{F30\%}$, here separated from ASY (and consequently, $L_{\text{F30\%}}$).

Estimates of $L_{\text{F30\%}}$ and related benchmarks are conditional on the selectivity pattern. The selectivity pattern used here was an average of terminal-year selectivities from each fleet, where each fleet-specific selectivity was weighted in proportion to its corresponding estimate of $F$ averaged over the last three years (2012–2014). If the selectivities or relative fishing mortalities among fleets were to change, so would the estimates of $L_{\text{F30\%}}$ and related benchmarks.

The maximum fishing mortality threshold (MFMT) is defined by the SAFMC as $F_{30\%}$, and the minimum stock size threshold (MSST) as $(1 - M)\text{SSB}_{\text{F30\%}}$. Overfishing is defined as $F >$ MFMT and overfished as SSB $<$ MSST. Current status of the stock is represented by SSB in the latest assessment year (2014), and current status of the fishery is represented by the geometric mean of $F$ from the latest three years (2012–2014). Recent SEDAR assessments have considered the mean over the terminal three years to be a more robust metric.

### 3.23 Uncertainty and Measures of Precision

This assessment used a mixed Monte Carlo and bootstrap (MCB) approach to characterize uncertainty in results of the base run. Monte Carlo and bootstrap methods (Efron and Tibshirani 1993; Manly 1997) are often used to characterize uncertainty in ecological studies, and the mixed approach has been applied successfully in stock assessment, including Restrepo et al. (1992), Legault et al. (2001), SEDAR4 (2004), and many South Atlantic SEDAR assessments since SEDAR19 (2009). The approach is among those recommended for use in SEDAR assessments (SEDAR Procedural Guidance 2010).

The approach translates uncertainty in model input into uncertainty in model output by fitting the model many times with different values of “observed” data and key input parameters. A chief advantage of the approach is that the results describe a range of possible outcomes, so that uncertainty is characterized more thoroughly than it could be by any single fit or handful of sensitivity runs. A minor disadvantage of the approach is that computational demands are relatively high.

In this assessment, the BAM was successively re-fit in $n = 4000$ trials that differed from the original inputs by bootstrapping on data sources, and by Monte Carlo sampling of several key input parameters. The value of $n = 4000$ was chosen because a minimum of 3000 runs were desired, and it was anticipated that not all runs would converge or otherwise be valid. Of the 4000 trials, approximately 8.8% were discarded, because the model did not properly converge (in most cases, an estimated quantity was at an upper or lower bound). This left $n = 3647$ MCB trials used to characterize uncertainty, which was sufficient for convergence of standard errors in management quantities.

The MCB analysis should be interpreted as providing an approximation to the uncertainty associated with each output. The results are approximate for two related reasons. First, not all combinations of Monte Carlo parameter inputs are equally likely, as biological parameters might be correlated. Second, all runs are given equal weight in the results, yet some might provide better fits to data than others.

#### 3.23.1 Bootstrap of observed data

To include uncertainty in time series of observed removals and indices of abundance, multiplicative lognormal errors were applied through a parametric bootstrap. To implement this approach in the MCB trials, random variables ($x_{s,y}$) were drawn for each year $y$ of time series $s$ from a normal distribution with mean 0 and variance $\sigma^2_{s,y}$ [that is, $x_{s,y} \sim N(0, \sigma^2_{s,y})$]. Annual observations were then perturbed from their original values ($\hat{O}_{s,y}$),

$$O_{s,y} = \hat{O}_{s,y}[\exp(x_{s,y} - \sigma^2_{s,y}/2)] \qquad (3)$$

The term $\sigma^2_{s,y}/2$ is a bias correction that centers the multiplicative error on the value of 1.0. Standard deviations in log space were computed from CVs in arithmetic space, $\sigma_{s,y} = \sqrt{\log(1.0 + CV^2_{s,y})}$.

Uncertainty used for the bootstrap analysis are shown in Table 6. Uncertainty in commercial landings was modeled based on the CVs provided by the commercial working group at the DW ($CV = 0.1$ for 1988-1993, $CV = 0.075$ for 1994-2001, $CV = 0.05$ for 2002-2014). No headboat landings CVs or headboat discard CVs by year were provided.

Based on improvements in sampling in the headboat program since its inception, a decreasing CV on landings over time was assumed (i.e. $CV = 0.15$ 1988-1995, $CV = 0.1$ for 1996-2007, and $CV = 0.05$ for 2008-2014). Based on discussions with the AW panel, a value of $CV = 0.20$ was assumed for headboat discards. General recreational landings and discards had complementary CVs, and those were used as provided, except with a few exceptions. A $CV$ greater than 1 was set to 1, which was sufficiently large to represent high uncertainty but not so high that bootstrapped values caused implausible time series (Table 6). CVs of indices of abundance were those provided by the DW (tabulated in Table 4 of this assessment report).

Uncertainty in age and length compositions were included by drawing new distributions for each year of each data source, following a multinomial sampling process. Ages (or lengths) of individual fish were drawn at random with replacement using the cell probabilities of the original data. For each year of each data source, the number of fish sampled was the same as in the original data.

### 3.23.2 Monte Carlo sampling

In each successive fit of the model, several parameters were fixed (i.e., not estimated) at values drawn at random from distributions described below.

**3.23.2.0.1 Natural mortality** A vector of age-specific natural mortality was provided by the Life History Working Group of the DW. The Charnov et al. (2013) estimator scaled to the Then et al. (2014) max age asymptotic $M$ was used to specify age-specific $M$, and then the uncertainty around the determination of maximum age was used to provide an upper and lower bound to the $M$ vector. While this approach included ageing uncertainty around $M$, discussions with the Assessment Panel indicated the true uncertainty around M was likely underestimated. As an alternative, the AW Panel recommended incorporating the uncertainty in both maximum age and the parameters of the Then et al. (2014) estimator of asymptotic $M$. Then et al. (2014) developed a relationship between maximum age and natural mortality from more than 200 studies that provided independent, direct estimates of $M$:

$$M = aT_{max}^b \tag{4}$$

A bootstrap was conducted where the mortality estimates included in Then et al. (2014) were re-sampled 10,000 times (with replacement) and the relationship between maximum age and $M$ re-computed for each bootstrap dataset. Uncertainty in natural mortality is also a function of uncertainty in the maximum age of fish in the population, which is typically based on the oldest reported fish in the landings. In the case of Gray Triggerfish, the maximum age was 15 years based on a single fish captured in 2011. Multiple age readings of fish greater than 10 years were not available for Gray Triggerfish. Therefore, uncertainty in the age of 10 year old Gray Triggerfish (the oldest age for which multiple age readings were available) was assumed to reflect the uncertainty in maximum age (15 years). The probabilities that age 10 Gray Triggerfish were actually older or younger were taken from the ageing error matrix developed for Gray Triggerfish. The ageing error matrix suggested age 10 Gray Triggerfish had a 0.18 probability of actually being age 9, a 0.12 probability of being age 8, a 0.07 probability of being age 7, a 0.03 probability of being age 6, and a 0.01 probability of being age-5. These probabilities were also applied to ages older than 15 (i.e., age 16-20) to create a symmetric distribution around the maximum observed age. A new vector of age-dependent natural mortality was developed for each MCB run by first drawing a $T_{max}$ from a distribution (10-20 year) about the assumed maximum age (15 years) based on the probabilities described above. Then a new relationship between $T_{max}$ and $M$ was chosen at random from the 10,000 bootstrap re-samplings of the data in Then et al. (2014). A new age-dependent natural mortality vector was then computed from this new estimate of asymptotic $M$ for each MCB trial as in the base run using the method of Charnov et al. (2013) described above.

3.23.2.0.2 **Discard mortality** The discard mortality working group provided an upper ($\delta = 0.20$) and lower ($\delta = 0.05$) bound on the assumed discard mortality rate ($\delta = 0.125$). A new discard mortality rate was assumed for each MCB run by drawing at random from a truncated normal distribution with mean $\delta = 0.125$ and standard deviation fixed to provide 95% confidence intervals at the upper and lower bounds.

3.23.2.0.3 **Batch fecundity** Prior to the MCB analysis, a bootstrap was conducted on the data used to estimate batch fecundity at age (Lang and Fitzhugh 2015). For each of 10,000 bootstrap runs, the 65 paired observations of batch fecundity and fish length were sampled 65 times with replacement, the regression model refit, and the bootstrap parameter estimates saved. The resulting parameter estimates were trimmed by removing runs where either parameter value was outside of its 95% confidence interval based on the original model fit in Lang and Fitzhugh (2015). The shape and scale parameters of the relationship between batch fecundity and fish length were highly correlated. Therefore, for each of the MCB runs an independent pair of parameters were drawn at random with replacement from the trimmed bootstrap parameter matrix. For each MCB run, predicted batch fecundity at age was calculated using a set of bootstrap parameters and a vector of length at age.

3.23.2.0.4 **Batch number** Prior to the MCB analysis, a similar but separate bootstrap procedure was run on the data used to estimate batch number at age for the base run. For each of 10,000 bootstrap runs, the 2841 paired observations of spawning indicator presence, fish age, and day of the year were sampled 2841 times with replacement. For each run, spawning fraction at age was calculated as in the base run. Spawning period duration at age was held constant at the observed values used in the the base run. Predicted batch number at age was then calculated as the product of the bootstrap vector of spawning fraction at age and the observed vector of spawning duration at age, and the resulting vector of batch number at age saved to a data matrix. Once all bootstraps were run, the batch number at age matrix was trimmed by first summing batch number at age for each run, yielding lifetime batch number; runs where lifetime batch number was outside of the 95% confidence interval were trimmed. During the MCB analysis, a vector of batch number at age was randomly drawn, with replacement, from the trimmed bootstrap batch number at age matrix for each MCB run.

3.23.2.0.5 **Index weight** The AW panel discussed a range of likelihood weights to apply to the fishery independent trap-video (CVID) index. A range of 4X the iteratively reweighted value to 8X the iteratively reweighted value (the index was upweighted 6X in the base run) was used in the MCB analysis. A new likelihood weight was assumed for each MCB run by drawing at random from a uniform distribution between these upper and lower bounds.

### 3.24 Projections

Projections were run to predict stock status in years after the assessment, 2015–2024. The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment. A single selectivity curve was applied to calculate landings and one for discards, averaged across fleets using geometric mean $F$s from the last three years of the assessment period, similar to computation of $L_{\mathrm{F30\%}}$ benchmarks (§3.22).

Expected values of SSB (time of peak spawning), $F$, recruits, and removals were represented by deterministic projections using parameter estimates from the base run. These projections were built on the spawner-recruit relationship ($h = 0.99$) with bias correction, and were thus consistent with estimated benchmarks in the sense that long-term fishing at $F_{30\%}$ would yield $L_{\mathrm{F30\%}}$ from a stock size at $\mathrm{SSB}_{\mathrm{F30\%}}$. Uncertainty in future time series was quantified through stochastic projections that extended the Monte Carlo/Bootstrap (MCB) fits of the stock assessment model.

#### 3.24.1 Initialization of projections

Point estimates of initial abundance at age in the projection (start 2015) were computed by the assessment model. Fishing rates that define the projections under new management were assumed to start in 2017. Because the assessment period ended in 2014, the projections required an initialization period (2015–2016). The level of landings in this period was assumed equal to the current landings, calculated as the mean landings over the last three years of the assessment (2012–2014). New management was assumed to start in 2017 with the $F$ indicated by the scenario definition.

#### 3.24.2 Uncertainty of projections

To characterize uncertainty in future stock dynamics, stochasticity was included in replicate projections, each an extension of a single MCB assessment model fit. Thus, projections carried forward uncertainties in landings and discards, natural mortality, reproduction, discard mortality, and index weighting, as well as in estimated quantities such as spawner-recruit parameters, selectivity curves, and initial (start of 2015) abundance at age.

Initial and subsequent recruitment values were generated with stochasticity using a Monte Carlo procedure, in which the estimated Beverton–Holt model (with $h = 0.99$ but $R_0$ and $\sigma_R^2$ estimated) of each MCB fit was used to compute mean annual recruitment values ($\bar{R}_y$). Variability was added to the mean values by choosing multiplicative deviations at random from a lognormal distribution,

$$R_y = \bar{R}_y \exp(\epsilon_y). \tag{5}$$

Here $\epsilon_y$ was drawn from a normal distribution with mean 0 and standard deviation $\sigma_R$, where $\sigma_R$ is the standard deviation from the relevant MCB fit.

The procedure generated 20,000 replicate projections of MCB model fits drawn at random (with replacement) from the MCB runs. In cases where the same MCB run was drawn, projections would still differ as a result of stochasticity in projected recruitment streams. Central tendencies were represented by the deterministic projections of the base run, as well as by medians of the stochastic projections. Precision of projections was represented graphically by the $5^{th}$ and $95^{th}$ percentiles of the replicate projections.

#### 3.24.3 Rebuilding time frame

Gray Triggerfish does not appear to be overfished and no rebuilding plan is necessary.

#### 3.24.4 Projection scenarios

Three constant F projection scenarios were considered:

- Scenario 1: $F = F_{\text{current}}$
- Scenario 2: $F = 75\% F_{30\%}$
- Scenario 3: $F = F_{30\%}$

## 3.25 Surplus Production Model

### 3.25.1 Overview

A logistic surplus production model (SPM), implemented in ASPIC (Version 7.03; Prager 2005), was used to estimate stock status of Gray triggerfish off the southeastern U.S. While primary assessment of the stock was performed using the age-structured model, the SPM was intended as a complement, for additional comparison with the age-structured model's results.

### 3.25.2 Data Sources

Data sources supplied to a SPM include a time series of removals (i.e. landings plus dead discards) and one or more indices of abundance (i.e. catch per unit of effort). These inputs should be in units of biomass (i.e. weight), therefore some of the data developed at the SEDAR-41 DW required additional formatting. These changes are detailed below. The range of years included in the SPM was the same as for the age-structured model (1988-2014).

#### Removals

The removals time series were comprised of commercial landings (1988-2014), recreational landings (1988-2014), commercial dead discards (1988-2014), and recreational dead discards (1988-2014), in pounds, summed by year. Recreational removals included general recreational and headboat fleets.

*Commercial Landings*

The SEDAR-41 DW reported commercial landings in pounds, thus these data did not need to be modified for the SPM.

*Recreational landings*

The SEDAR-41 DW reported recreational landings in pounds, thus these data did not need to be modified for the SPM.

#### Dead Discards

Discard estimates were generated in numbers at the SEDAR-41 DW. Since many discarded fish survive after release, discard mortality rates were applied to discards in numbers to calculate dead discards. For both commercial and recreational discards, a discard mortality rate of 0.125 was applied to all years based on recommendations made at the SEDAR-41 DW. Dead discards in numbers were then converted to weight, by multiplying by mean weights.

Mean weight of commercial discards was estimated from the geometric mean of the year-specific mean weights from the recreational discards. Mean weight of recreational discards was estimated using a length composition based approach. Lengths of headboat-at-sea observer discards were converted to weights using the length-weight conversion equation supplied by the SEDAR-41 DW. The geometric mean weight of these individuals was then calculated by year, and these annual mean weights were then smoothed using a three year moving average.

#### Indices of Abundance

Five indices of abundance were recommended by the SEDAR-41 DW for Gray Triggerfish: commercial handline index (hereafter commercial handline; units = lbs kept per hook-hour), headboat (number of fish kept per angler), Marine Recreational Information Program (MRIP), Southeast Reef Fish Survey (SERFS) chevron trap (number of fish caught per trap), and the SERFS video (number of fish observed per video). During the SEDAR-41 AW, the

SERFS chevron trap and video indices were combined into a single CVID index, which was used in the BAM instead of either of its component indices.

The commercial handline index was already in pounds and did not need to be converted. The headboat index was converted to pounds by multiplying by year-specific mean weights, generated by dividing headboat landings in pounds by landings in numbers for each year, then smoothing the mean weights by a three year moving average. The MRIP index was converted to pounds in the same manner as the headboat data. The CVID index was converted to weight with smoothed (three year moving average) annual mean weights derived using the length composition based approach based on chevron trap length composition data. All indices were re-standardized to a mean of one, following unit conversion, by dividing in each index by the mean of that index.

### 3.25.3 Model Configuration and Equations

Production modeling used the model formulation and ASPIC software (version 7.03) of Prager (1994; 2005). This is an observation-error estimator of the continuous-time form of the Schaefer (logistic) production model (Schaefer 1954; 1957). Estimation was conditioned on catch. The logistic model for population growth is a simple form of a differential equation which satisfies a number of ecologically realistic constraints, such as a carrying capacity (a consequence of limited resources). When written in terms of stock biomass, this model specifies that

$$\frac{dB_t}{dt} = rB_t - \frac{r}{K}B_t^2 \tag{6}$$

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

$$\frac{dB_t}{dt} = (r - F_t)B_t - \frac{r}{K}B_t^2 \tag{7}$$

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

For Gray Triggerfish, the SPM was configured using various combinations of removals, indices, starting dates, prior distributions, and starting values, resulting in approximately 214 configurations. Many of these runs were completed during early model development but many others incorporated small changes to data inputs or model specifications suggested by AW panel members during the Assessment Workshop. Most of these runs became obsolete and are not presented here.

In development of the SPM for Gray Triggerfish, it was evident that little contrast existed between the removals and abundance index time series, which tends to make fitting a SPM difficult. Despite many different configurations, the SPM often did not converge or provided unreasonable solutions, particularly when the entire time series was used. The run most closely matching the Beaufort Assessment Model (BAM) and configured according to recommendations by the SEDAR-41 AW panel is presented here as the best possible configuration (hereafter BPC run). This model configuration (run 213) utilized truncated time series data compared to the BAM, with removals and the four indices used in the BAM (Comm, HB, MRIP, CVID) from 2000-2014 . Following the recommendations of the AW panel, the CVID index was upweighted by a factor of three (i.e. CVs divided by three).

To evaluate the confidence in the model fit and parameter estimates of the BPC run, 1000 bootstrap runs were conducted. Percentile confidence intervals were also calculated for parameters.

# 4 Stock Assessment Results

## 4.1 Measures of Overall Model Fit

In general, the Beaufort Assessment Model (BAM) fit well to the available data. Predicted length compositions from each fishery were close to observed length compositions in most years, as were predicted age compositions (Figure 3). The largest fish in the commercial handline fishery and the smallest fish in the SERFS fishery independent trap survey were underpredicted in some years. The model was configured to fit observed commercial and recreational removals closely (Figures 4–8). Fits to the fishery independent trap-video index of abundance generally captured the observed trends but not all annual fluctuations (Figure 9). Predicted abundance matched the observed index almost exactly in the last four years of the time series.

## 4.2 Parameter Estimates

Estimates of all parameters from the catch-age model are shown in Appendix B. Estimates of management quantities and some key parameters are reported in sections below.

## 4.3 Stock Abundance and Recruitment

In general, there were no strong temporal trends in estimated abundance or evidence for truncation of older age classes over the course of the assessment period (Figure 10; Table 7). Total estimated abundance was at its highest in the mid-1990s and in the most recent 5 years, and was lower and variable through the early- and mid-2000s. Annual number of recruits is shown in Table 7 (age-1 column) and in Figure 11. The highest recruitments were predicted to have occurred in the early- to mid-1990s, while the most recent strong recruitment events (age-1 fish) were predicted to have occurred in 2011–2013. There were not strong temporal trends in recruitment over the assessment period, except perhaps an increasing trend since 2004. Annual variation in predicted recruitment was higher in the 1990s compared to the 2000s.

## 4.4 Total and Spawning Biomass

Estimated biomass at age followed a similar pattern as abundance at age, with the highest biomass in the mid-1990s and in the most recent 5 years, and low but stable biomass through the mid- 2000s (Figure 12; Table 8; Table 9). The highest spawning biomass (indexed as population fecundity) also occurred in the mid-1990s and in the most recent years, though spawning biomass showed a fairly consistent decline from its peak in 1997 until 2010, after which it increased sharply over the subsequent 4 years (Figure 13; Table 10).

## 4.5 Selectivity

Selectivity of the fishery independent trap-video survey is shown in Figure 14, and selectivities of removals from the commercial and recreational fleets are shown in Figures 15–19. Full selection occurred near ages 3–4, depending on the fleet or survey. The commercial handline fleet selected older fish compared to the recreational fleets. The headboat fleet and the general recreational fleet showed relatively strong dome-shaped selectivity, with the headboat fleet slightly more domed than the general recreational fleet, consistent with the different patterns in the depth distribution of these fleets relative to the distribution of Gray Triggerfish. Selectivity of headboat discards indicated discards were mostly age-1 Gray Triggerfish with some contribution from age-2 fish. Selectivity of general recreational discards was set equal to that of headboat discards, given the lack of age or length composition data specific to discards from the general recreational fleet.

Average selectivity of removals (landings and dead discards) was computed from $F$-weighted selectivities in the most recent three assessment years (Figure 20). This average selectivity was used in computation of point estimates of benchmarks, as well as in projections. All selectivities from the most recent period, including average selectivities, are tabulated in Table 11.

### 4.6 Fishing Mortality and Removals

Estimates of total $F$ at age are shown in Table 12 and estimates of landings and discards at age (in numbers and pounds whole weight) are shown in Tables 13, 14, 15, 16. In any given year, the maximum $F$ at age (i.e., apical F) may be less than that year's sum of fully selected $F$s across fleets. This inequality is due to the combination of two features of estimated selectivities: full selection occurs at different ages among gears and several sources of mortality have dome-shaped selectivity.

The estimated fishing mortality rates ($F$) were highest in the early 1990s, declined during the late 1990s and early 2000s, and peaked again in 2009 prior to declining toward the end of the assessment period (Figure 21; Table 17). The major contributors to fishing mortality are the general recreational fleet and the commercial handline fleet, and the relative contribution of the different fleets have been mostly constant over time, though the general recreational fleet has contributed more to the total fishing mortality since the mid-2000s.

Estimated time series of landings and discards (in number and pounds whole weight) by fleet are shown in Tables 18, 19, 20, 21. The majority of estimated removals were from the general recreational fleet and the commercial handline fleet, with much smaller contribution from the headboat fleet (Figures 22, 23; Tables 18, 19). The proportion of removals by the different fleets has been relatively constant over the assessment period.

### 4.7 Spawner-Recruitment Parameters

The Beverton–Holt spawner-recruit curve ($h = 0.99$) is shown in Figure 24, along with the effect of density dependence on recruitment, depicted graphically by recruits per spawner as a function of spawning stock (1E6 Eggs). Values of recruitment-related parameters were as follows: steepness $h = 0.99$ (fixed), unfished age-1 recruitment $\widehat{R_0} = 7,959,450$, and standard deviation of recruitment residuals in log space $\widehat{\sigma}_R = 0.44$ (which resulted in bias correction of $\varsigma = 1.10$). Uncertainty in these quantities was estimated through the MCB analysis (Figure 25).

### 4.8 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of $F$ (Figures 26 and 27). As in computation of MSY-related benchmarks, per recruit analyses applied the most recent selectivity patterns averaged across fleets, weighted by $F$ from the last three years (2012–2014). The yield per recruit curve increased monotonically with no well-defined peak, such that a wide range of F provided similar yield per recruit.

As in per recruit analyses, equilibrium landings and spawning biomass were computed as functions of $F$ (Figure 28).

### 4.9 Benchmarks / Reference Points

As described in §3.22, biological reference points (benchmarks) were derived analytically assuming equilibrium dynamics, corresponding to the expected spawner-recruit curve (Figure 24) with steepness fixed ($h = 0.99$) to achieve mean recruitment. Reference points estimated were $F_{30\%}$, $L_{\mathrm{F}30\%}$, $B_{\mathrm{F}30\%}$ and $\mathrm{SSB}_{\mathrm{F}30\%}$. Based on $F_{30\%}$, three possible values of $F$ at optimum yield (OY) were considered—$F_{\mathrm{OY}} = 65\% F_{30\%}$, $F_{\mathrm{OY}} = 75\% F_{30\%}$, and $F_{\mathrm{OY}} = 85\% F_{30\%}$—and for each, the corresponding yield was computed. Standard errors of benchmarks were approximated as those from MCB analysis (§3.23).

Maximum likelihood estimates (base run) of benchmarks, as well as median values from MCB analysis, are summarized in Table 22. Point estimates of $L_{\mathrm{F}30\%}$-related quantities were $F_{30\%} = 1.24$ ($\mathrm{y}^{-1}$), $L_{\mathrm{F}30\%} = 2379.23$ (1000 lb), $B_{\mathrm{F}30\%} = 8515.11$ (mt), and $\mathrm{SSB}_{\mathrm{F}30\%} = 5751203$ ($10^6 eggs$). Median estimates were $F_{30\%} = 1.24$ ($\mathrm{y}^{-1}$), $L_{\mathrm{F}30\%} = 2339.14$ (1000 lb), $B_{\mathrm{F}30\%} = 8389.44$ ($10^6$ eggs), and $\mathrm{SSB}_{\mathrm{F}30\%} = 5570736$ ($10^6$ eggs). Distributions of these benchmarks from the MCB analysis are shown in Figure 29.

Computed benchmarks included the MSY proxy (2379.23, 1000 lb whole weight), fishing mortality rate at $F30 = 1.24$ per year, and spawning stock at $F30$ (5751203, $1e6$ eggs) (Gabriel and Mace 1999).

### 4.10 Status of the Stock and Fishery

Estimated time series of stock status (SSB/MSST and $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{F}30\%}$) showed an increase through the 1990s followed by a general decline through 2010, and an increase in the most recent years (Figure 30, Table 10). Base-run estimates of spawning biomass have remained above the threshold (MSST) throughout the assessment period. Current stock status was estimated in the base run to be $\mathrm{SSB}_{2014}/\mathrm{MSST} = 4.5$ and $\mathrm{SSB}_{2014}/\mathrm{SSB}_{\mathrm{F}30\%} = 2.65$ (Table 22), indicating that the stock is not overfished. Median values from the MCB analysis indicated similar results ($\mathrm{SSB}_{2014}/\mathrm{MSST} = 4.57$ and $\mathrm{SSB}_{2014}/\mathrm{SSB}_{\mathrm{F}30\%} = 2.65$). The uncertainty analysis indicated that the terminal estimate of stock status is robust (Figures 31, 32). Of the MCB runs, 100% indicated that the stock was above MSST in 2014.

The estimated time series of $F/F_{30\%}$ suggested that overfishing has not occurred over the assessment period (Table 10). While estimates of exploitation status has varied over the assessment period, the conclusion that overfishing has not occurred is robust to the sources of uncertainty that were included in the MCB analysis (Figure 30). Current fishery status, with current $F$ represented by the geometric mean from 2012–2014, was estimated by the base run to be $F_{2012-2014}/F_{30\%} = 0.14$, and the median value was $F_{2012-2014}/F_{30\%} = 0.14$ (Table 22). Of the MCB runs, all agreed with the base run that the stock is not currently experiencing overfishing (Figures 31, 32).

### 4.11 Sensitivity and Retrospective Analyses

Sensitivity runs, described in §3.3, were used to explore data or modeling issues that arose during the assessment process, evaluate the implications of assumptions in the base assessment model, and to aid the interpretation of MCB results. In some cases, sensitivity runs are simply a tool for better understanding model behavior, and are not necessarily considered equally plausible representations of the stock and fishery dynamics. Time series of $F/F_{30\%}$ and $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{F}30\%}$ are plotted to demonstrate sensitivity to life history parameters, including natural mortality (Figure 33), batch number (Figure 34), the shape of the stock recruitment curve (Figure 35), the period over which recruitment deviations were estimated (Figure 36), discard mortality (Figure 37), and the fishing mortality used to initialize the model (Figure 38). Sensitivities were also conducted around assumptions about catchability (Figure 39), the form of the selectivity function for the various fishing fleets (Figure 40), and the potential for time varying selectivity associated with implementation and changes in management regulations (Figure 41). Sensitivities were also conducted to evaluate the effect of various index combinations (Figure 42 and 43), likelihood weights (Figure 44), and ageing error (45).

In general, indicators of biomass and exploitation status were most sensitive to assumptions about natural mortality, likelihood weights on the different data sources, the trap-video index weight, and catchability. Random walk catchability essentially negates the influence of the fishery independent trap-video index, such that results are similar to sensitivity analyses where that index is downweighted relative to other data sources. Constant natural mortality (rather than age-dependent) resulted in a change in status in the early 1990s and late 2000s, but terminal status remained unchanged from the base run. The model showed moderate sensitivity to assumptions about reproduction, the period over which recruitment deviations were estimated, selectivity assumptions, and the fishery dependent indices. The model was insensitive to discard mortality, the fishing mortality used to initialize the model, and ageing error. In general biomass benchmarks ($\mathrm{SSB}_{\mathrm{F}30\%}$) were more sensitive than fishing benchmarks ( $F/F_{30\%}$). Terminal status did not change from that estimated in the base run for any of the sensitivities (Figure 46, Table 23), though the time series of status did differ from the base for some sensitivities.

A 5-year retrospective analyses indicated good agreement with the base run for the first 3 years and then an increase in $F/F_{30\%}$ and slight decrease in $\mathrm{SSB}_{\mathrm{F}30\%}$ during the earliest years of the retrospective (2009 and 2010) (Figure 47). This pattern was reflected as an increase in F, a decrease in recruitment, and a slight decline in SSB (Figure 48). There was no loss of data sources over the five year period, but the relative contribution of different data sources did change. In particular, age composition data are strongest toward the end of the assessment period. The increase in $F/F_{30\%}$ in 2009 and 2010 is during a period when landings increased sharply for 2–3 years but the fishery independent index of abundance remained relatively stable. The subsequent decline in landings after this brief increase, the increase in the CPUE index at the end of the time series, and relatively strong subsequent recruitments may have contributed to the observed patterns.

### 4.12 Projections

Projections based on $F = F_{\mathrm{current}}$ show a relatively stable spawning stock, as well as stable landings and discards (Figure 49, Table 24). Projections based on $F = F_{30\%}$ (Figure 50, Table 25) showed an increase in fishing mortality in the year that management is implemented and an associated decline in spawing stock, landings, and discards, reaching the $F_{30\%}$ benchmark by 2019. Projections based on $F = 75\% F_{30\%}$ showed a similar pattern to those based on $F = F_{30\%}$ (Figure 51, Table 26).

### 4.13 Surplus Production Model

#### 4.13.1 Model Fit

For the BPC run, the model fit major trends in the indices (Figure 52). The model predicted an increase in abundance from 2000-2005, followed by relatively stable abundance thereafter.

#### 4.13.2 Parameter Estimates and Uncertainty

The ASPIC model estimates three main parameters ($\frac{B_1}{K}$, $MSY$, and $F_{MSY}$) as well as catchability coefficients ($q_i$) for each index $i$. Several other parameters can then be derived from these estimates: $r = 2F_{MSY}$, $K = \frac{2MSY}{F_{MSY}}$, and $B_{MSY} = \frac{K}{2}$. Recent status indicators $\frac{F}{F_{MSY}}$ and $\frac{B}{B_{MSY}}$ are calculated with the most recent estimates of $F$ (2014) and $B$ (2015). Estimates of the main parameters and recent status indicators for the BPC run are presented in Table 27. Prior distributions and model estimates of the main parameters for the BPC run are presented in Figure 53. Among bootstrap runs based on the BPC, distributions of $\frac{B_1}{K}$, $MSY$, and $F_{MSY}$ were unimodal but highly right skewed (Figure 54).

#### 4.13.3 Status of the Stock and Fishery

In the BPC run of the surplus production model, $\frac{B}{B_{MSY}}$ is greater than one suggesting that the South Atlantic stock of Gray triggerfish is not overfished (Table 27; Figure 55). The 95% bootstrap percentile confidence intervals for $\frac{B}{B_{MSY}}$ do contain one (Figure 54). The surplus production model estimated that $\frac{F}{F_{MSY}}$ is less than one, indicating the stock is not undergoing overfishing (Table 27; Figure 55). The 95% bootstrap percentile confidence intervals for $\frac{F}{F_{MSY}}$ do not contain one (Figure 54).

#### 4.13.4 Interpretation

As described above, the only data that go into a surplus production model are biomass of removals and abundance indices. Therefore such a model does not make use of many other sources of information such as sex, maturity, growth, fecundity, or population age and size structure. Because such data are available for Gray Triggerfish, a model that uses them would be preferred for a detailed assessment on which to base management.

# 5 Discussion

## 5.1 Comments on the Assessment

Estimated benchmarks played a central role in this assessment. Values of $\mathrm{SSB}_{\mathrm{F30\%}}$ and $F_{30\%}$ were used to determine the status of the stock and the fishery. Computation of benchmarks was conditional on selectivity. If selectivity patterns change in the future, for example as a result of different relative catch allocations among sectors or targeting, estimates of benchmarks would likely change as well.

The base run of the BAM indicated that the stock is not overfished ($\mathrm{SSB}_{2014}/\mathrm{SSB}_{\mathrm{F30\%}} = 2.65$), and that overfishing is not occurring ($F_{2012-2014}/F_{30\%} = 0.14$). Median values from the MCB analyses were in good agreement with the results from the base run ($\mathrm{SSB}_{2014}/\mathrm{SSB}_{\mathrm{F30\%}} = 2.65$ and $F_{2012-2014}/F_{30\%} = 0.14$). Sensitivity and uncertainty analyses indicate that these findings are robust.

In general, fishery dependent indices of abundance may not track actual abundance well, because of factors such as hyperdepletion or hyperstability. This issue can be exacerbated by management measures that change targeting practices within multi-species fisheries. In the case of Gray Triggerfish, fishery dependent indices were in conflict with each other and with the fishery independent index, and, therefore, were excluded from the assessment. Abundance indices are critical for developing accurate assessments of harvested stocks, highlighting the importance of fishery independent sampling throughout the geographic range of managed stocks.

Most assessed stocks in the southeast U.S. have shown histories of heavy exploitation. This does not appear to be the case for Gray Triggerfish, though the assessment period was relative short and early removals are not well known given the changes in desirability of Gray Triggerfish. Even so, high rates of fishing mortality can lead to adaptive responses in life-history characteristics, such as growth and maturity schedules. Such adaptations can affect expected yield and stock recovery, and thus resource managers might wish to consider possible evolutionary effects of fishing in their management plans (Dunlop et al. 2009; Enberg et al. 2009).

Because steepness could not be estimated reliably in this assessment, its value in the base run was fixed at 0.99. Fixing steepness at its upper bound does not reflect a belief that the stock has perfect compensation at any exploitation or stock level. Rather, it was a computational convenience to use the stock recruitment curve with $h = 0.99$ in order to treat recruitment as an average through times while estimating deviations from that mean. As a result, MSY-based management quantities are not appropriate, and the AW Panel chose to use the proxy of $F_{30\%}$.

The AW panel devoted considerable discussion to the estimates of natural mortality provided by the DW. The point estimate of natural mortality used for Gray Triggerfish ($M$=0.41) was based on an updated meta-analysis of more than 200 independent, direct estimates of $M$ (Then et al. 2014), including many more stocks from temperate and sub-tropical latitudes. This estimate is based on a maximum age of 15 years for Gray Triggerfish. Given the high variation in size-at-age of Gray Triggerfish and the typical correlation among growth parameters (e.g., $L_\infty$ and $k$), the AW panel did not recommend the growth based estimator ($M$=0.27) from Then et al. (2014) for the base run. Sensitivity analysis indicated that alternative point estimates and functional forms (e.g., constant vs. age-dependent) for natural mortality did not change the overall conclusions from the assessment.

### 5.2 Comments on the Projections

In general, projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- In general, projections of fish stocks are highly uncertain, particularly in the long term (e.g., beyond 5–10 years).
- Although projections included many major sources of uncertainty, they did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect projection results.
- The projections assumed that the modeled spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If future recruitment is characterized by runs of large or small year classes, possibly due to environmental or ecological conditions, stock projections may be affected.
- Projections apply the Baranov catch equation to relate $F$ and landings using a one-year time step, as in the assessment. The catch equation implicitly assumes that mortality occurs throughout the year. This assumption is violated when seasonal closures or small intensive fishing seasons are in effect, introducing additional and unquantified uncertainty into the projection results.
- In this assessment, projections at $F = F_{30\%}$ are equivalent to $P*$ projections with $P* = 0.5$.

### 5.3 Research Recommendations

- Increased fishery independent information, in particular reliable indices of abundance and age compositions.
- Increased age sampling and evaluation of ageing error over the stock area and from all fleets, particularly the general recreational fleet.
- In this assessment Gray Triggerfish were modeled as a unit stock off the southeastern U.S. For any stock, variation in exploitation and life-history characteristics might be expected at finer geographic scales. Modeling such sub-stock structure would require more data, such as information on the movements and migrations of adults and juveniles, as well as spatial patterns of larval dispersal and recruitment. In addition, it is unknown whether a spatial model would improve the assessment.

- More research to better understand the life history of Gray Triggerfish is needed, including natural mortality, maturity, and reproductive potential, particularly for the youngest ages.
- The effects of environmental variation on the changes in recruitment or survivorship.

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## 7 Tables

*Table 1. Life-history characteristics at age, including average body fork length (FL) and weight (mid-year), proportion mature females, batch number, and natural mortality. All values were treated as input to the assessment model.*

| Age | Avg. FL (mm) | Avg. FL (in) | CV length | Avg. Whole weight (kg) | Avg. Whole weight (lb) | Maturity | Batch number | Nat. mortality |
|---|---|---|---|---|---|---|---|---|
| 1 | 258.2 | 10.2 | 0.11 | 0.40 | 0.88 | 0.79 | 0.1 | 0.887 |
| 2 | 314.4 | 12.4 | 0.11 | 0.72 | 1.59 | 0.95 | 2.3 | 0.660 |
| 3 | 354.4 | 14.0 | 0.11 | 1.03 | 2.26 | 0.99 | 3.5 | 0.552 |
| 4 | 382.9 | 15.1 | 0.11 | 1.29 | 2.85 | 1.00 | 4.6 | 0.491 |
| 5 | 403.1 | 15.9 | 0.11 | 1.51 | 3.32 | 1.00 | 6.4 | 0.455 |
| 6 | 417.6 | 16.4 | 0.11 | 1.67 | 3.68 | 1.00 | 7.6 | 0.431 |
| 7 | 427.8 | 16.8 | 0.11 | 1.80 | 3.96 | 1.00 | 7.6 | 0.416 |
| 8 | 435.2 | 17.1 | 0.11 | 1.89 | 4.16 | 1.00 | 7.6 | 0.405 |

*Table 2. Size (FL) in inches and weight in pounds (lb) at age as applied to the population (Pop), fisheries landings (FD), and the SERFS chevron trap survey (CVT). The population growth curve was treated as input to the assessment model. The fishery landings and survey growth curves were estimated by the assessment model from starting values provided by the DW.*

| Age | Pop.FL | CV.Pop.FL | Pop.lb | FD.FL | CV.FD.FL | FD.lb | CVT.FL | CV.CVT.FL | CVT.lb |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 10.2 | 0.11 | 0.9 | 9.8 | 0.09 | 0.8 | 7.1 | 0.13 | 0.3 |
| 2 | 12.4 | 0.11 | 1.6 | 11.2 | 0.09 | 1.2 | 10.4 | 0.13 | 1.0 |
| 3 | 14.0 | 0.11 | 2.3 | 12.5 | 0.09 | 1.6 | 12.5 | 0.13 | 1.6 |
| 4 | 15.1 | 0.11 | 2.8 | 13.6 | 0.09 | 2.1 | 13.8 | 0.13 | 2.2 |
| 5 | 15.9 | 0.11 | 3.3 | 14.6 | 0.09 | 2.6 | 14.7 | 0.13 | 2.6 |
| 6 | 16.4 | 0.11 | 3.7 | 15.4 | 0.09 | 3.0 | 15.2 | 0.13 | 2.9 |
| 7 | 16.8 | 0.11 | 4.0 | 16.1 | 0.09 | 3.5 | 15.5 | 0.13 | 3.1 |
| 8 | 17.1 | 0.11 | 4.2 | 16.8 | 0.09 | 3.9 | 15.7 | 0.13 | 3.2 |

*Table 3. Observed time series of landings (L) and discards (D) for the commercial handline (cH), headboat (HB), and general recreational (GR) fleets. Commercial values are in units of 1000 lb whole weight. Recreational values are in units of 1000 fish. Dead discards were pooled with landings for the commercial handline fleet.*

| Year | cH.L | HB.L | GR.L | HB.D | GR.D |
|---|---|---|---|---|---|
| 1988 | 79.832 | 34.926 | 113.352 | 0.165 | 12.999 |
| 1989 | 96.487 | 37.367 | 394.704 | 0.198 | 33.973 |
| 1990 | 194.797 | 71.704 | 238.471 | 0.071 | 11.013 |
| 1991 | 271.694 | 85.529 | 313.797 | 0.016 | 39.422 |
| 1992 | 263.032 | 91.733 | 192.245 | 0.048 | 15.780 |
| 1993 | 329.064 | 107.070 | 268.924 | 0.024 | 10.317 |
| 1994 | 410.679 | 90.387 | 171.182 | 0.024 | 9.973 |
| 1995 | 488.437 | 93.367 | 148.134 | 0.117 | 13.301 |
| 1996 | 441.970 | 89.954 | 275.301 | 0.028 | 16.245 |
| 1997 | 536.451 | 106.170 | 290.987 | 0.088 | 13.215 |
| 1998 | 424.389 | 65.857 | 93.577 | 0.140 | 4.928 |
| 1999 | 279.378 | 37.218 | 112.743 | 0.333 | 7.997 |
| 2000 | 196.777 | 34.092 | 107.727 | 0.420 | 9.289 |
| 2001 | 215.776 | 32.978 | 126.007 | 0.438 | 10.384 |
| 2002 | 204.482 | 57.630 | 184.651 | 0.754 | 14.966 |
| 2003 | 192.111 | 45.751 | 170.767 | 0.294 | 20.212 |
| 2004 | 252.412 | 78.073 | 217.963 | 0.246 | 23.610 |
| 2005 | 276.017 | 63.582 | 207.746 | 0.259 | 22.925 |
| 2006 | 241.487 | 43.151 | 169.506 | 0.363 | 20.107 |
| 2007 | 323.169 | 66.403 | 308.856 | 0.225 | 34.170 |
| 2008 | 320.128 | 44.758 | 429.321 | 1.340 | 23.495 |
| 2009 | 370.283 | 59.945 | 497.253 | 1.294 | 32.223 |
| 2010 | 453.214 | 68.807 | 325.334 | 2.420 | 22.782 |
| 2011 | 498.734 | 53.356 | 167.214 | 1.440 | 9.541 |
| 2012 | 311.367 | 49.096 | 264.993 | 1.581 | 12.508 |
| 2013 | 339.273 | 56.487 | 166.817 | 1.095 | 20.260 |
| 2014 | 284.758 | 53.108 | 230.238 | 1.519 | 21.624 |

*Table 4. Observed index of abundance and CV from the fishery independent combined chevron trap-video survey (CVID).*

| Year | CVID | CVID CV |
|---|---|---|
| 1990 | 0.28 | 0.32 |
| 1991 | 1.08 | 0.24 |
| 1992 | 0.86 | 0.26 |
| 1993 | 0.80 | 0.24 |
| 1994 | 1.03 | 0.23 |
| 1995 | 1.33 | 0.22 |
| 1996 | 1.58 | 0.22 |
| 1997 | 1.44 | 0.22 |
| 1998 | 1.70 | 0.23 |
| 1999 | 0.75 | 0.27 |
| 2000 | 0.65 | 0.28 |
| 2001 | 0.88 | 0.25 |
| 2002 | 1.50 | 0.24 |
| 2003 | 0.83 | 0.31 |
| 2004 | 1.27 | 0.24 |
| 2005 | 0.77 | 0.25 |
| 2006 | 0.56 | 0.27 |
| 2007 | 0.95 | 0.25 |
| 2008 | 0.89 | 0.25 |
| 2009 | 0.70 | 0.26 |
| 2010 | 0.67 | 0.25 |
| 2011 | 0.87 | 0.19 |
| 2012 | 1.06 | 0.18 |
| 2013 | 1.24 | 0.17 |
| 2014 | 1.29 | 0.20 |

*Table 5. Sample sizes (number of trips) of length compositions (len) and age compositions (age) by survey or fleet. Data sources are commercial handline (cH), headboat (HB), headboat discard (HB.D), general recreational (GR), and SERFS chevron trap (CVT).*

| Year | len.cH | len.HB | len.CVT | len.HB.D | age.cH | age.HB | age.CVT |
|---|---|---|---|---|---|---|---|
| 1988 | 32 | 228 | . | . | . | . | . |
| 1989 | 38 | 265 | . | . | . | . | . |
| 1990 | 38 | 252 | 41 | . | . | 10 | . |
| 1991 | 36 | 196 | 134 | . | . | 24 | 47 |
| 1992 | 34 | 243 | 88 | . | . | . | 70 |
| 1993 | 77 | 269 | 118 | . | . | . | 112 |
| 1994 | 66 | 244 | 154 | . | . | . | 142 |
| 1995 | 136 | 250 | 156 | . | . | . | 134 |
| 1996 | 78 | 192 | 179 | . | . | . | 166 |
| 1997 | 51 | 312 | 194 | . | . | . | 164 |
| 1998 | 65 | 348 | 124 | . | . | . | 118 |
| 1999 | 95 | 265 | 62 | . | . | . | 60 |
| 2000 | 154 | 189 | 92 | . | . | . | 86 |
| 2001 | 137 | 207 | 99 | . | . | . | 78 |
| 2002 | 93 | 249 | 112 | . | . | . | 102 |
| 2003 | 78 | 306 | 34 | . | . | 20 | 33 |
| 2004 | 148 | 331 | 96 | . | 25 | . | 74 |
| 2005 | 136 | 260 | 108 | 42 | 47 | 19 | 99 |
| 2006 | 220 | 273 | 75 | 43 | 86 | 30 | 64 |
| 2007 | 285 | 342 | 123 | 42 | 196 | 47 | 96 |
| 2008 | 269 | 200 | 72 | 30 | 205 | 13 | 64 |
| 2009 | 242 | 316 | 90 | 51 | 180 | 30 | 79 |
| 2010 | 269 | 335 | 216 | 49 | 215 | 55 | 97 |
| 2011 | 297 | 327 | 169 | 32 | 211 | 36 | 116 |
| 2012 | 202 | 313 | 341 | 36 | 110 | 35 | 190 |
| 2013 | 148 | 401 | 367 | 43 | 97 | 129 | 281 |
| 2014 | 51 | 394 | 464 | 49 | 69 | 187 | 304 |

*Table 6. Coefficients of variation used for the MCB bootstraps of landings and discards. Commercial handline landings (CV.L.cH), headboat landings (CV.L.HB), general recreational landings (CV.L.GR), headboat discards (CV.D.HB), and general recreational discards (CV.D.GR).*

| Year | CV.L.cH | CV.L.HB | CV.L.GR | CV.D.HB | CV.D.GR |
|---|---|---|---|---|---|
| 1988 | 0.10 | 0.15 | 0.93 | 0.20 | 0.74 |
| 1989 | 0.10 | 0.15 | 1.32 | 0.20 | 0.36 |
| 1990 | 0.10 | 0.15 | 0.86 | 0.20 | 0.44 |
| 1991 | 0.10 | 0.15 | 0.56 | 0.20 | 0.28 |
| 1992 | 0.10 | 0.15 | 0.44 | 0.20 | 0.25 |
| 1993 | 0.10 | 0.15 | 0.45 | 0.20 | 0.60 |
| 1994 | 0.08 | 0.15 | 0.44 | 0.20 | 0.90 |
| 1995 | 0.08 | 0.15 | 0.56 | 0.20 | 1.53 |
| 1996 | 0.08 | 0.10 | 0.73 | 0.20 | 0.54 |
| 1997 | 0.08 | 0.10 | 0.62 | 0.20 | 0.35 |
| 1998 | 0.08 | 0.10 | 1.22 | 0.20 | 0.46 |
| 1999 | 0.08 | 0.10 | 0.70 | 0.20 | 0.52 |
| 2000 | 0.08 | 0.10 | 0.75 | 0.20 | 0.29 |
| 2001 | 0.08 | 0.10 | 0.86 | 0.20 | 0.32 |
| 2002 | 0.05 | 0.10 | 0.51 | 0.20 | 0.27 |
| 2003 | 0.05 | 0.10 | 0.70 | 0.20 | 0.31 |
| 2004 | 0.05 | 0.10 | 0.41 | 0.20 | 0.69 |
| 2005 | 0.05 | 0.10 | 0.36 | 0.20 | 0.24 |
| 2006 | 0.05 | 0.10 | 0.43 | 0.20 | 0.29 |
| 2007 | 0.05 | 0.10 | 0.21 | 0.20 | 0.33 |
| 2008 | 0.05 | 0.05 | 0.38 | 0.20 | 0.43 |
| 2009 | 0.05 | 0.05 | 0.31 | 0.20 | 0.37 |
| 2010 | 0.05 | 0.05 | 0.31 | 0.20 | 0.46 |
| 2011 | 0.05 | 0.05 | 0.31 | 0.20 | 0.41 |
| 2012 | 0.05 | 0.05 | 0.25 | 0.20 | 0.71 |
| 2013 | 0.05 | 0.05 | 0.13 | 0.20 | 0.24 |
| 2014 | 0.05 | 0.05 | 0.17 | 0.20 | 0.17 |

*Table 7. Estimated abundance at age (1000 fish) at start of year.*

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 3418.37 | 933.78 | 646.77 | 389.26 | 307.87 | 236.17 | 165.69 | 289.84 | 6387.76 |
| 1989 | 3814.69 | 1398.83 | 474.23 | 336.60 | 206.78 | 171.10 | 138.12 | 285.19 | 6825.52 |
| 1990 | 14040.06 | 1546.52 | 679.01 | 185.26 | 123.26 | 81.69 | 76.23 | 233.23 | 16965.26 |
| 1991 | 8579.79 | 5759.14 | 762.07 | 290.14 | 73.12 | 51.07 | 37.35 | 166.92 | 15719.61 |
| 1992 | 7112.22 | 3503.39 | 2848.72 | 332.89 | 113.28 | 29.13 | 22.15 | 103.22 | 14064.99 |
| 1993 | 10421.22 | 2916.94 | 1776.83 | 1456.64 | 162.23 | 55.81 | 15.05 | 69.63 | 16874.35 |
| 1994 | 14056.46 | 4280.37 | 1475.69 | 894.21 | 708.22 | 80.77 | 29.33 | 48.41 | 21573.46 |
| 1995 | 16027.55 | 5777.57 | 2177.32 | 767.89 | 451.80 | 363.80 | 43.38 | 44.32 | 25653.63 |
| 1996 | 10758.02 | 6587.71 | 2946.80 | 1151.19 | 393.34 | 233.80 | 195.79 | 49.51 | 22316.16 |
| 1997 | 7241.15 | 4418.10 | 3354.71 | 1543.52 | 592.38 | 206.45 | 128.07 | 140.63 | 17625.01 |
| 1998 | 3323.09 | 2972.50 | 2250.12 | 1760.68 | 796.66 | 311.97 | 113.46 | 155.95 | 11684.43 |
| 1999 | 4310.48 | 1365.44 | 1525.14 | 1238.97 | 982.24 | 454.86 | 183.98 | 164.75 | 10225.85 |
| 2000 | 8230.63 | 1769.78 | 700.26 | 838.17 | 698.47 | 570.68 | 273.37 | 217.53 | 13298.89 |
| 2001 | 12601.49 | 3382.38 | 906.13 | 380.78 | 468.55 | 404.34 | 343.04 | 307.70 | 18794.42 |
| 2002 | 8397.17 | 5180.37 | 1727.82 | 484.84 | 207.41 | 263.99 | 237.32 | 401.11 | 16900.02 |
| 2003 | 7827.13 | 3447.01 | 2638.12 | 908.94 | 257.89 | 114.32 | 152.31 | 391.49 | 15737.22 |
| 2004 | 4724.42 | 3210.32 | 1762.39 | 1423.53 | 500.72 | 146.80 | 67.64 | 338.80 | 12174.61 |
| 2005 | 5757.07 | 1931.34 | 1633.73 | 928.59 | 757.66 | 275.99 | 84.68 | 250.47 | 11619.53 |
| 2006 | 8800.55 | 2355.70 | 982.55 | 857.25 | 490.31 | 413.75 | 157.78 | 204.53 | 14262.42 |
| 2007 | 7932.21 | 3609.77 | 1200.09 | 518.03 | 456.26 | 269.84 | 238.01 | 220.79 | 14445.01 |
| 2008 | 7007.00 | 3242.83 | 1816.64 | 586.88 | 246.75 | 225.12 | 141.66 | 262.55 | 13529.44 |
| 2009 | 7079.48 | 2867.48 | 1626.36 | 863.21 | 268.07 | 116.52 | 113.58 | 227.32 | 13162.03 |
| 2010 | 8317.17 | 2891.14 | 1429.06 | 743.52 | 371.17 | 119.05 | 55.77 | 185.23 | 14112.10 |
| 2011 | 11177.12 | 3405.48 | 1452.23 | 685.75 | 333.61 | 169.32 | 57.76 | 129.77 | 17411.04 |
| 2012 | 12490.17 | 4592.34 | 1730.66 | 747.01 | 332.57 | 161.93 | 85.73 | 101.19 | 20241.62 |
| 2013 | 10967.48 | 5130.88 | 2329.88 | 882.84 | 371.72 | 169.21 | 86.48 | 106.90 | 20045.39 |
| 2014 | 8474.31 | 4502.06 | 2620.61 | 1244.34 | 467.23 | 200.43 | 94.75 | 113.60 | 17717.32 |
| 2015 | 8752.37 | 3475.17 | 2298.31 | 1398.25 | 668.40 | 258.01 | 115.17 | 125.96 | 17091.63 |

*Table 8. Estimated biomass at age (mt) at start of year*

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 1369.4 | 671.5 | 663.8 | 502.6 | 463.4 | 394.6 | 297.5 | 547.3 | 4910.2 |
| 1989 | 1528.2 | 1005.9 | 486.7 | 434.6 | 311.2 | 285.9 | 248.0 | 538.5 | 4839.1 |
| 1990 | 5624.5 | 1112.1 | 696.9 | 239.2 | 185.5 | 136.5 | 136.9 | 440.4 | 8572.1 |
| 1991 | 3437.1 | 4141.5 | 782.2 | 374.6 | 110.1 | 85.3 | 67.1 | 315.2 | 9313.1 |
| 1992 | 2849.2 | 2519.3 | 2923.9 | 429.8 | 170.5 | 48.7 | 39.8 | 194.9 | 9176.1 |
| 1993 | 4174.8 | 2097.6 | 1823.7 | 1880.9 | 244.2 | 93.2 | 27.0 | 131.5 | 10472.9 |
| 1994 | 5631.0 | 3078.1 | 1514.6 | 1154.6 | 1065.9 | 134.9 | 52.7 | 91.4 | 12723.3 |
| 1995 | 6420.7 | 4154.7 | 2234.8 | 991.5 | 680.0 | 607.8 | 77.9 | 83.7 | 15251.1 |
| 1996 | 4309.7 | 4737.3 | 3024.6 | 1486.5 | 592.0 | 390.6 | 351.6 | 93.5 | 14985.8 |
| 1997 | 2900.8 | 3177.1 | 3443.3 | 1993.1 | 891.6 | 344.9 | 230.0 | 265.6 | 13246.3 |
| 1998 | 1331.2 | 2137.6 | 2309.5 | 2273.5 | 1199.0 | 521.2 | 203.7 | 294.5 | 10270.3 |
| 1999 | 1726.8 | 981.9 | 1565.4 | 1599.8 | 1478.3 | 759.9 | 330.4 | 311.1 | 8753.7 |
| 2000 | 3297.2 | 1272.7 | 718.7 | 1082.3 | 1051.2 | 953.4 | 490.9 | 410.8 | 9277.3 |
| 2001 | 5048.2 | 2432.3 | 930.1 | 491.7 | 705.2 | 675.5 | 616.0 | 581.1 | 11480.0 |
| 2002 | 3363.9 | 3725.3 | 1773.4 | 626.0 | 312.2 | 441.0 | 426.2 | 757.5 | 11425.5 |
| 2003 | 3135.6 | 2478.8 | 2707.8 | 1173.7 | 388.1 | 191.0 | 273.5 | 739.3 | 11087.7 |
| 2004 | 1892.6 | 2308.6 | 1808.9 | 1838.1 | 753.6 | 245.3 | 121.5 | 639.8 | 9608.4 |
| 2005 | 2306.3 | 1388.9 | 1676.9 | 1199.0 | 1140.3 | 461.1 | 152.1 | 473.0 | 8797.5 |
| 2006 | 3525.5 | 1694.0 | 1008.5 | 1106.9 | 737.9 | 691.3 | 283.3 | 386.2 | 9433.7 |
| 2007 | 3177.7 | 2595.8 | 1231.8 | 668.9 | 686.7 | 450.8 | 427.4 | 416.9 | 9656.0 |
| 2008 | 2807.0 | 2332.0 | 1864.6 | 757.8 | 371.4 | 376.1 | 254.4 | 495.8 | 9259.1 |
| 2009 | 2836.0 | 2062.0 | 1669.3 | 1114.6 | 403.5 | 194.7 | 204.0 | 429.3 | 8913.4 |
| 2010 | 3331.9 | 2079.1 | 1466.8 | 960.1 | 558.6 | 198.9 | 100.2 | 349.8 | 9045.2 |
| 2011 | 4477.6 | 2448.9 | 1490.6 | 885.5 | 502.1 | 282.9 | 103.7 | 245.0 | 10436.3 |
| 2012 | 5003.6 | 3302.4 | 1776.3 | 964.6 | 500.5 | 270.5 | 154.0 | 191.1 | 12163.1 |
| 2013 | 4393.6 | 3689.7 | 2391.4 | 1140.0 | 559.5 | 282.7 | 155.3 | 201.9 | 12814.0 |
| 2014 | 3394.8 | 3237.5 | 2689.8 | 1606.8 | 703.2 | 334.9 | 170.1 | 214.5 | 12351.6 |
| 2015 | 3506.2 | 2499.1 | 2359.0 | 1805.5 | 1006.0 | 431.1 | 206.8 | 237.9 | 12051.4 |

*Table 9. Estimated biomass at age (1000 lb) at start of year*

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 3019.0 | 1480.4 | 1463.4 | 1108.0 | 1021.6 | 869.9 | 655.9 | 1206.6 | 10825.1 |
| 1989 | 3369.1 | 2217.6 | 1073.0 | 958.1 | 686.1 | 630.3 | 546.7 | 1187.2 | 10668.4 |
| 1990 | 12399.9 | 2451.8 | 1536.4 | 527.3 | 409.0 | 300.9 | 301.8 | 970.9 | 18898.2 |
| 1991 | 7577.5 | 9130.4 | 1724.5 | 825.9 | 242.7 | 188.1 | 147.9 | 694.9 | 20531.8 |
| 1992 | 6281.4 | 5554.1 | 6446.1 | 947.5 | 375.9 | 107.4 | 87.7 | 429.7 | 20229.8 |
| 1993 | 9203.8 | 4624.4 | 4020.6 | 4146.7 | 538.4 | 205.5 | 59.5 | 289.9 | 23088.8 |
| 1994 | 12414.2 | 6786.0 | 3339.1 | 2545.5 | 2349.9 | 297.4 | 116.2 | 201.5 | 28050.0 |
| 1995 | 14155.2 | 9159.5 | 4926.9 | 2185.9 | 1499.1 | 1340.0 | 171.7 | 184.5 | 33622.9 |
| 1996 | 9501.3 | 10443.9 | 6668.1 | 3277.2 | 1305.1 | 861.1 | 775.1 | 206.1 | 33038.0 |
| 1997 | 6395.2 | 7004.3 | 7591.2 | 4394.0 | 1965.6 | 760.4 | 507.1 | 585.5 | 29203.1 |
| 1998 | 2934.8 | 4712.6 | 5091.6 | 5012.2 | 2643.3 | 1149.0 | 449.1 | 649.3 | 22642.1 |
| 1999 | 3806.9 | 2164.7 | 3451.1 | 3527.0 | 3259.1 | 1675.3 | 728.4 | 685.9 | 19298.6 |
| 2000 | 7269.1 | 2805.8 | 1584.5 | 2386.1 | 2317.5 | 2101.9 | 1082.2 | 905.7 | 20452.9 |
| 2001 | 11129.4 | 5362.3 | 2050.5 | 1084.0 | 1554.7 | 1489.2 | 1358.0 | 1281.1 | 25309.0 |
| 2002 | 7416.1 | 8212.9 | 3909.7 | 1380.1 | 688.3 | 972.2 | 939.6 | 1670.0 | 25188.9 |
| 2003 | 6912.8 | 5464.8 | 5969.7 | 2587.6 | 855.6 | 421.1 | 603.0 | 1629.9 | 24444.2 |
| 2004 | 4172.5 | 5089.6 | 3987.9 | 4052.3 | 1661.4 | 540.8 | 267.9 | 1410.5 | 21182.9 |
| 2005 | 5084.5 | 3062.0 | 3696.9 | 2643.3 | 2513.9 | 1016.6 | 335.3 | 1042.8 | 19395.1 |
| 2006 | 7772.4 | 3734.6 | 2223.4 | 2440.3 | 1626.8 | 1524.1 | 624.6 | 851.4 | 20797.7 |
| 2007 | 7005.6 | 5722.8 | 2715.7 | 1474.7 | 1513.9 | 993.8 | 942.3 | 919.1 | 21287.8 |
| 2008 | 6188.4 | 5141.2 | 4110.7 | 1670.7 | 818.8 | 829.2 | 560.9 | 1093.1 | 20412.8 |
| 2009 | 6252.3 | 4545.9 | 3680.2 | 2457.3 | 889.6 | 429.2 | 449.7 | 946.4 | 19650.7 |
| 2010 | 7345.6 | 4583.6 | 3233.7 | 2116.7 | 1231.5 | 438.5 | 220.9 | 771.2 | 19941.2 |
| 2011 | 9871.4 | 5398.9 | 3286.2 | 1952.2 | 1106.9 | 623.7 | 228.6 | 540.1 | 23008.1 |
| 2012 | 11031.0 | 7280.5 | 3916.1 | 2126.6 | 1103.4 | 596.3 | 339.5 | 421.3 | 26815.0 |
| 2013 | 9686.2 | 8134.4 | 5272.1 | 2513.3 | 1233.5 | 623.2 | 342.4 | 445.1 | 28250.0 |
| 2014 | 7484.2 | 7137.5 | 5930.0 | 3542.4 | 1550.3 | 738.3 | 375.0 | 472.9 | 27230.6 |
| 2015 | 7729.8 | 5509.6 | 5200.7 | 3980.4 | 2217.8 | 950.4 | 455.9 | 524.5 | 26568.8 |

*Table 10. Estimated time series of status indicators, fishing mortality, and biomass. Fishing mortality rate is apical $F$. Total biomass (B, mt) is at the start of the year, and spawning biomass (SSB, $10^6$ eggs) at the time of peak spawning (mid-year). The $MSST_{\mathrm{F30}}$ is defined by* $\mathrm{MSST} = (1 - M)SSB_{\mathrm{F30}}$, *with constant* $M = 0.41$.

| Year | $F$ | $F/F_{30}$ | B | $B/B_{\mathrm{unfished}}$ | SSB | $SSB/SSB_{\mathrm{F30}}$ | $SSB/MSST_{\mathrm{F30}}$ |
|---|---|---|---|---|---|---|---|
| 1988 | 0.142 | 0.115 | 4910 | 0.390 | 8297384 | 1.443 | 2.44 |
| 1989 | 0.514 | 0.416 | 4839 | 0.384 | 6378598 | 1.109 | 1.88 |
| 1990 | 0.439 | 0.355 | 8572 | 0.681 | 5283005 | 0.919 | 1.56 |
| 1991 | 0.465 | 0.377 | 9313 | 0.740 | 7750922 | 1.348 | 2.28 |
| 1992 | 0.253 | 0.205 | 9176 | 0.729 | 9412252 | 1.637 | 2.77 |
| 1993 | 0.242 | 0.196 | 10473 | 0.832 | 10181180 | 1.770 | 3.00 |
| 1994 | 0.211 | 0.171 | 12723 | 1.011 | 11728430 | 2.039 | 3.46 |
| 1995 | 0.204 | 0.165 | 15251 | 1.212 | 14244870 | 2.477 | 4.20 |
| 1996 | 0.190 | 0.154 | 14986 | 1.191 | 17010240 | 2.958 | 5.01 |
| 1997 | 0.186 | 0.151 | 13246 | 1.052 | 17837170 | 3.101 | 5.26 |
| 1998 | 0.105 | 0.085 | 10270 | 0.816 | 17357120 | 3.018 | 5.12 |
| 1999 | 0.088 | 0.071 | 8754 | 0.695 | 15666530 | 2.724 | 4.62 |
| 2000 | 0.092 | 0.074 | 9277 | 0.737 | 13833770 | 2.405 | 4.08 |
| 2001 | 0.119 | 0.096 | 11480 | 0.912 | 13178190 | 2.291 | 3.88 |
| 2002 | 0.141 | 0.114 | 11426 | 0.908 | 14124770 | 2.456 | 4.16 |
| 2003 | 0.108 | 0.088 | 11088 | 0.881 | 14404920 | 2.505 | 4.25 |
| 2004 | 0.141 | 0.114 | 9608 | 0.763 | 14334630 | 2.492 | 4.22 |
| 2005 | 0.150 | 0.121 | 8798 | 0.699 | 13159870 | 2.288 | 3.88 |
| 2006 | 0.142 | 0.115 | 9434 | 0.749 | 12088140 | 2.102 | 3.56 |
| 2007 | 0.251 | 0.204 | 9656 | 0.767 | 11731430 | 2.040 | 3.46 |
| 2008 | 0.295 | 0.239 | 9259 | 0.736 | 11099340 | 1.930 | 3.27 |
| 2009 | 0.357 | 0.289 | 8913 | 0.708 | 10176800 | 1.770 | 3.00 |
| 2010 | 0.330 | 0.267 | 9045 | 0.719 | 9584838 | 1.667 | 2.83 |
| 2011 | 0.268 | 0.217 | 10436 | 0.829 | 9924101 | 1.726 | 2.92 |
| 2012 | 0.221 | 0.179 | 12163 | 0.966 | 11474510 | 1.995 | 3.38 |
| 2013 | 0.163 | 0.132 | 12814 | 1.018 | 13639290 | 2.372 | 4.02 |
| 2014 | 0.139 | 0.112 | 12352 | 0.981 | 15268560 | 2.655 | 4.50 |
| 2015 | . | . | 12051 | 0.957 | . | . | . |

*Table 11. Selectivity at age for trap-video index (CVID), commercial handlines (cH), headboat (HB), and general recreational (GR) landings (L) and discards (D).*

| Age | CVT | cH.L | HB.L | GR.L | HB.D | GR.D |
|---|---|---|---|---|---|---|
| 1 | 0.048 | 0.001 | 0.015 | 0.006 | 1.000 | 1.000 |
| 2 | 0.582 | 0.015 | 0.157 | 0.119 | 0.207 | 0.207 |
| 3 | 0.975 | 0.156 | 0.758 | 0.788 | 0.002 | 0.002 |
| 4 | 0.999 | 0.693 | 1.000 | 1.000 | 0.000 | 0.000 |
| 5 | 1.000 | 0.965 | 0.771 | 0.909 | 0.000 | 0.000 |
| 6 | 1.000 | 0.997 | 0.448 | 0.721 | 0.000 | 0.000 |
| 7 | 1.000 | 1.000 | 0.207 | 0.474 | 0.000 | 0.000 |
| 8 | 1.000 | 1.000 | 0.083 | 0.255 | 0.000 | 0.000 |

*Table 12. Estimated instantaneous fishing mortality rate (per yr) at age.*

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1988 | 0.007 | 0.018 | 0.101 | 0.142 | 0.132 | 0.105 | 0.075 | 0.051 |
| 1989 | 0.016 | 0.063 | 0.388 | 0.514 | 0.474 | 0.378 | 0.258 | 0.155 |
| 1990 | 0.004 | 0.048 | 0.298 | 0.439 | 0.426 | 0.352 | 0.264 | 0.193 |
| 1991 | 0.009 | 0.044 | 0.276 | 0.450 | 0.465 | 0.404 | 0.327 | 0.264 |
| 1992 | 0.004 | 0.019 | 0.119 | 0.228 | 0.253 | 0.230 | 0.200 | 0.177 |
| 1993 | 0.003 | 0.021 | 0.135 | 0.230 | 0.242 | 0.212 | 0.176 | 0.147 |
| 1994 | 0.002 | 0.016 | 0.101 | 0.192 | 0.211 | 0.191 | 0.165 | 0.146 |
| 1995 | 0.002 | 0.013 | 0.085 | 0.178 | 0.204 | 0.189 | 0.169 | 0.154 |
| 1996 | 0.003 | 0.015 | 0.095 | 0.173 | 0.190 | 0.171 | 0.147 | 0.127 |
| 1997 | 0.003 | 0.015 | 0.093 | 0.170 | 0.186 | 0.168 | 0.144 | 0.125 |
| 1998 | 0.002 | 0.007 | 0.045 | 0.093 | 0.105 | 0.097 | 0.087 | 0.079 |
| 1999 | 0.003 | 0.008 | 0.047 | 0.082 | 0.088 | 0.078 | 0.066 | 0.056 |
| 2000 | 0.002 | 0.009 | 0.057 | 0.091 | 0.092 | 0.078 | 0.062 | 0.049 |
| 2001 | 0.002 | 0.012 | 0.073 | 0.117 | 0.119 | 0.102 | 0.081 | 0.064 |
| 2002 | 0.003 | 0.015 | 0.090 | 0.140 | 0.141 | 0.119 | 0.093 | 0.072 |
| 2003 | 0.004 | 0.011 | 0.065 | 0.105 | 0.108 | 0.094 | 0.076 | 0.061 |
| 2004 | 0.008 | 0.016 | 0.089 | 0.140 | 0.141 | 0.119 | 0.094 | 0.074 |
| 2005 | 0.007 | 0.016 | 0.093 | 0.148 | 0.150 | 0.128 | 0.102 | 0.081 |
| 2006 | 0.004 | 0.014 | 0.088 | 0.140 | 0.142 | 0.122 | 0.097 | 0.077 |
| 2007 | 0.007 | 0.027 | 0.163 | 0.251 | 0.251 | 0.213 | 0.166 | 0.128 |
| 2008 | 0.006 | 0.030 | 0.192 | 0.293 | 0.295 | 0.253 | 0.198 | 0.150 |
| 2009 | 0.009 | 0.036 | 0.231 | 0.353 | 0.357 | 0.306 | 0.240 | 0.183 |
| 2010 | 0.006 | 0.029 | 0.182 | 0.310 | 0.330 | 0.292 | 0.243 | 0.202 |
| 2011 | 0.002 | 0.017 | 0.113 | 0.233 | 0.268 | 0.250 | 0.223 | 0.202 |
| 2012 | 0.003 | 0.019 | 0.121 | 0.207 | 0.221 | 0.196 | 0.164 | 0.136 |
| 2013 | 0.003 | 0.012 | 0.075 | 0.145 | 0.163 | 0.149 | 0.130 | 0.115 |
| 2014 | 0.004 | 0.012 | 0.076 | 0.130 | 0.139 | 0.123 | 0.103 | 0.086 |

*Table 13. Estimated landings at age in numbers (1000 fish)*

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1988 | 2367.91 | 11138.68 | 48011.33 | 40842.89 | 30833.48 | 19279.80 | 9811.25 | 11784.41 |
| 1989 | 8241.55 | 59912.38 | 119259.10 | 109064.20 | 63806.89 | 44301.25 | 25909.37 | 33936.98 |
| 1990 | 27525.96 | 52624.93 | 136413.30 | 52909.98 | 34914.08 | 19921.35 | 14590.02 | 33833.22 |
| 1991 | 14926.63 | 176426.20 | 143138.00 | 84532.68 | 22243.23 | 13994.15 | 8629.67 | 32179.05 |
| 1992 | 5908.96 | 46476.27 | 246416.70 | 54090.02 | 20527.61 | 4894.76 | 3309.79 | 13859.81 |
| 1993 | 9638.98 | 44666.51 | 173073.80 | 238837.10 | 28309.20 | 8741.56 | 1999.00 | 7879.43 |
| 1994 | 10186.24 | 48965.13 | 109696.40 | 124230.80 | 109169.30 | 11463.84 | 3673.88 | 5417.69 |
| 1995 | 9935.99 | 54758.15 | 137337.60 | 99638.14 | 67431.31 | 51136.61 | 5546.54 | 5224.14 |
| 1996 | 6675.74 | 69111.00 | 205393.30 | 145841.80 | 54976.54 | 30019.89 | 21951.68 | 4876.08 |
| 1997 | 4513.71 | 45698.55 | 229121.30 | 192409.60 | 81436.73 | 26037.14 | 14108.89 | 13638.53 |
| 1998 | 1119.87 | 15011.09 | 75742.25 | 123533.30 | 64311.04 | 23535.89 | 7731.51 | 9760.64 |
| 1999 | 1350.71 | 7190.71 | 53497.81 | 77467.17 | 66708.88 | 27854.54 | 9610.39 | 7390.22 |
| 2000 | 3196.42 | 11706.22 | 30006.82 | 57560.94 | 49309.00 | 34874.90 | 13427.62 | 8544.57 |
| 2001 | 5988.68 | 28248.78 | 49427.71 | 33258.55 | 42342.16 | 31919.30 | 21932.26 | 15792.99 |
| 2002 | 5052.55 | 53859.09 | 115157.20 | 50429.08 | 21981.80 | 24157.78 | 17321.72 | 23080.46 |
| 2003 | 3271.96 | 25349.41 | 127811.30 | 72048.73 | 21388.57 | 8348.49 | 9116.39 | 19099.70 |
| 2004 | 2870.61 | 32987.66 | 115484.90 | 147459.80 | 53071.98 | 13459.62 | 4980.65 | 19917.54 |
| 2005 | 3562.38 | 20559.91 | 111835.10 | 101307.30 | 85261.53 | 27089.54 | 6736.43 | 16043.84 |
| 2006 | 4989.43 | 23571.70 | 63948.16 | 88802.84 | 52505.68 | 38752.49 | 11978.50 | 12458.82 |
| 2007 | 8072.14 | 66397.22 | 140002.00 | 91683.88 | 82260.98 | 42442.51 | 30026.24 | 21860.82 |
| 2008 | 7537.48 | 68155.14 | 246113.20 | 119039.20 | 51258.91 | 41271.04 | 20945.94 | 30315.46 |
| 2009 | 9284.73 | 72419.62 | 260212.70 | 205796.50 | 65487.99 | 25209.94 | 19954.84 | 31459.07 |
| 2010 | 9289.96 | 57833.79 | 184489.40 | 158777.40 | 84832.91 | 24765.87 | 9929.59 | 28085.43 |
| 2011 | 8083.86 | 41066.31 | 119627.20 | 113552.40 | 63599.61 | 30650.91 | 9531.11 | 19651.65 |
| 2012 | 9047.89 | 60840.27 | 152541.20 | 111278.90 | 53365.22 | 23610.32 | 10651.94 | 10658.76 |
| 2013 | 5396.90 | 42289.12 | 130168.00 | 94920.15 | 45113.47 | 19118.16 | 8686.98 | 9620.90 |
| 2014 | 4014.76 | 38023.09 | 148232.60 | 120910.50 | 48915.74 | 18937.08 | 7584.28 | 7692.46 |

*Table 14. Estimated landings at age in whole weight (1000 lb)*

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1988 | 2.32 | 15.74 | 89.99 | 95.85 | 86.78 | 62.97 | 36.25 | 48.24 |
| 1989 | 8.09 | 84.65 | 223.54 | 255.94 | 179.58 | 144.70 | 95.72 | 138.92 |
| 1990 | 27.03 | 74.35 | 255.69 | 124.17 | 98.26 | 65.07 | 53.90 | 138.50 |
| 1991 | 14.66 | 249.26 | 268.29 | 198.38 | 62.60 | 45.71 | 31.88 | 131.73 |
| 1992 | 5.80 | 65.66 | 461.88 | 126.93 | 57.77 | 15.99 | 12.23 | 56.74 |
| 1993 | 9.46 | 63.11 | 324.40 | 560.49 | 79.68 | 28.55 | 7.38 | 32.26 |
| 1994 | 10.00 | 69.18 | 205.61 | 291.54 | 307.25 | 37.44 | 13.57 | 22.18 |
| 1995 | 9.76 | 77.36 | 257.42 | 233.82 | 189.78 | 167.02 | 20.49 | 21.39 |
| 1996 | 6.55 | 97.64 | 384.98 | 342.25 | 154.73 | 98.05 | 81.09 | 19.96 |
| 1997 | 4.43 | 64.56 | 429.46 | 451.53 | 229.20 | 85.04 | 52.12 | 55.83 |
| 1998 | 1.10 | 21.21 | 141.97 | 289.90 | 181.00 | 76.87 | 28.56 | 39.96 |
| 1999 | 1.33 | 10.16 | 100.27 | 181.79 | 187.75 | 90.98 | 35.50 | 30.25 |
| 2000 | 3.14 | 16.54 | 56.24 | 135.08 | 138.78 | 113.91 | 49.60 | 34.98 |
| 2001 | 5.88 | 39.91 | 92.65 | 78.05 | 119.17 | 104.26 | 81.02 | 64.65 |
| 2002 | 4.96 | 76.09 | 215.85 | 118.34 | 61.87 | 78.91 | 63.99 | 94.48 |
| 2003 | 3.21 | 35.81 | 239.57 | 169.08 | 60.20 | 27.27 | 33.68 | 78.19 |
| 2004 | 2.82 | 46.61 | 216.46 | 346.05 | 149.37 | 43.96 | 18.40 | 81.53 |
| 2005 | 3.50 | 29.05 | 209.62 | 237.74 | 239.97 | 88.48 | 24.89 | 65.68 |
| 2006 | 4.90 | 33.30 | 119.86 | 208.40 | 147.78 | 126.58 | 44.25 | 51.00 |
| 2007 | 7.93 | 93.81 | 262.42 | 215.16 | 231.52 | 138.63 | 110.92 | 89.49 |
| 2008 | 7.40 | 96.29 | 461.31 | 279.35 | 144.27 | 134.80 | 77.38 | 124.10 |
| 2009 | 9.12 | 102.32 | 487.73 | 482.95 | 184.31 | 82.34 | 73.72 | 128.78 |
| 2010 | 9.12 | 81.71 | 345.80 | 372.61 | 238.76 | 80.89 | 36.68 | 114.97 |
| 2011 | 7.94 | 58.02 | 224.23 | 266.48 | 179.00 | 100.11 | 35.21 | 80.45 |
| 2012 | 8.88 | 85.96 | 285.92 | 261.14 | 150.20 | 77.12 | 39.35 | 43.63 |
| 2013 | 5.30 | 59.75 | 243.98 | 222.75 | 126.97 | 62.44 | 32.09 | 39.38 |
| 2014 | 3.94 | 53.72 | 277.84 | 283.74 | 137.67 | 61.85 | 28.02 | 31.49 |

*Table 15. Estimated discards at age in numbers (1000 fish)*

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1988 | 12392.13 | 768.48 | 4.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1989 | 31581.06 | 2587.23 | 7.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1990 | 10816.42 | 266.61 | 0.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1991 | 34268.89 | 5166.15 | 5.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1992 | 14229.03 | 1588.69 | 11.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1993 | 9721.87 | 615.72 | 3.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1994 | 9348.76 | 645.52 | 1.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1995 | 12399.67 | 1014.74 | 3.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1996 | 14280.51 | 1984.56 | 7.93 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1997 | 11675.04 | 1616.99 | 10.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1998 | 4206.22 | 856.53 | 5.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999 | 7764.24 | 559.98 | 5.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2000 | 9254.97 | 452.59 | 1.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 10198.46 | 621.82 | 1.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2002 | 13784.57 | 1930.31 | 5.76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 18626.54 | 1865.95 | 12.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 20651.76 | 3190.04 | 15.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 21530.75 | 1641.05 | 12.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | 19291.50 | 1172.73 | 4.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 31176.74 | 3209.22 | 9.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 22475.31 | 2348.17 | 11.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 30701.24 | 2801.92 | 13.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 23359.21 | 1833.93 | 7.84 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 10269.03 | 709.28 | 2.68 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 13002.81 | 1083.05 | 3.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 19294.90 | 2051.65 | 8.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 20636.96 | 2492.40 | 13.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Table 16. Estimated discards at age in whole weight (1000 lb)*

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1988 | 12.17 | 1.09 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1989 | 31.01 | 3.66 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1990 | 10.62 | 0.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1991 | 33.65 | 7.30 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1992 | 13.97 | 2.24 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1993 | 9.55 | 0.87 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1994 | 9.18 | 0.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1995 | 12.17 | 1.43 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1996 | 14.02 | 2.80 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1997 | 11.46 | 2.28 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1998 | 4.13 | 1.21 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999 | 7.62 | 0.79 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2000 | 9.09 | 0.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 10.01 | 0.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2002 | 13.53 | 2.73 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 18.29 | 2.64 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 20.28 | 4.51 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 21.14 | 2.32 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | 18.94 | 1.66 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 30.61 | 4.53 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 22.07 | 3.32 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 30.14 | 3.96 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 22.94 | 2.59 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 10.08 | 1.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 12.77 | 1.53 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 18.94 | 2.90 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 20.26 | 3.52 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Table 17. Estimated time series of fully selected fishing mortality rates for commercial handlines (F.cH), headboat (F.HB), recreational (F.GR) landings (L) and discards (D). Also shown is apical F, the maximum F at age summed across fleets, which may not equal the sum of fully selected F's because of dome-shaped selectivities.*

| Year | F.cH.L | F.HB.L | F.GR.L | F.HB.D | F.GR.D | Apical F |
|---|---|---|---|---|---|---|
| 1988 | 0.024 | 0.032 | 0.093 | 0.00007 | 0.00541 | 0.142 |
| 1989 | 0.039 | 0.045 | 0.442 | 0.00007 | 0.01250 | 0.514 |
| 1990 | 0.115 | 0.080 | 0.279 | 0.00001 | 0.00116 | 0.439 |
| 1991 | 0.195 | 0.062 | 0.253 | 0.00000 | 0.00604 | 0.465 |
| 1992 | 0.153 | 0.039 | 0.083 | 0.00001 | 0.00301 | 0.253 |
| 1993 | 0.116 | 0.042 | 0.108 | 0.00000 | 0.00141 | 0.242 |
| 1994 | 0.125 | 0.036 | 0.069 | 0.00000 | 0.00100 | 0.211 |
| 1995 | 0.138 | 0.031 | 0.051 | 0.00001 | 0.00116 | 0.204 |
| 1996 | 0.106 | 0.024 | 0.076 | 0.00000 | 0.00200 | 0.190 |
| 1997 | 0.104 | 0.026 | 0.072 | 0.00002 | 0.00242 | 0.186 |
| 1998 | 0.071 | 0.018 | 0.025 | 0.00005 | 0.00186 | 0.105 |
| 1999 | 0.045 | 0.013 | 0.037 | 0.00011 | 0.00261 | 0.088 |
| 2000 | 0.035 | 0.017 | 0.049 | 0.00007 | 0.00162 | 0.092 |
| 2001 | 0.046 | 0.018 | 0.066 | 0.00005 | 0.00117 | 0.119 |
| 2002 | 0.050 | 0.025 | 0.080 | 0.00012 | 0.00236 | 0.141 |
| 2003 | 0.045 | 0.016 | 0.058 | 0.00005 | 0.00354 | 0.108 |
| 2004 | 0.052 | 0.028 | 0.076 | 0.00007 | 0.00655 | 0.141 |
| 2005 | 0.058 | 0.026 | 0.081 | 0.00006 | 0.00559 | 0.150 |
| 2006 | 0.054 | 0.021 | 0.080 | 0.00006 | 0.00325 | 0.142 |
| 2007 | 0.085 | 0.035 | 0.157 | 0.00004 | 0.00591 | 0.251 |
| 2008 | 0.097 | 0.022 | 0.204 | 0.00026 | 0.00459 | 0.295 |
| 2009 | 0.119 | 0.029 | 0.241 | 0.00025 | 0.00631 | 0.357 |
| 2010 | 0.157 | 0.035 | 0.166 | 0.00041 | 0.00384 | 0.330 |
| 2011 | 0.179 | 0.026 | 0.083 | 0.00018 | 0.00121 | 0.268 |
| 2012 | 0.106 | 0.020 | 0.113 | 0.00018 | 0.00140 | 0.221 |
| 2013 | 0.099 | 0.019 | 0.057 | 0.00014 | 0.00252 | 0.163 |
| 2014 | 0.067 | 0.016 | 0.068 | 0.00024 | 0.00344 | 0.139 |

*Table 18. Estimated time series of landings in number (1000 fish) for commercial handlines (L.cH), headboat (L.HB), and recreational (L.GR).*

| Year | L.cH | L.HB | L.GR | Total |
|---|---|---|---|---|
| 1988 | 25.67 | 34.94 | 113.46 | 174.07 |
| 1989 | 30.41 | 37.38 | 396.64 | 464.43 |
| 1990 | 63.12 | 71.66 | 237.95 | 372.73 |
| 1991 | 99.09 | 85.39 | 311.58 | 496.07 |
| 1992 | 110.96 | 91.83 | 192.70 | 395.48 |
| 1993 | 137.11 | 107.08 | 268.96 | 513.15 |
| 1994 | 161.63 | 90.30 | 170.86 | 422.80 |
| 1995 | 189.73 | 93.31 | 147.97 | 431.01 |
| 1996 | 173.77 | 89.94 | 275.14 | 538.85 |
| 1997 | 209.69 | 106.18 | 291.09 | 606.96 |
| 1998 | 161.06 | 65.94 | 93.75 | 320.75 |
| 1999 | 100.49 | 37.28 | 113.31 | 251.07 |
| 2000 | 66.46 | 34.12 | 108.05 | 208.63 |
| 2001 | 69.78 | 32.98 | 126.15 | 228.91 |
| 2002 | 68.10 | 57.68 | 185.26 | 311.04 |
| 2003 | 68.97 | 45.81 | 171.66 | 286.43 |
| 2004 | 92.83 | 78.21 | 219.19 | 390.23 |
| 2005 | 99.29 | 63.71 | 209.40 | 372.40 |
| 2006 | 84.17 | 43.15 | 169.68 | 297.01 |
| 2007 | 110.06 | 66.28 | 306.41 | 482.75 |
| 2008 | 112.17 | 44.74 | 427.73 | 584.64 |
| 2009 | 134.74 | 59.92 | 495.17 | 689.83 |
| 2010 | 166.80 | 68.69 | 322.51 | 558.00 |
| 2011 | 186.19 | 53.27 | 166.30 | 405.76 |
| 2012 | 119.15 | 49.06 | 263.79 | 431.99 |
| 2013 | 132.24 | 56.47 | 166.60 | 355.31 |
| 2014 | 111.08 | 53.10 | 230.13 | 394.31 |

*Table 19. Estimated time series of landings in whole weight (1000 lb) for commercial handlines (L.cH), headboat (L.HB), and recreational (L.GR).*

| Year | L.cH | L.HB | L.GR | Total |
|---|---|---|---|---|
| 1988 | 79.84 | 79.23 | 279.06 | 438.14 |
| 1989 | 96.51 | 80.96 | 953.67 | 1131.14 |
| 1990 | 194.69 | 134.28 | 507.99 | 836.96 |
| 1991 | 270.74 | 147.79 | 583.98 | 1002.51 |
| 1992 | 263.25 | 170.45 | 369.29 | 803.00 |
| 1993 | 329.12 | 216.08 | 560.12 | 1105.33 |
| 1994 | 409.85 | 182.90 | 364.02 | 956.78 |
| 1995 | 487.63 | 182.51 | 306.91 | 977.05 |
| 1996 | 441.81 | 176.80 | 566.66 | 1185.27 |
| 1997 | 536.76 | 217.70 | 617.73 | 1372.19 |
| 1998 | 425.90 | 143.61 | 211.07 | 780.57 |
| 1999 | 280.83 | 85.67 | 271.54 | 638.04 |
| 2000 | 197.29 | 79.64 | 271.34 | 548.27 |
| 2001 | 216.15 | 69.97 | 299.46 | 585.59 |
| 2002 | 204.99 | 112.93 | 396.57 | 714.49 |
| 2003 | 192.81 | 91.76 | 362.42 | 647.00 |
| 2004 | 253.56 | 165.96 | 485.68 | 905.20 |
| 2005 | 277.70 | 139.70 | 481.52 | 898.92 |
| 2006 | 242.22 | 94.62 | 399.22 | 736.07 |
| 2007 | 323.02 | 137.27 | 689.58 | 1149.87 |
| 2008 | 320.02 | 89.59 | 915.28 | 1324.90 |
| 2009 | 369.94 | 121.40 | 1059.94 | 1551.27 |
| 2010 | 450.81 | 139.20 | 690.53 | 1280.54 |
| 2011 | 494.51 | 105.94 | 350.97 | 951.43 |
| 2012 | 310.34 | 95.83 | 546.02 | 952.20 |
| 2013 | 338.75 | 110.83 | 343.10 | 792.67 |
| 2014 | 284.64 | 107.74 | 485.90 | 878.28 |

*Table 20. Estimated time series of discard mortalities in numbers (1000 fish) for headboat (D.HB), and recreational (D.GR).*

| Year | D.HB | D.GR | Total |
|---|---|---|---|
| 1988 | 0.17 | 13.00 | 13.17 |
| 1989 | 0.20 | 33.98 | 34.18 |
| 1990 | 0.07 | 11.01 | 11.08 |
| 1991 | 0.02 | 39.42 | 39.44 |
| 1992 | 0.05 | 15.78 | 15.83 |
| 1993 | 0.02 | 10.32 | 10.34 |
| 1994 | 0.02 | 9.97 | 10.00 |
| 1995 | 0.12 | 13.30 | 13.42 |
| 1996 | 0.03 | 16.25 | 16.27 |
| 1997 | 0.09 | 13.22 | 13.30 |
| 1998 | 0.14 | 4.93 | 5.07 |
| 1999 | 0.33 | 8.00 | 8.33 |
| 2000 | 0.42 | 9.29 | 9.71 |
| 2001 | 0.44 | 10.38 | 10.82 |
| 2002 | 0.75 | 14.97 | 15.72 |
| 2003 | 0.29 | 20.21 | 20.51 |
| 2004 | 0.25 | 23.61 | 23.86 |
| 2005 | 0.26 | 22.93 | 23.18 |
| 2006 | 0.36 | 20.11 | 20.47 |
| 2007 | 0.22 | 34.17 | 34.40 |
| 2008 | 1.34 | 23.49 | 24.83 |
| 2009 | 1.29 | 32.22 | 33.52 |
| 2010 | 2.42 | 22.78 | 25.20 |
| 2011 | 1.44 | 9.54 | 10.98 |
| 2012 | 1.58 | 12.51 | 14.09 |
| 2013 | 1.10 | 20.26 | 21.35 |
| 2014 | 1.52 | 21.62 | 23.14 |

*Table 21. Estimated time series of discard mortalities in whole weight (1000 lb) for headboat (D.HB), and recreational (D.GR).*

| Year | D.HB | D.GR | Total |
|---|---|---|---|
| 1988 | 0.17 | 13.10 | 13.26 |
| 1989 | 0.20 | 34.48 | 34.68 |
| 1990 | 0.07 | 10.93 | 11.00 |
| 1991 | 0.02 | 40.94 | 40.96 |
| 1992 | 0.05 | 16.19 | 16.24 |
| 1993 | 0.02 | 10.40 | 10.42 |
| 1994 | 0.02 | 10.07 | 10.09 |
| 1995 | 0.12 | 13.50 | 13.61 |
| 1996 | 0.03 | 16.81 | 16.84 |
| 1997 | 0.09 | 13.68 | 13.77 |
| 1998 | 0.15 | 5.20 | 5.35 |
| 1999 | 0.34 | 8.09 | 8.43 |
| 2000 | 0.42 | 9.31 | 9.73 |
| 2001 | 0.44 | 10.45 | 10.89 |
| 2002 | 0.78 | 15.49 | 16.27 |
| 2003 | 0.30 | 20.65 | 20.95 |
| 2004 | 0.26 | 24.56 | 24.81 |
| 2005 | 0.26 | 23.22 | 23.48 |
| 2006 | 0.37 | 20.24 | 20.61 |
| 2007 | 0.23 | 34.93 | 35.16 |
| 2008 | 1.37 | 24.04 | 25.41 |
| 2009 | 1.32 | 32.81 | 34.13 |
| 2010 | 2.45 | 23.09 | 25.54 |
| 2011 | 1.45 | 9.64 | 11.09 |
| 2012 | 1.61 | 12.70 | 14.30 |
| 2013 | 1.12 | 20.74 | 21.86 |
| 2014 | 1.56 | 22.25 | 23.81 |

*Table 22. Estimated status indicators, benchmarks, and related quantities from the base run of the Beaufort catch-age model, conditional on estimated current selectivities averaged across fleets. Also presented are median values and measures of precision (standard errors, SE) from the Monte Carlo/Bootstrap analysis. Measures of yield describe total removals, of which* ~ 97.3% *were estimated to be landings, and the remainder, dead discards. Rate estimates (F) are in units of* $\mathrm{y}^{-1}$*; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured as population fecundity (number of eggs)*

| Quantity | Units | Estimate | Median | SE |
|---|---|---|---|---|
| $F_{30\%}$ | $\mathrm{y}^{-1}$ | 1.24 | 1.24 | 0.62 |
| $85\%F_{30\%}$ | $\mathrm{y}^{-1}$ | 1.05 | 1.05 | 0.53 |
| $75\%F_{30\%}$ | $\mathrm{y}^{-1}$ | 0.93 | 0.93 | 0.47 |
| $65\%F_{30\%}$ | $\mathrm{y}^{-1}$ | 0.80 | 0.81 | 0.41 |
| $F_{30\%}$ | $\mathrm{y}^{-1}$ | 1.24 | 1.24 | 0.62 |
| $F_{40\%}$ | $\mathrm{y}^{-1}$ | 0.71 | 0.72 | 0.38 |
| $B_{\mathrm{F30\%}}$ | metric tons | 8515 | 8389 | 4448 |
| $\mathrm{SSB}_{\mathrm{F30\%}}$ | 1e6 eggs | 5751203 | 5570736 | 1610871 |
| MSST | 1e6 eggs | 3393210 | 3241071 | 779326 |
| $L_{\mathrm{F30\%}}$ | 1000 lb whole | 2379 | 2339 | 1090 |
| $R_{\mathrm{F30\%}}$ | number fish | 8710621 | 8607344 | 6364635 |
| $L_{85\%\mathrm{F30\%}}$ | 1000 lb whole | 2282.41 | 2245 | 1045 |
| $L_{75\%\mathrm{F30\%}}$ | 1000 lb whole | 2204.00 | 2165 | 1010 |
| $L_{65\%\mathrm{F30\%}}$ | 1000 lb whole | 2109.81 | 2075 | 970 |
| $F_{2012-2014}/F_{30\%}$ | — | 0.14 | 0.14 | 0.13 |
| $\mathrm{SSB}_{2014}/\mathrm{MSST}$ | — | 4.50 | 4.57 | 1.28 |
| $\mathrm{SSB}_{2014}/\mathrm{SSB}_{\mathrm{F30\%}}$ | — | 2.65 | 2.65 | 0.51 |

*Table 23. Results from sensitivity runs of the Beaufort catch-age model. Current F represented by geometric mean of last three assessment years.*

| Run | Description | $F_{30\%}$ | $SSB_{F30\%}$ (1e6 eggs) | $L_{F30\%}$ (1000 lb) | $F_{current}/F_{30\%}$ | $SSB_{end}/SSB_{F30\%}$ | R0 | sigmaR |
|---|---|---|---|---|---|---|---|---|
| Base | Base run | 1.27 | 5686089 | 2351.6 | 0.15 | 4.21 | 7886827 | 0.43 |
| S1 | Low M (5th percentile) | 0.89 | 4864406 | 1588.5 | 0.3 | 3.39 | 4273495 | 0.43 |
| S2 | High M (95th percentile) | 2.31 | 8274617 | 4763.7 | 0.05 | 5.16 | 20759230 | 0.43 |
| S3 | Scaled to growth–based M (0.28) | 0.62 | 4676798 | 1192.7 | 0.57 | 2.55 | 2496831 | 0.43 |
| S4 | Constant M=0.41 | 0.88 | 5263554 | 1836.3 | 0.23 | 3.79 | 2967378 | 0.43 |
| S5 | Constant M=0.27 | 0.52 | 4639670 | 1097.4 | 0.73 | 2.23 | 1236166 | 0.47 |
| S6 | Age–independent batch number | 3 | 11807490 | 2802.4 | 0.06 | 3.48 | 7879455 | 0.43 |
| S7 | Low batch number | 1.22 | 3713938 | 2324.6 | 0.15 | 4.25 | 7887141 | 0.43 |
| S8 | High batch number | 1.3 | 7782069 | 2365.5 | 0.14 | 4.19 | 7886694 | 0.43 |
| S9 | Ricker SR curve | 1.31 | 6662050 | 2770.7 | 0.16 | 3.28 | 6157925 | 0.37 |
| S10 | Steepness=0.46 | 1.24 | 1445935 | 595.5 | 0.14 | 18.04 | 10202270 | 0.49 |
| S11 | Steepness=0.84 | 1.27 | 5329526 | 2202.8 | 0.14 | 4.54 | 8148801 | 0.44 |
| S12 | Estimate rec devs starting in 1993 | 1.31 | 5140064 | 2158.7 | 0.16 | 4.12 | 7249330 | 0.39 |
| S13 | Estimate rec devs starting in 1998 | 1.29 | 6445023 | 2703.4 | 0.15 | 3.61 | 7075564 | 0.81 |
| S14 | Estimate rec devs starting in 2003 | 1.15 | 7280681 | 3040.4 | 0.12 | 4.27 | 9319123 | 0.59 |
| S15 | Estimate rec devs starting in 2008 | 1.1 | 6701856 | 2799.7 | 0.12 | 4.49 | 9672238 | 0.33 |
| S16 | Estimate rec devs starting in 2013 | 1.08 | 5805934 | 2429 | 0.14 | 4.47 | 7713078 | 0.52 |
| S17 | Low discard mortality | 1.3 | 5676265 | 2392.3 | 0.14 | 4.22 | 7870884 | 0.43 |
| S18 | High discard mortality | 1.25 | 5695773 | 2313.5 | 0.15 | 4.2 | 7902849 | 0.43 |
| S19 | F.init=0.01 | 1.28 | 5680815 | 2348.1 | 0.15 | 4.21 | 7872373 | 0.43 |
| S20 | F.init=0.1 | 1.27 | 5689895 | 2354.7 | 0.15 | 4.21 | 7898601 | 0.43 |
| S21 | F.init=0.2 | 1.27 | 5693961 | 2360.3 | 0.15 | 4.2 | 7917250 | 0.43 |
| S22 | RW catchability on trap index | 1.15 | 4281078 | 1847.8 | 0.24 | 3 | 5561889 | 0.56 |
| S23 | All selectivities logistic | 2.31 | 5043244 | 1796.5 | 0.16 | 4.1 | 7009213 | 0.43 |
| S24 | All selectivities domed | 1.22 | 9236176 | 3814.1 | 0.09 | 4.73 | 12711770 | 0.45 |
| S25 | Fit to GR pooled age composition | 1.8 | 6688567 | 2760 | 0.11 | 4.37 | 9168209 | 0.46 |
| S26 | Selectivity blocks 1995 size limit | 1.16 | 5859747 | 2454 | 0.14 | 4.26 | 8107718 | 0.44 |
| S27 | Selectivity blocks 1995, 2006 size | 1.25 | 5554220 | 2359.9 | 0.15 | 4.21 | 7714406 | 0.43 |
| S28 | Selectivity blocks 1999 bag limit | 1.17 | 5870320 | 2443.7 | 0.14 | 4.25 | 8138144 | 0.43 |
| S29 | All FD and FI indices | 1.16 | 5955483 | 2491.9 | 0.14 | 4.3 | 8321590 | 0.41 |
| S30 | All FD indices only | 1.11 | 3851133 | 1655.8 | 0.25 | 3.19 | 5711626 | 0.23 |
| S31 | Separate video & trap indices | 1.27 | 5296528 | 2228 | 0.16 | 4.34 | 7649695 | 0.33 |
| S32 | Upweight video index | 1.18 | 5476320 | 2260.8 | 0.14 | 4.1 | 7884492 | 0.34 |
| S33 | Unweighted (all wgts set to 1.0) | 1.12 | 3057274 | 1337.6 | 0.4 | 2.27 | 4387179 | 0.34 |
| S34 | Wgts from iterative reweighting | 1.16 | 4050725 | 1744.6 | 0.24 | 3.31 | 6048588 | 0.2 |
| S35 | Upweight CVID index 2X | 1.17 | 4417036 | 1890.6 | 0.21 | 3.57 | 6595547 | 0.2 |
| S36 | Upweight CVID index 4X | 1.22 | 4968723 | 2106.1 | 0.17 | 4.03 | 7320978 | 0.26 |
| S37 | Upweight CVID index 6X | 1.25 | 5694012 | 2380.1 | 0.15 | 4.15 | 7287951 | 0.59 |
| S38 | Upweight CVID index 10X | 1.27 | 5551037 | 2326.2 | 0.16 | 4.1 | 6799869 | 0.66 |
| S39 | Use ageing error matrix | 1.28 | 5770848 | 2368 | 0.14 | 4.22 | 7767628 | 0.5 |
| R1 | Retrospective data through 2013 | 1.44 | 5721248 | 2354.4 | 0.17 | 3.71 | 7867452 | 0.45 |
| R2 | Retrospective data through 2012 | 1.42 | 5817022 | 2360.6 | 0.22 | 3.1 | 7945229 | 0.47 |
| R3 | Retrospective data through 2011 | 1.36 | 5359752 | 2148.4 | 0.3 | 2.62 | 7294647 | 0.47 |
| R4 | Retrospective data through 2010 | 1.23 | 4839774 | 1916.5 | 0.38 | 2.26 | 6528332 | 0.49 |
| R5 | Retrospective data through 2009 | 1.26 | 4400309 | 1728.1 | 0.4 | 2.28 | 5908119 | 0.5 |

*Table 24. Projection results with fishing mortality rate fixed at $F = F_{\text{current}}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1E6 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.SdMSST = proportion of stochastic projection replicates with* SSB $\geq$ MSST*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

| Year | R.b | R.med | F.b | F.med | S.b(1E6) | S.med(1E6) | L.b(n) | L.med(n) | L.b(w) | L.med(w) | D.b(n) | D.med(n) | D.b(w) | D.med(w) | pr.SdMSST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | 8752 | 7143 | 0.13 | 0.14 | 15764619 | 14716309 | 375 | 373 | 874 | 866 | 12 | 9 | 12 | 9 | 1 |
| 2016 | 8753 | 7048 | 0.13 | 0.14 | 15880253 | 14817388 | 361 | 359 | 874 | 866 | 12 | 9 | 12 | 9 | 1 |
| 2017 | 8753 | 7153 | 0.17 | 0.19 | 15509853 | 14287337 | 443 | 438 | 1084 | 1079 | 16 | 12 | 16 | 12 | 1 |
| 2018 | 8753 | 7130 | 0.17 | 0.19 | 14923558 | 13607979 | 421 | 410 | 1027 | 1005 | 16 | 12 | 16 | 12 | 1 |
| 2019 | 8752 | 7119 | 0.17 | 0.19 | 14510382 | 13075839 | 411 | 396 | 996 | 962 | 16 | 12 | 16 | 12 | 1 |
| 2020 | 8751 | 7167 | 0.17 | 0.19 | 14262243 | 12694131 | 406 | 390 | 979 | 941 | 16 | 12 | 16 | 12 | 1 |
| 2021 | 8751 | 7180 | 0.17 | 0.19 | 14109626 | 12488133 | 404 | 387 | 970 | 931 | 16 | 12 | 16 | 12 | 1 |
| 2022 | 8750 | 7127 | 0.17 | 0.19 | 14018109 | 12452613 | 403 | 385 | 965 | 923 | 16 | 12 | 16 | 12 | 1 |
| 2023 | 8750 | 7128 | 0.17 | 0.19 | 13963150 | 12397543 | 402 | 385 | 961 | 921 | 16 | 12 | 16 | 12 | 1 |
| 2024 | 8750 | 7086 | 0.17 | 0.19 | 13930127 | 12348842 | 402 | 384 | 959 | 918 | 16 | 12 | 16 | 12 | 1 |

*Table 25. Projection results with fishing mortality rate fixed at $F = 75\%F_{30\%}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1E6 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.SdMSST = proportion of stochastic projection replicates with* SSB ≥ MSST. *The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

| Year | R.b | R.med | F.b | F.med | S.b(1E6) | S.med(1E6) | L.b(n) | L.med(n) | L.b(w) | L.med(w) | D.b(n) | D.med(n) | D.b(w) | D.med(w) | pr.SdMSST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | 8752 | 7143 | 0.13 | 0.14 | 15764619 | 14716309 | 375 | 373 | 874 | 866 | 12 | 9 | 12 | 9 | 1.000 |
| 2016 | 8753 | 7048 | 0.13 | 0.14 | 15880253 | 14817388 | 361 | 359 | 874 | 866 | 12 | 9 | 12 | 9 | 1.000 |
| 2017 | 8753 | 7153 | 0.93 | 0.90 | 12149758 | 11068755 | 1908 | 1763 | 4591 | 4267 | 85 | 60 | 87 | 61 | 1.000 |
| 2018 | 8746 | 7125 | 0.93 | 0.90 | 8659237 | 7821815 | 1339 | 1208 | 2983 | 2705 | 85 | 60 | 86 | 61 | 0.999 |
| 2019 | 8733 | 7104 | 0.93 | 0.90 | 7404045 | 6705857 | 1174 | 1046 | 2462 | 2207 | 85 | 60 | 86 | 61 | 0.991 |
| 2020 | 8726 | 7144 | 0.93 | 0.90 | 6961094 | 6322716 | 1126 | 1006 | 2295 | 2062 | 85 | 60 | 86 | 61 | 0.985 |
| 2021 | 8722 | 7153 | 0.93 | 0.90 | 6799704 | 6158930 | 1111 | 991 | 2238 | 2008 | 85 | 60 | 86 | 61 | 0.981 |
| 2022 | 8721 | 7102 | 0.93 | 0.90 | 6739035 | 6096618 | 1105 | 989 | 2217 | 1998 | 85 | 60 | 86 | 61 | 0.976 |
| 2023 | 8720 | 7105 | 0.93 | 0.90 | 6715832 | 6054406 | 1103 | 986 | 2209 | 1994 | 85 | 60 | 86 | 61 | 0.976 |
| 2024 | 8720 | 7061 | 0.93 | 0.90 | 6706898 | 6042515 | 1102 | 981 | 2206 | 1981 | 85 | 60 | 86 | 61 | 0.975 |

*Table 26. Projection results with fishing mortality rate fixed at $F = F_{30\%}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1E6 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.SdMSST = proportion of stochastic projection replicates with* SSB ≥ MSST*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

| Year | R.b | R.med | F.b | F.med | S.b(1E6) | S.med(1E6) | L.b(n) | L.med(n) | L.b(w) | L.med(w) | D.b(n) | D.med(n) | D.b(w) | D.med(w) | pr.SdMSST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | 8752 | 7143 | 0.13 | 0.14 | 15764619 | 14716309 | 375 | 373 | 874 | 866 | 12 | 9 | 12 | 9 | 1.000 |
| 2016 | 8753 | 7048 | 0.13 | 0.14 | 15880253 | 14817388 | 361 | 359 | 874 | 866 | 12 | 9 | 12 | 9 | 1.000 |
| 2017 | 8753 | 7153 | 1.24 | 1.20 | 11046383 | 10019127 | 2338 | 2159 | 5589 | 5188 | 113 | 80 | 115 | 81 | 1.000 |
| 2018 | 8743 | 7122 | 1.24 | 1.20 | 7257923 | 6550752 | 1495 | 1343 | 3210 | 2897 | 113 | 80 | 115 | 81 | 0.992 |
| 2019 | 8724 | 7096 | 1.24 | 1.20 | 6189578 | 5583905 | 1300 | 1154 | 2602 | 2334 | 113 | 79 | 115 | 80 | 0.961 |
| 2020 | 8715 | 7132 | 1.24 | 1.20 | 5886560 | 5298564 | 1254 | 1115 | 2445 | 2195 | 112 | 80 | 114 | 81 | 0.940 |
| 2021 | 8712 | 7144 | 1.24 | 1.20 | 5794900 | 5184110 | 1241 | 1105 | 2401 | 2158 | 112 | 80 | 114 | 81 | 0.931 |
| 2022 | 8711 | 7093 | 1.24 | 1.20 | 5765528 | 5149285 | 1237 | 1105 | 2386 | 2147 | 112 | 80 | 114 | 81 | 0.926 |
| 2023 | 8711 | 7096 | 1.24 | 1.20 | 5755892 | 5123559 | 1235 | 1104 | 2382 | 2142 | 112 | 79 | 114 | 80 | 0.925 |
| 2024 | 8711 | 7050 | 1.24 | 1.20 | 5752728 | 5114321 | 1235 | 1098 | 2380 | 2128 | 112 | 79 | 114 | 80 | 0.923 |

*Table 27. Parameter estimates from ASPIC surplus production model run 213 (best possible configuration) All parameter values are rounded to 3 significant digits. $MSY$, $B_1$, and $K$ are in units of 1000 pounds. Catchability parameters correspond to the commercial ($q_1$), headboat ($q_2$), GR ($q_3$), and CVID ($q_4$) indices.*

| Run | $F/F_{MSY}$ | $B/B_{MSY}$ | $B_1/K$ | $MSY$ | $F_{MSY}$ | $q_1$ | $q_2$ | $q_3$ | $q_4$ | $B_1$ | $K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 213 | 0.122 | 1.88 | 0.39 | 4100 | 0.537 | 7.57e-08 | 7.34e-08 | 7.45e-08 | 7.62e-08 | 5960 | 15300 |

## 8 Figures

*Figure 1. Index of abundance used in the assessment. CVT indicates the SERFS chevron trap index, Video indicates the SERFS video index, and combined indicates the combined chevron trap and video index (referred to as CVID in the text). Only the combined index was used in the assessment. The effect of separate indices was evaluated via sensitivity analysis.*

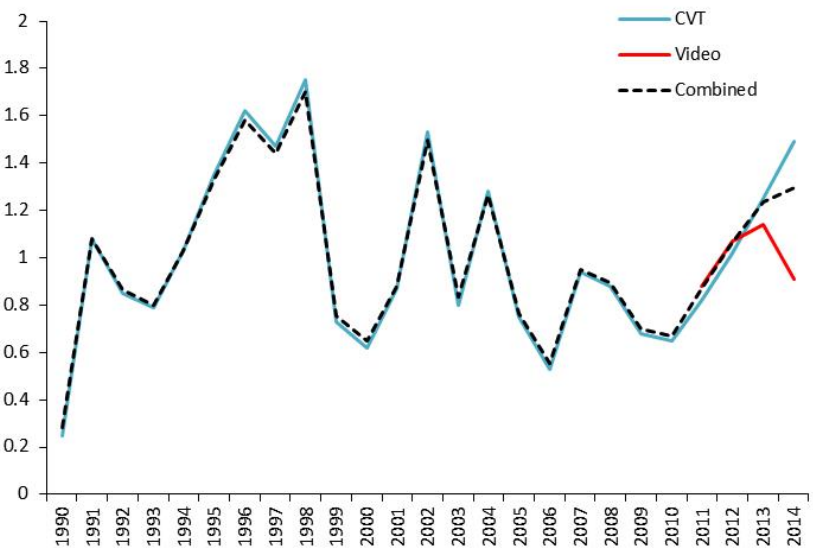


*Figure 2. Mean forklength at age (mm) and estimated upper and lower 95% confidence intervals of the population.*

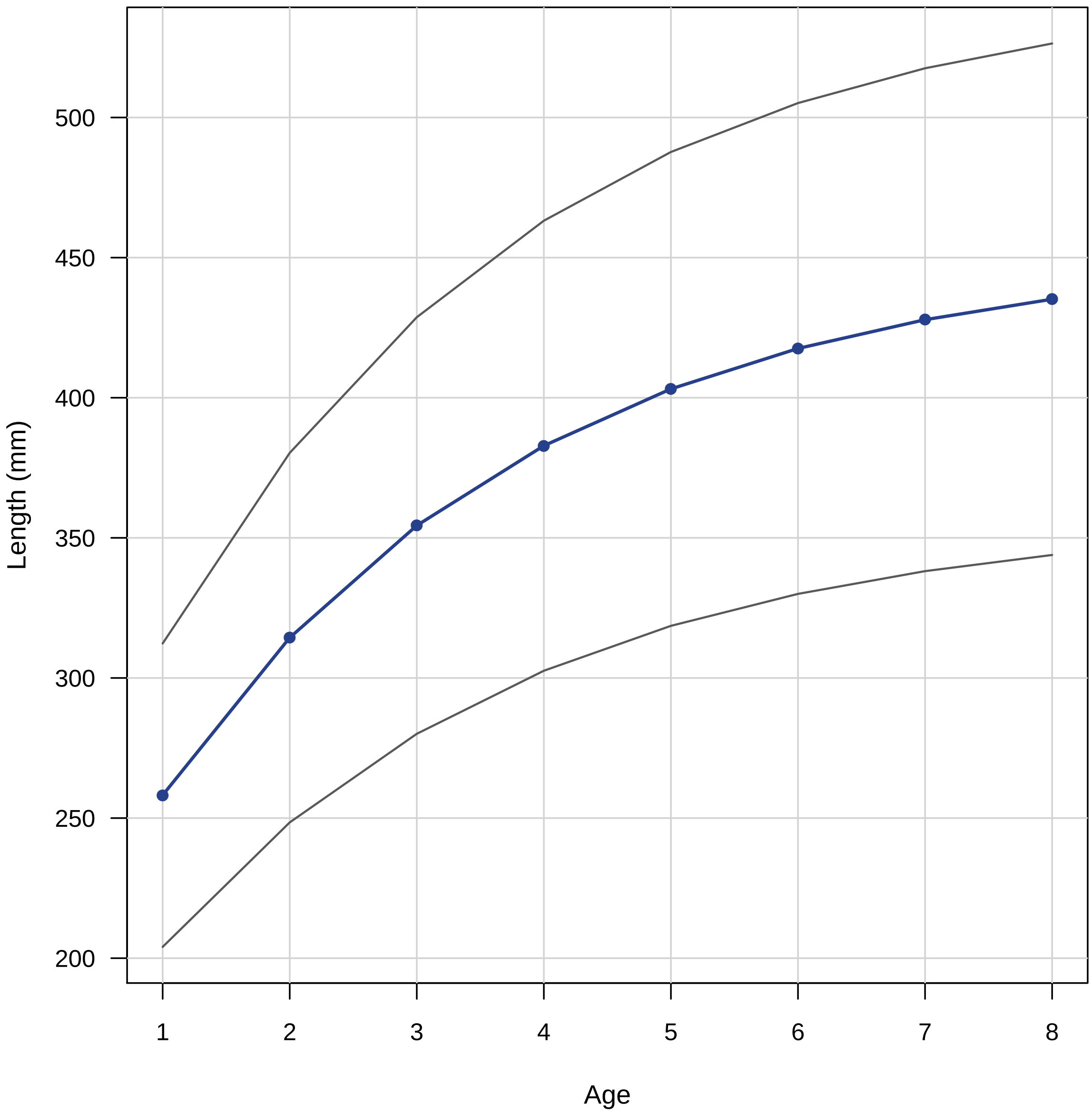


*Figure 3. Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, CVT to SERFS chevron trap, cH to commercial handline, HB to headboat and GR to general recreational.*

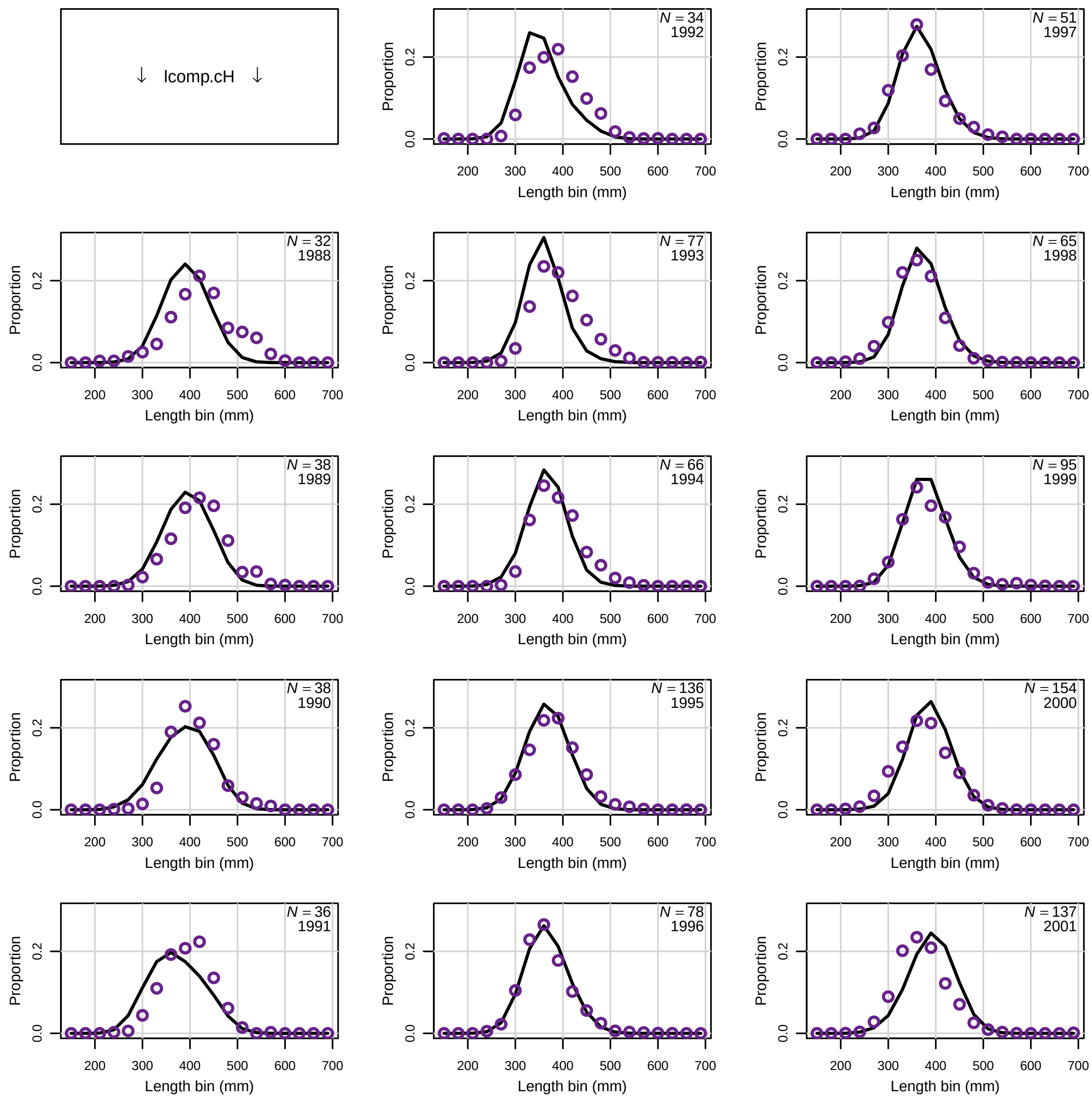


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

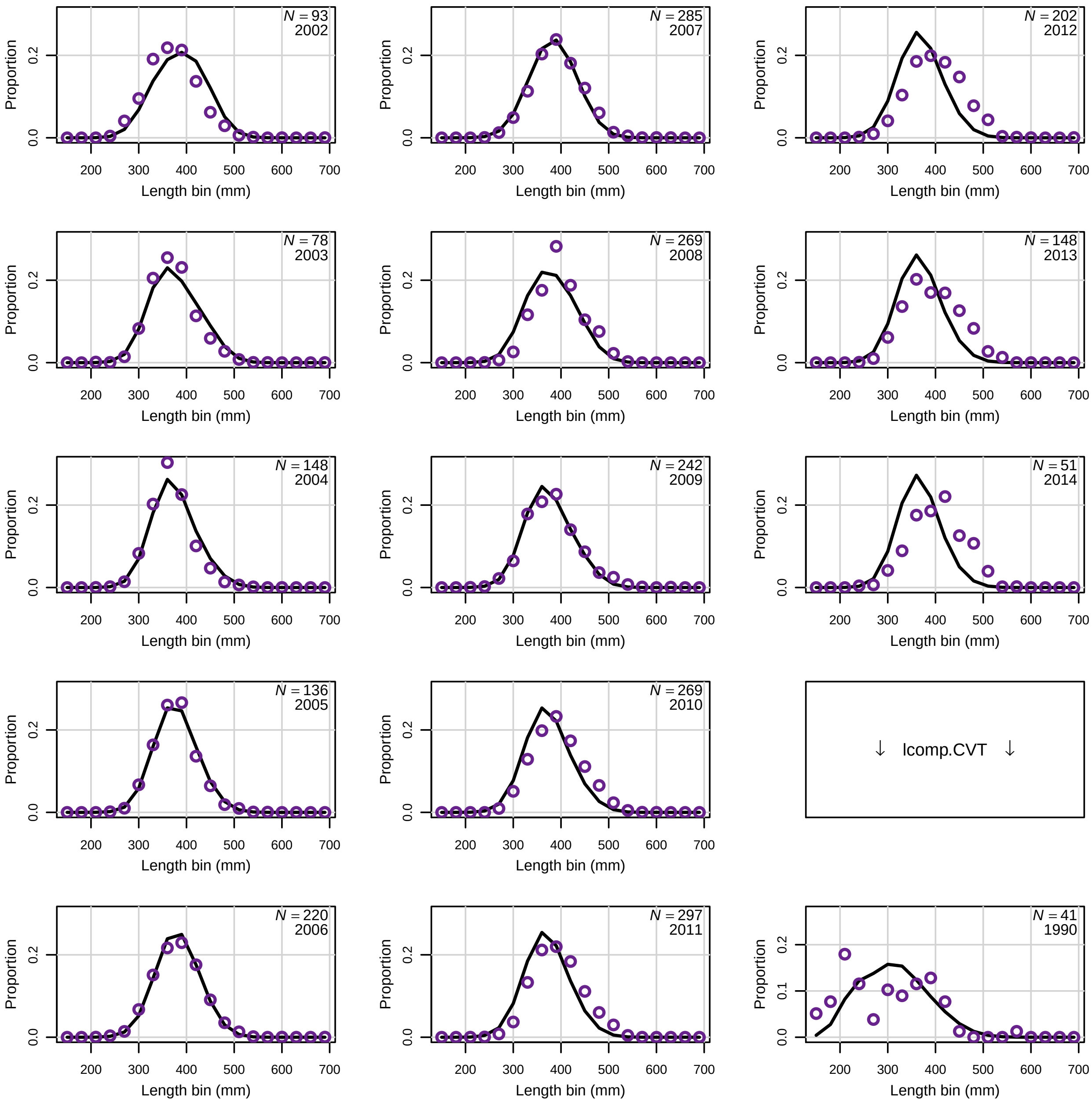


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

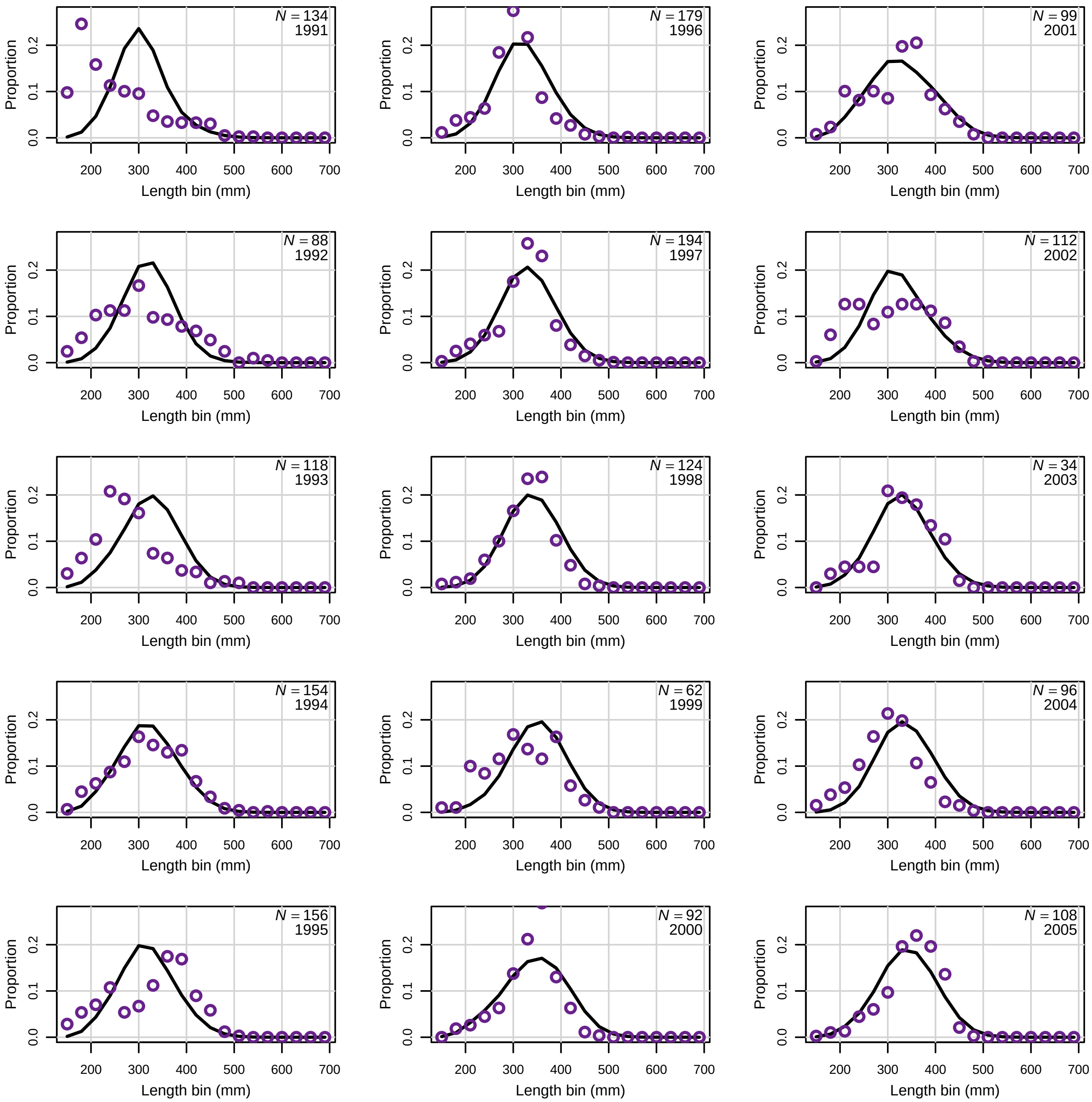


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

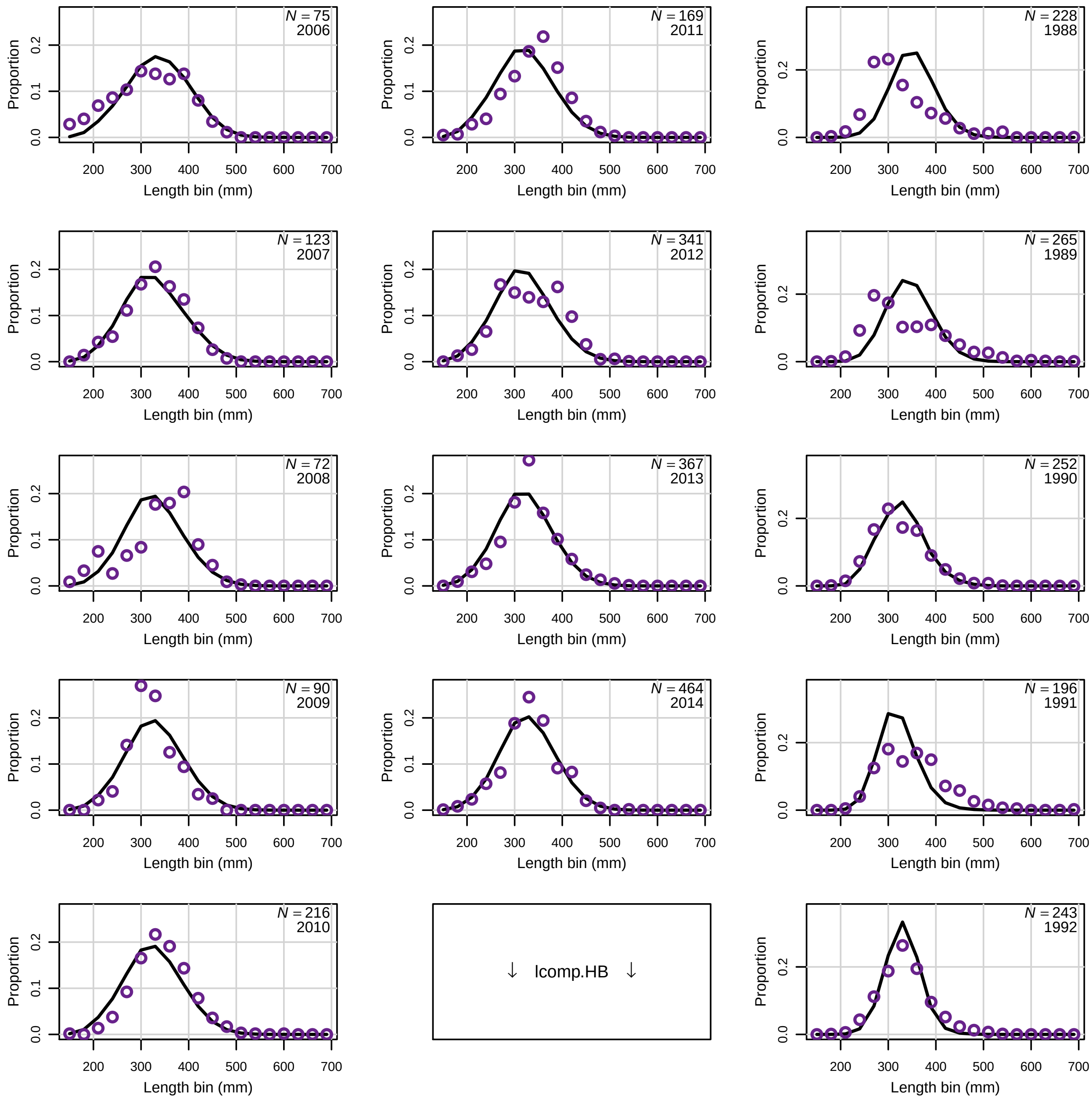


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

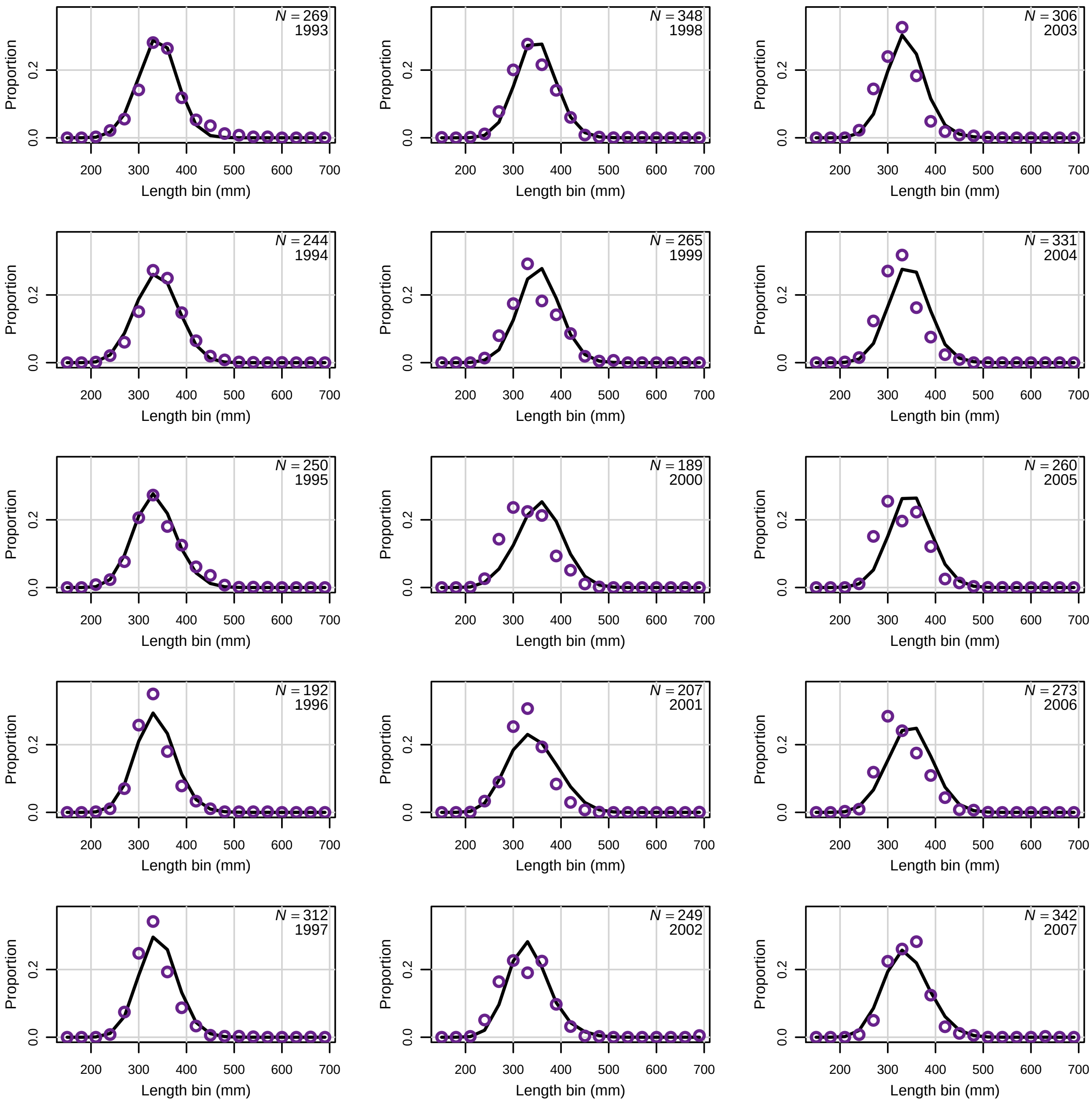


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

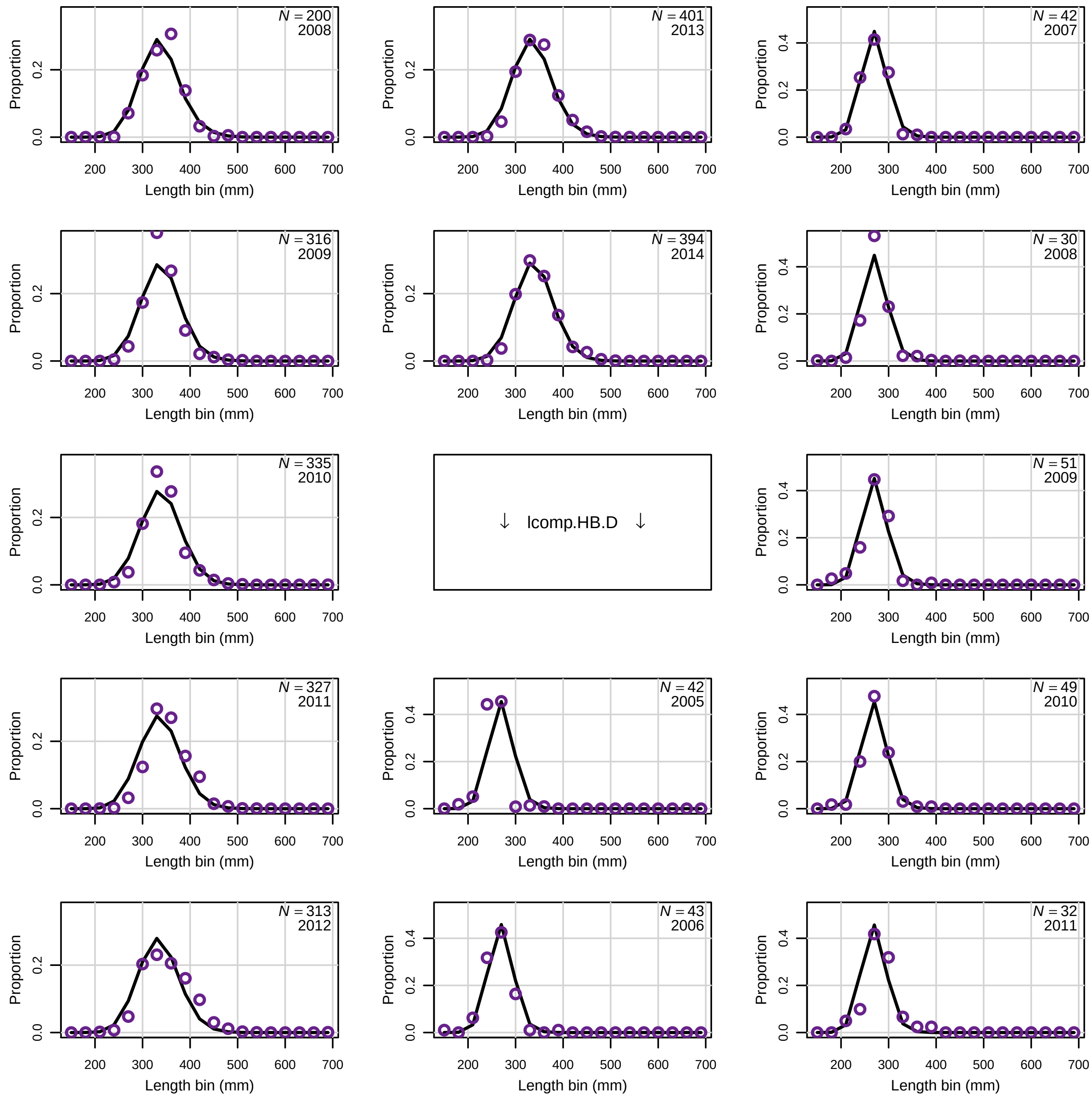


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

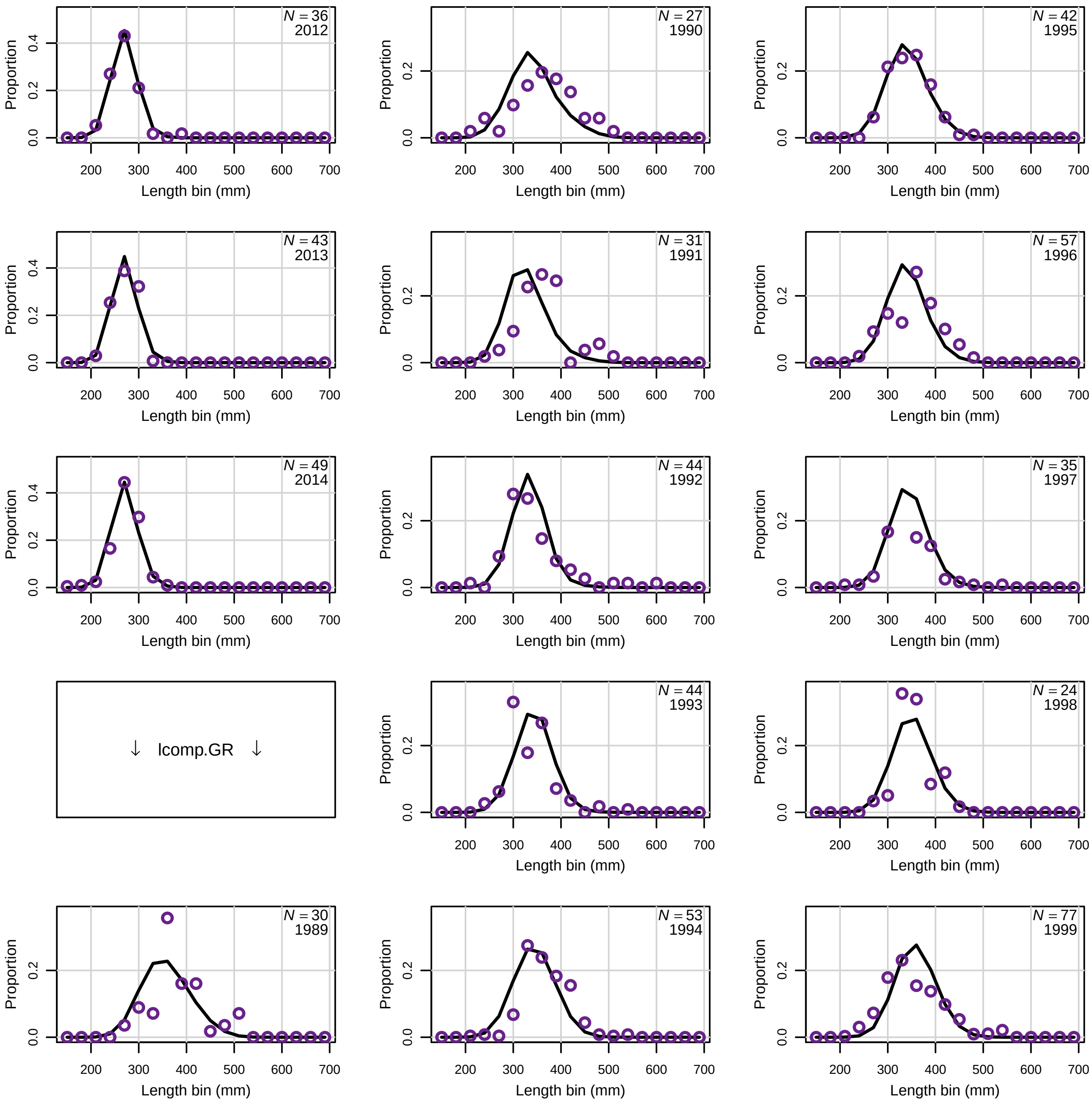


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

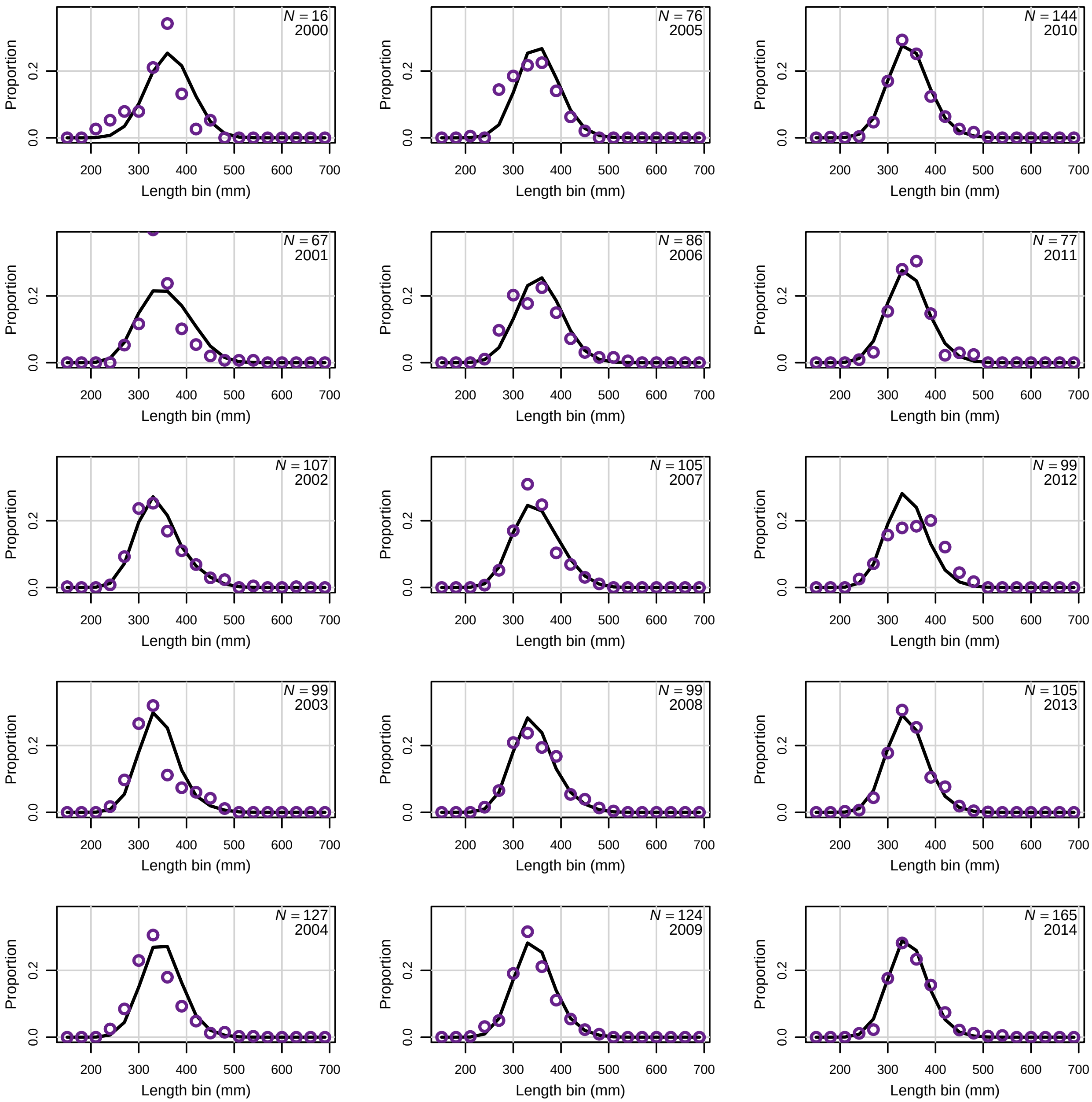


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

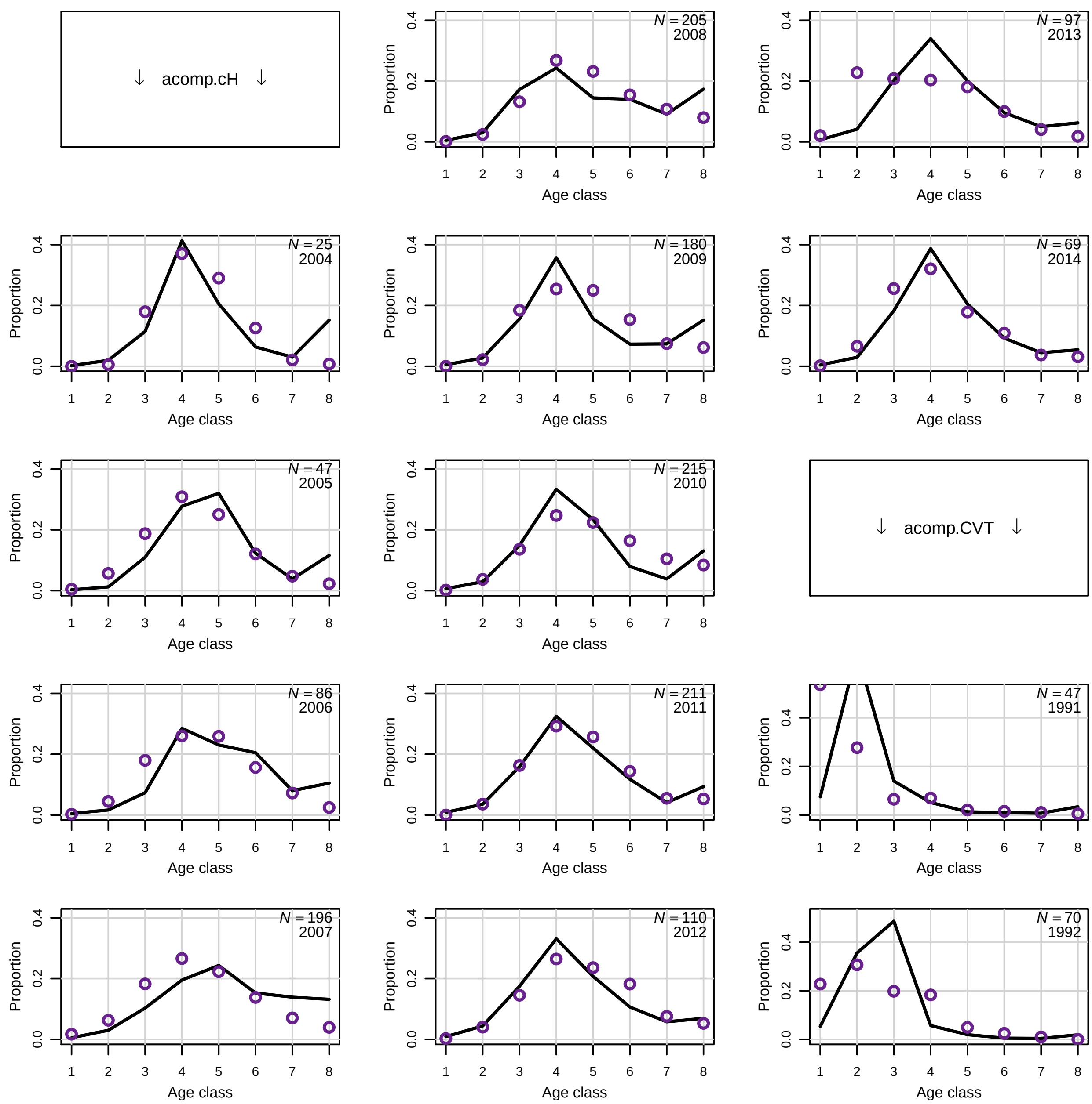


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

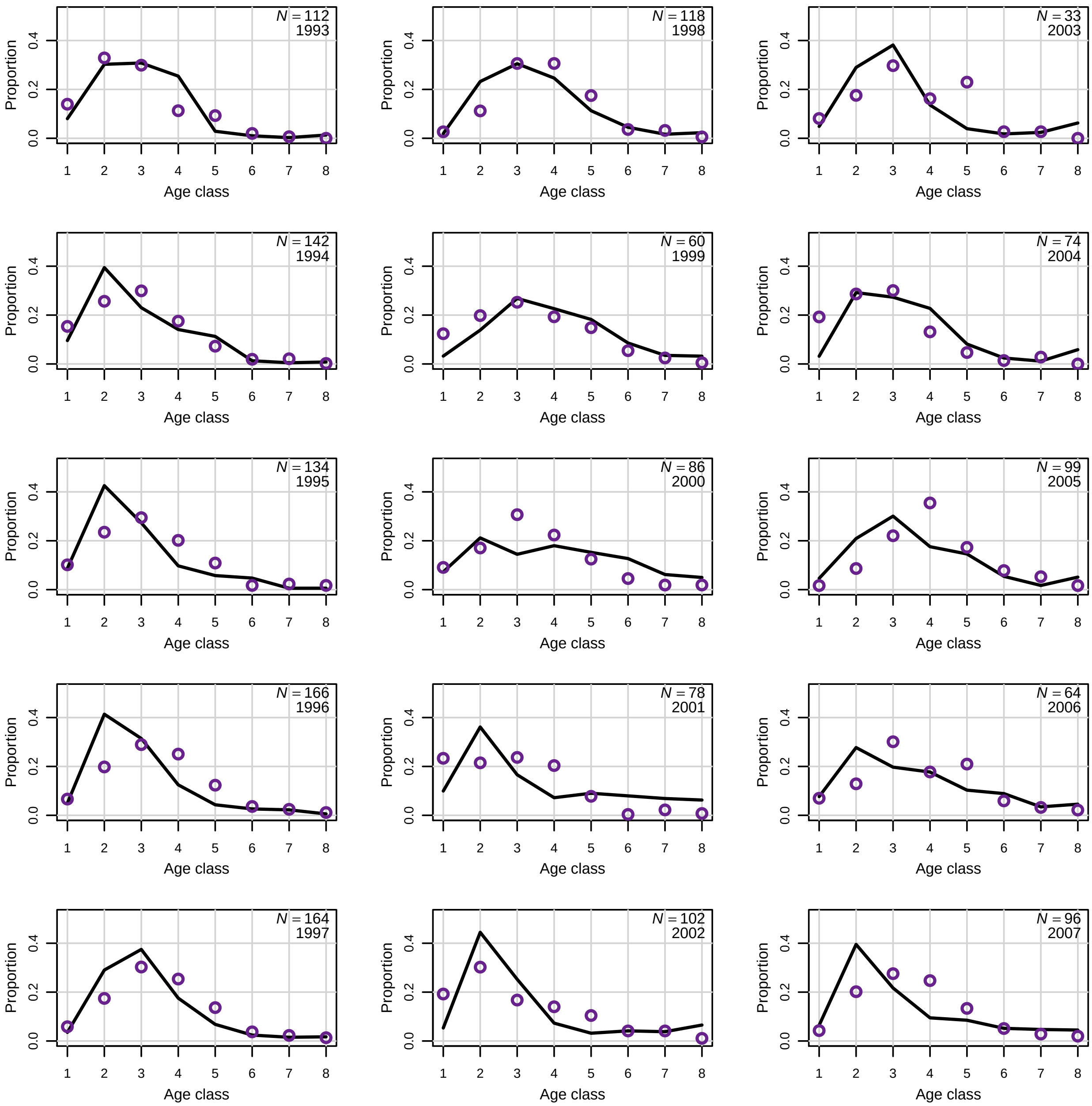


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

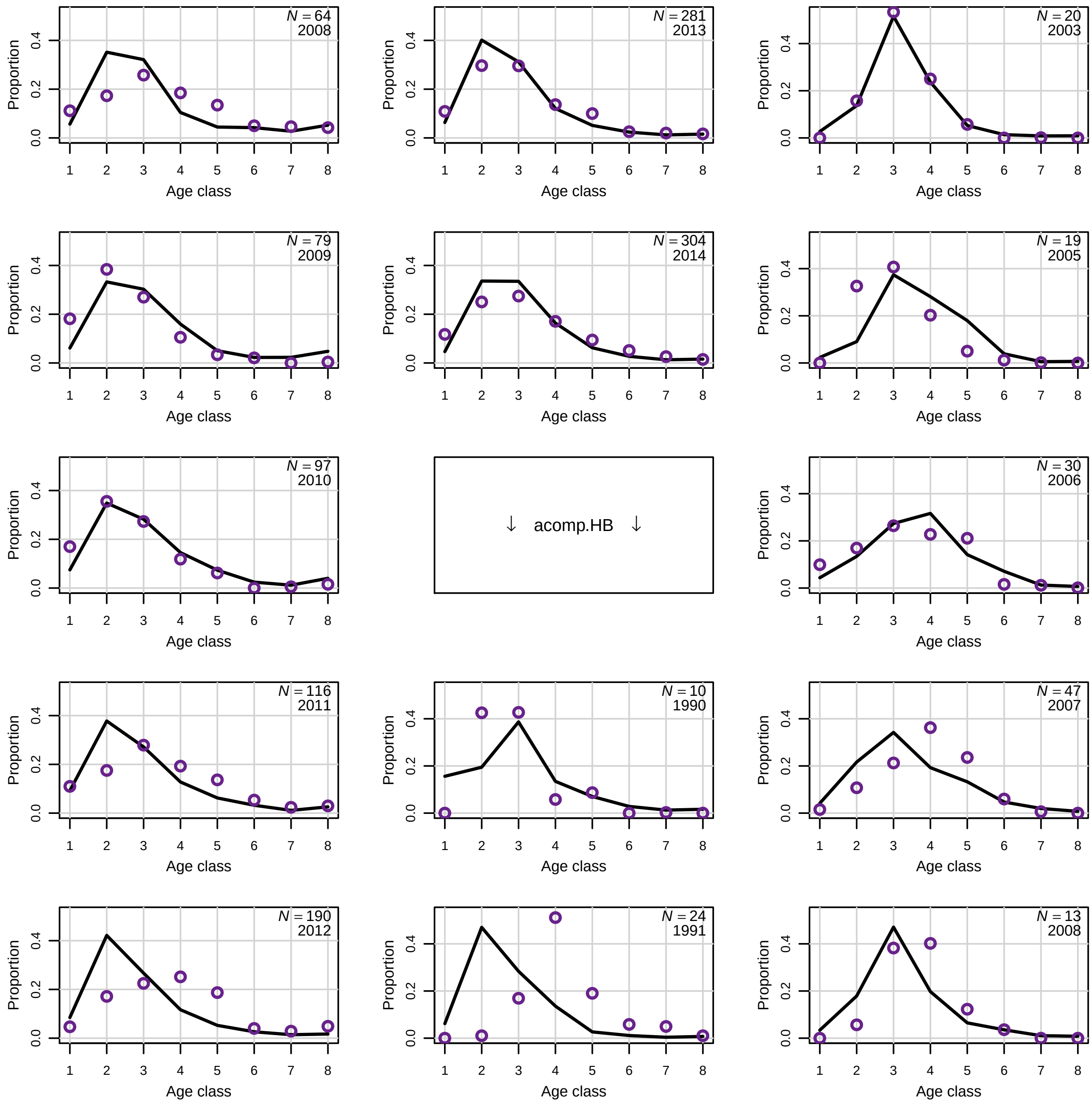


*Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.*

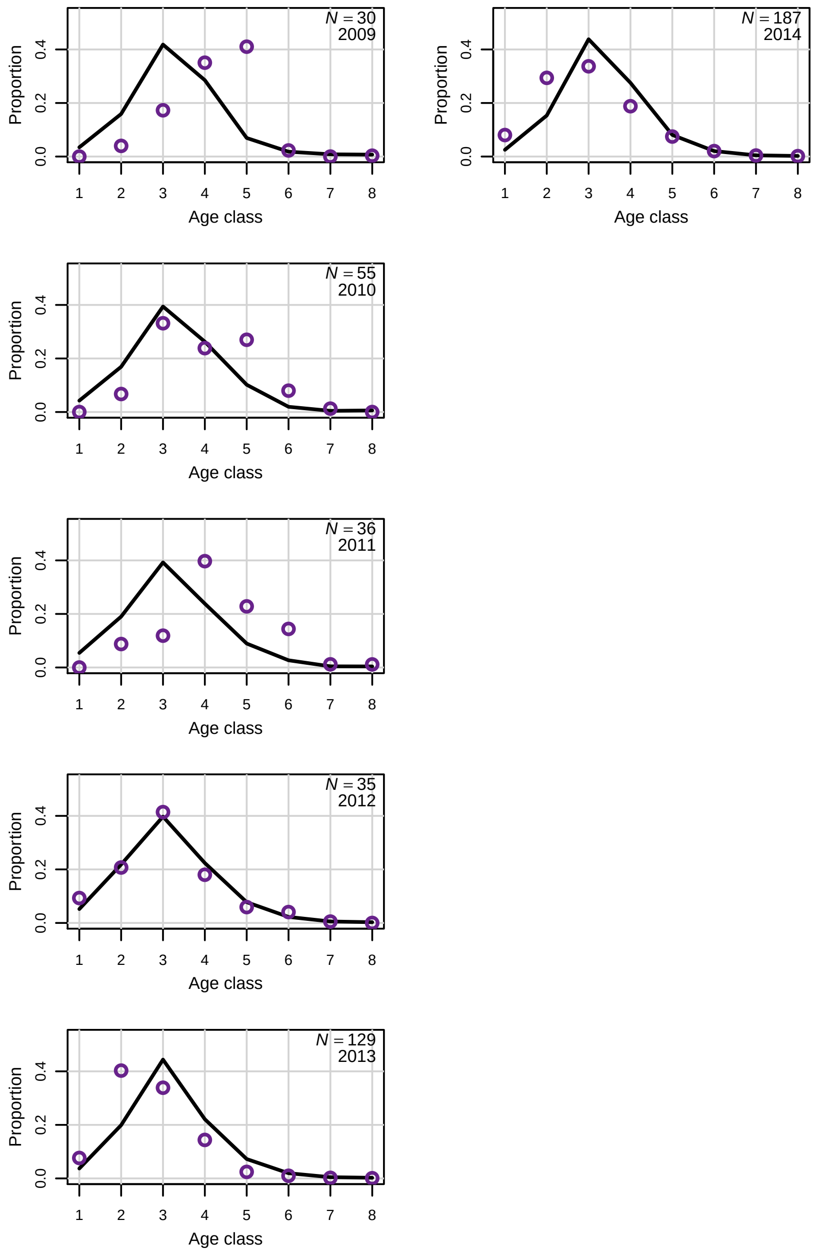


*Figure 4. Observed (open circles) and estimated (solid line, circles) commercial handline removals (landings and dead discards, 1000 lb whole weight). Open and solid circles are indistinguishable.*

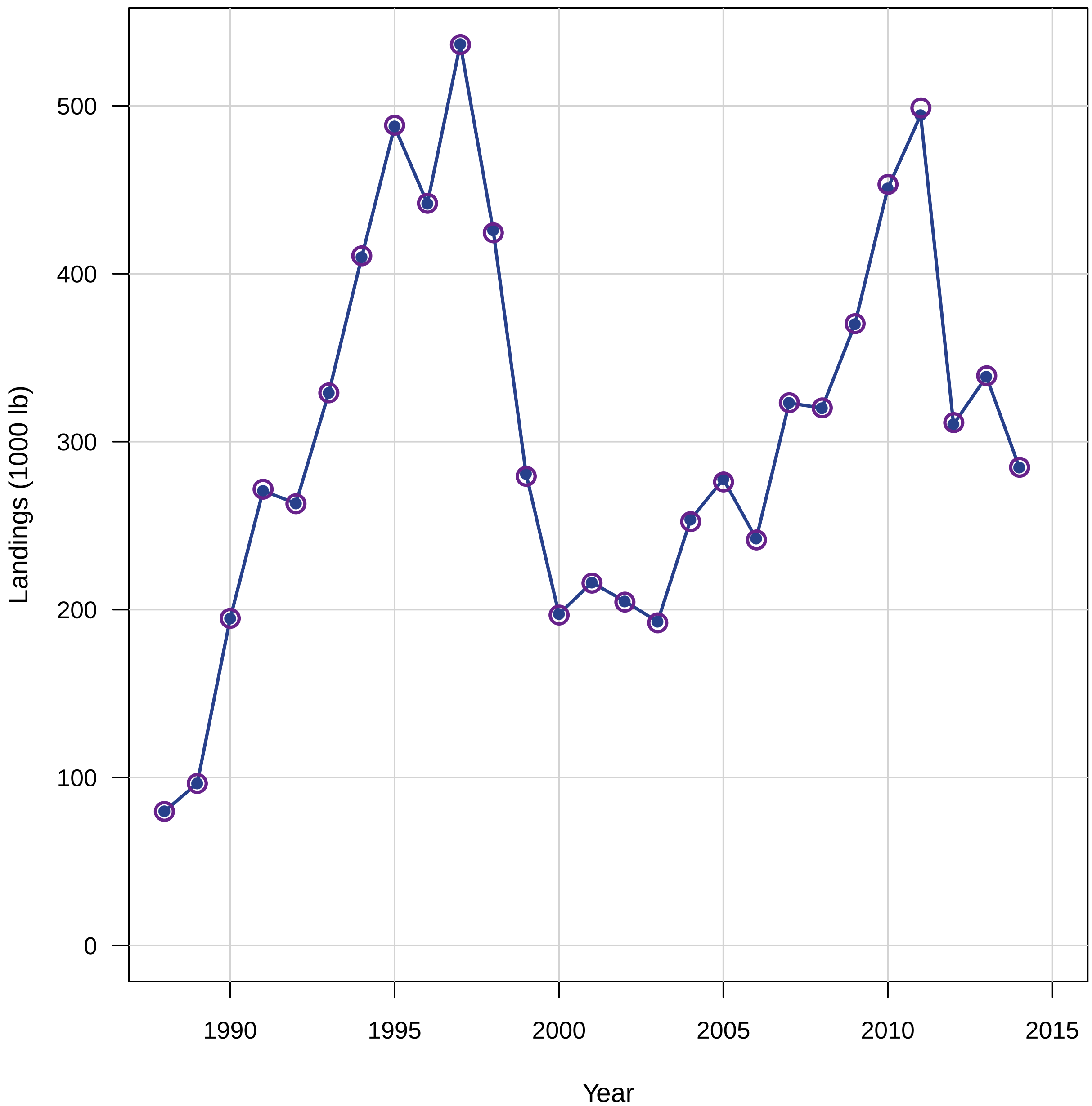


*Figure 5. Observed (open circles) and estimated (solid line, circles) headboat landings (1000 fish). Open and solid circles are indistinguishable.*

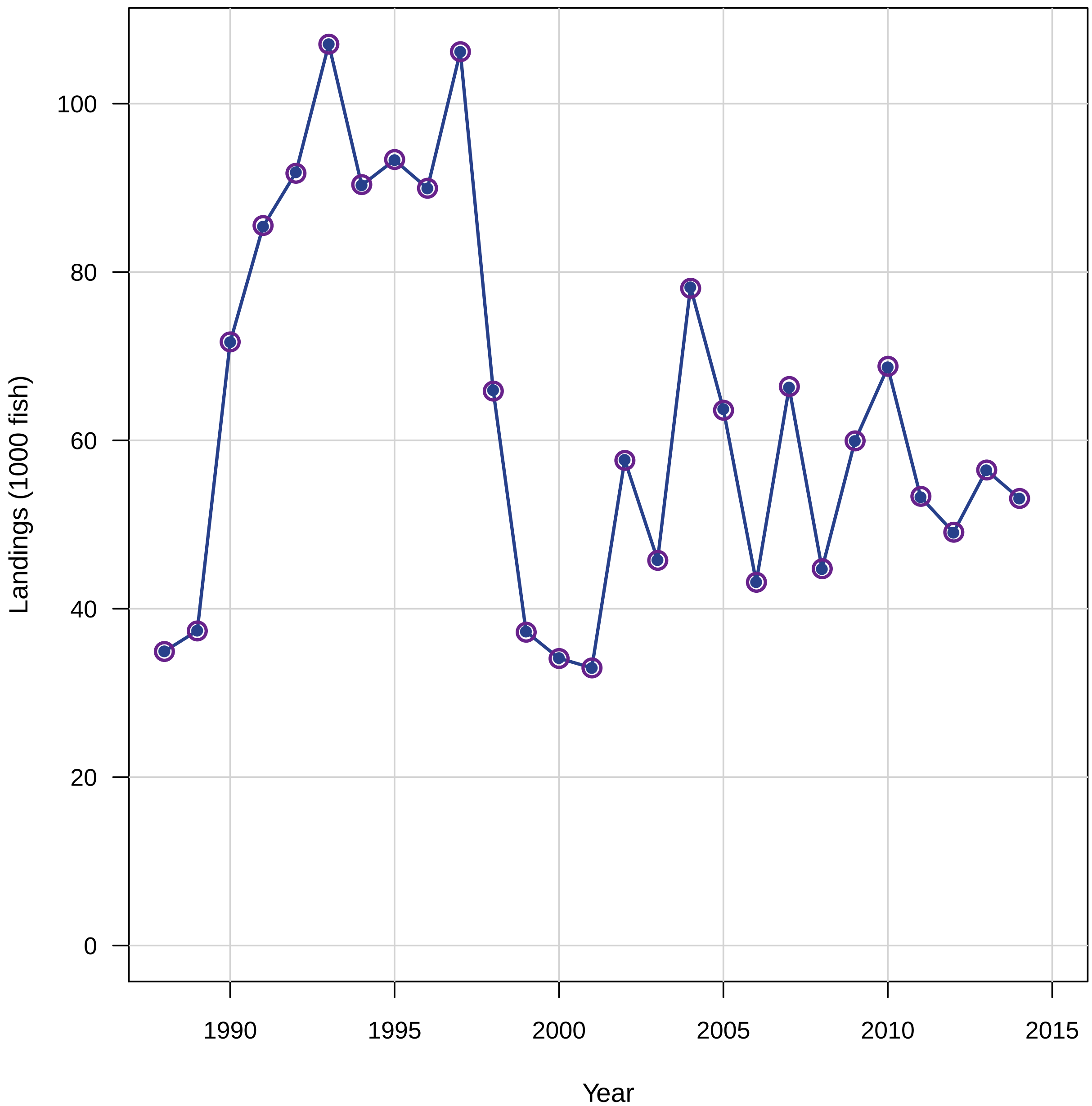


*Figure 6. Observed (open circles) and estimated (solid line, circles) general recreational landings (1000 fish). Open and solid circles are indistinguishable.*

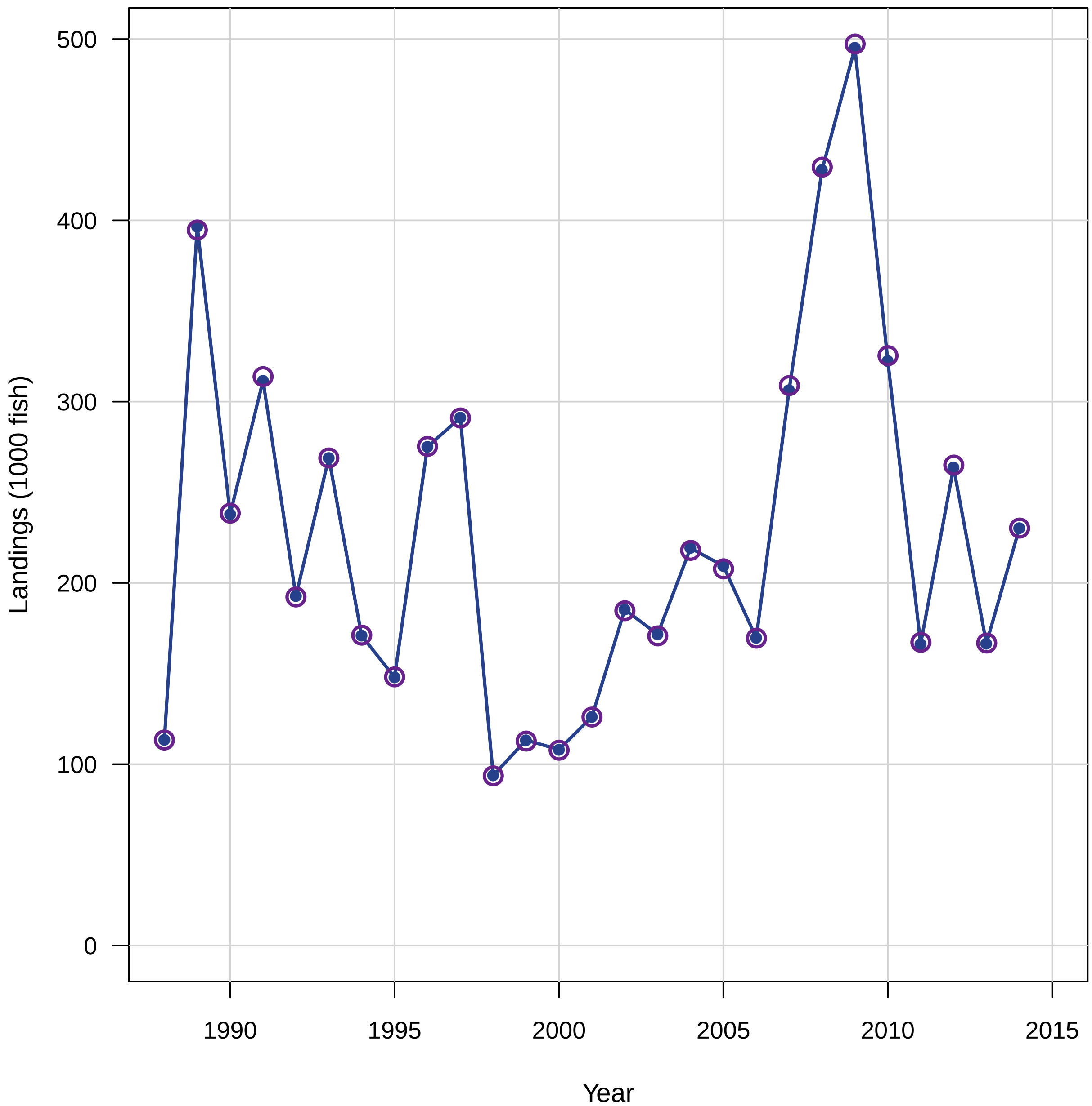


*Figure 7. Observed (open circles) and estimated (solid line, circles) headboat discard mortalities. Open and solid circles are indistinguishable.*

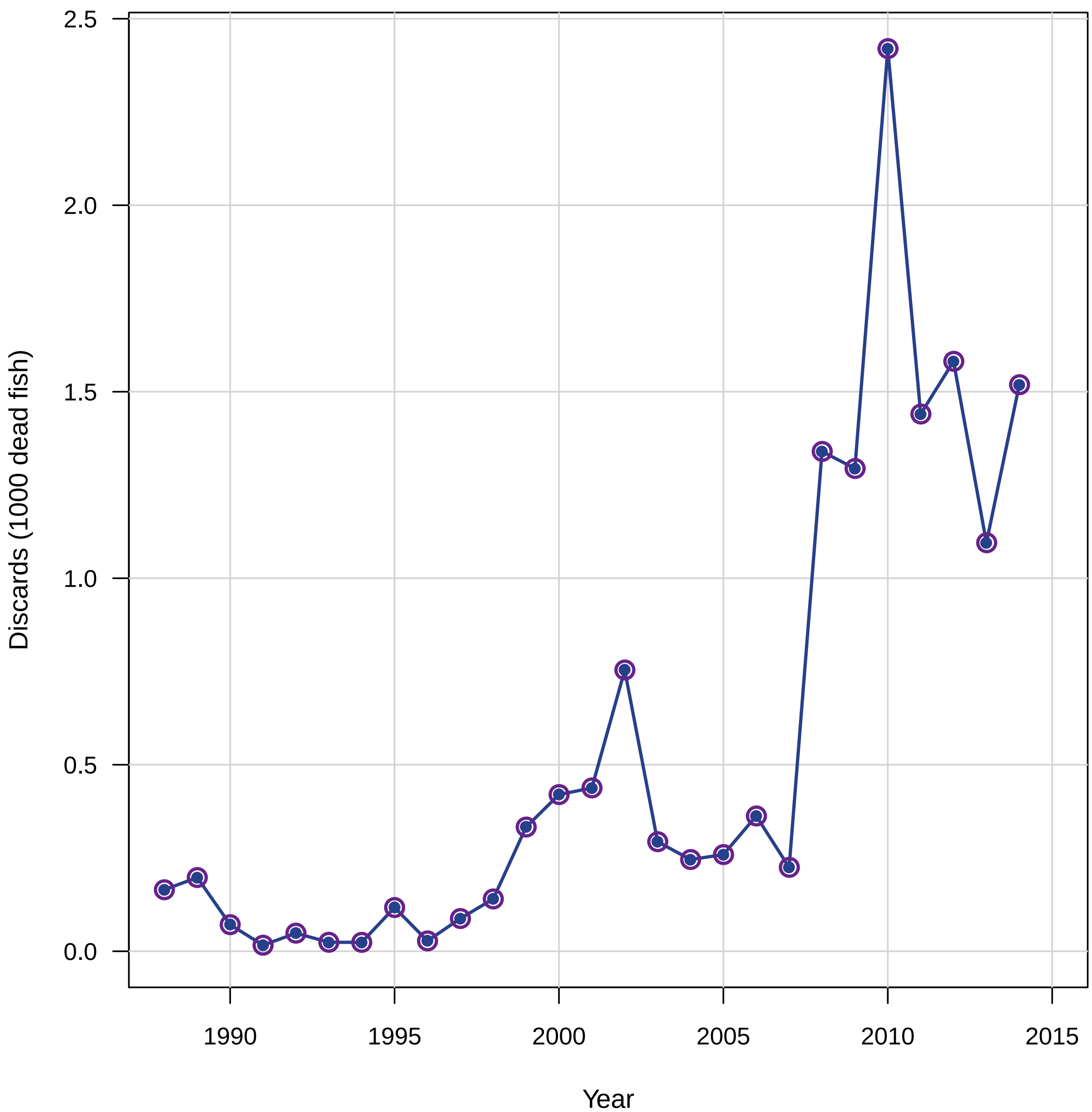


*Figure 8. Observed (open circles) and estimated (solid line, circles) general recreational discard mortalities. Open and solid circles are indistinguishable.*

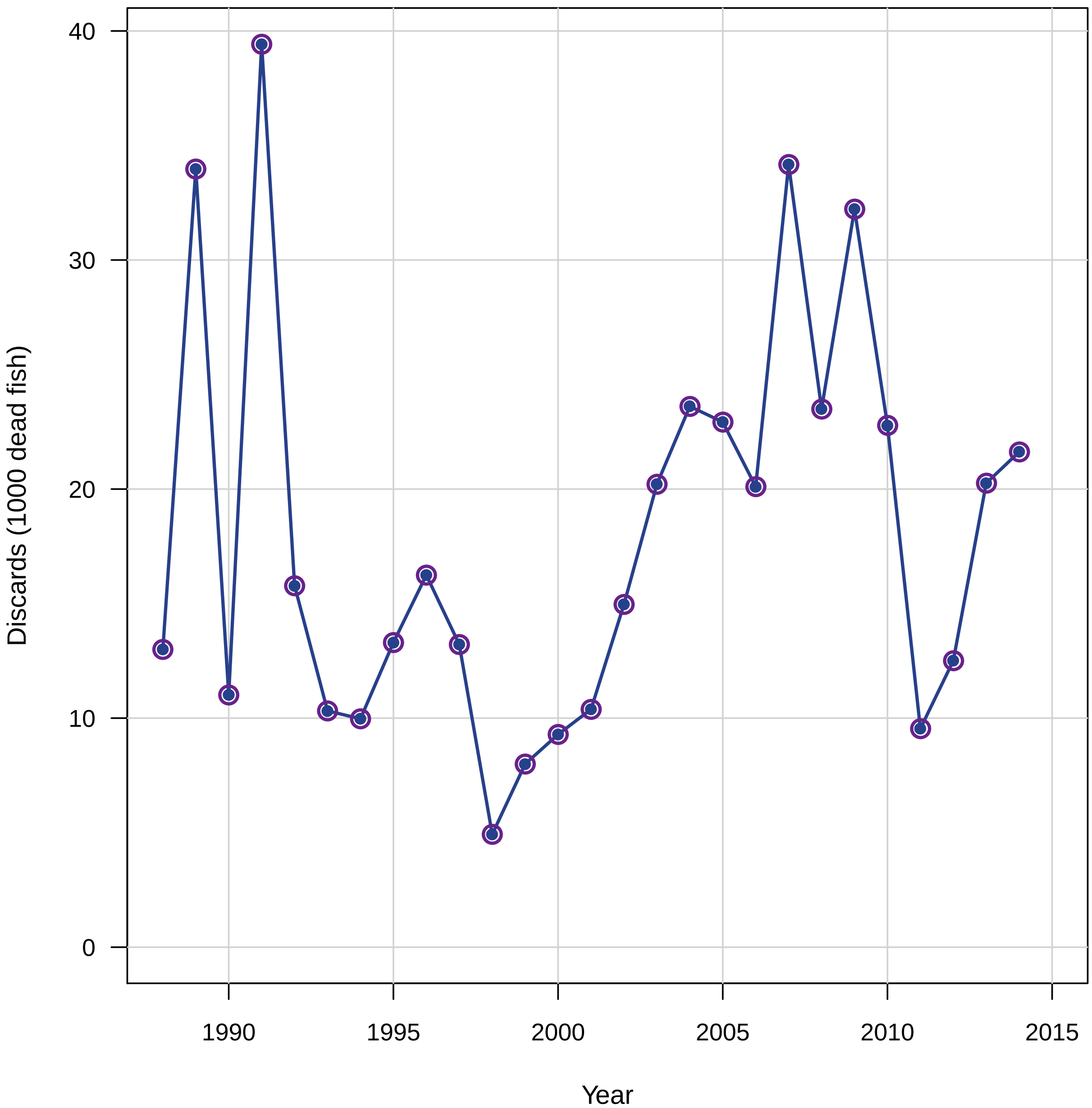


*Figure 9. Observed (open circles) and estimated (solid line, circles) index of abundance from the combined trap-video index (CVID).*

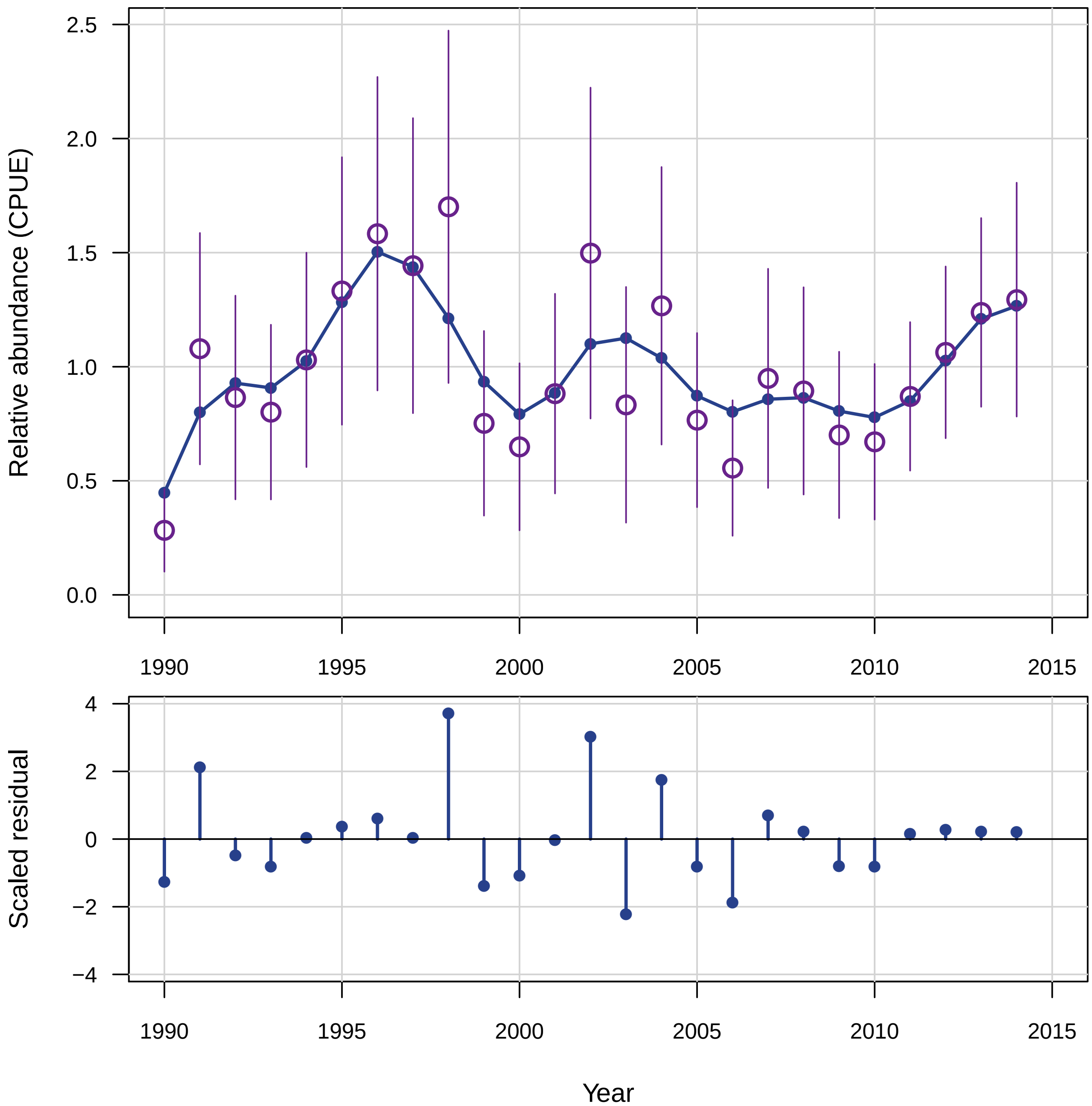


*Figure 10. Estimated abundance at age at start of year.*

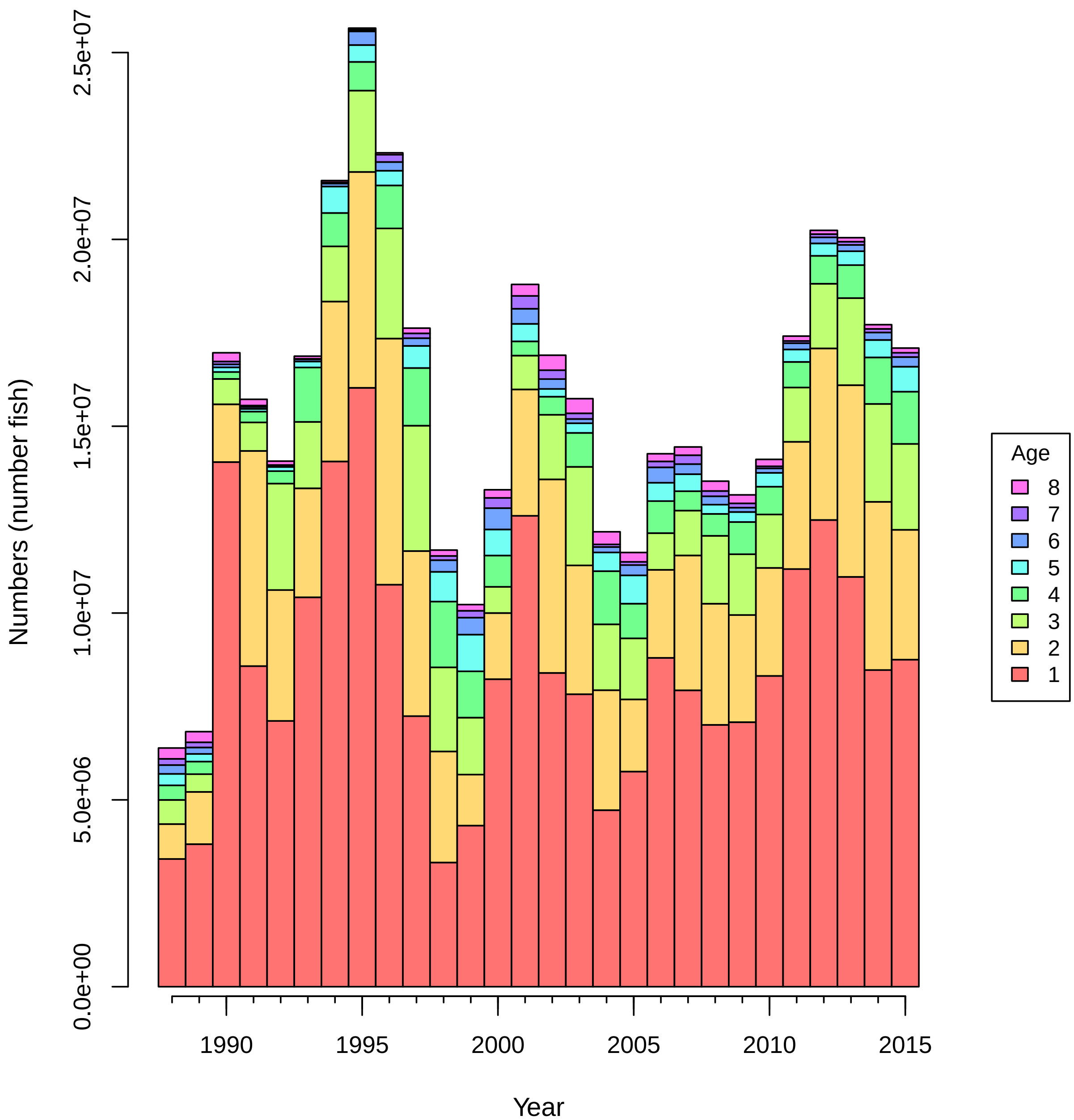


*Figure 11. Top panel: Estimated recruitment of age-1 fish. Horizontal dashed line indicates* $R_{\mathrm{F30\%}}$*. Bottom panel: log recruitment residuals.*

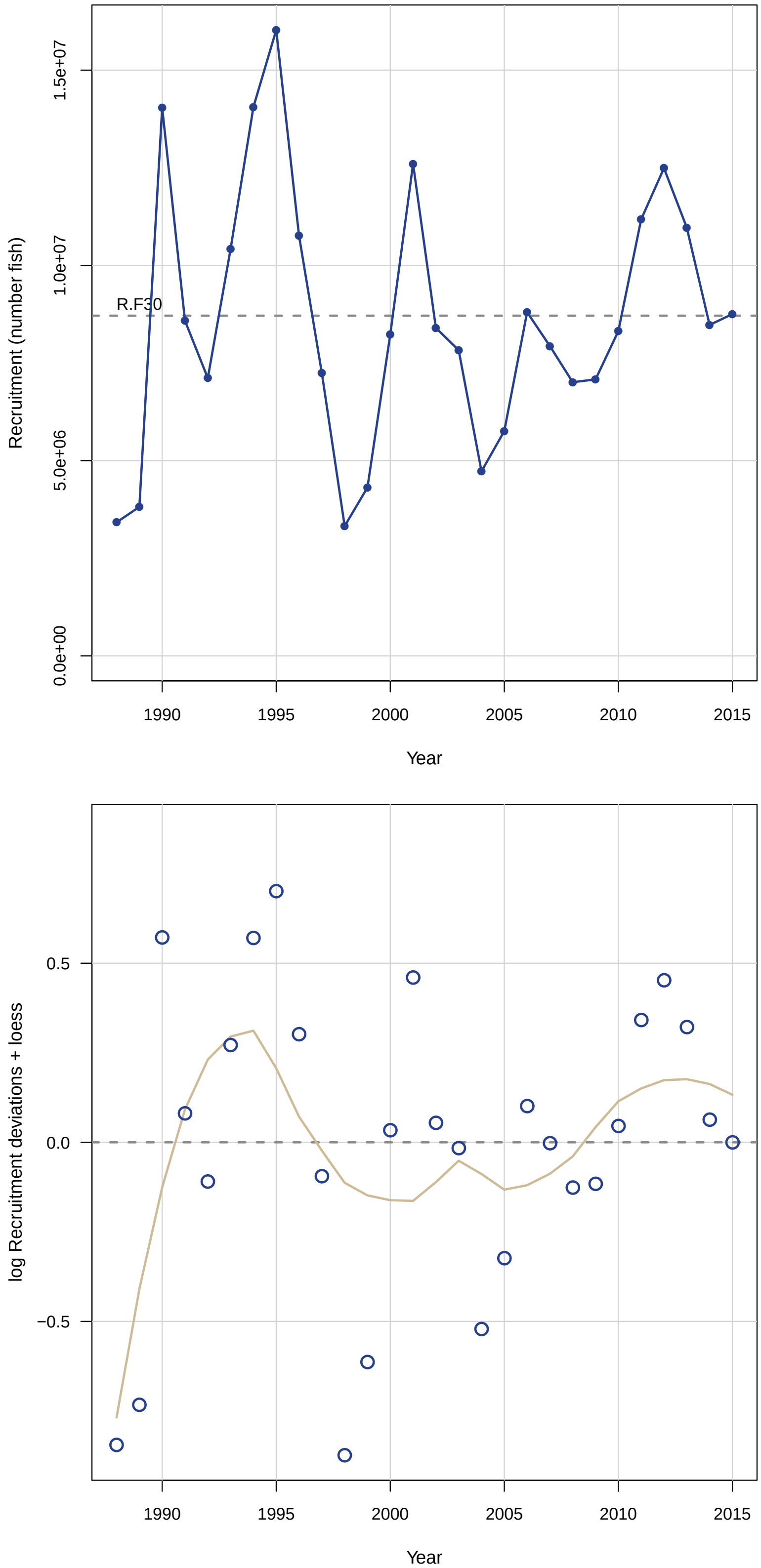


*Figure 12. Estimated biomass at age at start of year.*

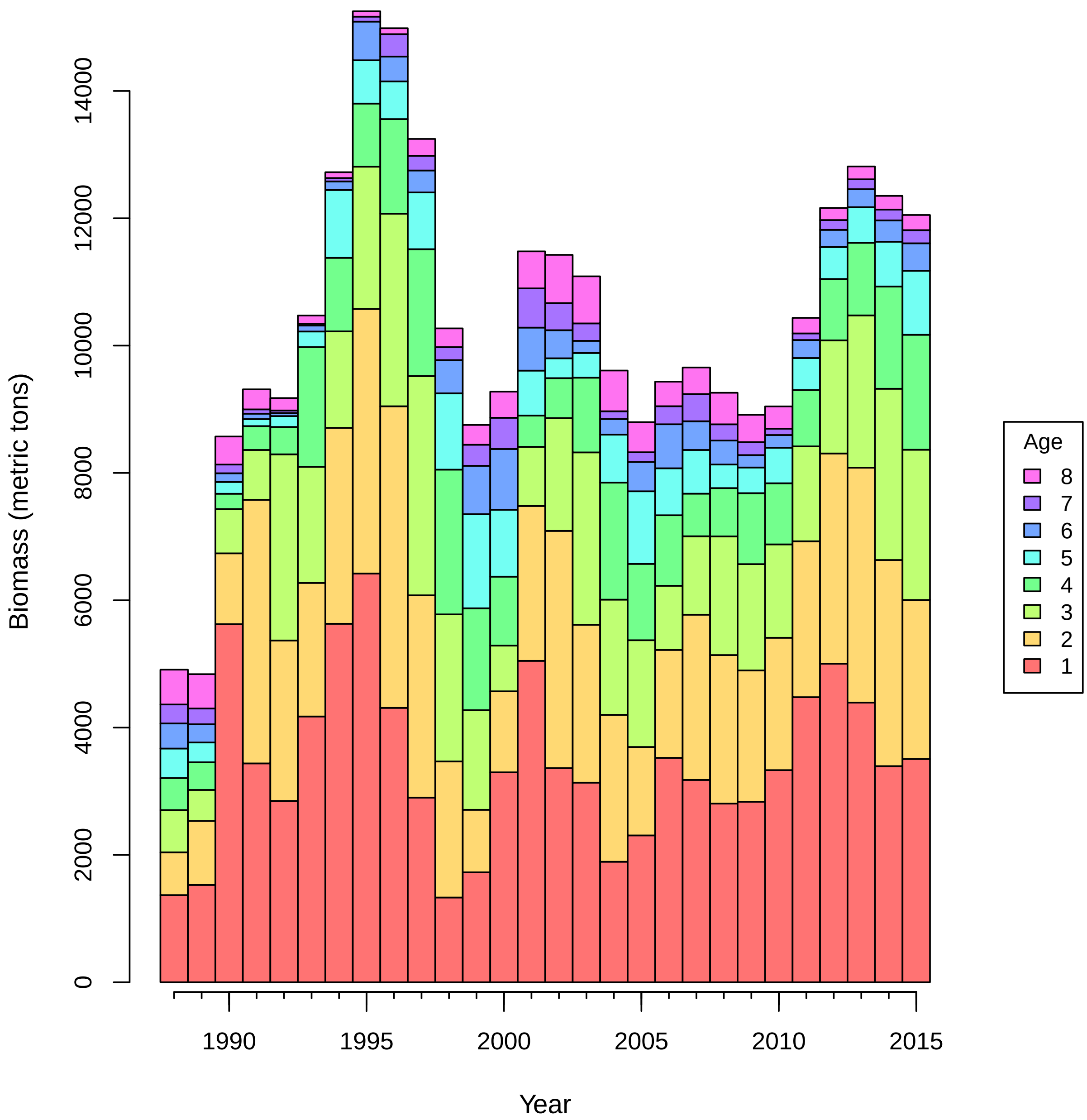


*Figure 13. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates $B_{F30\%}$. Bottom panel: Estimated spawning stock (population fecundity) at time of peak spawning.*

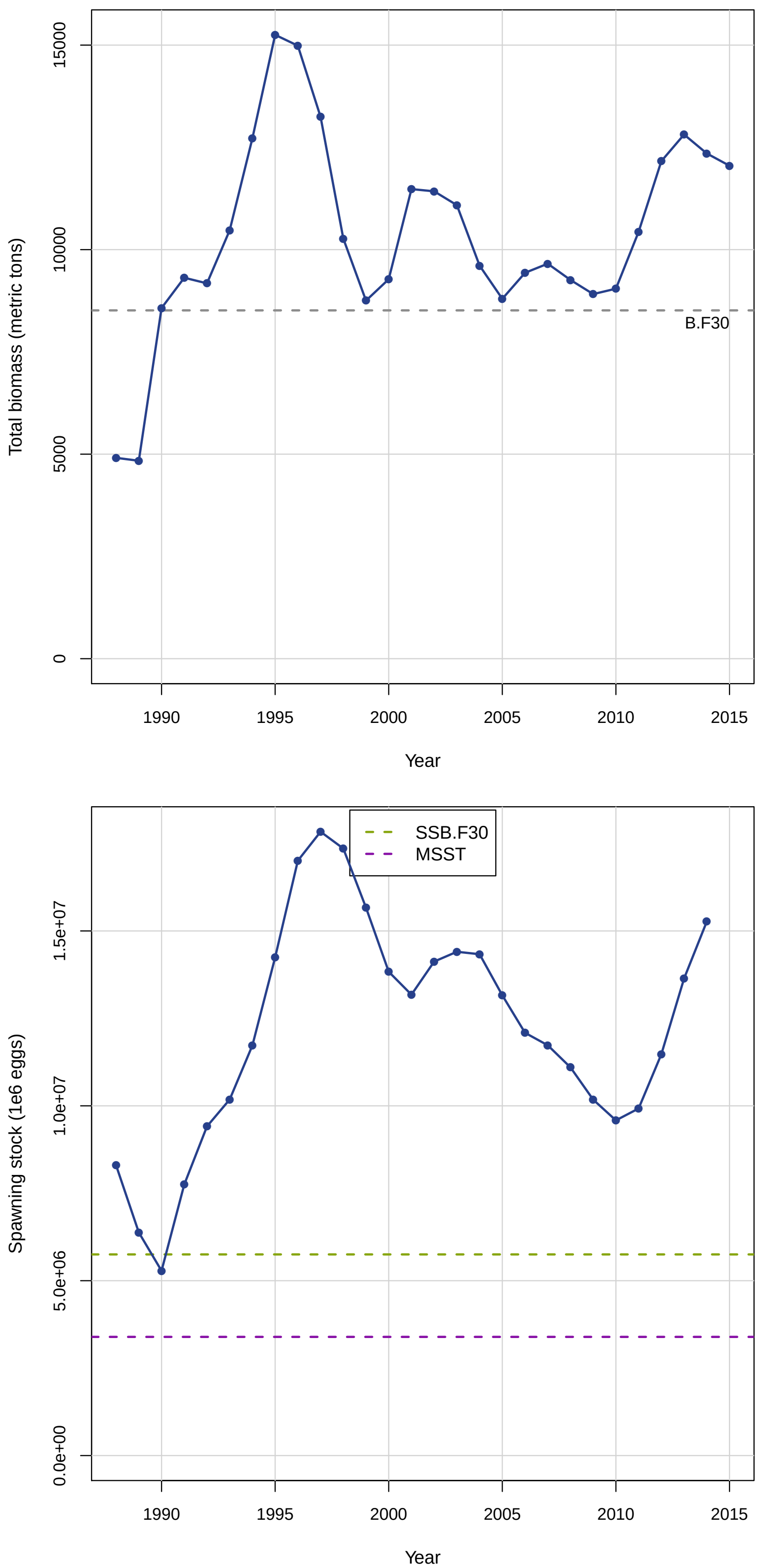


*Figure 14. Selectivity of fishery independent trap-video survey (CVID).*

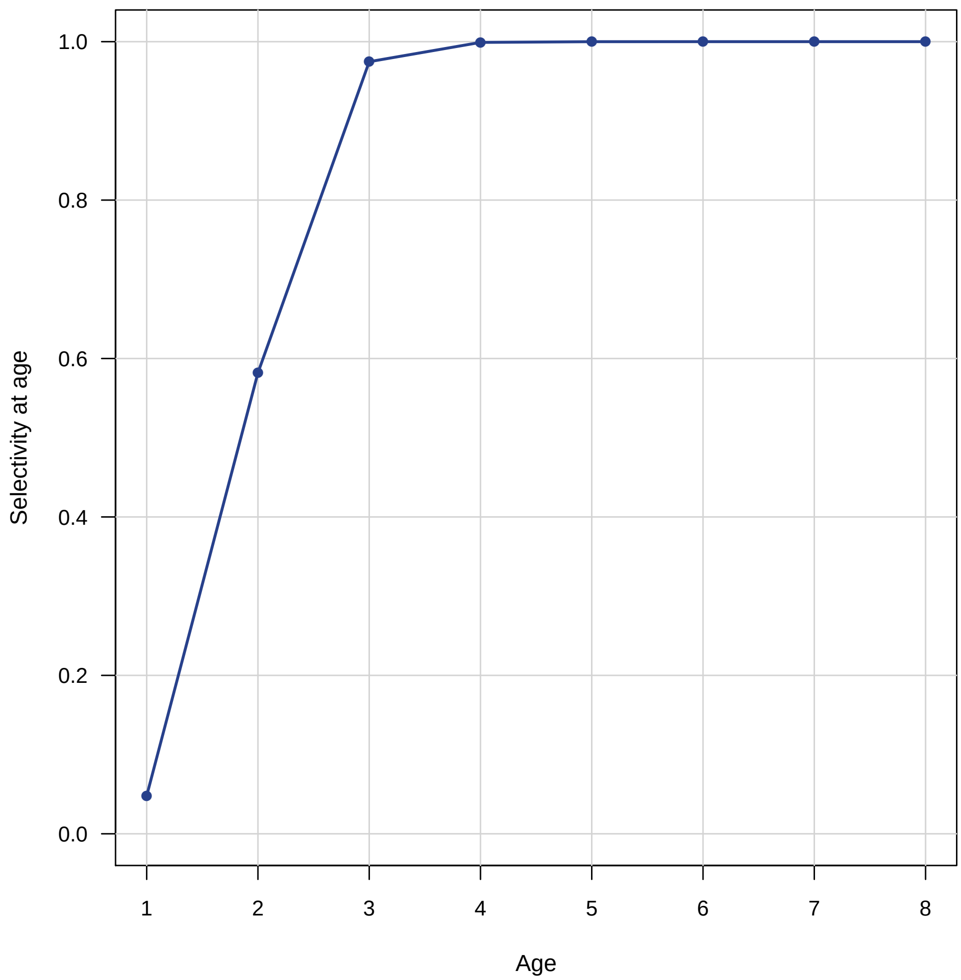


*Figure 15. Selectivity of commercial handline removals.*

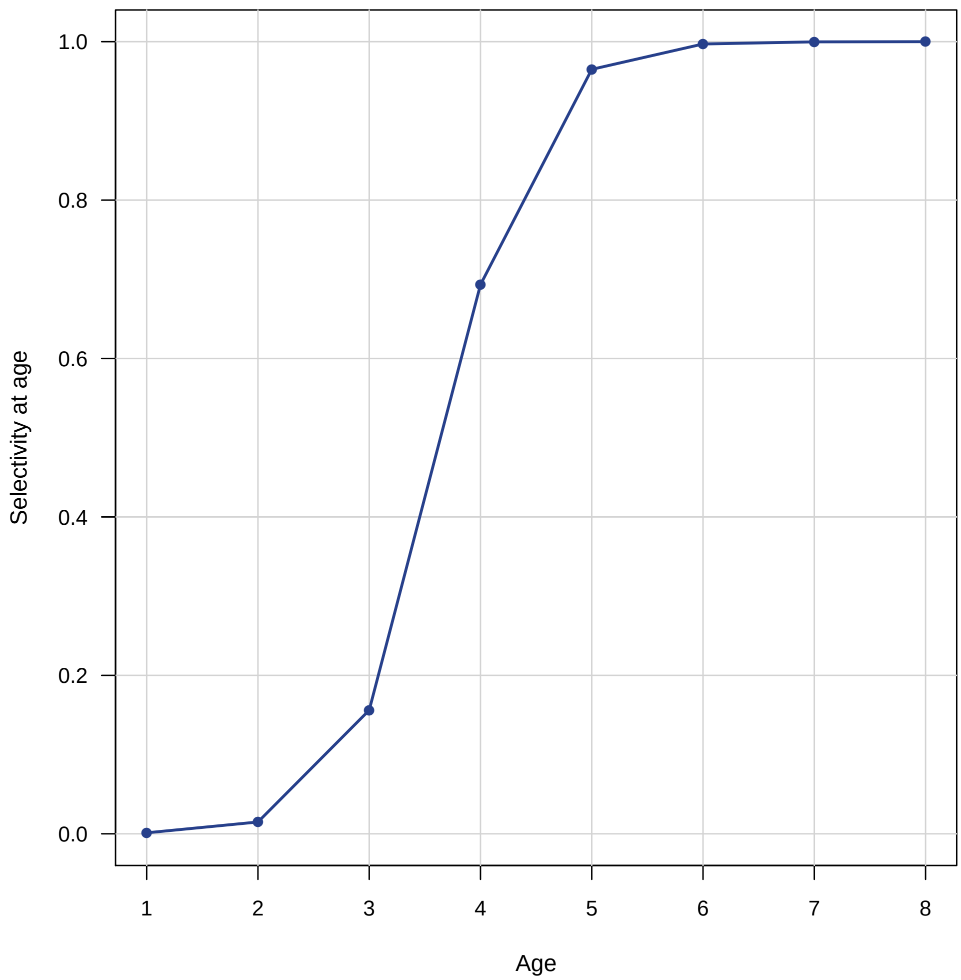


*Figure 16. Selectivity of headboat landings.*

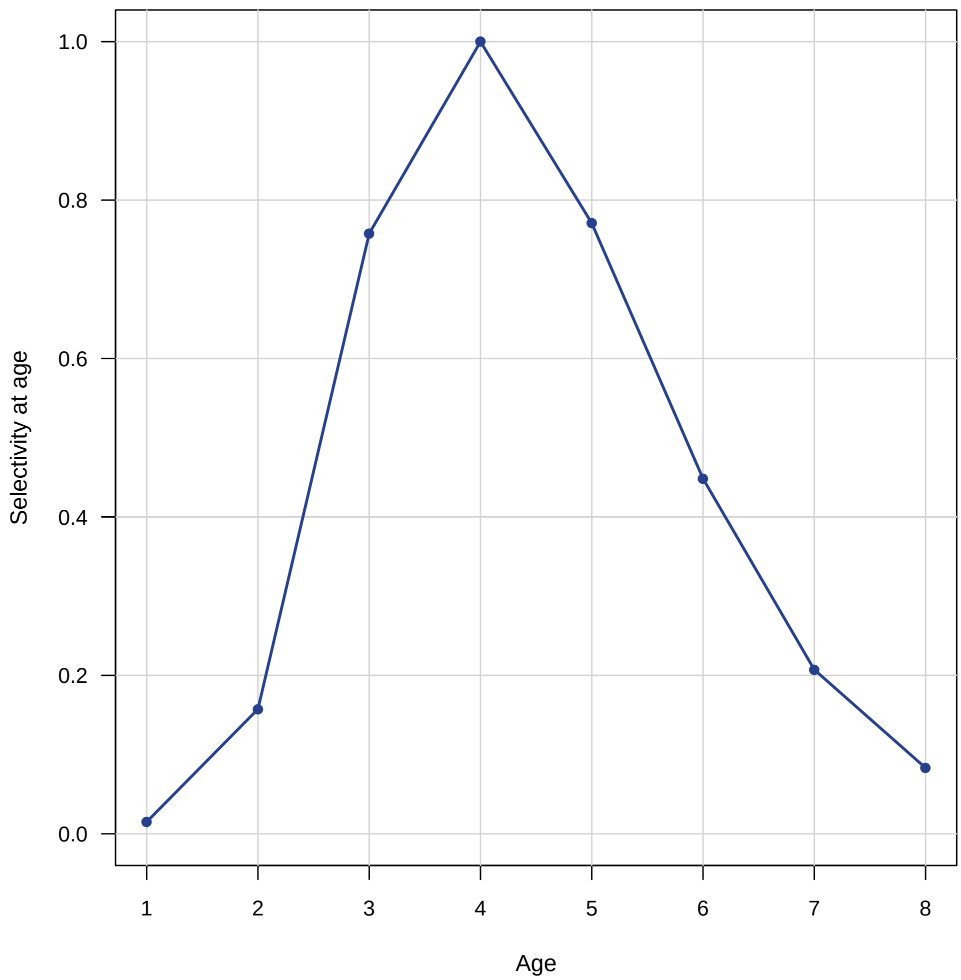


*Figure 17. Selectivity of general recreational landings.*

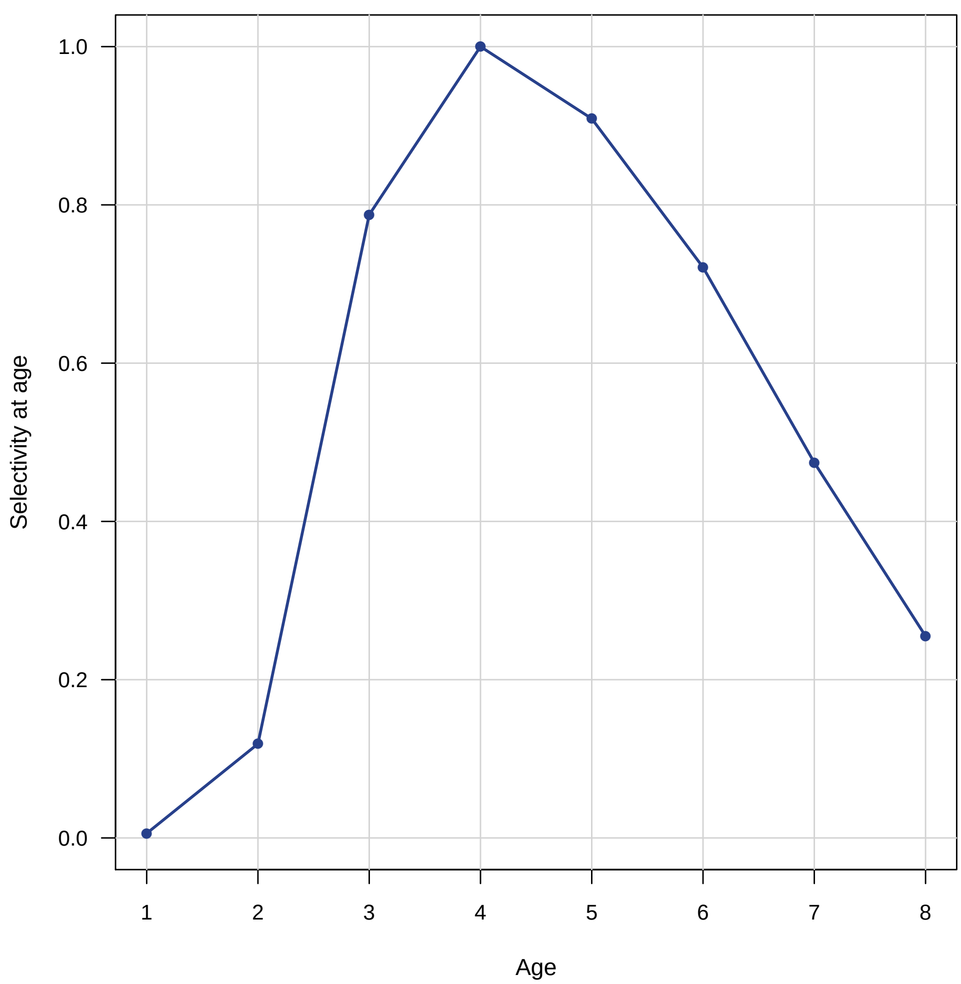


*Figure 18. Selectivity of headboat discards.*

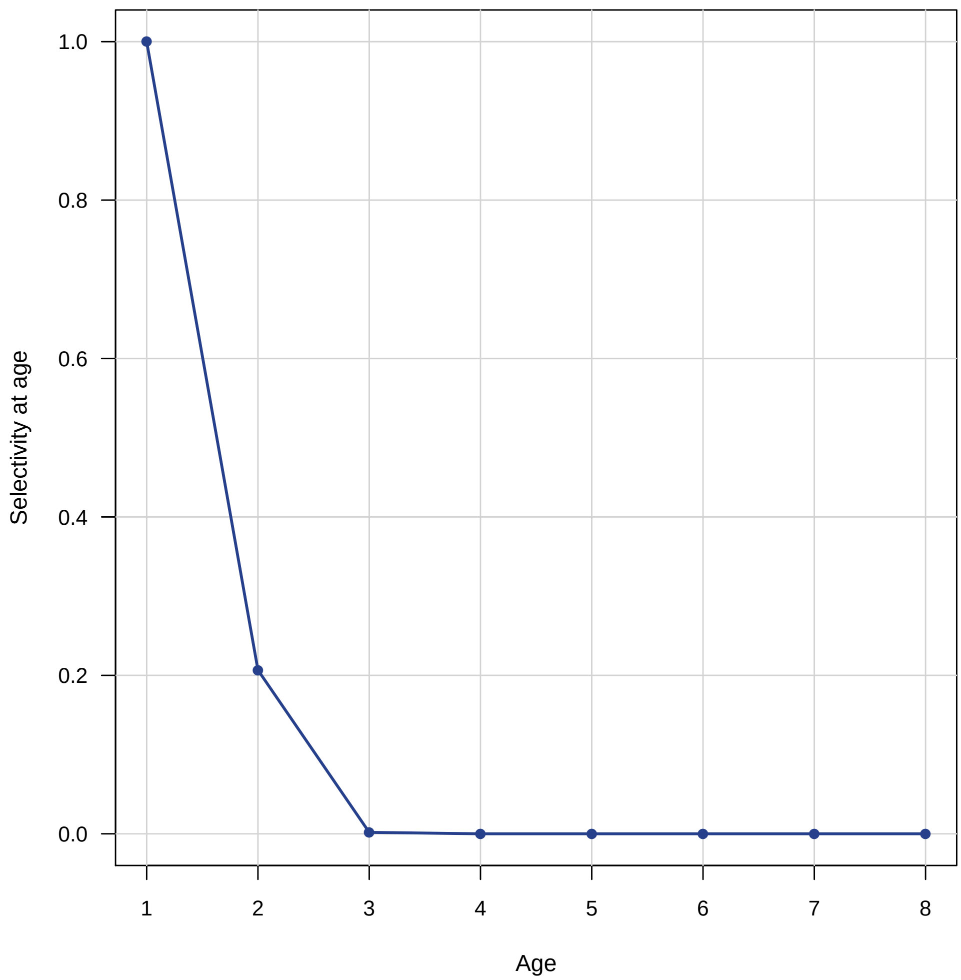


*Figure 19. Selectivity of general recreational discards.*

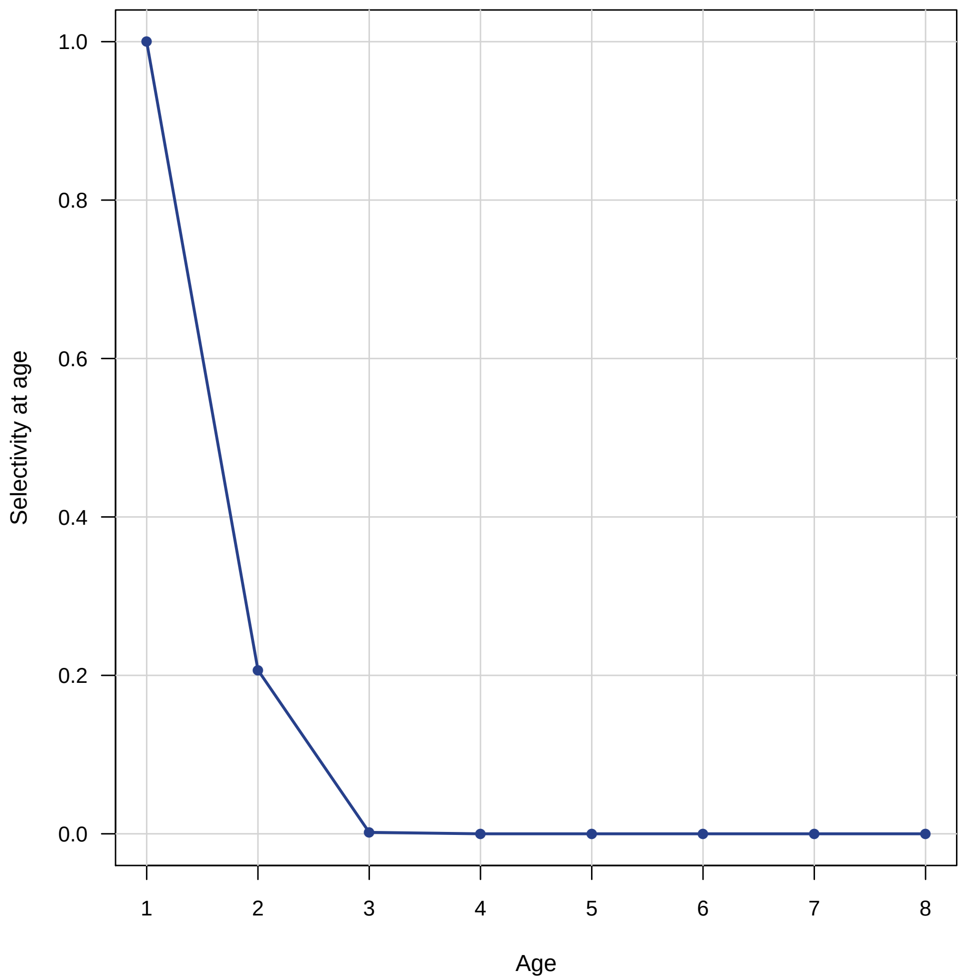


*Figure 20. Average selectivity of landings (top left), discards (top right), and total removals (bottom) from the terminal assessment years, weighted by geometric mean $F$s from the last three assessment years, and used in computation of benchmarks and projections.*

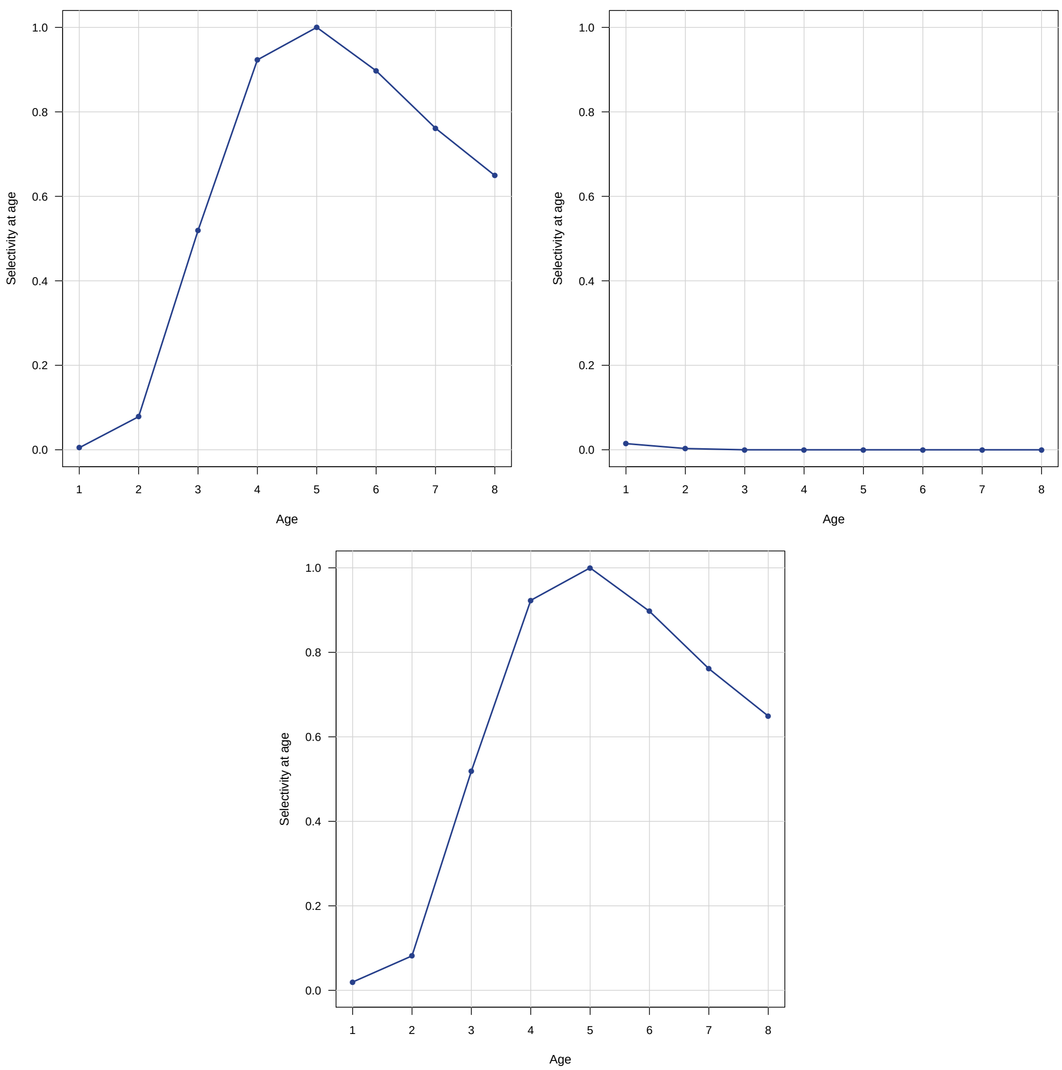


*Figure 21. Estimated fully selected fishing mortality rate (per year) by fleet. cH refers to commercial handlines, HB to headboat, and GR to general recreational. D refers to discards.*

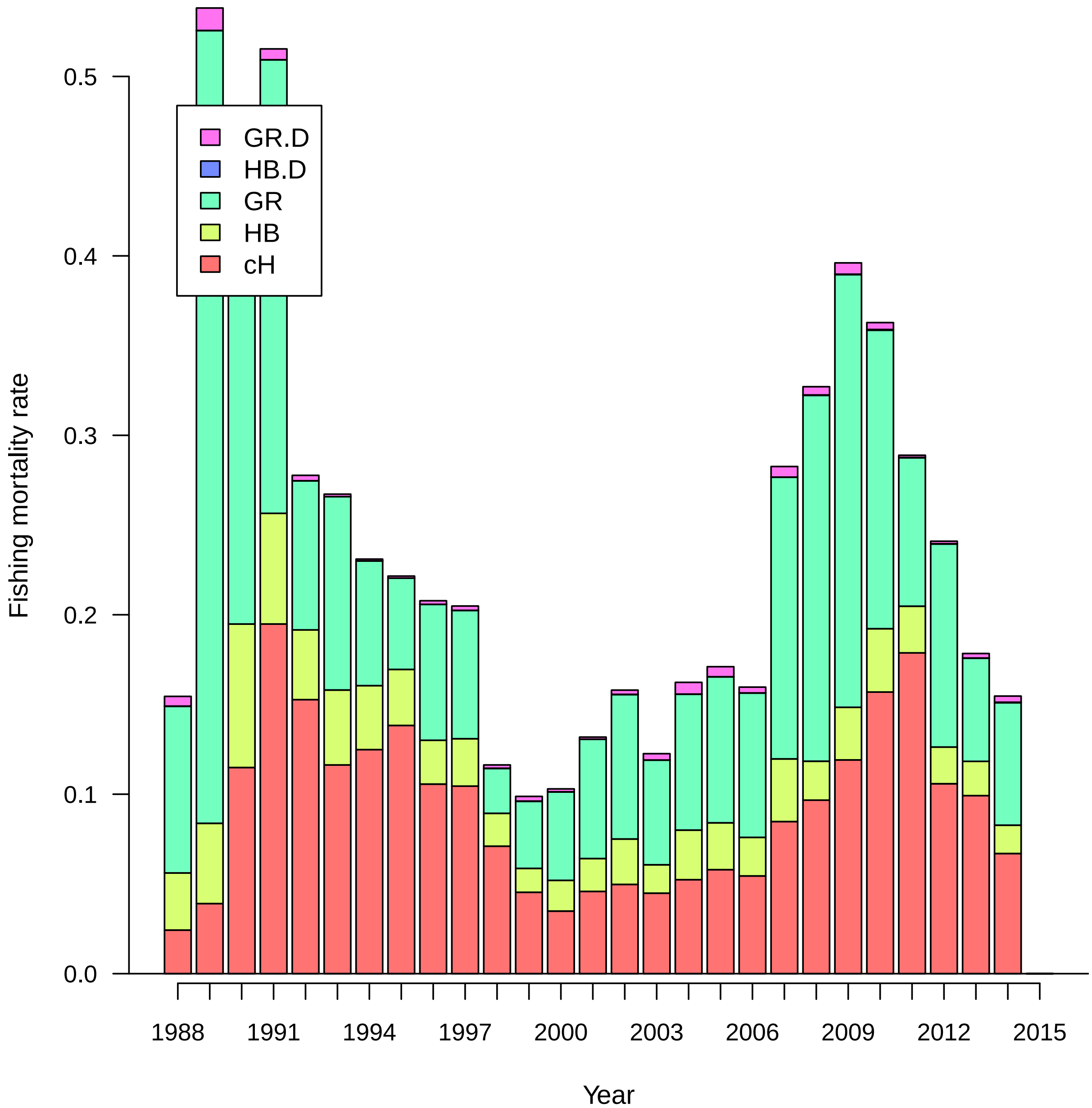


*Figure 22. Estimated landings in numbers by fleet from the catch-age model. cH refers to commercial handlines, HB to headboat, and GR to general recreational.*

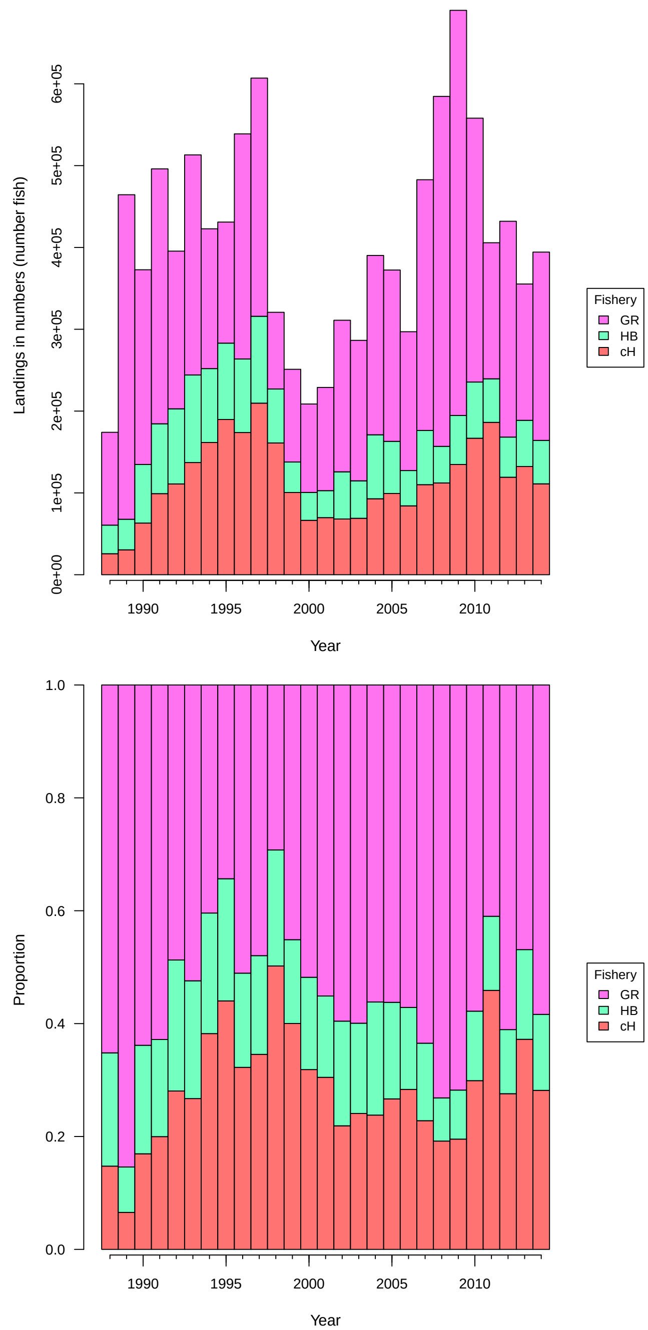


*Figure 23. Estimated landings in whole weight by fleet from the catch-age model. cH refers to commercial handlines, HB to headboat, and GR to general recreational.*

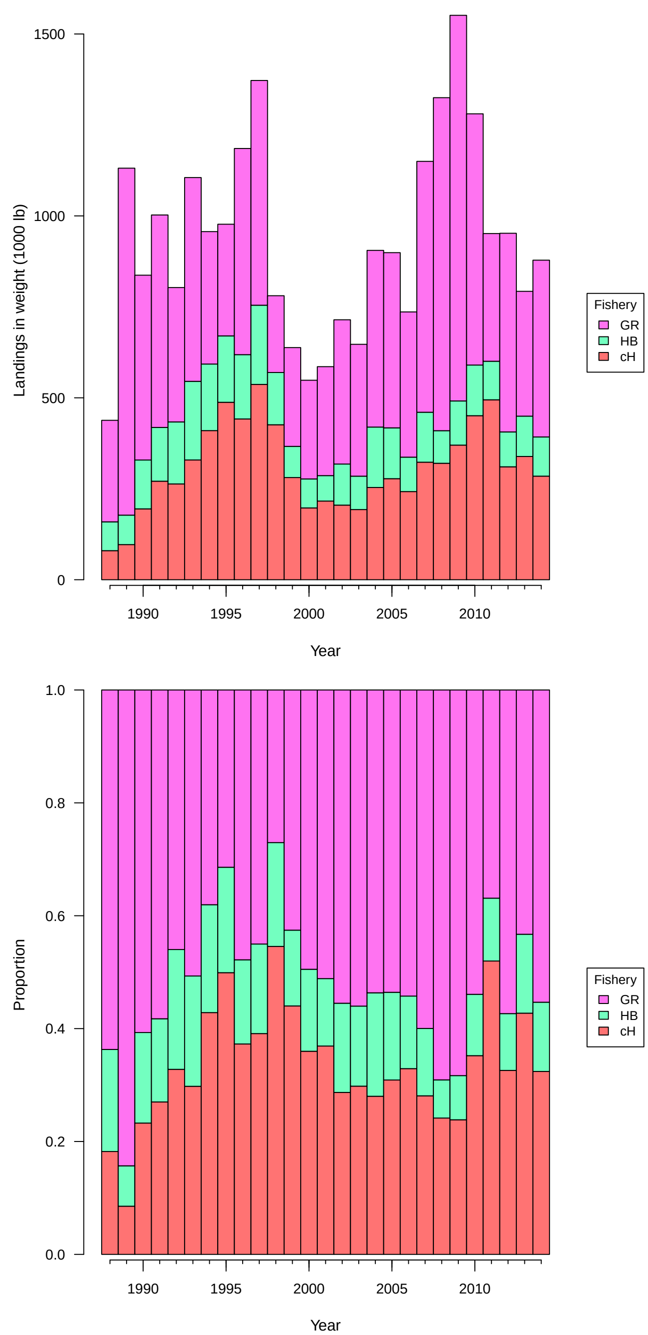


*Figure 24. Top panel: Beverton–Holt spawner-recruit curves, with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Bottom panel: log of recruits (number age-1 fish) per spawner as a function of spawners.*

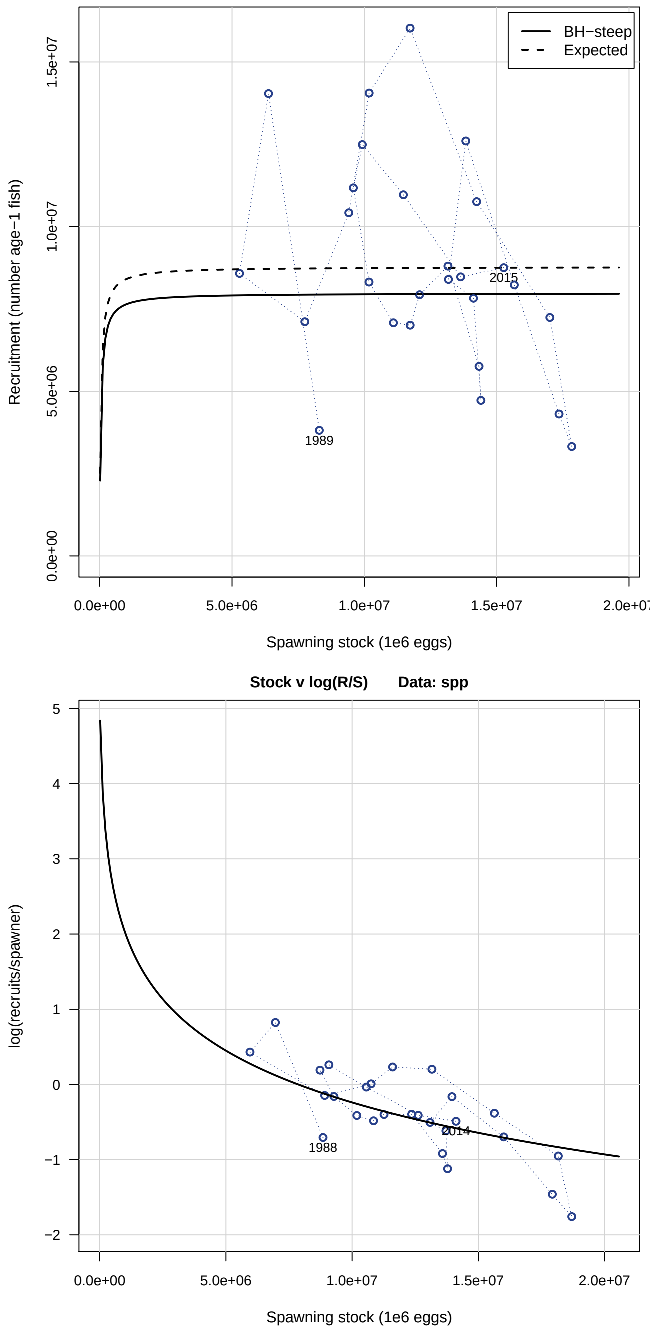


*Figure 25. Probability densities of spawner-recruit quantities R0 (unfished recruitment of age-1 fish), steepness (fixed at $h = 0.99$), unfished spawners per recruit, and standard deviation of recruitment residuals in log space. Solid vertical lines represent point estimates or values from the base run of the Beaufort Assessment Model; dashed vertical lines represent medians from the MCB runs.*

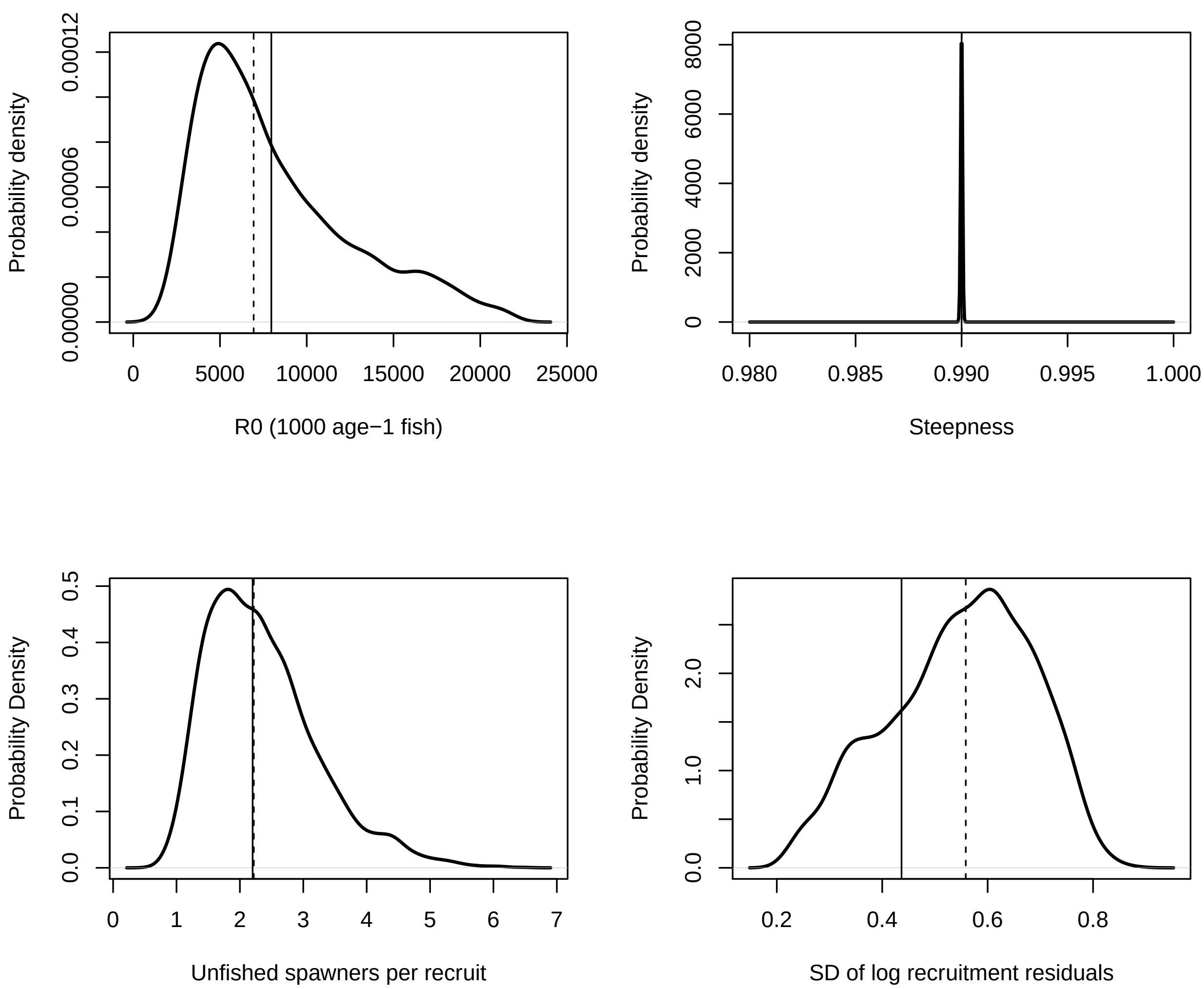


*Figure 26. Yield per recruit (lb) based on average selectivity from the end of the assessment period.*

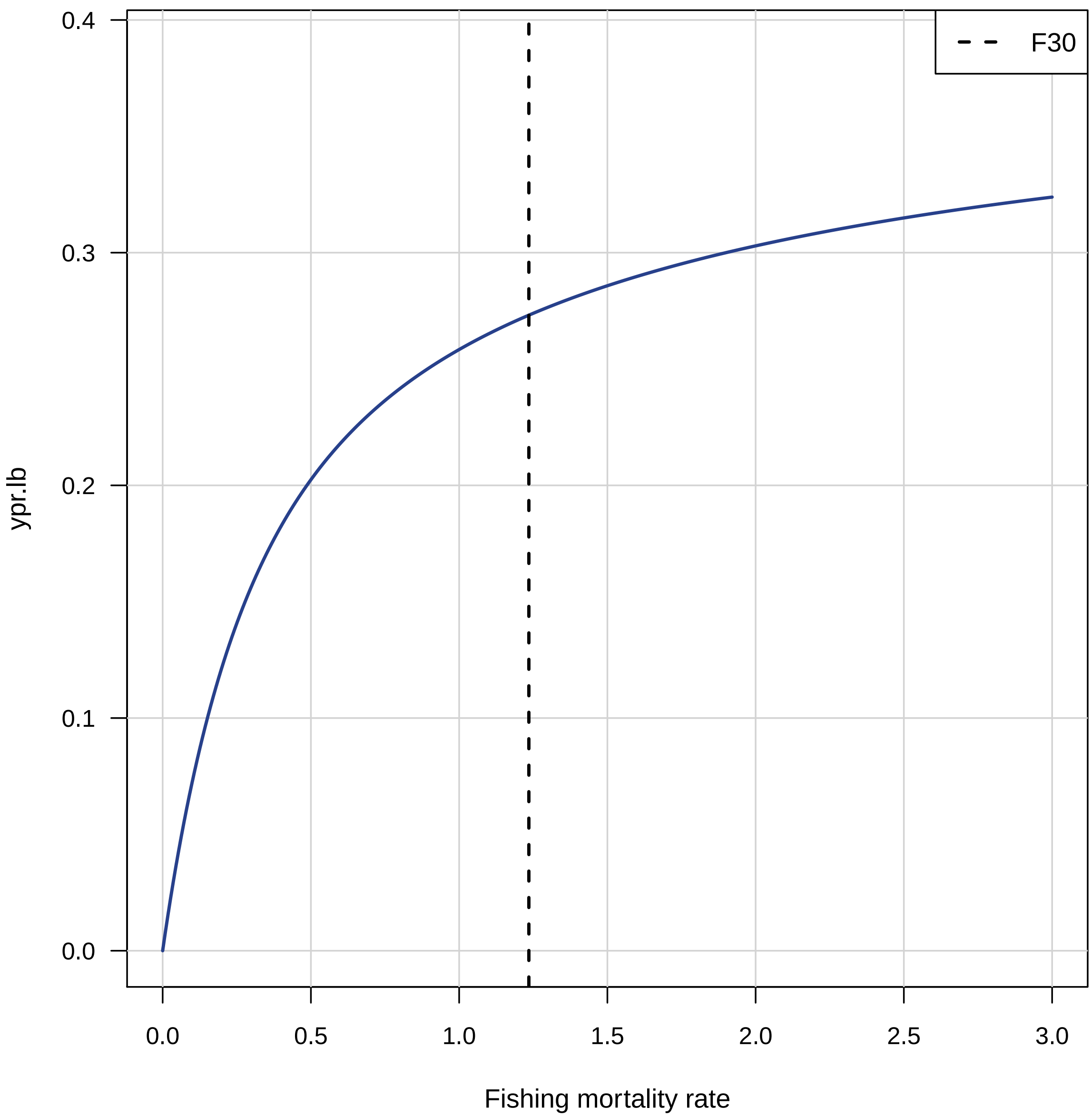


*Figure 27. Spawning potential ratio (spawning biomass per recruit relative to that at the unfished level), from which the X% level of SPR provides $F_{X\%}$. SPR is based on average selectivity from the end of the assessment period.*

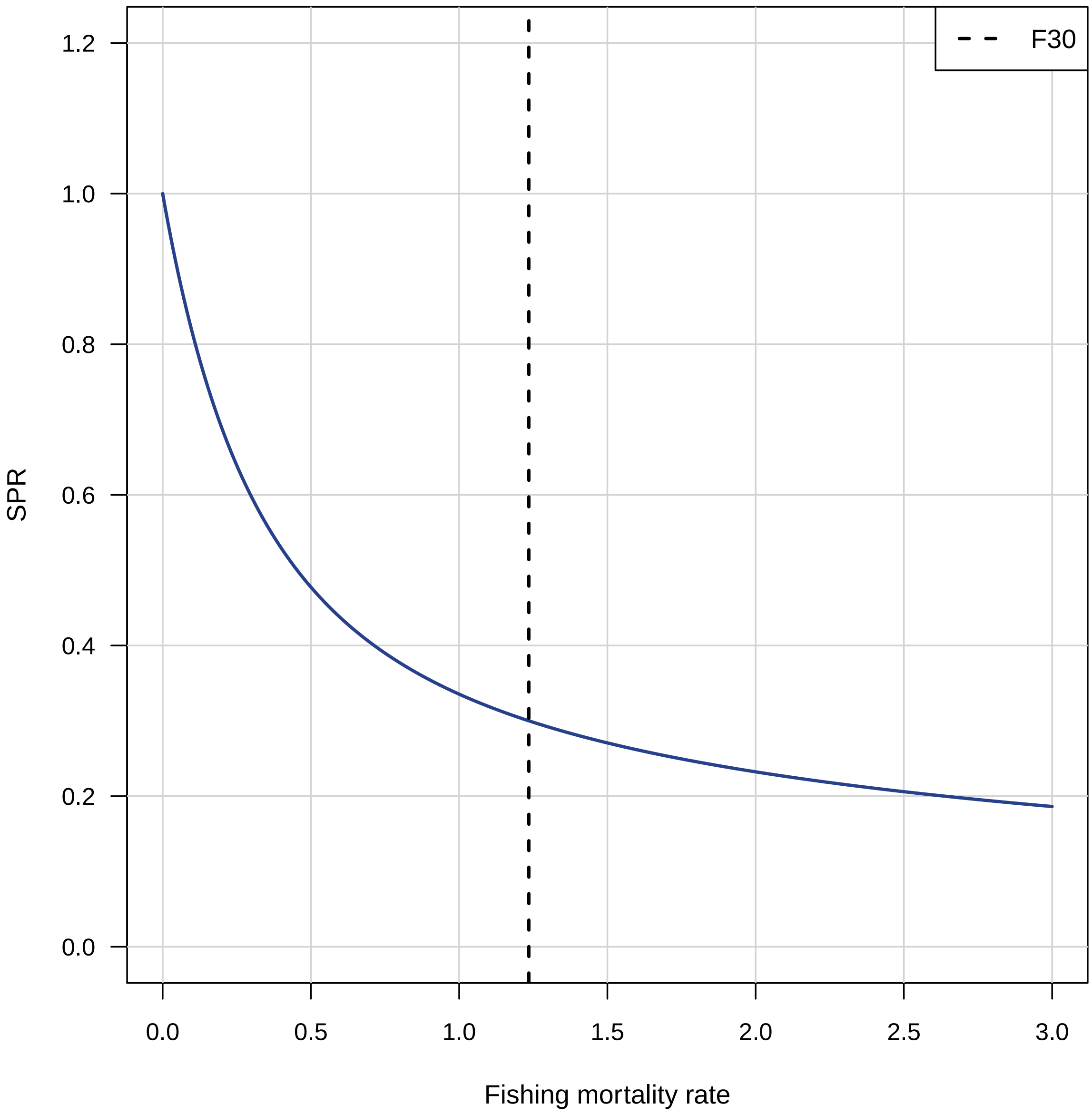


*Figure 28. Equilibrium spawning biomass based on average selectivity from the end of the assessment period.*

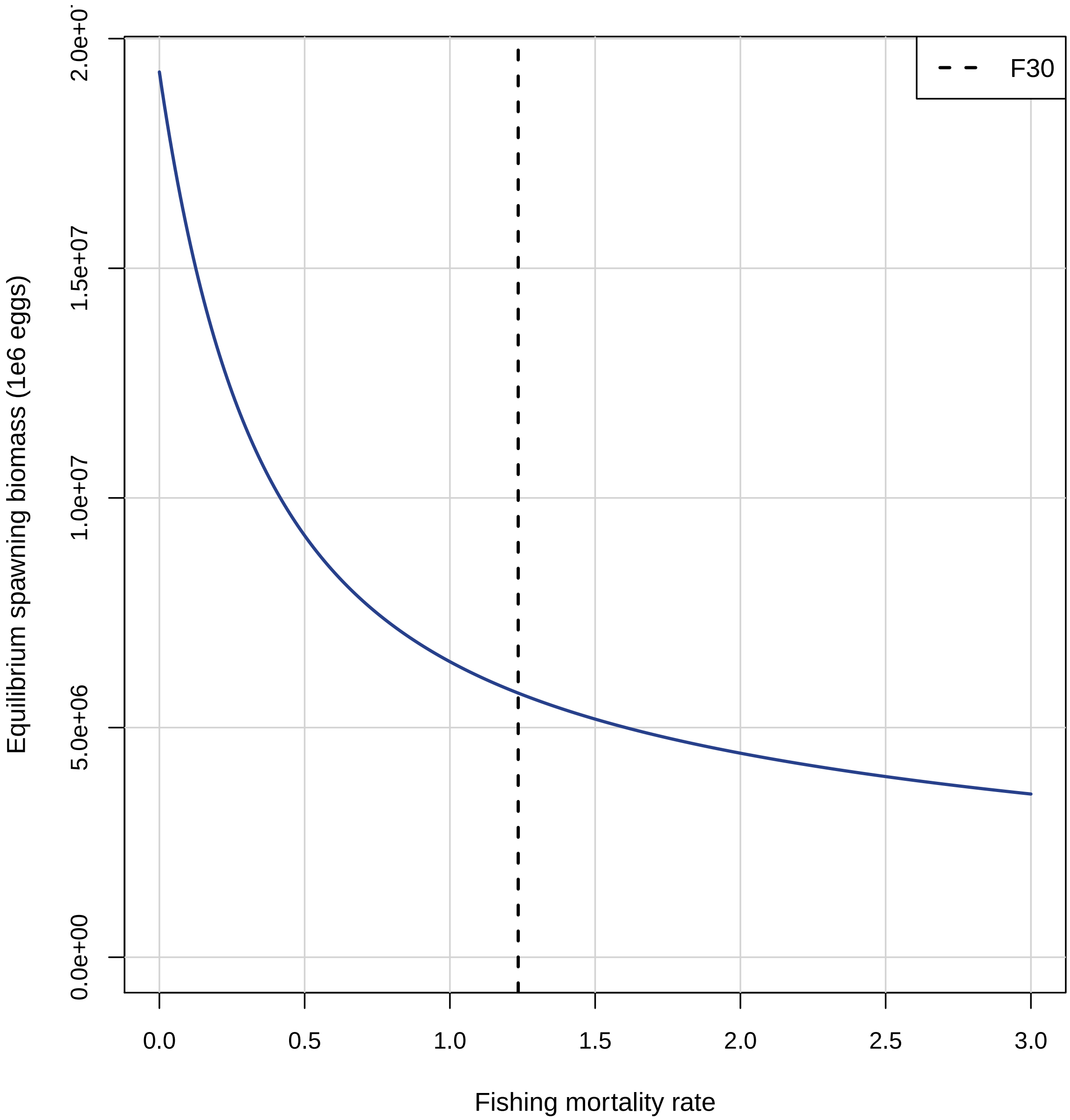


*Figure 29. Probability densities of $F_{30\%}$-related benchmarks from MCB analysis of the Beaufort Assessment Model. Solid vertical lines represent point estimates from the base run; dashed vertical lines represent median values.*

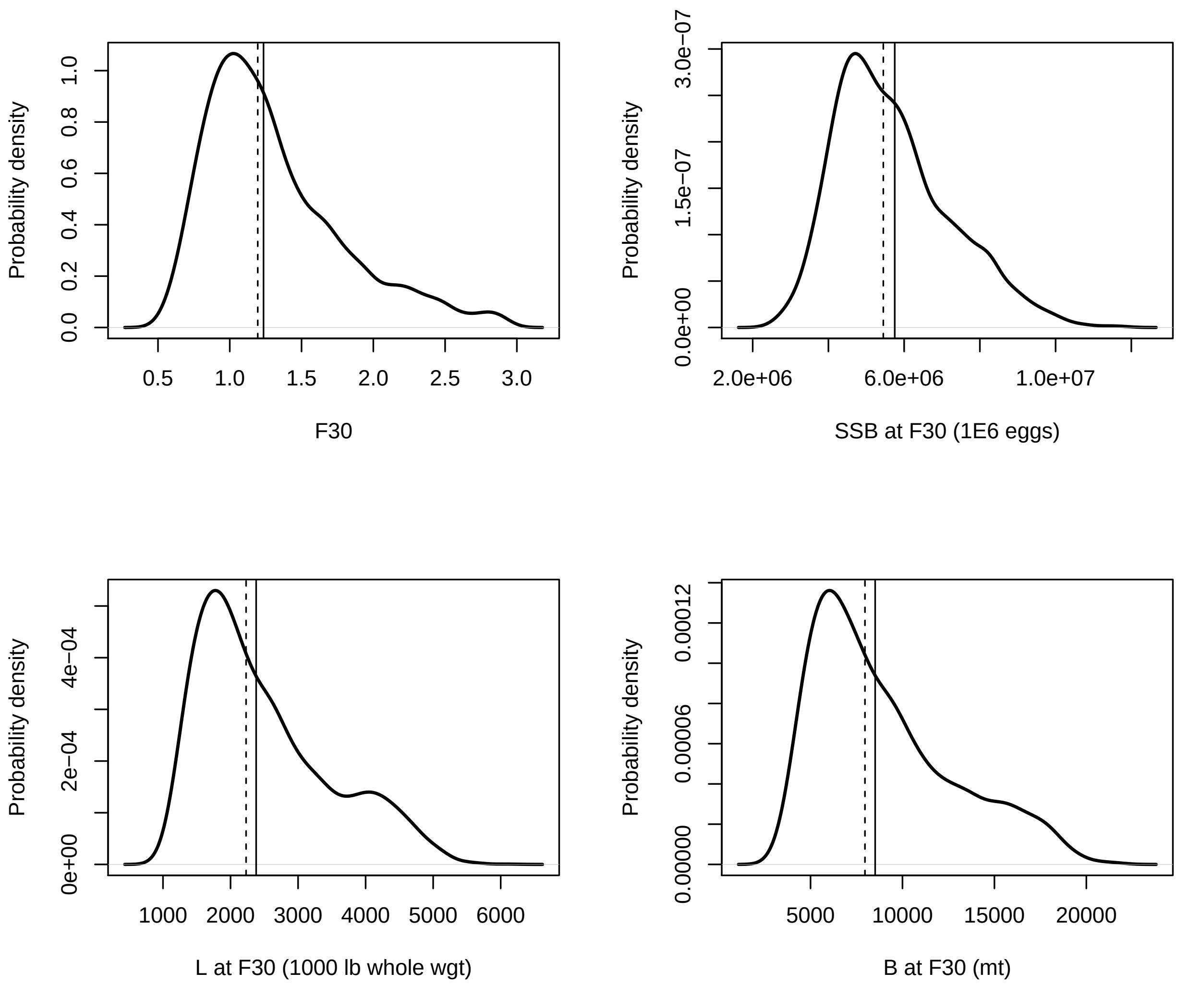


*Figure 30. Estimated time series relative to benchmarks. Solid line indicates estimates from base run of the Beaufort Assessment Model; dashed lines represent median values; gray error bands indicate* $5^{th}$ *and* $95^{th}$ *percentiles of the MCB trials. Top panel: spawning biomass relative to the minimum stock size threshold (*MSST*). Middle panel: spawning biomass relative to* $\mathrm{SSB}_{\mathrm{F30\%}}$*. Bottom panel: F relative to* $F_{30\%}$*.*

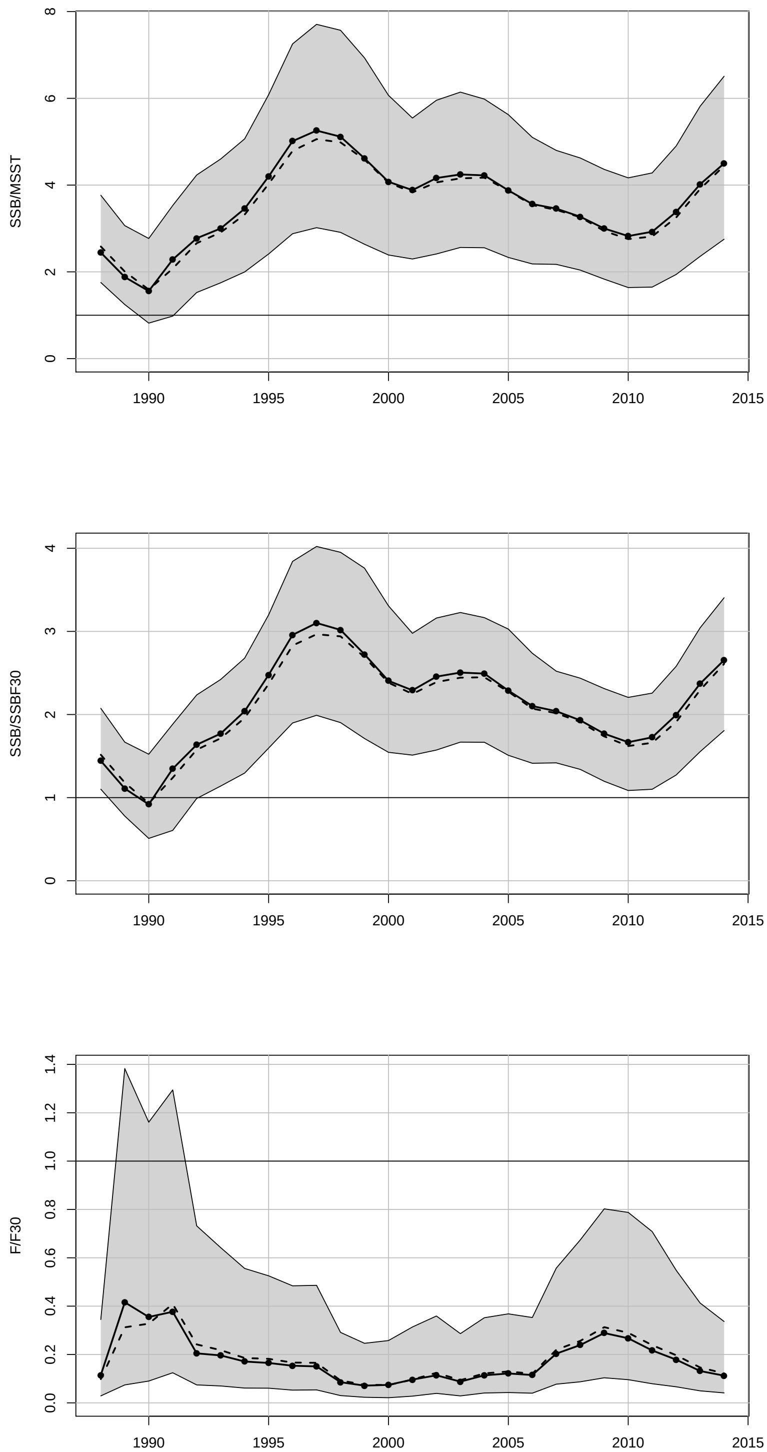
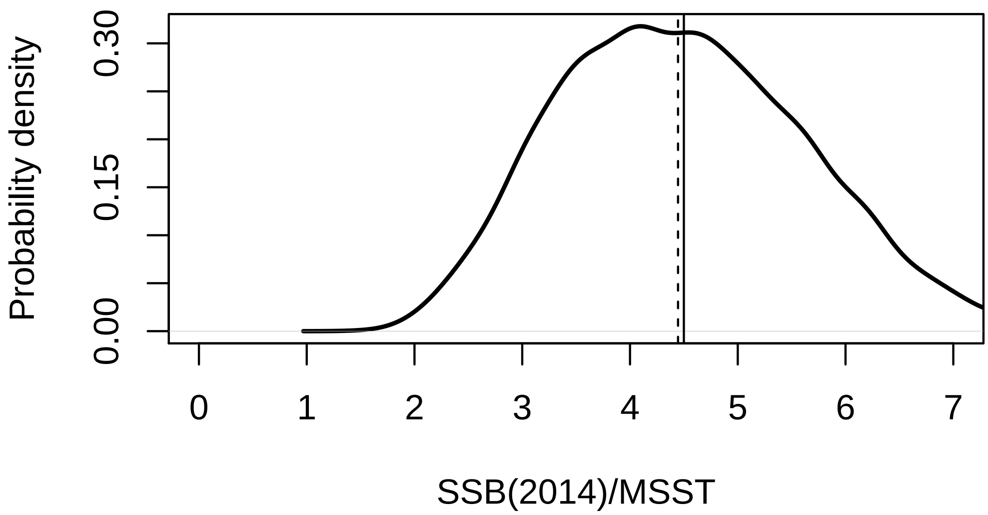


*Figure 31. Probability densities of terminal status estimates from MCB analysis of the Beaufort Assessment Model. Solid vertical lines represent point estimates from the base run; dashed vertical lines represent median values.*



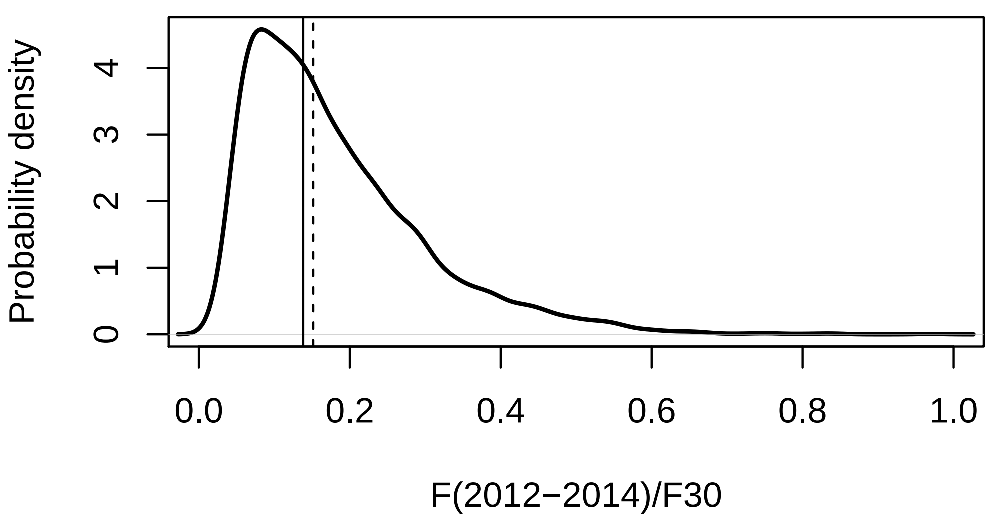



*Figure 32. Phase plots of terminal status estimates from MCB analysis of the Beaufort Assessment Model. The intersection of crosshairs indicates estimates from the base run; lengths of crosshairs defined by $5^{th}$ and $95^{th}$ percentiles. Proportion of runs falling in each quadrant indicated.*

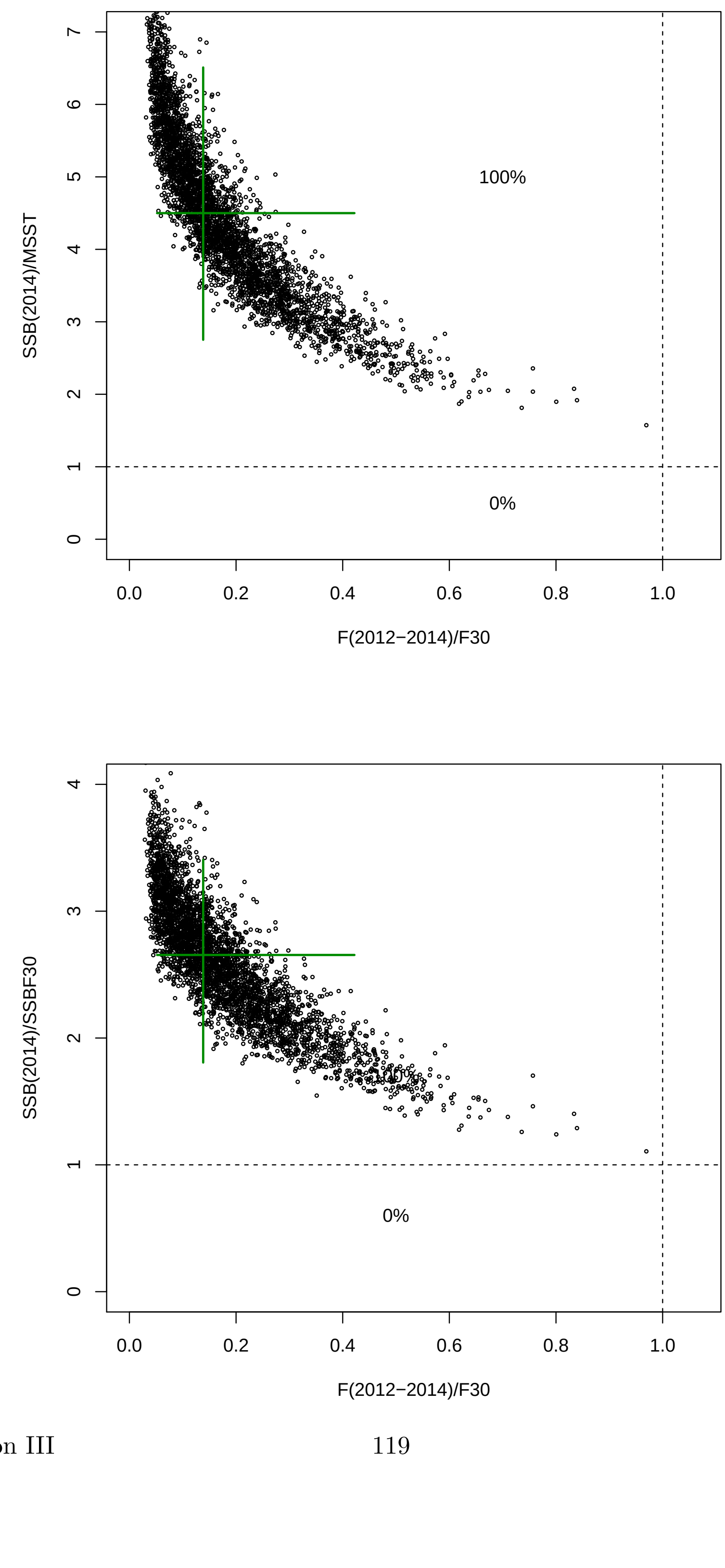


*Figure 33. Sensitivity to natural mortality (sensitivity runs S1–S5). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $SSB_{F30\%}$. *Any lines not visible overlap results of the base run.*

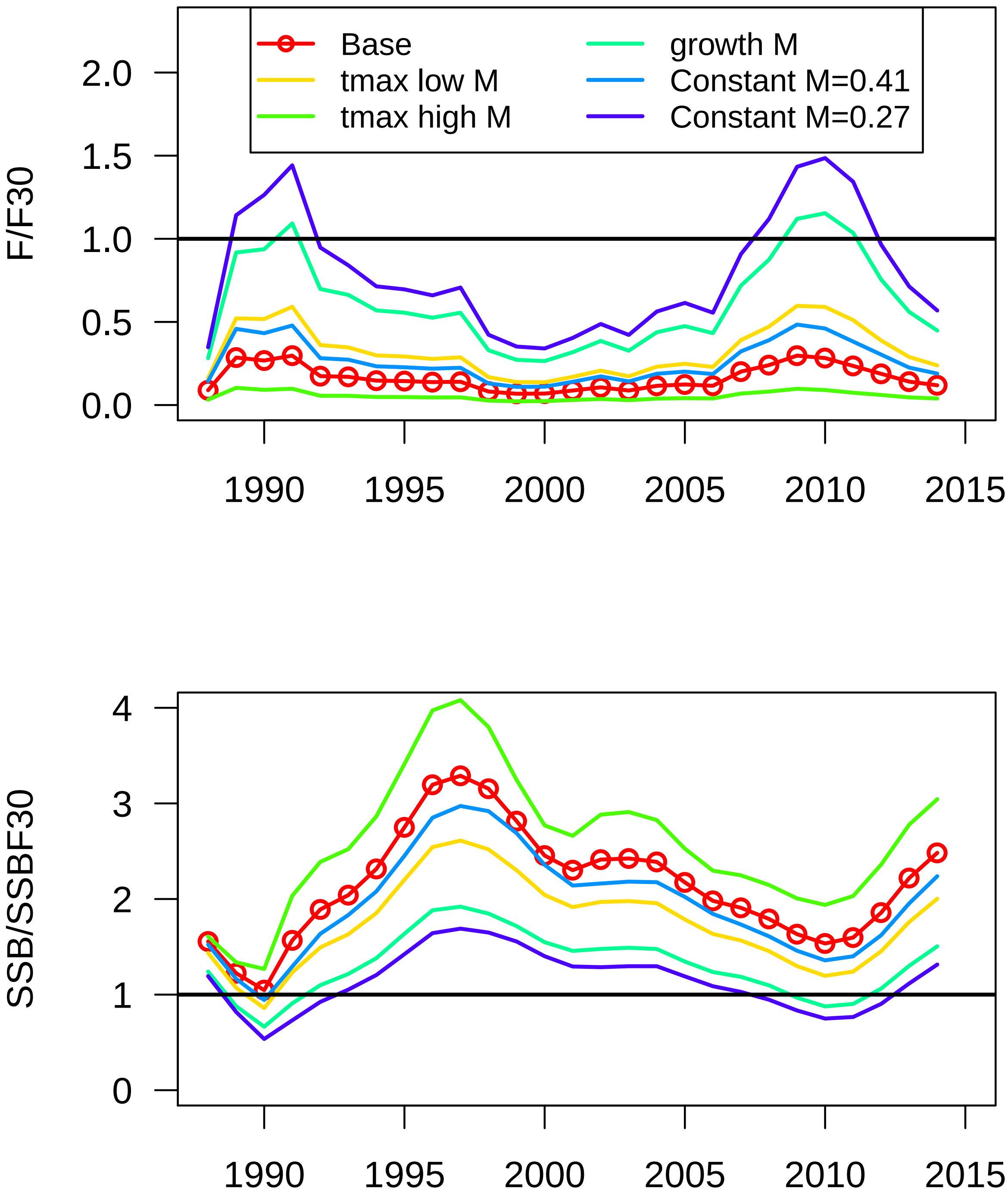
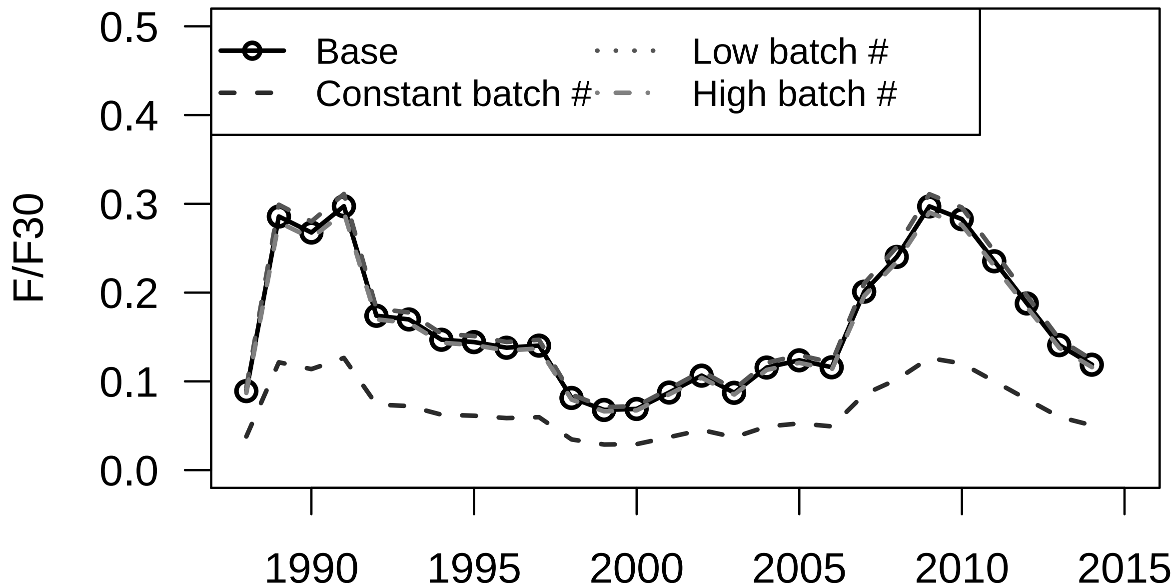


*Figure 34. Sensitivity to batch number (sensitivity runs S6–S8). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$. *Any lines not visible overlap results of the base run.*



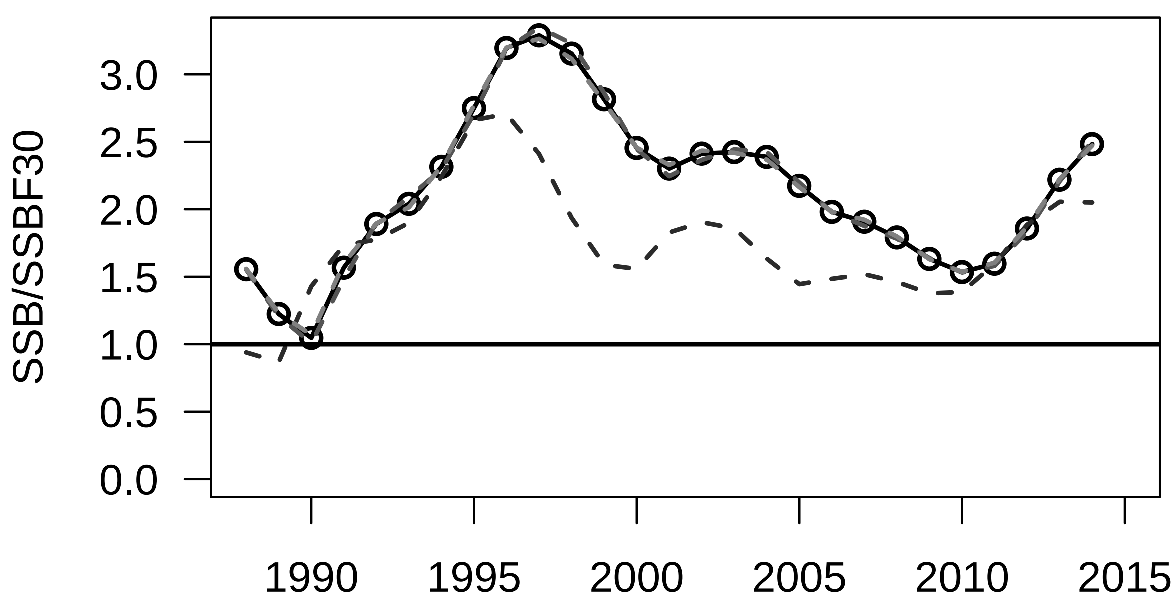



*Figure 35. Sensitivity to stock recruitment function (sensitivity runs S9–S11). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$. *Any lines not visible overlap results of the base run.*

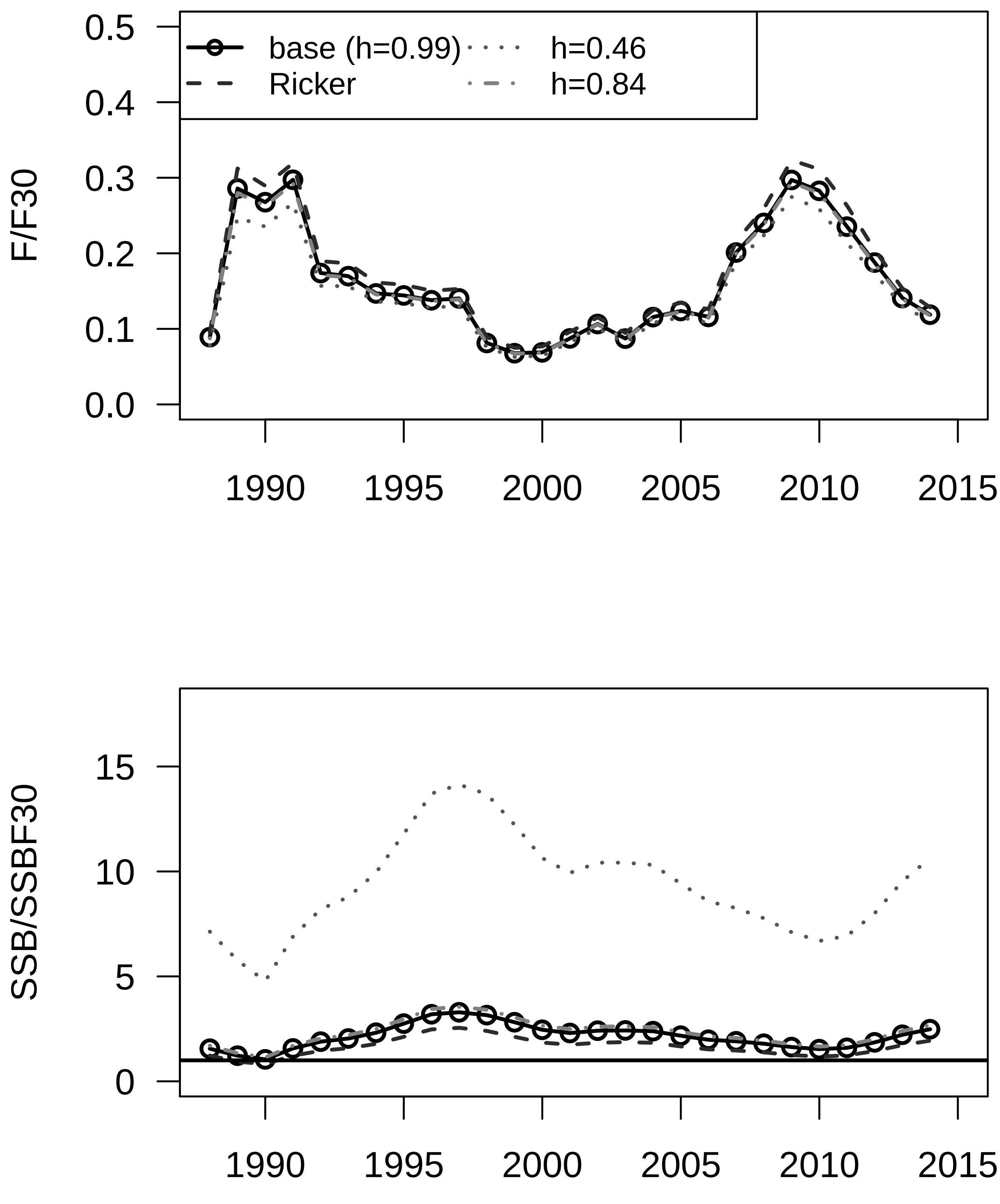


*Figure 36. Sensitivity to period over which recruitment deviations estimated (sensitivity run S12–S16). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{F30\%}$. *Any lines not visible overlap results of the base run.*

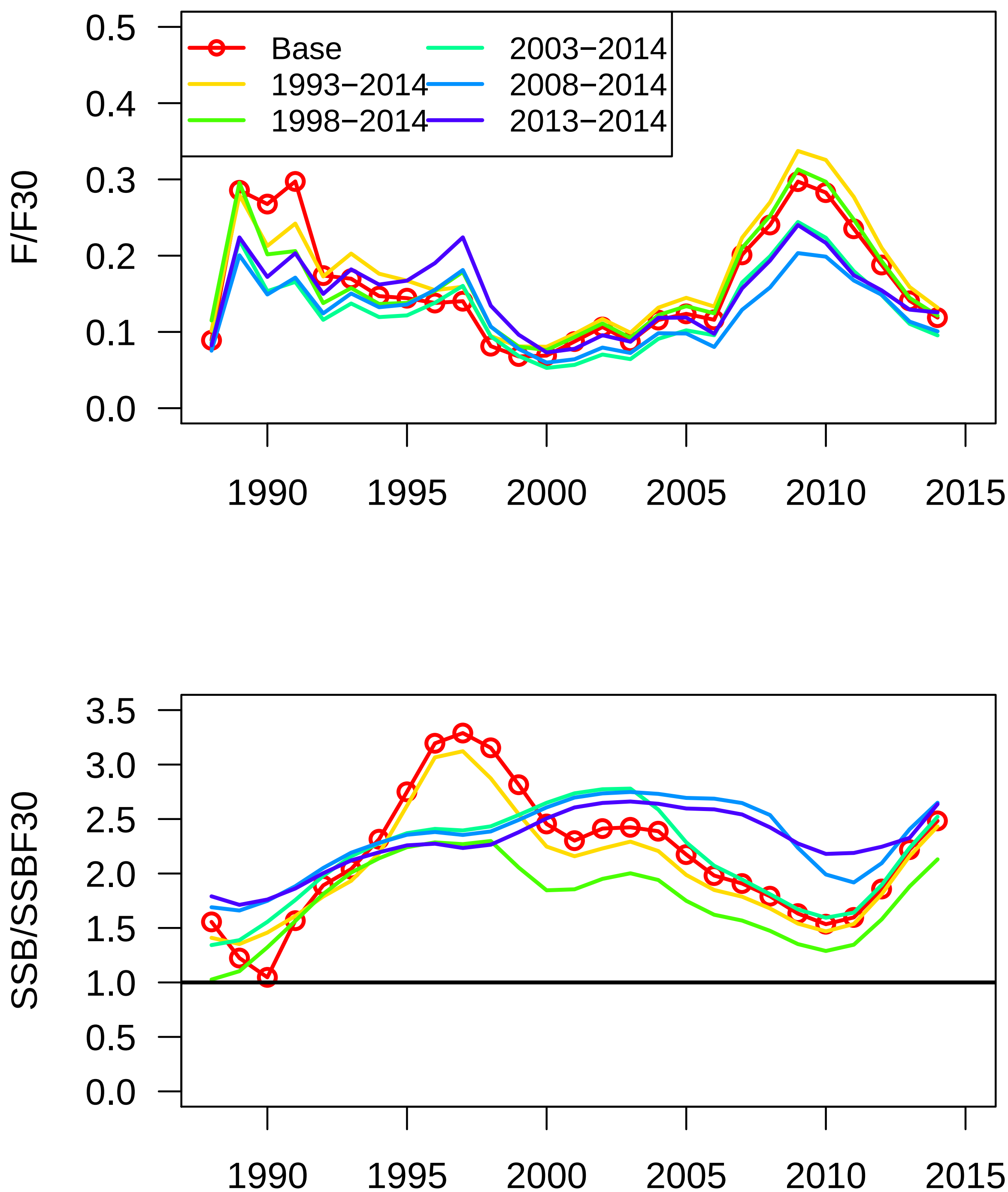


*Figure 37. Sensitivity to discard mortality (sensitivity run S17–S18). Top panel: Ratio of F to* $F_{30\%}$*. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{F30\%}$*. Any lines not visible overlap results of the base run.*

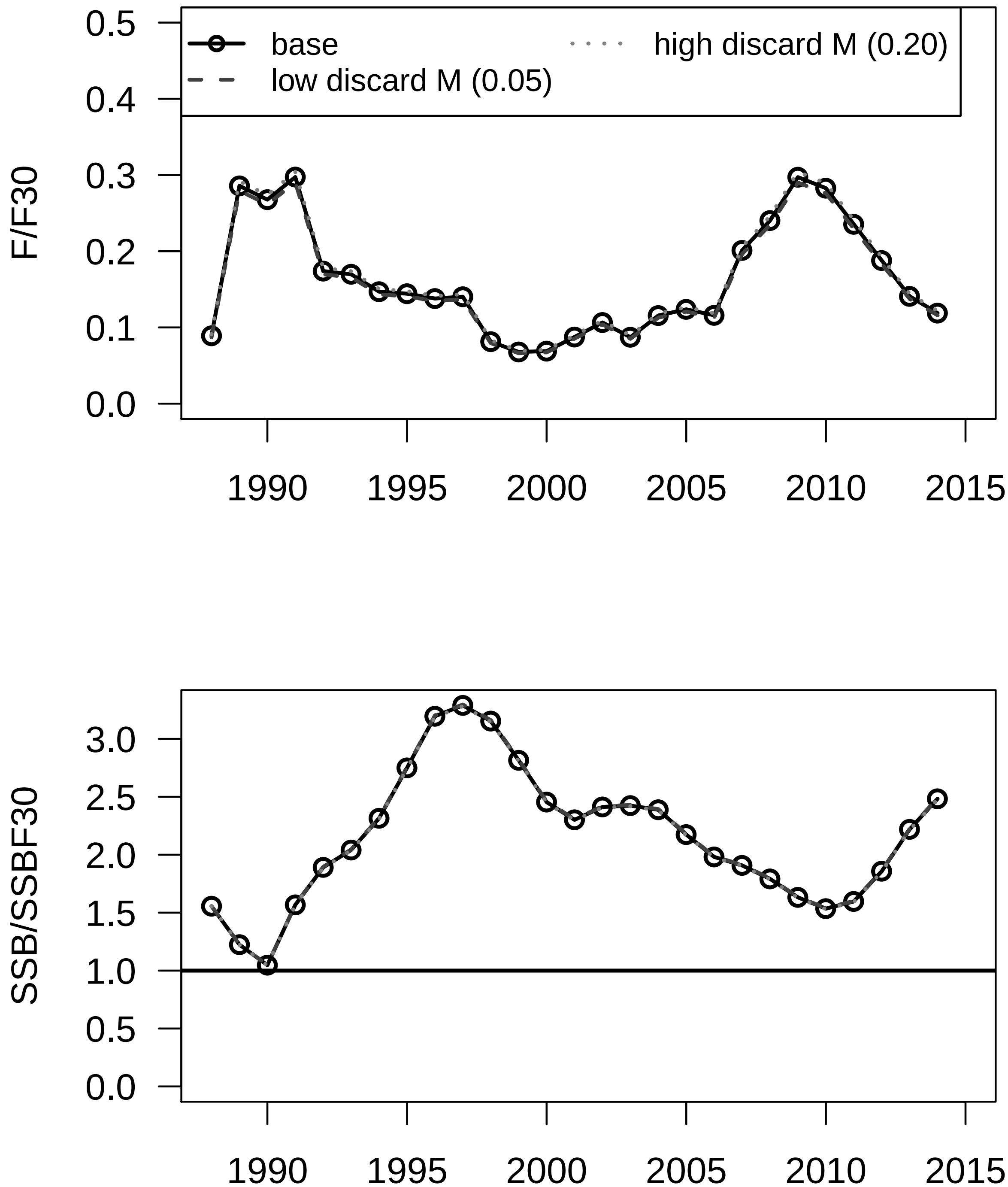


*Figure 38. Sensitivity to initial fishing mortality (sensitivity run S19–S21). Top panel: Ratio of F to* $F_{30\%}$*. Bottom panel: Ratio of* SSB *to* $SSB_{F30\%}$*. Any lines not visible overlap results of the base run.*

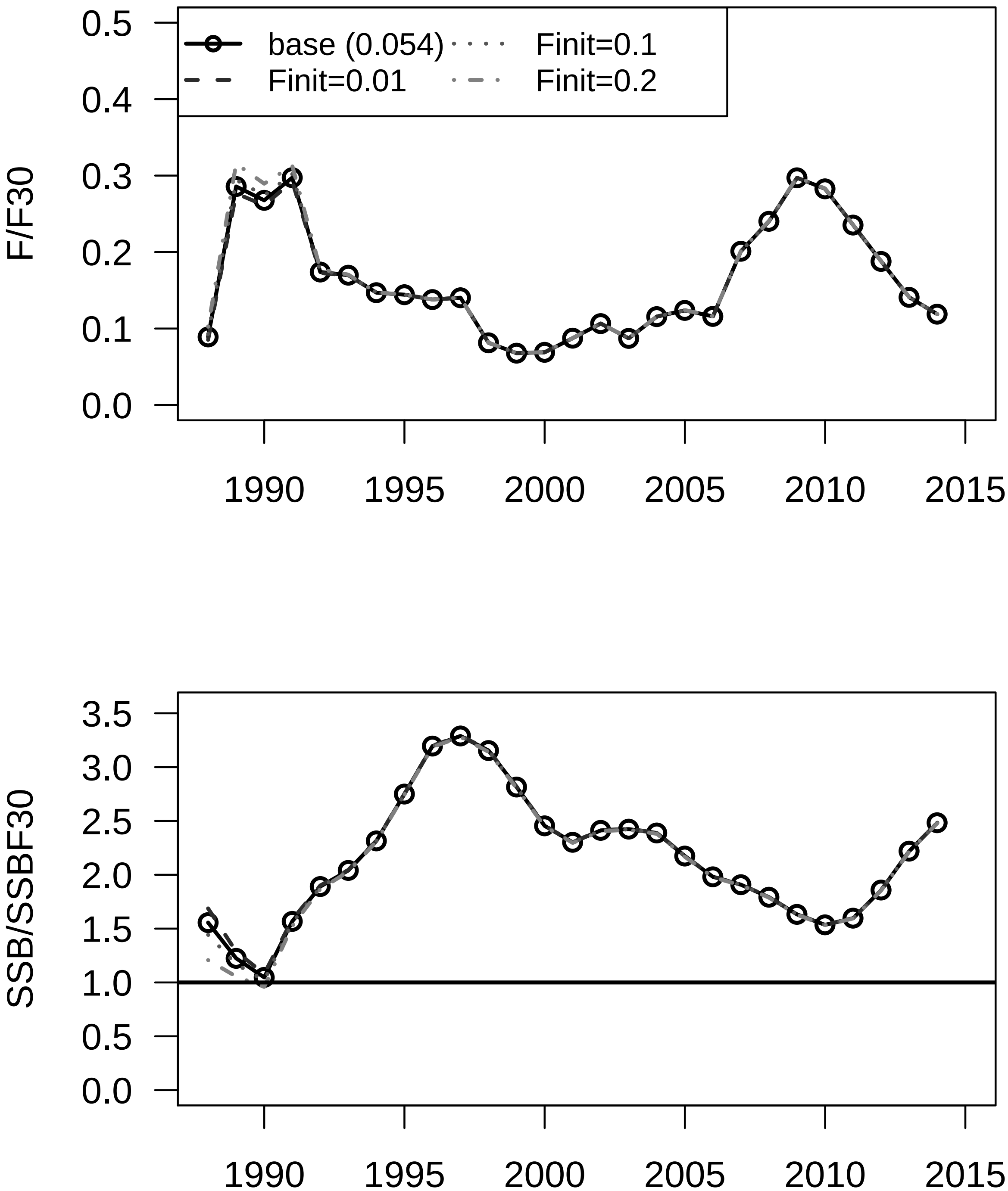


*Figure 39. Sensitivity to random walk catchability (sensitivity run S22). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{F30\%}$. *Any lines not visible overlap results of the base run.*

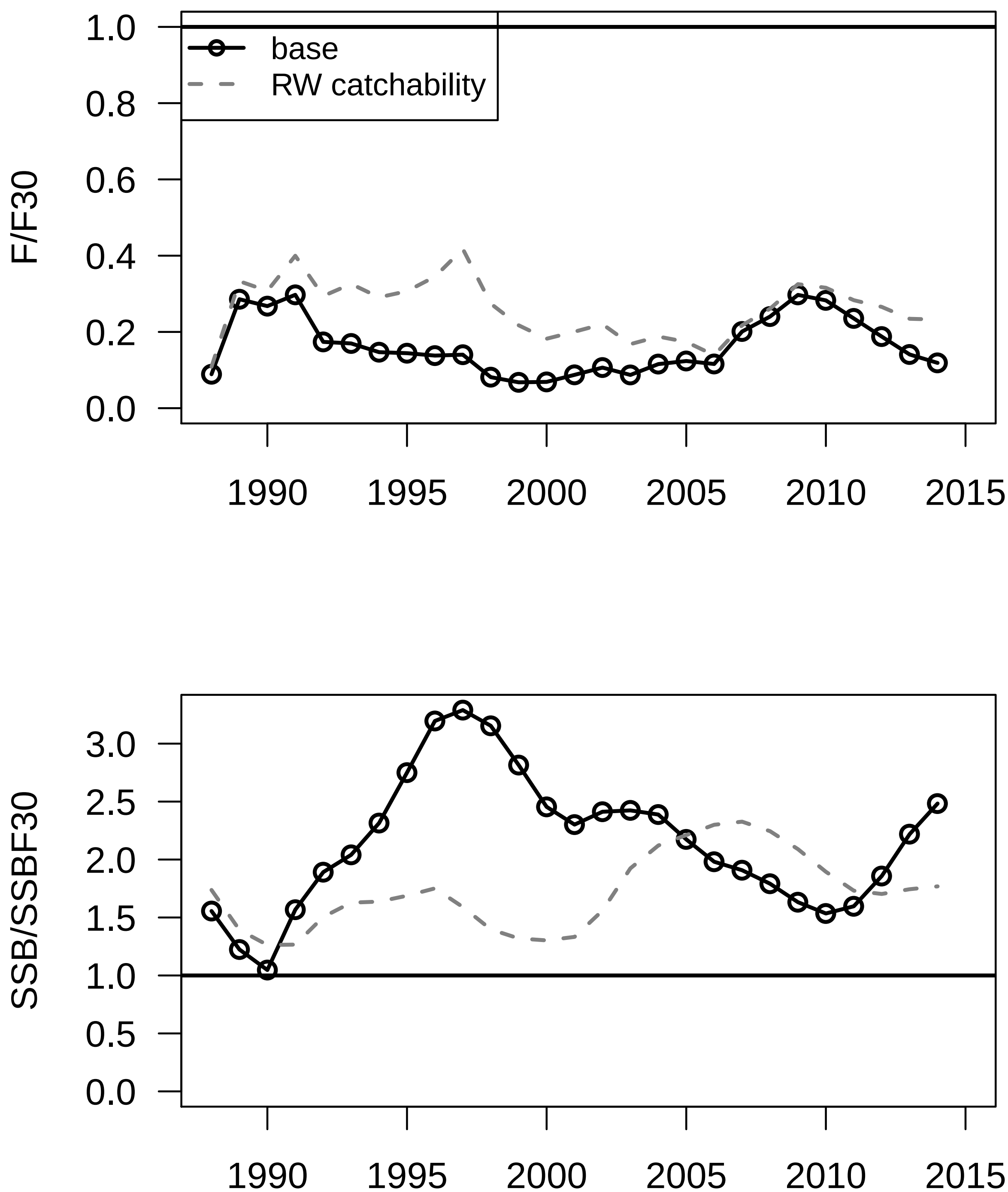


*Figure 40. Sensitivity to form of selectivity functions (sensitivity run S23–S25). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB to $SSB_{F30\%}$. Any lines not visible overlap results of the base run.*

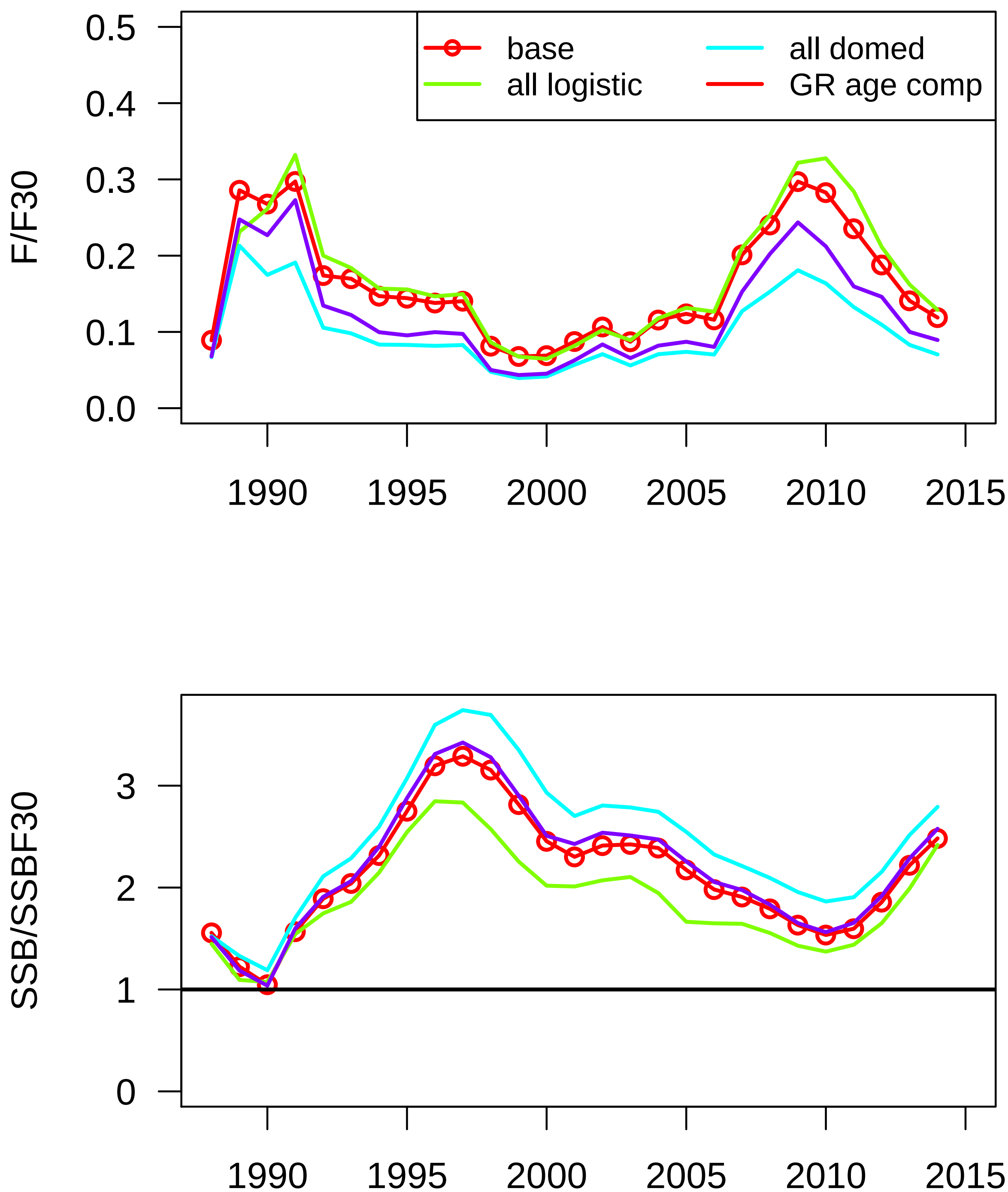


*Figure 41. Sensitivity to selectivity blocking (sensitivity run S26–S28). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{F30\%}$. *Any lines not visible overlap results of the base run.*

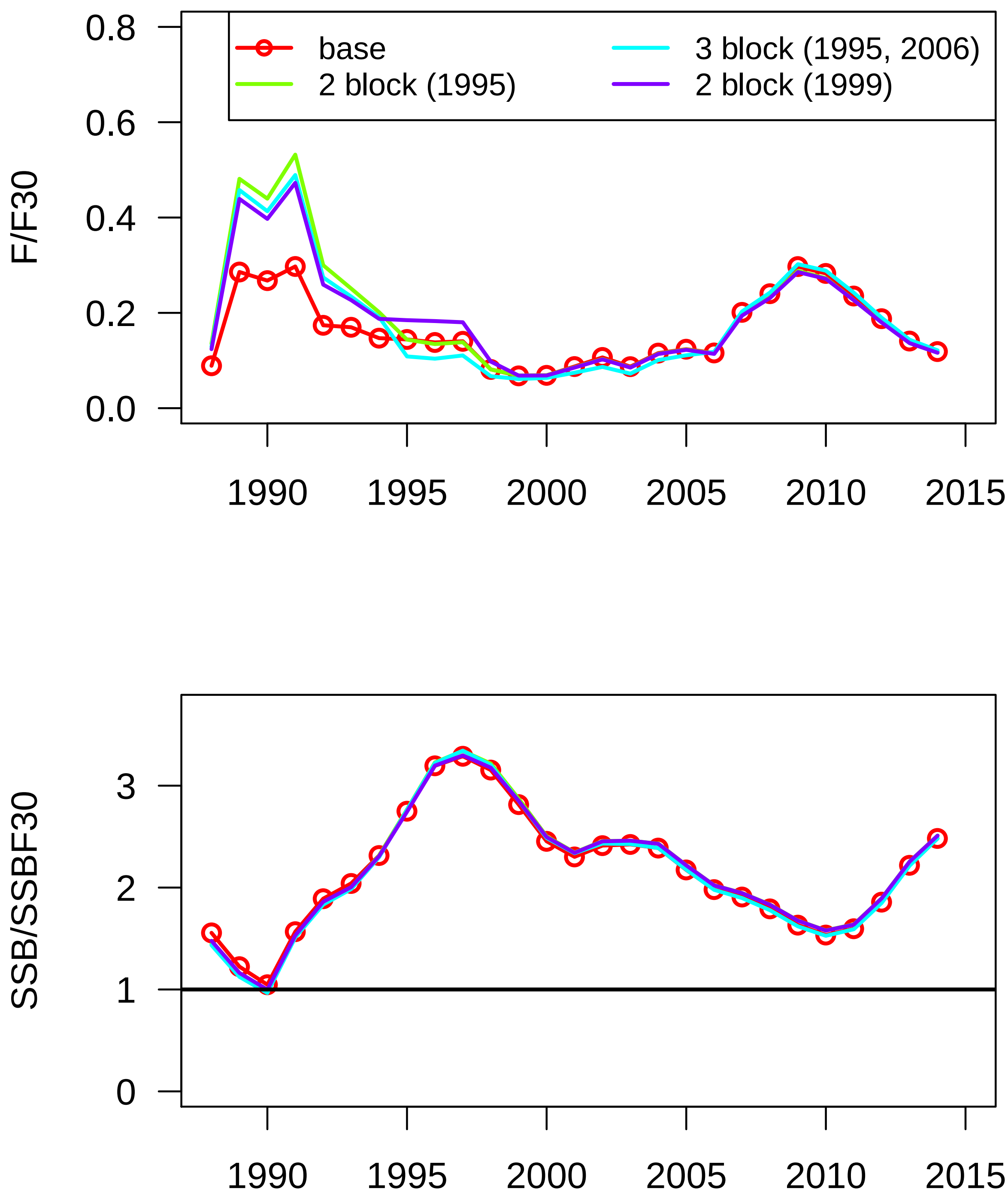
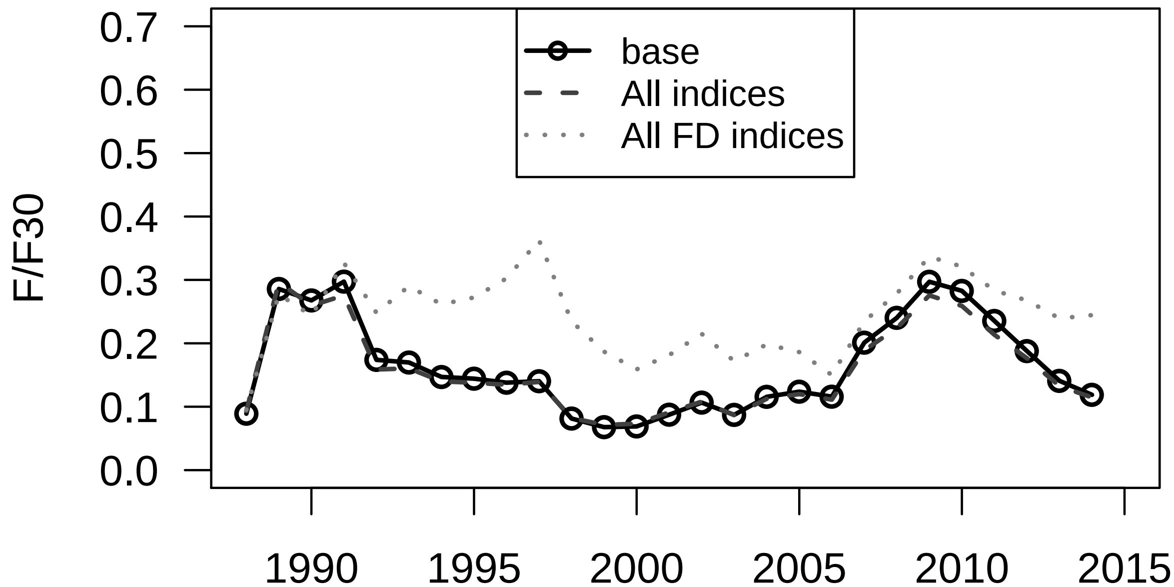


*Figure 42. Sensitivity to fishery independent and dependent indices (sensitivity run S29–S30). Top panel: Ratio of $F$ to $F_{30\%}$. Bottom panel: Ratio of SSB to $\text{SSB}_{\text{F30\%}}$. Any lines not visible overlap results of the base run.*



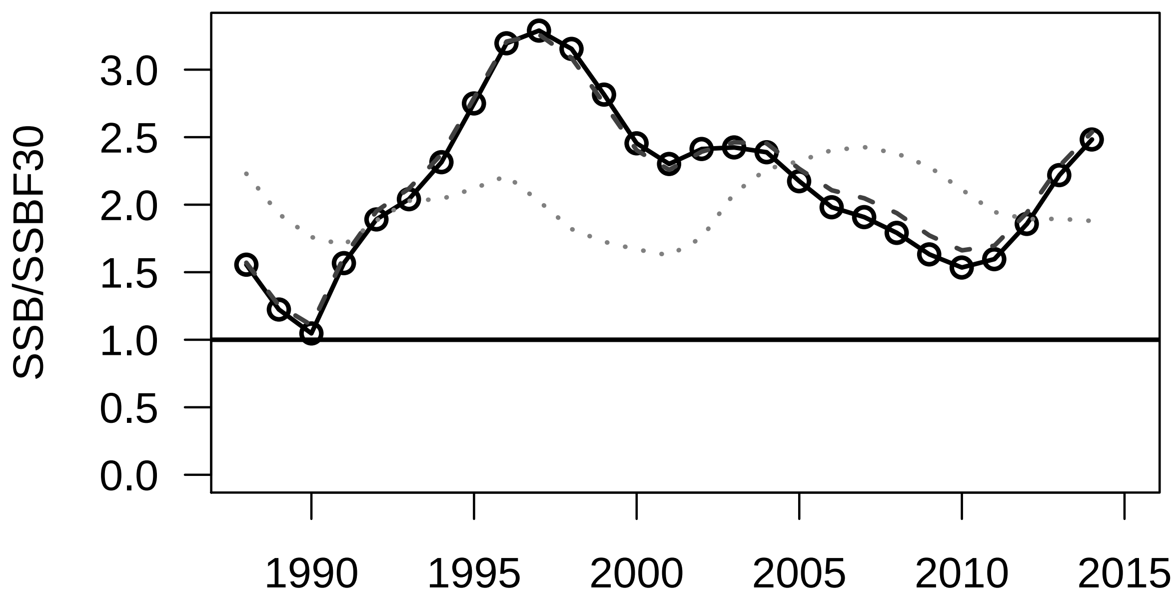



*Figure 43. Sensitivity to combined and separate trap and video indices (sensitivity run S31–S32). Top panel: Ratio of $F$ to $F_{30\%}$. Bottom panel: Ratio of SSB to $\mathrm{SSB}_{F30\%}$. Any lines not visible overlap results of the base run.*

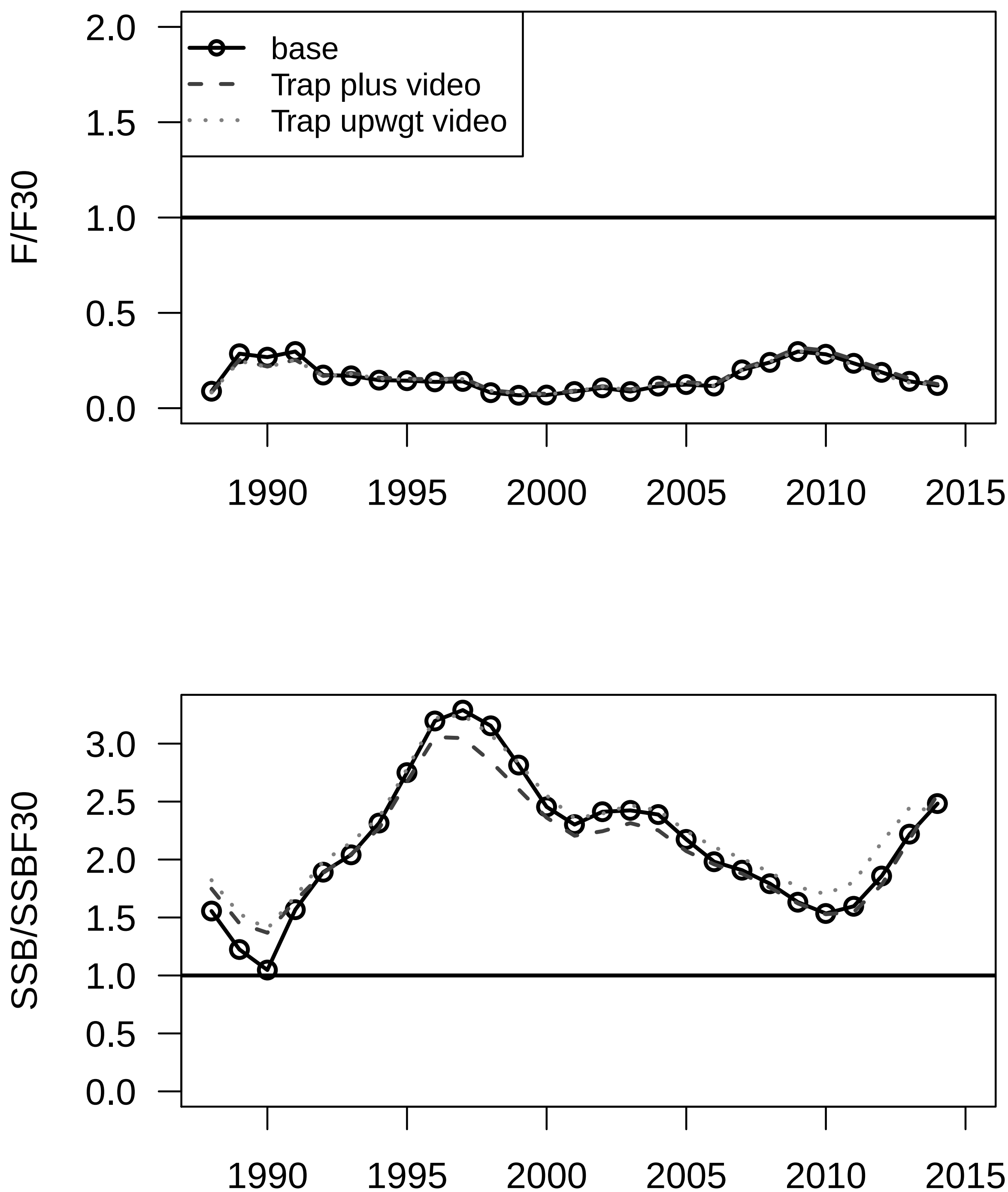


*Figure 44. Sensitivity to likelihood weighting (sensitivity run S33–S38). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{F30\%}$*. Any lines not visible overlap results of the base run.*

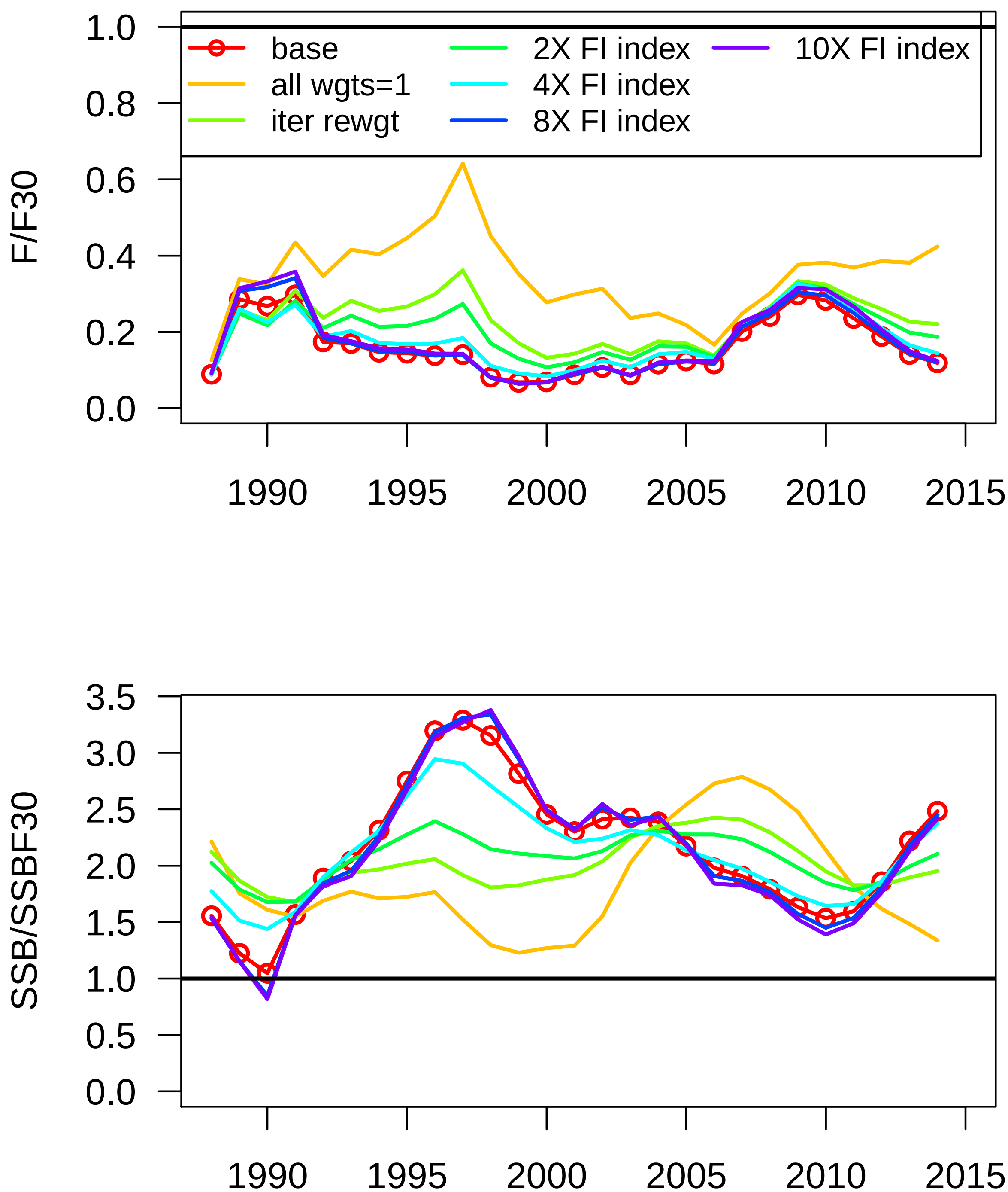
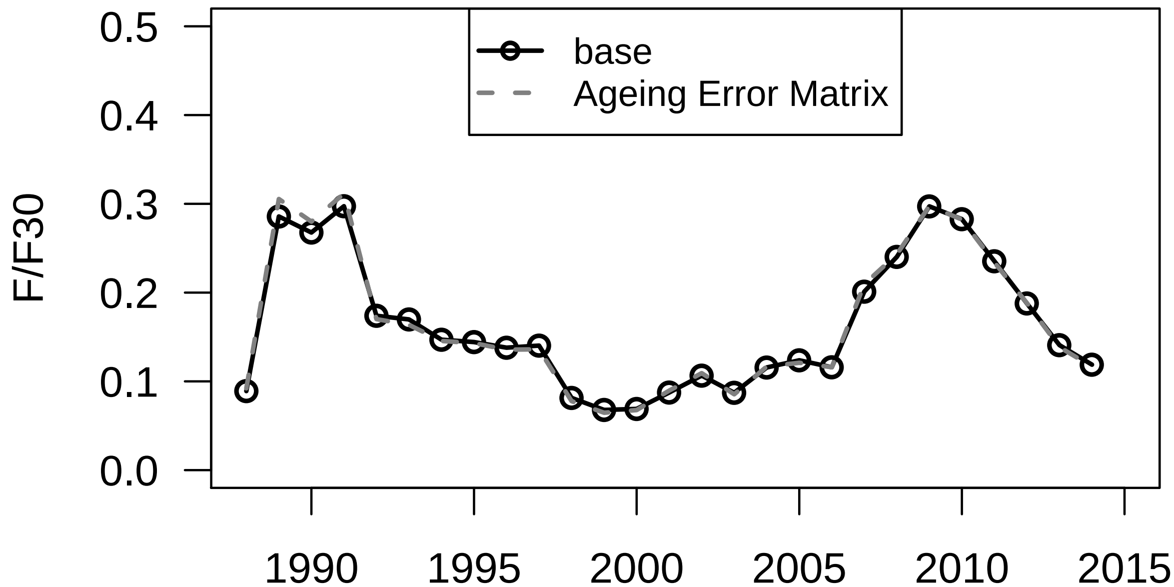


*Figure 45. Sensitivity to aging error matrix (sensitivity run S39). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$*. Any lines not visible overlap results of the base run.*



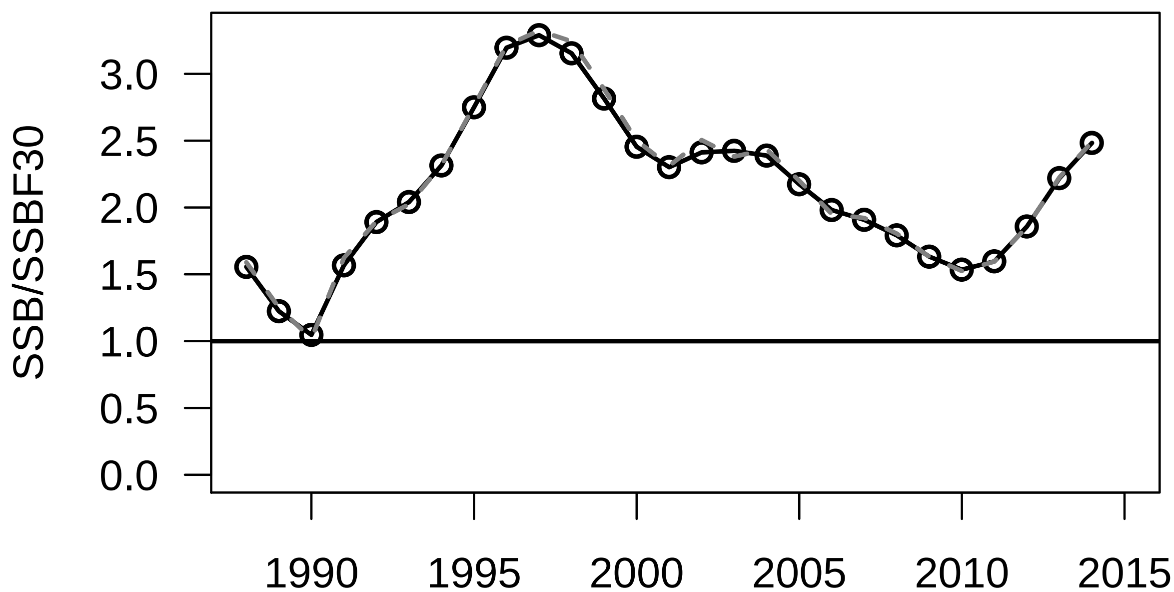



*Figure 46. Phase plot of terminal status indicators from sensitivity runs of the Beaufort Assessment Model.*

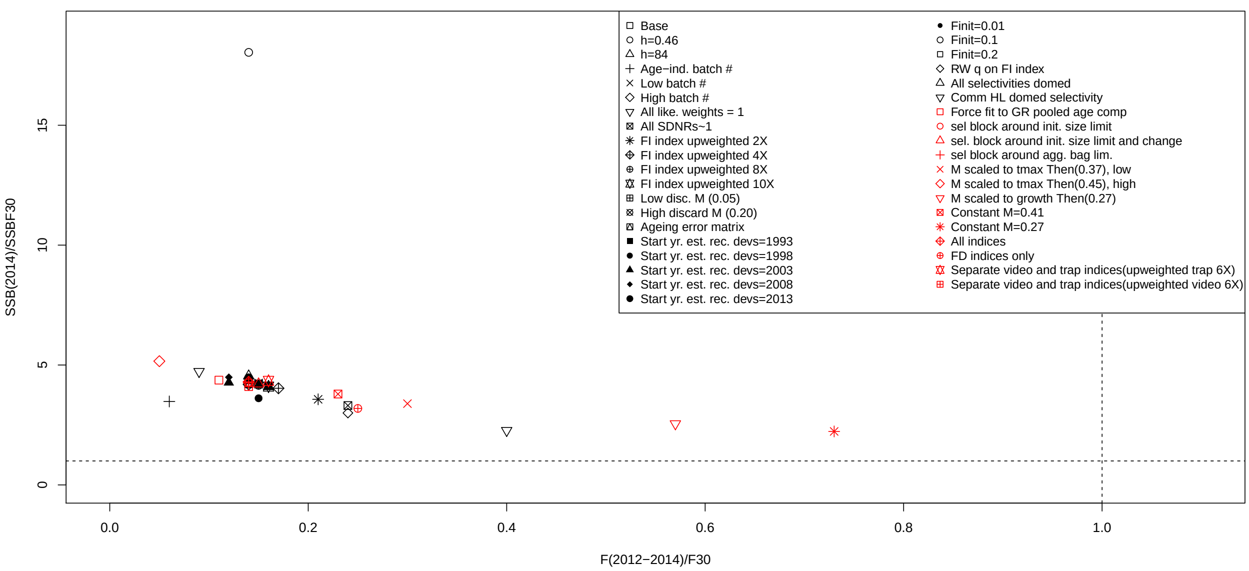


*Figure 47. Retrospective analyses. Sensitivity to terminal year of data. Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{F30\%}$*. Any lines not visible overlap results of the base run.*

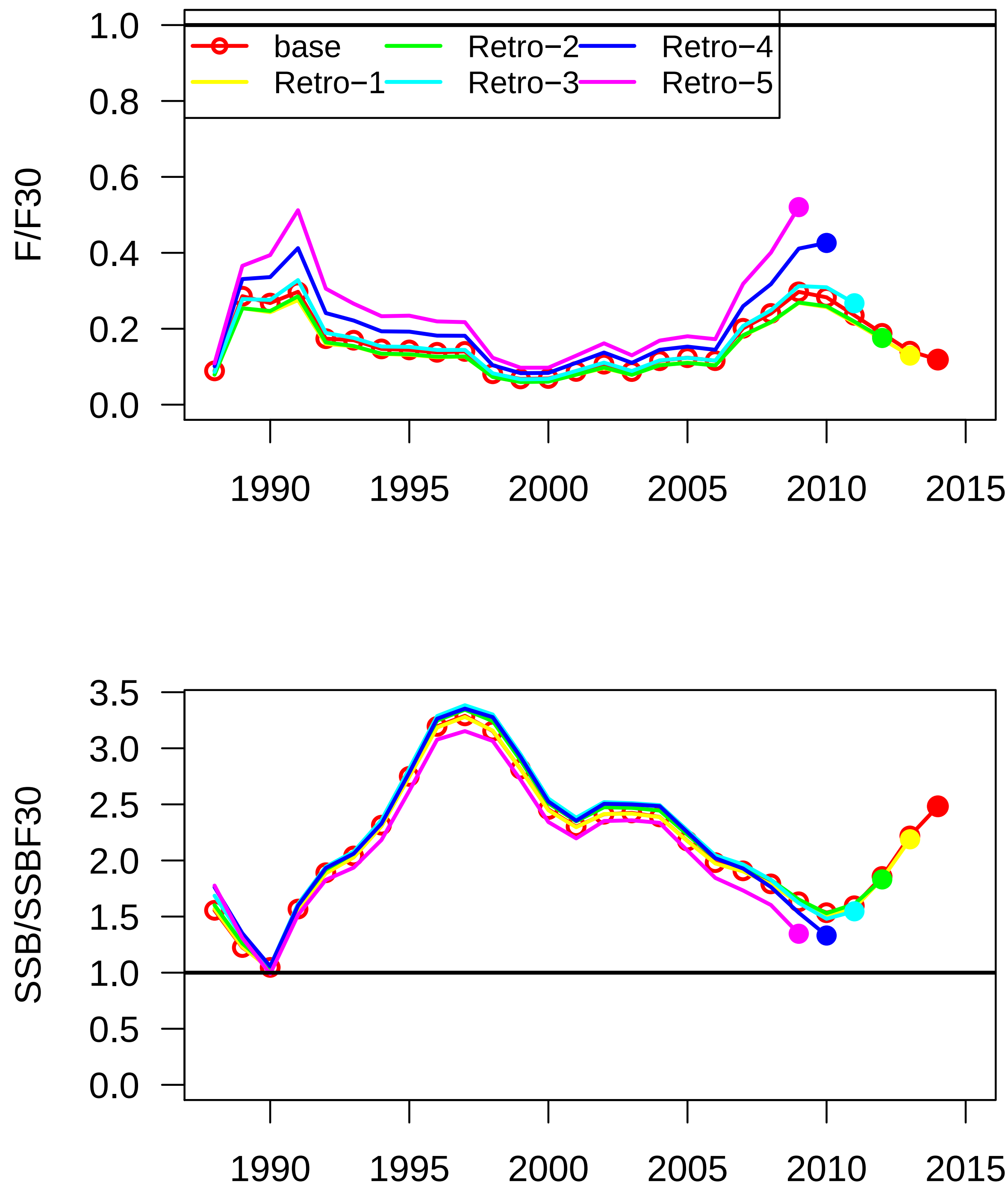


*Figure 48. Retrospective analyses. Sensitivity to terminal year of data. Top panel: Fishing mortality rates. Middle panel: Recruits. Bottom panel: Spawning biomass. Closed circles show terminal-year estimates. Any lines not visible overlap results of the base run.*

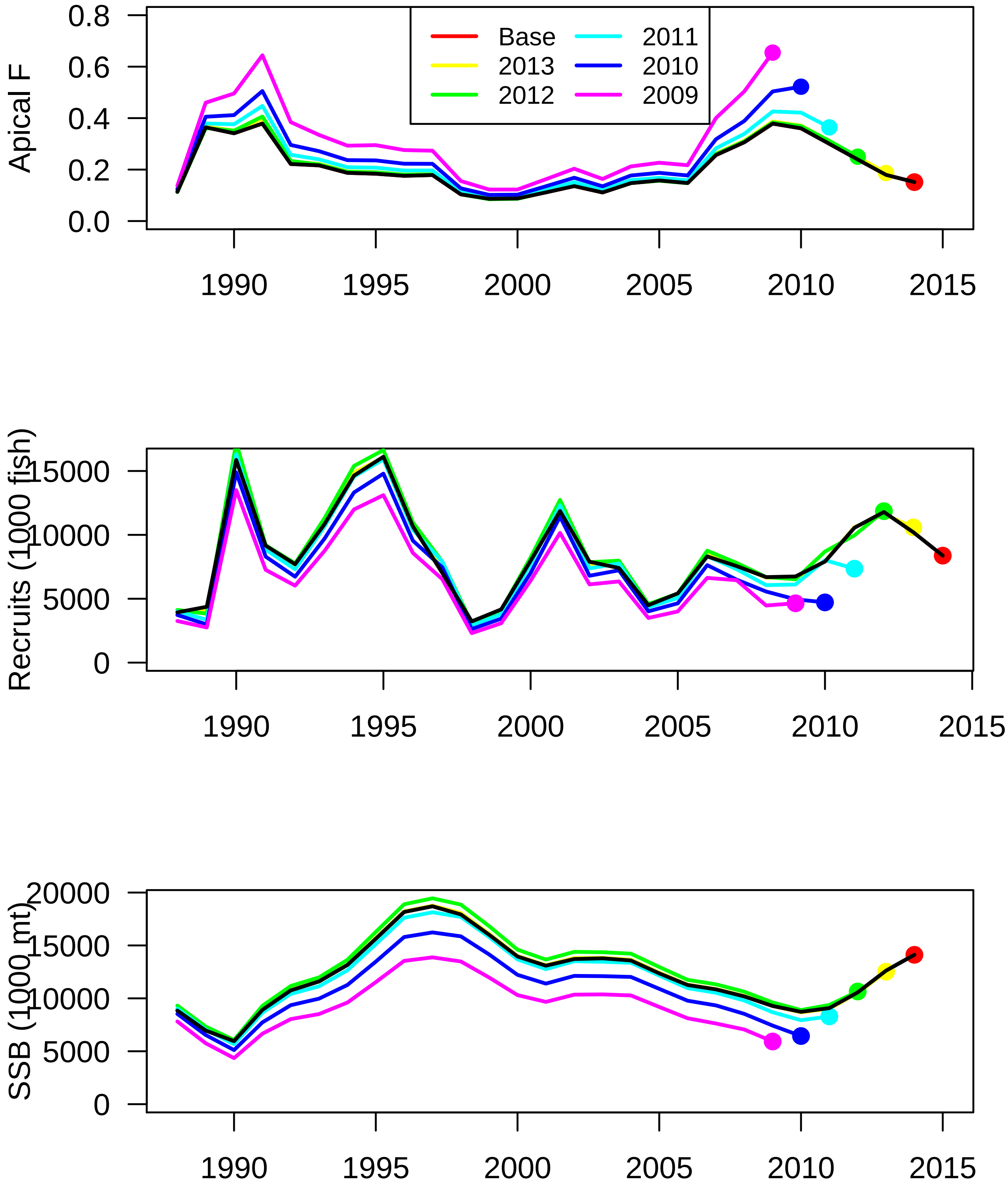


*Figure 49. Projection results under scenario 1—fishing mortality rate at $F = F_{\mathrm{current}}$. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to $5^{th}$ and $95^{th}$ percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities relevant to the panel (MSST, $F_{30\%}$, $L_{F30\%}$); dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB exceeds the replicate-specific MSST.*

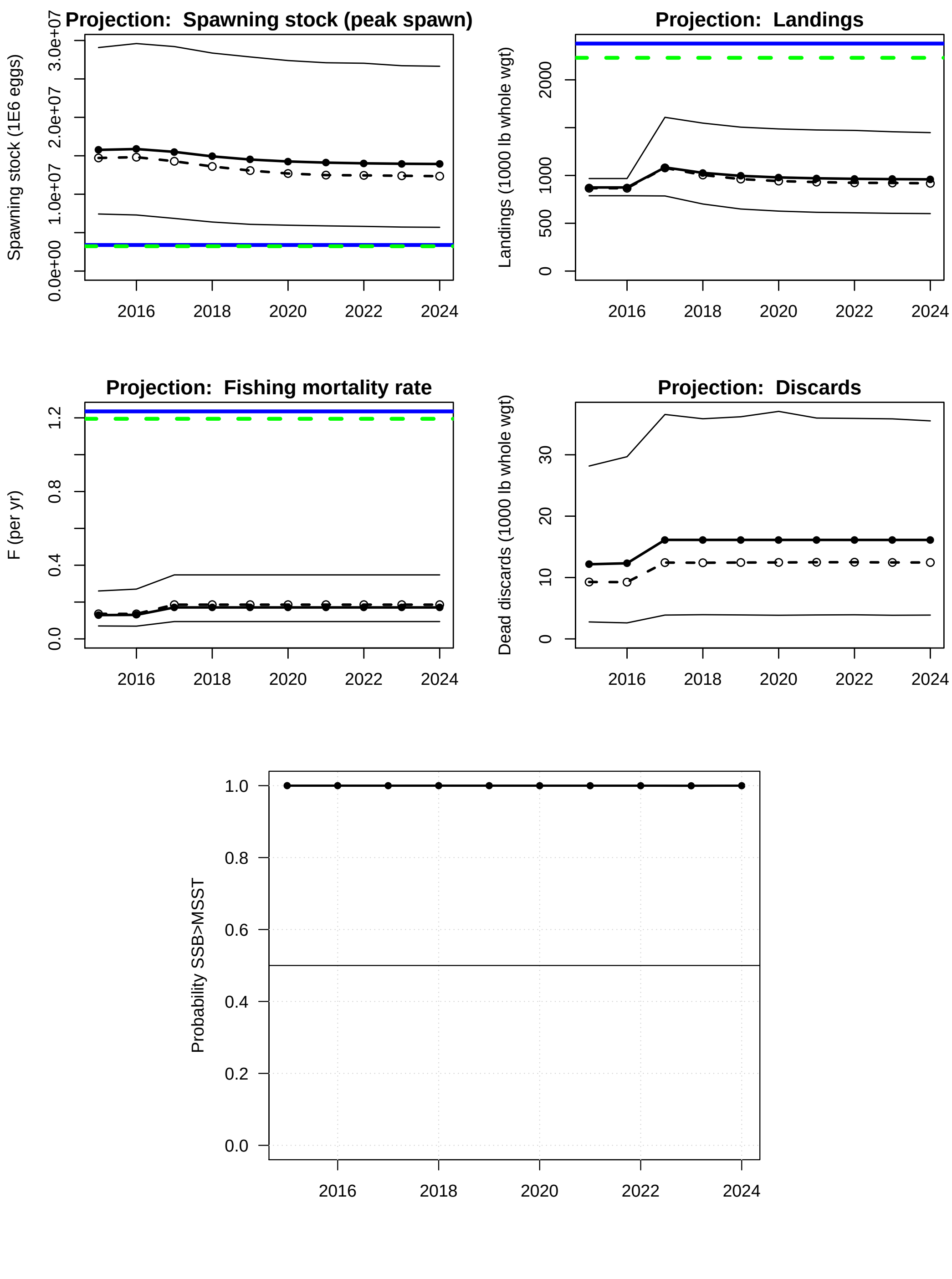


*Figure 50. Projection results under scenario 2—fishing mortality rate at $F = F_{30\%}$. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to $5^{th}$ and $95^{th}$ percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities relevant to the panel (MSST, $F_{30\%}$, $L_{F30\%}$); dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB exceeds the replicate-specific MSST.*

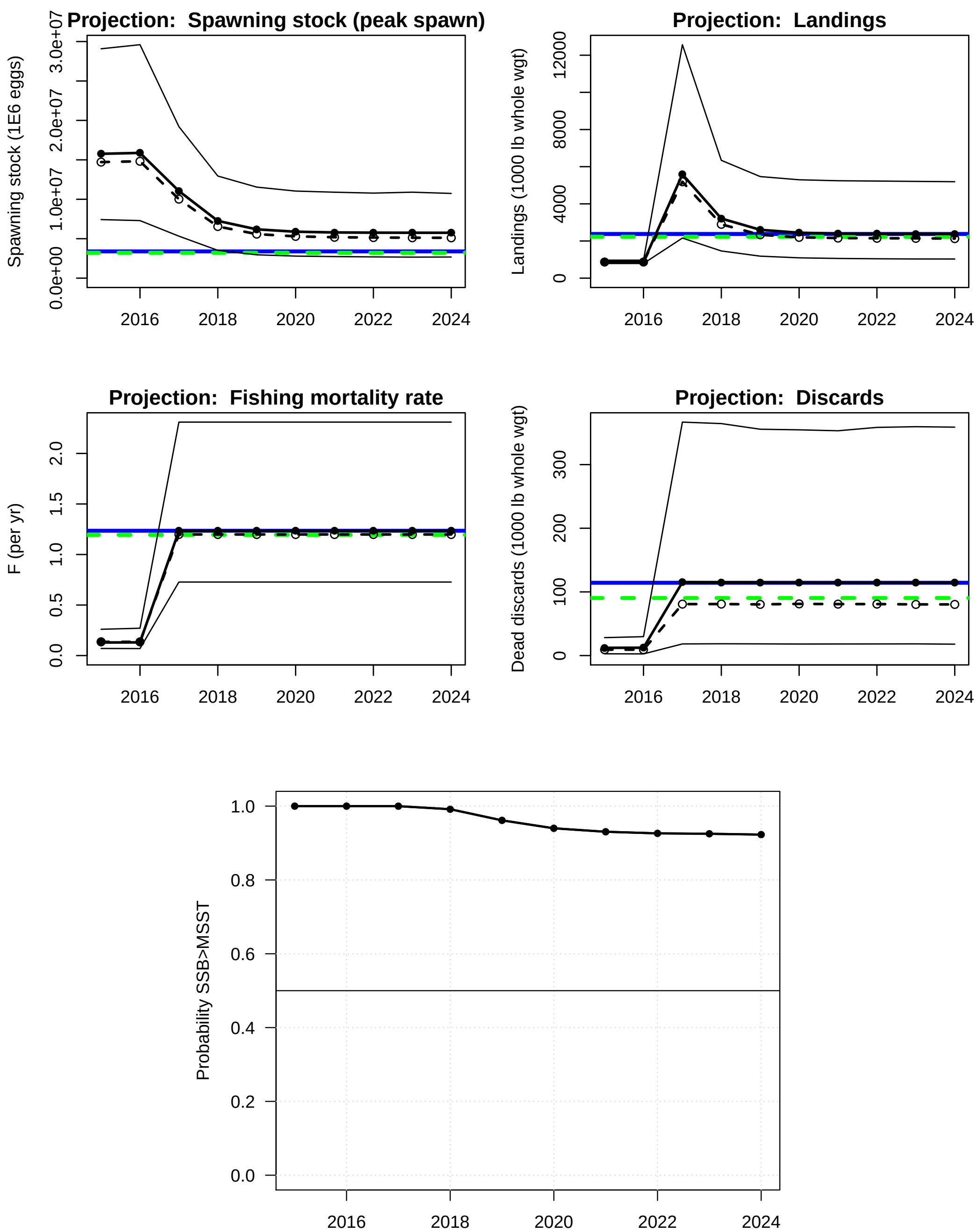


*Figure 51. Projection results under scenario 3—fishing mortality rate at $F = 75\%F_{30\%}$. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to $5^{th}$ and $95^{th}$ percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities relevant to the panel (MSST, $F_{30\%}$, $L_{F30\%}$); dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB exceeds the replicate-specific MSST.*

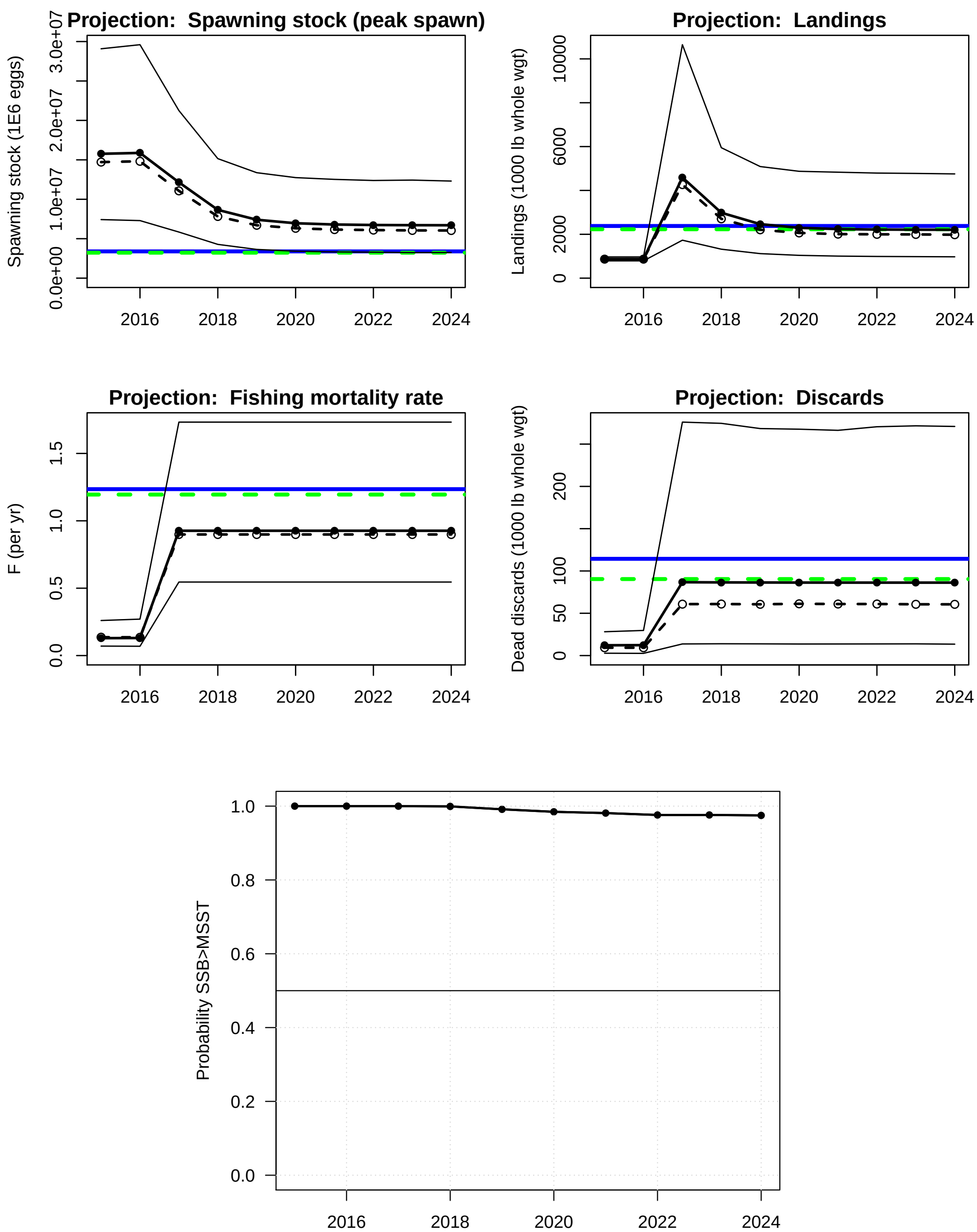


*Figure 52. Abundance indices observed (obs) and predicted (pred) by the ASPIC surplus production model, and observed total removals (100,000 lbs) for South Atlantic Gray Triggerfish. Comm = commercial, HB = headboat, MRIP = Marine Recreational Information Program, CVID = combined chevron trap-video index.*

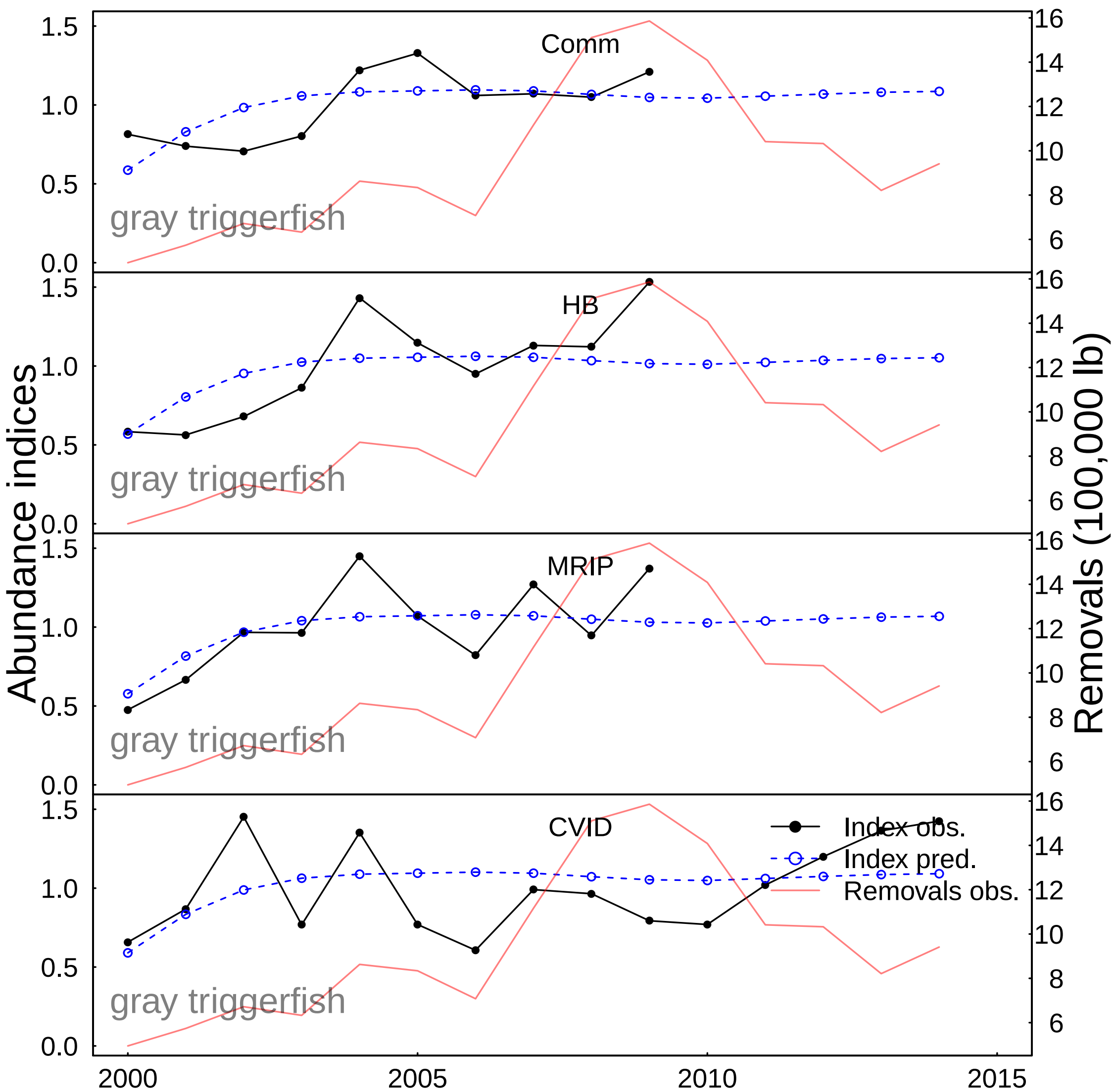


*Figure 53. Prior distributions (blue shapes) and estimated parameter values (vertical black lines) for the South Atlantic Gray Triggerfish ASPIC surplus production model.*

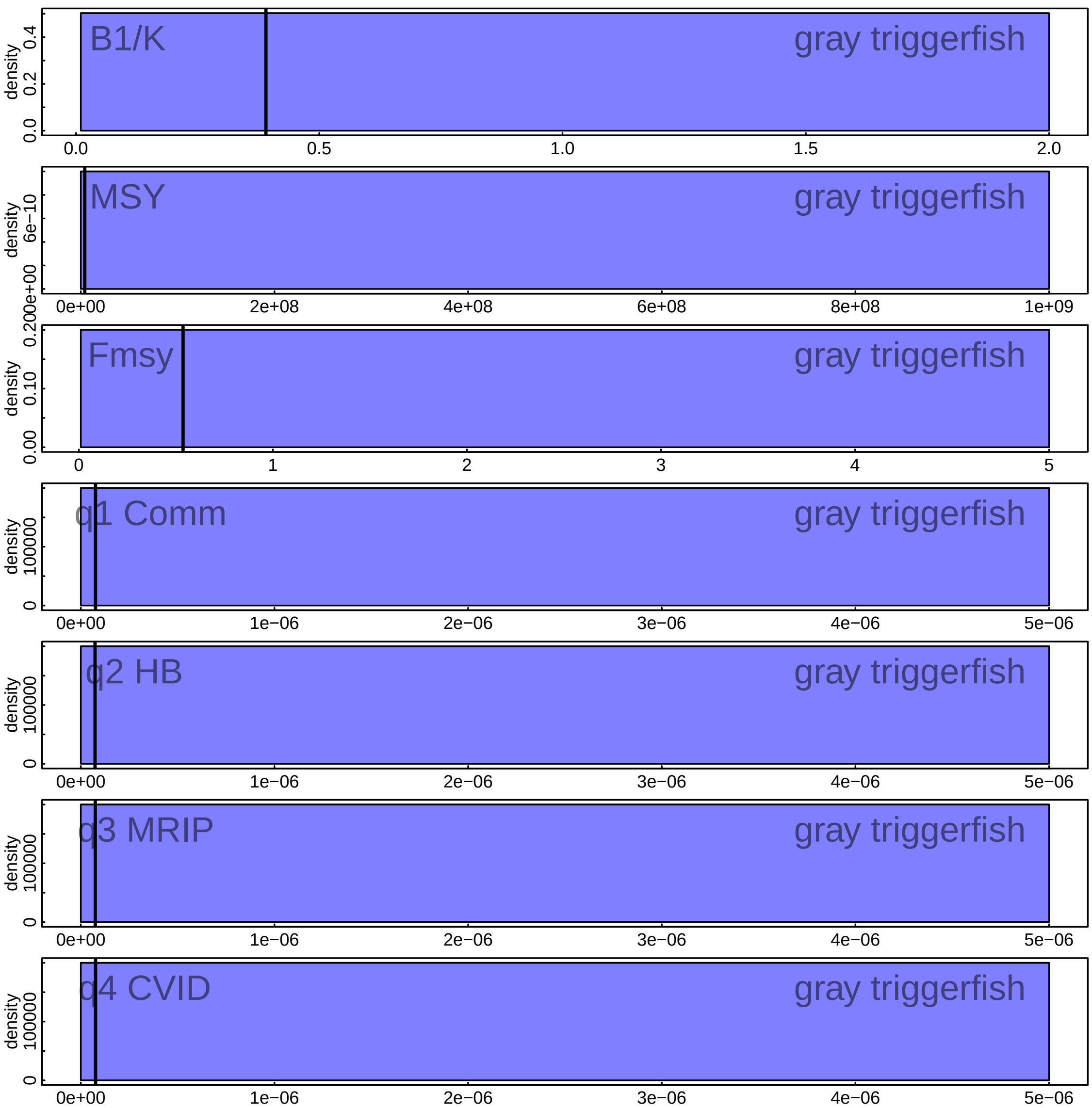


*Figure 54. Bootstrap parameter values from ASPIC surplus production model. Thick vertical lines represent ASPIC parameter estimates (solid) and 95% bootstrap percentile confidence intervals (dashed). Plotting range for each panel is limited to the 99% bootstrap percentile confidence interval. Thin solid vertical lines are drawn at one in plots of $F/F_{MSY}$ and $B/B_{MSY}$ for reference.*

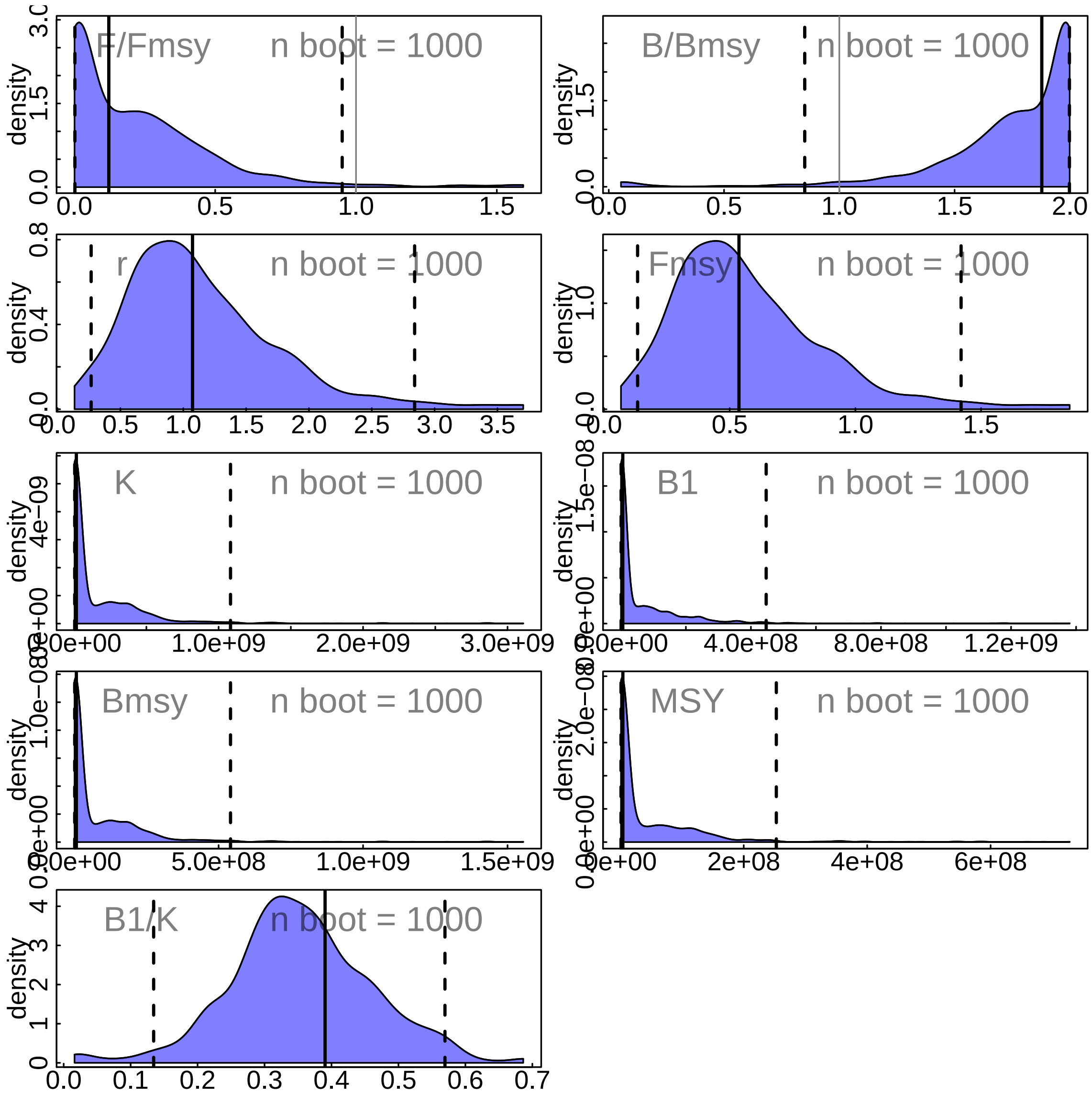
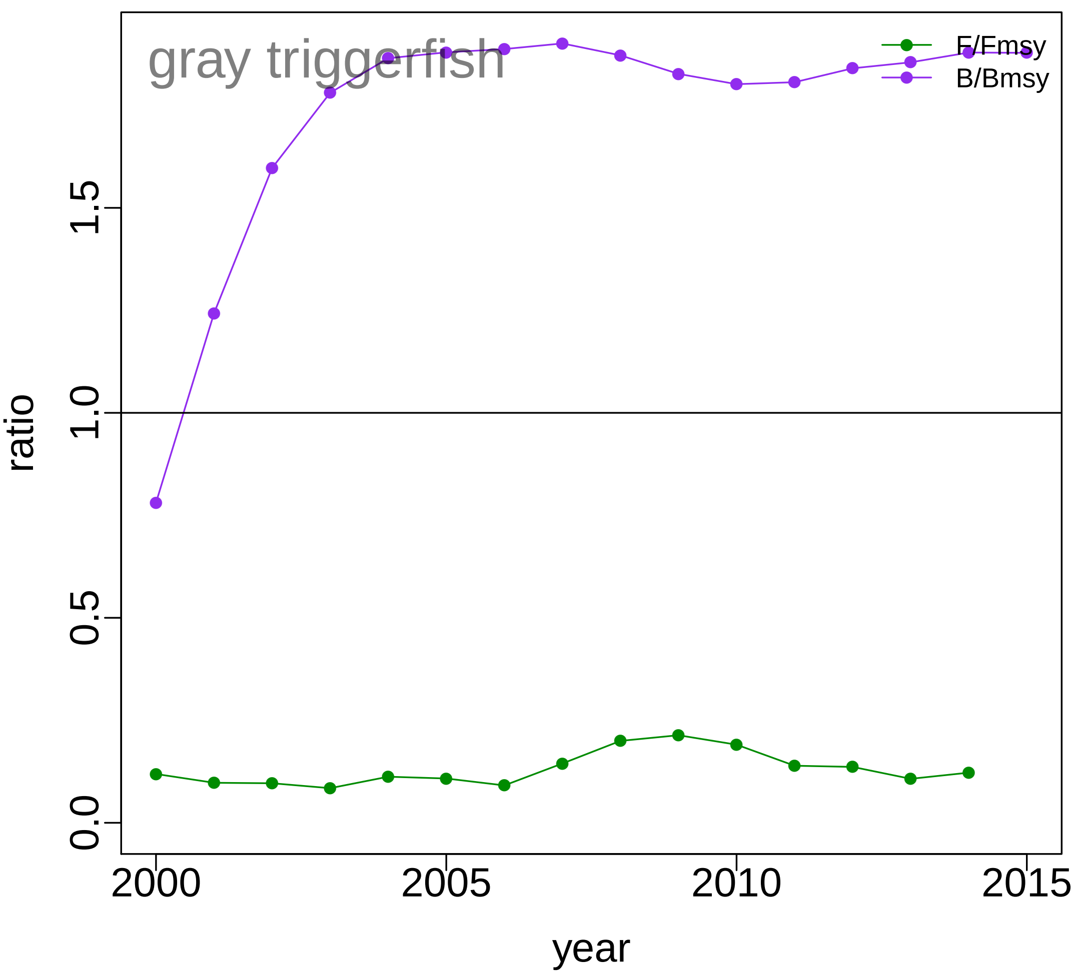


*Figure 55. ASPIC surplus production model estimates of fishing rate ($F/F_{MSY}$) and biomass ($B/B_{MSY}$) relative to that at MSY.*



# Appendix A Abbreviations and symbols

*Table 28. Acronyms and abbreviations used in this report*

| Symbol | Meaning |
|---|---|
| ABC | Acceptable Biological Catch |
| AW | Assessment Workshop (here, for gray triggerfish) |
| ASY | Average Sustainable Yield |
| $B$ | Total biomass of stock, conventionally on January 1 |
| BAM | Beaufort Assessment Model (a statistical catch-age formulation) |
| CPUE | Catch per unit effort; used after adjustment as an index of abundance |
| CV | Coefficient of variation |
| CVID | SERFS combined chevron trap and video survey |
| DW | Data Workshop (here, for gray triggerfish) |
| $F$ | Instantaneous rate of fishing mortality |
| $F_{30\%}$ | Fishing mortality rate at which $F_{30\%}$ can be attained |
| $F_{\mathrm{MSY}}$ | Fishing mortality rate at which MSY can be attained |
| FL | State of Florida |
| FHWAR | The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey |
| GA | State of Georgia |
| GLM | Generalized linear model |
| $K$ | Average size of stock when not exploited by man; carrying capacity |
| kg | Kilogram(s); 1 kg is about 2.2 lb. |
| klb | Thousand pounds; thousands of pounds |
| lb | Pound(s); 1 lb is about 0.454 kg |
| m | Meter(s); 1 m is about 3.28 feet. |
| $M$ | Instantaneous rate of natural (non-fishing) mortality |
| MARMAP | Marine Resources Monitoring, Assessment, and Prediction Program, a fishery-independent data collection program of SCDNR |
| MCB | Monte Carlo/Bootstrap, an approach to quantifying uncertainty in model results |
| MFMT | Maximum fishing-mortality threshold; a limit reference point used in U.S. fishery management; often based on $F_{\mathrm{MSY}}$ |
| mm | Millimeter(s); 1 inch = 25.4 mm |
| MRFSS | Marine Recreational Fisheries Statistics Survey, a data-collection program of NMFS, predecessor of MRIP |
| MRIP | Marine Recreational Information Program, a data-collection program of NMFS, descended from MRFSS |
| MSST | Minimum stock-size threshold; a limit reference point used in U.S. fishery management. The SAFMC has defined MSST for gray triggerfish as $(1-M)\mathrm{SSB}_{\mathrm{MSY}} = 0.7\mathrm{SSB}_{\mathrm{MSY}}$. |
| MSY | Maximum sustainable yield (per year) |
| mt | Metric ton(s). One mt is 1000 kg, or about 2205 lb. |
| $N$ | Number of fish in a stock, conventionally on January 1 |
| NC | State of North Carolina |
| NMFS | National Marine Fisheries Service, same as “NOAA Fisheries Service” |
| NOAA | National Oceanic and Atmospheric Administration; parent agency of NMFS |
| OY | Optimum yield; SFA specifies that OY $\leq$ MSY. |
| PSE | Proportional standard error |
| $R$ | Recruitment |
| SAFMC | South Atlantic Fishery Management Council (also, Council) |
| SC | State of South Carolina |
| SCDNR | Department of Natural Resources of SC |
| SDNR | Standard deviation of normalized residuals |
| SEDAR | SouthEast Data Assessment and Review process |
| SERFS | Southeast Regional Fishery-independent Sampling |
| SFA | Sustainable Fisheries Act; the Magnuson–Stevens Act, as amended |
| SL | Standard length (of a fish) |
| SRHS | Southeast Region Headboat Survey, conducted by NMFS-Beaufort laboratory |
| SPR | Spawning potential ratio |
| SSB | Spawning stock biomass; mature biomass of males and females |
| $\mathrm{SSB}_{\mathrm{MSY}}$ | Level of SSB at which MSY can be attained |
| $\mathrm{SSB}_{\mathrm{F30\%}}$ | Level of SSB at which $F_{30\%}$ can be attained |
| TIP | Trip Interview Program, a fishery-dependent biodata collection program of NMFS |
| TL | Total length (of a fish), as opposed to FL (fork length) or SL (standard length) |
| VPA | Virtual population analysis, an age-structured assessment |
| WW | Whole weight, as opposed to GW (gutted weight) |
| yr | Year(s) |

## Appendix B Parameter estimates from the Beaufort Assessment Model

```
# Number of parameters = 201  Objective function value = -4553.63  Maximum gradient component = 8.71505e-005
# Linf:
453.200000000
# K:
0.340000000000
# t0:
-0.980000000000
# len_cv_val:
0.107000000000
# Linf_L:
527.587605083
# K_L:
0.144001628920
# t0_L:
-3.41300371341
# len_cv_val_L:
0.0881726619556
# Linf_mcvt:
408.861759688
# K_mcvt:
0.459800122956
# t0_mcvt:
-0.273406784322
# len_cv_val_mcvt:
0.132328668204
# log_Nage_dev:
 -1.20484119639 -0.895303067326 -0.810345439810 -0.497709341862 -0.255027943579 -0.136039034315 -0.191286668621
# log_R0:
15.8898708852
# steep:
0.990000000000
# rec_sigma:
0.436659781173
# R_autocorr:
0.000000000000
# log_rec_dev:
 -0.844699608178 -0.732698909319 0.571954670047 0.0808804068291 -0.109368457805 0.271656534554 0.570539447821
 0.701194389577 0.301871061903 -0.0945053408292 -0.873510196110 -0.613288632301 0.0338003560697 0.460127087782
 0.0543661911911 -0.0161577097890 -0.521069639482 -0.323370631449 0.101289198945 -0.00229458929422 -0.126205355871
 -0.115700295935 0.0457818370353 0.341596397805 0.452512311127 0.321903303676 0.0633961720005
# selpar_L50_cH1:
3.67426908280
# selpar_slope_cH1:
2.50301807987
# selpar_L50_mcvt:
1.90032552835
# selpar_slope_mcvt:
3.32046774557
# selpar_L51_HB1:
2.78637324126
# selpar_slope1_HB1:
2.48774778484
# selpar_L52_HB1:
2.57048738930
# selpar_slope2_HB1:
1.01869767635
# selpar_L50_HB2:
2.50000000000
# selpar_slope_HB2:
2.00000000000
# selpar_afull_HB2:
4.00000000000
# selpar_sigma_HB2:
2.00000000000
# selpar_L50_HB_D:
1.00000000957
# selpar_slope_HB_D:
1.99999999458
# selpar_afull_HB_D:
1.00000000000
# selpar_sigma_HB_D:
0.796383054395
# selpar_L51_GR:
2.66713662798
# selpar_slope1_GR:
3.14064881434
# selpar_L52_GR:
4.03265847915
# selpar_slope2_GR:
0.920868329353
# log_q_cH:
-8.50000000000
# log_q_mcvt:
-15.2967017550
# log_q_HB:
-13.5000000000
# log_q_GR:
-13.5000000000
# M_constant:
```

```
0.410000000000
# log_avg_F_cH:
-2.52270829867
# log_F_dev_cH:
 -1.19573675119 -0.720500301435 0.358861397581 0.887172753299 0.643420140603 0.371224986410 0.442042508121 0.544466570288
 0.274938905158 0.264099654304 -0.121816386842 -0.570752061802 -0.833349191385 -0.560062389028 -0.478474085670 -0.581815828142
 -0.426637375366 -0.325388974992 -0.387597825957 0.0548480988323 0.186476567242 0.394949072528 0.670785524166 0.800995626605
 0.276909046742 0.212027551930 -0.181087231996
# log_avg_F_HB:
-3.60824655240
# log_F_dev_HB:
 0.161410482952 0.501692386604 1.08201664289 0.822285470111 0.360415978030 0.432495507623 0.274605549172 0.141831960983
 -0.104156967295 -0.0248540758348 -0.391683142431 -0.709926244612 -0.459254403144 -0.391871257842 -0.0682329201555
 -0.537206336896 0.0192716820490 -0.0371307673090 -0.232562228813 0.253397340743 -0.222239531490 0.0789103865782
 0.264029639307 -0.0408999074350 -0.282650164153 -0.349045978841 -0.540649100790
# log_avg_F_GR:
-2.36892781196
# log_F_dev_GR:
 -0.00715986451631 1.55193537140 1.09249346738 0.993721117603 -0.118685286647 0.140837400710 -0.297576515449 -0.609981737508
 -0.211372494331 -0.268905879893 -1.31785146469 -0.917514798585 -0.641434882319 -0.342236520595 -0.150712685141 -0.473108342221
 -0.211681112483 -0.140321515198 -0.151350310392 0.517294159789 0.778533262486 0.946427483744 0.575264275268 -0.123238626414
 0.189857987731 -0.487946075772 -0.315286413955
# log_avg_F_HB_D:
-10.0514644744
# log_F_dev_HB_D:
 0.465927256438 0.522841624275 -1.74975964951 -2.85129055050 -1.53811057613 -2.57424261344 -2.88943738574 -1.44113359616
 -2.53488709001 -0.987499227023 0.203937046313 0.925017917184 0.532340112579 0.136505435755 1.01440408578 0.177294803986
 0.457879593762 0.382589450773 0.307990448487 -0.103554793282 1.80333460097 1.77118099753 2.24667081182 1.43961065898
 1.40894509876 1.15058239758 1.72286314082
# log_avg_F_GR_D:
-5.88470470692
# log_F_dev_GR_D:
 0.665953294423 1.50253409138 -0.877668454602 0.775999626935 0.0801068463975 -0.682724715260 -1.02145379362
 -0.876637751309 -0.329326602534 -0.139623660314 -0.403478280492 -0.0630736548844 -0.538067920806 -0.864174332663
 -0.164170191184 0.242252271847 0.855790237441 0.698506570788 0.156634901457 0.753255062565 0.500684644715 0.819253392929
 0.322131164694 -0.836392147829 -0.689820746106 -0.0984061965832 0.211916342621
# F_init:
0.0594071602425
```

## 9. South Atlantic and Gulf of Mexico Comparison (TOR #10)

This section addresses AW ToR 10: Compare and contrast productivity measures and assessment assumptions between the Gulf of Mexico and South Atlantic stocks. Comparisons are presented in Table 28.

A template of Table 28 was prepared by the SEDAR41 Assessment Panel, with guidance from SAFMC Council members attending the AW. Input for the South Atlantic stock was based on this (SEDAR41) assessment. Input for the Gulf of Mexico stock was based on the most recent (SEDAR43) assessment of that stock, and values were provided or reviewed by assessment scientists from the NMFS-Miami laboratory.

Table 28. Productivity measures and assessment assumptions from the South Atlantic (SA, SEDAR41) and Gulf of Mexico (GoM, SEDAR43) stocks of gray triggerfish.

| Productivity measure/assumption | SA | GoM | Comments |
|---|---|---|---|
| Reproductive output | Fecundity (eggs/female) | Fecundity (eggs/female) | SA units = $1X10^6$ eggs/female<br>GoM units = $1X10^6$ eggs/female |
| Age at 50% maturity | 0.17 years for females | 1.5 years for females | SA: mature age-1 females contribute relatively few eggs |
| Natural mortality | M=0.41 | M=0.28 | SA max age = 15. SA age-dependent M was based on a scaled version of the Charnov estimator.<br>GoM max age = 19, GoM age dependent M was based on a scaled version of the Lorenzen estimator. |
| Assessment model type | Statistical catch at age | Statistical catch at age | SA software = BAM (implemented in AD Model Builder)<br>GoM software = Stock Synthesis 3.24p (implemented in AD Model Builder) |
| Assessment time frame | 1988–2014 | 1945-2013 | |
| Spawner-recruit model | Beverton-Holt | Beverton-Holt | SA: fixed steepness = 0.99 to model recruitment as variable around an average value |
| Spawner-recruit model parameter values | h=0.99<br>log(R0)=15.9<br>$\sigma_R$=0.43 | h=0.459<br>log(R0)=9.76<br>$\sigma_R$=0.358 | SA: steepness fixed, R0 and $\sigma_R$ estimated. R0 in number age-1 fish.<br>GoM: steepness, R0, and $\sigma_R$ estimated. R0 in 1000s age-0 fish. |
| Modeled population recruitment age | Age=1 | Age=0 | |
| Growth model | von Bertalanffy | von Bertalanffy | |
| Growth model parameter values | Linf=453.2 mm FL<br>K=0.34<br>t0=–0.98 | Linf =58.97 cm FL<br>K=0.14<br>t0=–1.66 | SA: Popn growth fixed, estimated external to the model. Fishery and survey growth parameters estimated internal to the model.<br>GoM: Fixed, estimated external to the model. Single growth model applied |

| | | | |
|---|---|---|---|
| | | | to population and fleets/surveys. |
| Scale of total removals over assessment time frame | Mean=0.95; Min=0.46, Max=1.59 | Com: 1212<br>Rec: 1395 | SA: based on total predicted removals; landings + dead discards in million lb.<br>GoM: observed landings (com from 1972 and rec from 1981), com in metric tons, rec in numbers x 1000 |
| MSY (or proxy) | 2,386,633 | 984,410 | whole pounds<br>SA: F30 proxy assuming average recruitment |
| Fmsy (or proxy) | 1.24 | 0.153 | SA: proxy=F30 |
| Bmsy (or proxy) | 8577 mt | NA | SA: F30 proxy assuming average recruitment |
| SSBmsy (or proxy) | 5,806,257 | 11.1 | SA: $1X10^6$ eggs, F30 proxy assuming average recruitment<br>GoM: $10^9$ lb, F30 proxy assuming low recruitment for 5 years followed by average recruitment |
| F SPR values | 1.24 | 0.385 | SA: $F_{SPR30}$<br>GOM: $F_{SPR30}$ |
| Fleets modeled (selectivity assumptions) | Commercial handline (flat-topped), headboat (domed), general recreational (domed) | Commercial East, Commercial West, Recreational East, Recreational West, Shrimp Fishery Bycatch | SA: com handline includes 'other' category and commercial discards (<5% of total). General rec includes headboat, charter, and private modes.<br>GoM: commercial (E & W) include aggregated handline, longline, and trap fisheries; recreational (E & W) include headboat, charter, and private modes. All fleets have dome selectivity except shrimp fishery bycatch fleet. Shrimp fishery bycatch fleet take only age 0. |
| Time varying catchability? | N | N | |
| Time varying selectivity? | N | Y | SA: Time varying selectivity investigated as a sensitivity run.<br>GoM Selectivity adjusted for size limit changes in 1999 and 2008. |

# SEDAR

Southeast Data, Assessment, and Review

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# SEDAR 41

## South Atlantic Gray Triggerfish

## SECTION IV: Research Recommendations

April 2016

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

# Contents

# IV. Research Recommendations

## 1. Data Workshop

### 1.1 Life History

- More research on gray triggerfish movements and migrations in Atlantic waters is needed. Available data and the results of studies in the Gulf of Mexico indicate high site fidelity, but that tropical storms may cause greater than normal movement that might help dispersal to depleted areas. This needs to be confirmed in the South Atlantic. Additional acoustic and traditional tagging is needed on known spawning locations to document spawning migrations or aggregations, and return of fish to non-spawning areas.
- Age validation study that should include edge type and the potential for using various age structures for use in assessment. This should include the logistical feasibility of using these alternative structures for routine sampling and processing.
- Early life history is largely unknown. E.g. size and age at settlement and length of the pelagic stage.
- Estimates of delayed bycatch mortality are needed. This should include the effect of cloacal protrusion as a result of barotrauma.
- Tagging studies are needed to define spawning locations (only shelf edge or not) and, movement, the results of which could be used to help inform fishing mortality and natural mortality.
- Impact of climate change on mortality and recruitment.
- Research on spawning behavior/nesting and how it impacts survivorship and stock productivity.
- Determine fecundity type and estimate annual fecundity in Atlantic waters.
- Alternative methods of reproductive output. The methods described in Klibansky's SEDAR41-DW49 may provide a more accurate estimate of reproductive output than previously used. Further investigation into this modeling effort and use for future assessments should be investigated.
- Duration of spawning indicators. The definition of spawning indicators has received significant discussion recently. As this has significant implications for the estimates of reproductive output, further research is needed to define consistent criteria for spawning indicators in finfish.
- Investigate gray triggerfish competition for nests. The presence of competition for nest space may affect, among other things, the spawning success (reproductive output) and the choice of a spawner recruit relationship. Further investigation into the nesting behavior of gray triggerfish is needed to provide information to address these issues.

## 1.2 Commercial Statistics

**Landings**

- Require species level reporting in state trip ticket programs. Some states in process of instituting species level reporting for all species.
- Improve gear and effort data collections.

**Discards**

- Investigate the validity and magnitude of "no discard" trips. This may include fisher interviews throughout the region.
- Examine potential impacts of "no discard" trips on estimated discards.
- Improve discard logbook data collections via program expansion or more detailed reporting (e.g. more detailed logbook, electronic reporting)
- Establish an observer program that is representative of the fisheries in the South Atlantic.

**Biosampling**

- Standardize TIP sampling protocol to get representative samples at the species level.
- Standardize TIP data extraction.
- Establish an observer program that is representative of the fisheries in the South Atlantic.
- Increase untargeted sampling in NE and Mid-Atlantic observer programs.
- Increase untargeted dockside sampling in NE and Mid-Atlantic.

## 1.3 Recreational Statistics

- Complete analysis of available historic photos for trends in CPUE and mean size of landed Red Snapper and Gray Triggerfish for pre-1981 time period. (Ultimately all species).
- Formally archive data and photos for all other SEDAR target species.
- For Hire Survey (FHS) should collect additional variables (e.g. depth fished).
- Increasing sample sizes for at-sea headboat observers (i.e. number of trips sampled).
- Compute variance estimate for headboat landings.
- Mandatory logbooks for all federally permitted for-hire vessels.

## 1.4 Indices

- Compare existing methods and/or develop new methods to define effective effort in fishery dependent data.
- Estimate selectivity of video gear in the SERFS.
    - Tagging, stereo cameras
- For video reading, evaluate methods to score water clarity and habitat.

- Evaluate effect of (non) independence between chevron traps and videos, including methods to combine the indices.
- Continue exploring the use of continuous predictor variables (e.g., splines or polynomials) for ZIP and ZINB standardization models.
- Headboat at-sea observer program needs depth data from all states (not just FL) and increased coverage overall.
- SCDNR charterboat logbook program should be replicated by other states.
- Develop fishery independent hook-gear index (S41-DW08).

## 2. Assessment Workshop

- Increased fishery independent information, in particular reliable indices of abundance and age compositions.
- Increased age sampling and evaluation of ageing error over the stock area and from all fleets, particularly the general recreational fleet.
- In this assessment Gray Triggerfish were modeled as a unit stock off the southeastern U.S. For any stock, variation in exploitation and life-history characteristics might be expected at finer geographic scales. Modeling such sub-stock structure would require more data, such as information on the movements and migrations of adults and juveniles, as well as spatial patterns of larval dispersal and recruitment. In addition, it is unknown whether a spatial model would improve the assessment.
- More research to better understand the life history of Gray Triggerfish is needed, including natural mortality, maturity, and reproductive potential, particularly for the youngest ages.
- The effects on environmental variation on the changes in recruitment or survivorship.

## 3. Review Workshop

- Increased fishery independent information, in particular reliable indices of abundance and age compositions.
- Increased age sampling and evaluation of ageing error over the stock area and from all fleets, particularly the general recreational fleet.
- More research to better understand the life history of Gray Triggerfish is needed, including natural mortality, maturity, and reproductive potential, particularly for the youngest ages.
- The effects of environmental variation on the changes in recruitment or survivorship of Gray Triggerfish.

# SEDAR

## Southeast Data, Assessment, and Review

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# SEDAR 41

## South Atlantic Gray Triggerfish

## SECTION V: Review Workshop Report

April 2016

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

## Table of Contents

# 1. Introduction

## 1.1 Workshop Time and Place

The SEDAR 41 Review Workshop for South Atlantic Gray Triggerfish (*Balistes capriscus*) was held March 15-18, 2016 in North Charleston, SC. Review Panel members were presented all information generated throughout the Data (DW) and Assessment (AW) Workshops and webinars, and the Review Workshop (RW) Panel then developed a consensus review and analysis of the stock assessment model and inputs according to a number of SEDAR Terms of Reference.

## 1.2 Terms of Reference

1. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:
    a) Are data decisions made by the DW and AW sound and robust?
    b) Are data uncertainties acknowledged, reported, and within the normal or expected levels?
    c) Are data properly applied within the assessment model?
    d) Are data input series reliable and sufficient to support the assessment approach and findings?

2. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and consider the following:
    a) Are methods scientifically sound and robust?
    b) Are assessment models configured properly and used consistent with standard practices?
    c) Are the methods appropriate for the available data?

3. Evaluate the assessment findings and consider the following:
    a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
    b) Is the stock overfished? What information helps you to reach this conclusion?
    c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
    d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

4. Evaluate the stock projections, including discussing the strengths and weaknesses, and consider the following:
    a) Are the methods consistent with accepted practices and available data?
    b) Are the methods appropriate for the assessment model and outputs?
    c) Are the results informative and robust, and are they useful to support inferences of probably future conditions?
    d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
    a) Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.
    b) Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.
    a) Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
    b) Provide recommendations on possible ways to improve the SEDAR process.

7. Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation, and peer review of fishery management information.

8. Compare and contrast assessment uncertainties between the Gulf of Mexico and South Atlantic stocks.

9. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Peer Review Summary Report in accordance with the project guidelines.

## 1.3 List of Participants

**REVIEW WORKSHOP PANELISTS**

| | | |
|---|---|---|
| Luiz Barbieri | Review Panel Chair | SAFMC SSC |
| Mike Armstrong | Reviewer | CIE |
| Jon Helge Volstad | Reviewer | CIE |
| Stephen Smith | Reviewer | CIE |
| Steve Cadrin | Reviewer | SAFMC SSC |
| Churchill Grimes | Reviewer | SAFMC SSC |

**ANALYTICAL REPRESENTATIVES**

| | | |
|---|---|---|
| Kevin Craig | Lead Analyst, GTF | SEFSC Beaufort |
| Kate Siegfried | Lead Analyst, RS | SEFSC Beaufort |
| Kyle Shertzer | Assessment Team | SEFSC Beaufort |
| Erik Williams | Assessment Team | SEFSC Beaufort |
| Rob Cheshire | Assessment Team | SEFSC Beaufort |
| Eric Fitzpatrick | Assessment Team | SEFSC Beaufort |

**APPOINTED OBSERVERS**

| | | |
|---|---|---|
| Rusty Hudson | Recreational/Commercial | FL / SFA |
| Robert Johnson | For-Hire | FL |

**APPOINTED COUNCIL REPRESENTATIVES**

| | | |
|---|---|---|
| Zack Bowen | Council Member | SAFMC |
| Mark Brown | Council Member | SAFMC |
| Chris Conklin | Council Member | SAFMC |

**COUNCIL AND AGENCY STAFF**

| | | |
|---|---|---|
| Julia Byrd | Coordinator | SEDAR |
| Julie O'Dell | Admin | SEDAR / SAFMC |
| Chip Collier | Fishery Biologist | SAMFC |
| Mike Errigo | Fishery Biologist | SAFMC |
| Nick Farmer | Fishery Biologist | SERO |

**WORKSHOP ATTENDEES**

Joey Ballenger, SCDNR
Peter Barile, SFA
Myra Brouwer, SAFMC
John Carmichael, SAFMC
Brian Cheuvront, SAFMC
Lora Clarke, PEW

Amy Dukes, SCDNR
Jimmy Hull, FL fisherman
Julie Neer, SAFMC
Adam Nelson, FL fisherman
David Nelson, FL fisherman
Michael Nelson, FL fisherman
Paul Nelson, FL fisherman
Marcel Reichert, SCDNR
Tracey Smart, SCDNR

*Appointees marked with a * were appointed to the workshop panel but did not attend the workshop.

## 1.4 Document List

SEDAR 41 review workshop working papers and reference documents.

| Document # | Title | Authors |
|---|---|---|
| **Documents Prepared for the Review Workshop** | | |
| SEDAR41-RW01 | Addendum to SEDAR41-DW16: Report on Life History of South Atlantic Gray Triggerfish, *Balistes capriscus*, from Fishery-Independent Sources: UPDATE on analyses of maturity, spawning fraction, and sex ratio | Kolmos et al. 2016 |
| SEDAR41-RW02 | Age structured production model (ASPM) for U.S. South Atlantic Red Snapper (*Lutjanus campechanus*) | SFB-NMFS 2016 |
| SEDAR41-RW03 | Age structured production model (ASPM) for U.S. South Atlantic Gray Triggerfish (*Balistes capriscus*) | SFB-NMFS 2016 |
| SEDAR41-RW04 | Red Snapper: Additional BAM diagnostics, analyses, and code | SFB-NMFS 2016 |
| SEDAR41-RW05 | Model Diagnostics and Source Code for SEDAR 41 Gray Triggerfish (*Balistes capriscus*) Benchmark Stock Assessment | SFB-NMFS 2016 |
| | | |
| | | |
| **Reference Documents** | | |
| SEDAR41-RD01 | List of documents and working papers for SEDAR 32 (South Atlantic Blueline Tilefish and Gray Triggerfish) – all documents available on the SEDAR website. | SEDAR 32 |
| SEDAR41-RD02 | List of documents and working papers for SEDAR 9 (Gulf of Mexico Gray Triggerfish, Greater Amberjack, and Vermilion Snapper) – all documents available on the SEDAR website. | SEDAR 9 |
| SEDAR41-RD03 | 2011 Gulf of Mexico Gray Triggerfish Update Assessment | SEDAR 2011 |
| SEDAR41-RD04 | List of documents and working papers for SEDAR 24 (South Atlantic red snapper) – all documents available on the SEDAR website. | SEDAR 24 |
| SEDAR41-RD05 | List of documents and working papers for SEDAR 31 (Gulf of Mexico red snapper) – all documents available on the SEDAR website. | SEDAR 31 |

| | | |
|---|---|---|
| SEDAR41-RD06 | List of documents and working papers for SEDAR 15 (South Atlantic red snapper and greater amberjack) – all documents available on the SEDAR website. | SEDAR 15 |
| SEDAR41-RD07 | 2009 Gulf of Mexico red snapper update assessment | SEDAR 2009 |
| SEDAR41-RD08 | List of documents and working papers for SEDAR 7 (Gulf of Mexico red snapper) – all documents available on the SEDAR website. | SEDAR 7 |
| SEDAR41-RD09 | SEDAR 24 South Atlantic Red Snapper: management quantities and projections requested by the SSC and SERO | NMFS - Sustainable Fisheries Branch 2010 |
| SEDAR41-RD10 | Total removals of red snapper (*Lutjanus campechanus*) in 2012 from the US South Atlantic | NMFS - Sustainable Fisheries Branch 2013 |
| SEDAR41-RD11 | Amendment 17A to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | SAFMC 2010 |
| SEDAR41-RD12 | Amendment 28 to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | SAFMC 2013 |
| SEDAR41-RD13 | Total removals of red snapper (*Lutjanus campechanus*) in 2013 from the U.S. South Atlantic | NMFS - Sustainable Fisheries Branch 2014 |
| SEDAR41-RD14 | South Atlantic red snapper (*Lutjanus campechanus*) monitoring in Florida for the 2012 season | Sauls et al. 2013 |
| SEDAR41-RD15 | South Atlantic red snapper (*Lutjanus campechanus*) monitoring in Florida for the 2013 season | Sauls et al. 2014 |
| SEDAR41-RD16 | A directed study of the recreational red snapper fisheries in the Gulf of Mexico along the West Florida shelf | Sauls et al. 2014 |
| SEDAR41-RD17 | Using generalized linear models to estimate selectivity from short-term recoveries of tagged red drum *Sciaenops ocellatus*: Effects of gear, fate, and regulation period | Bacheler et al. 2009 |
| SEDAR41-RD18 | Direct estimates of gear selectivity from multiple tagging experiments | Myers and Hoenig 1997 |

| | | |
|---|---|---|
| SEDAR41-RD19 | Examining the utility of alternative video monitoring metrics for indexing reef fish abundance | Schobernd et al. 2014 |
| SEDAR41-RD20 | An evaluation and power analysis of fishery independent reef fish sampling in the Gulf of Mexico and U.S. South Atlantic | Conn 2011 |
| SEDAR41-RD21 | Consultant's Report: Summary of the MRFSS/MRIP Calibration Workshop | Boreman 2012 |
| SEDAR41-RD22 | 2013 South Atlantic Red Snapper Annual Catch Limit and Season Length Projections | SERO 2013 |
| SEDAR41-RD23 | Southeast Reef Fish Survey Video Index Development Workshop | Bacheler and Carmichael 2014 |
| SEDAR41-RD24 | Observer Coverage of the 2010-2011 Gulf of Mexico Reef Fish Fishery | Scott-Denton and Williams |
| SEDAR41-RD25 | Circle Hook Requirements in the Gulf of Mexico: Application in Recreational Fisheries and Effectiveness for Conservation of Reef Fishes | Sauls and Ayala 2012 |
| SEDAR41-RD26 | GADNR Marine Sportfish Carcass Recovery Project | Harrell 2013 |
| SEDAR41-RD27 | Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States | Gulf and South Atlantic Fisheries Foundation 2008 |
| SEDAR41-RD28 | A Continuation of Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States | Gulf and South Atlantic Fisheries Foundation 2010 |
| SEDAR41-RD29 | Continuation of Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States | Gulf and South Atlantic Fisheries Foundation 2013 |
| SEDAR41-RD30 | Amendment 1 and Environmental Assessment and Regulatory Impact Review to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | SAFMC 1988 |
| SEDAR41-RD31 | Final Rule for Amendment 1 to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region | Federal Register 1989 |
| SEDAR41-RD32 | Population Structure and Genetic Diversity of Red Snapper (Lutjanus campechanus) in the U.S. | Gold and Portnoy 2013 |

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| | South Atlantic and Connectivity with Red Snapper in the Gulf of Mexico | |
| SEDAR41-RD33 | Oogenesis and fecundity type of Gulf of Mexico gray triggerfish reflects warm water environmental and parental care | Lang and Fitzhugh 2014 |
| SEDAR41-RD34 | Depth-related Distribution of Postjuvenile Red Snapper in Southeastern U.S. Atlantic Ocean Waters: Ontogenetic Patterns and Implications for Management | Mitchell et al. 2014 |
| SEDAR41-RD35 | Gray Triggerfish Age Workshop | Potts 2013 |
| SEDAR41-RD36 | Age, Growth, and Reproduction of Gray Triggerfish *Balistes capriscus* Off the Southeastern U.S. Atlantic Coast | Kelly 2014 |
| SEDAR41-RD37 | Assessment of Genetic Stock Structure of Gray Triggerfish (*Balistes capriscus*) in U.S. Waters of the Gulf of Mexico and South Atlantic Regions | Saillant and Antoni 2014 |
| SEDAR41-RD38 | Genetic Variation of Gray Triggerfish in U.S. Waters of the Gulf of Mexico and Western Atlantic Ocean as Inferred from Mitochondrial DNA Sequences | Antoni et al. 2011 |
| SEDAR41-RD39 | Characterization of the U.S. Gulf of Mexico and South Atlantic Penaeid and Rock Shrimp Fisheries Based on Observer Data | Scott-Denton et al. 2012 |
| SEDAR41-RD40 | Does hook type influence the catch rate, size, and injury of grouper in a North Carolina commercial fishery | Bacheler and Buckel 2004 |
| SEDAR41-RD41 | Fishes associated with North Carolina shelf-edge hardbottoms and initial assessment of a proposed marine protected area | Quattrini and Ross 2006 |
| SEDAR41-RD42 | Growth of grey triggerfish, *Balistes capriscus*, based on growth checks of the dorsal spine | Ofori-Danson 1989 |
| SEDAR41-RD43 | Age Validation and Growth of Gray Triggerfish, *Balistes capriscus*, In the Northern Gulf of Mexico | Fioramonti 2012 |
| SEDAR41-RD44 | A review of the biology and fishery for Gray Triggerfish, *Balistes capriscus*, in the Gulf of Mexico | Harper and McClellan 1997 |

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| SEDAR41-RD45 | Stock structure of gray triggerfish, *Balistes capriscus*, on multiple spatial scales in the Gulf of Mexico | Ingram 2001 |
| SEDAR41-RD46 | Evaluation of the Efficacy of the Current Minimum Size Regulation for Selected Reef Fish Based on Release Mortality and Fish Physiology | Burns and Brown-Peterson 2008 |
| SEDAR41-RD47 | Population Structure of Red Snapper from the Gulf of Mexico as Inferred from Analysis of Mitochondrial DNA | Gold et al. 1997 |
| SEDAR41-RD48 | Successful Discrimination Using Otolith Microchemistry Among Samples of Red Snapper *Lutjanus campechanus* from Artificial Reefs and Samples of *L.campechanus* Taken from Nearby Oil and Gas Platforms | Nowling et al. 2011 |
| SEDAR41-RD49 | Population Structure and Variation in Red Snapper<br>(Lutjanus campechanus) from the Gulf of Mexico and Atlantic Coast of Florida as Determined from<br>Mitochondrial DNA Control Region Sequence | Garber et al. 2003 |
| SEDAR41-RD50 | Population assessment of the red snapper from the southeastern United States | Manooch et al. 1998 |
| SEDAR41-RD51 | Otolith Microchemical Fingerprints of Age-0 Red Snapper, *Lutjanus campechanus*, from the Northern Gulf of Mexico | Patterson et al. 1998 |
| SEDAR41-RD52 | Implications of reef fish movement from unreported artificial reef sites in the northern Gulf of Mexico | Addis et al. 2013 |
| SEDAR41-RD53 | Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species | Then et al. 2014 |
| SEDAR41-RD54 | Length selectivity of commercial fish traps assessed from in situ comparisons with stereo-video: Is there evidence of sampling bias? | Langlois et al. 2015 |
| SEDAR41-RD55 | MRIP Calibration Workshop II – Final Report | Carmichael and Van Vorhees (eds.) 2015 |
| SEDAR41-RD56 | Total Removals of red snapper (*Lutjanus campechanus*) in 2014 from the U.S. South Atlantic | SEFSC 2015 |
| SEDAR41-RD57 | Assessing reproductive resilience: an example with South Atlantic red snapper *Lutjanus campechanus* | Lowerre-Barbiere et al. 2015 |

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| SEDAR41-RD58 | Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey and its partners | Smart et al. 2014 |
| SEDAR41-RD59 | MRIP Transition Plan for the Fishing Effort Survey | Atlantic and Gulf Subgroup of the MRIP Transition Team 2015 |
| SEDAR41-RD60 | Technical documentation of the Beaufort Assessment Model (BAM) | Williams and Shertzer 2015 |
| SEDAR41-RD61 | Stock Assessment of Red Snapper in the Gulf of Mexico 1872-2013, with Provisional 2014 Landings: SEDAR Update Assessment | Cass-Calay et al. 2015 |
| SEDAR41-RD62 | Excerpt from the December 2013 SAFMC SEDAR Committee Minutes (pages 11-21 where SEDAR 41 ToR were discussed) | SAFMC SEDAR Committee |
| SEDAR41-RD63 | Population structure of red snapper (*Lutjanus campechanus)* in U.S. waters of the western Atlantic Ocean and the northeastern Gulf of Mexico | Hollenbeck et al. 2015 |
| SEDAR41-RD64 | SEDAR31-AW04: The Effect of Hook Type on Red Snapper Catch | Saul and Walter 2013 |
| SEDAR41-RD65 | SEDAR31-AW12: Estimation of hook selectivity on red snapper (*Lutjanus campechanus*) during a fishery independent survey of natural reefs in the Gulf of Mexico | Pollack et al. 2013 |
| SEDAR41-RD66 | Effect of Circle Hook Size on Reef Fish Catch Rates, Species Composition, and Selectivity in the Northern Gulf of Mexico Recreational Fishery | Patterson et al. 2012 |
| SEDAR41-RD67 | Effect of trawling on juvenile red snapper (*Lutjanus campechanus*) habitat selection and life history parameters | Wells et al. 2008 |
| SEDAR41-RD68 | SEDAR24-AW05: Selectivity of red snapper in the southeast U.S. Atlantic: dome-shaped or flat topped? | SFB-SEFSC 2010 |
| SEDAR41-RD69 | Hierarchical analysis of multiple noisy abundance indices | Conn 2010 |
| SEDAR41-RD70 | Data weighting in statistical fisheries stock assessment models | Francis 2011 |
| SEDAR41-RD71 | Corrigendum to Francis 2011 paper | Francis |

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| SEDAR41-RD72 | Quantifying annual variation in catchability for commercial and research fishing | Francis et al. 2003 |
| SEDAR41-RD73 | Evolutionary assembly rules for fish life histories | Charnov et al. 2012 |
| SEDAR41-RD74 | User's Guide for ASPIC Suite, version 7: A Stock-Production Model Incorporating Covariates and auxiliary programs | Prager 2015 |
| SEDAR41-RD75 | Standing and Special Reef Fish SSC, September 2015 Meeting Summary (see pages 4-7 for SEDAR 43 review) | Gulf of Mexico Standing and Special Reef Fish SSC |
| SEDAR41-RD76 | Standing and Special Reef Fish SSC, January 2016 Meeting Summary (see pages 2-7 for SEDAR 43 review) | Gulf of Mexico Standing and Special Reef Fish SSC |
| SEDAR41-RD77 | SEDAR 43 Gulf of Mexico Gray Triggerfish Stock Assessment Report | SEDAR 43 |
| SEDAR41-RD78 | Review of 2014 SEDAR 31 Gulf of Mexico Red Snapper Update Assessment | Gulf of Mexico Standing and Special Reef Fish SSC |
| SEDAR41-RD79 | Influence of soak time and fish accumulation on catches of reef fishes in a multispecies trap survey | Bacheler et al. 2013 |

# 2. Review Panel Report

**Executive Summary**

The Review Workshop (RW) Panel was presented outputs and results of the SEDAR 41 South Atlantic Gray Triggerfish stock assessment. The primary assessment model used was the Beaufort Assessment Model (BAM), a software package that implements a statistical catch-at-age framework. The formulation is an age-structured population model that is fit using standard statistical methods to data available from surveys and fishing fleets, such as landings, discards, indices of abundance, age compositions, and length compositions. The modeling framework is nearly identical to other common assessment packages, such Age Structure Assessment Program (ASAP) and Stock Synthesis (SS), and the programming language (AD Model Builder) is the same across all three. A secondary, surplus-production model (Stock Production Model Incorporating Covariates, ASPIC) was also explored as a way to evaluate model uncertainty and provide a comparison of assessment results. However, the low contrast in Gray Triggerfish landings and indices of abundance caused ASPIC results to be considered non-informative. Further, an error with the Chevron Trap survey age composition data used in the base configuration of the BAM model was discovered during the RW (the age compositions used at the Assessment Workshop were based on the number of annuli and the corrected data were based on calendar-year age). Based on the magnitude of changes to the data, results and model diagnostics developed from the Assessment Workshop base model as well as concerns about overfitting the CVID survey, the Review Panel felt that the proposed base model parameterization was inappropriate to provide information on Gray Triggerfish stock status or benchmarks. The Review Panel recommends that further modeling is needed to fit the corrected age data and to resolve the fit to the CVID survey (perhaps investigating a multispecies year effect in 1990) to consider possible effects from Hurricane Hugo.

## 2.1 Statements Addressing Each ToR

1. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:
    a) Are data decisions made by the DW and AW sound and robust?
    b) Are data uncertainties acknowledged, reported, and within the normal or expected levels?
    c) Are data properly applied within the assessment model?
    d) Are data input series reliable and sufficient to support the assessment approach and findings?

*General comments*

**Data decisions made by the DW and AW were sound and robust**. The Review Panel acknowledges the considerable efforts of the DW and AW to compile the data and evaluate their strengths and weaknesses. The development of input data and parameters for the BAM and ASPIC models required an extremely thorough compilation and evaluation of all available data at the DW. Modifications made subsequently by the AW were fully explained.

**Data uncertainties were acknowledged, reported, and were within the normal or expected levels,** where this could be ascertained from information provided to the RW. Data on fishery catches and length/age compositions, and fishery-dependent and independent relative abundance indices, varied widely in coverage and quality. Complex manipulations and standardisation methods were often required to try and develop coherent time series from diverse data sources of differing designs, coverage and accuracy, and the combined data will have biases that in some cases are poorly understood especially in earlier years of the time series. All decisions made by the DW and AW in compiling data were explained and justified in detail. Data quality metrics were provided by the DW in terms of numbers of samples, CVs, or alternative plausible data series or biological parameters. These were used by the AW to weight data series in the assessment model, estimate the uncertainty in the assessment results using the Monte Carlo/bootstrap method, or to explore the sensitivity of the assessment to data decisions and uncertainty. The sensitivity analyses were carried out altering one input at a time, and did not explore the impact of combinations of adjustments.

**The data were properly applied within the assessment model**. Any issues with application of the data such as time periods for fitting, use of length and age data from the same sampling schemes, or weighting of data according to data quality metrics, were explored at the SEDAR-41 RW if not previously evaluated by the DW and AW.

**Data input series were mostly considered reliable and sufficient to support the assessment approach and findings**. Reliability and sufficiency was evaluated based on a-priori criteria where possible, supported by data quality metrics such as numbers of samples or CVs and by model fits. The assessment is supported by a well-designed fishery-independent trap survey since 1990 and a wide range of fishery-dependent data covering landings and discards. The Review Panel was mostly concerned about how the fishery-dependent and fishery-independent data were treated in the BAM assessment than with the inherent reliability of the data, leading to the decision to put the assessment on hold pending a response from the AW as a whole to suggestions made by the Review Panel (this is explained under Term of Reference 2 below).

An evaluation of the strengths and weaknesses of the data sources and decisions is given below for each type of data used.

*Life history parameters*

Life history data and assumptions used in the Gray Triggerfish assessment include stock structure, reproductive biology and natural mortality. The assessment was sensitive to estimates of natural mortality (M) as is generally the case, although sensitivity to trends in M could not be evaluated as there is no information on this. An age-dependent, yearinvariant estimate of M was determined by a meta-analysis approach using growth parameters and maximum observed age. Reproductive biology was included in the model by computing total annual egg production at age based on maturity, length, number of batches and batch fecundity, allowing the effect of age structure on reproductive output to be reflected in setting SSB reference points and stock status. Interannual variation in fecundity, a possible source of uncertainty, was not able to be included as historical information was not available.

Age in Gray Triggerfish is difficult to determine from hard structures, a previous impediment to developing a stock assessment. Strenuous efforts have been made to develop and validate accurate methods to determine age based on increments in dorsal spines (converted to calendar years), and those results are used in the BAM model. Gray Triggerfish age readings show a broad distribution of length at age relative to the annual growth increment in length (Fig. 1 – from presentation to SEDAR-41 RW), which in combination with selectivity assumptions affect the ability for BAM to estimate annual age compositions through fit to sample length compositions.

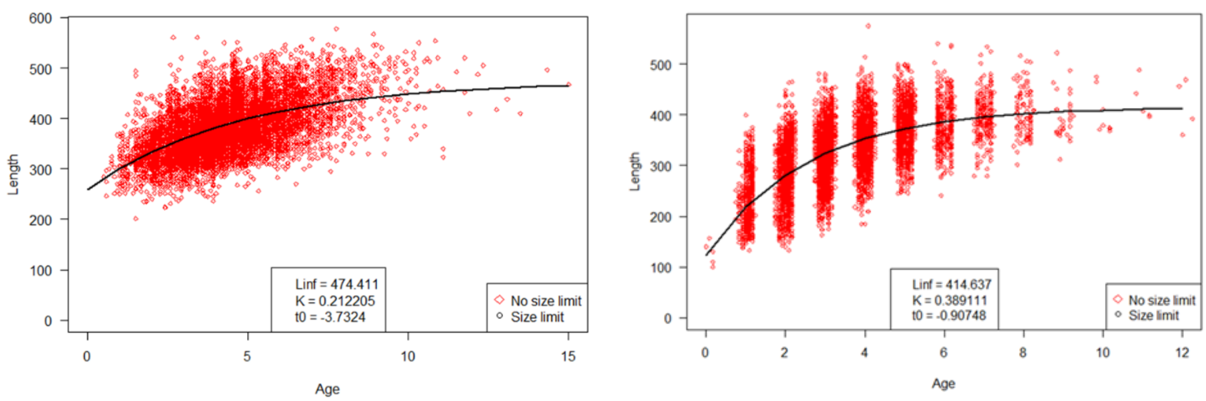


Fig. 1. Left: fishery dependent length-age data for Gray Triggerfish; right: fishery-independent (CVID trap) data.

*Fishery removals*

Reconstruction of a historical series of commercial and recreational fishery removals–landings and dead discards–was made back to 1988 for the assessment. This required a large number of decisions to impute missing values or to calibrate data series where design has changed, particularly for the change from the NMFS Marine Recreational Fisheries Statistics Survey (MRFSS) surveys (1981 to 2003) to the Marine Recreational Information Program (MRIP: 2004 to present), and for developing discards time series.

Landings of commercial handline fleets have improved in accuracy over time, and the DW proposed CVs that could be used for MCB uncertainty analysis in the assessment. Recreational landings of headboats are estimated from the Southeast Region Headboat

Survey (SRHS) log book scheme which has improved in quality over time due to introduction of mandatory reporting in 1996 and improved logbook supply from 2008 onwards. Private boat and charter boat landings since early 1980s were estimated from MRFSS/MRIP, which has a robust and peer-reviewed statistical design with improved design and precision over time, and for which CVs are estimated directly based on efficient estimators.

Discards estimates are inherently less reliable than landings for both the commercial and recreational fleets, and for the commercial handline fleet involved extrapolating observations for 2001-2011 to other years back to 1988. Separate discards estimates for the open and closed seasons since 2012 were made for this fishery based on effort. Recreational head boat discards estimates are available from SRHS log books since 2004, but for previous years back to 1988 are inferred using MRIP charter boat data adjusted using ratios of SRHS to MRIP estimates for 2004-2013. Gray Triggerfish discards estimates from SRHS and MRIP are self-reported and are not verified. All these uncertainties and data manipulations introduce error in the time series.

*Length and age compositions*

For Red Snapper, the SEDAR-41 AW used age composition data in preference to length composition data in BAM where both data exist, but for Gray Triggerfish the AW fitted both length and age compositions for headboats and the CVID survey which will result in some over-weighting of composition data. Length compositions from 1988 onwards were fitted for landings of commercial lines, headboats and from 1990 for the CVID survey. Headboat discards length frequencies were fitted from 2005 onwards. Age compositions for the commercial handline fleet and headboat landings were fitted mainly from the 2000s onwards and for the CVID survey from 1990 onwards. The CVID age data for Gray Triggerfish were found towards the end of the review meeting to have not been converted to calendar ages. Revised data were provided, and the assessment was rerun. (*see ToR's 2 and 3 for elaboration on this*)

The age compositions used at the Assessment Workshop were based on the number of annuli and the corrected data were based on calendar-year age. The change in estimates of age composition were substantial for 1991 to 2007, in which the corrected age compositions are approximately one year older. The change in estimates was less substantial after 2007. The difference in magnitude of the change results from a change in sampling protocol. From 1991 to 2007, sampling protocol was based on a target number of age samples per length bin, and the sample requirements were typically collected early in the sampling season, requiring conversion to calendar year by adding one to the annuli count an age. Sampling after 2007 was based on a random sampling design. Thus, post 2007, fish retained for age determination were distributed throughout the entire sampling season, requiring less of a correction.

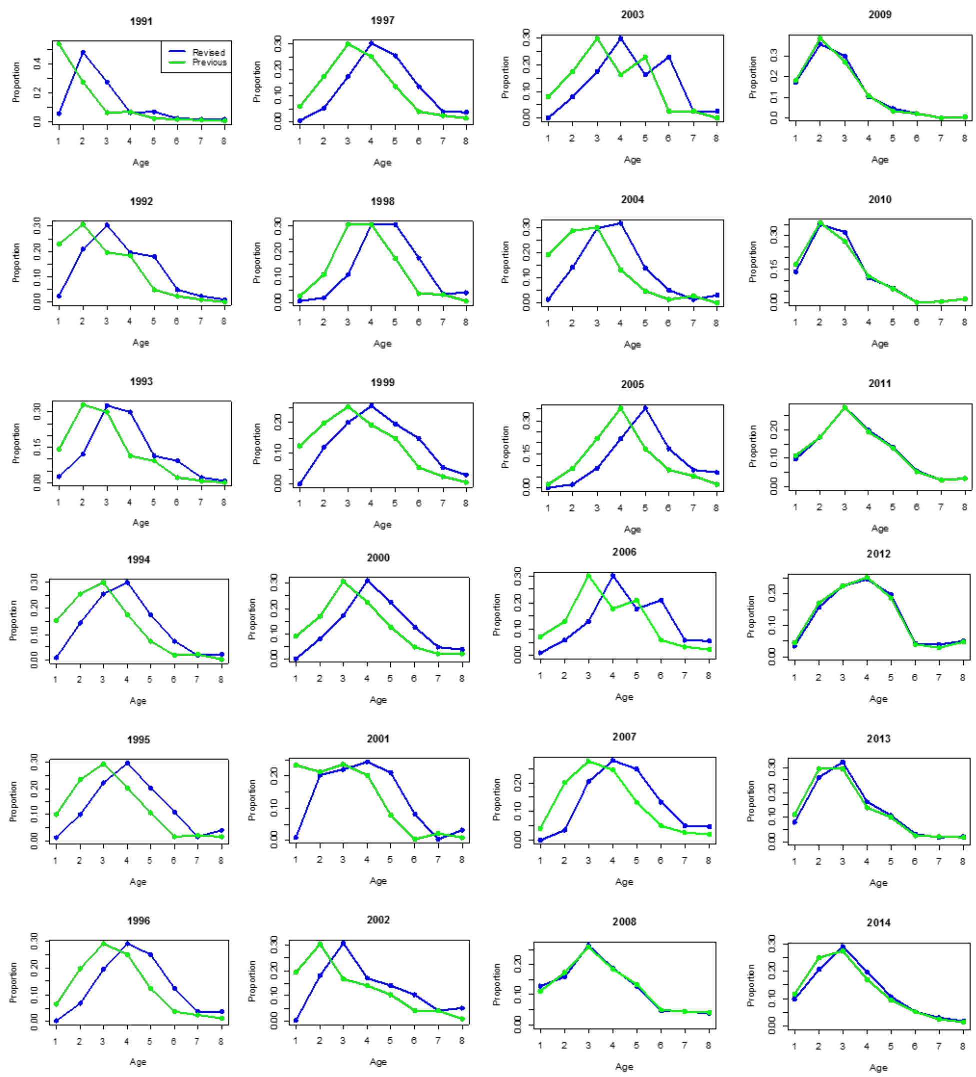


Figure 2. Age composition of the Chevron Video Trap Survey from the Assessment Workshop (green) and corrected (blue).

The Review Panel also expressed concerns regarding the broad length at age distributions relative to annual growth increment for many of the age classes making up a large portion of fishery-dependent and fishery-independent data (see Fig. 1 above), which will affect the ability of BAM to estimate annual age compositions through fit to length composition sample data. The Review Panel requested a sensitivity run of BAM with length data omitted where age data were available. This resulted in a deterioration in fit to some age composition data suggesting that the sampling for age, given the age error matrix, was inadequate for those years or could also reflect the correlations between length and age data collected from the same samples and the use of length data to weight the age compositions in each length class.

*Relative abundance indices*

The Review Panel considers the rationale for including CPUE data from three fisheries-dependent surveys and the two fisheries-independent series from the Chevron Trap Survey and the combined CVID trap/video survey in the BAM stock assessment model to be reasonable. The combination of trap/video survey indices from 2010 is clearly supported since the video camera is mounted on the trap, and hence cannot be considered independent. The standardized index for the fisheries-independent survey based on a zero-inflated model accounts for yearly shifts in sampling distributions relative to covariates that affect catch rates for Grey Triggerfish, and is restricted to depths from 10 to 94 m where Grey Triggerfish has been captured in any of the monitoring programs.

The various sources of systematic errors (e.g., spatial coverage, selectivity, trap saturation) and random errors (e.g., sample sizes) in each individual series are well documented. The established growth curves based on different data sources suggest that larger fish have lower probability to be captured in the CVID trap/video survey than by recreational fisheries.

Since Gray Triggerfish is unlikely to be the target for most fishing trips, the fishery-dependent CPUE series has potential to provide robust indices of abundance during periods of stable management measures that affect fishing behavior. However, the management measures applied to red snapper fishing since 2010 are likely to have caused a shift in targeting to other species which could also potentially cause a shift in catchability or selectivity for Gray Triggerfish.

The application of the fishery-dependent relative abundance data in the assessment model follows standard practice and appears sound. However, since the CPUE indices of abundance partly cover different depths/areas it should be noted that they do not individually cover the entire stock. The inclusion of these indices with equal weight in the model could therefore cause bias. A combination of the CPUE series external to the model based on their spatial/depth coverage is an alternative that may be explored in future assessments.

The use of the CVID chevron trap and video survey in the BAM model for Gray Triggerfish was considered in detail at the Review Workshop meeting due to the Assessment Panel's decision to up-weight the series by a factor of 6 to ensure a good fit to the index. This fishery-independent index covers center of geographic distribution of the stock (North Carolina – North Florida), full depth range, and extends over nearly the entire time series (1990-2014). However, the first year (1990) of the CVID chevron trap survey were conducted after hurricane Hugo, and may have experienced drastic lower catching efficiency due to strong habitat disturbances. The Review Panel recommends that in future assessments the inclusion of this first year be reconsidered.

The results of the stock assessment modeling depend on the relative weights assigned to different data sets. However, there is no consensus amongst practitioners as to the best approach to data weighting. This stock assessment follows the common practice of weighting compositional catch data and abundance indices in two stages. The input data are first assigned relative weights before the model is run, and then iteratively weighted during a model run to improve model fit. Ideally, stage one weighting would use information about sample sizes (primary sampling units, and lower level sample sizes) and the way in which the data were collected (i.e., multi-stage survey designs), through calculated precision and effective sample sizes (Francis 2011; Pennington and Vølstad 1994). In particular, abundance indices by cohorts are likely to have different precision due to differences in the number of primary sampling units (e.g., trips, or trap-sets) where the cohorts are caught (Aanes and Vølstad 2015). In general, the multi-stage sampling can introduce complex correlation structures among cohorts, and drastically reduce the effective sample sizes for estimating compositions, and indices of cohorts (Aanes and Vølstad 2015). This would allow different weighting to each data point. The annual CV's for the abundance indices from the fisheries-independent surveys are computed using bootstrapping (SEDAR41-DW52) but the weight assigned to the input data to the BAM model is chosen ad-hoc. In particular the six-fold up-weighting of the fishery-independent abundance indices (across cohorts) in the base model is poorly justified. The abundance indices appear to be assigned fixed stage one weights. However, since sample sizes vary over the years and across cohorts, a fixed CV could cause bias.

An estimate of the variance of the fishery-independent indices based only on the between trap variability will underestimate the true variance of the abundance indices if catchability varies over time. Pennington and Godø (1995) estimated the actual variance of survey abundance indices by cross-calibrating independent VPA estimates and survey catch per tow indices. The CPUE series could potentially be used to cross-calibrate the fishery-independent indices in a time series analysis.

Finally, the Review Panel recommends that future assessments investigate the possibility of a gear saturation effect for the Chevron Trap survey gear. Under the standard soak time of 90 mins Bacheler *et al*. (2013) have shown that catch rates of Gray Triggerfish tapers off once a moderate number of total individuals were already caught in a trap.

2. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and consider the following:
    a) Are methods scientifically sound and robust?
    b) Are assessment models configured properly and used consistent with standard practices?
    c) Are the methods appropriate for the available data?

The Review Panel concluded that this ToR was not met.

The base configuration of the Beaufort Assessment Model (BAM) from the Assessment Workshop was revised with corrected age compositions of the Chevron Trap survey during the Review Workshop. Although the determination of stock status was not influenced by the correction, results from the original base model run and from the corrected base model were somewhat different. The Review Panel requested and received two revised models to resolve apparent difficulties in fitting to the survey and associated estimates of abundance in the first year of the assessment series. Based on the magnitude of changes to the data, results and model diagnostics from the Assessment Workshop base model as well as concerns about overfitting the survey, the Review Panel recommends that further modeling is needed to model the corrected data appropriately.

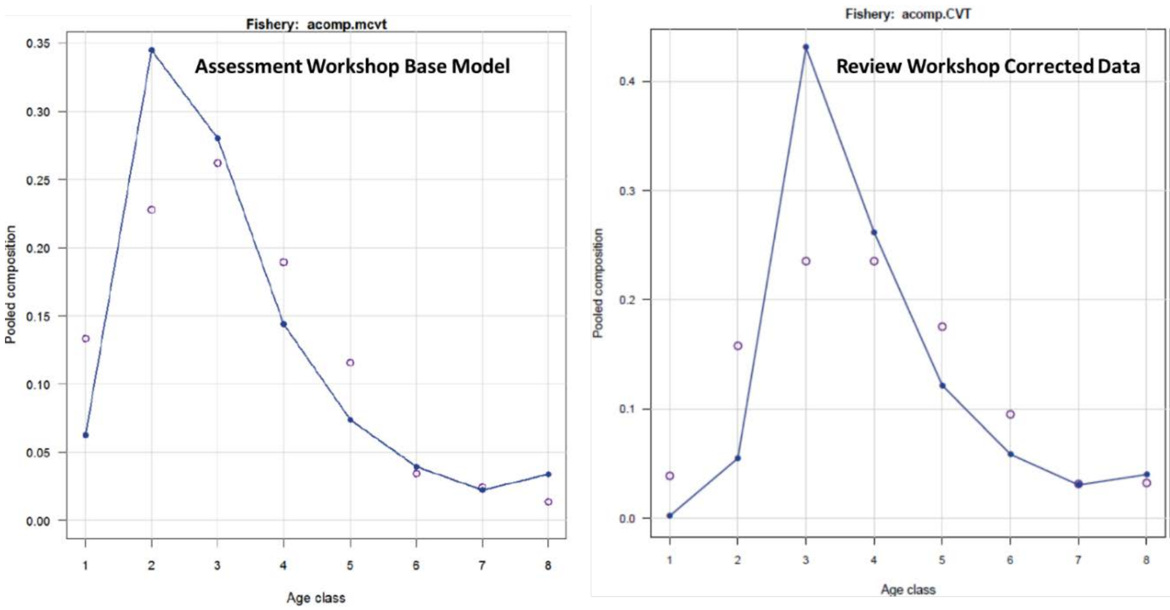


Figure 3. Observed and predicted age composition of the Chevron Video Trap Survey from the Assessment Workshop based model (left) and the corrected data and revised model from the Review Workshop (right).

In addition to the data corrections and model diagnostics, the Review Panel was concerned that the up-weighted survey (up-weighted 6-fold) in the Assessment Workshop base model was overfitting to the survey (i.e., fitting to survey measurement error rather than signals of abundance trends). The estimates of abundance at age in the first year of the assessment were the lowest in the assessment time series, despite being relatively early in the exploitation history. The low abundance estimates are produced by closely fitting to the first year of the trap survey, which was the lowest in the survey time series. An alternative with no up-weighting of the survey (sensitivity run 6) produced estimates of abundance in the first year of the assessment that were similar to the rest of the time series.

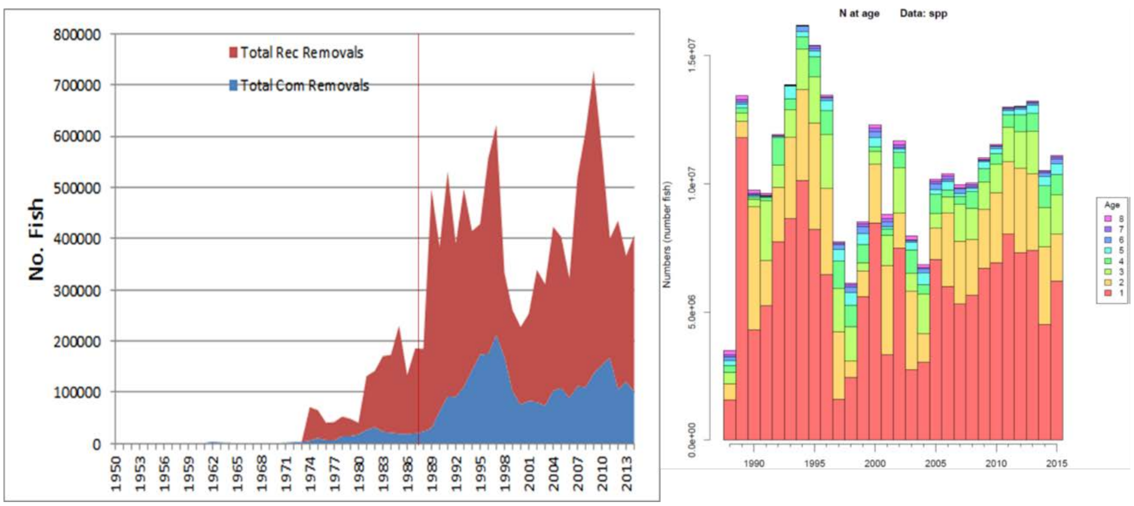


Figure 4. Exploitation history and abundance at age estimated from the corrected base model.

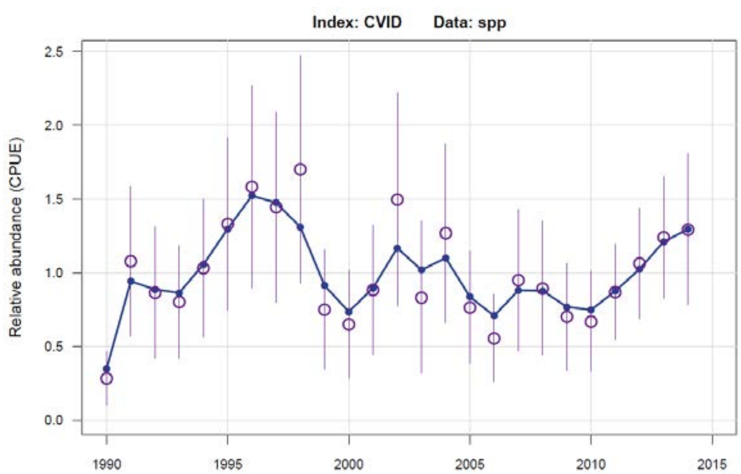


Figure 5. Observed and predicted Chevron Video Trap Survey indices from the corrected base model.

The Review Panel requested alternative analyses to help it understand the results. An alternative BAM configuration with a starting year of 1974 estimated a series of low recruitment to explain the low survey index in 1990. The Review Panel was also concerned that the need to up-weight the survey may result from using composition samples twice (as age compositions and length compositions). An exploratory analysis that removed length compositions for fleets with age compositions, with no up-weighting of the survey, still did not fit the survey well.

The extremely low estimates of abundance in the first year of the assessment may result from an unusual survey observation in the first year of the survey, rather than overfitting the entire survey series. An exploratory analysis that removed the 1990 survey observation produced estimates of abundance in the first year of the assessment that were similar to the rest of the time series. The Chevron trap survey began in 1988, but the protocol was being refined in 1988 and 1990. There have been no changes to the design of the survey since 1990. However, Hurricane Hugo was 7-8 months prior to the 1990 survey. A study of Jamaican reef fish found changes in abundance, behavior, and distribution a year after Hurricane Allen (Kaufman 1983).

3. Evaluate the assessment findings and consider the following:
    a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

The base model estimated very low levels of abundance in the initial years of 1988 and 1989 at a time when exploitation was expected to be quite low. Sensitivity runs determined that a combination of fitting the model closely to the low 1990 CVID point by using 6 times up-weighting and the assumed selectivity for the CVID resulted in low abundance and recruitment in the first two years. Fitting the CVID without up-weighting essentially resulted in no appreciable trend over the time series although the fit was contained within the confidence intervals for all the survey points. An additional issue was identified with inclusion of both age and length compositions in the fitting process which was explored after the CVID age compositions had been corrected for errors discovered late in the week. Additional runs to establish a base case with the corrected age compositions and removing length compositions when age compositions resulted in poor fits to the Headboat and CVID age compositions. At this point, the review panel concluded that there wasn’t enough time left in the meeting to establish a base case for gray triggerfish and the assessment panel needed to review the findings to date and work with the assessment team to develop a new base case.

    b) Is the stock overfished? What information helps you to reach this conclusion?

Without an accepted base case, the review panel was unable to determine if the stock was overfished with respect the standard reference points. However, based on the information presented the review panel could say that there was no evidence for a decline in abundance or biomass at this time.

    c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

Without an accepted base case, the review panel was unable to determine if overfishing was occurring with respect the standard reference points. Based on the information presented to the review panel there was no evidence that current levels of removals have resulted in overfishing.

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

The stock recruitment curve was not informative as there was little evidence for low recruitment at low stock size. Inference was based on setting steepness to 0.99 and mean annual recruitment was assumed. Lognormal deviations around the mean were estimated in the model.

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

Without a reliable base case, quantitative estimates of status determination were not available.

4. Evaluate the stock projections, including discussing the strengths and weaknesses, and consider the following:
    a) Are the methods consistent with accepted practices and available data?
    b) Are the methods appropriate for the assessment model and outputs?
    c) Are the results informative and robust, and are they useful to support inferences of probably future conditions?
    d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Since the base BAM model for Gray Triggerfish was not accepted by the Review Panel projections results were only reviewed in terms of the methodological approaches used—i.e., projections results were not considered as providing plausible scenarios and, therefore, were not investigated in detail.

The projection method used is consistent with those used widely in SEDAR assessments based on statistical models such as BAM and Stock Synthesis, and is consistent with the available data. Further the method described for the stochastic projections that extended the Monte Carlo/ Bootstrap (MCB) fits of the assessment model with added stochasticity in recruitment, and hence the propagation of uncertainty from the assessment into the projection period is internally consistent.

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
    a) Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.

b) Ensure that the implications of uncertainty in technical conclusions are clearly stated.

Like it was described above for ToR 4, because the base BAM model for Gray Triggerfish was not accepted by the Review Panel assessment uncertainty results were only reviewed in terms of the methodological approaches used. Further, the Review Panel is concerned that many of the reported uncertainties on quantities of interest are a consequence of the assumed (and fixed) observation variance parameters. No clear evidence of the appropriateness of these assumed values has been presented.

Because of the large number of parameters in BAM a thorough evaluation of convergence and model sensitivity is necessary, but difficult. Uncertainties in the assessment were explored through (1) a mixed Monte Carlo and bootstrap (MCB) analysis to quantify random errors in the assessment output; (2) sensitivity analysis around the base BAM run; and (3) the use of alternative assessment models.

The MCB runs included ranges of values of natural mortality, discard mortality and fecundity at age agreed by the assessment working group, together with bootstrap selection of data using well-justified error distributions

The sensitivity analyses were used to explore a wide range of data decisions, model assumptions and model configurations to examine the robustness of stock status determination. The model was run for a plausible range of values for each factor. The Review Panel noted that the sensitivity testing by alternating one factor at a time, although commonly done, may not fully reflect the uncertainty in model outputs from a complex model such as BAM with a large number of parameters where many are likely to be correlated (e.g., Saltelli and Annoni (2010). Global sensitivity analysis (Saltelli et al. 2008) may be used to untangle the contribution of single factors/parameters and interactions between parameters to the overall variability in model output. Anderson et al. (2011) provide an excellent overview of the literature, and many examples of applications of global sensitivity analysis to Integrated Assessment Models in climate research, and some of these are likely to be applicable to the BAM model.

Model uncertainty was mainly explored by running an alternative Stock Production Model Incorporating Covariates (ASPIC software of Prager, Version 7.03, 2005) that relies on length-age aggregated catch and CPUE indices, with no compositional catch being included. However, since the Assessment Panel concluded that none of the ASPIC runs produced during the Assessment Workshop produced plausible results and reasonable model diagnostics the use of this alternative modeling approach could not be properly evaluated for Gray Triggerfish in SEDAR 41. The Review Panel recommends that this approach be further explored at the next Gray Triggerfish assessment.

6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.
    a) Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
    b) Provide recommendations on possible ways to improve the SEDAR process.

- Increased fishery independent information, in particular reliable indices of abundance and age compositions.
- Increased age sampling and evaluation of ageing error over the stock area and from all fleets, particularly the general recreational fleet.
- More research to better understand the life history of Gray Triggerfish is needed, including natural mortality, maturity, and reproductive potential, particularly for the youngest ages.
- The effects of environmental variation on the changes in recruitment or survivorship of Gray Triggerfish.

7. Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation, and peer review of fishery management information.

    The Review Panel concluded that, as configured, the SEDAR 41 Gray Triggerfish stock assessment model could not be considered the best scientific information available.

8. Compare and contrast assessment uncertainties between the Gulf of Mexico and South Atlantic stocks.

    It was not possible to complete this ToR since the SEDAR 41 stock assessment could not be successfully completed (i.e., many of the assessment uncertainties could not be fully evaluated).

9. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

    The extremely low estimates of abundance in the first year of the assessment may result from an unusual survey observation in the first year of the survey, rather than overfitting the entire survey series. An exploratory analysis that removed the 1990 survey observation produced estimates of abundance in the first year of the assessment that were similar to the rest of the time series. The Chevron trap survey began in 1988, but the protocol was being refined in 1988 and 1990. There have been no changes to the design of the survey since 1990. However, Hurricane Hugo was 7-8 months prior to the 1990 survey. A study of Jamaican reef fish found changes in abundance, behavior, and distribution a year after Hurricane Allen (Kaufman 1983).

The Review Panel recommends that further modeling is needed to fit the corrected age data and to resolve the fit to the CVID survey (perhaps investigating a multispecies year effect in 1990) to consider possible effects from Hurricane Hugo and a justification for removing the 1990 survey observation.

10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Peer Review Summary Report in accordance with the project guidelines.

    This report constitutes the Review Panel's summary evaluation of the stock assessment and discussion of the Terms of Reference. The Review Panel will complete edits to its report and submit a final document to the SEDAR program for inclusion in the full set of documents associated with SEDAR 41.

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## 2.2 Summary Results of Analytical Requests