SEDAR

Southeast Data, Assessment, and Review

SEDAR 94

Stock Assessment Report

Florida Hogfish: [redacted] East Florida/Florida Keys Stock

August 2026

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

Table of Contents

Section I. Introduction	PDF page	3
Section II. Data Workshop Report	PDF page	43
Section III. Assessment Workshop Report	PDF page	284
Section IV. Research Recommendations	PDF page	520
Section V. Review Workshop Report	PDF page	528
Section VI. Post-Review Workshop Addenda	PDF pg	557

SEDAR

Southeast Data, Assessment, and Review

SEDAR 94

Florida Hogfish

SECTION III: Assessment Report

June 2026

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

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

Table of Contents

Table of Contents....2
1 Introduction....5
1.1 Workshop Times and Places....5
1.2 Terms of Reference....5
1.3 List of Participants....7
1.4 List of Working Papers and Reference Documents....8
2 Stock Synthesis Model Configurations....8
2.1 Overview....8
2.2 Life History....9
2.3 Fleet and Survey Configuration....10
2.3.1 Commercial....10
2.3.2 Recreational....10
2.3.3 Indices....12
2.3.4 Length Composition Data....13
2.3.5 Conditional Age-at-Length Data....13
2.4 Initial Conditions....14
2.5 Spatio-Temporal Structure....14
2.6 Recruitment Dynamics....15
2.7 Fishing Mortality....15
2.8 Catchability....16
2.9 Selectivity....16
2.9.1 Retention....17
2.9.2 Discards....17
2.10 Maximum Likelihood and Error Structure....18
2.11 Super-Periods and Data Weighting....18
2.12 Model Diagnostics....19
2.12.1 Convergence....19
2.12.2 Goodness of fit....20
2.12.3 Model Consistency....20
2.12.4 Model Validation (Prediction Skill)....21
2.12.5 Sensitivity Runs....21
2.13 Per-recruit Analyses....22
2.14 Uncertainty in Parameters and Derived Quantities....23
2.14.1 MCMC....23

2.14.2 Parametric Bootstrap 24
2.15 Bridge Building 25
3 FL KEYS/EFL Stock Synthesis Model Results 25
3.1 Life History 25
3.2 Landings and Discards 26
3.3 Indices 26
3.4 Length and Age Composition 26
3.4.1 Data Weighting 26
3.4.2 Length Composition 27
3.4.3 Conditional Age-at-Length 28
3.5 Estimated Parameters and Derived Quantities 28
3.5.1 Stock Biomass (Total and Spawning) 29
3.5.2 Recruitment 29
3.5.3 Fishing Mortality 29
3.5.4 Selectivity and Retention 30
3.6 Model Diagnostics 31
3.6.1 Convergence 31
3.6.2 Goodness of fit 31
3.6.3 Model Consistency 32
3.6.4 Model Validation (Prediction Skill) 33
3.6.5 Sensitivity Runs 33
3.7 Per-recruit Analyses 35
3.8 Uncertainty in Parameters and Derived Quantities 35
3.8.1 MCMC Analysis 35
3.8.2 Parametric Bootstrap 35
3.9 Stock Status Determination Criteria 36
3.10 Bridge Building 37
3.11 FL KEYS/EFL Discussion 37
3.12 FL KEYS/EFL Projections 41
3.12.1 Results 42
3.12.2 Discussion 43
3.13 FL KEYS/EFL Tables 45
3.14 FL KEYS/EFL Figures 74
4 WFS Stock Synthesis Model Results 140
4.1 Life History 140

4.2 Landings and Discards 140
4.3 Indices 140
4.4 Length and Age Composition 141
4.4.1 Data Weighting 141
4.4.2 Length Composition 141
4.4.3 Conditional Age-at-Length 142
4.5 Estimated Parameters and Derived Quantities 142
4.5.1 Stock Biomass (Total and Spawning) 143
4.5.2 Recruitment 143
4.5.3 Fishing Mortality 143
4.5.4 Selectivity and Retention 144
4.6 Model Diagnostics 144
4.6.1 Convergence 144
4.6.2 Goodness of fit 145
4.6.3 Model Consistency 145
4.6.4 Model Validation (Prediction Skill) 146
4.6.5 Sensitivity Runs 147
4.7 Per-recruit Analyses 147
4.8 Uncertainty in Parameters and Derived Quantities 148
4.8.1 MCMC Analysis 148
4.8.2 Parametric Bootstrap 148
4.9 Stock Status Determination Criteria 148
4.10 Bridge Building 149
4.11 WFS Discussion 150
4.12 WFS Projections 152
4.12.1 Results 152
4.12.2 Discussion 153
4.13 WFS Tables 154
4.14 WFS Figures 174
5 Literature Cited 234

1 Introduction

A benchmark assessment was conducted for Florida Hogfish which effectively served as two independent stock assessments within Florida waters: the Florida Keys/East Florida stock and the West Florida Shelf stock. Assessment models were constructed within the Stock Synthesis integrated modeling framework in version 3.30.24.1 (Methot and Wetzel 2013). This assessment renewed all available data streams from SEDAR 37 (2014) and the SEDAR 37U (2018) update assessment for the West Florida Shelf, provided and recommended measures of stock status according to each stock's management jurisdiction, and provided projections of spawning stock biomass, recruitment, and retained yield to inform the Acceptable Biological Catch (ABC) and the Annual Catch Limit (ACL) for each stock.

1.1 Workshop Times and Places

SEDAR 94 addressed two stock assessments for Hogfish in Florida waters, the Florida Keys/East Florida stock and the West Florida Shelf stock, and was provided by the State of Florida's Fish and Wildlife Research Institute (FWRI) with assistance from numerous state and federal collaborators. A series of four Assessment Workshop webinars were convened by SEDAR between December 2025 and April 2026.

1.2 Terms of Reference

1) Review any changes in data and data sources following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.
2) Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered.
    a) Fully document and describe the impacts (on population parameters and management benchmarks) of any changes to the model structure, methods, application or fitting procedures made between this assessment and both the prior benchmark (SEDAR 37) and update (SEDAR 37U) assessments.
    b) Provide a continuity model consistent with the prior benchmark (SEDAR 37) and update (SEDAR 37U) assessment configurations, 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. Provide additional continuity models which update these prior assessment's configurations and terminal years with MRIP-FES landings and discards.
3) Provide estimates of stock population parameters, if feasible:
    a) Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship (if applicable), and other parameters as necessary to describe the population.
    b) Include appropriate and representative measures of precision for parameter estimates.
    c) Compare and contrast population parameters and time series estimated in this assessment with values from the previous benchmark (SEDAR 37) and update (SEDAR 37U) assessments, and comment on the impacts of changes in data, assumptions or assessment methods on estimated population conditions.
4) Characterize uncertainty in the assessment and estimated values.
    a) Consider uncertainty in input data, modeling approach, and model configuration.
    b) Consider and include other sources as appropriate for this assessment.
    c) Provide appropriate measures of model performance, reliability, and 'goodness of fit'.
    d) Provide measures of uncertainty for estimated parameters.
5) Provide estimates of yield and productivity.
    a) Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.
6) Provide estimates of population benchmarks or management criteria consistent with available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management

programs, and National Standards. Include values for fishing mortality (including assumed discard mortality if appropriate), spawning stock biomass, fishery yield, SPR and recruitment for potential population benchmarks.

a) Evaluate existing or proposed management criteria as specified in the management summary.
b) Review and provide recommendations for proxy values (e.g. MSY) when necessary, and provide appropriate justifications.
c) Compare and contrast reference values (e.g. equilibrium yield at $F_{MSYProxy}$) estimated in this assessment with values from the previous benchmark (SEDAR 37) and update (SEDAR 37U) assessments, and comment on the impacts of changes in data, assumptions or assessment methods on reference point differences.
d) Define recent fishing mortality rates ($F_{Current}$) and recent spawning stock biomass ($SSB_{Current}$) that will be compared to management benchmarks to determine management benchmarks as the geometric mean of the most recent three years and the terminal data year, respectively.

7) Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment.
8) Provide declarations of stock status relative to management benchmarks or alternative data poor approaches if necessary.
9) Provide uncertainty distributions of proposed reference points, stock status, and yield.
   a) Provide the probability of overfishing at various harvest or exploitation levels.
   b) Provide a probability density function for biological reference point estimates.
   c) If the stock is overfished, provide the probability of rebuilding within mandated time periods as described in the management summary or applicable federal regulations.
   d) Characterize the differences in fishing mortality, virgin biomass, terminal total biomass, terminal spawning stock biomass, and equilibrium yield at $F_{MSYProxy}$ as a result of updating recreational catch and effort data from MRIP-CHTS to MRIP-FES by comparing SEDAR 37U to a continuity model with MRIP-FES landings and discards and SEDAR 37U configuration and terminal year.
10) Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time.
   a) Request estimates of retained landings in numbers and biomass from data providers for interim years between the terminal year and first year of the projections, if available, to be used to project future stock conditions. If estimates of retained landings are unavailable, use the average of the previous three years.
   b) Follow SAFMC Catch Level Projections Recommendations for Florida Keys-East Florida Stock.
   c) Recommend levels of recruitment to be used in the projections.
   d) Stock projections (including yields) shall be developed in accordance with the following ($F_{Current}$ is the geometric mean of the most recent three years of data):
      i) If stock is overfished:
         $F=0$, $F_{Current}$, $F=F_{MSY}$, F at 75% of F_{MSY}, F_{OY})
         $F=F_{Rebuild}$ (per Magnuson-Stevens Act)
      ii) If overfishing is occurring:
         $F=F_{Current}$, $F=F_{MSY}$, F at 75% of F_{MSY}, F_{OY}
      iii) If stock is neither overfished nor undergoing overfishing:
         $F=F_{Current}$, $F=F_{MSY}$, F at 75% of F_{MSY}, F_{OY}
      iv) If data limitations preclude classic projections (i.e. A, B, C above), explore alternative models to provide management advice.
      v) If an alternative proxy for F_{MSY} is recommended, provide outputs for both the current and recommended proxies.
11) Provide recommendations for future research and data collection.
   a) Be as specific as practicable in describing sampling design and sampling intensity.
   b) Emphasize items that will improve future assessment capabilities and reliability.
   c) Consider data, monitoring, and assessment needs.

12) Review, evaluate, and report on the status and progress of all research recommendations listed in the last assessment, peer review reports, and SSC report concerning this stock.
13) Complete the Assessment Workshop Report in accordance with project schedule deadlines (Section III of the SEDAR Stock Assessment Report).

1.3 List of Participants

Assessment Team

Chris Swanson ..... USF/FWC
Dustin Addis ..... FWC
Heather Christiansen ..... FWC/FWRI

Assessment Process Participants

Luiz Barbieri ..... GFMC SSC/FWC-FWRI
Genny Nesslage ..... SAFMC SSC/CBL
Steve Saul ..... GFMC SSC/ASU
Steve Turner ..... SAFMC SSC

Assessment Process Webinar Observers

Shanae Allen ..... FWC/FWRI
Jordan Bajema ..... FWC
Alena Figueroa ..... FWC
Jeanette Huber ..... FWC
K W .....
Daniel Luers ..... NOAA
Rich Malinowski ..... NMFS
Robert Muller ..... FWC/FWRI
Halie O'Farrell ..... FWC/FWRI
Ed Walker .....
Sabrine Zemik .....

Staff

Julie Neer ..... SEDAR
Chip Collier ..... SAFMC Staff
Judd Curtis ..... SAFMC Staff
Leonardo Eguia ..... GFMC Staff
Sarah Gardiner ..... GFMC Staff
Lisa Hollensead ..... GFMC Staff
Emily Ott ..... SEDAR
Ryan Rindone ..... GFMC Staff

1.4 List of Working Papers and Reference Documents

Document #	Title	Authors	Date Submitted
Documents Prepared for the Assessment Process			
SEDAR94-AP-01	A Unified Reef Visual Census (RVC) and REEF Citizen Science Index	Brice X. Semmens and Dan A. Greenberg	26 March 2026
SEDAR94-AP-02	Weighted Length Compositions for Recreational FL Keys-EFL Hogfish Landings Using MRIP, Biscayne National Park Creel Survey, and Headboat Data	Shanae D. Allen	15 May 2026

2 Stock Synthesis Model Configurations

2.1 Overview

The base models for the SEDAR 94 Florida Hogfish stock assessment of the Florida Keys/East Florida stock (hereafter, 'KEYS base model') and the West Florida Shelf stock (hereafter, 'WFS base model') were developed in Stock Synthesis (SS) version 3.30.24.1. Stock Synthesis is an age- and size-structured assessment model in the integrated analysis class of models. It has 1) a population sub-model that simulates growth, maturity, fecundity, recruitment, movement, and mortality processes, 2) an observation sub-model which predicts values for the input data, 3) a statistical sub-model which characterizes goodness of fit and obtains best-fitting parameters and their associated variance, and 4) a forecast sub-model which projects various user-determined management quantities (Methot et al. 2026). Further descriptions of SS options, equations, and algorithms can be found in the SS user's manual (Methot et al. 2026), the NOAA Fisheries Toolbox website (http://nft.nefsc.noaa.gov/), and Methot and Wetzel (2013).

The KEYS base model was of moderate complexity and informed by two fishing fleets (including landings, discards, compositional landings-at-length, and compositional discards-at-length where available), three fishery-independent indices of relative abundance (including length compositions), and two fishery-independent CAAL data that were not associated with any fleet or survey. The data sources and their corresponding temporal scale are presented in Figure 3.1. The KEYS base model estimated 165 out of 272 parameters including, but not limited to, growth parameters (asymptotic length [L_{inf}], von Bertalanffy growth coefficient [k], and the reference length for the start of von Bertalanffy growth [L_{min}]), virgin recruitment (*ln(R0)*), *steepness*, variability in recruitment (*sigmaR*), time-varying stock-recruit deviations, fishing mortality rates for each fleet and year that it was operational, and length-based selectivity parameters for fleets, landings, discards, retention and indices with length composition data. Model-derived estimates include maximum sustainable yield (MSY), MSY-proxy reference points (e.g., $F_{30\%SPR}$ and $F_{40\%SPR}$), and a full time series of population abundance-at-age (units: 1,000s of fish) and biomass (female plus male spawning stock biomass, total, and exploitable in metric tons). The 'r4ss' (Taylor et al. 2021) and 'ss3diags' (Carvalho et al. 2021) R software packages were utilized extensively to summarize and plot model outputs and perform diagnostic tests.

The WFS base model was of fair to moderate complexity and informed by three fishing fleets (including landings, discards, compositional landings-at-length, and compositional discards-at-length where available), three fishery-independent indices of relative abundance (including length and age compositions where available), and two fishery-independent CAAL data that were not associated with any fleet or survey. The data sources and their corresponding temporal scale are presented in Figure 4.1. The WFS base model estimated 87 out of 124 parameters including, but not limited to, growth parameters (asymptotic length [L_{inf}], von Bertalanffy growth coefficient [k], and the reference length for the start of von Bertalanffy growth [L_{min}]), virgin recruitment (*ln(R0)*), variability in recruitment (*sigmaR*), time-varying stock-recruit deviations, and length-based selectivity parameters for fleets, landings, discards, retention and indices with length composition data. Model-derived estimates include MSY-proxy reference points (e.g., $F_{30\%SPR}$) and a full time series of population abundance-at-age (units: 1,000s of fish), biomass (female plus male spawning stock biomass, total, and exploitable in metric tons), and fishing mortality rates for each fleet and year that it was operational.

2.2 Life History

Growth was estimated within SS according to the von Bertalanffy growth function where initial values for the asymptotic length (L_{inf}), the von Bertalanffy growth coefficient (k), and the CV as a function of length-at-age were based on the results of the external size-truncated model conducted during the Data Workshop (see Section 2.6.5 in the Data Workshop Report). The L_{max} parameter in SS was specified as equivalent to L_{inf}. The CV parameter was used in SS to describe the variability in length-at-age for the minimum (CV_{young}) and the maximum (CV_{old}) observed ages. Growth was initially configured such that fish grew according to the von Bertalanffy growth model immediately upon 'settlement' at age-0 (A_{min}) beginning at a length of 2 cm (L_{min}), but L_{min} was freely estimated.

The platoons feature within SS was also utilized to help account for "Lee's phenomenon" (Rosa Lee 1912), where the removal of faster growing individuals at a higher rate than slower growing ones leaves behind a population cumulatively comprised of slower growing individuals in the cohorts (McBride and Richardson 2007, Kraak et al. 2019). For the KEYS base model, total recruitment was divided into 5 platoons where the distribution among platoons approximated a normal distribution (0.031, 0.237, 0.464, 0.237, 0.031). In the WFS base model, total recruitment was divided into 3 growth platoons where the distribution among platoons also approximated a normal distribution (0.15, 0.70, 0.15). In both models, the parameter controlling the within/between standard deviation ratio was estimated. As a 'rule of thumb', ratio values below 0.5 were considered to have produced unrealistic distributions of mean size-at-age while ratios above 2.0 indicated no meaningful shift in mean size-at-age (R. Methot, *pers. comm*.).

In the KEYS base model, natural mortality followed the Lorenzen (1996) formulation (see Section 2.7.2 in Data Workshop Report) and the natural mortality-at-age vector was treated as a fixed input. The WFS base model utilized the Lorenzen option within SS where the Hamel and Cope (2022) longevity-based estimate of constant M (0.235 yr^{-1}; see Section 2.7.2 in Data Workshop Report) was treated as a fixed input for the natural mortality parameter across ages 3 – 23. Both models assumed natural mortality-at-age was constant over time.

Both models were configured with two genders to account for the reproductive biology of Hogfish as protogynous hermaphrodites (female at birth, then a portion of the population transitions to male). Thus, it was assumed that the sex-ratio at birth was 100% female. Immature females transitioned to mature females based on fixed stock-specific logistic functions of age (see section 2.8.2 in Data Workshop Report), and mature females transitioned to mature males based on fixed stock-specific cumulative normal distribution functions of length (see section 2.8.3 in Data Workshop Report). Given the

uncertainty of sperm limitation for this species, spawning stock biomass was modeled using the mature biomass of both females and males (Brooks et al. 2008). A fixed length-weight relationship ($w = a*L^b$) was used to convert body length (cm) to body weight (kg) with parameters $a = 2.55e^{-5}$; b = 2.9273 for both stocks as analyses conducted during the Data Workshop revealed no stock-specific differences for this relationship. Fecundity was configured as eggs/kg on body weight ($eggs = a * wt^b$) and parameterized such that the number of eggs was equivalent to spawning biomass by fixing $a = 1$ and $b = 1$ (see Section 2.8.4 in Data Workshop Report).

2.3 Fleet and Survey Configuration

The fleet configurations within each base model were informed by the amount of available length and age composition data, observed differences in sampled lengths and ages, uncertainty in the landings and discards, workgroup recommendations from the Data Workshop, and AW panel discussions.

2.3.1 Commercial

Commercial landings of Florida Hogfish from 1927 – 2024 were obtained from Florida's Marine Fisheries Trip Ticket and NOAA Fisheries' Accumulated Landings System (ALS) and were reviewed by the Data Workshop and recommended for use within each stock's assessment model. Although historical estimates (1927 – 1985) were considered highly uncertain, their lowest estimated precision (CV = 0.25 for 1927 – 1961) was still more precise than most annual recreational landings estimates (CV > 0.3; see Section 4.3 of the Data Workshop Report). Commercial landings were predominantly from spear, hook-and-line, and trap gears (see Section 3.3 of the Data Workshop Report) and are presented in Tables 3.1 – 4 and Figures 3.2 – 3 for years 1950 – 2024 for the Florida Keys/East Florida stock and Tables 4.1 – 4 and Figures 4.2 – 3 for years 1950 – 2024 for the West Florida Shelf stock.

Annual sample sizes for length and CAAL composition data by commercial gear type were also limited and highly variable. Given the relatively small contribution of the commercial sector and the sparse, noisy sampling data, the AW panel determined that, for each stock, aggregating all commercial gears into a single fleet was the most parsimonious modeling approach. This differed from SEDAR 37, which modeled spear, hook-and-line, and trap gears as separate commercial fleets for each stock.

No commercial discards were available for model inclusion in either stock (see Section 3.4 in the Data Workshop Report).

2.3.2 Recreational

Estimates of recreational landings and discards of Hogfish from 1981 – 2024 by anglers using private, rental boats, or charter boats came from the Marine Recreational Information Program (MRIP) and Florida's State Reef Fish Survey (SRFS). The 'Full SRFS' estimates, which were comprised of SRFS (2021 – 2024) and the SRFS ratio-calibrated private mode (1981 – 2020), MRIP charter mode, and MRIP shore mode (see Sections 4.3 and 4.4 in the Data Workshop Report) were reviewed by the Data Workshop and determined for use rather than the MRIP estimates. Estimates from the Southeast Region Headboat Survey (SRHS) were also available and recommended for use by the Data Workshop from 1981 – 2024 for the Florida Keys/East Florida stock and from 1986 – 2024 for the West Florida Shelf stock.

Recreational fishermen predominantly landed Hogfish in both stocks using spear and hook-and-line gears, but estimates were highly uncertain and often above CV thresholds of 30% and 50% (see Section 4.3 of the Data Workshop Report). In the SRHS, fishermen landed and discarded Hogfish using hook-and-line gears only and were often <1% of the SRFS landings and discards estimates. Therefore, in both stocks, the SRHS landings and discards estimates were respectively combined with the SRFS hook-and-line gear

estimates. Recreational landings and discard estimates by gear from the 'Full SRFS' and SRHS timeseries were compiled for each base model and are presented in Tables 3.5 – 6 and Figures 3.4 – 5 for the Florida Keys/East Florida stock and in Tables 4.5 – 6 and Figures 4.4 – 5 for the West Florida Shelf stock.

In the Florida Keys/East Florida stock, annual input sample sizes of recreational length and CAAL composition data by gear and mode were also low (combined across gears and modes: average 65 positive trips per year and 12 fish aged per year). Consequently, the AW panel determined to aggregate the recreational fisheries by gear and mode into a single combined recreational fleet (Tables 3.5 – 6). This differed from that in SEDAR 37 (2014), which despite having also combined the SRHS with the old MRFSS/MRIP hook-and-line estimates, defined two recreational fleets by gear (spear, hook-and-line). Lastly, for the KEYS base model, the landings estimates for 1981 (1.285 million fish) and 1984 (6.644 million fish), which were flagged by the Data Workshop, were each replaced with more 'reasonable' estimates by using the geometric mean of their respective six surrounding years (i.e., 3 years before and 3 years after) to become 295,197 fish in 1981 and 239,962 fish in 1984.

This trend in low data availability was also true for the West Florida Shelf stock where annual input sample sizes of recreational length and CAAL composition data by gear were very low (average 13 positive trips per year and 27 fish aged per year). Initially, the AW panel also wanted to aggregate the recreational fisheries by and gear and mode into a single combined recreational fleet, but determined that since the recreational hook-and-line fishery was continuing to develop and expand and had overtaken the spear fishery in landings in recent years, it should be tracked separately. Therefore, the recreational two-fleet structure by gear (spear, hook-and-line) was retained (Tables 4.5 – 6) as was done in SEDAR 37U (2018).

2.3.2.1 Historical Reconstruction of Recreational Landings

Historical recreational landings were extrapolated back to 1950 using available harvest data (i.e., the full SRFS timeseries plus SRHS landings) and were based on a combination of data related to possible changes in recreational anglers. This extrapolation was done to estimate the potential magnitude of recreational landings that would have occurred leading up to the initiation of the MRIP data in 1981, particularly since license data suggested a peak in recreational effort occurred in the mid-1970s. This data would help provide contrast in information as the fishery developed through time predominantly in the Florida Keys/East Florida region. Contrast in the data is helpful when estimating stock-recruitment parameters within an assessment model, particularly the *steepness* parameter which can be informed if the stock experienced a reduction in biomass and recruitment due to heavier fishing mortality and then recovery if that fishing mortality significantly decreases.

Previous estimates of historic recreational catch have been based on human population from the U.S. Census (Florida spotted seatrout, Murphy et al. 2011) or coastwide estimates of saltwater anglers and days spent saltwater fishing from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) (South Atlantic Spanish mackerel, Brennan and Fitzpatrick 2012). The human population method assumes that the number of anglers is proportional to the total coastal population and does not account for periods when recreational fishing expanded faster (or slower) than human population. The FHWAR method applied to Spanish mackerel uses coastwide estimates of saltwater fishing effort and assumes that the rate of expansion in saltwater angling was the same across the entire region. Here, information from the FHWAR survey was combined with historical fishing license data to estimate historical recreational catch in each year from 1950 – 1980.

Historic fishing license data were available in the USFWS National Fishing License Reports from 1958 – 2013; for Florida, no data were available in 1959 and 1960. These reports provide values for the number

of certified paid fishing license holders (participants) in each state, where a license holder is one individual regardless of the number of licenses purchased. The reports do not differentiate between saltwater and freshwater anglers. The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) provides data about the state in which these activities occurred; number of trips taken; days of participation; and expenditures for food, lodging, transportation, and equipment. The survey was conducted 1991, 1996, 2001, 2006, and 2011 by the Census Bureau for the U.S. Fish and Wildlife Service. An estimate of the percentage of anglers in each state that fish in saltwater is provided in these reports ("%saltwater"). This percentage was extrapolated linearly between years when the survey was not conducted. Prior to 1991, the "%saltwater" was only available nationally and only every five years from 1955 – 1985. These national percentages were used to extrapolate back the statewide estimates. The total number of license holders from the USFWS Historic Fishing License data was then adjusted by the percent estimates from the FHWAR surveys to get the total number of saltwater participants by year and state. Lastly, CPUE was calculated for each year and state by dividing the recreational landings estimates by the total number of saltwater participants. The number of saltwater participants was then multiplied by the average CPUE to estimate historical harvest since 1950. These historical estimates were also available during SEDAR 37 (2014). An update to this method was recently applied to south Atlantic Red Snapper (SEDAR98-DW-08) but showed negligible differences (<=1%) in estimates between the two methods. Thus, the original SEDAR 37 methodology was retained here.

In the Florida Keys/East Florida region, recreational landings estimates from the Full SRFS plus SRHS averaged 97.6% (geometric mean) of the total Florida-wide landings between 1981 – 1985. Therefore, the annual numbers of saltwater angler participants in Florida were multiplied by 0.976097 to estimate the annual numbers of participants for the Florida Keys/East Florida region (Table 3.7). CPUE was calculated only using years 1982, 1983, and 1985 (CPUE = 0.263904) as landings estimates for 1981 and 1984 were flagged by the Data Workshop and, when incorporated, egregiously inflated CPUE values (CPUE >2.6). Thus, historical recreational landings estimates were reconstructed for the Florida Keys/East Florida region for the assessment model and are presented in Table 3.7. A comparison of these reconstructed landings alongside the historic commercial landings estimates (in numbers) for years 1950 – 2024 is provided in Figure 3.6. Commercial landings were generally low relative to recreational landings and averaged 5.75% of total landings in numbers across the entire timeseries. The reconstructed recreational landings provided a ramp-up into higher landings estimated to have occurred during the 1970s at a similar magnitude to those of the 1980s through early-1990s (Figure 3.6).

Historic recreational landings estimates were also reconstructed for the West Florida Shelf. First, the annual number of saltwater angler participants in Florida was multiplied by 0.023903 so that what wasn't apportioned to the Florida Keys/East Florida above went to the West Florida Shelf (i.e., 1 – 0.976097). The CPUE was calculated using years 1981 – 1983 (CPUE = 0.929120; no landings estimates for years 1984 – 1985) which was then multiplied by the number of saltwater angler participants to reconstruct the number of landings (Table 4.7). A comparison of these reconstructed landings alongside the historic commercial landings estimates (in numbers) for years 1950 – 2024 is provided in Figure 4.6. Commercial landings were a little higher, averaging 21.53% of the total landings in numbers across the entire timeseries. The reconstructed recreational landings were not found to add any further contrast to the data but rather portrayed a ramp-up into a landings trend that was already gradually increasing through time thereby extending that trend (Figure 4.6).

2.3.3 Indices

For the KEYS base model, three fishery-independent surveys were modeled: the Reef Visual Census Florida Keys (RVC KEYS), the Reef Visual Census Dry Tortugas (RVC DRTO), and a combined video

survey (combined video; Table 3.8, Figure 3.7). Although the Reef Visual Census Southeast Florida (RVC SEFL) index was submitted for use by the Data Workshop, discussions from the AW panel ultimately led to its removal given frequent duplication with the RVC KEYS index (e.g., overlapping length composition data, 8 years of data with 5 years of overlap) and model parsimony. While there is no individual young-of-year (YOY) survey, the length composition data from the RVC KEYS survey indicates the presence of age-0 fish which have recruited to the reefs and could be used to help inform recruitment within the KEYS base model.

Three fishery-independent surveys were used within the WFS base model: the FWRI FIM polyhaline seagrass survey (seagrass trawl), the SEAMAP-FWRI trawl survey (SEAMAP trawl), and a combined video survey (combined video; Table 4.8, Figure 4.7). The seagrass trawl survey was configured within the WFS base model as an age-0 recruitment index. The fishery-dependent MRIP hook-and-line CPUE, which was submitted for use by the Data Workshop, was ultimately not recommended for inclusion following AW panel discussions and the presence of three fishery-independent indices tracking young-of-year, subadult, and adult life stages.

2.3.4 Length Composition Data

Weighted length compositions for the SEDAR 94 base models were compiled for catch (landings and releases) of Hogfish by fishery and primary gear type. Raw length composition data from fishery-dependent sources may be a biased reflection of the length composition of the catch due to uneven sampling in space and time. Therefore, when calculating landings- and releases-at-length (fish landed or released per length bin in numbers), it is recommended to weight the sampled lengths of landed or released fish at the finest possible scale by the inverse of sampling proportion (Maunder et al. 2020).

Weighted length compositions of the landings and releases are described in detail in SEDAR94-AP-01. In brief, length compositions of landings and releases were catch-weighted according to scales that generally satisfied a minimum level of sampling and captured key differences in sampled lengths. Input sample sizes for length compositions were set equal to the number of trips with at least one measured Hogfish. They were then internally re-weighted using fleet-specific Dirichlet-Multinomial parameters or Francis multipliers to estimate effective sample sizes (for additional details refer below to Section 2.11).

Catch-weighted length compositions of landed and released alive Hogfish are summarized by fleet in Figures 3.8 – 9 for the KEYS base model and in Figure 4.8 for the WFS base model. Length samples were assigned to have occurred mid-year (July) and were binned into 2 cm fork length intervals from 2 – 86 cm (KEYS base model) or 2 – 90 cm (WFS base model).

2.3.5 Conditional Age-at-Length Data

Conditional age-at-length inputs by fleet are presented in Figures 3.10 – 13 for the KEYS base model and Figures 4.9 – 10 for the WFS base model. This input allows the integrated models to use the information from sparse age-length data without assuming that the data was representative of ages across the full range of sizes. Input sample sizes for the number of ages sampled in a given length bin by year were set equal to the number of aged fish and were assigned to have occurred mid-year (July).

Conditional age-at-length data is particularly useful when internally estimating growth and is conditioned on the selectivity associated with the data.

Conditional age-at-length inputs are presented in Figures 3.10 – 13 for the KEYS base model and Figures 4.9 – 10 for the WFS base model and were available from the retained landings of the fishery fleets as well as from the various fishery-independent life history research parsed by gear. Conditional age-at-length data is particularly useful when internally estimating growth. It allows the integrated models to use

the information from sparse age-length data, without assuming that the data was representative of ages across the full range of sizes, and is conditioned on the selectivity associated with the data. For the WFS base model, only the CAAL data from the SEAMAP trawl survey and the fishery-independent spear data collected from various life history research were retained. During the model development process, it was found that inclusion of the sparse commercial and recreational CAAL data resulted in conflict with the length data and prohibited reasonable estimates of L_{inf} (e.g., chasing the upper bound of 130 cm FL). The AW panel was concerned that growth could not be reasonably estimated internally opted to retain only the CAAL data which were considered most informative to growth.

2.4 Initial Conditions

The KEYS base model used 1950 as the starting year and did not assume the stock was at equilibrium because Hogfish removals are known to have occurred in the southeastern U.S. since the late 1930s, primarily in the Florida Keys region. Available estimates of historical commercial and recreational landings were not considered stable over time; instead, they were characterized as a ramp-up to peak catch levels observed during the 1970s through the early-1990s. Although the precision of these historical catch estimates was low, their inclusion allowed for fleet- and year-specific estimation of fishing mortality rates and was considered preferable to assuming unknown fleet-specific equilibrium catch and initial fishing mortality rates. The model also assumed that removals prior to 1950 remained below MSY and that the population had not declined below B_{MSY}.

The start year of the WFS base model was 1986 and the stock was also not assumed to be at equilibrium. As mentioned above, the historic commercial and reconstructed recreational catch suggested a low level of landings which gradually increased through time. The inclusion of this data was explored during the model development process; however, the use of the reconstructed data did not further inform model parameters in a more significant way compared to if the model only had data available from 1986. The trade-off of additional uncertainty for no difference in model results led to the AW panel's decision of starting the model in 1986. Therefore, an *ln(R0)* offset parameter was configured for 1985 which estimated an initial depletion of the stock before the model began in 1986.

2.5 Spatio-Temporal Structure

The SEDAR 94 base models were configured as single area models within their respective stock boundaries as defined by the 25° 9' N latitudinal line off Cape Sable, Florida (see Section 2.3 in Data Workshop Report). The West Florida Shelf encompassed the eastern Gulf waters north of this boundary while the Florida Keys/East Florida stock comprised waters south of this boundary, around the Florida peninsula, and north to the Florida/Georgia border. Fishing fleets were separated by sector (e.g., commercial and recreational), each having a distinct selectivity, with low sample sizes across data components at finer regional spatial scales precluding further spatial separation of fleets within stock boundaries.

Hogfish in the Florida Keys/East Florida stock were modeled from age-0 through age-16 years (maximum age observed in this stock), while Hogfish in the West Florida Shelf stock were modeled from age-0 through age-23 (maximum age observed in this stock). Recruits for both stocks were defined as fish which recruited to the biological population at calendar age-0. Each model was configured with one season (i.e., annual) from January through December where fishing was treated to have occurred throughout the whole season. Hogfish are protracted spawners with a core spawning season in winter months. Therefore, spawning was configured to occur on January 1 and, given a pelagic larval duration of ~34 days (see Section 2.4 in Data Workshop Report), settlement of recruits was configured to occur in February. Surveys, length composition data, and CAAL data were configured to occur mid-year (July 1).

2.6 Recruitment Dynamics

Each SEDAR 94 base model assumed the Beverton-Holt stock-recruitment relationship. In SS, this stock-recruitment function uses three parameters which were simultaneously estimated: 1) *steepness* (the initial slope of the ascending limb), 2) the virgin recruitment estimated in log-space (*ln(R0)*), and 3) the standard deviation of the natural log of recruitment (*sigmaR*). *SigmaR* penalizes deviations from the spawner-recruitment curve (calculated from *ln(R0)* and *steepness*), and it defines the difference between the arithmetic mean spawner-recruitment curve and the expected geometric mean (Methot et al. 2026).

All three stock-recruitment parameters were estimated within the KEYS base model. However, only the *ln(R0)* and *sigmaR* parameters were estimated within the WFS base model. The total landings time series for the West Florida Shelf showed little contrast as it generally increased over time, with the highest removals occurring near the end of the series. Because the data did not provide enough information to estimate the *steepness* parameter, the model consistently converged on a value of 0.99. As a result, *steepness* was fixed at this value, effectively assuming average recruitment rather than estimating a stock-recruitment relationship. This issue was also encountered in SEDAR 37 and SEDAR 37U, where the same approach was adopted.

Simple annual deviations from the stock-recruitment function, which were constrained to sum to zero, were estimated assuming a lognormal error structure. Main recruitment deviations were estimated for years of greater data-richness (1981 – 2021, KEYS; 1986 – 2024, WFS) and corresponded to when the length and age composition data for the fleets began to become available. Recruitment for years 1950 – 1980 in the KEYS base model followed the stock-recruitment curve. No early recruitment deviations were estimated in both models. In SS, expected recruitments need to be bias-adjusted because of its assumed lognormal error structure. The adjustment is accomplished by applying a full-bias correction to the recruitment deviations which have enough data to inform the model about the range of recruitment variability (Methot et al. 2026). Following the recommendation from Methot and Taylor (2011) to use the full bias adjustment on data-rich years, the KEYS base model used full bias adjustment between 1991 – 2022 and the WFS base model used full bias adjustment between 1995 – 2022, after which both models phased out to no bias adjustment through 2024.

Earlier in the KEYS base model development process, main recruitment deviations were configured to extend to the terminal year, 2024, and deviations were not constrained to sum to zero. Estimated recruitment in the last three years (2022 – 2024) was highly elevated, following the index of abundance trends and corresponded to the stock continuing to recover after management intervention beginning in 2017. However, this configuration also produced a retrospective pattern due to the model's inability to predict that recovery trend as the terminal years of the model withdraw. The AW panel felt the increasing trend in recruitment was likely realistic given the data; however, introducing process error by removing the deviations for years 2022 – 2024 (i.e., recruitment followed the stock-recruitment curve instead) still allowed recruitment to increase, but eliminated the retrospective pattern.

2.7 Fishing Mortality

Fishing mortality (F) can be estimated with two approaches in SS: a mid-season harvest rate using Pope's approximation or a season-long fishing mortality rate using the Baranov catch equation (Methot et al. 2026). When estimated as a season-long rate, F can be a parameter for each year and fleet (F_{Par}) or can be a tuned factor using Pope's and Baranov catch equations sequentially (i.e., a hybrid, F_{hybrid}). As a parameter, F_{Par} is influenced most by both types of catch data (retained and discards) and associated standard errors; whereas the tuning of F_{hybrid} is influenced by only the retained catch and can result in the near exact match to the observed retained catch but poorer fits to the discard data.

In the KEYS base model, fishing mortality for the commercial fleet was configured using F_{hybrid} because the standard errors for the landings were generally small (~0.05) and there were no available discard estimates; whereas the recreational fleet was configured using F_{Par} because discards were available and the standard errors associated with the landings were often >0.4. While the same was true for the West Florida Shelf data, the WFS base model did not show significant improvement to model fit of the indices, length compositions, or CAAL data when configured with F_{Par}. Therefore, rather than unnecessarily add annual fleet-specific fishing mortality parameters to the model (i.e., overparameterize), all three fleets were configured using F_{hybrid}.

For tracking and reporting purposes, both base models utilized the annual exploitation rate (biomass), calculated as the ratio of the total annual catch in biomass to the age-1+ biomass at the beginning of the year, to characterize the fishing mortality rates of Hogfish. This was chosen to account for the differing spear and hook-and-line selectivities, to track both female and male portions of the population (not just one or the other), and to be consistent and comparable with both SEDAR 37 (2014) and SEDAR 37U (2018) assessments.

2.8 Catchability

For each of the three respective fishery-independent surveys within each SEDAR 94 base model, constant catchability was assumed. In the SEDAR 37 FLK/EFL base model, time varying catchability was applied to an earlier-starting RVC KEYS index to account for a change in survey design, and which resulted in a doubling of estimated survey catchability. For the SEDAR 94 KEYS base model, the RVC KEYS index started in 1999 and thereby circumvented the need to estimate changes in survey catchability.

2.9 Selectivity

Selectivity patterns describe the probability of capture-at-length or -age by a given fishery or gear. Selectivity can be used to model different gear types, targeting, and fish availability according to the spatial utilization of fish and/or fishery. When configuring length-based selectivity, SS will also estimate a derived age-based selectivity.

The KEYS base model was configured using length-based selectivity for all fleets and indices where selectivity for the commercial fleet and retention for the recreational fleet followed major changes in size limits and bag/trip limits in the south Atlantic regulation of Hogfish in the Florida Keys/East Florida. Selectivity of both the commercial and recreational fleets were configured using the six-parameter double normal function to best accommodate each fleet's differences in gear's selectivity patterns. Five of the six parameters were freely estimated and the fixed parameter (p5 – initial selectivity at start bin) was configured such as to extend the logistic decay of small fish selectivity down to the start bin. Without any estimated discards, commercial selectivity was configured to change following major changes in South Atlantic regulations of Hogfish. Time-varying selectivity was applied for years 1950 – 1994 (no size or bag limit regulations), 1995 – 2017 (minimum size limit of 12" fork length), and 2018 – 2024 (minimum size limit of 16" fork length and 25lb ww bag limit per boat/day).

Both RVC indices (Florida Keys and Dry Tortugas) were configured with dome-shaped selectivity using the six-parameter double normal function based on the survey area, length composition data, as well as the survey design being constrained to depths less than 30 m. For both indices, five of the six parameters were freely estimated where p5 (initial selectivity at start bin) was fixed as above. Selectivity for both indices was also held constant over time.

Selectivity for the combined video survey in the KEYS base model was configured using a single-logistic function (flat-topped) based on the gear (stereo-imaging cameras), survey area and design where sampled

depths occurred greater than 30 m, and length composition data. Both parameters were freely estimated and held constant over time.

The WFS base model was configured using length-based selectivity for all fleets and indices except for the FWRI FIM polyhaline seagrass survey which was specified as an age-0 recruitment index (i.e., selectivity = 1 only on age-0 fish). All three fishing fleets were configured using the six-parameter double normal function for flexibility and were based on fishermen input on where the fisheries largely operate and their respective observed composition data. Selectivity of all three fishing fleets varied through time following eastern Gulf regulatory changes in minimum size limits of Hogfish for years 1986 – 1999 (no size or bag limit regulations), 2000 – 2017 (minimum size limit of 12" fork length), and 2018 – 2024 (minimum size limit of 14" fork length). For the commercial fleet, 5 of the 6 parameters were freely estimated and allowed for selection of larger and older fish through the final length bin. However, for both recreational fleets, the length composition data were heavily domed and showed very little selectivity of fish into the larger length bins. Following model parsimony, only 4 of the 6 parameters were estimated where p5 and p6 (final selectivity at last bin) was also fixed to decay the large fish selectivity down to the final bin.

The SEAMAP-FWRI trawl survey in the WFS was configured with dome-shaped selectivity using the six-parameter double normal function and based on gear design (i.e., a trawl), survey area where Hogfish were primarily collected, and the length composition data. Five of six parameters were freely estimated and held constant through time.

The combined video survey in the WFS was configured using a single-logistic function (flat-topped) based on the gear (stereo-imaging cameras), survey area, sampling depths, and length composition data. Both parameters were freely estimated and held constant over time.

2.9.1 Retention

Size regulations for Hogfish are in the form of a minimum size limit; therefore, retention was modeled as an asymptotic function of size using a four-parameter logistic function.

In the KEYS base model, time varying asymptotic retention was applied to the recreational fleet to account for changes in size and bag limits. The first three retention parameters were freely estimated but varied for years 1950 – 1994 (no size or bag limit regulations), 1995 – 2017 (minimum size limit of 12" fork length and bag limit of 5 fish/person), and 2018 – 2024 (minimum size limit of 16" fork length and bag limit of 1 fish/person). The fourth parameter (male offset) was not applicable and was fixed at zero.

For the WFS base model, asymptotic retention was applied only to the recreational hook-and-line fleet where the first three retention parameters were freely estimated and the first two varied for years 1986 – 1999 (no size or bag limit regulations), 2000 – 2017 (minimum size limit of 12" fork length), and 2018 – 2024 (minimum size limit of 14" fork length) to account for changes in size limits. The fourth parameter (male offset) was not applicable and was fixed at zero. Discard estimates were unavailable for the commercial fleet and were insufficient (i.e., only two observations) for the recreational spear fleet (i.e., only two years of highly uncertain observations); therefore, retention was not modeled separately.

2.9.2 Discards

Live and dead discards were calculated and fit for the recreational fleet within the KEYS base model and for the recreational hook-and-line fleet within the WFS base model. Live discards were estimated by applying the converse of the retention function to the total catch, while dead discards were the result of assumed discard mortality rates (Methot and Wetzel 2013). The recreational discard mortality rate was treated as a fixed input (41.4 %, see section 4.7 in the Data Workshop Report) for each base model.

Discard mortality rates are a logistic function of size such that mortality may decline from 1.0 to an asymptotic level as fish get larger. However, the discard mortality rate was treated as constant across size by setting both the ascending slope (p1) and descending slope (p2) parameters to 0.1 and the parameter producing the discard mortality rate (p3) to the specified value (i.e., 0.414). Discard mortality rates were also assumed to be constant through time.

2.10 Maximum Likelihood and Error Structure

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

The error structure for landings, discards, and indices was assumed to be lognormal, except where noted. For most data sources, the variance of the observations was available only as a coefficient of variation (CV). In SS, if lognormal error structures were required, CVs were converted to a standard error (SE) in log-space using $SE = \sqrt{ln(1 + CV^2)}$. Within the landings data, commercial landings contained little uncertainty (see Section 3.3 of the Data Workshop Report) because the programs which collect those data consider it a census (assumed to be complete or nearly so) rather than a survey (which is from a sample). Limitations of the SRHS design prevented variance estimates from being developed for the headboat landings and discard estimates, and while proxy CV values were available for this assessment, the CVs for the SRFS estimates were used since they were combined into one recreational fleet. Uncertainty in the index observations was estimated through the standardization techniques used therein to determine final observed index CV values (see Section 5.4 of the Data Workshop Report).

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

The variance associated with each data source can be highly influential, especially when there are conflicts among data sources. Because true effective sample sizes are unknown, input sample sizes were initially set equal to the number of trips with at least one measured Hogfish for length composition data to avoid over-weighting observations of lengths in the likelihoods. The input sample sizes for CAAL data were set to the number of Hogfish sampled because there are fewer fish aged at a given length bin.

2.11 Super-Periods and Data Weighting

In both SEDAR 94 base models, the length composition data for the respective commercial and recreational fleets were characterized by low annual sample sizes, often well below 30 or 50, which produced very coarse and angular distributions for selectivity functions to fit. To help reduce noise and

increase input sample sizes, the super-period approach within SS was utilized which allowed the data to be representative blend across a set of time steps and cause the model to create an expected value for this observation using the same set of time steps (Methot et al. 2026). For the respective fishery fleets within each base model, the super-periods followed when the data became available and when the regulatory time blocks occurred to align with the changes in selectivity and/or retention. In the KEYS base model, super-periods were not applied to the size composition data of either RVC index, but a single super-period was applied across the whole timeseries for the combined video survey due to similar annual sample size issues. In the WFS base model, no super-periods were applied to the SEAMAP survey or the combined video survey composition data.

In the KEYS base model, the Dirichlet-Multinomial distribution, which estimates a parameter (*theta*, θ) that internally scales the input sample size for composition data, was implemented on all length composition data (Thorson et al. 2017; Methot et al. 2026). All *theta* parameters were also given a normal prior N(0, 1.813) as recommended by Ian Taylor (Methot et al. 2026). For the CAAL data (i.e., commercial landings, recreational landings, fishery-independent spear, and fishery-independent trawl), theta parameters were generally estimated greater than 4 and nearly 5 (i.e., they were associated with 99 – 100% weight with little information in the likelihood about the parameter value) and the theta ratios ($\theta/(1+\theta)$) were close to 1.0, indicating that the model was attempting to tune the input sample sizes as high as possible (Methot et al. 2026). Since the CAAL input sample sizes were based on the number of fish aged within each length bin, manually changing them to a higher input sample size seemed unachievable apart from aggregating them into larger age-at-length bins. Therefore, the CAAL data were left unweighted.

For the WFS base model, Francis weighting was applied to the length composition data as well as to the CAAL data (TA1.8 in Francis 2011). Francis (2011) and Punt (2017) developed re-weighting procedures to adjust the effective sample sizes of length and age data iteratively until the multipliers reached a stable value. Multipliers are calculated so that variability of model inputs is consistent with the model fits to mean length or mean age (Francis 2011). Iterations of the WFS base model were sequentially conducted until the decrease in total likelihood of the model resulted in a difference of two units or less and subjective intervention by the analyst was minimized.

Both Francis and Dirichlet-multinomial weighting methods were explored within each respective base model and final weighting methods were chosen based on individual model performance, diagnostics, and AW panel discussions.

2.12 Model Diagnostics

Model diagnostics of the SEDAR 96 base models were performed in R using the 'r4ss' and 'ss3diags' (github.com/JABBAmodel/ss3diags) packages and largely followed the recommendations put forth in the Carvalho et al. (2021) "cookbook" for integrated stock assessment models. While each diagnostic is briefly summarized below, further descriptions can be found in Carvalho et al. (2021) and references therein.

2.12.1 Convergence

Convergence of the base model was initially assessed by determining that there were no parameters estimated at a bound, the final gradient was 0.0001 or less, and that the Hessian matrix was positive definite.

2.12.1.1 Correlation Analysis

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

2.12.1.2 Jitter Analysis

Once individual model convergence was established, a jitter analysis varied the parameter's starting values to gauge whether the base model had converged on a global solution instead of a local minimum. For this analysis, initial values were jittered by 20% and 100 iterations were performed.

2.12.2 Goodness of fit

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

2.12.3 Model Consistency

2.12.3.1 Likelihood Profiles

Consistency within the base model was evaluated by identifying how the sources of information influence various model estimates. This was done first through likelihood component profiles on two important stock-recruitment parameters where applicable: the virgin recruitment parameter, *ln(R0)*, and the *steepness* parameter. The *ln(R0)* parameter, largely regarded as an ideal global scaling parameter, was sequentially fixed to plausible values ranging in log-space from 7.0 – 9.0 by 0.1 (KEYS base model) or from 6.5 – 8.5 by 0.1 (WFS base model) and the change in total and data-component likelihoods were examined. In the KEYS base model, the *steepness* parameter was fixed to values ranging from 0.3 – 0.99 by 0.05. Ideally, the plotted relationship between negative marginal likelihood values and the range of parameter values yields a well-defined minimum that aligns with that estimated by the base model. If a given parameter is not well estimated, the profile plot may show conflicting signals across data sources and/or a flat marginal likelihood surface. This indicates that multiple parameter values are equally likely given the data. In such instances, the parameter may not be influential in the model, or the model shows instability and model assumptions may need to be reconsidered.

2.12.3.2 Age-structured Production Models

An age-structured production model (ASPM) and an ASPM with estimated recruitment deviations (ASPMdev) were also developed in SS to investigate which processes were influencing the shape of the production function and whether composition data were influencing the variability in recruitment. For the ASPM, this was completed first by fixing all parameters to those values estimated by the base model, except for the *ln(R0)* parameter and the initial fishing mortality parameters. Next, the likelihood

components (i.e., lambdas) for the length composition and CAAL data were set to zero along with the recruitment deviations for both the early and main periods, such that only the catch and indices of abundance were fit by the model. For the ASPMdev, the recruitment deviations of the ASPM were configured back to the values in the base model and the bias-correction factor was re-adjusted following Methot and Taylor (2011). Trends in both spawning stock biomass and fishing mortality were compared between the base model, the ASPM, and the ASPMdev.

2.12.3.3 Retrospective Analysis

Each base model was subjected to a retrospective analysis which removed six successive years of data from the terminal year of the model (i.e., years 2018 – 2024) corresponding to the most recent regulatory time blocks beginning in 2018. Iteratively removing data associated with the model's terminal year elucidates the effect of the final year on model results. If results of this analysis show a retrospective bias (consistent patterns of increasing or decreasing model estimates and related derived quantities with each retrospective peel), it can be an indication of model misspecification of temporal dynamics. It is preferable for estimates associated with each retrospective peel to be randomly distributed around the base model results. Model performance was evaluated through visual inspection of retrospective patterns and the Mohn's Rho (ρ) metric (Mohn 1999, Hurtado-Ferro et al. 2015). Here, the 'rule of thumb' ρ values (-0.15 to 0.20) as proposed by Hurtado-Ferro et al. (2015) for longer-lived species were used to characterize retrospective bias.

2.12.4 Model Validation (Prediction Skill)

Having established model consistency and structural stability, the predictive skill of the base model was evaluated to check whether the model's predictive capacity is consistent with the future reality. This was done in two ways. First, a retrospective forecast was performed by adding model-based hindcasts to each of the seven-year peels of the retrospective analysis. Then, a forecast bias, which is an average relative error corresponding to the retrospective bias (i.e., Mohn's Rho (ρ) metric), was computed to gauge model performance and consistency when adding data.

The second method was through the hindcast cross-validation approach (Kell et al. 2021), which compares observations to their predicted future values, and was applied to both the indices and length composition data. Predictive skill was evaluated based on the mean absolute scaled error (MASE), which scales the mean absolute error of the forecasted value to the mean absolute error of the naïve in-sampled value and indicates whether the average model forecasts are better or worse than a random walk. For example, MASE scores >1 indicate average model forecasts are worse than a random walk (i.e., no predictive skill). However, a MASE score of 0.5 would indicate that the model forecasts twice as accurately as a naïve baseline prediction, thereby containing predictive skill.

2.12.5 Sensitivity Runs

2.12.5.1 Florida Keys/East Florida: Start Year

During the model development process, a preliminary base model for the KEYS was constructed to explore the start year of 1986. This configuration followed the SEDAR 37 base model as well as discussions at the Data Workshop concerning when catch or effort data start becoming more available with less uncertainty (e.g., see Sections 3.7 and 4.9.2 in the Data Workshop Report). In addition to a start year sensitivity, this model was unable to adequately estimate any stock-recruitment relationship (h = 0.99), indicating that it contained insufficient contrast in the data (e.g., the stock experienced a reduction in SSB and recruitment due to periods of heavier fishing followed by periods of less intense fishing pressure where the SSB and recruitment were able to begin recovering again). However, profiling the *steepness* parameter for this model revealed an improved model fit if *steepness* was <0.99. When

including the historical catch data, the model was able to estimate a *steepness* value, which ultimately led AW panel discussions to determine this configuration would become the new base model. Therefore, this preliminary model was retained as a sensitivity to these differing assumptions.

2.12.5.2 Florida Keys/East Florida and West Florida Shelf: Discard Mortality

In accordance with Data Workshop (see Data Workshop Report Section 4.7), model runs examining sensitivity to discard mortality rates for the fishing fleets were recommended. Since discards from the commercial fleets in both base models and the recreational spear fleet in the WFS base model were unavailable and/or assumed negligible, sensitivity runs were conducted only for the recreational fleet (KEYS base model) or the recreational hook-and-line fleet (WFS base model). This was completed by configuring the fixed parameter inputs in the discard mortality equation to produce the respective discard mortality rates for each scenario. For the recreational fleet, the upper bound sensitivity was set at 59% while the lower bound was set at 23.8%.

2.12.5.3 Florida Keys/East Florida and West Florida Shelf: Natural Mortality

Sensitivity runs exploring alternative assumptions on natural mortality were conducted based on recommendations from the Data Workshop (see Section 2.7.4 in the Data Workshop Report). While several were explored during the model development process, only three per stock will be presented here. All scenarios continued to assume natural mortality was inversely related to length.

For the KEYS base model, the first sensitivity explored the assumption of using the longevity-based estimator from Hamel and Cope (2022), where $M = 5.4/t_{max}$ (as was performed for the WFS base model) and fixed as the reference value for age-3 fish. For the Florida Keys/East Florida stock, the maximum age observed has been 16 years, thus $M = 0.338$ yr^{-1}. The second scenario sought to explore further recommendations of Maunder et al. (2023) and Hamel and Cope (2022) by internally estimating natural mortality within the KEYS base model and using the standard deviation = 0.31 (in log-space) as a prior. Lastly, the third scenario continued to internally estimate natural mortality, but removed the standard deviation prior in effort to understand where the model would internally absorb mortality if given free reign. This was done to help provide potential insight into how the model felt natural mortality was needed to occur in order to better fit the data.

The first sensitivity run for the WFS base model utilized the mortality-at-weight formulation of Lorenzen (1996) as a fixed input (as was performed for the KEYS base model) and explored the effects of reducing the base model's natural mortality-at-age. A second sensitivity run applied the longevity-based estimator from Hamel and Cope (2022; i.e., $M = 0.235$ yr^{-1}) as the reference age for age-3 fish; this configuration similarly reduced natural mortality at younger ages but was found to have increased it across older ages when compared to the prior Lorenzen (1996) method. The third sensitivity run reported here also followed as in the KEYS base model where internal estimation of natural mortality was explored across ages 3 – 23 without the use of the standard deviation prior in log-space. The use of the standard deviation prior was explored but will not be reported here as the freely estimated sensitivity run resulted in a comparatively better fit to the data.

2.13 Per-recruit Analyses

The expected results of a yield-per-recruit (YPR) analysis are to obtain targets of fishing mortality and age at first capture in effort to evaluate regulations regarding gear types (e.g. hook/mesh sizes and minimum sizes), fishing seasons, or fishing effort (e.g. harvest strategies; Haddon 2001). Overall, the assumed goal is to identify the maximum yield from the fishery and then to adjust that target based on risk aversion and uncertainty. Inherent in YPR analyses is the inconsideration of whether the target fishing effort is sustainable, and it assumes that the fishery has reached an equilibrium with the fishing

mortality it exerts. It also assumes characteristics of natural mortality, growth, and recruitment are constant with stock size (Haddon 2001).

2.14 Uncertainty in Parameters and Derived Quantities

A total of 165 out of 272 parameters were estimated within the KEYS base model for Hogfish in the Florida Keys/East Florida. Of the 272 total parameters, 24 were used to describe life history components (6 estimated), 5 were related to the stock-recruitment relationship (3 estimated), 41 estimated annual recruitment deviations, 150 described annual fleet-specific fishing mortality rates for years 1950 – 2024 (75 estimated), 3 were related to index catchabilities, 5 estimated the Dirichlet-Multinomial theta parameters for length composition data, and 44 described selectivity, retention and discard mortality for the 2 fleets and 3 indices (35 estimated).

Within the WFS base model, a total of 87 out of 124 parameters were estimated. Of the 87 total parameters, 26 were used to describe life history components (5 estimated), 6 were related to the stock-recruitment relationship (3 estimated), 40 estimated annual recruitment deviations, 3 were related to index catchabilities, and 50 described selectivity, retention and discard mortality for the 3 fleets and 3 indices (39 estimated).

Parameter input for SS includes an initial starting value, the range of values a parameter could take (min/max), an associated standard deviation, the prior type and standard deviation (where applicable), and the phase which the parameter will be estimated (positive value) or fixed (negative value). Both base models also used the soft bounds option which moves parameters away from the bounds with a weak penalty (Methot et al. 2026).

Derived quantities include annual numbers- and biomass-at-age, spawning stock biomass, fishing mortality rates-at-age, and internally calculated reference points (e.g., F_{MSY}, $F_{30\%SPR}$, SSB_{MSY}, $SSB_{F30\%SPR}$). Also, recent fishing mortality rates ($F_{Current}$) and recent spawning stock biomass ($SSB_{Current}$) as the geometric mean of the most recent three years were compared to management benchmarks to determine stock status.

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

2.14.1 MCMC

Monte Carlo Markov Chain (MCMC) analyses provided posterior distributions of model parameters and selected derived quantities. MCMC allows probabilistic reporting of the uncertainty associated with the estimated values. Estimates of population values in the terminal year of the stock assessment are often the most uncertain. Assuming the MCMC posterior distributions provide reliable estimates of model uncertainty, the probability that the estimated terminal year value is above or below the overfished/overfishing reference points can be calculated. In this way, a level of risk associated with failing to reach the reference points can be quantitatively specified. Posterior distributions of current spawning stock biomass ($SSB_{Current}$) and fishing mortality rates ($F_{Current}$) as the geometric mean of the most recent three years (2022 – 2024) were compared to associated reference points (i.e., MSST, MFMT).

Convergence of single chains was assessed by Geweke's diagnostic to determine whether the mean of the first 10% of the chain was not significantly different from the last 50% of the chain, while convergence of

the combined chains was assessed using Gelman and Rubin's (1992) potential reduction scale factor implemented in the 'coda' package (Plummer et al. 2006) in R.

2.14.1.1 Florida Keys/East Florida

Two configurations of the KEYS base model precluded a conventional approach to the MCMC analysis: 1) the need for constraining the recruitment deviations to sum to zero, and 2) the use of F as an annual fleet-specific estimable parameter (i.e., F_{Par}). In MCMC, recruitment deviations cannot sum to zero as the constraint prevents the algorithm from exploring the space efficiently, leading to illogical patterns in the posteriors and slow convergence; conversely, F as a freely estimable parameter allows too much space for the algorithm to explore and also leads to poor mixing and slow convergence. To explore this issue, an MCMC 'proxy' model was developed which took the KEYS base model and removed the sum to zero constraint on the recruitment deviations and allowed deviations to continue through 2024 (ending main recruitment deviations in 2021 led to a negatively summed total deviation, which was resolved by extending to 2024). Next, the expected recreational landings estimated by the KEYS base model, which accounted for the observation error in the catch as well as the discards, was used as the data input for recreational landings in the MCMC 'proxy' model and the F_{hybrid} configuration was utilized to produce an exact fit to that catch. Since the F_{hybrid} configuration was already being utilized for the commercial fleet, it precluded the need to apply this approach in the MCMC 'proxy' model, and the commercial catch was left unchanged. During the model development process, the results between the KEYS base model and this MCMC 'proxy' model were found to be similar and differences were driven predominantly by changes to the recruitment deviation configuration. While unconventional, the goal of this alternative ensemble approach was to help provide further measures of potential uncertainty within the KEYS base model.

In total, eight MCMC chains were produced based on the MCMC 'proxy' model. For each chain, a total of 2,000,000 iterations were performed but only one out of every 500 iterations were saved, resulting in 4,000 potential iterations used to generate estimates of uncertainty in fishing mortality and spawning stock biomass. Visual inspection of trace plots to adjust appropriate levels of burn-in and thinning as well as to address any autocorrelation in the iterations led to a burn-in of 800 with further thinning of every 8, resulting in 400 samples per chain.

2.14.1.2 West Florida Shelf

Eight MCMC chains were produced from the WFS base model. In each chain, 1,000,000 iterations were performed with every 500 iterations saved, resulting in 2,000 potential iterations used to generate posterior distributions. Visual inspection of trace plots to adjust appropriate levels of burn-in and thinning as well as to address any autocorrelation in the iterations led to a burn-in of 500, resulting in 1,500 samples per chain.

2.14.2 Parametric Bootstrap

Parametric bootstrap resampling methods were used to analyze the uncertainty associated with the data and to detect possible model misspecification. One thousand bootstrapped datasets were produced by randomly drawing datasets according to assumed error distributions centered on fitted values. By fitting the model to each of the bootstrapped datasets, base model parameter estimates and derived quantities were compared to the distribution of parameter estimates and derived quantities from the bootstraps. Large discrepancies between the base model estimates and the median of the distribution produced by bootstrap analysis may indicate model misspecification of error distributions, data conflicts, or considerable autocorrelation within datasets (Methot and Wetzel 2013).

2.15 Bridge Building

The second TOR (2a) specifies the development of continuity models consistent with the prior benchmark assessment's configuration. Unfortunately, as is frequent with models developed over a decade ago, a strict continuity model was largely unreproducible due to significant changes occurring with several data streams. For example, the recreational landings and discard data estimates were no longer based on the older MRFSS and MRIP ad-hoc survey combination method, there were no commercial discard estimates available here, the combined video survey design is not the same from 2012, and all fishery-dependent indices developed during SEDAR 37 (2014) were not recommended for use or utilized in either the KEYS or WFS base models.

Thus, a bridge building exercise was performed for each stock which compared the estimates of spawning stock biomass, fishing mortality rates, and recruitment from 1) the SEDAR 37 base model, 2) a SEDAR 37 base model re-formed using the original data put into the respective SEDAR 94 configuration, and 3) the SEDAR 94 KEYS or WFS base model. Notable changes to the SEDAR 37 FLK/EFL base model to bring it into the SEDAR 94 KEYS base model configuration include: adding the regulatory time blocks starting in 1995, condensing the three commercial fleets and their respective length and age composition data into one commercial fleet, condensing the two recreational fleets and their respective length and age composition data into one fleet, removing the fishery-dependent indices, correct a misspecified input to the hermaphroditism function, match super-period application to the length composition data, match application of Dirichlet-multinomial weighting, estimate growth, and apply the platoon function. Similarly, bringing the SEDAR 37U WFS base model into the SEDAR 94 WFS base model configuration included: adding the regulatory time blocks starting in 2000, condensing the three commercial fleets and their respective length and age composition data into one commercial fleet, removing the fishery-dependent indices, correct a misspecified input to the hermaphroditism function, match super-period application to the length composition data, match application of Francis weighting, estimate growth, and apply the platoon function.

This TOR (2b) also requested development of additional models which replaced the MRFSS/MRIP recreational landings plus dead discards in the SEDAR 37 base models with the Full SRFS landings plus dead discards timeseries. In the SEDAR 37 base model, discards were not modeled separately; rather, dead discards were incorporated into the landings by applying a discard mortality rate of 100% for spear and 10% for hook-and-line gears. While the TOR actually specified using the MRIP-FES timeseries, the AW panel resolved that since the Full SRFS timeseries was recommended for use over the MRIP-FES by the Data Workshop panel and the TORs were written well beforehand, the Full SRFS timeseries should be used to satisfy this TOR.

3 FL KEYS/EFL Stock Synthesis Model Results

3.1 Life History

The KEYS base model internally estimated growth where asymptotic length (L_{inf}) was estimated at 51.2 cm FL and the growth coefficient (k) was estimated at 0.177. Using the platoons feature within SS, this corresponded to the 3rd platoon (of the 5 total platoons) which was apportioned 46.4% of annual recruitment. The estimated mean length-at-age was found similar to the results of the external growth model developed during the Data Workshop (Figure 3.14; see Section 2.3.5 in the Data Workshop Report) and the additional platoons allowed fish to grow faster (i.e., larger) and slower (i.e., smaller). For example, in the fourth platoon, where 23.7% of annual recruitment was apportioned, mean fish size was as large as 63.1 cm FL; but in the second platoon, also receiving 23.7% of recruitment, mean fish size was

as large as 33.9 cm FL. These faster growing fish became vulnerable to the fisheries sooner whereas the slower growing fish encountered the fisheries much less, helping to mimic the "Lee phenomenon" hypothesized to be occurring in this stock. Furthermore, the platoon within/between standard deviation ratio parameter was estimated at 0.73, suggesting a shift to lower mean size-at-age has been occurring for this population.

3.2 Landings and Discards

Fits to the landings data for the commercial and recreational fleets are presented in Figures 3.15 – 16. The fits to the commercial landings were nearly exact (total negative log-likelihood = 3.500e-05) while the recreational landings were allowed more flexibility given their higher observation error (total negative log-likelihood = 17.053). The KEYS base model generally fit the observed recreational landings well except in 1988, which expected much higher landings, and in years 2008, 2012, and 2015, which expected lower landings. Figures 3.17 – 18 compare model estimated landings across fleets in biomass and numbers of fish, respectively.

Fits to the recreational discard data were well (total negative log-likelihood = -1.544) as most estimates were close to the observed values and within the 95% confidence intervals (Figure 3.19) except for year 2009 which estimated higher numbers of fish discarded.

3.3 Indices

The KEYS base model fits to the three fishery-independent indices (RVC Florida Keys, RVC Dry Tortugas, and combined video) are presented in Figures 3.20 – 22. Model fits to the indices were overall well (total negative log-likelihood = 7.023) and seemed to follow a similar common trend.

Model fits to the RVC Florida Keys index were fair (RMSE = 0.2527), but misfit in certain years contributed the most to the model's overall total negative log-likelihood for the index component. The observed trend started very low and gradually increased through time until the series high in 2024. But the model expected higher abundances in those first two years before becoming more aligned through 2018. Fits to years 2022 and 2024 were an average between the two as the model balanced fitting the other two indices (Figure 3.20).

Fits to the RVC Dry Tortugas index were closest (RMSE = 0.1646) and the observed trend was similar to the RVC Florida Keys index. The fitted values followed the observed stable but variable trend through the 2000s and then increased from 2018 – 2024 (Figure 3.21).

Lastly, model fits to the combined video index were the worst of the three (RMSE = 0.3804), but this index also contained the greatest amount of observed error. The fitted values generally followed the observed trend which began as an initial high in 1993 and gradually decreased though 1997, became stable but variable through 2017, then began gradually increasing again (Figure 3.22).

3.4 Length and Age Composition

3.4.1 Data Weighting

Weighting of the length composition data using the Dirichlet-multinomial distribution resulted in $ln(\theta)$ parameters < 5 with most close to 0 (commercial landings: $\theta = 2.093$, recreational discards: $\theta = 0.987$, recreational landings: $\theta = -0.764$, combined video: $\theta = 0.442$, RVC indices: $\theta = -0.347$; Table 3.9). Thus, theta ratios were all below 1.0 (commercial landings: 0.890, recreational discards: 0.728, recreational landings: 0.318, combined video: 0.609, RVC indices: 0.414). Fits to all three indices also improved (via RMSE) when compared to an unweighted model. The RVC Dry Tortugas index decreased from RMSE =

0.201 to 0.165, the RVC Florida Keys decreased from RMSE = 0.276 to 0.253, and the combined video decreased from RMSE = 0.400 to 0.380.

3.4.2 Length Composition

The KEYS base model fits to the length composition data along with the Pearson residuals associated with the landings, discards, and indices are presented in Figures 3.23 – 27. The quality of the fit varied among fleets and indices and fits aggregated across time were reasonable (total negative log-likelihood = 582.548). The model's predicted distributions were able to match the observed overall distributions but partially underestimated the peak for the recreational discards (Figure 3.23).

The retained length composition data for the commercial fleet were weighted annually by the commercial landings and were aggregated into three super-periods: 1989 – 1994 (n_input = 48), 1995 – 2017 (n_input = 457), and 2018 – 2023 (n_input = 24); no length data were available for year 2024. Fits to these data largely agreed with the observed distributions (Figures 3.24a and 3.27a), matched the changes in minimum size limits, and smoothed through jagged-looking length bins in earlier and later periods characterized by low input sample sizes. For both the 1989 and 2018 super-periods, under-sampling in years 1991 and 2021 influenced atypically larger proportions of fish calculated for the largest length bins (Figure 3.24a). The commercial fleet's length composition data also reflected larger individuals were more regularly targeted when compared to the recreational fishery, especially during the second super-period (1995 – 2017; Figure 3.24a – b).

The recreational retained length composition data were weighted annually by the recreational landings, were characterized by comparatively larger sample sizes, and were aggregated into five super-periods: 1981 – 1985 (n_input = 230), 1986 – 1994 (n_input = 555), 1995 – 2004 (n_input = 749), 2005 – 2017 (n_input = 1,247), and 2018 – 2024 (n_input = 119; Figures 3.24b and 3.27a). The first two super-periods (1981 – 1994) characterize the first time block (no size limits) and were split to accommodate alternative models developed during the AW process which started in 1986. While there is no minimum size limit during this time, length composition data show similar patters to the second time block containing a 12" FL (30.5 cm) minimum size limit. The third and fourth super-periods (1995 – 2017; second time block) were split to align with the recreational discards which became available in 2005 (Figure 3.24c). The fifth super-period (2018 – 2024) reflected a shift in mode to the new 16" FL (40.6 cm), however smaller fish were still shown to be retained (Figure 3.24b). Fits to the recreational discard length composition data were split into two super-periods: 2005 – 2017 and 2018 – 2024. Distributions show discards are predominantly individuals smaller than the respective minimum size limits; while there were some fish above the minimum size limit discarded from 2005 – 2017, there were no fish discarded above 16" FL (40.6 cm) in the 2018 - 2024 time block when the daily bag limit reduced to 1 fish/person (Figure 3.24c).

The observed length distributions for both RVC indices utilized 5 cm bin widths to resolve the digit bias observed in 2 cm bin widths where model fits to the overall distributions appeared well (Figure 3.23). Annual fits to the RVC Florida Keys length compositions were reasonable (Figures 3.25 and 3.27b; total n_input = 5,194); modal lengths were generally around 20 cm FL, but annual variability led to some years being underestimated at the mode with overestimation at adjacent sizes or vice-versa. While Hogfish in the Florida Keys were observed by this survey up to the 85 cm FL bin, individuals were predominantly less than 40 cm FL (Figure 3.25). Fits to the annual observed length compositions for the RVC Dry Tortugas index were also fair but exhibited comparatively more annual variability and noise across length bins (Figures 3.26 and 3.27c; total n_input = 2,974). Fish were generally larger in the Dry Tortugas, with modal lengths around 35 – 40 cm FL and more frequently observed individuals up to the largest length bin compared to the RVC Florida Keys survey.

The observed length composition data of the combined video survey were generally more uniform in distribution, rather than having a stronger dome-shape as seen in the other length compositions (Figure 3.23). Annual sample sizes for this survey were very low (commonly less than 20) leading to noisy compositions; without any changes in catchability or regulatory time blocks to consider for this index, a single super-period was applied for years 2002 – 2024 (n_input = 184). Models fits to these aggregated data became reasonable and were able to smooth through the coarse and irregular length bins (Figures 3.23 and 3.27a).

3.4.3 Conditional Age-at-Length

The KEYS base model fits to the CAAL data associated with the landings as well as fishery-independent spear and trawl data are presented in Figures 3.28 – 32. The quality of the fit varied among data sources and fits to their aggregated mean ages were generally acceptable (total negative log-likelihood = 618.568; Figure 3.28). Ages sampled from the fleets were infrequent and the average number of ages available annually per length bin was 2 – 3; therefore, to reduce noise and help the model's internal estimation of growth, years where only one or two age-at-length observations were available were removed.

The fits to the annual mean ages for the commercial fleet followed the trends of the observations generally well and mean age occurred between ages 4 – 7 (Figure 3.28). The model did not fit year 2015 by expecting a slightly lower mean age and year 2016 had the greatest uncertainty due to single observations for each age-at-length bin. No ages were sampled from 2017 – 2024 (except for one otolith sampled in 2022 which was removed). The annual fits to the observed ages were reasonable and the model was able to track the observed ages across length bins (Figure 3.29). Between 1998 – 2011, sampled ages-at-length contained larger individuals (~28 – 54 cm FL) predominantly collected from the spear gear but were more length-truncated (~30 – 40 cm FL) across 2012 – 2015 from additional hook-and-line and trap gear samples.

Model fits to the annual mean ages for the recreational landings were largely within the bounds of uncertainty with mean age stable but variable around age 5 (Figure 3.28). Annual fits to the observed ages-at-length were adequate; the combined age data were comprised of both spear and hook-and-line gears, were more consistently sampled across years compared to the commercial fishery, and were normally within 30 – 50 cm FL (Figure 3.30). Ages-at-length above 50 cm FL were more commonly sampled from the spear gear.

The fishery-independent CAAL data were constructed from the life-history research of McBride and Richardson (2007), Faletti and Stallings (2021), Towne et al. (2021), and from unpublished FWRI research (see Section 2.6 in Data Workshop Report). The data were parsed by gear into two fleets: a spear fleet and a trawl fleet, and they were not linked to any other fleet or index. Their main purpose of inclusion was to inform the internal estimation of growth. The fits to the annual mean ages for the fishery-independent spear fleet were suitable and followed the observed trends, largely between ages 3 – 6 (Figure 3.28). Annual fits to the observed ages-at-length were well and were considered the most informative data source for the internal estimation of growth, encompassing annually the widest range of ages-at-length (~6 – 62 cm FL; Figure 3.31). Contrastly, the fishery-independent trawl fleet were predominantly smaller individuals (<30 cm FL) and were helpful with informing growth of the younger individuals. Fits to the annual mean ages were well with observations variable around ages 1 – 3 (Figure 3.28); fits to the annual observed ages-at-length were also consistent (Figure 3.32).

3.5 Estimated Parameters and Derived Quantities

The SEDAR 94 KEYS base model estimated most parameters reasonably well (i.e., |CV| < 1; Table 3.10). Of the 165 active parameters, 37 exhibited poor estimation (i.e., |CV| > 1); including 26 recruitment

deviations, 2 years estimating the annual recreational fishing mortality rates, and 9 parameters describing selectivity (mostly commonly the top logit and/or end logit parameters). No parameters were estimated near bounds.

3.5.1 Stock Biomass (Total and Spawning)

The predicted total biomass and spawning stock (mature female plus male) biomass are summarized in Table 3.11 and Figures 3.33 – 34. Both trends in biomasses gradually decreased through time from 1950 until about the year 2000, then became stable but variable through 2017, then began increasing again through 2024 (Figures 3.33 – 34).

The unfished spawning stock biomass (SSB_0) was estimated at 5,462.14 mt (Table 3.11, Figure 3.34a) where the estimated female spawning biomass was 1,391 mt and the male biomass as 4,071 mt (Figure 3.34b). In 1986, the depletion ratio (SSB/ SSB_0) was 0.446 and decreased to an average 0.223 from 1995 – 2017; it was lowest from 2006 – 2010 (avg. ratio = 0.189) but since 2018 has increased in trend from 0.246 to 0.382 in 2024 (Table 3.11). Temporal trends in spawning biomass appeared to be influenced predominantly by changes in male spawning biomass, whereas female spawning biomass showed greater stability through time (Figure 3.34b), consistent with the historical tendency of males being targeted more heavily than females.

3.5.2 Recruitment

The relationship between spawning biomass and age-0 fish as parameterized by the Beverton-Holt stock-recruitment model is presented in Figure 3.35. The *steepness* parameter was estimated at 0.472, the *sigmaR* parameter was estimated at 0.449, and the *ln(R0)* parameter was estimated at 8.000 (Table 3.10), which equates to 2,981,882 age-0 Hogfish.

The estimated annual recruitment of age-0 Hogfish to the biological population in the Florida Keys/East Florida is summarized in Table 3.11 and Figure 3.36a-b. From 1950 – 1980, age-0 recruitment followed the stock-recruitment curve, declining gradually as the population declined through time (Figure 3.36a). Recruitment was stable but variable from 1981 – 1992 (avg. 2.257 million fish), diminished considerably from 1993 – 1998 (avg. 0.942 million fish), then began gradually increasing in trend again with variation through 2024 to 2.052 million fish (Figure 3.36a). Recent notably high years of recruitment were estimated to be in 2007 (2.523 million fish), 2012 (2.486 million fish), 2013 (2.032 million fish), and 2015 (2.830 million fish). Higher recruitment may also likely have occurred for years 2022 – 2024 based on the trend in both RVC indices as well as additional models developed during this process which estimated annual deviations in recruitment through 2024 (e.g., see the MCMC 'proxy' model description above in Section 2.13.1). Uncertainty in the estimated recruitment was highest during the 1980s when only catch and sparse fishery length composition data were available.

Annual deviations of estimated recruitment from the stock-recruitment curve were configured from 1981 – 2021 and followed the annual trend of the estimated recruitment above (Figure 3.36b). Values deviated around the stock-recruitment curve, except between 1993 and 1998 where they were negatively deviated, and from 2016 – 2021 where they were slightly but continually positively deviated (Figure 3.36b). The estimated (and applied) recruitment bias adjustment ramp as recommended by Methot and Taylor (2011) is shown in Figure 3.37.

3.5.3 Fishing Mortality

The annual exploitation fishing mortality rates on Florida Keys/East Florida Hogfish are presented in Table 3.12 and Figure 3.38. Exploitation rates generally followed the trend in catch; between 1981 and 1994 exploitation averaged 0.102 yr^{-1} with a high in 1988 (0.217 yr^{-1}). From 1995 – 2017, exploitation

rates were variable with notable highs in 2005 (F = 0.262 yr^{-1}), 2009 (F = 0.216 yr^{-1}), and 2015 (F = 0.179 yr^{-1}; Table 3.12, Figure 3.38). After new regulations (SAFMC Snapper Grouper Amendment 37) were implemented near the end of 2017, exploitation averaged 0.022 yr^{-1} for years 2018 – 2024.

Fleet-specific fishing mortality rates (i.e., instantaneous apical rates representing the fishing mortality level on the most vulnerable age class) are also provided in Table 3.12 and Figure 3.39. Apical fishing mortality rates were considerably higher for the recreational fleet and, like the exploitation rates above, followed the trend in annual catch. In contrast, commercial fishing mortality rates were very low but were highest between 1986 – 2005 (Table 3.12, Figure 3.39).

3.5.4 Selectivity and Retention

Selectivity for all fleets and indices was estimated using length-based selectivity functions which the KEYS base model used to further derive age-based selectivity (Figures 3.40 – 44). Fishing fleet-specific length-based selectivity and/or retention patterns, as well as assumed discard mortality rates, are illustrated in Figures 3.40 – 41.

Selectivity of Hogfish for the commercial fleet was time-varying to follow changes in minimum size regulations; without discard estimates (which must be assumed negligible) or discard length composition data, selectivity here functions as retention. Selectivity was dome-shaped generally between 27 – 41 cm FL from 1950 – 1994, 29 – 41 cm FL from 1995 – 2017, and 39 – 53 cm FL from 2018 – 2024; an asymptote of 60% was reached in all three time blocks (Figure 3.40). In the first two time blocks, fish became vulnerable beginning at age-2 before becoming more fully selected by ages 5 and 6; age-derived selectivity of fish in the 2018 – 2024 time block was more gradual due to the increase in minimum size, beginning around age-3 and continuing to age-16 (Figure 3.43).

Dome-shaped selectivity of Hogfish by the recreational fleet was generally between 23 – 54 cm FL, reaching an asymptote of 9% by 55 cm FL (Figure 3.41). Age-derived selectivity was primarily across ages 2+ with fuller selectivity occurring between ages 4 – 6 (Figure 3.44). Retention was time-varying and fish were fully retained by 9 cm FL from 1950 – 1994 (Figure 3.41a), 33 cm FL from 1995 – 2017 (Figure 3.41b), and 55 cm from 2018 – 2024 (Figure 3.41c). Note that where retention was estimated to occur well below 23 cm FL from 1950 – 1994, it meant fish vulnerability still followed the estimated selectivity curve and that, given the absence of minimum size limits, whatever negligible number of fish were encountered were retained. Furthermore, this time period contained no discard length composition data; thus, discards-at-length from 1950 – 1994 followed selectivity and the additive inverse of retention. From 1995 – 2017, Hogfish were discarded largely between 21 – 33 cm FL (Figure 3.41b), whereas fish from 2018 – 2024 were discarded in greater proportion across a wider range from 21 – 51 cm FL due to the increased minimum size limit and reduction in daily bag limit (Figure 3.41c).

The selectivity (vulnerability to observations by divers) of Hogfish by the RVC Florida Keys index was dome-shaped, occurring mostly between 11 – 53 cm FL and reached an asymptote of 12% by 55 cm FL (Figure 3.42). Juvenile fish started to become vulnerable at about 9 cm and individuals became fully selected between 21 – 29 cm FL (Figure 3.42). Age-derived selectivity occurred across all ages with fish becoming more fully selected at ages 2 – 3 (Figure 3.44). In the RVC Dry Tortugas index, selectivity was dome-shaped and primarily occurred on larger individuals between 29 – 87 cm FL (Figure 3.42). As a result, age-derived selectivity appeared more flat-topped by gradually increasing from age 1 to the maximum age (Figure 3.44). Fish observed by the combined video index, which operated near and north of the Dry Tortugas but sampled deeper waters, began to be selected around 11 cm FL and became fully selected by 41 cm FL (Figure 3.42). Age-derived selectivity of this index started at age-1 and became more fully selected by ages 10+ (Figure 3.44).

3.6 Model Diagnostics

3.6.1 Convergence

The SEDAR 94 KEYS base model converged with a total objective function of 2314.27. The model contained no parameters on the bounds, had a small final gradient <0.0001, and had a positive definite Hessian matrix. Highly correlated parameters were inspected, but all were found to be structurally correlated and therefore left as-is estimated in their different model phases.

The results of the jitter analysis found that no jittered runs contained a total likelihood lower than the base model, suggesting that the base model had converged on a global solution (Figure 3.45). From the 100 jittered runs, 70% had a low gradient (<0.0001) but the maximum gradient was 0.3174.

3.6.2 Goodness of fit

The joint residual plots for the indices (Figure 3.46a), mean length composition data (Figure 3.46b), the conditional age-at-length data (Figure 3.46c), and the mean general size composition data (Figure 3.46d) indicated reasonable fits to the data as combined RMSE values were 0.302, 0.023, 0.316, and 0.105 respectively. As illustrated by the loess-smoother and size of the boxplots, residual variability of the indices was more positively biased at the beginning of the timeseries due to the more poorly fit combined video index (RMSE = 0.38). When the RVC indices became available in 1999, the overall trend centered around zero through 2009 then became more negatively deviated until reaching near zero again in the terminal years (Figure 3.46a). Due to the application of super-periods, the frequency of mean length residuals was only during the start of those periods; residuals and interquartile ranges of these data were small and consistent across time, indicating general agreement with the fisheries and index data (Figure 3.46b). In the conditional age-at-length data, residuals were more negatively biased in the beginning and end of the timeseries as influenced by the poorer-fitting fishery-independent trawl ages (RMSE = 0.657) and, to a lesser extent, the recreational ages (RMSE = 0.234; Figure 3.46c). Lastly, the fits to the mean size data for the RVC indices were well and mostly centered around zero across the timeseries (Figure 3.46d).

The residual series of all three indices passed the runs test, indicating residuals were sufficiently random and without significant autocorrelation (Figure 3.47). The RVC Florida Keys index had a residual in 1999 larger than three standard deviations and this misfit in the KEYS base model was likely balancing with the trends of the other two indices that suggested abundance in prior years was more elevated. It's unclear if this low relative abundance reflects more localized depletion in the Florida Keys or reflects the survey design change in the sampling of available habitat. Earlier index values available during the Data Workshop (i.e., 1997 – 1998) also indicated low abundances; but rather than estimate time-varying catchability (as was done with this index in SEDAR 37 [2014]), the AW panel determined to further curtail the index to 1999 to account for the change in survey.

Only the recreational length composition data had sufficient observations for the runs test and passed (Figure 3.48a). The other length composition data had too few observations due to the application of the super-periods. For the RVC size composition data, both indices failed due to each having two years of residuals greater than three standard deviations with some possible temporal autocorrelation (Figure 3.48b). The KEYS base model estimated for each RVC index a more consistent mean size across time, however, the data showed greater annual variability in mean sizes causing some misfit as described above in Section 3.3.2. While the fits to the annual distributions would not change, these residual patterns may likely be improved if Francis data weighting was utilized since the changes to effective sample sizes would extend the confidence intervals for these annual mean lengths. The conditional age-at-length residuals for the commercial landings and both fishery independent fleets passed the runs test (Figure

3.49). The fishery independent spear ages had one residual greater than three standard deviations and, as noted above, the fishery independent trawl data showed large residuals. The residuals for the recreational landings failed the runs test and showed some positive temporal autocorrelation from 2009 – 2016 as well as a residual in 2004 greater than three standard deviations (Figure 3.49).

3.6.3 Model Consistency

3.6.3.1 Likelihood Profiles

The profile likelihood on the *ln(R0)* parameter revealed that the parameter was largely influenced by the recruitment and RVC size data components but conflicted with the index data component (Figure 3.50). The profile minimum agreed with the KEYS base model estimate of 8.0, but also indicated a parameter estimate between ~7.8 – 8.2 would not produce a significantly worse fit to the data (i.e., change in log-likelihood <2 units). Agreement from the RVC size data component was primarily influenced by the RVC Dry Tortugas size data while the RVC Florida Keys size data preferred an *ln(R0)* estimate greater than 8.3. The length, discard, and conditional age-at-length data were largely non-informative to the *ln(R0)* parameter but showed some indication that the estimate should be >7.2 and <8.4.

Similarly, the profile of the *steepness* parameter indicated influence from the recruitment component, but conflict with the index component. The profile minimum agreed with the KEYS base model estimate of 0.472 but showed a parameter estimate between 0.4 – 0.6 would not produce a significantly worse fit to the data (Figure 3.51). The recruitment component favored a *steepness* estimate between 0.35 – 0.5 while the index component suggested a much weaker stock-recruitment relationship (*steepness* >0.75). The remaining length, size, discard, and conditional age-at-length data components were largely non-informative but indicated the parameter estimate should be >0.35.

3.6.3.2 Age-structured Production Models

The results from the ASPM indicate that for most of the timeseries there is enough information in both the catch and index data for the production function to largely drive the stock dynamics and for the model to be adequately informed about scale (Figures 3.52 – 53). The ASPM also greatly benefited from the F as a parameter configuration (process error) which allowed the model to access the observational error of the catch in order to compensate for the lack of recruitment deviations. In other words, rather than being able to adjust how many recruits will be needed to fit the upcoming data (bottom-up), the ASPM was able to tune fishing mortality to adjust the numbers in the population and fit the data (top-down). This resulted in the ASPM artificially estimating a significantly high exploitation rate in 1984 in order to reduce the spawning biomass low enough so that estimated recruitment (based on the stock-recruitment curve) would be low enough to fit the data through the mid-1990s (Figure 3.52a-c). After year 2000 when all three indices were available, the ASPM had a close enough estimate of absolute scale in which to adequately fit the indices (Figure 3.53b-d) and continued to follow the population trends of the KEYS base model.

The estimate of *ln(R0)* by all three models generally overlapped in distribution (Figure 3.53a) and corroborated the results of the *ln(R0)* profile. The ASPM with recruitment deviations (ASPMdev) estimated a slightly smaller population scale with larger exploitation rates but followed the same trend as the KEYS base model (and to a lesser extent the ASPM), indicating the inclusion of length and age composition data in the KEYS base model is still informative to estimates of population scale (Figure 3.52a-b). The trend in age-0 recruitment and recruitment deviations of the ASPMdev was also very similar to the KEYS base model, suggesting the model needed that process error in order to better fit the trends in the indices (Figure 3.52c-d). Indeed, without the influence of the composition data, fits to all three indices by the ASPMdev were improved.

Fits to the RVC Dry Tortugas index ($RMSE_{ASPMdev}$ = 0.109; $RMSE_{ASPM}$ = 0.202; Figure 3.53c; Table 3.13) were the best, followed by the RVC Florida Keys index ($RMSE_{ASPMdev}$ = 0.205; $RMSE_{ASPM}$ = 0.310; Figure 3.53a; Table 3.13). The combined video survey was the worse fitting of the three indices ($RMSE_{ASPMdev}$ = 0.352; $RMSE_{ASPM}$ = 0.493; Figure 3.53d; Table 3.13) with the ASPM largely underestimating the first 5 years of the survey.

3.6.3.3 Retrospective Analysis

The retrospective analysis showed a slight pattern in estimates of spawning stock biomass and exploitation after removing successive terminal years. Spawning stock biomass tended to decrease in trend while exploitation tended to increase in trend; thus, estimates of the population became more favorable with the addition of each successive year of data (Figure 3.54a-b). All runs were within the 95% confidence interval of the KEYS base model, converged, and contained no parameters on the bounds. Furthermore, the calculated values for Mohn's rho for SSB (ρ_M = -0.112; Table 3.14) and exploitation (ρ_M = 0.112; Table 3.14) were within the "acceptable" range for longer-lived species according to Hurtado-Ferro et al. (2015).

As mentioned earlier in Section 2.6, the KEYS base model's inclusion of process error in the form of recruitment deviations ending in 2021 and the sum-to-zero constraint eliminated the stronger retrospective pattern observed in earlier models. Also mentioned earlier in section 2.13.1 was the use of an MCMC 'proxy' model to aid in estimates of uncertainty in model parameters and derived quantities. Since this model had to remove the sum-to-zero constraint and extend recruitment deviations through 2024, we report a retrospective pattern could still be seen in that model. The calculated Mohn's rho value for SSB was -0.222 and 0.230 for exploitation; hence, we continued to treat this model as supplementary in providing further measures of uncertainty rather than a replacement to the KEYS base model.

3.6.4 Model Validation (Prediction Skill)

Retrospective forecasting showed that the one year forward projections were largely consistent with the overall estimated trend in the reference model and were similar in trend to the results of the retrospective analysis (Figure 3.54a-b). All retrospective forecasts fell within the 95% confidence interval of the KEYS base model. The forecast rho value for spawning stock biomass increased slightly to ρ_F = -0.099 and exploitation decreased to ρ_F = -0.095 (Table 3.14), suggesting model stability as well as consistency when successive data became available.

A hindcast with cross-validation of the terminal seven years of data was performed to gauge predictive capacity of the KEYS base model. From the indices, eleven total observations were available, and a joint MASE score of 0.657 indicated the KEYS base model predicted these indices almost twice as accurately as a naïve forecast (Table 3.15). All three indices scored similar MASE values; the combined video survey was lowest (MASE = 0.63, Table 3.15), followed by the RVC Dry Tortugas index (MASE = 0.67, Table 3.15), and the Florida Keys index (MASE = 0.69, Table 3.15). Only the RVC Dry Tortugas mean size data indicated predictive capacity (MASE = 0.597, Table 3.15) while the number of super-period observations for commercial, recreational, and combined video mean length data precluded computing of prediction residuals. The MASE values for the conditional age-at-length (CAAL) data demonstrated low mean absolute errors and all CAAL data sources were better predicted by the KEYS base model than a naïve baseline prediction (joint MASE = 0.167; Table 3.15).

3.6.5 Sensitivity Runs

3.6.5.1 Start Year

The results from the sensitivity model using 1986 as a start year exhibited substantial consistency with the KEYS base model (Figure 3.55a – f). Estimates of exploitation (Figure 3.55a), spawning stock biomass

(Figure 3.55b), and recruitment (Figure 3.55e), were all on average <10% difference from the KEYS base model estimates. However, the differences between the two models came down to estimated differences in stock productivity and subsequent SPR-based reference points for biomass.

Since the data in the 'StYr_1986' model were insufficient to estimate a stock-recruitment relationship, *steepness* was fixed at 0.99. This meant that, although estimates of SSB and recruitment were similar between the two models, recruitment would be centered around the same average at lower stock sizes as it would be at larger and unfished stock sizes (Figure 3.55f). This difference becomes significant primarily when considering reference points for the stock. For example, the estimates of exploitation at 30% and 40% SPR were largely consistent between the two models (KEYS base model = 0.190 and 0.128, 'StYr_1986' model = 0.186 and 0.133, respectively). However, the $SSB_{F40\%SPR}$ value estimated by the 'StYr_1986' model was 1,321.570 mt (compared to 912 mt by the KEYS base model) and the $SSB_{F30\%SPR}$ value was 989.077 mt (compared to 154.312 mt by the KEYS base model). Furthermore, the $SSB_{F30\%SPR}$ value estimated by the KEYS base model was in close proximity to equilibrium yield values nearing zero (see below Section 3.7) and contained high uncertainty (CV = 2.54). MSY-based reference points were also not possible for the 'StYr_1986' model given the absence of a stock-recruitment relationship.

Interestingly, profiling the *steepness* parameter in the 'StYr_1986' model indicated a significantly better model fit to the data (via total log-likelihood) when set well below 0.99 (Figure 3.55g) and was influenced most by both the recruitment component and the RVC size composition component.

3.6.5.2 Discard Mortality

The KEYS base model was rather insensitive to changes in discard mortality estimates. Higher (59%) discard mortality rates corresponded to higher exploitation rates, and vice-versa, but produced on average a 5% difference in annual exploitation from the KEYS base model (Figure 3.56a). Increases in exploitation corresponded to decreases in spawning stock biomass which overall only exhibited an average 2% change (Figure 3.56b). Age-0 recruitment was nearly unchanged with <1% average difference (Figure 3.56c).

3.6.5.3 Natural Mortality

The differing assumptions on natural mortality primarily resulted in mortality-at-age values which were higher than those input to the KEYS base model, especially at the youngest ages (Figure 3.57a). In the KEYS base model, age-3 fish experienced $M = 0.279$ yr^{-1} based on the Lorenzen (1996) mortality-at-weight equation (see Section 2.7 in the Data Workshop Report). The three sensitivity runs, 'HamelCope_age3', 'est_HamelCope_age3', and 'est_HamelCope_age3_noprior' resulted in age-3 M values of 0.338 yr^{-1}, 0.435 yr^{-1}, and 0.312 yr^{-1}, respectively. Estimates of exploitation rate (Figure 3.57b) and spawning stock biomass (Figure 3.57c) were consistent and were within the uncertainty provided by the KEYS base model. However, a scalar pattern that emerged was that as M increased across scenarios, so did estimates of age-0 recruitment (Figure 3.57d). This makes sense because the greatest increases to *M-at-age* occurred on age-0 individuals; therefore, the model needed to generate more age-0 fish to ensure enough adult fish were available in the population.

From a likelihood perspective, both the 'HamelCope_age3' and 'est_HamelCope_age3_noprior' scenarios fit the data similarly to the KEYS base model (i.e., within 2 LL units) and produced comparable estimates of life history and stock-recruitment parameters. For example, estimated (L_{inf}) values were 54.0 and 52.5 cm FL, respectively, while *steepness* estimates were 0.44 and 0.46. These results were particularly informative because when the model was allowed to freely estimate natural mortality internally without a prior (i.e., 'est_HamelCope_age3_noprior'), the outputs closely aligned with those of the KEYS base model.

Surprisingly, when *M* was estimated internally using the standard deviation prior in log-space, it resulted in a significantly higher *M* and poorer model fits to the data (via LL). In response, the model adjusted several life history and stock-recruitment parameters to compensate for the elevated mortality. Virgin recruitment (R_0) and annual recruitment, on average, was nearly four times greater than the KEYS base model and L_{inf} increased to 64.2 cm FL. With this larger asymptotic length, the model consistently underestimated mean lengths for fish ages 1–11 as the growth coefficient (*k*) was reduced to 53% (*k* = 0.095) the value estimated by the KEYS base model.

3.7 Per-recruit Analyses

The yield-per-recruit (YPR), spawner-per-recruit (SSB/R), static spawning potential ratio (SPR), and total equilibrium yield analyses were computed as a function of the instantaneous exploitation rate on Florida Keys/East Florida Hogfish and are presented in Table 3.16 and Figures 3.58 – 59a. Presented with these values is also their relation to various MSY- and SPR-based reference points. The SPR values by year were calculated and are presented in Figure 3.59b. The retained yield at F_{MSY} for Florida Keys/East Florida Hogfish was estimated to be 94.552 mt (208,451 lbs.; Figure 3.58d) while the total yield (retained yield plus dead discards) at F_{MSY} was 165.068 mt (363,913 lbs.; Figure 3.58c). The retained yield associated with $F_{40\%SPR}$ was estimated at 71.100 mt (156,749 lbs.; Figure 3.58d) but at $F_{30\%SPR}$ was estimated to be 17.249 mt (38,027 lbs.; Figure 3.58d) with high uncertainty (CV = 2.54).

3.8 Uncertainty in Parameters and Derived Quantities

3.8.1 MCMC Analysis

Of the eight chains produced, only six were found to have converged based on Geweke's diagnostic; thus, a total of 2,400 iterations remained. The six chains were combined, and convergence was evaluated using trace plots (Figure 3.60) and the Gelman and Rubin's (1992) potential scale reduction factor (PSRF) for selected model parameters (*ln(R0)*, SSB_0, and *steepness*) and derived quantities (exploitation in 2024, SSB in 2024, F_{MSY}, SSB at F_{MSY}, and the retained yield at F_{MSY}). PSRF values for all selected parameters and stock status criteria were close to 1 and since none of the PSRF upper confidence intervals exceeded the 'rule of thumb' value of 1.1, it was concluded that the MCMC converged (Table 3.17).

Posterior distributions from the MCMC 'proxy' model were produced for stock-recruitment parameters (Figure 3.61) as well as the derived quantities of $F_{current}$ (Figure 3.62a), F_{MSY} (Figure 3.62b), the retained yield associated with F_{MSY} (Figure 3.62c), $SSB_{current}$ (Figure 3.62d), SSB at F_{MSY} (Figure 3.62e), 75% of the SSB at F_{MSY} (Figure 3.62f), $F_{40\%SPR}$ (Figure 3.63a), and SSB at $F_{40\%SPR}$ (Figure63b). Estimated values of the KEYS base model were generally found to fall within the interquartile ranges of these posterior distributions (Figures 3.61 – 63) which further evidenced the MLE values were not "captured in a strange neighborhood". Given the high uncertainty of 30% SPR-based reference points estimated by the KEYS base model, posterior distributions were not attempted.

3.8.2 Parametric Bootstrap

Results of the bootstrap analysis indicated that the model exhibited a measure of instability when fitting to the randomly generated data sets. From the 1,000 bootstrapped data sets, 669 runs had a gradient >0.0001 yet the maximum gradient observed was still relatively low at 0.707. A total of 746 runs had at least one parameter on the bounds. However, distributions of selected parameter estimates and derived quantities were largely consistent with those observed in the posterior distributions from the MCMC 'proxy' model and the KEYS base model estimates generally fell within the interquartile ranges (Figure 3.64).

3.9 Stock Status Determination Criteria

A summary of the Florida Keys/East Florida Hogfish stock status determination criteria and their values as presented in the TORs and according to the SAFMC from the SEDAR 94 KEYS base model is presented in Table 3.18. Stock status of Florida Keys/East Florida Hogfish was considered in SEDAR 37 (2014) according to both MSY and MSY_{proxy} based reference points (e.g., SPR 30%) and *steepness* was estimated to be 0.83 using a full beta prior (h = 0.748, sd = 0.146) based on Shertzer and Conn (2002). Subsequently, the SAFMC Snapper Grouper Amendment 37 set MSY to $F_{30\%SPR}$. The KEYS base model also estimated the *steepness* parameter with the assumption of a stock-recruitment relationship and we continue by presenting both MSY- and SPR-based reference points for consideration (Figures 3.65 – 66). However, while SPR-based reference points are characterized here, it should be noted that due to the lower value of the *steepness* parameter estimated by the KEYS base model (h = 0.47), most 30% SPR reference points were estimated with high uncertainty (i.e., CV >2).

The Maximum Fishing Mortality Threshold (MFMT) for Florida Keys/East Florida Hogfish is currently defined as $F_{30\%SPR}$ and overfishing is occurring if the recent average of fishing mortality rates ($F_{current}$) exceeds the MFMT. $F_{current}$ is calculated as the geometric mean of exploitation rates for 2022 – 2024. Based on this, the MFMT was estimated by the KEYS base model to be 0.190 yr^{-1}, $F_{current}$ was estimated to be 0.020 yr^{-1}, and F_{2024} was estimated to be 0.016 yr^{-1} (Figure 3.66a). The F_{MSY} was estimated to be 0.077 yr^{-1} (Figure 3.65a) and $F_{40\%SPR}$ was estimated to be 0.128 yr^{-1} (Figure 3.66a). Using either of these reference points, the Florida Keys/East Florida Hogfish stock was not found to be experiencing overfishing ($F_{current}/F_{30\%SPR}$ = 0.105; $F_{current}/F_{MSY}$ = 0.258; $F_{current}/F_{40\%SPR}$ = 0.156).

The minimum stock size threshold (MSST) for Florida Keys/East Florida Hogfish is currently defined as 75 percent of the spawning stock biomass associated with $F_{30\%SPR}$ (i.e., 0.75* $SSB_{F30\%SPR}$). The stock is overfished if the recent average spawning stock biomass ($SSB_{current}$) is less than MSST. The $SSB_{current}$ is calculated as the geometric mean of the spawning stock biomass for 2022 – 2024 and was estimated to be 1,964.579 mt (2,204.623 lbs.) with SSB_{2024} estimated to be 2,084.69 mt (4,595,955 lbs.). The $SSB_{F30\%SPR}$ was estimated by the KEYS base model with high uncertainty (CV = 2.54) at 154.312 mt (340,200 lbs.) and MSST was therefore defined as 115.734 mt (255,150 lbs.; Figure 3.66b). The SSB_{MSY} was estimated at 1,952.400 mt (4,304,305 lbs.; Figure 3.65b) and the $SSB_{F40\%SPR}$ was estimated at 912.573 mt (2,011,879 lbs.; Figure 3.66b). Based on these results, the Florida Keys/East Florida Hogfish stock was not found to be overfished ($SSB_{current}/SSB_{F30\%SPR}$ = 16.975; $SSB_{current}/SSB_{MSY}$ = 1.342; $SSB_{current}/SSB_{F40\%SPR}$ = 2.870).

From the posterior distributions of the MCMC 'proxy' model, the median value for F_{MSY} was estimated to be 0.099 yr^{-1} (Figure 3.62b), $F_{current}$ was estimated to be 0.019 yr^{-1} (Figure 3.62a), SSB_{MSY} was estimated to be 1,650.74 mt (3,639,259 lbs.; Figure 3.62e), $MSST_{MSY}$ was 1,238.055 mt (2,729,444 lbs.; Figure 3.62f), and $SSB_{current}$ was estimated to be 2,084.086 mt (4,594,623 lbs.; Figure 3.62d). Median values of $F_{40\%SPR}$ and $SSB_{F40\%SPR}$ were 0.133 yr^{-1} (Figure 3.63a) and 1,124.165 mt (2,478,360 lbs.; Figure 3.63b), respectively. The MCMC distribution of the retained yield at F_{MSY} had a median value of 97.388 mt (214,704 lbs.; Figure 3.62c). Additional posterior distributions of the MSY-based F_{ratio} ($F_{current}/F_{MSY}$) and SSB_{ratio} ($SSB_{current}/MSST_{MSY}$) are presented in Figure 3.67 where median values were 0.193 and 1.685, respectively. The estimates for these reference points as derived by the KEYS base model were just outside the interquartile ranges of these posterior distributions; however, the uncertainty indicated a more favorable stock condition, namely that the F_{ratio} was lower (Figure 3.67a) and the SSB_{ratio} was higher (Figure 3.67b). The distribution of the F_{ratio} was entirely below one, indicating a high probability that overfishing is not occurring while 99% of the distribution for the SSB_{ratio} was above one, indicating a high probability that the stock is not overfished.

3.10 Bridge Building

The SEDAR 37 base model characterized a stock that was heavily depleted in the start year and remained depleted through the terminal year. This was very different in comparison to the SEDAR 94 KEYS base model which estimated around double or more the spawning stock size for most overlapping years and the bridge building model which estimated more of a middle ground between the two (Figure 3.68a). Typically, this display of model behavior in SS would be identified with some temporal or configuration misspecification and addressed. Unfortunately, however, at the time of the SEDAR 37 assessment the diagnostic capabilities of SS were not as developed as we have available today and misspecifications were missed in that model development process. For example, by applying the 'cookbook' diagnostics to the SEDAR 37 base model, the ASPM model immediately crashed the population without access to the composition data or recruitment deviations while the ASPMdev model was near exact to the base model; this suggests the base model sustained the population almost entirely on the process error of recruitment deviations. Corresponding to the trend in SSB, estimates of exploitation rate in the SEDAR 37 base model were higher than reported here but tended to follow the same trend. Exploitation rates from the bridge building model were closer in scale to the KEYS base model and typically fell within the 95% confidence intervals (Figure 3.68b). Age-0 recruitment of the bridge building model was more often similar to the KEYS base model while the SEDAR 37 base model was closer in magnitude to the lower 95% confidence interval (Figure 3.68c).

However, stock-recruitment dynamics were quite different between all three models (Figure 3.68d) due to differences in available data and configuration. For example, s*teepness* was estimated in both the KEYS base model and the SEDAR 37 base model, but at very different values (S94: $h = 0.472$; S37: $h = 0.829$). In SEDAR 37, the *steepness* parameter was not configured for use in the initial equilibrium recruitment which meant any decline in SSB between SSB_0 and the start year did not correspond with any decline in recruitment (i.e., $h = 0.99$). Depletion in the 1986 start year was significant (~90%) and since the SSB_0 estimate was similar to the KEYS base model estimate, the absence of any reduction in recruitment was influential to the *steepness* parameter and resulted in a comparatively higher value. The KEYS base model also had access to the historic catch data which greatly informed the *steepness* parameter. In contrast, the bridge building model, without the historic catch data or a prior, had a difficult time estimating *steepness* and needed to be fixed at 0.99. This resulted in similar SSB and recruitment magnitudes (Figure 3.68a,c) but also higher recruitment estimates during the 1990s when stock size was much lower.

Lastly, a continuity model which aimed at exploring the impact of updating the recreational landings timeseries from the old MRFSS/MRIP to the SRFS back-calculated historical timeseries within the SEDAR 37 base model was developed (i.e., "SEDAR 37 SRFS"). For each gear, spear (Figure 3.69a) and hook-and-line (Figure 3.69b), the differences in catch magnitude between the two survey methods were minimal and higher SRFS estimates became more consistent starting in 2004 (Figure 3.69c). This was not too surprising as the SRFS estimates for these years (1986 – 2012) behave more like a scalar reduction to the MRIP estimates. Consequently, differences in model estimated population dynamics were minimal as trends in spawning stock biomass (Figure 3.70a), recruitment (Figure 3.70b), and exploitation rate (Figure 3.70c) were often within the uncertainty estimated by the SEDAR 37 base model in the first half of the timeseries before becoming higher through 2012.

3.11 FL KEYS/EFL Discussion

The SEDAR 94 Florida Keys/East Florida Benchmark Assessment incorporated fourteen years of new data since the previous assessment (SEDAR 37; terminal year = 2012); changes to the data took place in nearly every component and all historical data were procured and recompiled following SEDAR Data

Best Practices as closely as possible. This assessment utilized stock-specific characterizations of life history data, reanalyzed older reproduction data according to recent recommendations (Lowerre-Barbieri et al. 2022), and applied recent methods to estimate natural mortality (Hamel and Cope 2022; Lorenzen 2022). It made use of revised estimates of recreational landings and discards (via SRFS and SRFS-calibrated data for the Florida private mode and MRIP-FES data for charter and shore modes), incorporated historic commercial landings and reconstructed recreational landings, and revised recreational discard mortality rates based on recent data collections. Lastly, this assessment incorporated additional fishery-independent age-at-length data and updated original fishery-independent surveys but removed several fishery-dependent CPUE timeseries.

Data used in the KEYS base model were often characterized by high uncertainty and limited availability, necessitating several configuration changes to maintain model parsimony. One of the most important changes involved the treatment of fishing fleets. Recreational landings, discards, and composition data separated by spear and hook-and-line gears were highly uncertain, with annual CVs frequently exceeding 0.5 and sample sizes often being low. To address these limitations, the gears were combined into a single recreational fleet, resulting in modest improvements in the precision of landings and discard estimates. However, annual CVs still commonly exceeded 0.3 – 0.5, and length-composition data remained noisy, requiring the use of super-periods to increase effective sample sizes. Similar challenges existed for the commercial fishery. Although commercial landings estimates were relatively precise, annual sample sizes for composition data were low, discard estimates were unavailable, and commercial landings represented only a small proportion of total landings (on average, less than 5%). As a result, commercial gears were also aggregated into a single fleet, and super-periods were applied to the length-composition data. These data limitations underscore the importance of improving more targeted and consistent biological sampling in both the recreational and commercial fisheries to reduce uncertainty in model estimates and strengthen future Hogfish stock assessments.

By configuring recreational fishing mortality as an annual parameter within the KEYS base model, uncertainty in the recreational landings and discard data could be better accommodated. The model generally reproduced the observed trend and magnitude of recreational landings, although it estimated higher landings in 1988 and lower landings in 2008, 2012, and 2015. These deviations were linked to the model's interpretation of population dynamics. Specifically, the model estimated a decline in female numbers-at-age during the late 1990s and early 2000s, a signal that was likely informed by the co-occurring period of low recreational landings. To generate this reduction in females, the model first estimated a decline in mean male numbers-at-age beginning in 1988, which reduced reproductive output. Because sex transition in the model is governed by the cumulative hermaphroditism function, the initial decline in males subsequently propagated through the population and contributed to further reductions in female numbers, which in turn led to continued reductions in mean male numbers-at-age through approximately 2009. As spawning biomass declined, the model was unable to produce enough fish to support the unusually high recreational landings estimates observed in several later years. Consequently, the model favored lower landings estimates in those years to remain consistent with the broader population dynamics implied by the full dataset. The configuration of recreational fishing mortality to annual parameters was supported by a runs test of the recreational landing's residuals from 1981 – 2024, which indicated the residuals were sufficiently random and lacked significant temporal autocorrelation ($p = 0.36$). Additional support came from a sensitivity analysis conducted during the model development process in which recreational landings were fit exactly (i.e., F_{hybrid}). Although that configuration improved agreement with the recreational landings data, it produced poorer fits to other data sources, particularly the abundance indices, discards, and length composition data. Together, these results suggest that

allowing the model flexibility to deviate from the input recreational landings estimates resulted in a more internally consistent fit across all available datasets.

Historically, the recreational private mode catch time series has been the largest contributor to recreational landings and discards for the Florida Keys/East Florida Hogfish stock. In recent stock assessments, incorporation of Florida's SRFS data effectively acted as a scalar reduction to the pre-2021 private mode catch series, resulting in reductions to estimates of spawning stock biomass and productivity when comparing to models utilizing the MRIP-FES calibration. This pattern was observed in the SEDAR 79 (2024) Mutton Snapper benchmark assessment and the SEDAR 96 (2024) Yellowtail Snapper operational assessment. For Hogfish, however, the ad-hoc calibrated MRFSS-MRIP estimates used in SEDAR 37 were already similar in magnitude to the "Full SRFS" estimates evaluated here and the MRIP-FES calibration estimates were never used in a Florida Keys/East Florida Hogfish assessment. As a result, incorporating SRFS produced only minor changes in estimated stock size and exploitation rates, as demonstrated by the "SEDAR 37 SRFS" continuity model. In contrast, results from the "S37data_S94config" continuity model indicated that the larger difference in biomass estimates between the KEYS base model and the SEDAR 37 base model were driven primarily by the configuration changes implemented for SEDAR 94. These findings suggest that model structural and configuration changes, rather than the adoption of SRFS catch estimates, were the primary source of the observed differences in estimated biomass.

In SEDAR 37, all three Hogfish stocks in the southeastern U.S. were assumed to be exhibit the same life history characteristics where knowledge on growth, mortality, reproduction, and hermaphroditism was predominantly informed by West Florida Shelf data. Thus, a key modification to the KEYS base model in the current assessment was the incorporation of stock-specific life-history information for the Florida Keys/East Florida stock. Central to this effort was the availability and inclusion of fishery-independent CAAL data from multiple life-history studies, which allowed growth to be estimated directly within the assessment model. Although some of these data were available during SEDAR 37 (e.g., the McBride dataset), they were not incorporated as direct model inputs. Without these fishery-independent data, the SEDAR 37 model could not reliably estimate growth, as reported therein by a sensitivity run which estimated an asymptotic length of 42.6 cm FL. In contrast, growth parameter estimates from the KEYS base model were consistent with those from the external growth model developed during the Data Workshop and the estimated platoon parameter (0.73) indicated evidence of age truncation and Lee's phenomenon within the Florida Keys/East Florida stock (McBride and Richardson 2007). Estimates of mean length-at-age for platoon 4 (63.1 cm FL at age 16) and platoon 5 (77.8 cm FL at age 16) were further supported by observations of larger Hogfish within the commercial length composition data (i.e., commercial TIP data from northeast Florida that were not aged) and anecdotally by fish observed but not measured during dives in the Dry Tortugas (D. Morley, *pers. comm.*). Similarly, mean length-at-age estimates for platoons 3 and 4 were consistent with growth parameter estimates reported by Drake (2021) for Hogfish sampled in Puerto Rico and the U.S. Virgin Islands (L_{inf} = 62.4 cm FL), where habitat conditions are more comparable to the Florida Keys reef tract than to those of the West Florida Shelf or northeast Florida regions (see also section 2.9.4 of the Data Workshop report for comparative discussion on the growth estimates from Cuba). Lastly, incorporating stock-specific hermaphroditism transition rates allowed the KEYS base model to better represent the earlier female-to-male transition observed in the Florida Keys/East Florida stock. Overall, this assessment has benefited substantially from the incorporation of targeted life-history research and the use of stock-specific biological information.

The development and application of the MCMC "proxy" model in this assessment was an uncommon approach but may provide a useful pathway for future Stock Synthesis assessments that benefit from the

flexibility of the F as parameter configuration. This may be particularly valuable when catch data contain considerable observation error and there is a desire to characterize uncertainty beyond model-based standard errors or self-testing bootstrap analyses. Stock Synthesis models configured with the F_{hybrid} approach typically fit landings almost exactly, effectively ignoring observation error and assuming that catches are known without uncertainty. In the southeastern U.S., this assumption is often reasonable for commercial fisheries because monitoring programs function more like a census than a statistical survey and observation error is low (CV = 0.05). However, as demonstrated in this assessment, recreational landings estimates from private, shore, and charter modes are survey-based and can contain considerable uncertainty that should be accounted for within the assessment framework. Estimating F as a parameter allows uncertainty in landings to be integrated with other data sources, enabling the model to estimate catches that differ slightly from the survey estimates while remaining within the bounds of the reported observation error. The MCMC "proxy" model therefore retained the same underlying assumption of a "known" catch used in other F_{hybrid} configurations but treated the KEYS base model's expected catch values as the reference truth rather than the original survey estimates (e.g., SRFS or MRIP). But when including annual fleet-specific F values in an MCMC routine, it greatly expands the parameter space and often causes simulants to explore regions far from the MLE estimates. The MCMC "proxy" model therefore provided a practical configuration workaround for the KEYS base model, capturing uncertainty in parameters and derived quantities while relying on the landings estimates generated by the KEYS base model.

The results of the model diagnostics suggest the SEDAR 94 KEYS base model may be suitable for use in the management of Florida Keys/East Florida Hogfish. The KEYS base model demonstrated adequate fits to the various data components while the jitter analysis and low gradient (<0.0001) lent support that the KEYS base model converged to a global solution. The KEYS base model also exhibited model consistency as the removal of successive years of data back to the 2018 (first model year of new regulations) showed no discernable retrospective patterns in estimates of exploitation rates and spawning stock biomass. The results of the *ln(R0)* profiling, as well as the ASPM and ASPMdev, suggested that the estimates of absolute abundance and trend were consistent and primarily influenced by both the catch information and the variability in recruitment. Retrospective forecasting and the hindcast cross-validation techniques also suggested the KEYS base model exhibited more predictive skill than a random-walk for several data sources.

The MSY-based reference values for Florida Keys/East Florida Hogfish as estimated by the SEDAR 94 KEYS base model moderately supported the historical stock status paradigm of the prior assessments by indicating that the stock experienced intermittent overfishing over a 36-year period and remained overfished for 22 years. Exploitation rates oscillated above and below the candidate F_{MSY} largely between 1981 – 2017; from 1950 – 1980 and from 2017 – 2024 they were estimated below F_{MSY}. The estimated spawning stock biomass dropped below the candidate SSB_{MSY} target in 1993 but rose above it again in the terminal year 2024; the stock was below the candidate $MSST_{MSY}$ from 1996 – 2018. Using these reference point values, the current stock would not be undergoing overfishing ($F_{current}/F_{MSY} = 0.258$), nor would it be considered overfished ($SSB_{current}/MSST_{MSY} = 1.342$). However, estimates of stock condition based on SPR reference values by the KEYS base model differed substantially from this historical perspective. Using the candidate $F_{40\%SPR}$ proxy, exploitation rates were mainly below $F_{40\%SPR}$ with only eight years above it. The spawning stock biomass has remained above both a candidate $SSB_{F40\%SPR}$ target (reaching it in 2006) and $MSST_{F40\%SPR}$ for the duration of the timeseries. From these reference point values, the current stock would also be considered not overfished ($SSB_{current}/MSST_{F40\%SPR} = 2.870$), nor undergoing overfishing ($F_{current}/F_{40\%SPR} = 0.156$). For either of these candidate reference values, the uncertainty in derived quantities was well captured by both the MCMC and bootstrapping analyses with

distributions inclining towards even more favorable stock conditions. In addition, the Florida Keys/East Florida Hogfish stock has shown signs of recovery since 2018, both in observed measures (e.g., RVC indices) and in model-based estimates, likely due in part to the regulatory changes implemented in late 2017.

The SAFMC Snapper Grouper Amendment 37 defines MSY as $F_{30\%SPR}$ and the MSST as 75% of $SSB_{F30\%SPR}$. Under these reference values, the SEDAR 94 KEYS base model indicates that the current Florida Keys/East Florida Hogfish stock is also neither overfished ($SSB_{current}$/MSST > 1.0) nor undergoing overfishing ($F_{current}$/MFMT < 1.0). However, these reference values provide the least protection for the stock as the stock would need to undergo considerable decline to trigger any management intervention moving forward. Current biomass was estimated to be nearly 17 times the MSST, with no evidence of an overfished condition since 1950. The assessment identified only a few years of overfishing having occurred – 1988, 2005, and 2009. The per-recruit analysis conducted in this assessment indicated that $F_{30\%SPR}$ maximizes yield-per-recruit, but it led to very low long-term yields and was estimated to be highly uncertain. Furthermore, projection analyses suggested yields at this exploitation rate were not sustainable. By comparison, F_{MSY} reduced yield-per-recruit by 32% but increased equilibrium total yield by 486% (74,902 to 363,913 lbs.), while $F_{40\%SPR}$ yielded a 13% reduction in yield-per-recruit but a 387% increase in total yield (to 289,974 lbs.). Overall, F_{MSY} (0.077 yr^{-1}) was more conservative than $F_{40\%SPR}$ (0.128 yr^{-1}) but produced higher equilibrium yields, supporting consideration of alternative candidate reference points to $F_{30\%SPR}$ for this stock.

The disparity in $F_{30\%SPR}$ values between the SEDAR 37 FLK/EFL base model and the SEDAR 94 KEYS base model was primarily driven by differences in model configuration, life-history assumptions, and estimates of stock productivity. Notably, the *steepness* parameter was estimated at $h = 0.83$ in the SEDAR 37 FLK/EFL base model, compared with $h = 0.47$ in the current assessment. As demonstrated by the per-recruit analysis, these differences in stock-recruitment dynamics resulted in substantially different $F_{30\%SPR}$ estimates and corresponding positions on the equilibrium yield curve. Additional insight was provided by the "S37data_S94config" continuity model. Using $F_{30\%SPR}$ reference points and the geometric mean $F_{current}$ (2010 – 2012), this model suggested that applying configuration changes similar to those used in the current assessment to the SEDAR 37 FLK/EFL base model could have produced a more favorable terminal stock condition (e.g., $SSB_{ratio} = 1.24$ and $F_{ratio} = 0.70$). Consequently, the stock may have been perceived as being in better condition than indicated by the original assessment. Furthermore, evidence of undiagnosed model misspecification in the SEDAR 37 FLK/EFL base model, as indicated by the ASPM diagnostic described in Section 3.10, adds uncertainty regarding the validity of that model's conclusions. Taken together, the differences in model assumptions, configuration, and apparent misspecification led to substantially different perceptions of stock status and highlight the uncertainty associated with the SEDAR 37 FLK/EFL base model. These findings suggest that the contrasting stock status outcomes between the two assessments were driven more by differences in assessment methodology and underlying assumptions than by changes in the underlying population dynamics themselves.

3.12 FL KEYS/EFL Projections

Short- and long-term deterministic projections were conducted to estimate Florida Keys/East Florida Hogfish spawning stock biomass and yield under a range of harvest scenarios. These were performed under several assumed conditions: growth, and stock-recruitment parameters were kept constant (at values estimated by the SEDAR 94 KEYS base model) while relative apical F, selectivity, and discarding and retention associated with the terminal three years (2022 – 2024) would remain the same into the future. The average relative apical F values from 2022 – 2024 as estimated by the base model were used to determine the fleet allocations in the projection scenarios. These were 1.43% for the commercial fleet

and 98.57% for the recreational fleet. The method to project the assessment results was developed in the R statistical computing environment by SEFSC assessment scientists (https://github.com/SEFSC/SFD-AllocationForecasting).

Although the Florida Keys/East Florida Hogfish stock is currently managed using the $F_{30\%SPR}$ proxy reference point, projections from the KEYS base model (as well as the per-recruit analysis in Section 3.6) suggested this F value (0.189 yr^{-1}) was of much higher risk. In long-term equilibrium projections using the stock-recruitment curve, $F_{30\%SPR}$ held constant depleted the population to <20% within the first 7 years (by 2032) and was <5% in the terminal 10 years of the projections. By assuming recruitment to be constant at the whole timeseries average (1950 – 2024), the population declined until being 21% depleted in the final 10 years of the projections; however, results from the KEYS base model indicate it is unlikely recruitment could be sustained at that average given the degree of depletion. Furthermore, estimates of exploitation rate by the KEYS base model only exceeded this value in 3 years (1988, 2005, and 2009). Therefore, we discuss projections using the F_{MSY} and $F_{40\%SPR}$ proxy reference values but tabulate the $F_{30\%SPR}$ proxy reference value scenarios in Tables 3.19 – 20 to satisfy the TOR.

First, long-term deterministic projections were conducted to determine the equilibrium fishing mortality rate that achieves F_{MSY} or 40%SPR ($F_{40\%SPR}$), as well as the associated spawning stock biomass (SSB_{MSY} or $SSB_{40\%SPR}$), by using an iterative process to set exploitation rates each year that ensures 1) MSY or the MSY_{proxy} (i.e. SPR 40%) is achieved at equilibrium, and 2) annual relative apical fishing mortality between fleets is maintained at the average of the base model's terminal three years (2022 – 2024). This iterative process to achieve equilibrium F_{MSY} or $F_{40\%SPR}$ is different than the Newton-Raphson method utilized by the base model, thus results will be near-exact rather than identical to base model reference point values (Methot et al. 2026). Projections were for 100 years (2025 – 2124) where recruitment either followed the Beverton-Holt stock-recruitment relationship, as parameterized by the KEYS base model, or was held constant at the long-term (1950 – 2024) average; equilibrium was assumed to have been obtained in the final 10 years of the projection (i.e., 2115 – 2124) as recommended by Van Beveren et al. (2021). Please note, however, that due to the configuration of the KEYS base model where main recruitment deviations ended in 2021, projected recruitment within all scenarios *not* relying on the stock-recruitment curve began in 2022. This was a limitation imposed by the structural framework of SS and could not be changed.

Next, short-term deterministic projections, which used a similar iterative process as the long-term projections, were conducted under a range of harvest scenarios and assumed age-0 recruitment remained constant at the recent 5-year average (2020 – 2024) estimated by the KEYS base model (Schueller et al. 2022; Van Beveren et al. 2021). Per the TORs, short-term projections explored the effects of holding fishing mortality rates constant at the equilibrium F_{MSY} or $F_{40\%SPR}$ (as determined via the long-term projection above), at 75% of that equilibrium F_{MSY} or $F_{40\%SPR}$, and at $F_{current}$ (from section 3.8) in order to produce annual yield values. While only the first 5 years of the short-term projection are recommended for use, reported projections were extended until 2034.

3.12.1 Results

The projection results for the constant F scenarios including the associated fishing mortality rates, retained landings (in pounds and numbers), spawning stock biomass (mt), and age-0 recruitment (in numbers) as estimated for assessment years (1950 – 2024) and forecast years (2025 – 2044) are presented in Figures 3.71 – 78 and Tables 3.21 – 25. The equilibrium fishing mortality rate that achieved 40% SPR ($F_{40\%SPR}$) in the long-term projections was 0.129 yr^{-1} (Figure 3.71, Table 3.21) and was near exact to the KEYS base model estimate (0.128 yr^{-1}). Likewise, the equilibrium F_{MSY} in the long-term projection was 0.073 yr^{-1} (Figure 3.75, Table 3.24) compared to 0.077 yr^{-1} by the KEYS base model.

Retained landings from the long-term constant $F_{40\%SPR}$ projection scenario initially increased to values similar to yields prior to 2018, then quickly declined through the 5-yr projection period from 395,330 lbs. in 2025 to 315,678 lbs. in 2029 (Table 3.21, Figure 3.72). Spawning stock biomass declined in response to the higher exploitation rates but became similar to recent years since 2020 (Table 3.21, Figure 3.73); when following the stock-recruitment curve, SSB declined further until becoming more like the mid-2000s years (Table 3.21, Figure 3.73) as recruitment continued to decline through the projection period (Table 3.21, Figure 3.74).

Resulting trends from the short-term $F_{40\%SPR}$ scenario presented as a middle ground between the two long-term projection scenarios given the differing assumptions on recruitment (Table 3.22, Figures 3.71 – 74). $F_{40\%SPR}$ is higher than most exploitation rates estimated throughout the model timeseries and was nearly six-and-a-half times higher than recent exploitation rates ($F_{40\%SPR}/F_{current} = 6.43$). When exploitation rates were held at 75% $F_{40\%SPR}$ (0.097 yr^{-1}; Table 3.22, Figure 3.71), they were a little higher than the whole timeseries (1950 – 2024) average of 0.065 yr^{-1} and were nearly five times higher than recent exploitation rates (75% $F_{40\%SPR}/F_{current} = 4.82$). In the short-term $F_{40\%SPR}$ scenario, retained landings were 387,977 lbs. (114,417 fish) in 2025 and 295,513 lbs. (88,248 fish) in 2029 (Table 3.22, Figure 3.72). In the 75% $F_{40\%SPR}$ scenario, retained landings were 290,920 lbs. (85,881 fish) in 2025 and 254,188 lbs. (74,818 fish) in 2029 (Table 3.22, Figure 3.72). In both scenarios, projected SSB immediately declined (Table 3.22, Figure 3.73) but stabilized near recent year values due to the assumptions on recruitment (Table 3.22, Figure 3.74).

Results from both the long- and short-term constant F_{MSY} projection scenarios were comparatively more stable across time. The exploitation rate at F_{MSY} was nearly four times greater than the current exploitation rate ($F_{MSY}/F_{current} = 3.88$) and 75% F_{MSY} (0.054 yr^{-1}; Table 3.25, Figure 3.75) was nearly three times greater (75% $F_{MSY}/F_{current} = 2.91$). Unlike the $F_{30\%SPR}$ or $F_{40\%SPR}$ scenarios, whose initial spike in retained landings led to immediate declines in SSB and subsequent further declines in yield, the retained landings from the long- and short-term constant F_{MSY} scenarios (Tables 3.24 – 25, Figure 3.76) shaped more steady projections of the SSB (Tables 3.24 – 25, Figure 3.77) given the constant recruitment (Tables 3.24 – 25, Figure 3.78). Retained landings from the short-term constant F_{MSY} scenario were 217,900 lbs. (64,372 fish) in 2025 and 207,928 lbs. (60,588 fish) in 2029 (Table 3.25, Figure 3.76). In the 75% F_{MSY} scenario, retained landings were 163,401 lbs. (48,298 fish) in 2025 and 169,282 lbs. (48,986 fish) in 2029 (Table 3.25, Figure 3.76). Since recruitment in the short-term is held constant at values lower than the long-term or stock-recruit curve estimate (Table 3.25, Figure 3.78), SSB under the constant F_{MSY} scenario declined slightly; however, SSB under the constant 75% F_{MSY} scenario was steadier with a slight increase over time (Table 3.25, Figure 3.77).

Short-term projections for the $F_{current}$ scenario estimated comparatively lower F values (i.e., 0.020 yr^{-1}; Table 3.23, Figure 3.71) and resulted in retained landings increasing to 59,990 lbs. (17,750 fish) in 2025 and 71,199 lbs. (20,355 fish) in 2029 (Table 3.23, Figure 3.72). Projected SSB continued to increase to values estimated similar to the 1980s, reaching 2,517.76 metric tons in 2029 (Table 3.23, Figure 3.73).

3.12.2 Discussion

The various constant F scenarios reflect progressing degrees of risk and management. As for many projection exercises, there were numerous caveats to the methods, including unchanging fleet selectivity and fleet allocations, growth, natural mortality, stock-recruitment parameters, other fixed quantities in the base model, process error in recruitment for the terminal three years, and assumptions of recruitment in future years. Projection results should, therefore, be interpreted carefully.

The estimates of retained yield from the first five years of the short-term $F_{30\%SPR}$ projection decreased from 570,132 to 339,973 lbs. and were similar in magnitude to the average retained landings across earlier parts of the timeseries (e.g., 1950 – 1994: avg. 365,791 lbs.; 1986 – 1994: avg. 562,018 lbs.) when the stock was experiencing its fastest decline. This scenario, and the 75% $F_{30\%SPR}$ scenario, present the highest risk given the greater landings and the underlying assumption that recruitment will not diminish with a depleting stock size, which occurred in the long-term equilibrium scenario when recruitment followed the stock-recruitment curve.

In the short-term constant $F_{40\%SPR}$ and 75% $F_{40\%SPR}$ scenarios, the estimated retained yield from the first five years were similar to the average yield from 1995 – 2017 (287,855 lbs.). During this period, spawning biomass remained above $SSB_{F40\%SPR}$ and followed a more stable but variable trend, while exploitation rates fluctuated between levels that approached or exceeded $F_{40\%SPR}$. Furthermore, as the population's biomass began to increase again in 2018, projections under the constant $F_{40\%SPR}$ scenario suggest that, depending on recruitment assumptions, this increasing trend may be overturned.

The results from the short-term F_{MSY} projections were slightly more conservative than $F_{40\%SPR}$ and indicated a level of harvest that either would not significantly decrease the population from where it has recovered or allow much further recovery, thereby acting as an in-between of more recent (2018+) and prior (1995 – 2017) average yields.

The most conservative constant F scenario representing the least amount of risk was $F_{current}$ and was the only constant F projection where the SSB continued to recover (increase) though time. Results under this scenario represent a status-quo where projected yields were like the average landings from 2018 – 2024 (52,415 lbs.) with both SSB and exploitation rates projected to continue well within any MSY or SPR-based thresholds.

3.13 FL KEYS/EFL Tables

Table 3.1. Historic commercial landings (metric tons) and annual CVs of Florida Keys/East Florida Hogfish by gear for years 1950 – 1985.

	Landings (mt)				
Year	Spear	Hook-and-line	Trap	Combined	CV
1950	0.000	6.305	0.000	6.305	0.25
1951	0.000	11.340	0.000	11.793	0.25
1952	0.000	12.292	0.000	12.292	0.25
1953	0.000	11.294	0.000	11.294	0.25
1954	0.000	12.338	0.000	12.338	0.25
1955	0.000	11.022	0.000	11.068	0.25
1956	0.000	9.163	0.000	9.163	0.25
1957	0.000	4.128	0.000	4.128	0.25
1958	0.000	2.087	0.000	2.087	0.25
1959	0.000	2.449	0.000	2.449	0.25
1960	0.000	1.678	0.000	1.678	0.25
1961	0.454	0.726	0.000	0.726	0.25
1962	0.000	1.225	0.000	1.225	0.2
1963	0.000	3.629	0.000	3.629	0.2
1964	0.000	6.123	0.000	6.123	0.2
1965	0.045	3.719	0.000	3.719	0.2
1966	0.000	4.808	0.000	4.808	0.2
1967	0.000	5.534	0.000	5.534	0.2
1968	0.000	5.488	0.000	5.488	0.2
1969	0.000	3.946	0.000	3.946	0.2
1970	0.000	4.853	0.000	4.853	0.2
1971	0.000	4.264	0.000	4.264	0.2
1972	0.000	4.672	0.000	4.672	0.2
1973	0.000	3.266	0.000	3.266	0.2
1974	0.000	3.447	0.000	3.447	0.2
1975	0.000	3.447	0.000	3.447	0.2
1976	0.000	1.860	0.000	1.860	0.2
1977	0.000	5.162	0.000	5.162	0.2
1978	0.000	1.025	0.000	1.025	0.1
1979	0.000	0.918	0.000	0.918	0.1
1980	0.000	8.917	0.000	8.917	0.1
1981	0.000	8.187	0.000	8.187	0.1
1982	0.000	1.028	0.000	1.028	0.1
1983	0.000	2.097	0.000	2.097	0.1
1984	0.000	1.051	0.000	1.051	0.1
1985	0.000	2.013	0.000	2.013	0.1

Table 3.2. Historic commercial landings (numbers) and annual CVs of Florida Keys/East Florida Hogfish by gear for years 1950 – 1985.

	Landings (numbers)				
Year	Spear	Hook-and-line	Trap	Combined	CV
1950	0	4,894	0	4,894	0.25
1951	352	8,803	0	9,155	0.25
1952	0	9,542	0	9,542	0.25
1953	0	8,768	0	8,768	0.25
1954	0	9,577	0	9,577	0.25
1955	35	8,556	0	8,592	0.25
1956	0	7,113	0	7,113	0.25
1957	0	3,204	0	3,204	0.25
1958	0	1,620	0	1,620	0.25
1959	0	1,901	0	1,901	0.25
1960	0	1,303	0	1,303	0.25
1961	0	563	0	563	0.25
1962	0	951	0	951	0.2
1963	0	2,817	0	2,817	0.2
1964	0	4,754	0	4,754	0.2
1965	0	2,887	0	2,887	0.2
1966	0	3,732	0	3,732	0.2
1967	0	4,296	0	4,296	0.2
1968	0	4,261	0	4,261	0.2
1969	0	3,063	0	3,063	0.2
1970	0	3,768	0	3,768	0.2
1971	0	3,310	0	3,310	0.2
1972	0	3,627	0	3,627	0.2
1973	0	2,535	0	2,535	0.2
1974	0	2,676	0	2,676	0.2
1975	0	2,676	0	2,676	0.2
1976	0	1,444	0	1,444	0.2
1977	0	4,007	0	4,007	0.2
1978	0	796	0	796	0.1
1979	0	713	0	713	0.1
1980	0	6,922	0	6,922	0.1
1981	0	6,356	0	6,356	0.1
1982	0	798	0	798	0.1
1983	0	1,628	0	1,628	0.1
1984	0	816	0	816	0.1
1985	0	1,562	0	1,562	0.1

Table 3.3. Commercial landings (metric tons) and annual CVs of Florida Keys/East Florida Hogfish by gear for years 1986 – 2024.

	Landings (mt)				
Year	Spear	Hook-and-line	Trap	Combined	CV
1986		21.740		21.740	0.05
1987		29.068		29.068	0.05
1988		29.238		29.238	0.05
1989		35.769		35.769	0.05
1990		34.682		34.682	0.05
1991	6.859	11.537	13.412	31.808	0.05
1992	11.284	21.296	9.599	42.180	0.05
1993	11.272	22.035	9.730	43.037	0.05
1994	10.632	14.830	3.123	28.585	0.05
1995	8.042	10.800	2.887	21.729	0.05
1996	7.909	9.224	2.677	19.809	0.05
1997	6.954	10.664	3.834	21.452	0.05
1998	7.065	5.283	3.340	15.688	0.05
1999	4.374	4.151	7.153	15.678	0.05
2000	5.292	3.680	5.088	14.060	0.05
2001	5.481	4.261	1.030	10.772	0.05
2002	5.878	4.135	0.857	10.870	0.05
2003	3.888	6.730	1.219	11.837	0.05
2004	5.617	6.185	1.091	12.892	0.05
2005	3.987	3.056	0.606	7.650	0.05
2006	3.722	1.865	0.858	6.444	0.05
2007	3.387	2.603	0.596	6.586	0.05
2008	3.398	1.965	0.634	5.997	0.05
2009	3.336	2.412	0.750	6.498	0.05
2010	2.441	2.423	0.451	5.315	0.05
2011	2.854	2.257	0.578	5.689	0.05
2012	3.732	1.738	0.969	6.438	0.05
2013	4.936	2.012	0.828	7.775	0.05
2014	6.046	2.340	1.391	9.777	0.05
2015	6.442	2.042	1.525	10.008	0.05
2016	5.311	1.812	0.880	8.003	0.05
2017	3.659	0.852	0.314	4.825	0.05
2018	1.610	0.374	0.077	2.060	0.05
2019	0.814	0.124	0.119	1.057	0.05
2020	1.190	0.107	0.043	1.341	0.05
2021	1.348	0.151	0.035	1.534	0.05
2022	1.188	0.159	0.037	1.383	0.05
2023	1.032	0.061	0.043	1.137	0.05
2024	1.007	0.087	0.025	1.118	0.05

Table 3.4. Commercial landings (numbers) and annual CVs of Florida Keys/East Florida Hogfish by gear for years 1986 – 2024.

Landings (numbers)

Year	Spear	Hook-and-line	Trap	Combined	CV
1986	0	16,876	0	16,876	0.05
1987	0	22,565	0	22,565	0.05
1988	0	22,696	0	22,696	0.05
1989	0	27,767	0	27,767	0.05
1990	0	26,923	0	26,923	0.05
1991	5,324	8,956	10,411	24,692	0.05
1992	8,760	16,532	7,452	32,743	0.05
1993	8,751	17,106	7,553	33,409	0.05
1994	8,253	11,512	2,425	22,190	0.05
1995	6,243	8,383	2,241	16,867	0.05
1996	6,139	7,160	2,078	15,377	0.05
1997	5,398	8,279	2,976	16,653	0.05
1998	5,485	4,101	2,592	12,178	0.05
1999	3,396	3,222	5,553	12,170	0.05
2000	4,108	2,857	3,950	10,914	0.05
2001	4,255	3,308	800	8,362	0.05
2002	4,563	3,210	666	8,438	0.05
2003	3,018	5,224	946	9,189	0.05
2004	4,360	4,801	847	10,008	0.05
2005	3,095	2,373	471	5,939	0.05
2006	2,889	1,447	666	5,003	0.05
2007	2,629	2,021	463	5,113	0.05
2008	2,638	1,526	492	4,655	0.05
2009	2,590	1,872	582	5,044	0.05
2010	1,895	1,881	350	4,126	0.05
2011	2,215	1,752	448	4,416	0.05
2012	2,897	1,349	752	4,998	0.05
2013	3,832	1,562	642	6,036	0.05
2014	4,693	1,817	1,080	7,589	0.05
2015	5,000	1,585	1,183	7,769	0.05
2016	4,123	1,407	683	6,213	0.05
2017	1,910	445	164	2,519	0.05
2018	840	195	40	1,076	0.05
2019	425	65	62	552	0.05
2020	621	56	23	700	0.05
2021	704	79	18	801	0.05
2022	620	83	19	722	0.05
2023	539	32	23	594	0.05
2024	526	45	13	584	0.05

Table 3.5. Recreational landings (numbers) of Florida Keys/East Florida Hogfish by gear for years 1981 – 2024 and annual CVs. The 'Full SRFS' estimates are comprised of 'SRFS & SRFS-calibrated Private' mode, MRIP charter mode, and MRIP shore mode landings estimates. 'SRFS & SRFS-calibrated Private' estimates are comprised of SRFS private mode (2021 – 2024) and SRFS ratio-calibrated MRIP private mode (1981 – 2020). The 'Full SRFS Combined' is comprised of the 'Full SRFS' estimates plus the SRHS estimates.

Landings (thousands)

Year	Full SRFS Spear	CV	Full SRFS HL	CV	SRHS HL	CV	Full SRFS Combined	CV
1981	1,261.618	0.64	22.688	0.62	1.063	0.05	1,285.369	0.77
1982	49.56	0.58	-	-	0.105	0.05	106.740	0.76
1983	182.971	0.80	10.475	0.93	0.314	0.05	193.760	0.77
1984	374.61	0.65	6,269.688	1.04	0.567	0.05	6,644.906	1.01
1985	-	-	176.795	0.97	0.273	0.05	177.068	1.07
1986	95.631	0.74	44.713	0.64	0.589	0.05	140.933	0.62
1987	175.257	0.52	115.874	0.41	0.562	0.05	287.793	0.50
1988	2.391	1.07	66.048	0.81	0.512	0.05	207.630	0.60
1989	61.153	0.96	107.177	0.55	0.392	0.05	168.651	0.58
1990	151.498	0.67	94.21	0.66	0.226	0.05	245.934	0.56
1991	28.131	0.87	59.774	0.80	0.239	0.05	88.144	0.79
1992	126.627	0.49	80.219	0.61	0.383	0.05	244.231	0.50
1993	89.084	0.54	182.23	0.50	0.251	0.05	271.565	0.52
1994	131.068	0.51	66.587	0.49	0.188	0.05	197.843	0.54
1995	64.259	0.64	93.467	0.53	0.414	0.05	158.139	0.63
1996	47.283	0.55	61.529	0.56	0.23	0.05	109.042	0.54
1997	38.643	0.65	27.429	0.50	0.226	0.05	66.140	0.59
1998	31.882	0.54	15.534	0.51	0.236	0.05	47.623	0.61
1999	78.313	0.54	20.54	0.50	0.207	0.05	99.008	0.71
2000	23.817	0.67	12.236	0.69	0.166	0.05	36.220	0.82
2001	21.254	0.51	48.929	0.56	0.2	0.05	70.384	0.79
2002	57.898	0.56	23.566	0.55	0.152	0.05	81.615	0.81
2003	87.332	0.50	48.728	0.62	0.146	0.05	136.206	0.58
2004	62.844	0.52	105.71	0.70	0.467	0.05	169.022	0.69
2005	138.33	0.74	25.447	0.51	0.543	0.05	164.319	0.77
2006	77.115	0.61	50.908	0.48	0.608	0.05	128.631	0.57
2007	115.967	0.48	63.299	0.61	0.336	0.05	179.602	0.52
2008	330.684	0.64	27.319	0.59	0.203	0.05	358.206	0.65
2009	150.09	0.53	95.188	0.76	0.134	0.05	245.412	0.56
2010	163.503	0.68	28.789	0.89	0.071	0.05	192.364	0.74
2011	46.612	0.59	36.482	0.71	0.095	0.05	83.188	0.68
2012	343.894	0.79	42.228	0.58	0.106	0.05	386.226	0.79
2013	76.11	0.46	62.8	0.57	0.124	0.05	139.034	0.53
2014	235.219	0.48	49.699	0.41	0.181	0.05	285.100	0.51
2015	389.797	0.62	122.587	0.27	0.283	0.05	512.667	0.49
2016	176.357	0.44	62.756	0.45	0.167	0.05	239.280	0.48
2017	61.083	0.53	17.219	0.56	0.078	0.05	78.379	0.57
2018	17.155	0.80	1.345	0.90	0.012	0.05	18.512	0.74
2019	-	-	5.689	1.07	0	0.05	5.689	0.39
2020	0.01	1.00	8.975	0.66	0.015	0.05	9.000	0.82
2021	27.456	0.23	5.756	0.54	0.007	0.05	37.713	0.25
2022	6.861	0.28	13.481	0.59	0.006	0.05	18.421	0.28
2023	11.236	0.24	3.976	0.50	0.043	0.05	10.158	0.29
2024	8.971	0.30	4.325	0.48	0.012	0.05	13.308	0.28

Table 3.6. Recreational discards (numbers) of Florida Keys/East Florida Hogfish by gear for years 1981 – 2024 and annual CVs. The 'Full SRFS' estimates are comprised of 'SRFS & SRFS-calibrated Private' mode, MRIP charter mode, and MRIP shore mode landings estimates. 'SRFS & SRFS-calibrated Private' estimates are comprised of SRFS private mode (2021 – 2024) and SRFS ratio-calibrated MRIP private mode (1981 – 2020). The 'Full SRFS Combined' is comprised of the 'Full SRFS' estimates plus the SRHS estimates.

Discards (thousands)

Year	Full SRFS Spear	CV	Full SRFS HL	CV	SRHS HL	CV	Full SRFS Combined	CV
1981	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-
1987	-	-	2.714	1.09	-	-	2.714	1.09
1988	-	-	228.086	1.09	-	-	230.511	1.08
1989	-	-	5.37	1.09	-	-	5.370	1.09
1990	1.677	1.09	14.419	0.86	-	-	16.095	0.80
1991	-	-	-	-	-	-	-	-
1992	2.996	1.09	14.775	0.71	-	-	34.489	0.62
1993	-	-	5.31	1.09	-	-	5.310	1.09
1994	-	-	21.894	0.76	-	-	21.894	0.78
1995	2.072	1.09	66.178	0.70	-	-	68.249	0.70
1996	2.062	1.09	23.835	0.64	-	-	25.897	0.79
1997	-	-	11.35	0.67	-	-	11.350	0.67
1998	-	-	30.742	0.54	-	-	30.723	0.62
1999	0.643	1.09	31.21	0.49	-	-	31.863	0.53
2000	1.363	1.09	12.994	0.72	-	-	14.357	0.91
2001	-	-	9.715	0.92	-	-	9.715	1.08
2002	3.148	0.97	-	-	-	-	3.148	1.09
2003	-	-	25.348	0.60	-	-	25.348	0.74
2004	0.466	1.09	70.534	0.83	0.023	0.5	71.023	0.84
2005	-	-	147.51	0.80	0.099	0.5	147.609	0.80
2006	2.132	1.09	33.235	0.84	0.178	0.5	35.545	0.81
2007	7.263	1.09	48.359	0.85	0.115	0.5	55.737	0.82
2008	-	-	35.794	0.62	0.175	0.5	35.969	0.63
2009	-	-	10.026	1.08	0.073	0.5	10.099	1.08
2010	-	-	8.871	0.81	0.039	0.5	8.910	0.76
2011	-	-	3.643	0.77	0.032	0.5	3.675	1.06
2012	-	-	51.392	0.80	0.086	0.5	51.478	0.82
2013	2.483	1.09	51.632	0.52	0.11	0.5	54.225	0.55
2014	4.141	0.84	87.451	0.36	0.109	0.5	91.701	0.42
2015	-	-	60.743	0.55	0.155	0.5	60.898	0.69
2016	1.953	1.09	35.694	0.69	0.112	0.5	37.759	0.72
2017	-	-	55.895	0.86	0.149	0.5	56.044	0.88
2018	-	-	42.916	0.57	0.118	0.5	43.034	0.70
2019	-	-	43.62	0.76	0.066	0.5	43.686	0.78
2020	-	-	43.522	0.62	0.099	0.5	43.621	0.68
2021	6.089	0.78	69.36	0.29	0.258	0.5	80.429	0.29
2022	-	-	67.396	0.36	0.132	0.5	75.619	0.38
2023	0.165	0.90	95.582	0.31	0.213	0.5	122.053	0.40
2024	0.928	1.26	44.626	0.32	0.13	0.5	45.971	0.35

Table 3.7. Historical reconstruction of recreational landings (Full SRFS Combined) of Florida Keys/East Florida Hogfish from 1950 – 1980. The estimated number of saltwater angler participants in Florida was multiplied by the ratio 0.976097 to obtain the estimated number of participants within the Florida Keys/East Florida region. The number of participants was then multiplied by the average catch/number of participants from years 1982, 1983, and 1985 (CPUE = 0.263904) to reconstruct the number of landings.

	Number of Saltwater Anglers		Reconstructed Landings (numbers)
Year	Florida	Florida Keys/East Florida	Florida Keys/East Florida
1950	265,900	259,544	68,495
1951	274,187	267,633	70,629
1952	282,475	275,723	72,764
1953	290,762	283,812	74,899
1954	299,049	291,901	77,034
1955	307,337	299,990	79,169
1956	315,624	308,080	81,303
1957	323,911	316,169	83,438
1958	332,199	324,258	85,573
1959	365,676	356,935	94,197
1960	374,577	365,623	96,489
1961	414,720	404,807	106,830
1962	391,199	381,848	100,771
1963	399,699	390,145	102,961
1964	418,956	408,941	107,921
1965	442,416	431,840	113,964
1966	453,819	442,972	116,902
1967	493,510	481,714	127,126
1968	496,090	484,232	127,791
1969	521,289	508,828	134,282
1970	562,752	549,301	144,963
1971	705,592	688,726	181,758
1972	731,204	713,726	188,355
1973	772,865	754,391	199,087
1974	834,392	814,448	214,936
1975	870,670	849,858	224,281
1976	821,995	802,346	211,742
1977	739,438	721,764	190,476
1978	667,847	651,884	172,035
1979	716,261	699,140	184,506
1980	588,882	574,806	151,694

Table 3.8. Indices of relative biomass or abundance values and associated CVs for Florida Keys/East Florida Hogfish from years 1993 – 2024.

	RVC Florida Keys		RVC Dry Tortugas		Combined Video	
Year	Index	CV	Index	CV	Index	CV
1993	-	-	-	-	1.852	0.34
1994	-	-	-	-	1.441	0.49
1995	-	-	-	-	1.552	0.38
1996	-	-	-	-	1.009	0.38
1997	-	-	-	-	0.930	0.32
1998	-	-	-	-	-	-
1999	0.300	0.13	1.133	0.08	-	-
2000	0.592	0.09	0.834	0.09	-	-
2001	0.652	0.08	-	-	-	-
2002	0.806	0.08	-	-	1.536	0.52
2003	0.948	0.08	-	-	0.686	0.44
2004	1.063	0.09	0.855	0.07	0.945	0.36
2005	0.938	0.07	-	-	0.768	0.35
2006	0.815	0.07	0.577	0.08	0.635	0.34
2007	0.907	0.06	-	-	0.346	0.54
2008	1.402	0.05	0.791	0.07	0.407	0.43
2009	1.004	0.05	-	-	0.660	0.35
2010	0.797	0.07	0.834	0.06	1.427	0.25
2011	0.865	0.06	-	-	0.782	0.31
2012	1.059	0.05	1.133	0.05	0.752	0.40
2013	-	-	-	-	0.705	0.23
2014	1.324	0.05	0.813	0.06	0.492	0.28
2015	-	-	-	-	0.760	0.21
2016	1.543	0.05	0.791	0.07	0.923	0.16
2017	-	-	-	-	1.214	0.15
2018	1.158	0.05	1.112	0.05	1.262	0.16
2019	-	-	-	-	1.175	0.17
2020	-	-	-	-	1.648	0.16
2021	-	-	1.390	0.08	1.094	0.19
2022	0.943	0.10	-	-	1.536	0.52
2023	-	-	1.518	0.07	0.686	0.44
2024	1.882	0.07	1.219	0.09	0.945	0.36

Table 3.9. Dirichlet-multinomial weights applied to length and size composition data of the SEDAR 94 KEYS base model. Theta ratios are calculated as theta/(1+theta).

Data Type	Fleet/Index	*ln(theta)*	*theta*	*theta ratio*
Length Composition	Commercial landings	2.093	8.11	0.89
	Recreational discards	0.987	2.68	0.73
	Recreational landings	-0.764	0.47	0.32
	Combined video index	0.442	1.56	0.61
Size Composition	RVC Florida Keys and RVC Dry Tortugas indices	-0.347	0.71	0.41

Table 3.10. List of Stock Synthesis parameters for the SEDAR 94 KEYS base model. The list includes expected parameter values (Value), lower (Min) and upper (Max) bounds of the parameters, associated standard deviation (Std Dev) and coefficients of variation (CV), prior type (Prior), prior standard deviation (Prior Std Dev), and the phase (Phase) of estimation. Parameters designated as fixed were held at their initial values and have no associated range or SE.

	Parameter Label	Value	Min	Max	Std Dev	CV	Prior	Prior Std Dev	Phase
1	L_at_Amin_Fem_GP_1	6.649	2	20	0.754	0.113			3
2	L_at_Amax_Fem_GP_1	51.170	30	80	3.391	0.066			3
3	VonBert_K_Fem_GP_1	0.177	0.05	0.4	0.024	0.138			4
4	CV_young_Fem_GP_1	0.479	0.05	0.9	0.051	0.107			7
5	CV_old_Fem_GP_1	0.367	0.05	0.9	0.045	0.122			7
6	Wtlen_1_Fem_GP_1	2.55E-05	-3	3					Fixed
7	Wtlen_2_Fem_GP_1	2.927	-3	4					Fixed
8	Mat50%_Fem_GP_1	2.080	1	4					Fixed
9	Mat_slope_Fem_GP_1	-3.034	-4	-0.1					Fixed
10	Eggs_scalar_Fem_GP_1	1.000	-3	3					Fixed
11	Eggs_exp_wt_Fem_GP_1	1.000	-3	3					Fixed
12	L_at_Amin_Mal_GP_1	0.000	-1	1					Fixed
13	L_at_Amax_Mal_GP_1	0.000	-1	1					Fixed
14	VonBert_K_Mal_GP_1	0.000	-1	1					Fixed
15	CV_young_Mal_GP_1	0.000	-1	1					Fixed
16	CV_old_Mal_GP_1	0.000	-1	1					Fixed
17	Wtlen_1_Mal_GP_1	2.55E-05	-3	3					Fixed
18	Wtlen_2_Mal_GP_1	2.927	-3	4					Fixed
19	Herm_Infl_age	6.080	1	11					Fixed
20	Herm_stdev	2.330	1	5					Fixed
21	Herm_asymptote	0.999	0.01	1					Fixed
22	CohortGrowDev	1.000	0	1					Fixed
23	Platoon_SD_Ratio	0.730	0.1	3	0.253	0.346			1
24	FracFemale_GP_1	1.000	0	1					Fixed
25	SR_LN(R0)	8.000	6	14	0.150	0.019			1
26	SR_BH_steep	0.472	0.2	0.99	0.049	0.103			2
27	SR_sigmaR	0.449	0.1	2	0.101	0.226			7
28	SR_regime	0.000	-5	5					Fixed
29	SR_autocorr	0.000	0	0					Fixed
30	Main_RecrDev_1981	-0.012	-4	4	0.404	33.109			3
31	Main_RecrDev_1982	-0.042	-4	4	0.400	9.532			3
32	Main_RecrDev_1983	-0.088	-4	4	0.396	4.503			3
33	Main_RecrDev_1984	-0.083	-4	4	0.398	4.807			3
34	Main_RecrDev_1985	0.234	-4	4	0.391	1.676			3
35	Main_RecrDev_1986	-0.037	-4	4	0.374	10.120			3
36	Main_RecrDev_1987	0.222	-4	4	0.341	1.537			3
37	Main_RecrDev_1988	0.168	-4	4	0.315	1.873			3
38	Main_RecrDev_1989	0.016	-4	4	0.300	18.933			3
39	Main_RecrDev_1990	0.349	-4	4	0.230	0.659			3
40	Main_RecrDev_1991	-0.045	-4	4	0.226	5.040			3
41	Main_RecrDev_1992	0.112	-4	4	0.183	1.636			3
42	Main_RecrDev_1993	-0.595	-4	4	0.221	0.372			3
43	Main_RecrDev_1994	-0.159	-4	4	0.174	1.092			3
44	Main_RecrDev_1995	-0.644	-4	4	0.206	0.320			3
45	Main_RecrDev_1996	-0.757	-4	4	0.211	0.279			3
46	Main_RecrDev_1997	-0.320	-4	4	0.174	0.545			3
47	Main_RecrDev_1998	-1.010	-4	4	0.264	0.261			3
48	Main_RecrDev_1999	0.091	-4	4	0.162	1.767			3
49	Main_RecrDev_2000	-0.334	-4	4	0.247	0.740			3
50	Main_RecrDev_2001	-0.177	-4	4	0.242	1.363			3
51	Main_RecrDev_2002	0.238	-4	4	0.211	0.888			3
52	Main_RecrDev_2003	0.151	-4	4	0.232	1.534			3
53	Main_RecrDev_2004	0.163	-4	4	0.210	1.286			3
54	Main_RecrDev_2005	-0.147	-4	4	0.243	1.659			3
55	Main_RecrDev_2006	0.189	-4	4	0.193	1.025			3
56	Main_RecrDev_2007	0.722	-4	4	0.132	0.183			3
57	Main_RecrDev_2008	-0.053	-4	4	0.176	3.346			3
58	Main_RecrDev_2009	0.286	-4	4	0.139	0.485			3
59	Main_RecrDev_2010	-0.334	-4	4	0.194	0.581			3
60	Main_RecrDev_2011	0.029	-4	4	0.151	5.192			3

61	Main_RecrDev_2012	0.547	-4	4	0.107	0.196	3
62	Main_RecrDev_2013	0.335	-4	4	0.116	0.345	3
63	Main_RecrDev_2014	-0.203	-4	4	0.158	0.780	3
64	Main_RecrDev_2015	0.659	-4	4	0.125	0.190	3
65	Main_RecrDev_2016	0.166	-4	4	0.201	1.212	3
66	Main_RecrDev_2017	0.032	-4	4	0.207	6.477	3
67	Main_RecrDev_2018	0.129	-4	4	0.208	1.609	3
68	Main_RecrDev_2019	0.010	-4	4	0.234	22.484	3
69	Main_RecrDev_2020	0.081	-4	4	0.234	2.891	3
70	Main_RecrDev_2021	0.109	-4	4	0.229	2.098	3
71	F_fleet_1_YR_1950_s_1	0.010					_
72	F_fleet_1_YR_1951_s_1	0.010					_
73	F_fleet_1_YR_1952_s_1	0.010					_
74	F_fleet_1_YR_1953_s_1	0.010					_
75	F_fleet_1_YR_1954_s_1	0.010					_
76	F_fleet_1_YR_1955_s_1	0.010					_
77	F_fleet_1_YR_1956_s_1	0.010					_
78	F_fleet_1_YR_1957_s_1	0.010					_
79	F_fleet_1_YR_1958_s_1	0.010					_
80	F_fleet_1_YR_1959_s_1	0.010					_
81	F_fleet_1_YR_1960_s_1	0.010					_
82	F_fleet_1_YR_1961_s_1	0.010					_
83	F_fleet_1_YR_1962_s_1	0.010					_
84	F_fleet_1_YR_1963_s_1	0.010					_
85	F_fleet_1_YR_1964_s_1	0.010					_
86	F_fleet_1_YR_1965_s_1	0.010					_
87	F_fleet_1_YR_1966_s_1	0.010					_
88	F_fleet_1_YR_1967_s_1	0.010					_
89	F_fleet_1_YR_1968_s_1	0.010					_
90	F_fleet_1_YR_1969_s_1	0.010					_
91	F_fleet_1_YR_1970_s_1	0.010					_
92	F_fleet_1_YR_1971_s_1	0.010					_
93	F_fleet_1_YR_1972_s_1	0.010					_
94	F_fleet_1_YR_1973_s_1	0.010					_
95	F_fleet_1_YR_1974_s_1	0.010					_
96	F_fleet_1_YR_1975_s_1	0.010					_
97	F_fleet_1_YR_1976_s_1	0.010					_
98	F_fleet_1_YR_1977_s_1	0.010					_
99	F_fleet_1_YR_1978_s_1	0.010					_
100	F_fleet_1_YR_1979_s_1	0.010					_
101	F_fleet_1_YR_1980_s_1	0.010					_
102	F_fleet_1_YR_1981_s_1	0.010					_
103	F_fleet_1_YR_1982_s_1	0.010					_
104	F_fleet_1_YR_1983_s_1	0.010					_
105	F_fleet_1_YR_1984_s_1	0.010					_
106	F_fleet_1_YR_1985_s_1	0.010					_
107	F_fleet_1_YR_1986_s_1	0.010					_
108	F_fleet_1_YR_1987_s_1	0.010					_
109	F_fleet_1_YR_1988_s_1	0.010					_
110	F_fleet_1_YR_1989_s_1	0.010					_
111	F_fleet_1_YR_1990_s_1	0.010					_
112	F_fleet_1_YR_1991_s_1	0.010					_
113	F_fleet_1_YR_1992_s_1	0.010					_
114	F_fleet_1_YR_1993_s_1	0.010					_
115	F_fleet_1_YR_1994_s_1	0.010					_
116	F_fleet_1_YR_1995_s_1	0.010					_
117	F_fleet_1_YR_1996_s_1	0.010					_
118	F_fleet_1_YR_1997_s_1	0.010					_
119	F_fleet_1_YR_1998_s_1	0.010					_
120	F_fleet_1_YR_1999_s_1	0.010					_
121	F_fleet_1_YR_2000_s_1	0.010					_
122	F_fleet_1_YR_2001_s_1	0.010					_
123	F_fleet_1_YR_2002_s_1	0.010					_
124	F_fleet_1_YR_2003_s_1	0.010					_
125	F_fleet_1_YR_2004_s_1	0.010					_
126	F_fleet_1_YR_2005_s_1	0.010					_
127	F_fleet_1_YR_2006_s_1	0.010					_
128	F_fleet_1_YR_2007_s_1	0.010					_
129	F_fleet_1_YR_2008_s_1	0.010					_
130	F_fleet_1_YR_2009_s_1	0.010					_

131	F_fleet_1_YR_2010_s_1	0.010					_
132	F_fleet_1_YR_2011_s_1	0.010					_
133	F_fleet_1_YR_2012_s_1	0.010					_
134	F_fleet_1_YR_2013_s_1	0.010					_
135	F_fleet_1_YR_2014_s_1	0.010					_
136	F_fleet_1_YR_2015_s_1	0.010					_
137	F_fleet_1_YR_2016_s_1	0.010					_
138	F_fleet_1_YR_2017_s_1	0.010					_
139	F_fleet_1_YR_2018_s_1	0.010					_
140	F_fleet_1_YR_2019_s_1	0.010					_
141	F_fleet_1_YR_2020_s_1	0.010					_
142	F_fleet_1_YR_2021_s_1	0.010					_
143	F_fleet_1_YR_2022_s_1	0.010					_
144	F_fleet_1_YR_2023_s_1	0.010					_
145	F_fleet_1_YR_2024_s_1	0.010					_
146	F_fleet_2_YR_1950_s_1	0.039	0	3	0.023	0.579	2
147	F_fleet_2_YR_1951_s_1	0.041	0	3	0.024	0.580	2
148	F_fleet_2_YR_1952_s_1	0.043	0	3	0.025	0.581	2
149	F_fleet_2_YR_1953_s_1	0.045	0	3	0.026	0.582	2
150	F_fleet_2_YR_1954_s_1	0.047	0	3	0.027	0.582	2
151	F_fleet_2_YR_1955_s_1	0.049	0	3	0.028	0.583	2
152	F_fleet_2_YR_1956_s_1	0.050	0	3	0.029	0.584	2
153	F_fleet_2_YR_1957_s_1	0.052	0	3	0.031	0.584	2
154	F_fleet_2_YR_1958_s_1	0.054	0	3	0.032	0.585	2
155	F_fleet_2_YR_1959_s_1	0.060	0	3	0.035	0.585	2
156	F_fleet_2_YR_1960_s_1	0.062	0	3	0.036	0.586	2
157	F_fleet_2_YR_1961_s_1	0.070	0	3	0.041	0.587	2
158	F_fleet_2_YR_1962_s_1	0.066	0	3	0.039	0.587	2
159	F_fleet_2_YR_1963_s_1	0.068	0	3	0.040	0.588	2
160	F_fleet_2_YR_1964_s_1	0.073	0	3	0.043	0.588	2
161	F_fleet_2_YR_1965_s_1	0.077	0	3	0.046	0.589	2
162	F_fleet_2_YR_1966_s_1	0.080	0	3	0.047	0.590	2
163	F_fleet_2_YR_1967_s_1	0.089	0	3	0.052	0.591	2
164	F_fleet_2_YR_1968_s_1	0.090	0	3	0.053	0.592	2
165	F_fleet_2_YR_1969_s_1	0.096	0	3	0.057	0.593	2
166	F_fleet_2_YR_1970_s_1	0.106	0	3	0.063	0.594	2
167	F_fleet_2_YR_1971_s_1	0.136	0	3	0.082	0.598	2
168	F_fleet_2_YR_1972_s_1	0.145	0	3	0.087	0.600	2
169	F_fleet_2_YR_1973_s_1	0.158	0	3	0.095	0.603	2
170	F_fleet_2_YR_1974_s_1	0.177	0	3	0.107	0.605	2
171	F_fleet_2_YR_1975_s_1	0.191	0	3	0.116	0.608	2
172	F_fleet_2_YR_1976_s_1	0.185	0	3	0.112	0.608	2
173	F_fleet_2_YR_1977_s_1	0.169	0	3	0.102	0.606	2
174	F_fleet_2_YR_1978_s_1	0.154	0	3	0.093	0.605	2
175	F_fleet_2_YR_1979_s_1	0.168	0	3	0.102	0.606	2
176	F_fleet_2_YR_1980_s_1	0.138	0	3	0.084	0.603	2
177	F_fleet_2_YR_1981_s_1	0.320	0	3	0.265	0.827	2
178	F_fleet_2_YR_1982_s_1	0.105	0	3	0.082	0.785	2
179	F_fleet_2_YR_1983_s_1	0.201	0	3	0.163	0.809	2
180	F_fleet_2_YR_1984_s_1	0.307	0	3	0.316	1.027	2
181	F_fleet_2_YR_1985_s_1	0.254	0	3	0.272	1.068	2
182	F_fleet_2_YR_1986_s_1	0.162	0	3	0.103	0.638	2
183	F_fleet_2_YR_1987_s_1	0.203	0	3	0.098	0.481	2
184	F_fleet_2_YR_1988_s_1	0.672	0	3	0.347	0.516	2
185	F_fleet_2_YR_1989_s_1	0.166	0	3	0.089	0.538	2
186	F_fleet_2_YR_1990_s_1	0.299	0	3	0.141	0.472	2
187	F_fleet_2_YR_1991_s_1	0.107	0	3	0.085	0.794	2
188	F_fleet_2_YR_1992_s_1	0.418	0	3	0.161	0.386	2
189	F_fleet_2_YR_1993_s_1	0.284	0	3	0.141	0.497	2
190	F_fleet_2_YR_1994_s_1	0.408	0	3	0.190	0.466	2
191	F_fleet_2_YR_1995_s_1	0.416	0	3	0.195	0.468	2
192	F_fleet_2_YR_1996_s_1	0.213	0	3	0.099	0.464	2
193	F_fleet_2_YR_1997_s_1	0.112	0	3	0.052	0.465	2
194	F_fleet_2_YR_1998_s_1	0.168	0	3	0.073	0.434	2
195	F_fleet_2_YR_1999_s_1	0.371	0	3	0.174	0.468	2
196	F_fleet_2_YR_2000_s_1	0.124	0	3	0.072	0.579	2
197	F_fleet_2_YR_2001_s_1	0.121	0	3	0.071	0.590	2
198	F_fleet_2_YR_2002_s_1	0.072	0	3	0.045	0.631	2
199	F_fleet_2_YR_2003_s_1	0.214	0	3	0.089	0.417	2
200	F_fleet_2_YR_2004_s_1	0.362	0	3	0.157	0.433	2

201	F_fleet_2_YR_2005_s_1	0.834	0	3	0.254	0.304			2
202	F_fleet_2_YR_2006_s_1	0.244	0	3	0.101	0.414			2
203	F_fleet_2_YR_2007_s_1	0.230	0	3	0.083	0.363			2
204	F_fleet_2_YR_2008_s_1	0.223	0	3	0.093	0.414			2
205	F_fleet_2_YR_2009_s_1	0.594	0	3	0.198	0.333			2
206	F_fleet_2_YR_2010_s_1	0.097	0	3	0.055	0.570			2
207	F_fleet_2_YR_2011_s_1	0.053	0	3	0.029	0.539			2
208	F_fleet_2_YR_2012_s_1	0.177	0	3	0.074	0.420			2
209	F_fleet_2_YR_2013_s_1	0.269	0	3	0.094	0.349			2
210	F_fleet_2_YR_2014_s_1	0.407	0	3	0.121	0.297			2
211	F_fleet_2_YR_2015_s_1	0.491	0	3	0.142	0.290			2
212	F_fleet_2_YR_2016_s_1	0.345	0	3	0.131	0.378			2
213	F_fleet_2_YR_2017_s_1	0.254	0	3	0.127	0.499			2
214	F_fleet_2_YR_2018_s_1	0.093	0	3	0.051	0.546			2
215	F_fleet_2_YR_2019_s_1	0.041	0	3	0.017	0.415			2
216	F_fleet_2_YR_2020_s_1	0.059	0	3	0.031	0.522			2
217	F_fleet_2_YR_2021_s_1	0.158	0	3	0.047	0.294			2
218	F_fleet_2_YR_2022_s_1	0.107	0	3	0.039	0.363			2
219	F_fleet_2_YR_2023_s_1	0.077	0	3	0.024	0.315			2
220	F_fleet_2_YR_2024_s_1	0.063	0	3	0.018	0.295			2
221	LnQ_base_RVC_KEYS(3)	-7.207	-18	5					Fixed
222	LnQ_base_RVC_DRTO(4)	-6.377	-18	5					Fixed
223	LnQ_base_COMB_VIDEO(5)	-6.928	-18	5					Fixed
224	Size_DblN_peak_COM(1)	29.896	15	60	2.796	0.094			3
225	Size_DblN_top_logit_COM(1)	-9.531	-15	15	74.964	7.865			4
226	Size_DblN_ascend_se_COM(1)	3.161	0.01	15	0.879	0.278			5
227	Size_DblN_descend_se_COM(1)	3.046	0.01	5	0.711	0.233			5
228	Size_DblN_start_logit_COM(1)	-999.000	-15	15					Fixed
229	Size_DblN_end_logit_COM(1)	0.387	-15	15	0.415	1.073			3
230	Size_DblN_peak_REC(2)	32.770	15	50	0.607	0.019			3
231	Size_DblN_top_logit_REC(2)	-12.290	-15	15	46.133	3.754			4
232	Size_DblN_ascend_se_REC(2)	3.812	0.1	15	0.146	0.038			5
233	Size_DblN_descend_se_REC(2)	4.601	0.1	15	0.229	0.050			5
234	Size_DblN_start_logit_REC(2)	-999.000	-15	7					Fixed
235	Size_DblN_end_logit_REC(2)	-2.351	-15	15	0.329	0.140			3
236	Retain_L_infl_REC(2)	6.443	4	50	50.294	7.806			3
237	Retain_L_width_REC(2)	0.683	0.01	10	12.928	18.920			4
238	Retain_L_asymptote_logit_REC(2)	2.723	-15	15	0.356	0.131			5
239	Retain_L_maleoffset_REC(2)	0.000	-1	1					Fixed
240	DiscMort_L_infl_REC(2)	0.100	0	1					Fixed
241	DiscMort_L_width_REC(2)	0.100	0	1					Fixed
242	DiscMort_L_level_old_REC(2)	0.414	0.01	1					Fixed
243	DiscMort_L_male_offset_REC(2)	0.000	-1	2					Fixed
244	Size_DblN_peak_RVC_KEYS(3)	22.080	5	50	0.673	0.030			3
245	Size_DblN_top_logit_RVC_KEYS(3)	-2.735	-15	15	0.589	0.215			4
246	Size_DblN_ascend_se_RVC_KEYS(3)	3.796	0.1	15	0.130	0.034			3
247	Size_DblN_descend_se_RVC_KEYS(3)	4.924	0.1	15	0.363	0.074			5
248	Size_DblN_start_logit_RVC_KEYS(3)	-999.000	-15	15					Fixed
249	Size_DblN_end_logit_RVC_KEYS(3)	-2.014	-15	15	0.337	0.167			3
250	Size_DblN_peak_RVC_DRTO(4)	55.507	30	70	3.188	0.057			3
251	Size_DblN_top_logit_RVC_DRTO(4)	-2.166	-15	15	2.980	1.376			4
252	Size_DblN_ascend_se_RVC_DRTO(4)	6.188	0.1	15	0.116	0.019			3
253	Size_DblN_descend_se_RVC_DRTO(4)	6.900	0.1	15	5.596	0.811			5
254	Size_DblN_start_logit_RVC_DRTO(4)	-999.000	-5	5					Fixed
255	Size_DblN_end_logit_RVC_DRTO(4)	-0.979	-15	15	1.661	1.696			3
256	Size_inflection_COMB_VIDEO(5)	27.744	15	40	3.062	0.110			3
257	Size_95%width_COMB_VIDEO(5)	11.501	0.1	15	2.864	0.249			4
258	ln(DM_theta)_Len_P1	2.093	-5	20	0.807	0.385	0	1.813	2
259	ln(DM_theta)_Len_P2	0.987	-5	20	0.895	0.907	0	1.813	2
260	ln(DM_theta)_Len_P3	-0.764	-5	20	0.195	0.255	0	1.813	2
261	ln(DM_theta)_Len_P4	0.442	-5	20	0.613	1.387	0	1.813	2
262	ln(DM_theta)_Sz_P5	-0.347	-5	20	0.141	0.406	0	1.813	2
263	Size_DblN_peak_COM(1)_BLK1repl_1995	31.034	15	60	0.437	0.014			3
264	Size_DblN_peak_COM(1)_BLK1repl_2018	41.809	15	60	1.193	0.029			3
265	Size_DblN_ascend_se_COM(1)_BLK1repl_1995	1.883	0.01	15	0.286	0.152			5
266	Size_DblN_ascend_se_COM(1)_BLK1repl_2018	1.473	0.01	6	0.777	0.528			5
267	Retain_L_infl_REC(2)_BLK1repl_1995	28.543	6	50	0.317	0.011			3
268	Retain_L_infl_REC(2)_BLK1repl_2018	42.700	6	50	2.200	0.052			3
269	Retain_L_width_REC(2)_BLK1repl_1995	1.332	0.1	10	0.200	0.150			4
270	Retain_L_width_REC(2)_BLK1repl_2018	5.030	0.1	10	1.342	0.267			4

271	Retain_L_asymptote_logit_REC(2)_BLK1repl_1995	3.081	-15	15	0.560	0.182	5
272	Retain_L_asymptote_logit_REC(2)_BLK1repl_2018	9.293	-15	15	77.497	8.339	5

Table 3.11. Predicted total biomass (metric tons, pounds), spawning stock biomass (SSB; metric tons, pounds), age 1+ abundance (1000s of fish), age-0 recruits (1000s of fish), and depletion (SSB/SSB0) for Florida Keys/East Florida Hogfish. Virgin is the estimated unfished condition while Initial is the estimated initial conditions of the stock before the model start year.

Year	Biomass (mt)	Biomass (lbs.)	SSB (mt)	SSB (lbs.)	Age 1+ Abundance (000s)	Age-0 Recruits (000s)	B/B0	SSB/SSB0
Virgin	5,768	12,716,770	5,462	12,041,957	6,588	2,982	1.000	1.000
Initial	5,768	12,716,770	5,462	12,041,957	6,588	2,982	1.000	1.000
1950	5,768	12,716,770	5,462	12,041,957	6,588	2,982	1.000	1.000
1951	5,685	12,532,288	5,380	11,860,561	6,522	2,969	0.985	0.985
1952	5,596	12,336,870	5,292	11,667,216	6,457	2,955	0.970	0.969
1953	5,508	12,142,841	5,206	11,476,229	6,396	2,941	0.955	0.953
1954	5,423	11,956,506	5,122	11,293,113	6,338	2,928	0.940	0.938
1955	5,341	11,774,625	5,041	11,114,517	6,282	2,914	0.926	0.923
1956	5,263	11,602,686	4,965	10,945,753	6,229	2,901	0.912	0.909
1957	5,190	11,441,727	4,893	10,787,924	6,180	2,888	0.900	0.896
1958	5,125	11,297,963	4,829	10,647,049	6,136	2,877	0.888	0.884
1959	5,064	11,164,209	4,770	10,516,072	6,094	2,866	0.878	0.873
1960	4,998	11,018,770	4,705	10,373,587	6,047	2,854	0.866	0.861
1961	4,935	10,879,394	4,643	10,236,945	6,002	2,842	0.856	0.850
1962	4,865	10,726,437	4,575	10,087,163	5,951	2,829	0.843	0.838
1963	4,807	10,597,180	4,518	9,960,529	5,910	2,817	0.833	0.827
1964	4,748	10,467,107	4,460	9,833,366	5,867	2,806	0.823	0.817
1965	4,685	10,328,966	4,399	9,698,201	5,822	2,793	0.812	0.805
1966	4,622	10,190,207	4,337	9,562,440	5,775	2,780	0.801	0.794
1967	4,559	10,050,786	4,276	9,426,084	5,728	2,767	0.790	0.783
1968	4,488	9,893,553	4,206	9,272,356	5,674	2,752	0.778	0.770
1969	4,420	9,743,727	4,139	9,125,881	5,623	2,737	0.766	0.758
1970	4,350	9,590,241	4,071	8,976,055	5,570	2,722	0.754	0.745
1971	4,272	9,417,486	3,995	8,807,335	5,510	2,704	0.741	0.731
1972	4,157	9,163,955	3,883	8,559,602	5,418	2,677	0.721	0.711
1973	4,039	8,903,898	3,767	8,305,320	5,324	2,649	0.700	0.690
1974	3,916	8,632,575	3,647	8,040,898	5,225	2,618	0.679	0.668
1975	3,781	8,334,752	3,516	7,750,924	5,116	2,582	0.655	0.644
1976	3,641	8,028,023	3,380	7,452,528	5,001	2,544	0.631	0.619
1977	3,525	7,771,118	3,267	7,203,362	4,905	2,510	0.611	0.598
1978	3,436	7,574,268	3,181	7,013,456	4,831	2,484	0.596	0.582
1979	3,376	7,443,357	3,124	6,888,013	4,781	2,466	0.585	0.572
1980	3,307	7,290,797	3,058	6,741,163	4,720	2,444	0.573	0.560
1981	3,269	7,207,485	3,022	6,662,105	4,689	2,383	0.567	0.553
1982	3,040	6,702,009	2,802	6,177,286	4,460	2,226	0.527	0.513
1983	3,054	6,733,843	2,822	6,222,173	4,414	2,119	0.530	0.517
1984	2,963	6,531,239	2,744	6,049,110	4,239	2,091	0.514	0.502
1985	2,778	6,124,816	2,561	5,646,237	4,015	2,765	0.482	0.469
1986	2,675	5,896,858	2,438	5,374,583	4,286	2,050	0.464	0.446

Table 3.11 continued. Predicted total biomass (metric tons, pounds), spawning stock biomass (SSB; metric tons, pounds), age 1+ abundance (1000s of fish), age-0 recruits (1000s of fish), and depletion (SSB/SSB0) for Florida Keys/East Florida Hogfish. Virgin is the estimated unfished condition while Initial is the estimated initial conditions of the stock before the model start year.

Year	Biomass (mt)	Biomass (lbs.)	SSB (mt)	SSB (lbs.)	Age 1+ Abundance (000s)	Age-0 Recruits (000s)	B/B0	SSB/SSB0
1987	2,655	5,852,347	2,412	5,317,440	4,097	2,624	0.460	0.442
1988	2,606	5,744,299	2,368	5,220,172	4,278	2,451	0.452	0.433
1989	2,198	4,846,797	1,964	4,328,953	3,938	1,906	0.381	0.359
1990	2,212	4,876,537	1,987	4,380,519	3,755	2,659	0.383	0.364
1991	2,135	4,707,156	1,913	4,217,575	3,981	1,747	0.370	0.350
1992	2,201	4,853,344	1,982	4,369,672	3,733	2,069	0.382	0.363
1993	2,006	4,421,635	1,824	4,022,003	3,545	975	0.348	0.334
1994	1,893	4,174,210	1,743	3,841,621	2,885	1,470	0.328	0.319
1995	1,702	3,753,282	1,582	3,487,250	2,694	857	0.295	0.290
1996	1,531	3,375,564	1,422	3,134,092	2,241	720	0.265	0.260
1997	1,461	3,221,130	1,375	3,031,224	1,963	1,092	0.253	0.252
1998	1,431	3,155,256	1,343	2,961,778	2,026	540	0.248	0.246
1999	1,378	3,037,176	1,287	2,838,209	1,721	1,582	0.239	0.236
2000	1,255	2,765,787	1,149	2,533,927	2,045	962	0.217	0.210
2001	1,254	2,764,861	1,131	2,493,274	1,958	1,113	0.217	0.207
2002	1,272	2,803,993	1,156	2,549,624	2,006	1,711	0.220	0.212
2003	1,332	2,936,227	1,189	2,620,745	2,394	1,596	0.231	0.218
2004	1,348	2,970,971	1,184	2,611,133	2,519	1,612	0.234	0.217
2005	1,308	2,883,183	1,152	2,539,946	2,558	1,162	0.227	0.211
2006	1,102	2,429,384	967	2,131,500	2,168	1,445	0.191	0.177
2007	1,146	2,526,938	1,001	2,206,761	2,287	2,523	0.199	0.183
2008	1,218	2,684,613	1,031	2,272,988	2,973	1,186	0.211	0.189
2009	1,293	2,849,938	1,109	2,445,919	2,648	1,747	0.224	0.203
2010	1,197	2,638,051	1,053	2,321,490	2,637	908	0.207	0.193
2011	1,295	2,855,956	1,160	2,558,178	2,349	1,391	0.225	0.212
2012	1,416	3,121,635	1,281	2,824,166	2,483	2,486	0.245	0.235
2013	1,493	3,290,995	1,301	2,869,206	3,124	2,032	0.259	0.238
2014	1,530	3,372,367	1,319	2,908,118	3,220	1,196	0.265	0.241
2015	1,494	3,293,420	1,316	2,902,342	2,758	2,830	0.259	0.241
2016	1,437	3,167,888	1,241	2,734,901	3,364	1,665	0.249	0.227
2017	1,459	3,217,559	1,249	2,754,500	3,129	1,463	0.253	0.229
2018	1,511	3,331,185	1,346	2,967,620	2,936	1,689	0.262	0.246
2019	1,654	3,646,049	1,492	3,289,760	3,054	1,595	0.287	0.273
2020	1,809	3,989,000	1,641	3,616,728	3,104	1,807	0.314	0.300
2021	1,952	4,304,107	1,776	3,914,903	3,264	1,956	0.338	0.325
2022	2,045	4,508,299	1,855	4,088,583	3,418	1,931	0.355	0.340
2023	2,159	4,760,067	1,961	4,323,772	3,528	1,989	0.374	0.359
2024	2,286	5,039,547	2,085	4,595,955	3,657	2,052	0.396	0.382

Table 3.12. Annual exploitation rates on Florida Keys/East Florida Hogfish combined across all fleets as well as annual estimates of instantaneous apical fishing mortality rates by fleet. Apical fishing mortality rates represent the instantaneous fishing mortality level on the most vulnerable age class for each fleet.

Year	Exploitation (Biomass)	Commercial	Recreational	Year	Exploitation (Biomass)	Commercial	Recreational
1950	0.0132	0.0018	0.0393	1988	0.2168	0.0206	0.6724
1951	0.0146	0.0033	0.0412	1989	0.0722	0.0275	0.1658
1952	0.0154	0.0037	0.0431	1990	0.1185	0.0269	0.2991
1953	0.0158	0.0034	0.0449	1991	0.0537	0.0246	0.1072
1954	0.0167	0.0038	0.0468	1992	0.1642	0.0334	0.4182
1955	0.0171	0.0034	0.0486	1993	0.1210	0.0365	0.2842
1956	0.0173	0.0029	0.0504	1994	0.1546	0.0262	0.4079
1957	0.0170	0.0013	0.0522	1995	0.1445	0.0235	0.4163
1958	0.0172	0.0007	0.0540	1996	0.0826	0.0229	0.2134
1959	0.0192	0.0008	0.0601	1997	0.0519	0.0256	0.1123
1960	0.0197	0.0006	0.0622	1998	0.0650	0.0193	0.1685
1961	0.0219	0.0002	0.0697	1999	0.1247	0.0208	0.3710
1962	0.0210	0.0004	0.0664	2000	0.0497	0.0200	0.1241
1963	0.0222	0.0013	0.0685	2001	0.0477	0.0152	0.1205
1964	0.0241	0.0021	0.0725	2002	0.0328	0.0150	0.0717
1965	0.0252	0.0013	0.0775	2003	0.0800	0.0161	0.2143
1966	0.0264	0.0017	0.0804	2004	0.1291	0.0177	0.3622
1967	0.0292	0.0020	0.0887	2005	0.2620	0.0117	0.8339
1968	0.0298	0.0020	0.0903	2006	0.0908	0.0106	0.2439
1969	0.0314	0.0015	0.0963	2007	0.0885	0.0105	0.2298
1970	0.0346	0.0019	0.1057	2008	0.0861	0.0090	0.2233
1971	0.0440	0.0017	0.1363	2009	0.2162	0.0096	0.5936
1972	0.0469	0.0019	0.1454	2010	0.0422	0.0078	0.0971
1973	0.0506	0.0014	0.1582	2011	0.0257	0.0075	0.0530
1974	0.0564	0.0015	0.1765	2012	0.0716	0.0080	0.1766
1975	0.0609	0.0015	0.1906	2013	0.1008	0.0095	0.2687
1976	0.0590	0.0009	0.1846	2014	0.1491	0.0119	0.4073
1977	0.0554	0.0025	0.1687	2015	0.1793	0.0126	0.4913
1978	0.0501	0.0005	0.1536	2016	0.1270	0.0104	0.3451
1979	0.0549	0.0005	0.1679	2017	0.0984	0.0060	0.2543
1980	0.0483	0.0045	0.1385	2018	0.0255	0.0033	0.0928
1981	0.1043	0.0043	0.3199	2019	0.0113	0.0015	0.0409
1982	0.0351	0.0006	0.1049	2020	0.0158	0.0016	0.0587
1983	0.0670	0.0012	0.2013	2021	0.0399	0.0017	0.1582
1984	0.0991	0.0006	0.3073	2022	0.0268	0.0015	0.1071
1985	0.0825	0.0012	0.2542	2023	0.0192	0.0011	0.0772
1986	0.0612	0.0137	0.1617	2024	0.0155	0.0011	0.0626
1987	0.0790	0.0185	0.2031				

Table 3.13. Index root mean square error (RMSE) values from the SEDAR 94 KEYS base model (Base), the age-structured production model (ASPM), and the ASPM with estimated recruitment deviations (ASPMdev).

Index	Base	ASPM	ASPMdev
RVC Florida Keys	0.2527	0.3100	0.2055
RVC Dry Tortugas	0.1646	0.2016	0.1085
Combined Video	0.3804	0.4934	0.3524

Table 3.14. Mohn's rho (ρ_M) and forecast Mohn's rho (ρ_F) values calculated from the retrospective and retrospective forecasting analyses, respectively, on estimates of spawning stock biomass (SSB) and exploitation fishing mortality rates (F) from the SEDAR 94 KEYS base model. Analyses were performed across 6 successive years of removal from the terminal year 2024.

Quantity	Year Peel	Mohn's Rho (ρ_M)	Forecast Mohn's Rho (ρ_F)
SSB	2023	-0.059	-0.065
SSB	2022	-0.011	-0.027
SSB	2021	-0.072	-0.048
SSB	2020	-0.143	-0.106
SSB	2019	-0.186	-0.161
SSB	2018	-0.198	-0.188
SSB	Combined	-0.112	-0.099
F	2023	0.065	0.106
F	2022	0.069	-0.392
F	2021	0.040	-0.196
F	2020	0.123	0.278
F	2019	0.096	-0.119
F	2018	0.280	-0.247
F	Combined	0.112	-0.095

Table 3.15. Hindcast cross-validation summary statistics for the KEYS base model. N = number of observations to compute each statistic. MASE = mean absolute scaled error, with values < 1 (in green) indicative of superior prediction skill over a naïve baseline forecast (random walk) and values > 1 (in red) indicative of poor prediction skill. Model MAE = mean absolute error of model prediction residuals. Naïve MAE = mean absolute error of naïve predictions

Model Component	Data Source	MASE	Model MAE	Naïve MAE	N
Index of Abundance	RVC_KEYS	0.693	0.311	0.448	2
	RVC_DRTO	0.672	0.119	0.177	3
	COMB_VIDEO	0.628	0.139	0.221	6
	joint	0.657	0.165	0.250	11
Conditional Age-at-Length	REC	0.305	0.091	0.298	3
	FI_LHR_SP	0.142	0.019	0.134	1
	FI_LHR_TW	0.040	0.038	0.944	1
	joint	0.167	0.066	0.395	5
Size Composition	RVC_KEYS	1.984	0.120	0.060	2
	RVC_DRTO	0.597	0.038	0.064	3
	joint	1.132	0.071	0.063	5

Table 3.16. The yield-per-recruit (YPR), spawner-per-recruit (SSB/R), static spawning potential ratio (SPR), and total equilibrium yield in metric tons computed over a range of exploitation rates on Florida Keys/East Florida Hogfish.

Exploitation	YPR	SSB/R	SPR	Total Yield (mt)
0.000	0.000	1.831	1.000	0.123
0.005	0.009	1.743	0.951	26.680
0.010	0.018	1.661	0.907	50.138
0.015	0.025	1.584	0.865	70.771
0.020	0.032	1.512	0.825	88.819
0.025	0.039	1.445	0.789	104.498
0.031	0.045	1.382	0.755	117.999
0.036	0.051	1.323	0.722	129.495
0.041	0.056	1.268	0.692	139.138
0.047	0.061	1.216	0.664	147.067
0.052	0.066	1.167	0.637	153.407
0.058	0.070	1.122	0.612	158.270
0.064	0.074	1.078	0.589	161.759
0.069	0.078	1.037	0.566	163.968
0.075	0.082	0.999	0.545	164.980
0.081	0.085	0.962	0.525	164.874
0.087	0.088	0.928	0.506	163.721
0.093	0.091	0.895	0.489	161.585
0.099	0.094	0.864	0.472	158.528
0.105	0.097	0.835	0.456	154.604
0.111	0.099	0.807	0.441	149.863
0.117	0.101	0.781	0.426	144.354
0.123	0.104	0.756	0.412	138.121
0.129	0.106	0.732	0.399	131.203
0.135	0.108	0.709	0.387	123.639
0.141	0.110	0.687	0.375	115.465
0.147	0.111	0.667	0.364	106.712
0.153	0.113	0.647	0.353	97.412
0.160	0.114	0.628	0.343	87.595
0.166	0.116	0.611	0.333	77.286
0.172	0.117	0.593	0.324	66.512
0.178	0.119	0.577	0.315	55.296
0.185	0.120	0.562	0.307	43.662
0.191	0.121	0.547	0.298	31.630
0.197	0.122	0.532	0.291	19.221
0.204	0.123	0.519	0.283	6.453
0.210	0.125		0.276	

Table 3.17. Gelman and Rubin's (1992) potential scale reduction factor (PSRF) values from the combined six MCMC chains for selected model parameters (*ln(R0)* and *steepness*) and derived quantities (SSB_0, SSB in 2024, F exploitation in 2024, $F_{40\%SPR}$, F_{MSY}, SSB at F_{MSY}, and the retained yield at F_{MSY}) of the SEDAR 94 KEYS base model.

PSRF	PSRF Upper CI	Parameter or Derived Quantity
1.00	1.01	*ln(R0)*
1.00	1.01	*steepness*
1.00	1.01	SSB_0
1.00	1.00	SSB_{2024}
1.00	1.00	F_{2024}
1.03	1.06	$F_{40\%SPR}$
1.02	1.03	F_{MSY}
1.00	1.01	SSB_{MSY}
1.01	1.01	Retained yield at F_{MSY}

Table 3.18. The stock status determination criteria for Florida Keys/East Florida Hogfish according to the South Atlantic Fishery Management Council (SAFMC). All MSY or SPR proxy values of 30%SPR and 40%SPR were derived from the SEDAR 94 KEYS base model.

South Atlantic and Gulf of Mexico Fishery Management Councils

Criteria	Definition	MSY	30% SPR	40% SPR
MSY	The retained yield at F_{MSY} or $F_{SPRproxy}$	94.552 mt (208,451 lbs.)	17.249 mt (38,027 lbs.)	71.100 mt (156,709 lbs.)
$F_{MSY\ or\ proxy}$	The fishing mortality rate associated with MSY or SPR proxy	0.077 yr^{-1}	0.190 yr^{-1}	0.128 yr^{-1}
MFMT (Maximum Fishing Mortality Threshold)	$F_{MSY\ or\ SPR\ proxy}$	0.077 yr^{-1}	0.190 yr^{-1}	0.128 yr^{-1}
$F_{current}$ (recent average fishing mortality rate)	The geometric mean of F exploitation for 2022 – 2024		0.020 yr^{-1}	
$SSB_{MSY\ or\ SPRproxy}$	The estimated spawning stock biomass associated with F_{MSY} or $F_{SPRproxy}$	1,952.4 mt (4,304,305 lbs.)	154.312 mt (340,300 lbs.)	912.573 mt (2,011,879 lbs.)
MSST (Minimum Stock Size Threshold)	$0.75*SSB_{MSY\ or\ SPRproxy}$	1,464.3 mt (3,228,229 lbs.)	115.734 mt (255,150 lbs.)	684.43 mt (1,508,909 lbs.)
$SSB_{current}$ (recent average of SSB)	The geometric mean of SSB for 2022 – 2024		1,964.579 mt (4,331,156 lbs.)	

Table 3.19**.** Projection results when exploitation rates = $F_{30\%SPR}$ (0.190) for Florida Keys/East Florida Hogfish. Equilibrium projections assume predicted recruitment follows either the spawner-recruit curve (S-R) or the long-term average from 1950 – 2024 (2.145 million fish). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	$F_{30\%SPR}$ Equilibrium Long-Term Projections (S-R)					**$F_{30\%SPR}$ Equilibrium Long-Term Projections**				
Year	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2025	2,095.40	0.190	2,155.98	570,691	168,223	2,145.97	0.191	2,185.38	580,881	172,753
2026	1,952.30	0.190	1,875.40	497,337	146,197	2,145.97	0.191	1,916.61	510,476	151,453
2027	1,822.94	0.190	1,652.00	433,813	129,071	2,145.97	0.191	1,696.18	447,544	134,281
2028	1,714.14	0.190	1,482.80	383,751	116,153	2,145.97	0.191	1,529.40	398,698	121,997
2029	1,620.17	0.190	1,348.56	344,973	106,122	2,145.97	0.191	1,407.67	363,882	113,866
2030	1,537.71	0.190	1,238.86	314,323	98,017	2,145.97	0.191	1,320.37	339,911	108,658
2031	1,464.66	0.190	1,147.39	289,426	91,271	2,145.97	0.191	1,258.52	323,561	105,358
2032	1,398.92	0.190	1,069.30	268,588	85,490	2,145.97	0.191	1,214.62	312,262	103,220
2033	1,339.71	0.190	1,002.13	250,929	80,478	2,145.97	0.191	1,184.14	304,507	101,837
2034	1,286.12	0.190	943.77	235,761	76,087	2,145.97	0.191	1,163.39	299,210	100,945

Table 3.20. Projection results when exploitation rates = $F_{30\%SPR}$ (0.190) and 75% $F_{30\%SPR}$ (0.142) for Florida Keys/East Florida Hogfish. Short-term projections assume predicted age-0 recruitment is equal to the average from 2022 to 2024 (1.926 million). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	$F_{30\%SPR}$ Short-Term Projections					**0.75 * $F_{30\%SPR}$ Short-Term Projections**				
Year	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2025	1,926.50	0.190	2,155.77	570,132	167,826	1,926.50	0.142	2,155.77	427,532	126,030
2026	1,926.50	0.190	1,869.46	494,613	144,732	1,926.50	0.142	1,978.62	393,651	115,229
2027	1,926.50	0.190	1,635.39	427,970	126,381	1,926.50	0.142	1,821.10	361,314	106,084
2028	1,926.50	0.190	1,457.90	376,586	113,371	1,926.50	0.142	1,690.87	333,212	98,817
2029	1,926.50	0.190	1,327.66	339,998	104,783	1,926.50	0.142	1,587.27	310,172	93,232
2030	1,926.50	0.190	1,233.56	314,744	99,271	1,926.50	0.142	1,507.44	292,090	89,053
2031	1,926.50	0.190	1,166.21	297,431	95,761	1,926.50	0.142	1,447.68	278,162	85,948
2032	1,926.50	0.190	1,117.87	285,407	93,477	1,926.50	0.142	1,403.57	267,813	83,724
2033	1,926.50	0.190	1,083.77	277,093	91,990	1,926.50	0.141	1,372.19	260,447	82,200
2034	1,926.50	0.190	1,060.06	271,359	91,021	1,926.50	0.141	1,350.48	255,349	81,193

Table 3.21. Projection results when exploitation rates = $F_{40\%SPR}$ (0.129) for Florida Keys/East Florida Hogfish. Equilibrium projections assume predicted recruitment follows either the spawner-recruit curve (S-R) or the long-term average from 1950 – 2024 (2.145 million fish). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	$F_{40\%SPR}$ Equilibrium Long-Term Projections (S-R)					**$F_{40\%SPR}$ Equilibrium Long-Term Projections**				
Year	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2025	2,095.40	0.129	2,155.98	388,356	114,684	2,145.97	0.130	2,185.38	395,330	117,777
2026	2,026.02	0.129	2,015.12	363,898	106,997	2,145.97	0.130	2,059.46	373,607	110,836
2027	1,962.11	0.129	1,893.44	340,320	100,535	2,145.97	0.130	1,944.46	351,083	104,475
2028	1,907.09	0.129	1,794.33	320,020	95,315	2,145.97	0.130	1,848.36	331,348	99,374
2029	1,858.12	0.129	1,710.20	303,064	91,019	2,145.97	0.130	1,771.09	315,678	95,612
2030	1,814.10	0.129	1,637.66	288,840	87,386	2,145.97	0.130	1,710.44	303,796	92,943
2031	1,774.46	0.129	1,574.65	276,752	84,259	2,145.97	0.130	1,663.73	294,951	91,083
2032	1,738.09	0.129	1,518.71	266,203	81,491	2,145.97	0.130	1,627.52	288,264	89,752
2033	1,705.01	0.129	1,469.29	257,001	79,038	2,145.97	0.130	1,600.22	283,304	88,809
2034	1,674.85	0.129	1,425.40	248,919	76,849	2,145.97	0.130	1,579.99	279,639	88,140

Table 3.22. Projection results when exploitation rates = $F_{40\%SPR}$ (0.129) and 75% $F_{30\%SPR}$ (0.097) for Florida Keys/East Florida Hogfish. Short-term projections assume predicted age-0 recruitment is equal to the average from 2020 to 2024 (1.926 million). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	$F_{40\%SPR}$ Short-Term Projections					**0.75 * $F_{40\%SPR}$ Short-Term Projections**				
Year	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2025	1,926.50	0.129	2,155.77	387,977	114,417	1,926.50	0.097	2,155.77	290,920	85,881
2026	1,926.50	0.129	2,008.97	361,975	105,975	1,926.50	0.097	2,083.63	282,153	82,639
2027	1,926.50	0.129	1,875.57	335,863	98,479	1,926.50	0.097	2,011.21	272,361	79,612
2028	1,926.50	0.129	1,763.71	313,326	92,573	1,926.50	0.097	1,945.21	262,819	76,996
2029	1,926.50	0.129	1,673.19	295,513	88,248	1,926.50	0.097	1,887.62	254,188	74,818
2030	1,926.50	0.129	1,601.54	281,984	85,181	1,926.50	0.097	1,839.18	246,758	73,048
2031	1,926.50	0.129	1,545.76	271,867	83,037	1,926.50	0.097	1,799.77	240,519	71,627
2032	1,926.50	0.129	1,502.12	264,205	81,501	1,926.50	0.097	1,767.69	236,111	70,717
2033	1,926.50	0.129	1,468.76	258,484	80,410	1,926.50	0.097	1,742.11	232,258	69,913
2034	1,926.50	0.129	1,443.60	254,228	79,632	1,926.50	0.097	1,722.37	229,227	69,295

Table 3.23. Projection results when exploitation rates = $F_{current}$ (0.020) for Florida Keys/East Florida Hogfish. Short-term projections assume predicted age-0 recruitment is equal to the average from 2020 to 2024 (1.926 million). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

$F_{current}$ Short-Term Projections

Year	Age-0 Recruits	F	SSB	Retained Yield	Retained Num
2025	1,926.50	0.020	2,155.77	59,990	17,750
2026	1,926.50	0.020	2,262.18	63,201	18,531
2027	1,926.50	0.020	2,358.30	66,169	19,226
2028	1,926.50	0.020	2,443.60	68,845	19,834
2029	1,926.50	0.020	2,517.76	71,199	20,355
2030	1,926.50	0.020	2,581.60	73,242	20,796
2031	1,926.50	0.020	2,636.39	75,004	21,170
2032	1,926.50	0.020	2,681.80	76,471	21,477
2033	1,926.50	0.020	2,720.02	77,714	21,734
2034	1,926.50	0.020	2,752.18	78,762	21,948

Table 3.24. Projection results when exploitation rates = F_{MSY} (0.073) for Florida Keys/East Florida Hogfish. Equilibrium projections assume predicted recruitment follows either the spawner-recruit curve (S-R) or the long-term average from 1950 – 2024 (2.145 million fish). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	F_{MSY} Equilibrium Long-Term Projections (S-R)					**F_{MSY} Equilibrium Long-Term Projections**				
Year	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2025	2,095.40	0.073	2,155.98	218,112	64,521	2,145.97	0.073	2,185.38	222,050	66,262
2026	2,090.78	0.073	2,146.29	217,779	64,067	2,145.97	0.073	2,193.60	223,641	66,363
2027	2,086.26	0.073	2,136.87	216,692	63,675	2,145.97	0.073	2,194.87	223,564	66,123
2028	2,083.28	0.073	2,130.67	215,583	63,402	2,145.97	0.073	2,193.32	222,748	65,783
2029	2,080.71	0.073	2,125.35	214,639	63,209	2,145.97	0.073	2,190.30	221,783	65,472
2030	2,078.45	0.073	2,120.68	213,883	63,066	2,145.97	0.073	2,186.84	220,926	65,230
2031	2,076.60	0.073	2,116.85	213,294	62,964	2,145.97	0.073	2,183.70	220,251	65,065
2032	2,074.61	0.073	2,112.75	212,729	62,863	2,145.97	0.073	2,180.06	219,635	64,931
2033	2,072.90	0.073	2,109.24	212,265	62,778	2,145.97	0.073	2,176.98	219,162	64,837
2034	2,071.48	0.073	2,106.32	211,893	62,707	2,145.97	0.073	2,174.55	218,815	64,775

Table 3.25. Projection results when exploitation rates = F_{MSY} (0.073) and 75% F_{MSY} (0.054) for Florida Keys/East Florida Hogfish. Short-term projections assume predicted age-0 recruitment is equal to the average from 2020 to 2024 (1.926 million). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	F_{MSY} Short-Term Projections					**0.75 * F_{MSY} Short-Term Projections**				
Year	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2025	1,926.50	0.073	2,155.77	217,900	64,372	1,926.50	0.054	2,155.77	163,401	48,298
2026	1,926.50	0.073	2,139.95	216,661	63,479	1,926.50	0.054	2,182.07	166,019	48,654
2027	1,926.50	0.073	2,117.77	213,933	62,404	1,926.50	0.054	2,198.84	167,707	48,850
2028	1,926.50	0.073	2,094.41	210,819	61,406	1,926.50	0.054	2,209.31	168,732	48,950
2029	1,926.50	0.073	2,071.79	207,928	60,588	1,926.50	0.054	2,215.04	169,282	48,986
2030	1,926.50	0.073	2,051.14	205,480	59,958	1,926.50	0.054	2,217.67	169,532	48,983
2031	1,926.50	0.073	2,033.16	203,499	59,495	1,926.50	0.054	2,218.60	169,613	48,968
2032	1,926.50	0.073	2,016.90	201,820	59,133	1,926.50	0.054	2,217.49	169,510	48,927
2033	1,926.50	0.073	2,003.19	200,482	58,862	1,926.50	0.054	2,215.90	169,363	48,884
2034	1,926.50	0.073	1,991.89	199,432	58,663	1,926.50	0.054	2,214.27	169,212	48,846

3.14 FL KEYS/EFL Figures

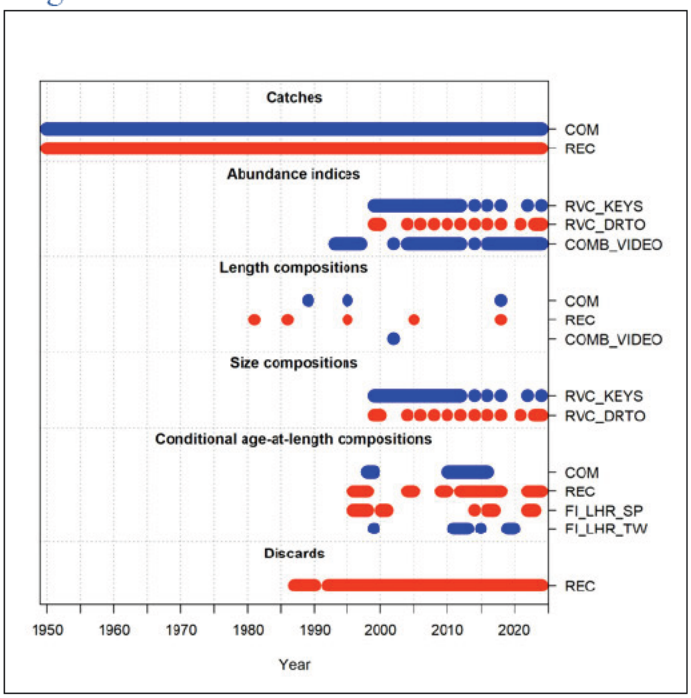


Figure 3.1. Data sources used in the Florida Keys/East Florida Hogfish Stock Synthesis assessment model (KEYS base model).

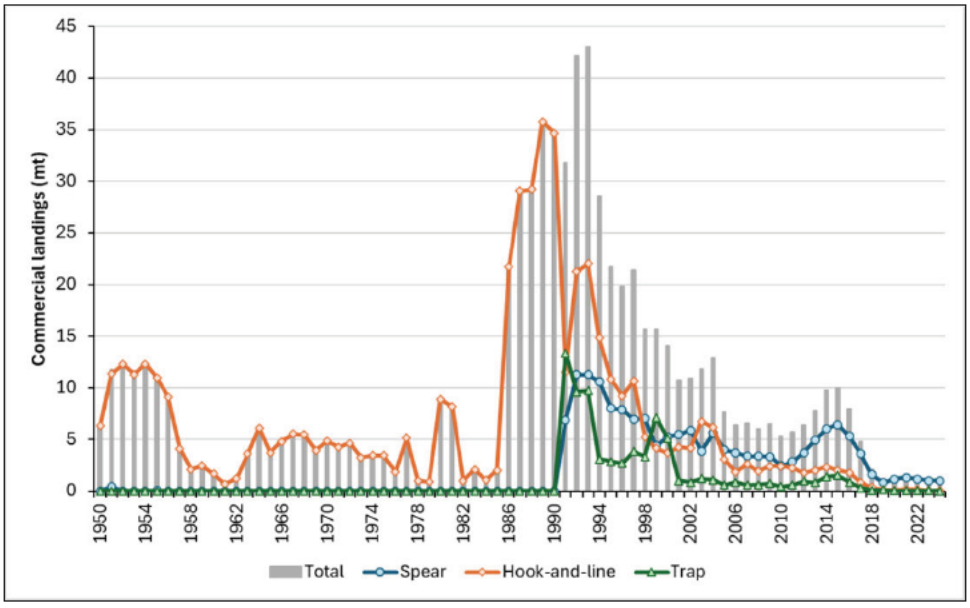


Figure 3.2. Commercial landings (metric tons) of Florida Keys/East Florida Hogfish by gear for years 1950 – 2024.

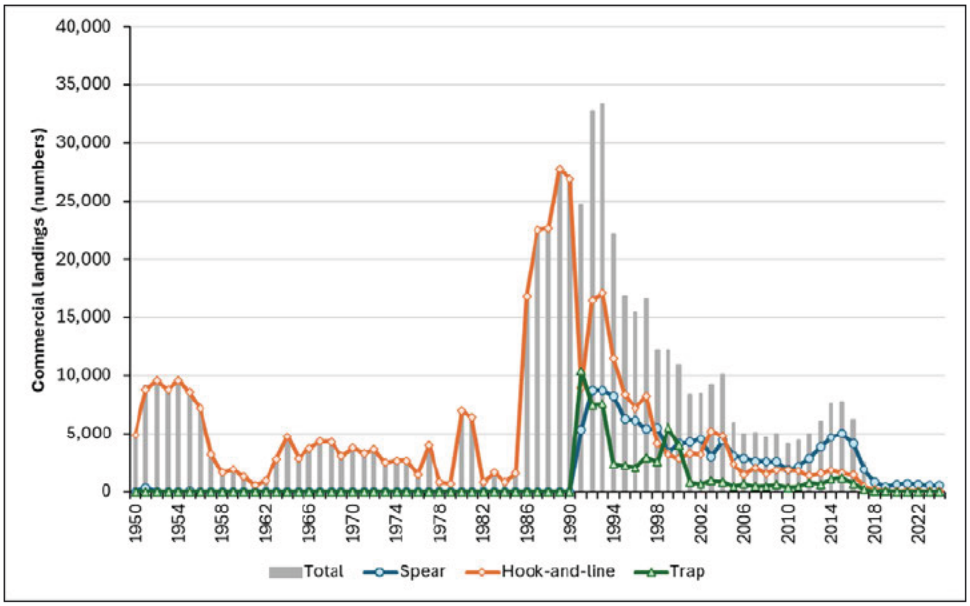


Figure 3.3. Commercial landings (numbers) of Florida Keys/East Florida Hogfish by gear for years 1950 – 2024.

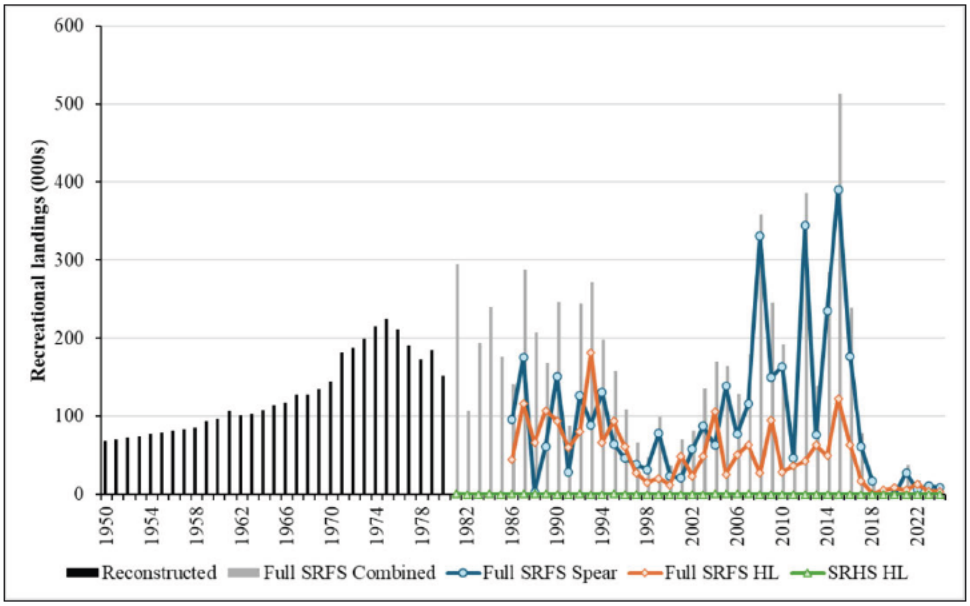


Figure 3.4. Recreational landings (numbers) of Florida Keys/East Florida Hogfish for years 1950 – 2024. The reconstructed historic landings are from 1950 – 1980 (black bars). The 'Full SRFS' estimates are from 1981 – 2024 (grey bars) and are comprised of 'SRFS & SRFS-calibrated Private' mode, MRIP charter mode, and MRIP shore mode landings estimates. 'SRFS & SRFS-calibrated Private' estimates are comprised of SRFS private mode (2021 – 2024) and SRFS ratio-calibrated MRIP private mode (1981 – 2020). The 'Full SRFS Combined' is comprised of the 'Full SRFS' estimates plus the SRHS estimates where the flagged estimates for 1981 and 1984 were replaced with the geometric mean of their six respective surrounding years. Landings by gear are presented beginning in 1986.

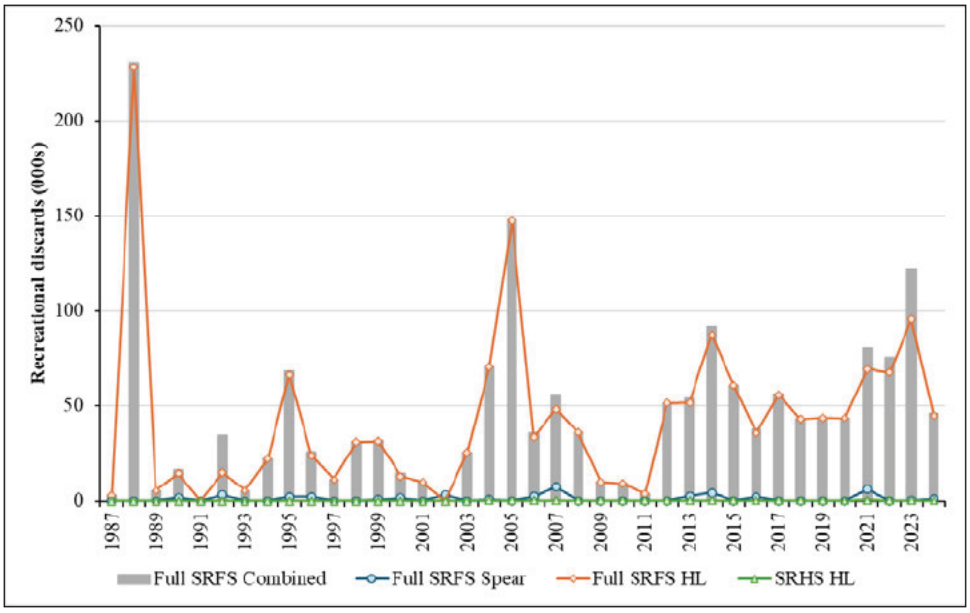


Figure 3.5. Recreational discards (numbers) of Florida Keys/East Florida Hogfish by gear for years 1987 – 2024. The 'Full SRFS' estimates are comprised of 'SRFS & SRFS-calibrated Private' mode, MRIP charter mode, and MRIP shore mode landings estimates. 'SRFS & SRFS-calibrated Private' estimates are comprised of SRFS private mode (2021 – 2024) and SRFS ratio-calibrated MRIP private mode (1981 – 2020). The 'Full SRFS Combined' is comprised of the 'Full SRFS' estimates plus the SRHS estimates.

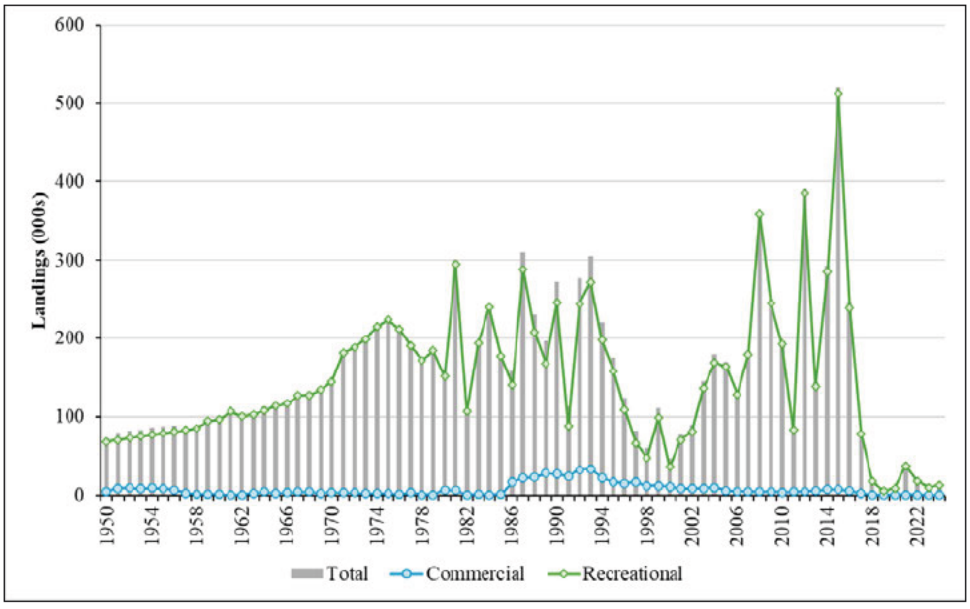


Figure 3.6. A comparison of the commercial landings (numbers; blue dots) with the recreational landings (numbers; green diamonds) of Florida Keys/East Florida Hogfish from 1950 – 2024.

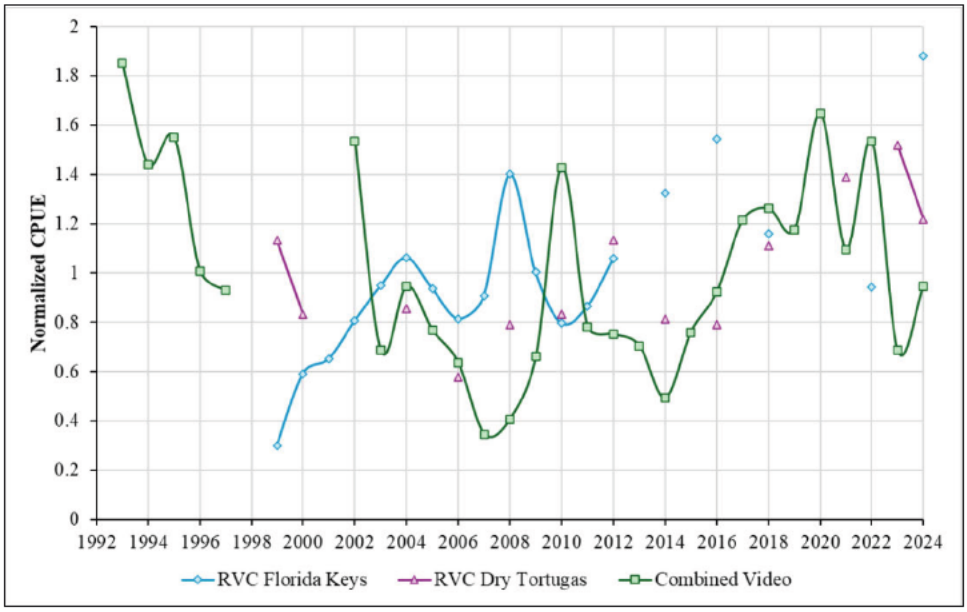


Figure 3.7. Normalized indices of relative abundance for Florida Keys/East Florida Hogfish from 1993 – 2024 from the Reef Fish Visual Census (RVC) and combined video surveys. The RVC Florida Keys was from 1999 – 2012, 2014, 2016, 2018, 2022, and 2024 while the RVC Dry Tortugas was from 1999 – 2000, biennially from 2004 – 2018, 2021, 2023, and 2024. The combined video was from 1993 – 1997 then 2002 – 2024.

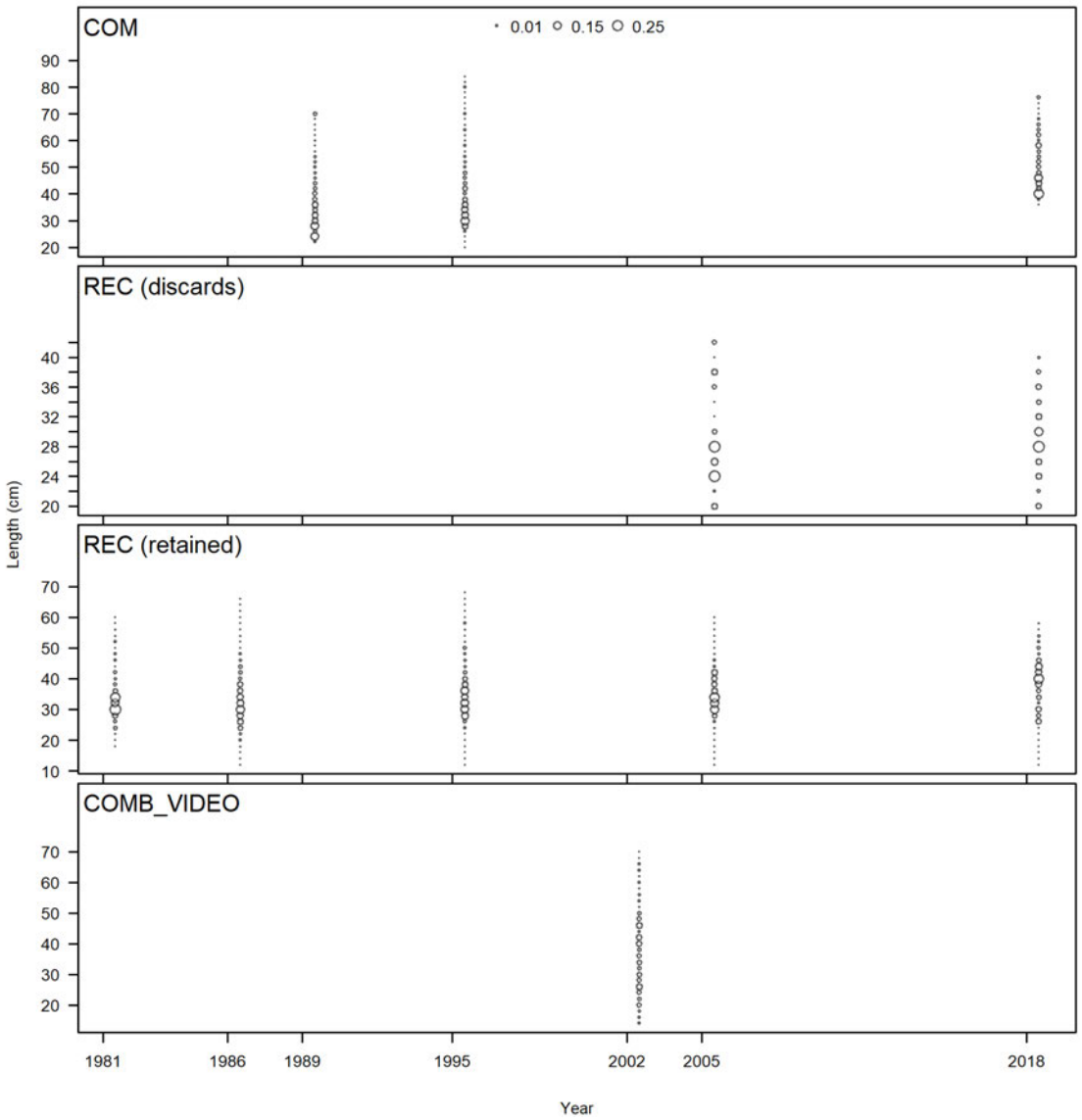


Figure 3.8. Catch-weighted length compositions (2 cm FL bins) of Florida Keys/East Florida Hogfish landings (retained) and discards by fishery for years 1981 – 2024. Commercial = COM, Full SRFS plus SRHS = REC, and combined video Index = COMB_VIDEO.

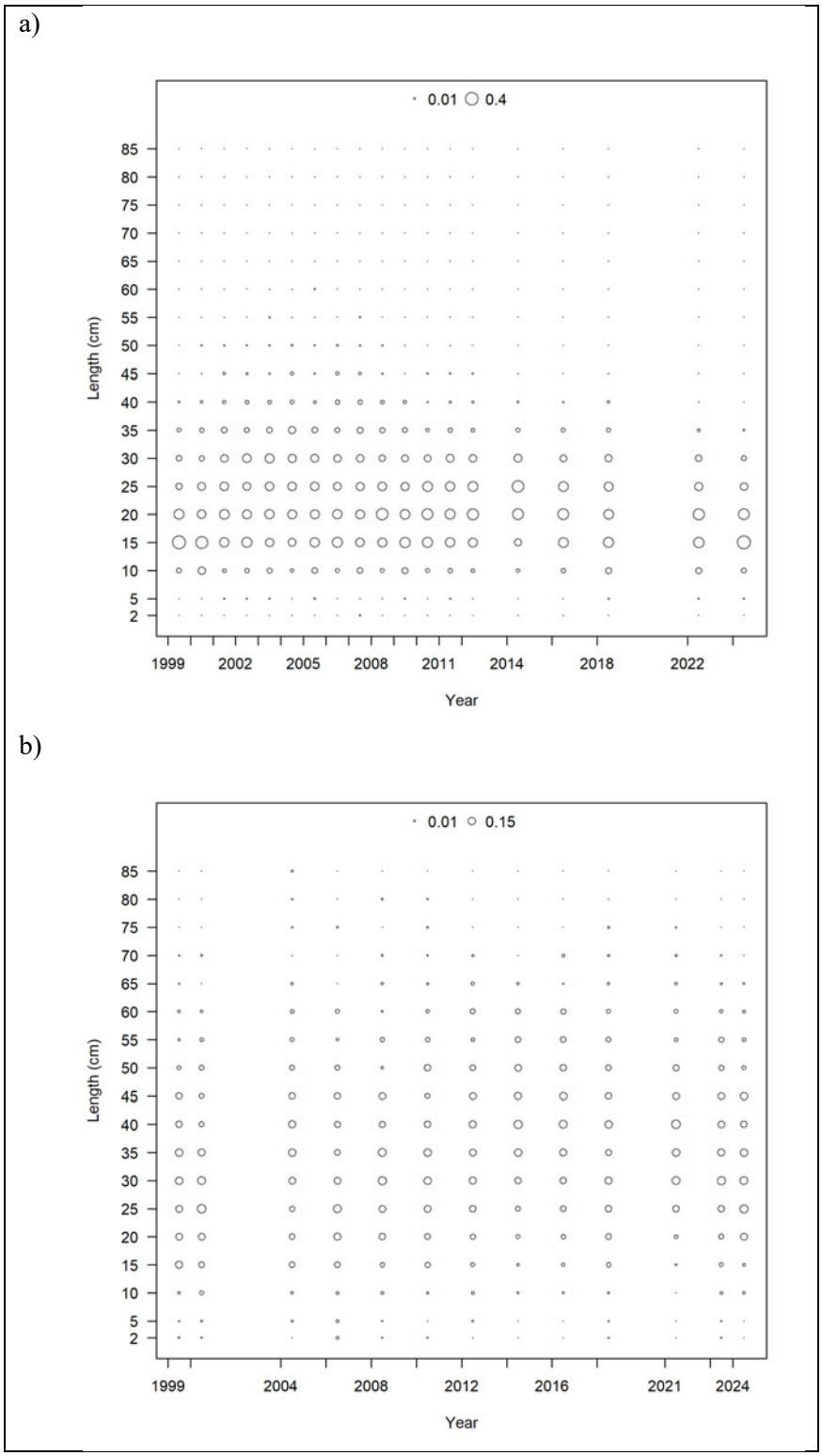


Figure 3.9. Generalized size compositions (5 cm FL bins) of Florida Keys/East Florida Hogfish from a) the RVC Florida Keys index and b) the RVC Dry Tortugas index for years 1999 – 2024.

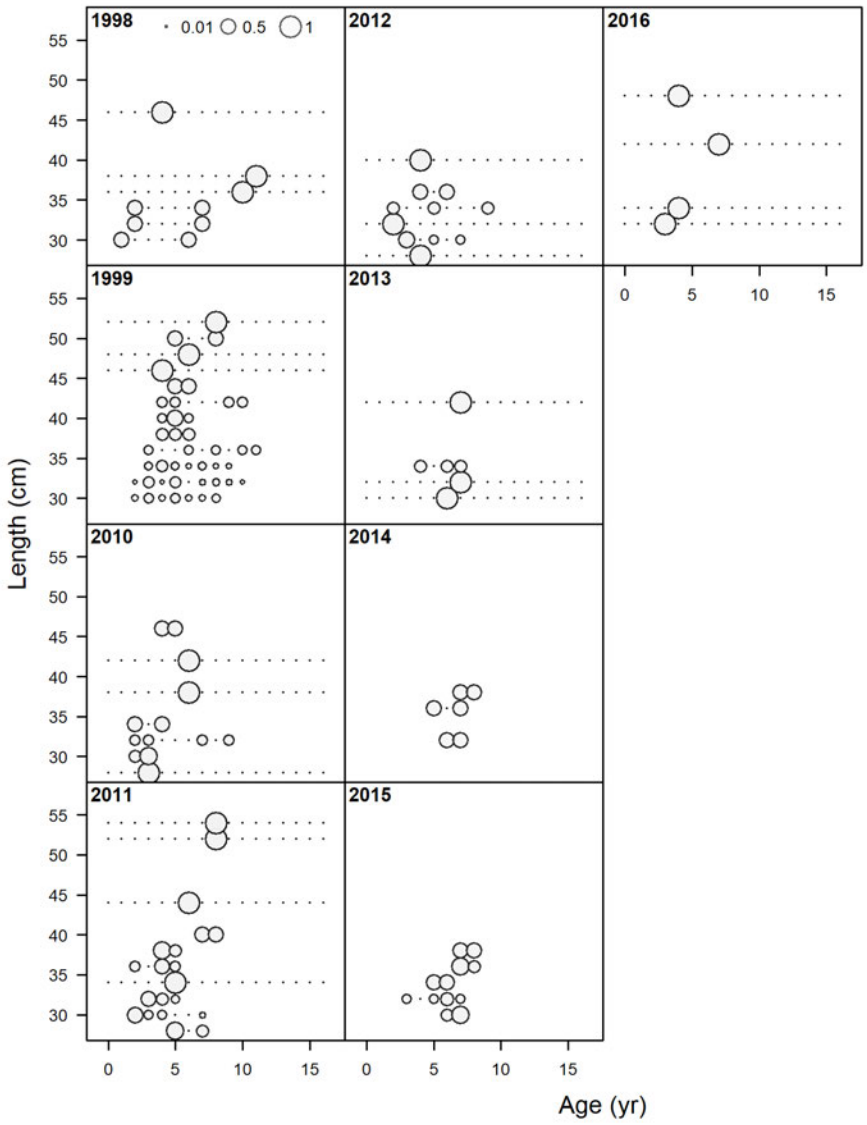


Figure 3.10. Observed conditional age-at-length in 2 cm FL bins of Florida Keys/East Florida Hogfish for the commercial fleet during years 1998 – 2016.

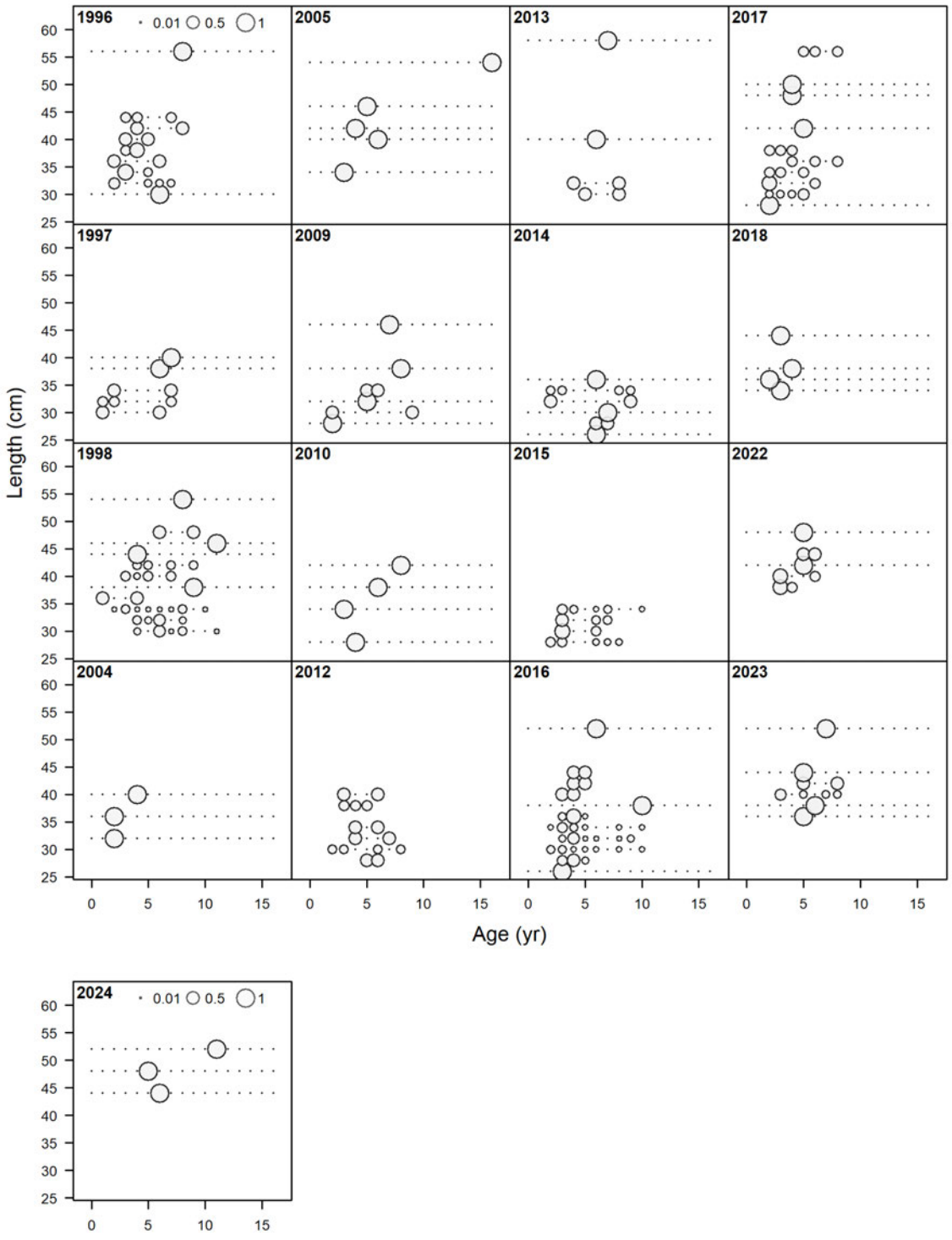


Figure 3.11. Observed conditional age-at-length in 2 cm FL bins of Florida Keys/East Florida Hogfish for the recreational fleet during years 1996 – 2024.

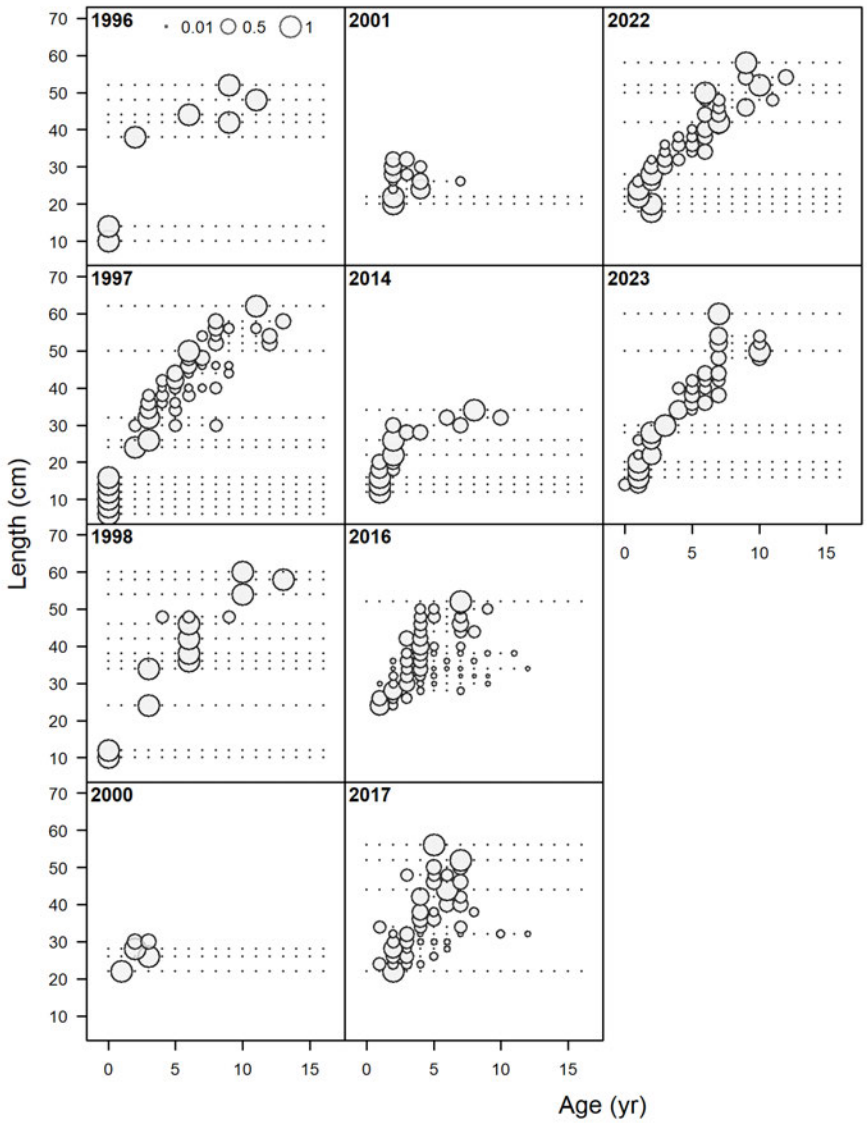


Figure 3.12. Observed conditional age-at-length in 2 cm FL bins of Florida Keys/East Florida Hogfish collected by the spear gear from fishery-independent data sources during years 1996 – 2023.

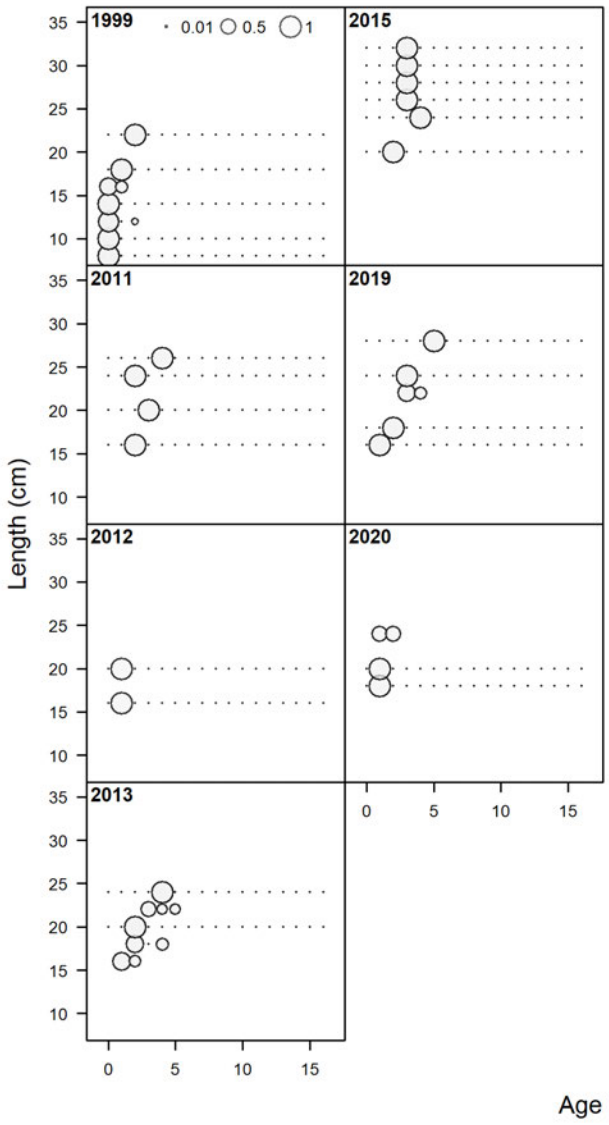


Figure 3.13. Observed conditional age-at-length in 2 cm FL bins of Florida Keys/East Florida Hogfish collected by the trawl gear from fishery-independent data sources during years 1999 – 2020.

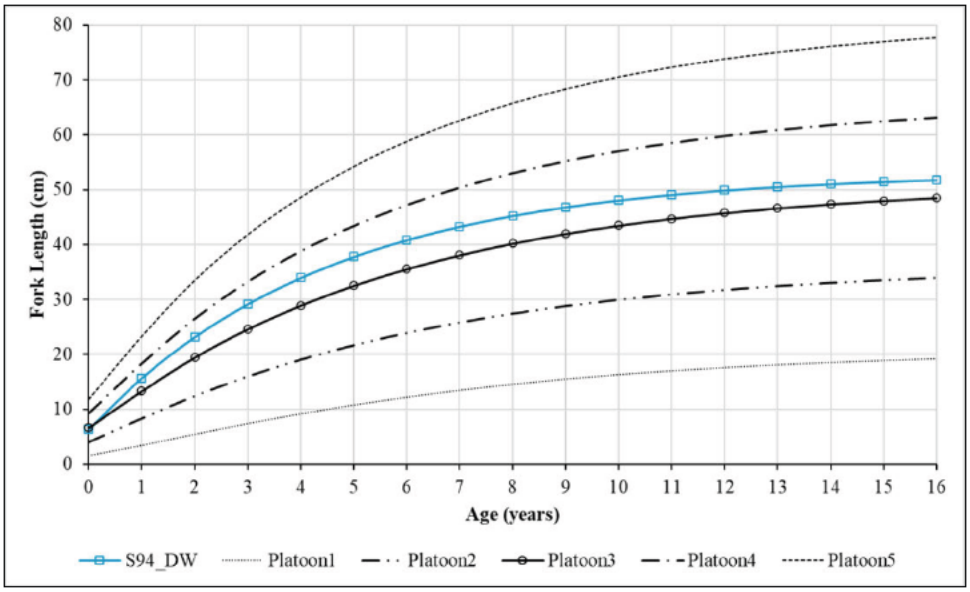


Figure 3.14. Mean size-at-age across 5 platoons for Florida Keys/East Florida Hogfish as estimated by the SEDAR 94 KEYS base model. Distribution of recruitment among platoons approximated a normal distribution (0.031, 0.237, 0.464, 0.237, 0.031) and the 3rd platoon (black circles) followed the L_{inf} (51.2 cm FL) and k (0.177) parameters estimated by the SEDAR 94 KEYS base model. A comparison with the external growth model developed during the Data Workshop is shown by the blue squares.

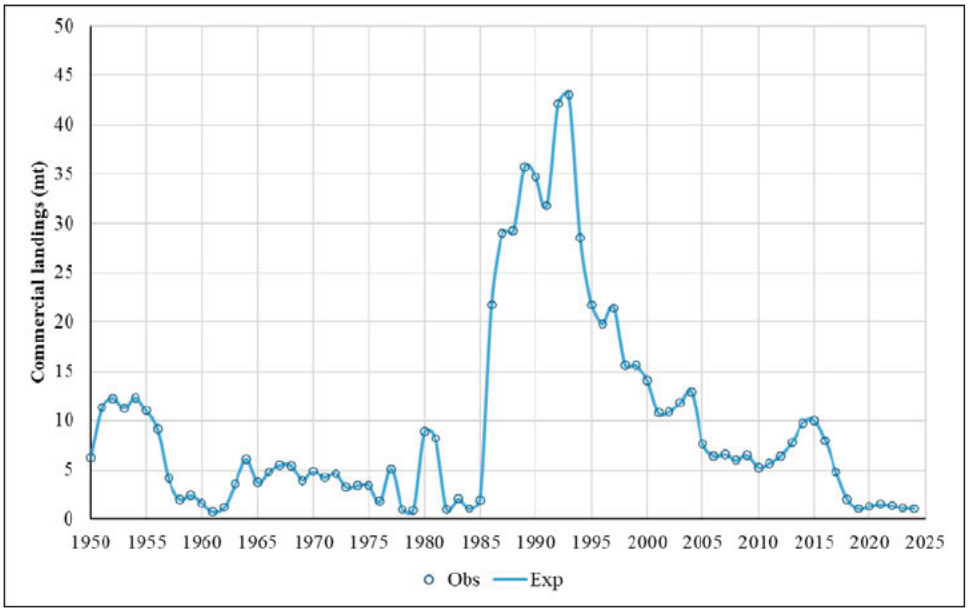


Figure 3.15. Florida Keys/East Florida Hogfish observed (dots) and expected (solid line) landings by the commercial fleet (in metric tons) from the SEDAR 94 KEYS base model.

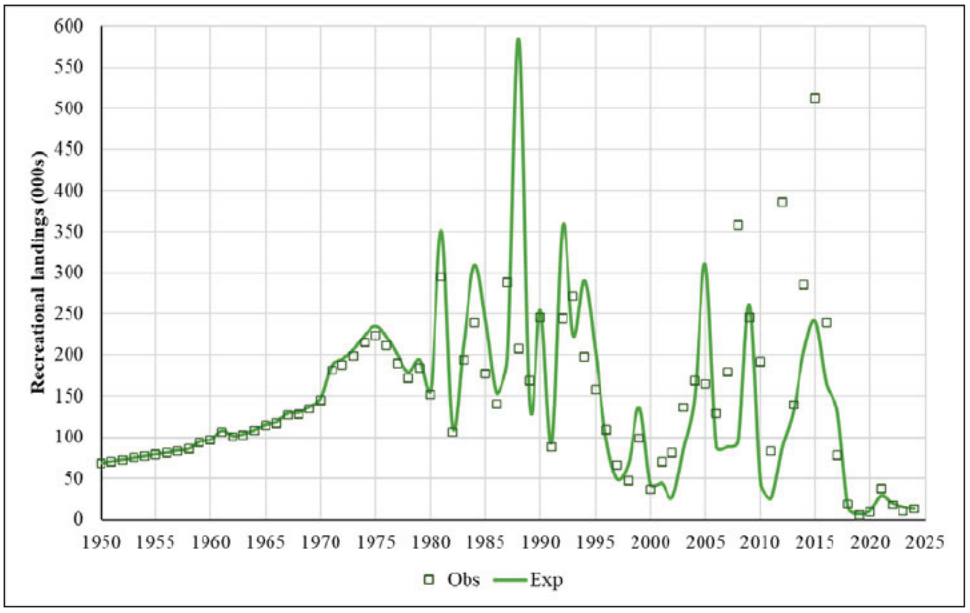


Figure 3.16. Florida Keys/East Florida Hogfish observed (squares) and expected (solid line) landings by the recreational fleet (in thousands of fish) from the SEDAR 94 KEYS base model.

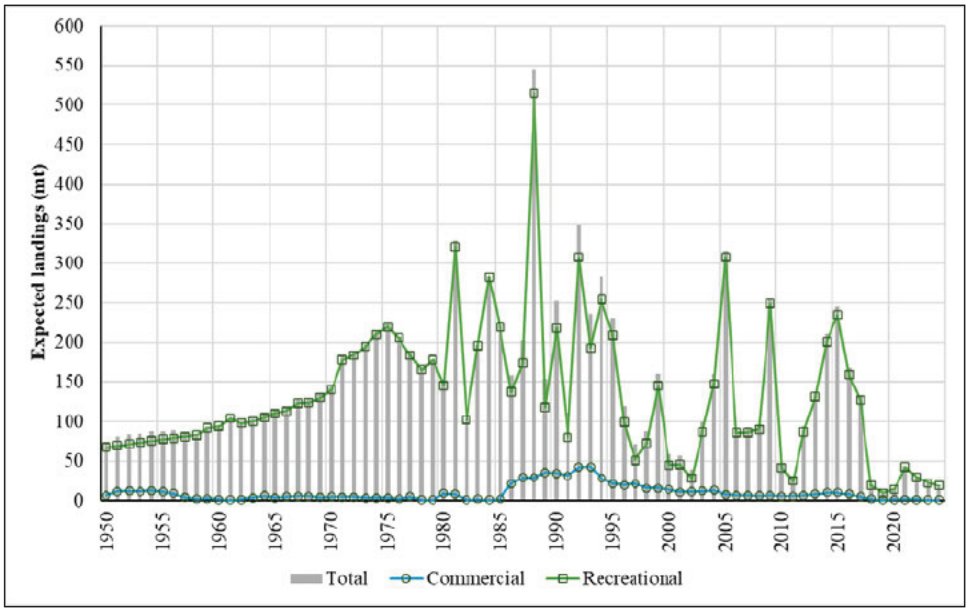


Figure 3.17. Expected landings of Florida Keys/East Florida Hogfish by fleet (in metric tons) as estimated from the SEDAR 94 KEYS base model.

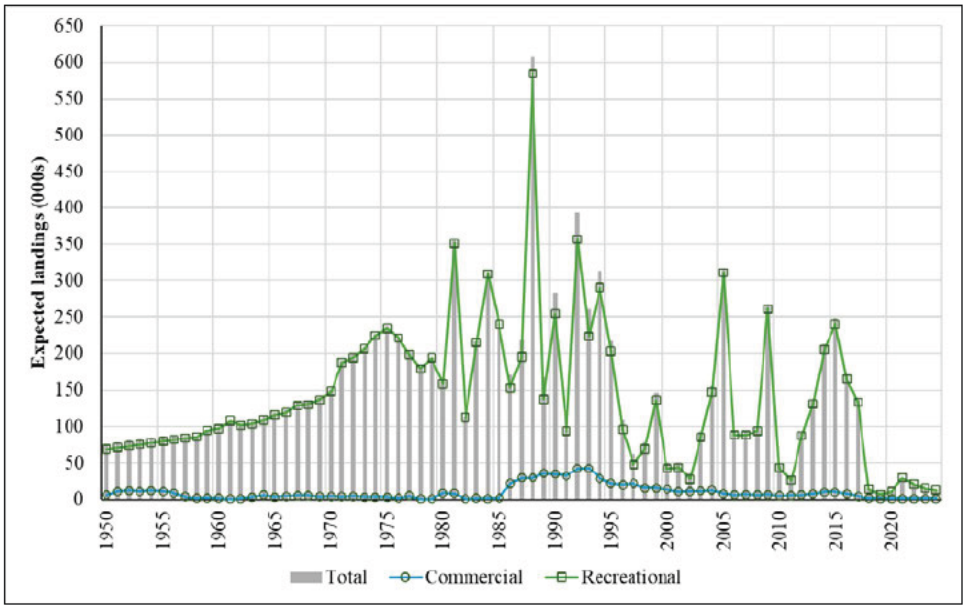


Figure 3.18. Expected landings of Florida Keys/East Florida Hogfish by fleet (in thousands of fish) as estimated from the SEDAR 94 KEYS base model.

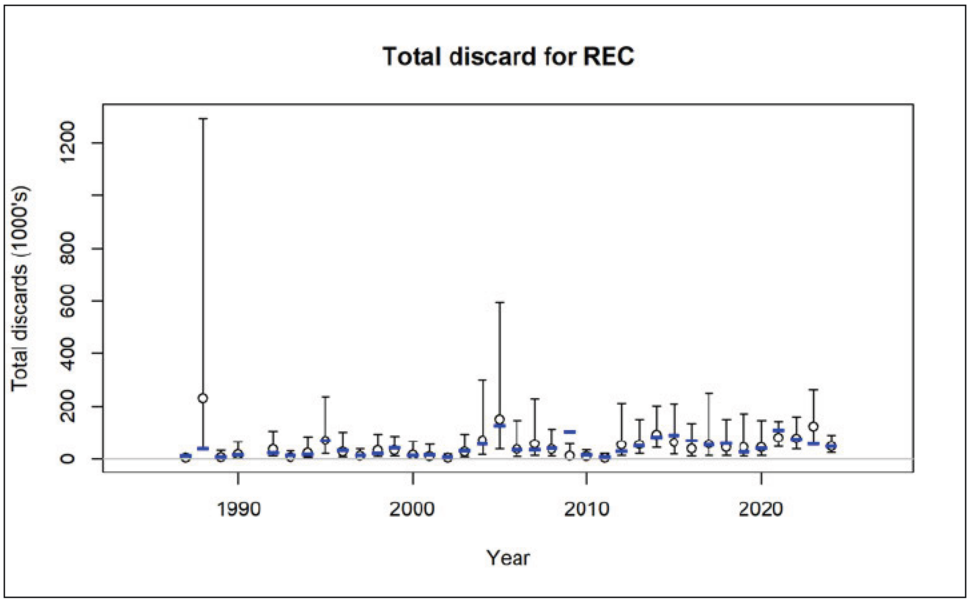


Figure 3.19. Florida Keys/East Florida Hogfish observed (dots with 95% confidence intervals) and expected (blue dashes) discards (i.e., before applying the discard mortality rate for each fleet) by the recreational fleet (in thousands of fish) from the SEDAR 94 KEYS base model.

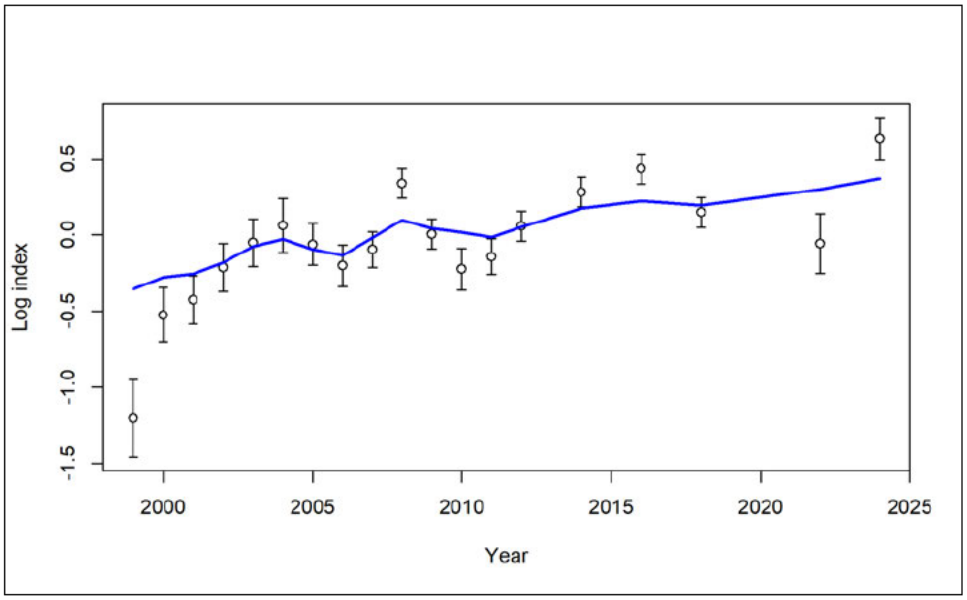


Figure 3.20. The Florida Keys/East Florida Hogfish observed (dots with 95% confidence intervals) and predicted (blue line) RVC Florida Keys index of relative abundance (log-transformed) from the SEDAR 94 KEYS base model.

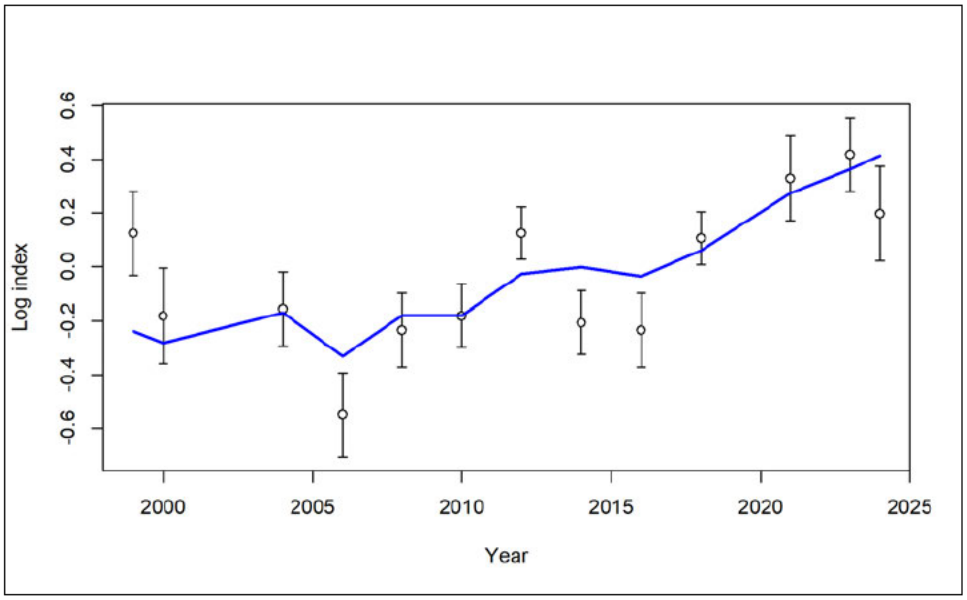


Figure 3.21. The Florida Keys/East Florida Hogfish observed (dots with 95% confidence intervals) and predicted (blue line) RVC Dry Tortugas index of relative abundance (log-transformed) from the SEDAR 94 KEYS base model.

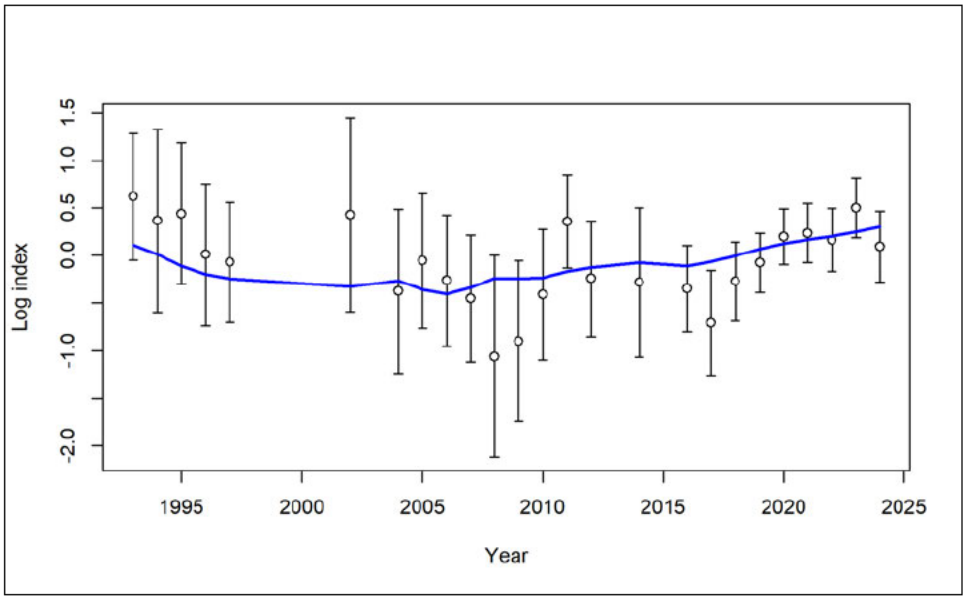


Figure 3.22. The Florida Keys/East Florida Hogfish observed (dots with 95% confidence intervals) and predicted (blue line) combined video index of relative abundance (log-transformed) from the SEDAR 94 KEYS base model.

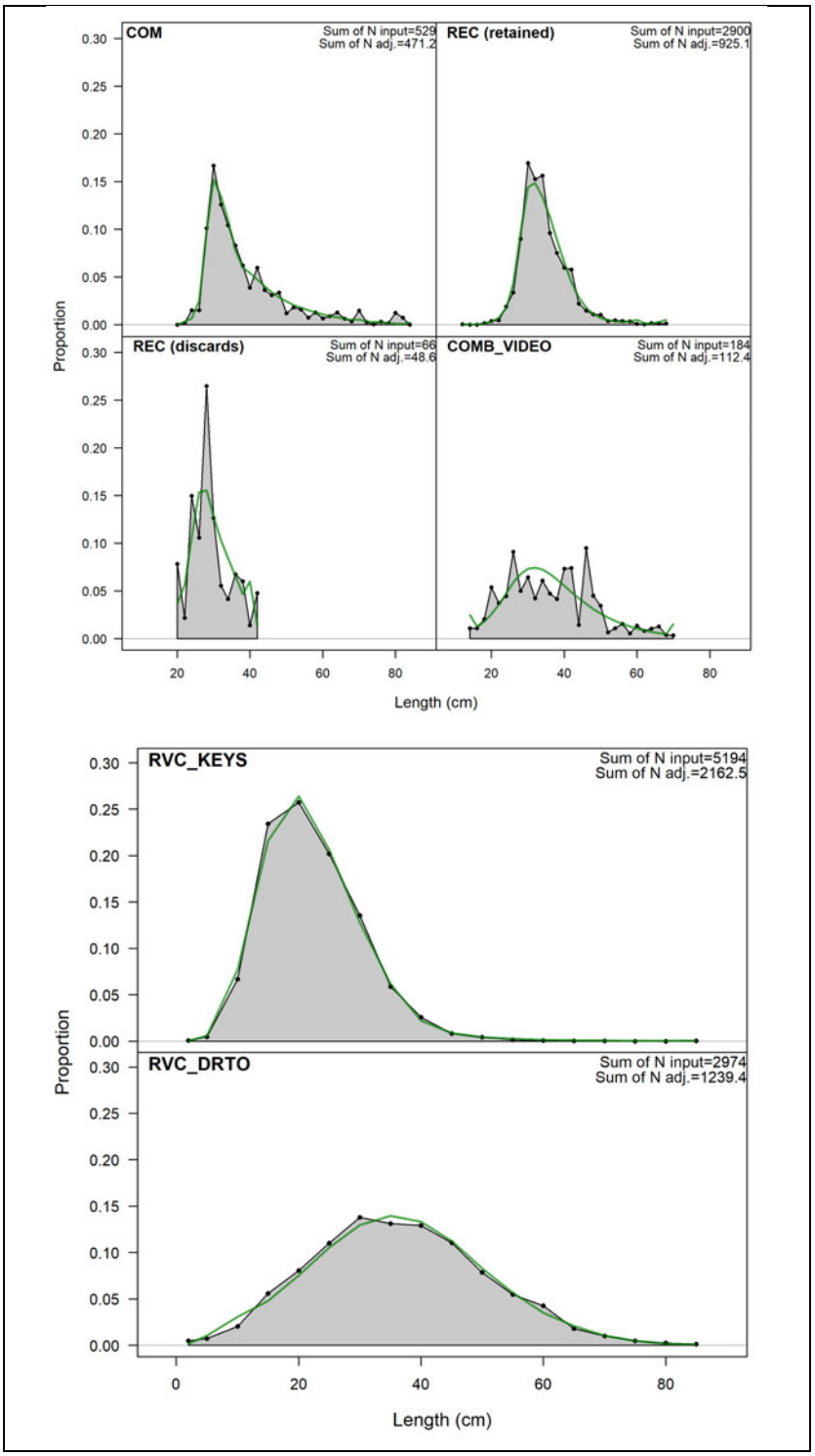


Figure 3.23. Model fits to the length composition of retained and discarded catch within a given fleet or survey aggregated across years for Florida Keys/East Florida Hogfish. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. In the upper right hand corners, 'N input.' is the input sample size while 'N adj.' is the effective sample size calculated using the Dirichlet-Multinomial data-weighting adjustment.

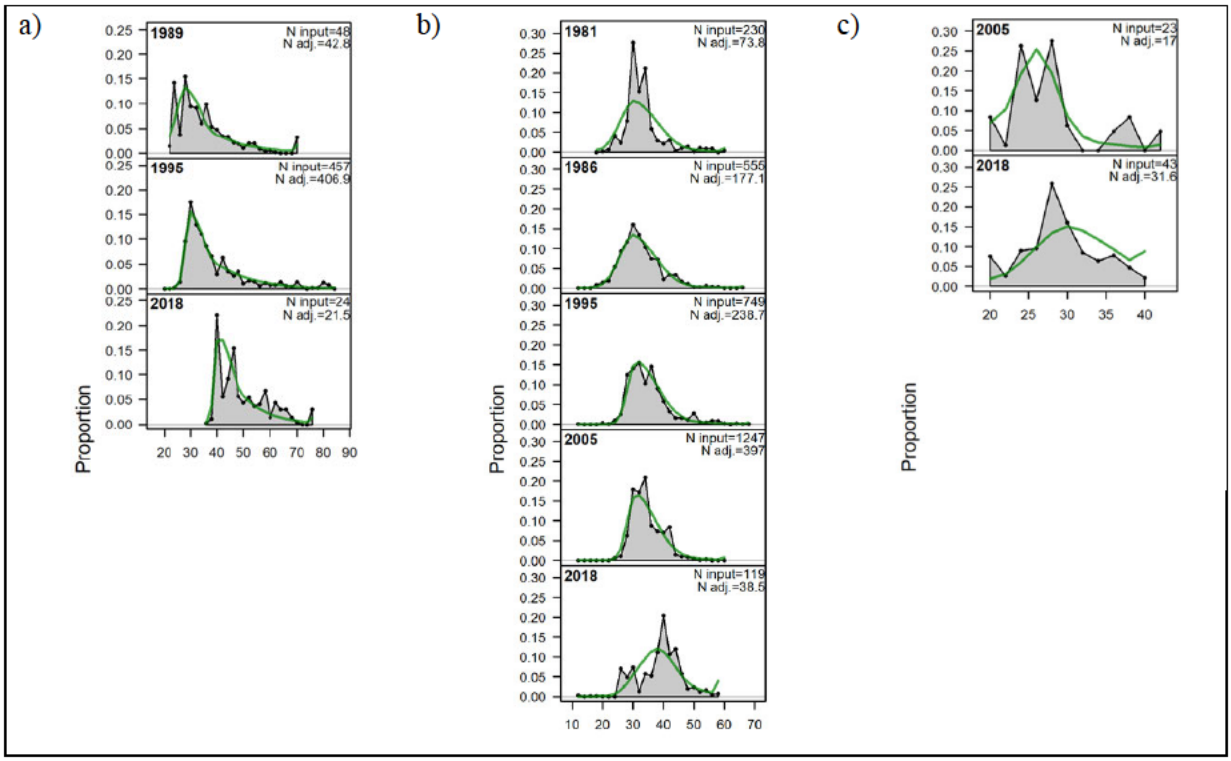


Figure 3.24. Model fits to the length composition of a) retained catch by the commercial fleet, b) retained catch by the recreational fleet, and c) discards for the recreational fleet by super-period for Florida Keys/East Florida Hogfish. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. In the upper right hand corners, 'N input.' is the input sample size while 'N adj.' is the effective sample size calculated using the Dirichlet-Multinomial data-weighting adjustment. Data are in 2 cm fork length bins.

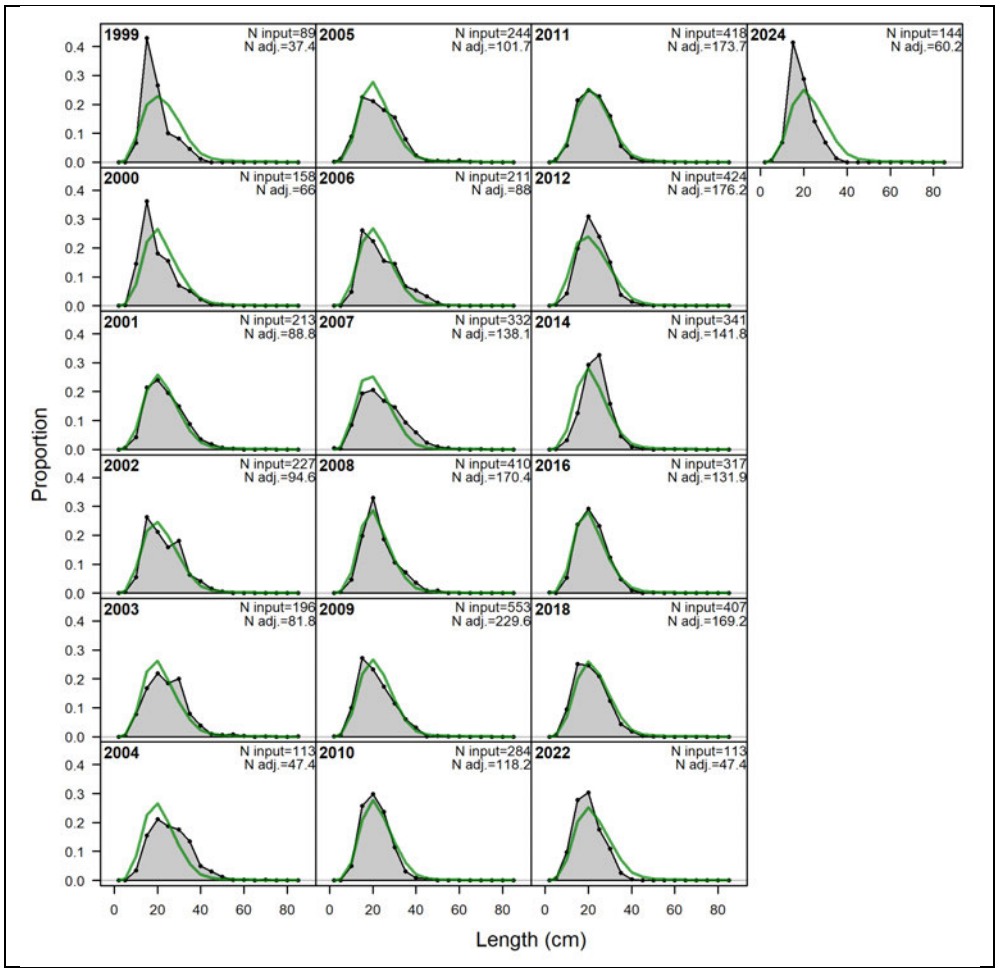


Figure 3.25. Model fits to the length composition data by the RVC Florida Keys index for Florida Keys/East Florida Hogfish. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. In the upper right hand corners, 'N input.' is the input sample size while ‘N adj.’ is the effective sample size calculated using the Dirichlet-Multinomial data-weighting adjustment. Data are in 5 cm fork length bins.

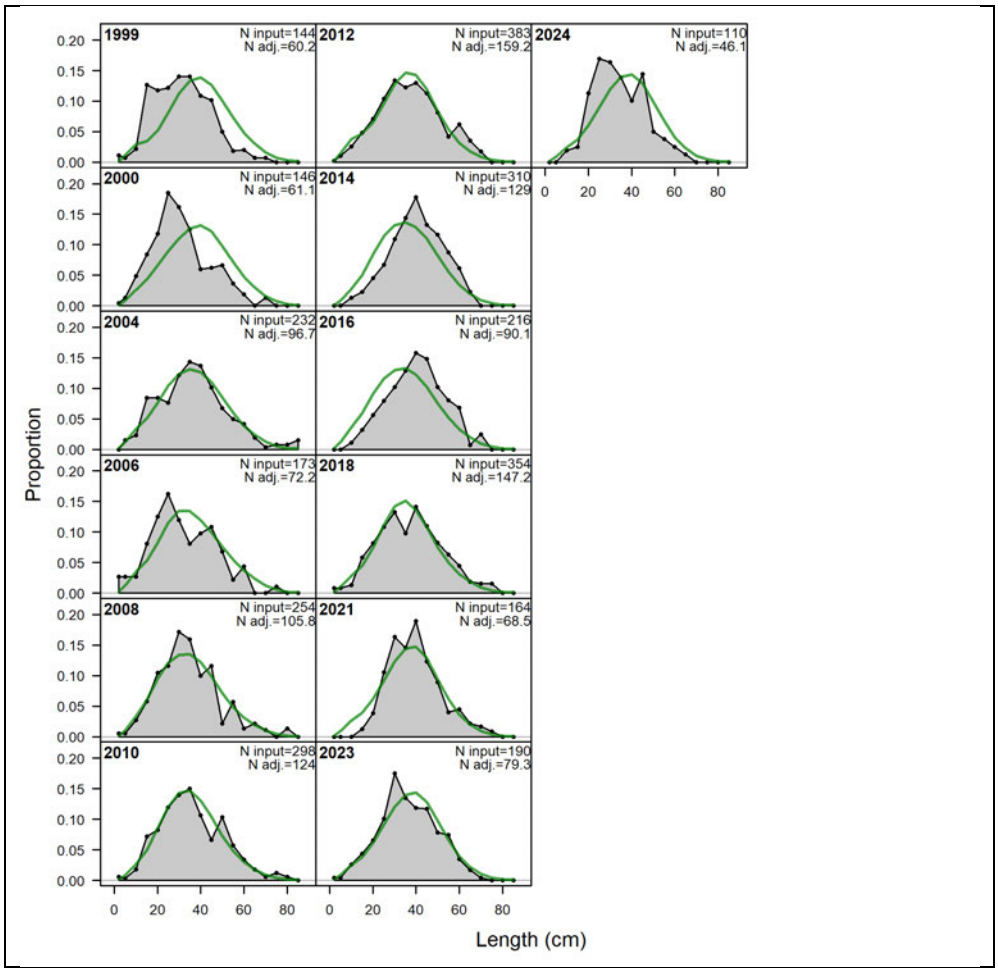


Figure 3.26. Model fits to the length composition data by the RVC Dry Tortugas index Florida Keys/East Florida Hogfish. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. In the upper right hand corners, 'N input.' is the input sample size while 'N adj.' is the effective sample size calculated using the Dirichlet-Multinomial data-weighting adjustment. Data are in 5 cm fork length bins.

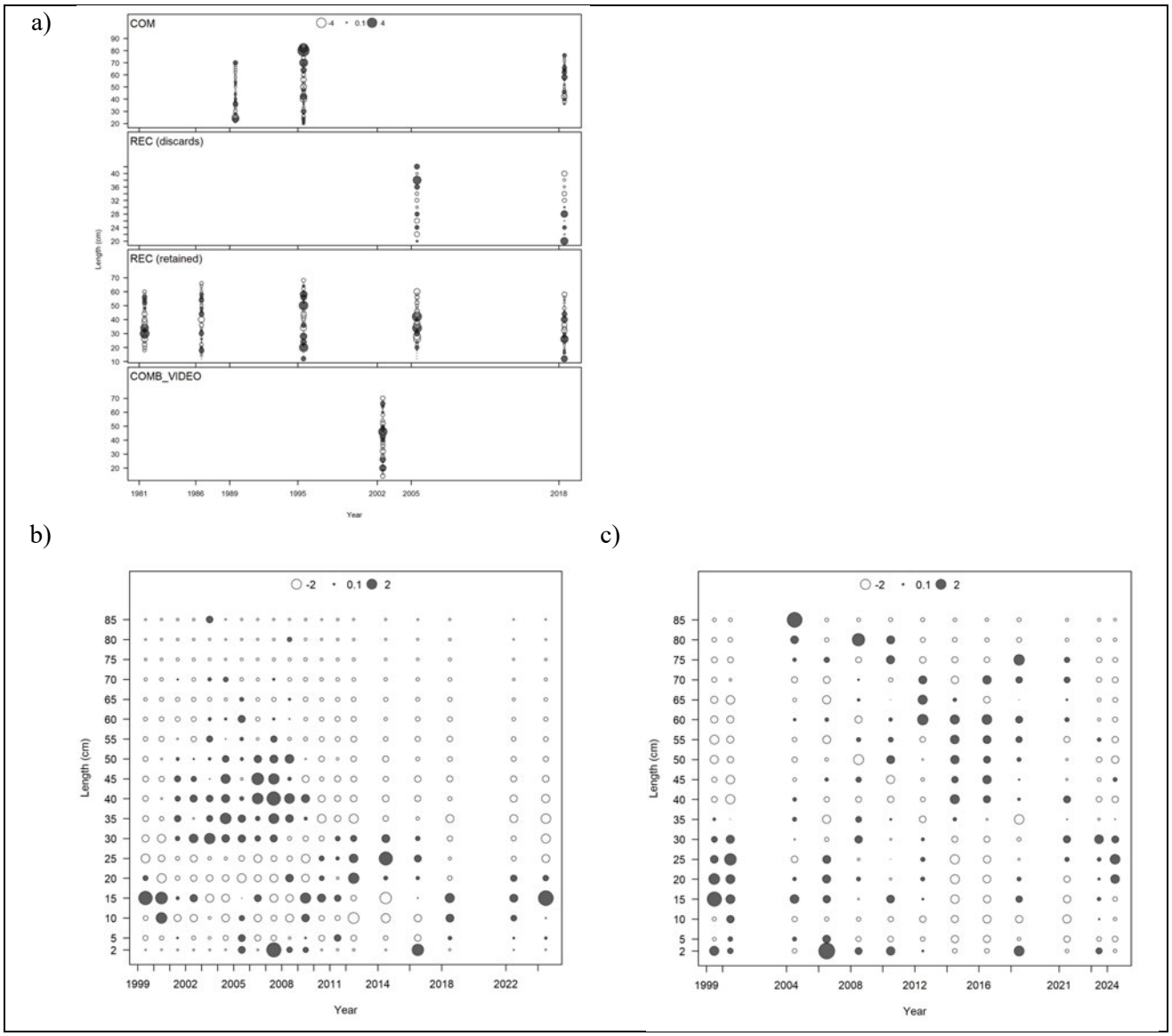


Figure 3.27. Pearson residuals for length composition data for a) the commercial and recreational fleets as well as the combined video index by super-period, b) the RVC Florida Keys index by year, and c) the RVC Dry Tortugas index by year for Florida Keys/East Florida Hogfish. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

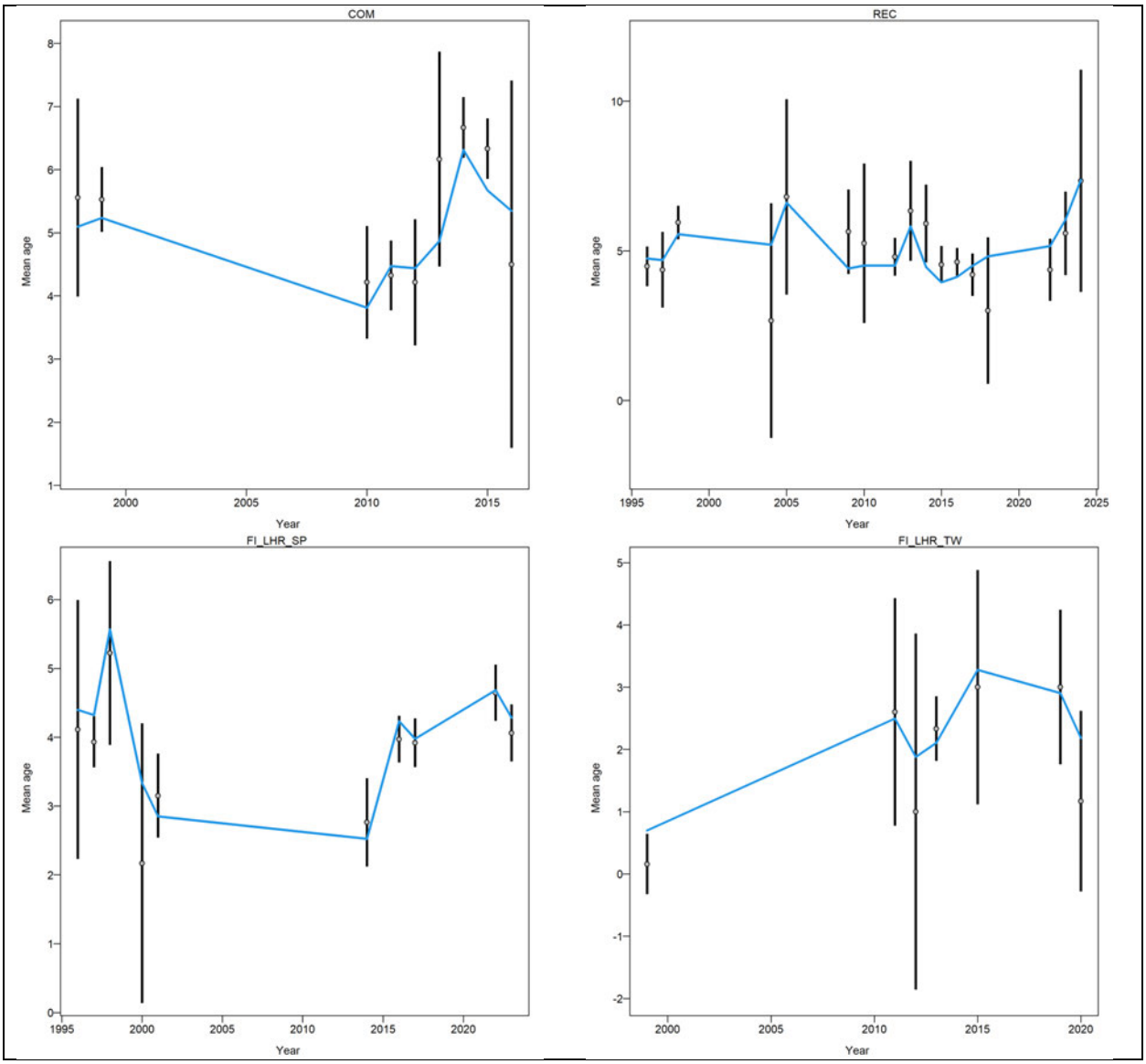


Figure 3.28. Mean ages of Florida Keys/East Florida Hogfish from conditional age-at-length data (commercial retained catch, recreational retained catch, fishery-independent spear, and fishery-independent trawl) aggregated across length bins. Observed values are dots with 95% confidence intervals and predicted values are the blue lines).

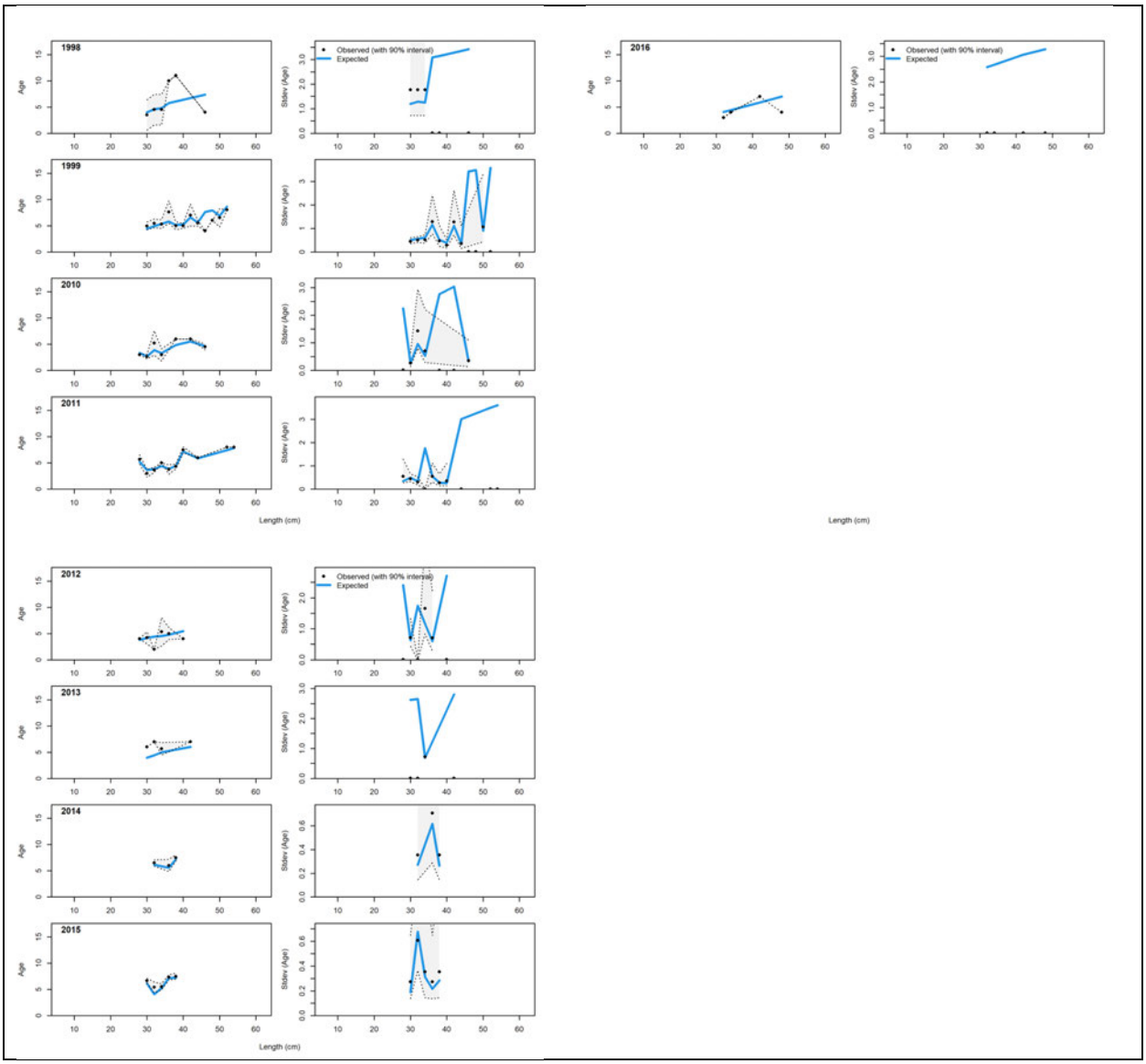


Figure 3.29. Model fits to the annual conditional age-at-length data from retained catch by the commercial fleet for Florida Keys/East Florida Hogfish. In the left plots, the blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals. In the right plots, the blue lines represent predicted standard error of mean age-at-length by size class while the black dots and grey shaded regions represent the observed standard error of mean age-at-length by size class with 90% confidence intervals.

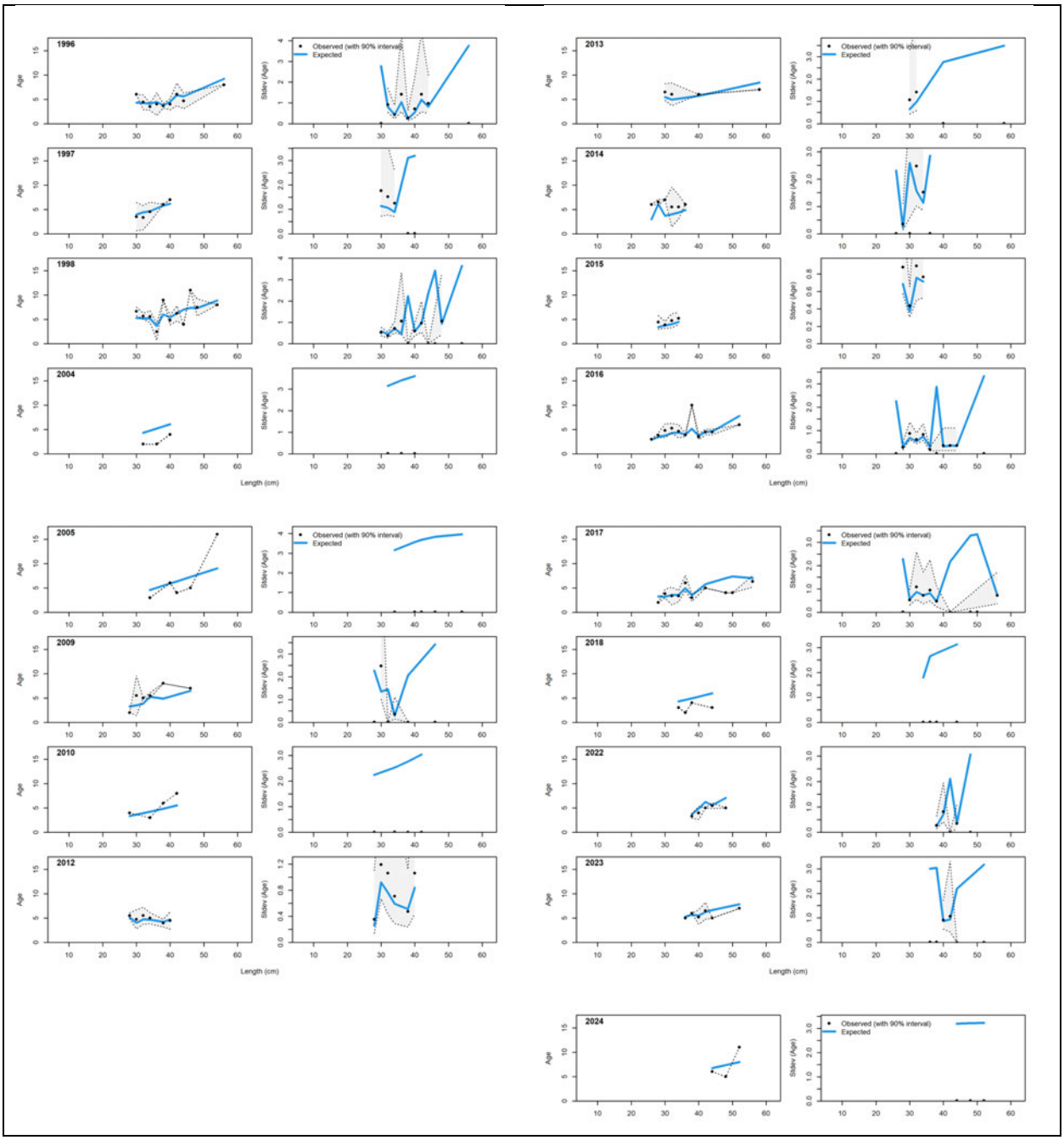


Figure 3.30. Model fits to the annual conditional age-at-length data from retained catch by the recreational fleet for Florida Keys/East Florida Hogfish. In the left plots, the blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals. In the right plots, the blue lines represent predicted standard error of mean age-at-length by size class while the black dots and grey shaded regions represent the observed standard error of mean age-at-length by size class with 90% confidence intervals.

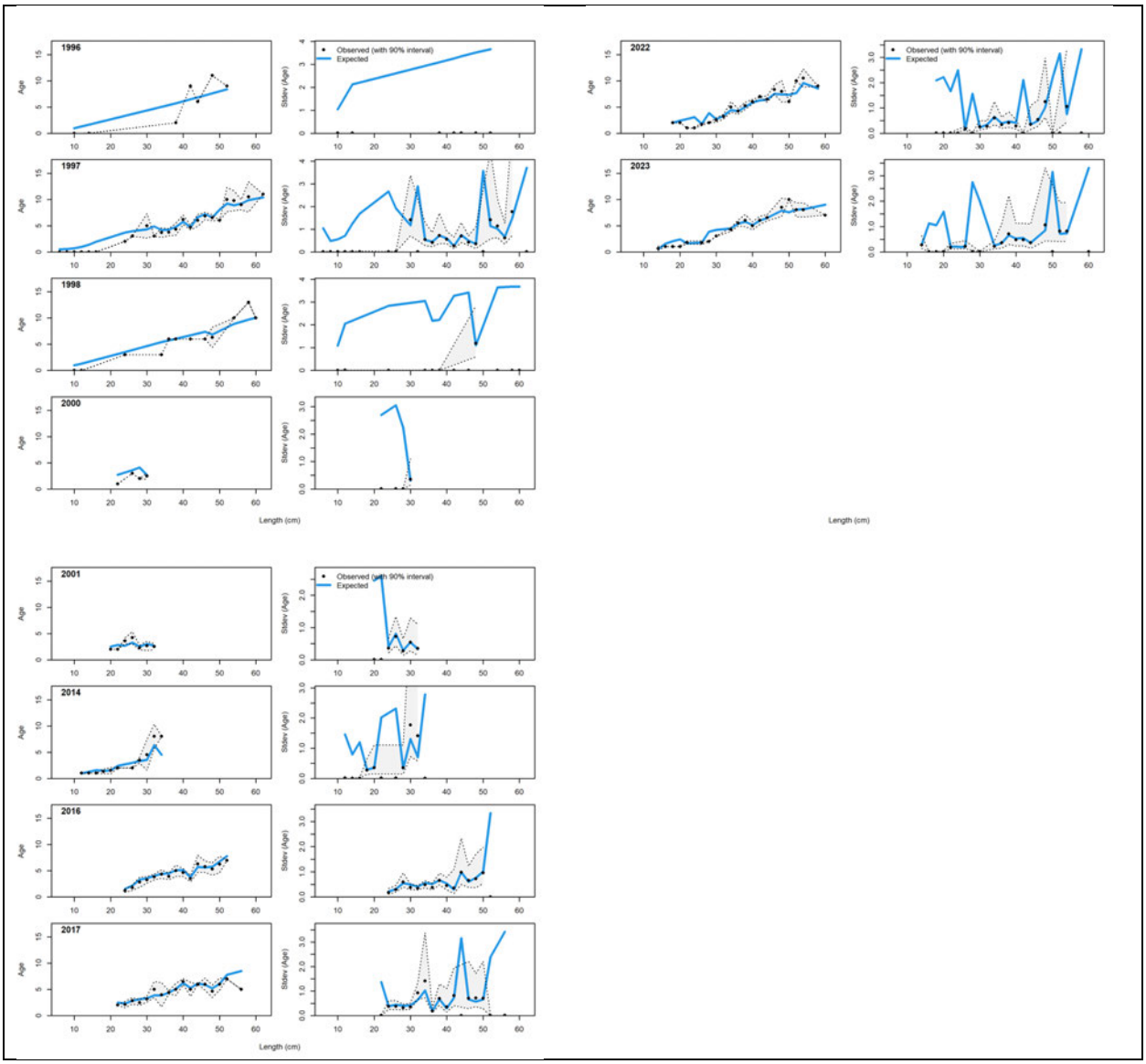


Figure 3.31. Model fits to the annual conditional age-at-length data from fishery-independent spear data sources for Florida Keys/East Florida Hogfish. In the left plots, the blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals. In the right plots, the blue lines represent predicted standard error of mean age-at-length by size class while the black dots and grey shaded regions represent the observed standard error of mean age-at-length by size class with 90% confidence intervals.

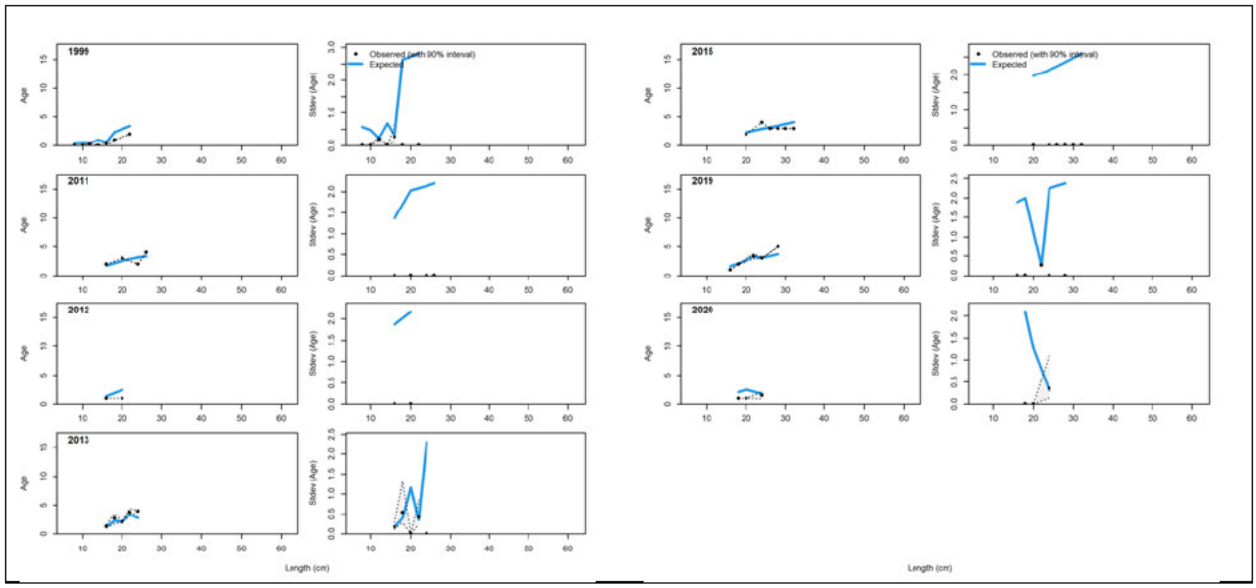


Figure 3.32. Model fits to the annual conditional age-at-length data from fishery-independent trawl data sources for Florida Keys/East Florida Hogfish. In the left plots, the blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals. In the right plots, the blue lines represent predicted standard error of mean age-at-length by size class while the black dots and grey shaded regions represent the observed standard error of mean age-at-length by size class with 90% confidence intervals.

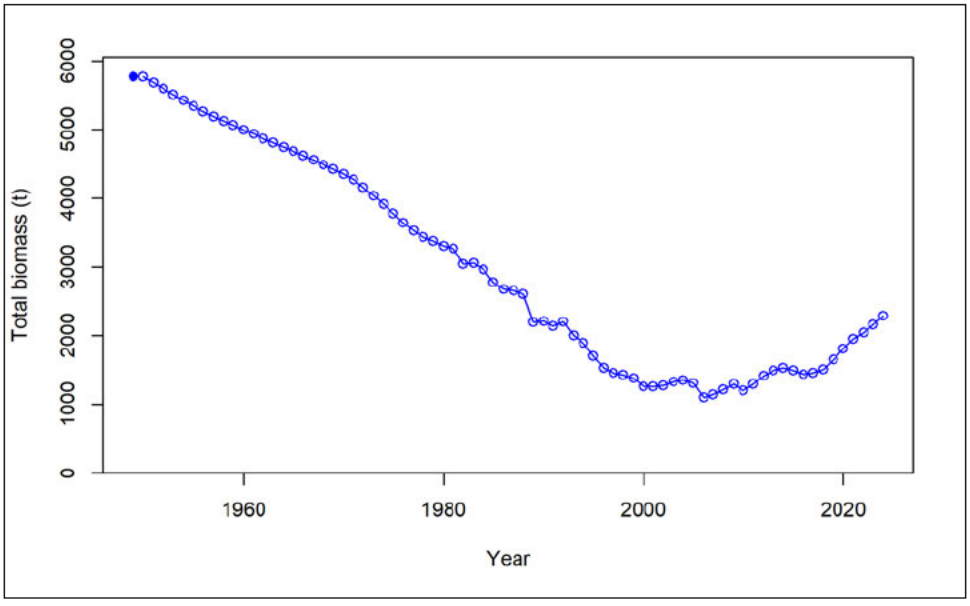


Figure 3.33. Estimates of total biomass (in metric tons) of Florida Keys/East Florida Hogfish (open circles) from 1950 – 2024. The solid blue circle is the estimated unfished total biomass.

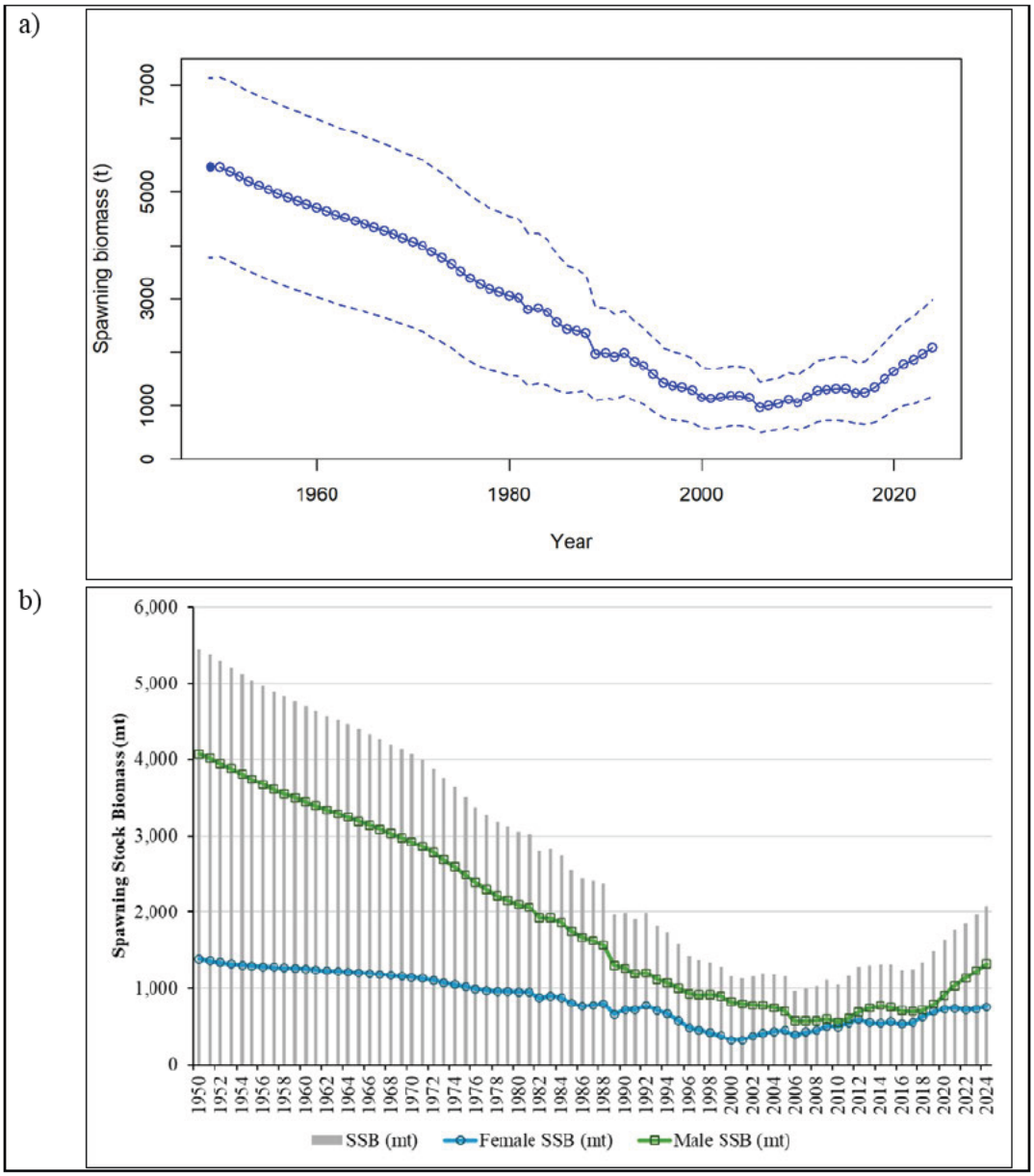


Figure 3.34. Estimates of mature female and male spawning stock biomass a) combined (in metric tons, open circles) with approximate 95% confidence intervals (dashed lines) where the solid blue circle is the estimated unfished spawning stock biomass, and b) separated by sex (female = blue circles, male = green squares, combined = grey bars) for Florida Keys/East Florida Hogfish from 1950 – 2024.

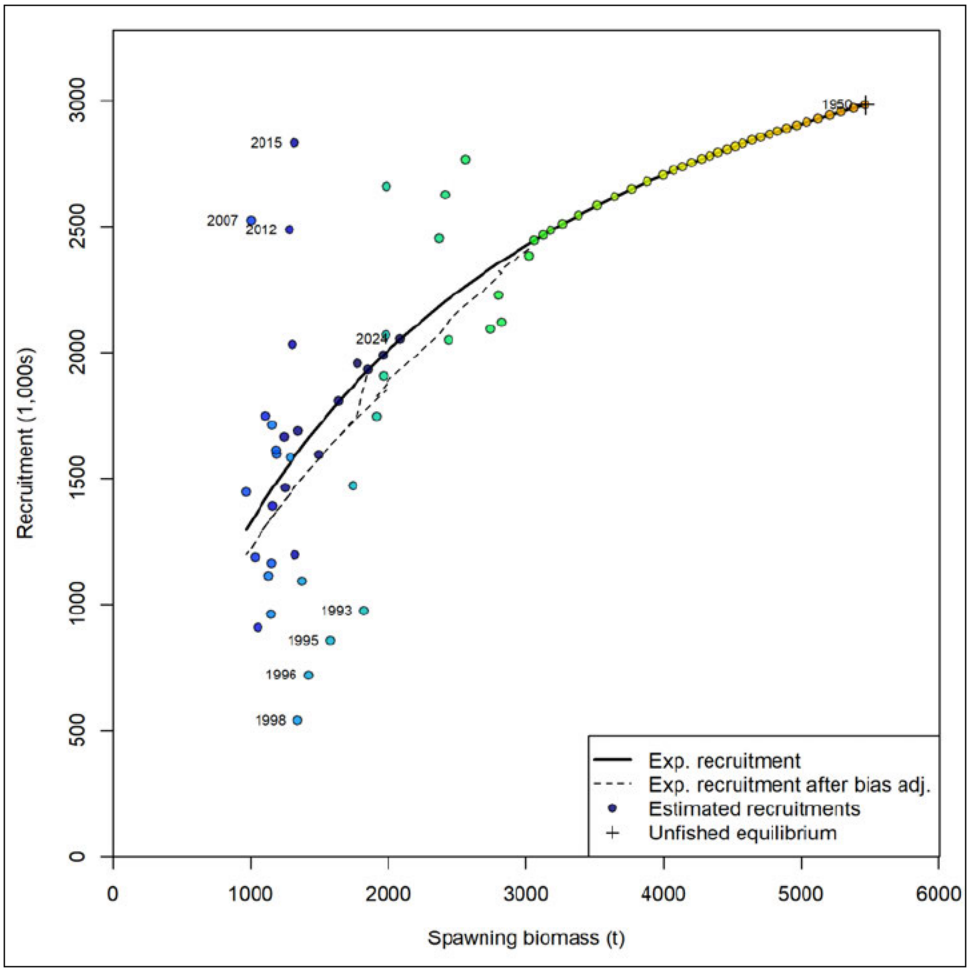


Figure 3.35. Expected stock-recruitment relationship for Florida Keys/East Florida Hogfish. Steepness was estimated at 0.472 and sigmaR was estimated at 0.449. Plotted are expected annual recruitments from the SEDAR 94 KEYS base model (circles), expected recruitment from the stock-recruitment relationship (black line), and bias adjusted recruitment from the stock-recruit relationship (dashed line). Point colors indicate year, with warmer colors indicating earlier years and cooler colors showing later years.

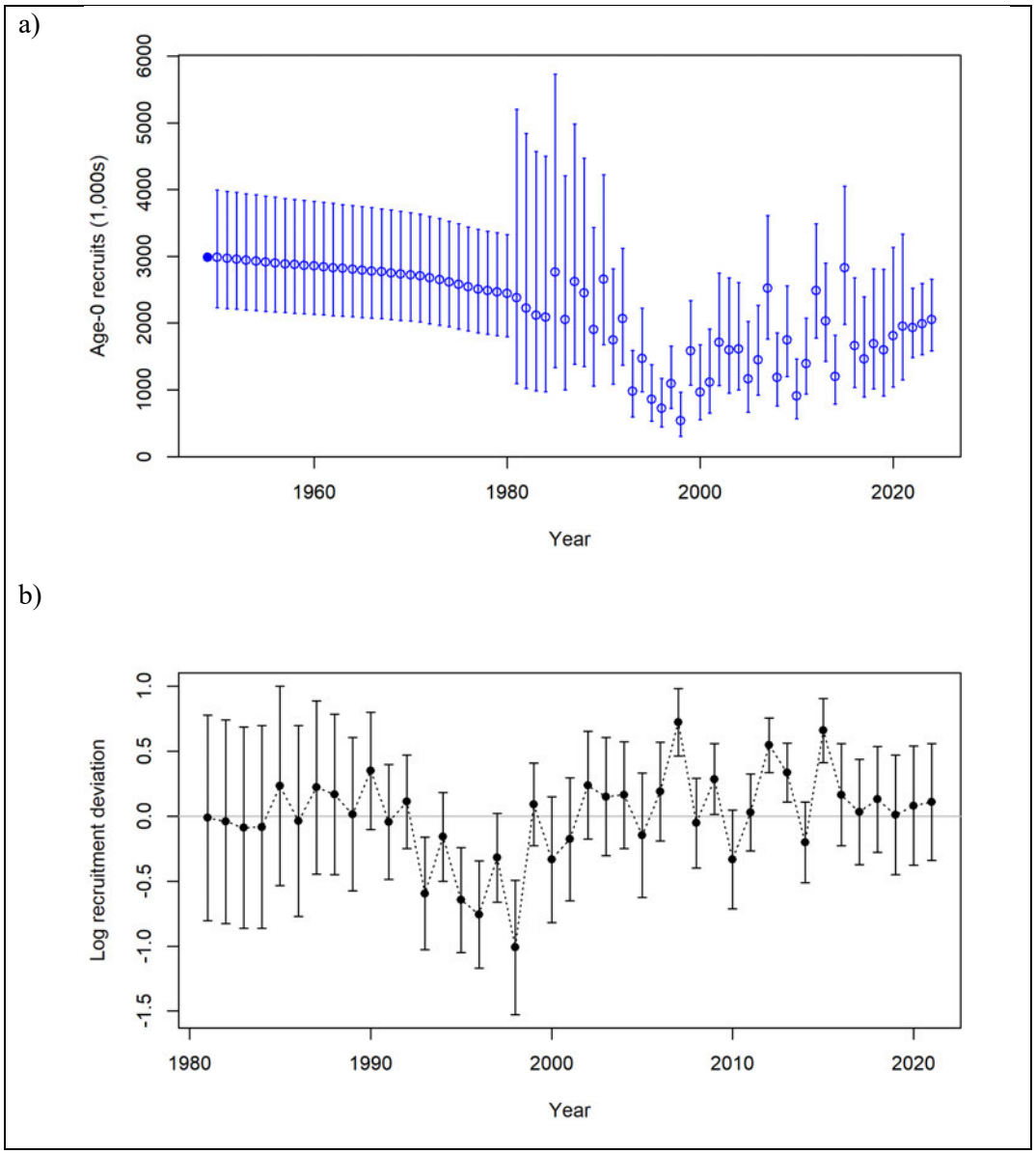


Figure 3.36. Estimated recruitment for Florida Keys/East Florida Hogfish. a) Annual estimated age-0 recruitment (open circles) with 95% confidence intervals (lines) as well as estimated initial equilibrium recruitment (blue dot). b) Log-scaled main recruitment deviations (dots) with 95% confidence intervals (lines) from 1981 – 2021. Recruitment for years 1950 – 1980 and 2022 – 2024 was estimated following the expected stock-recruitment curve.

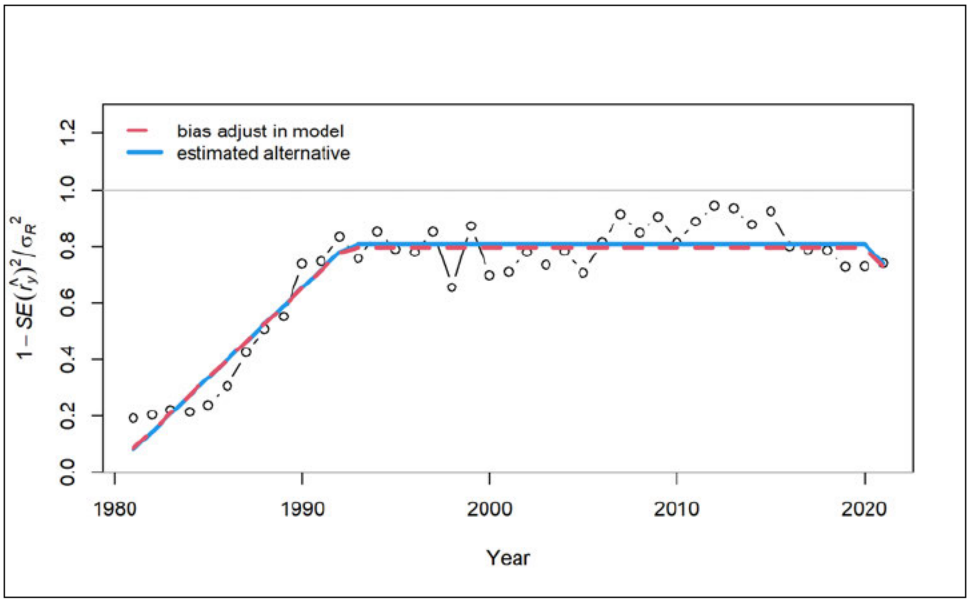


Figure 3.37. Points are transformed variances. Red line shows current settings for bias adjustment specified for the SEDAR 94 KEYS base model, which coincides with the least squares estimate of alternative bias adjustment relationship for recruitment deviations (dashed red line). For more information, see Methot and Taylor (2011).

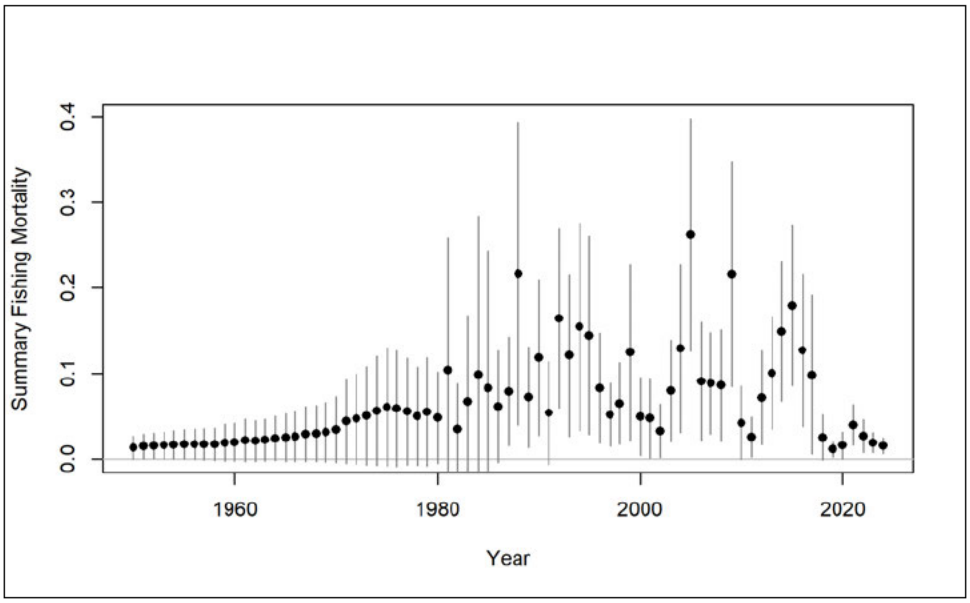


Figure 3.38. Annual exploitation fishing mortality rates, calculated as the ratio of the total annual catch in biomass to the age-1+ biomass at the beginning of the year, for Florida Keys/East Florida Hogfish with 95% confidence intervals from the SEDAR 94 KEYS base model.

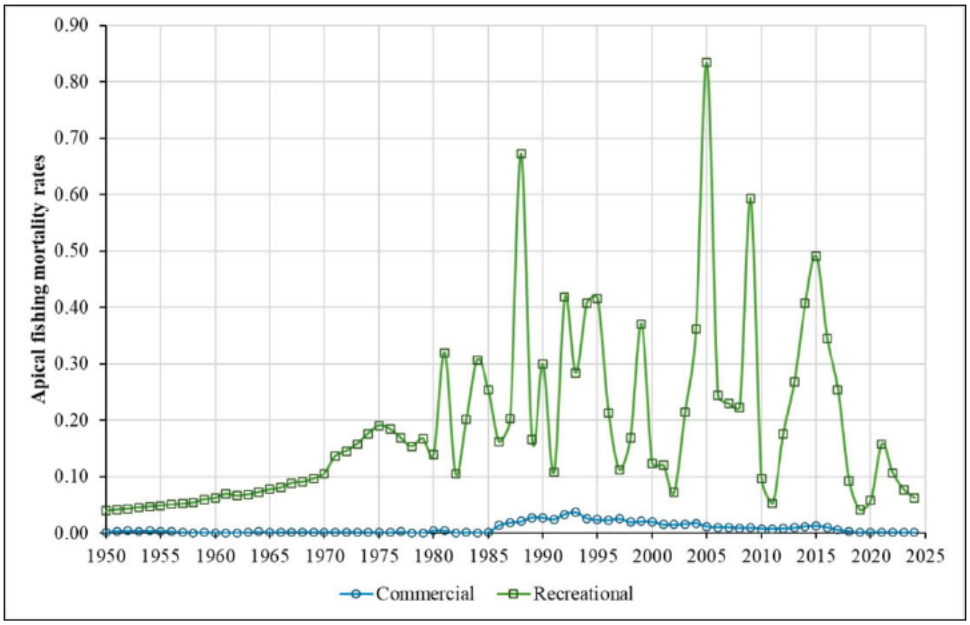


Figure 3.39. Annual fleet-specific instantaneous apical fishing mortality rates for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS base model. This represents the instantaneous fishing mortality level on the most vulnerable (i.e., selectivity = 1) age class for each fleet.

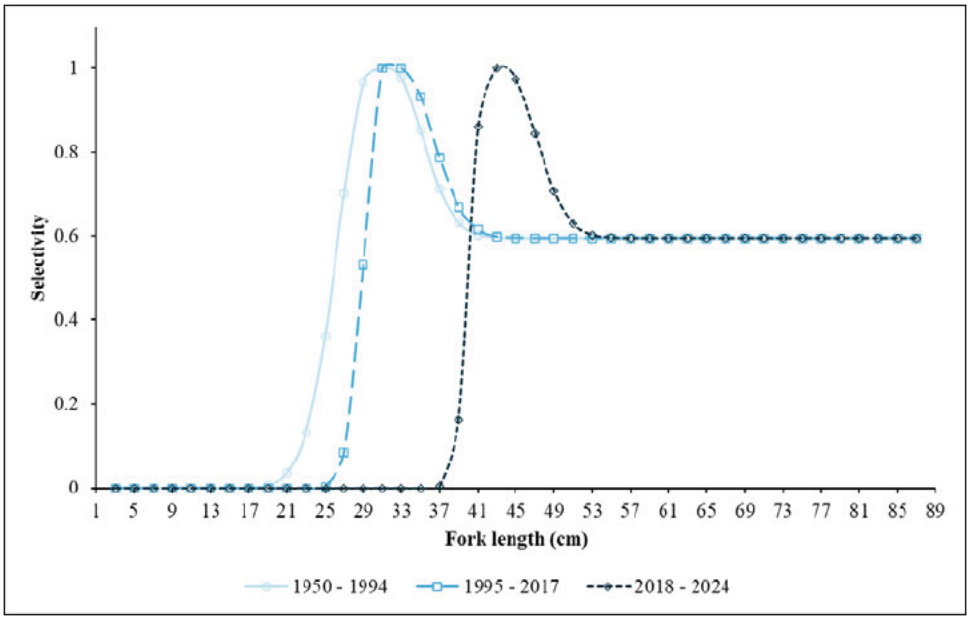


Figure 3.40. Length-based selectivity of the commercial fleet by time block for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS base model.

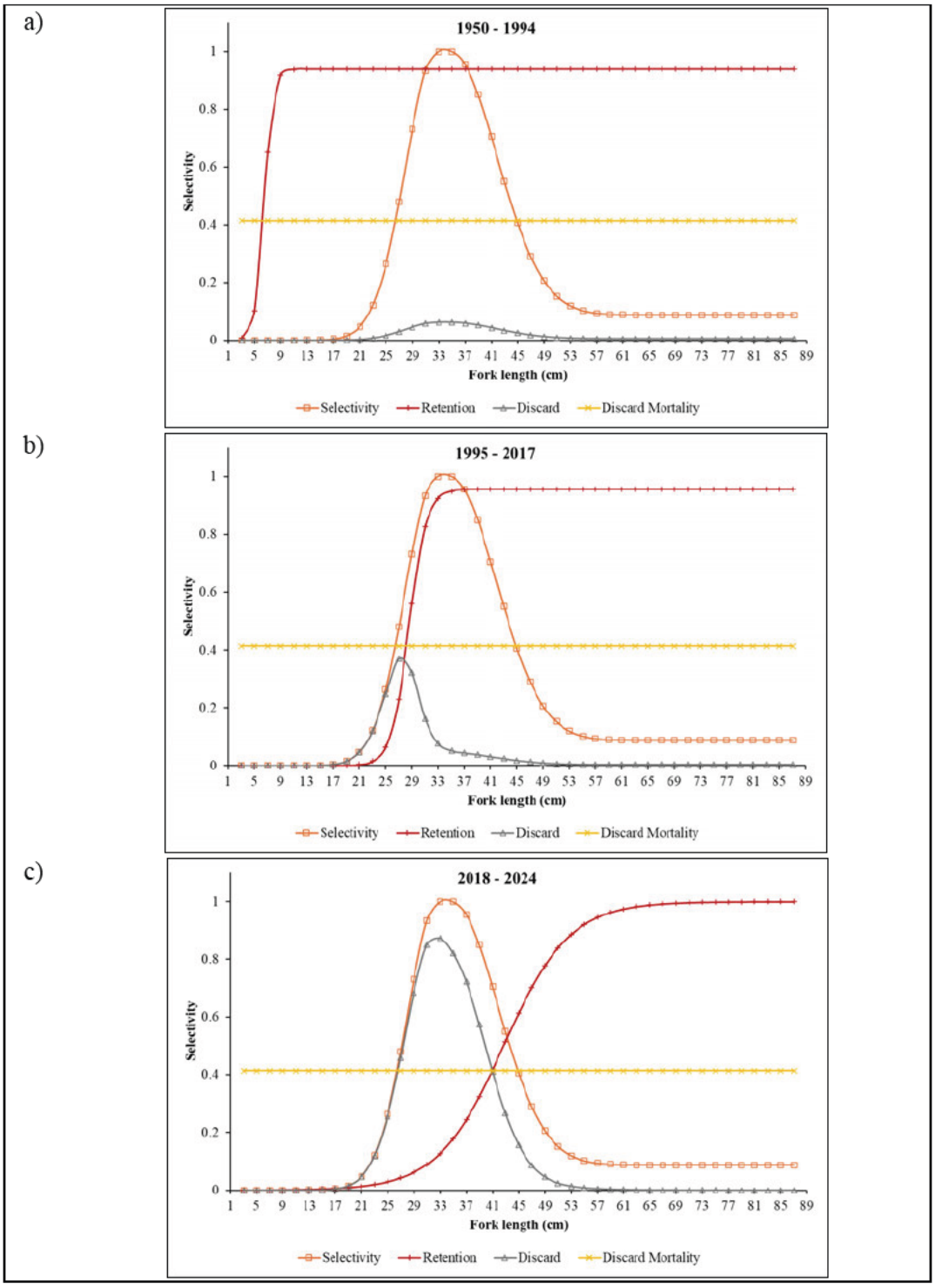


Figure 3.41. Length-based selectivity, retention, discard, and discard mortality (41.4%) patterns of the recreational fleet by time block a) 1950 – 1994, b) 1995 – 2017, and c) 2018 – 2024 for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS base model.

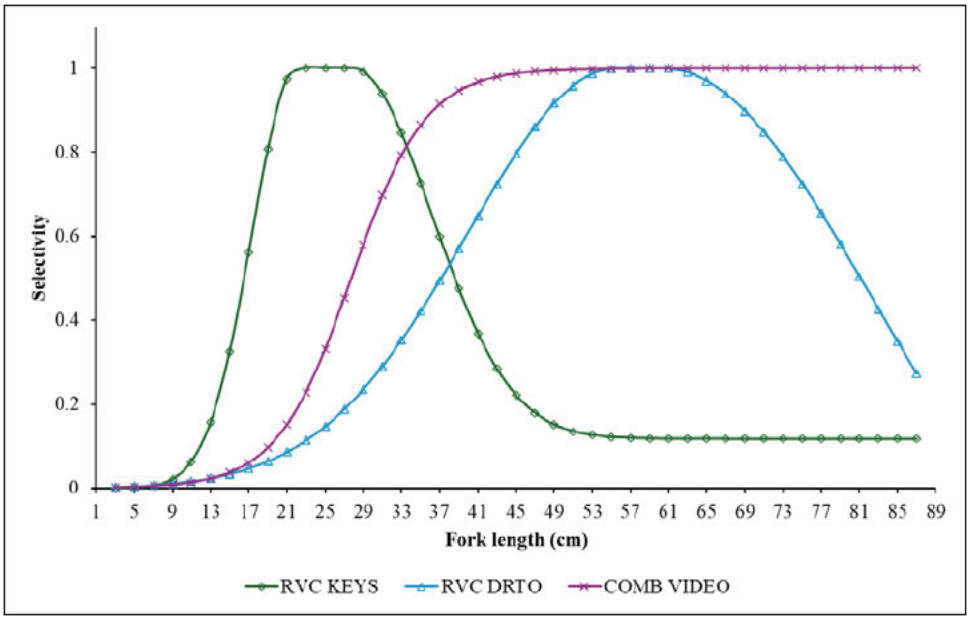


Figure 3.42. Length-based selectivity of the RVC Florida Keys index (green diamonds), RVC Dry Tortugas index (blue triangles), and combined video index (purple x's) for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS base model.

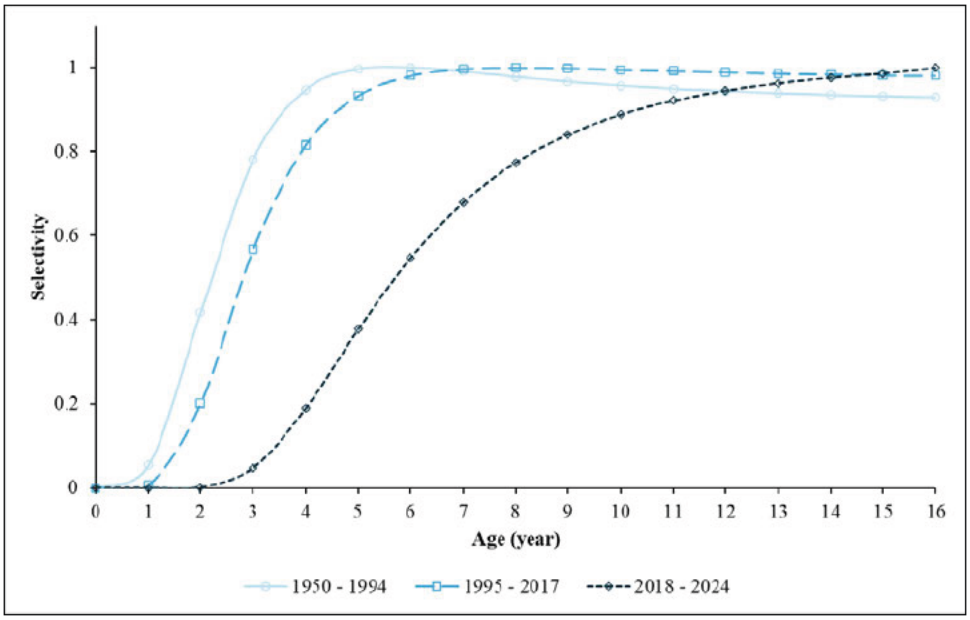


Figure 3.43. Age-derived selectivity of the commercial fleet by time block for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS base model.

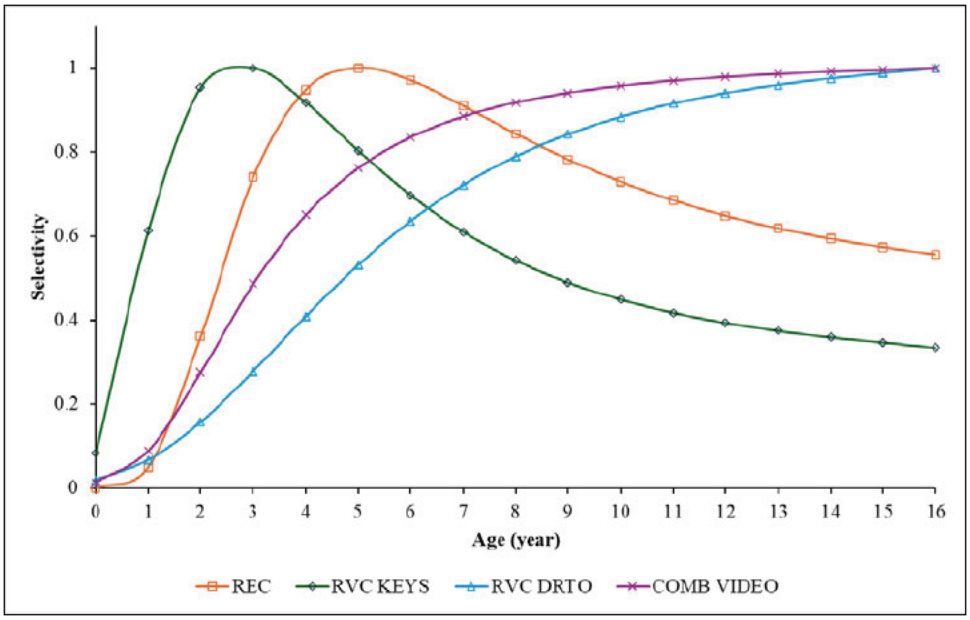


Figure 3.44. Age-derived selectivity of the recreational fleet (orange square), RVC Florida Keys index (green diamonds), RVC Dry Tortugas index (blue triangles), and combined video index (purple x's) for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS base model.

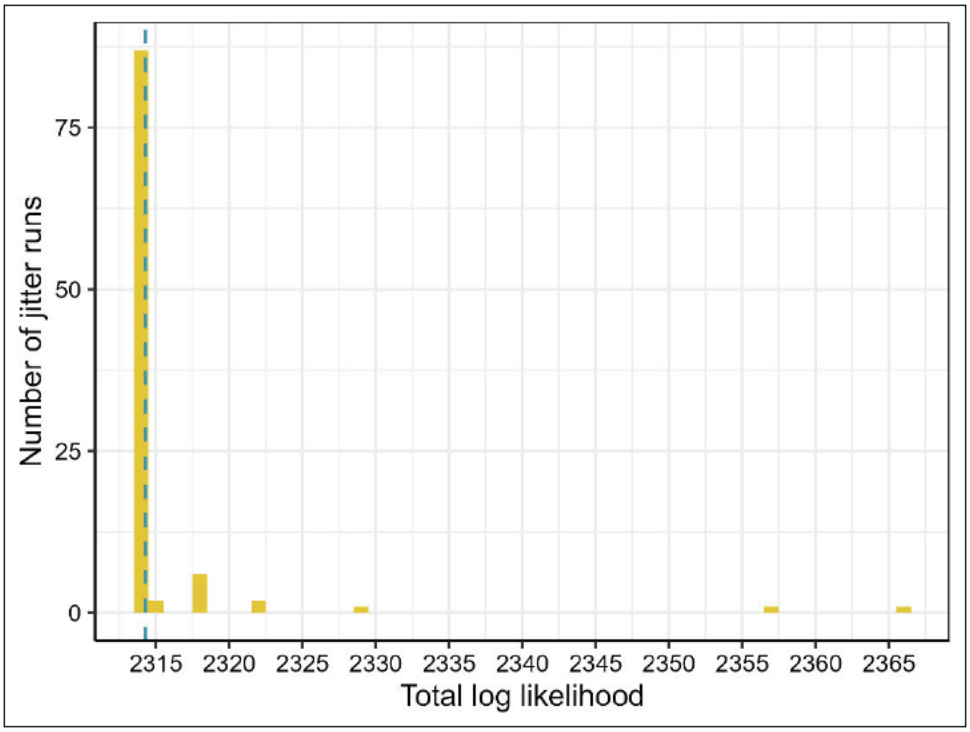


Figure 3.45. Total log-likelihood values of model runs performed by the jitter analysis (yellow bars) and the SEDAR 94 KEYS base model (blue dashed line).

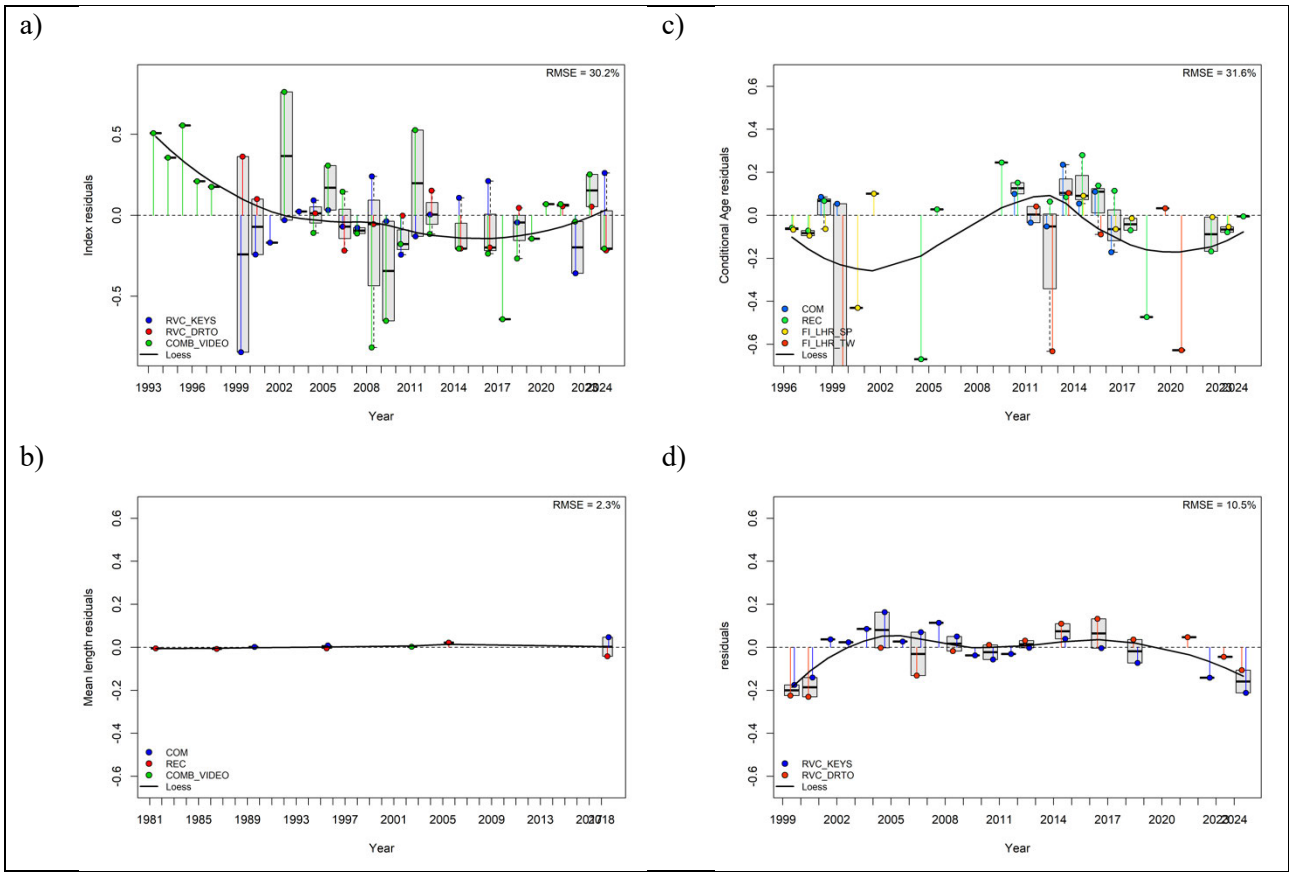


Figure 3.46. Joint residual plots for a) the indices of abundance, b) the annual mean length estimates, and c) the annual conditional age-at-length estimates, and d) the annual mean general size composition (i.e., RVC lengths) of available fleets and indices from the SEDAR 94 KEYS base model. Vertical lines with points show the residuals, boxplots show residual medians and quantiles, and solid black lines are a loess smoother. Root-mean squared errors (RMSE) are included in the upper right-hand corner of each plot.

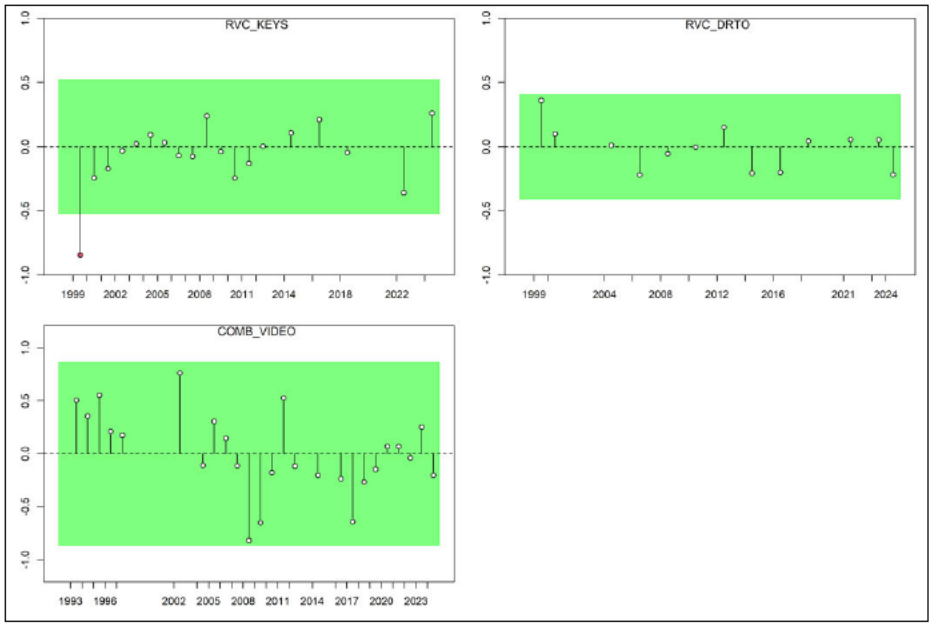


Figure 3.47. Runs tests results for the indices of abundance from the SEDAR 94 KEYS base model. Green shading indicates no evidence ($p \geq 0.05$) and red shading evidence ($p < 0.05$) to reject the hypothesis of a randomly distributed time-series of residuals, respectively. Shaded regions span three residual standard deviations to either side from zero and red points outside of the shading indicate a violation of that 'three-sigma limit'.

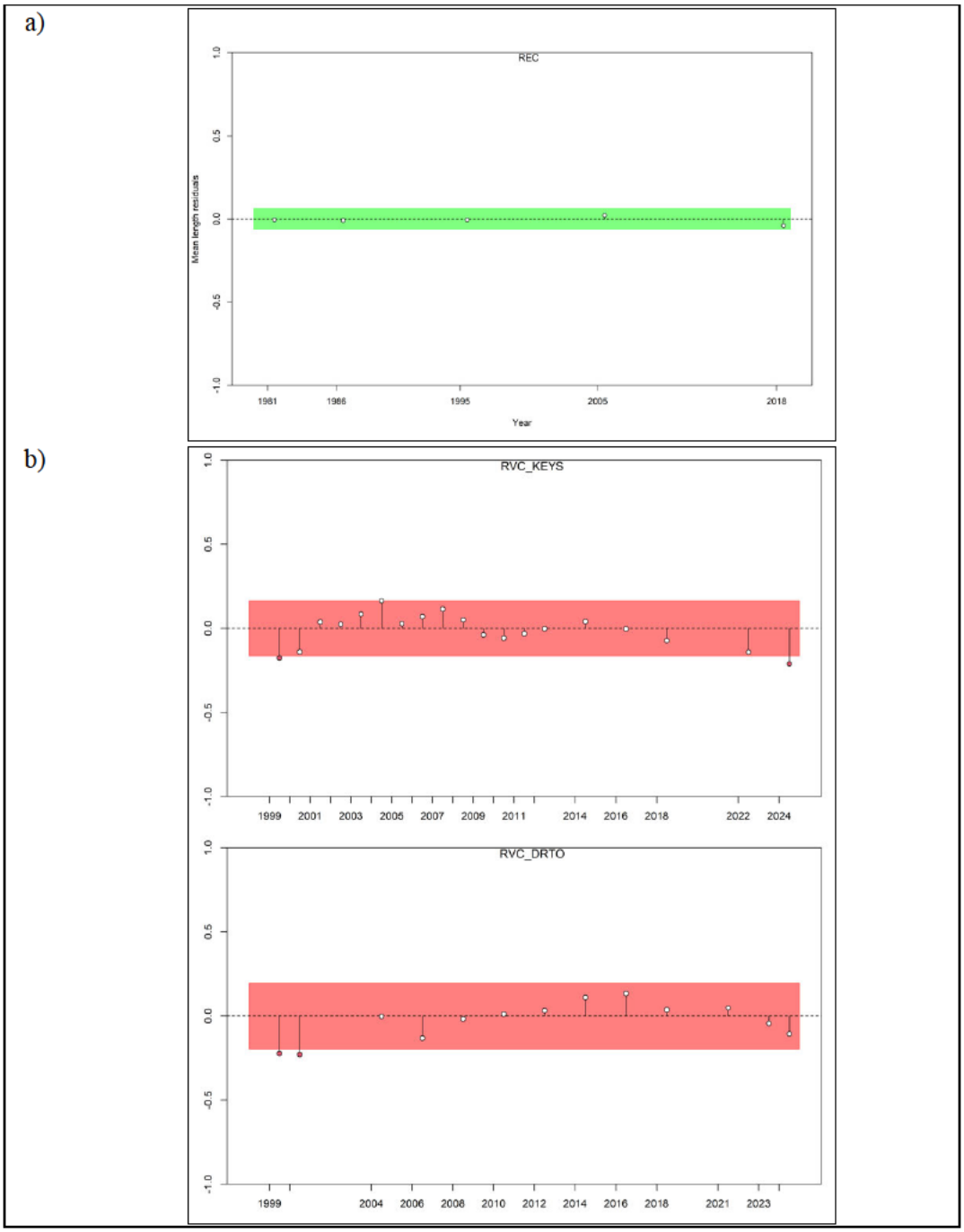


Figure 3.48. Runs tests results for a) the annual mean length estimates of the recreational fleet and b) the annual mean general size composition (i.e., RVC lengths) from the SEDAR 94 KEYS base model. Green shading indicates no evidence ($p \geq 0.05$) and red shading evidence ($p < 0.05$) to reject the hypothesis of a randomly distributed time-series of residuals, respectively. Shaded regions span three residual standard deviations to either side from zero and red points outside of the shading indicate a violation of that 'three-sigma limit'.

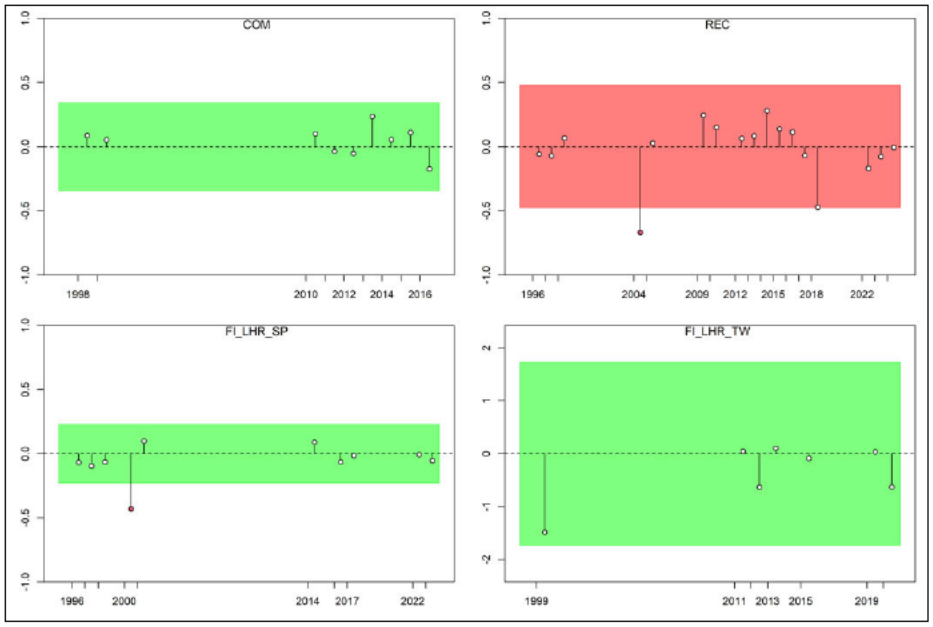


Figure 3.49. Runs tests results for the conditional age-at-length estimates from the SEDAR 94 KEYS base model. Green shading indicates no evidence ($p \geq 0.05$) and red shading evidence ($p < 0.05$) to reject the hypothesis of a randomly distributed time-series of residuals, respectively. Shaded regions span three residual standard deviations to either side from zero and red points outside of the shading indicate a violation of that 'three-sigma limit'.

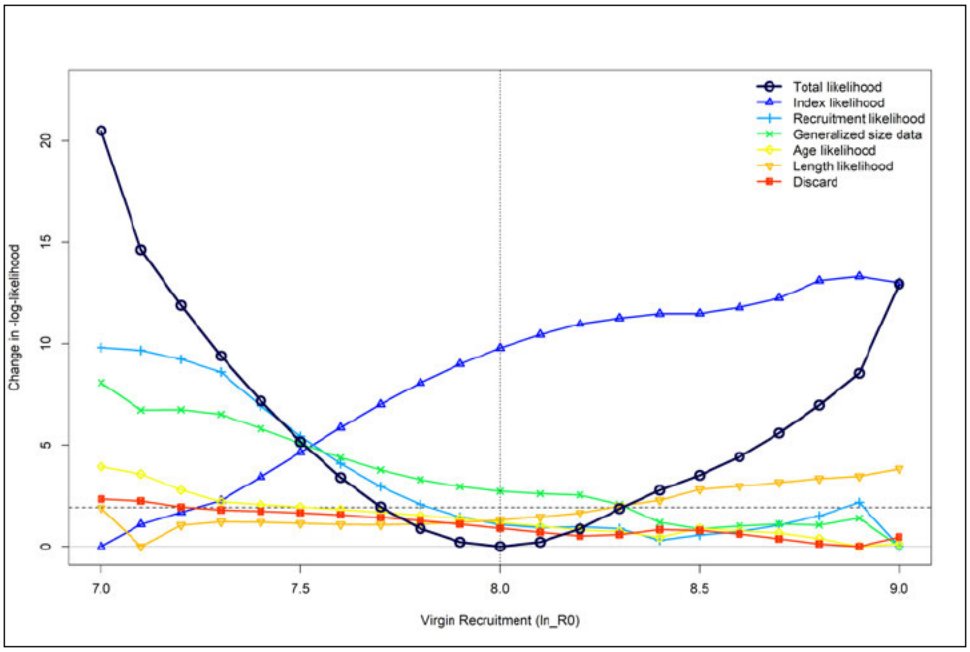


Figure 3.50. Log-likelihood profiles of the unfished (i.e., virgin) recruitment (*ln(R0)*) parameter for various data components in the SEDAR 94 KEYS base model. The horizontal dashed line indicates a 2 unit difference in log-likelihood while the vertical dotted line is the estimate from the SEDAR 94 KEYS base model.

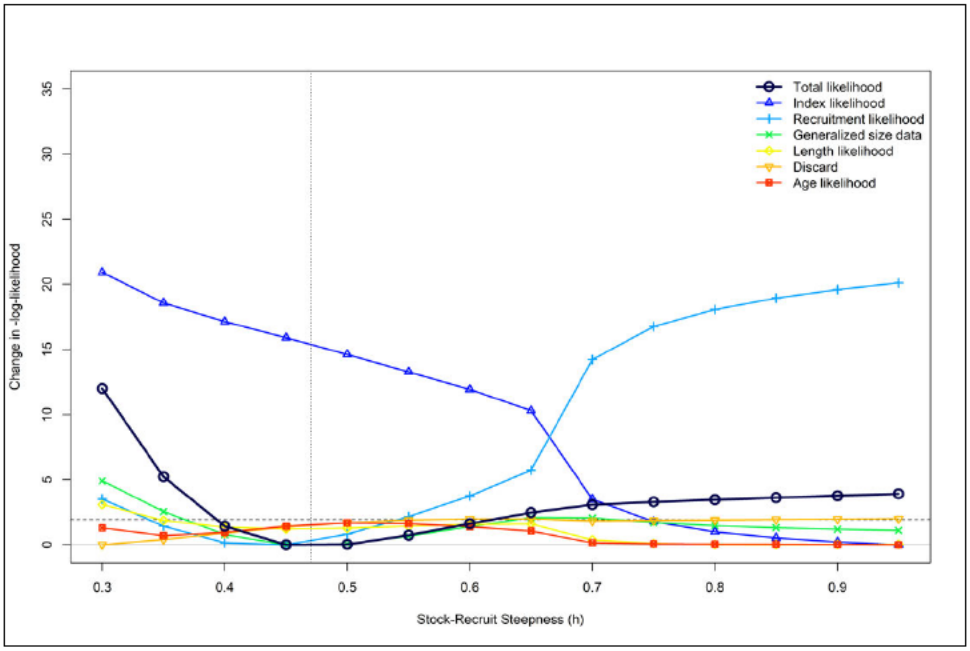


Figure 3.51. Log-likelihood profiles of the *steepness (h)* parameter for various data components in the SEDAR 94 KEYS base model. The horizontal dashed line indicates a 2 unit difference in log-likelihood while the vertical dotted line is the estimate from the SEDAR 94 KEYS base model.

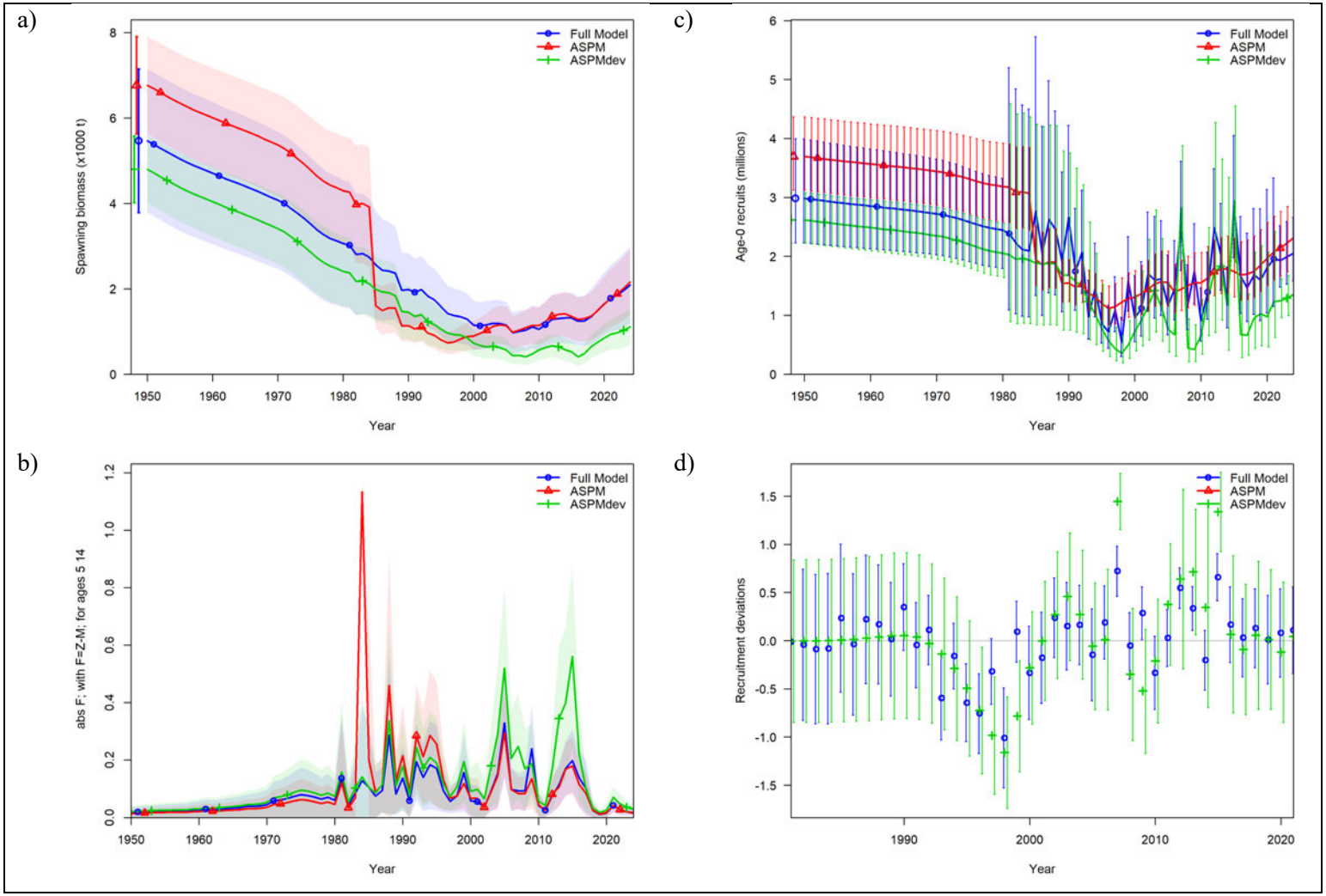


Figure 3.52. Results comparison between the SEDAR 94 KEYS base model (Full Model), the deterministic Age-Structured-Production Model (ASPM), and the ASPM with recruitment deviations (ASPMdev) showing a) spawning stock biomass, b) exploitation rates, c) estimates of age-0 recruitment, and d) estimates of recruitment deviations.

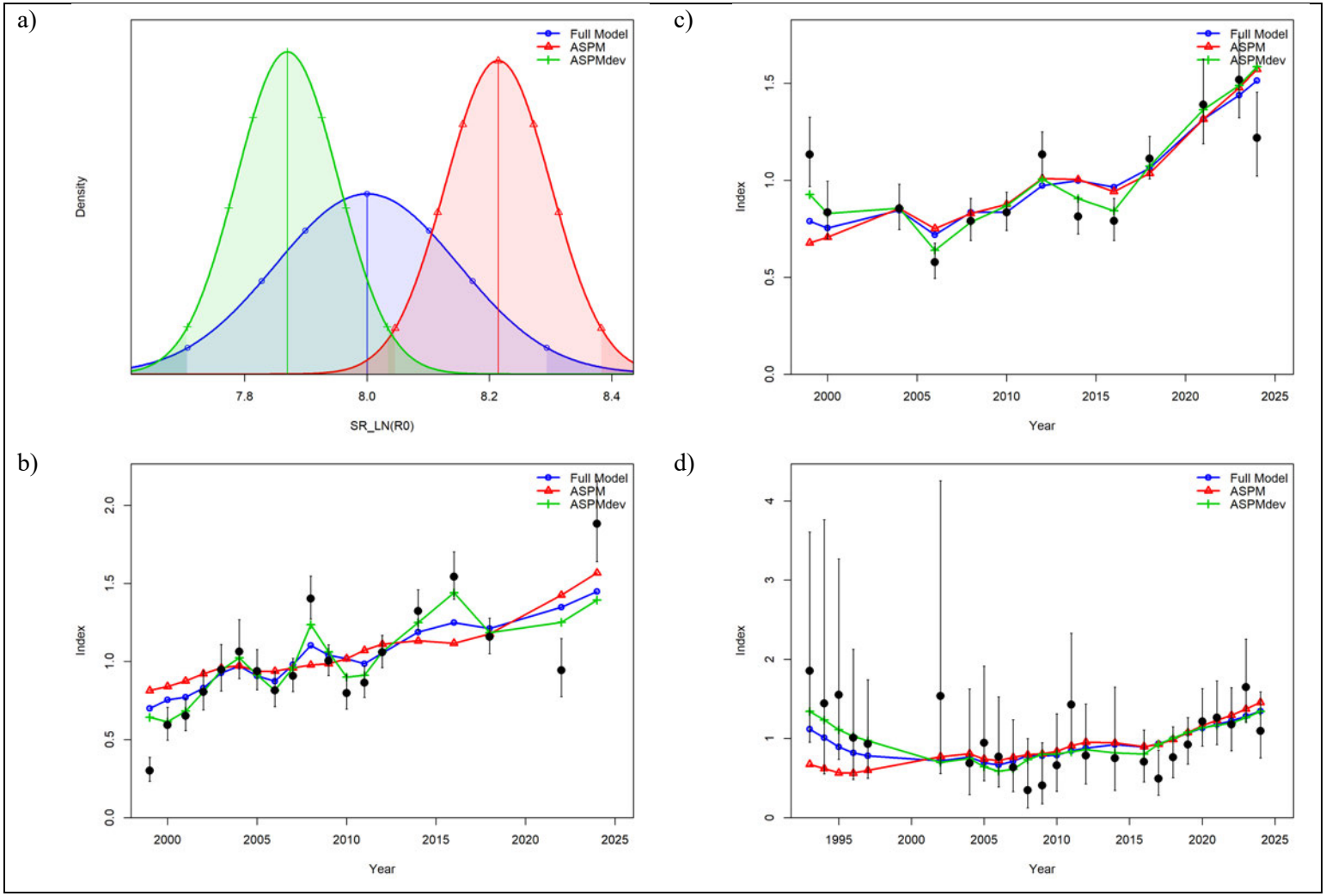


Figure 3.53. Results comparison between the SEDAR 94 KEYS base model (Full Model), the deterministic Age-Structured-Production Model (ASPM), and the ASPM with recruitment deviations (ASPMdev) showing a) estimates of the virgin recruitment parameter in log-space *ln(R0)*, b) observed and predicted values for the RVC Florida Keys index, c) observed and predicted values for the RVC Dry Tortugas index., and d) observed and predicted values for the combined video index.

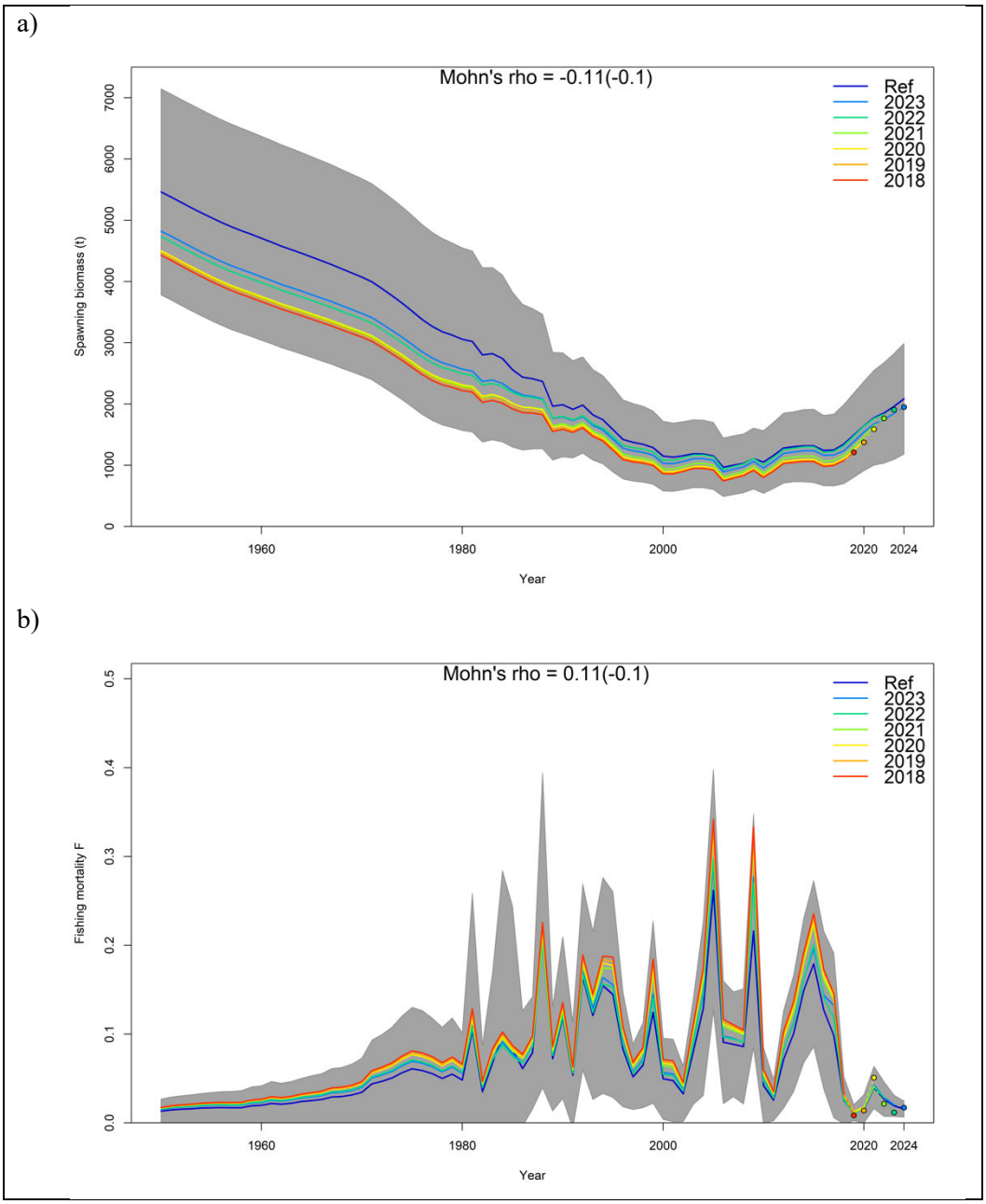


Figure 3.54. Retrospective forecast results of a) spawning stock biomass and b) exploitation rates conducted by re-fitting the SEDAR 94 KEYS base model (Ref) after sequentially removing seven years of observations. The Mohn's rho (ρ_M) statistic and corresponding forecast rho (ρ_F) values (in parenthesis) are provided at the top of each panel. One-year-ahead projections denoted by color-coded dashed lines with terminal points are shown for each peel. Grey shaded areas are the 95 % confidence intervals from the SEDAR 94 KEYS base model.

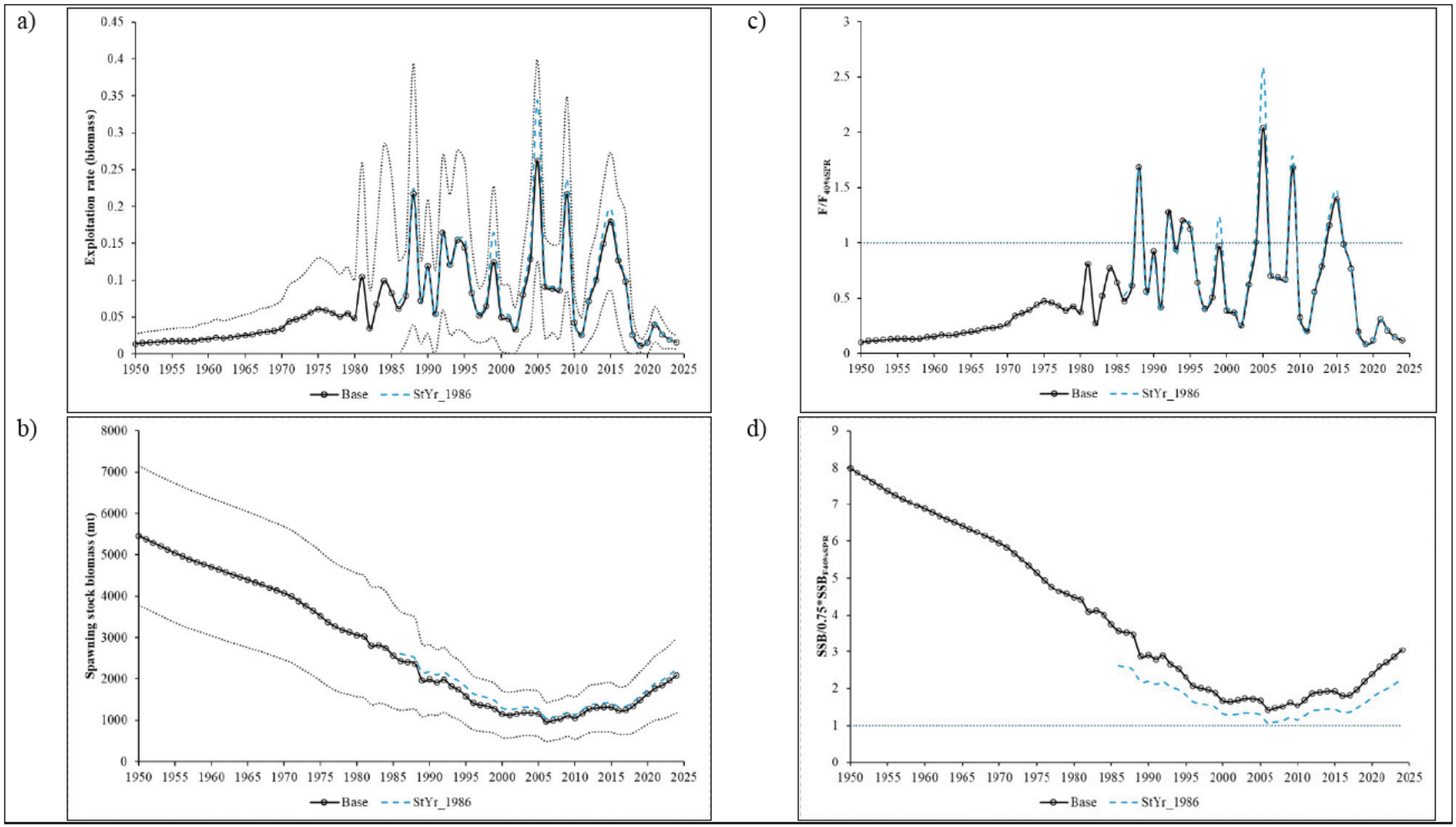


Figure 3.55. The a) exploitation rate, b) spawning stock biomass, c) $F/F_{40\%SPR}$ ratio, and d) $SSB/0.75*SSB_{F40\%SPR}$ ratio from the KEYS base model compared to a sensitivity run with 1986 as the start year and *steepness* = 0.99 for Florida Keys/East Florida Hogfish.

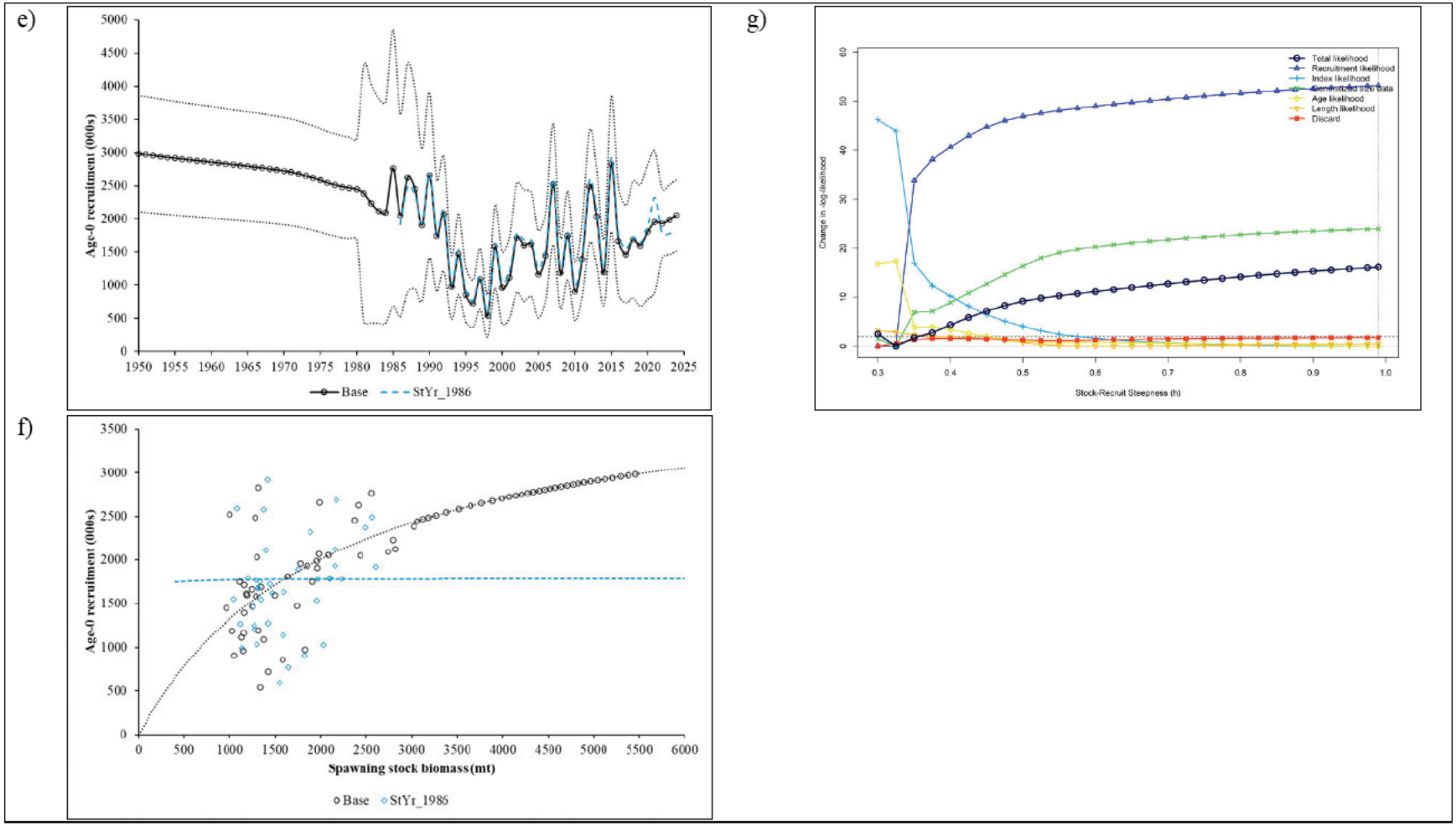


Figure 3.55 *cont*. The e) age-0 recruitment and f) stock-recruitment relationship from the KEYS base model compared to a sensitivity run with 1986 as the start year and *steepness* = 0.99 for Florida Keys/East Florida Hogfish. Panel (g) shows the *steepness* parameter profile of the sensitivity model with 1986 as the start year and *steepness* = 0.99.

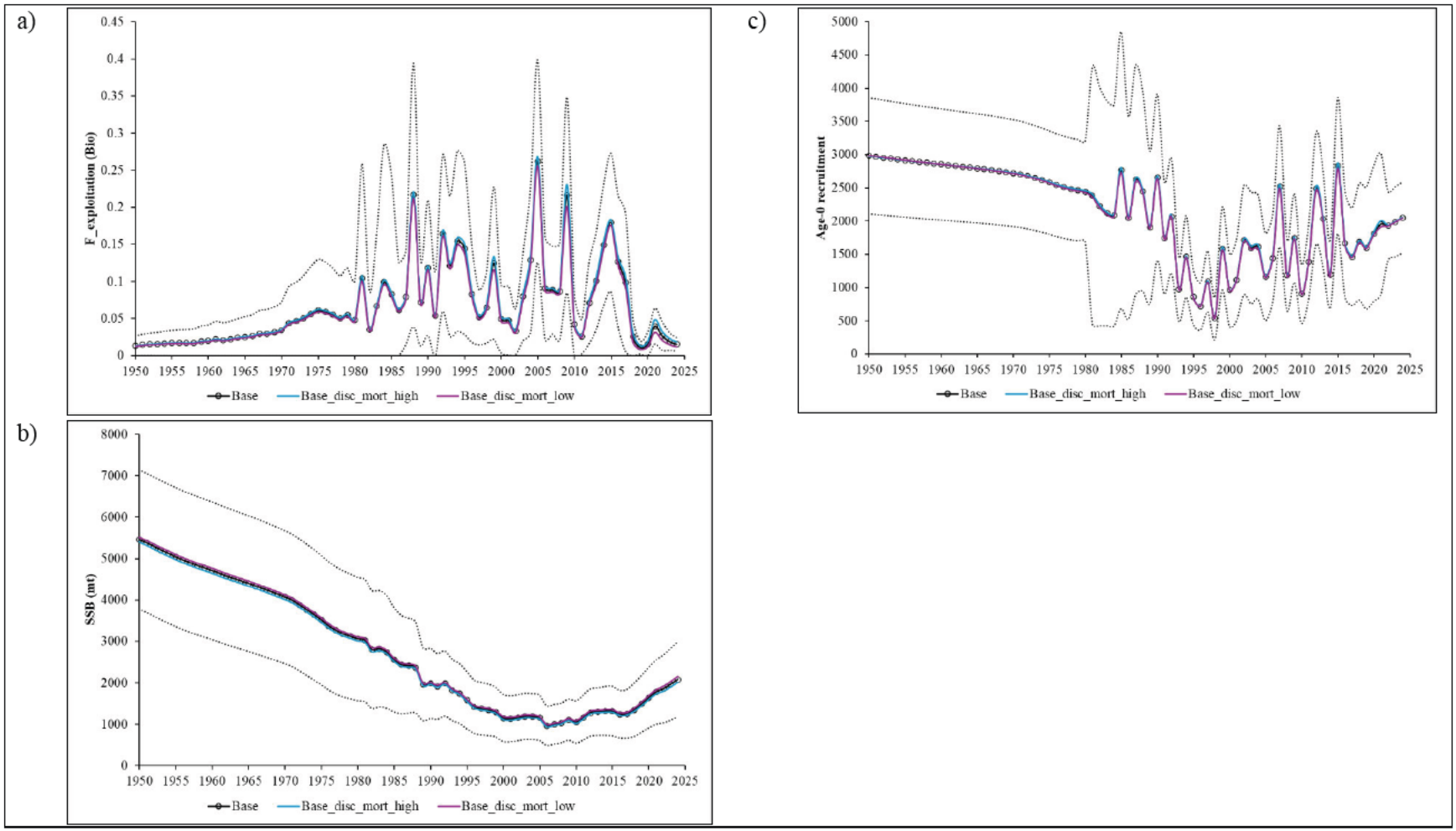


Figure 3.56. The a) exploitation rate, b) spawning stock biomass, and c) age-0 recruitment from the KEYS base model compared to sensitivity runs exploring high (59%) and low (23.8%) discard mortality rates for Florida Keys/East Florida Hogfish.

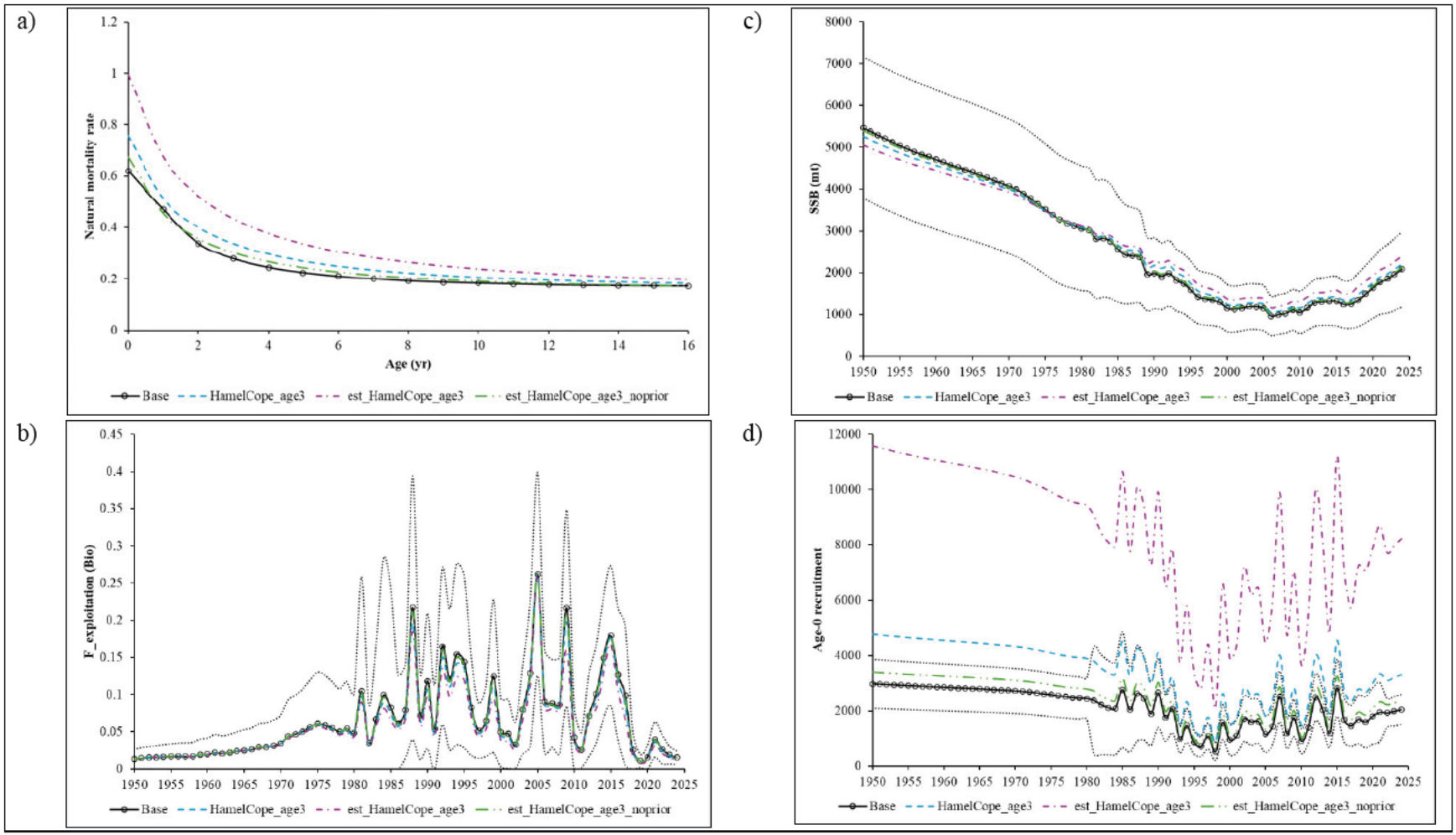


Figure 3.57. The a) natural mortality rate, b) exploitation rate, c) spawning stock biomass, and d) age-0 recruitment from the KEYS base model compared to sensitivity runs exploring assumptions on natural mortality for Florida Keys/East Florida Hogfish. 'HamelCope_age3' uses the Hamel and Cope (2022) longevity-based estimate (M=0.338 yr^{-1}) for age-3 fish, 'est_HamelCope_age3' estimates M using the standard deviation (0.31) prior in log-space, and 'est_HamelCope_age3_noprior' removes the standard deviation prior to freely estimate.

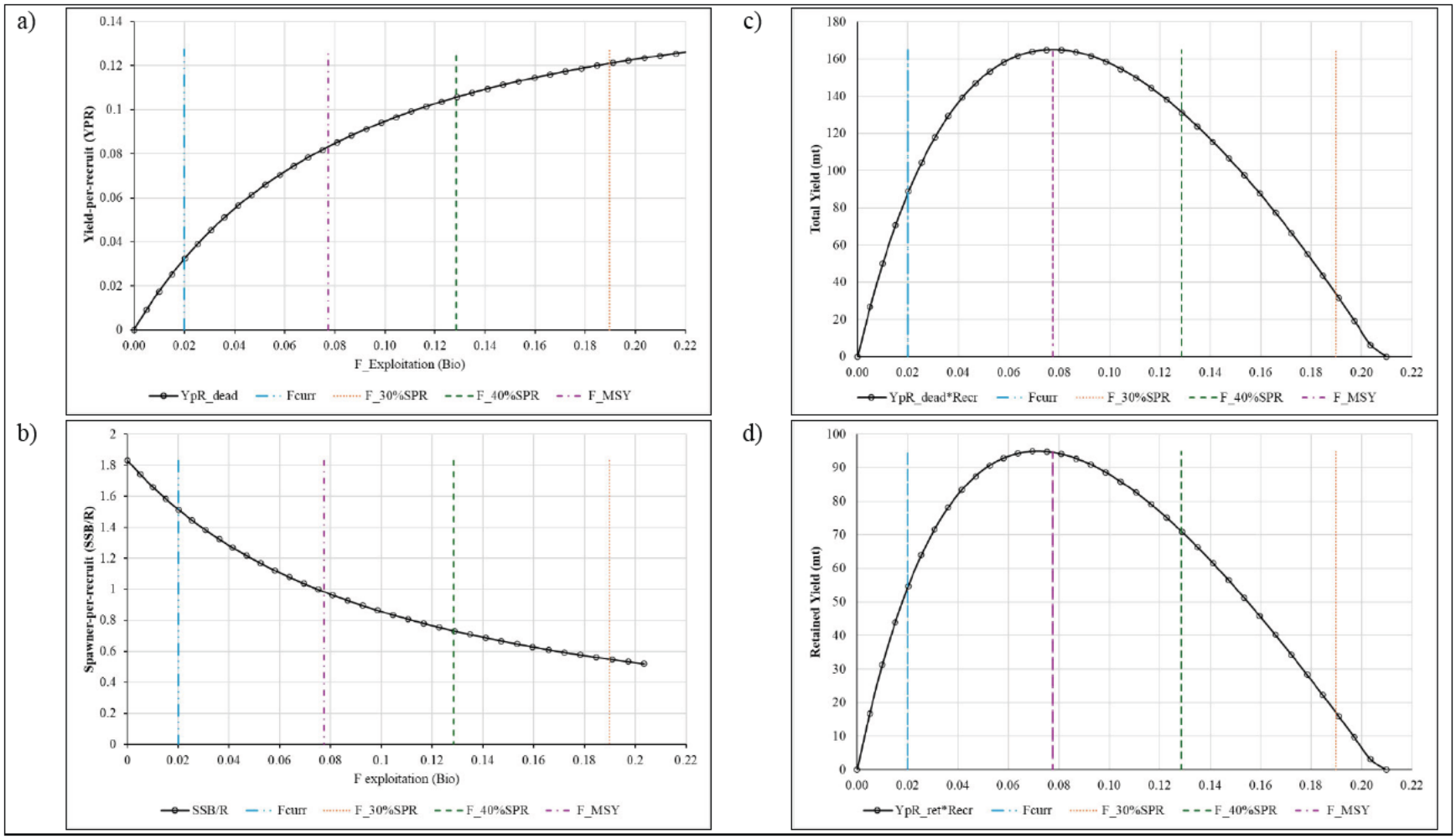


Figure 3.58. The a) yield-per-recruit, b) spawner-per-recruit, c) total equilibrium yield, and d) retained equilibrium yield computed as a function of the instantaneous exploitation rate on Florida Keys/East Florida Hogfish.

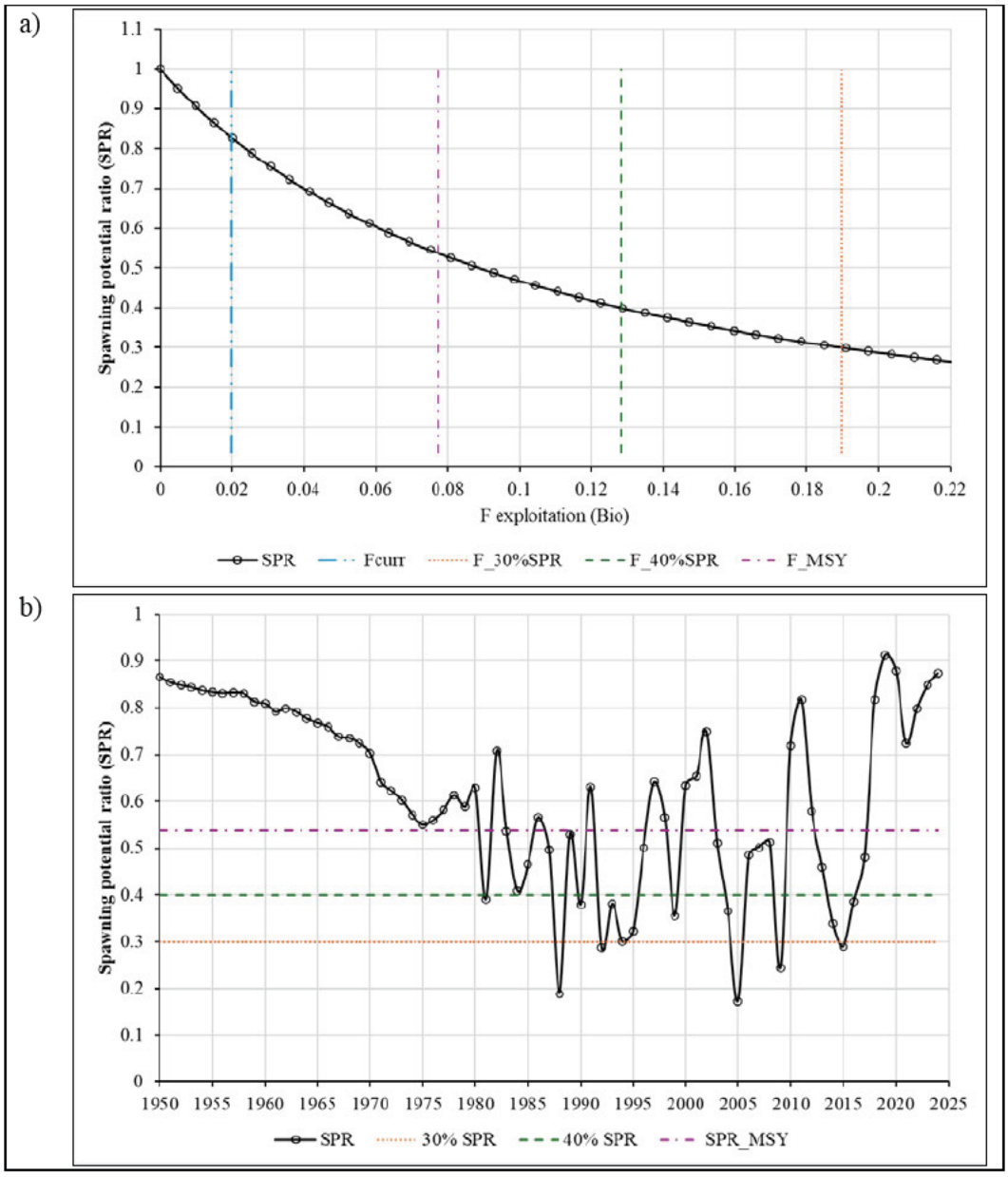


Figure 3.59. The a) static spawning potential ratio (SPR) computed as a function of the instantaneous exploitation rate, and b) static spawning potential ratio (SPR) by year for Florida Keys/East Florida Hogfish.

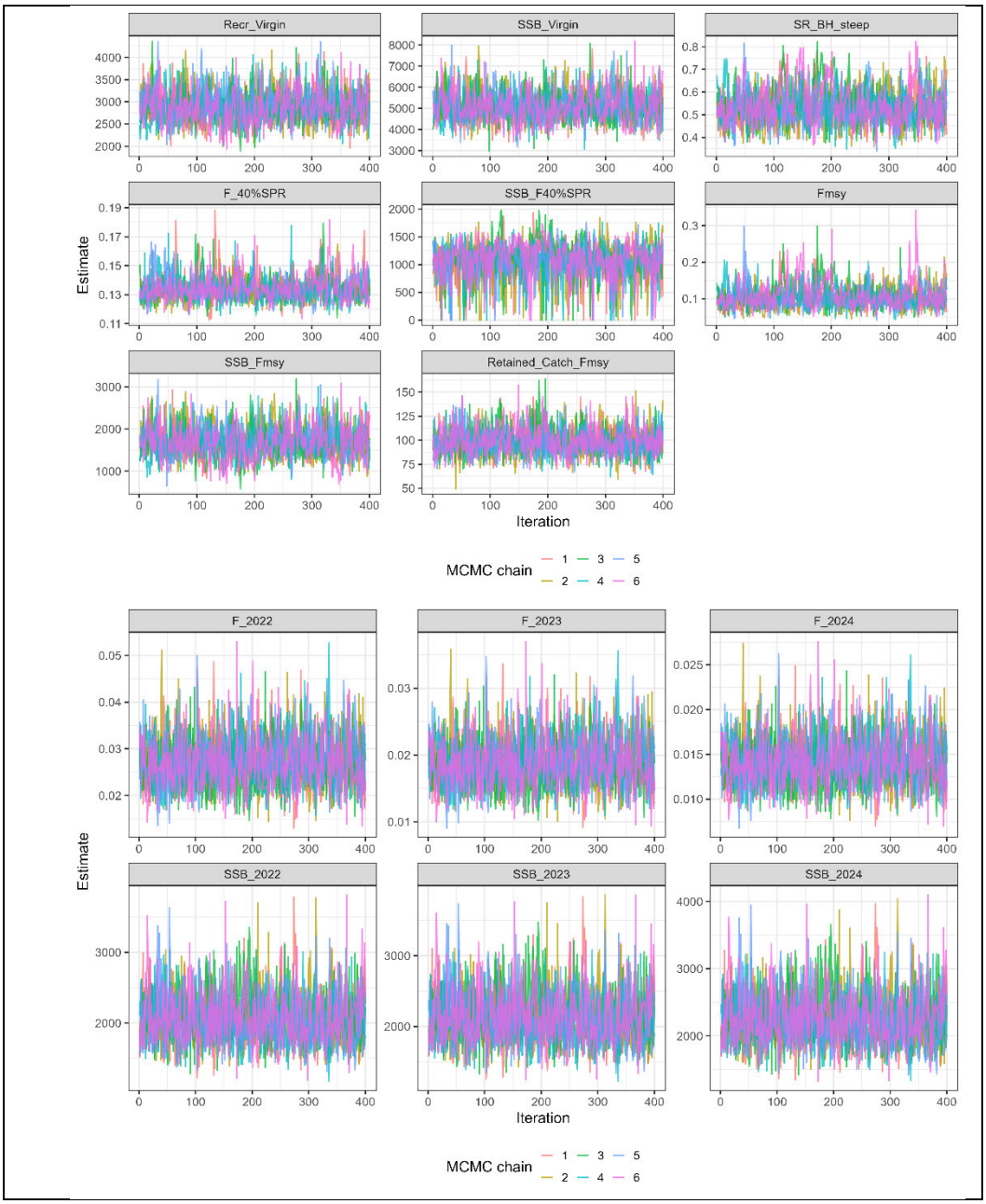


Figure 3.60. Combined trace plots of the six MCMC chains for selected parameters and derived quantities from the MCMC 'proxy' model based on the SEDAR 94 KEYS base model.

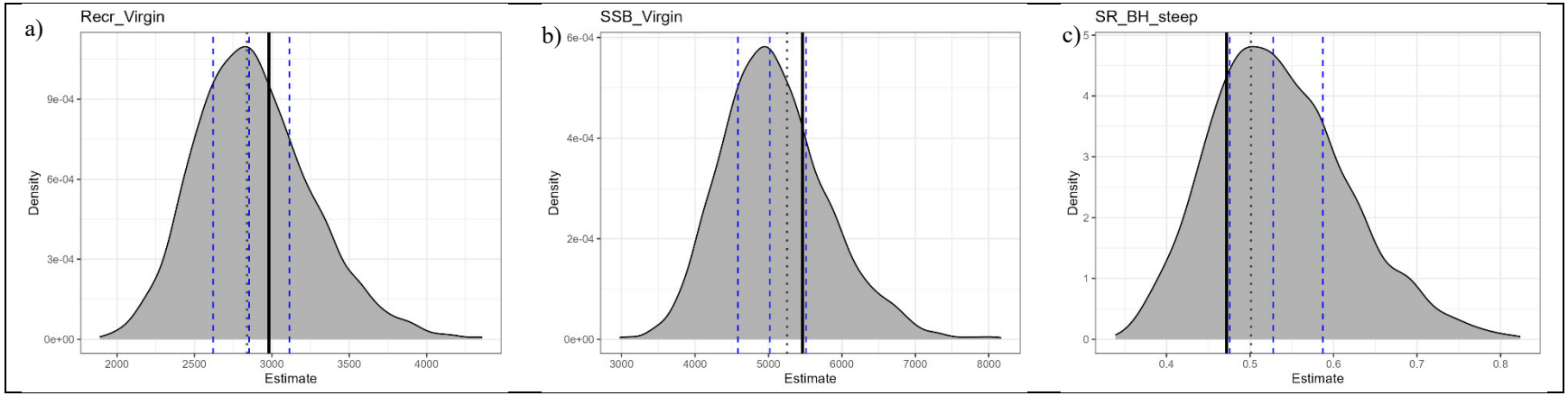


Figure 3.61. The posterior distributions for a) R_0 (i.e., virgin recruitment), b) SSB_0 (i.e., virgin spawning stock biomass), and c) steepness from the combined six-chain MCMC of the MCMC 'proxy' model based on the SEDAR 94 KEYS base model. The blue dashed lines indicate the median and interquartile range, the black dotted line is the estimate from the MCMC 'proxy' model, and the solid black line is the estimate from the SEDAR 94 KEYS base model.

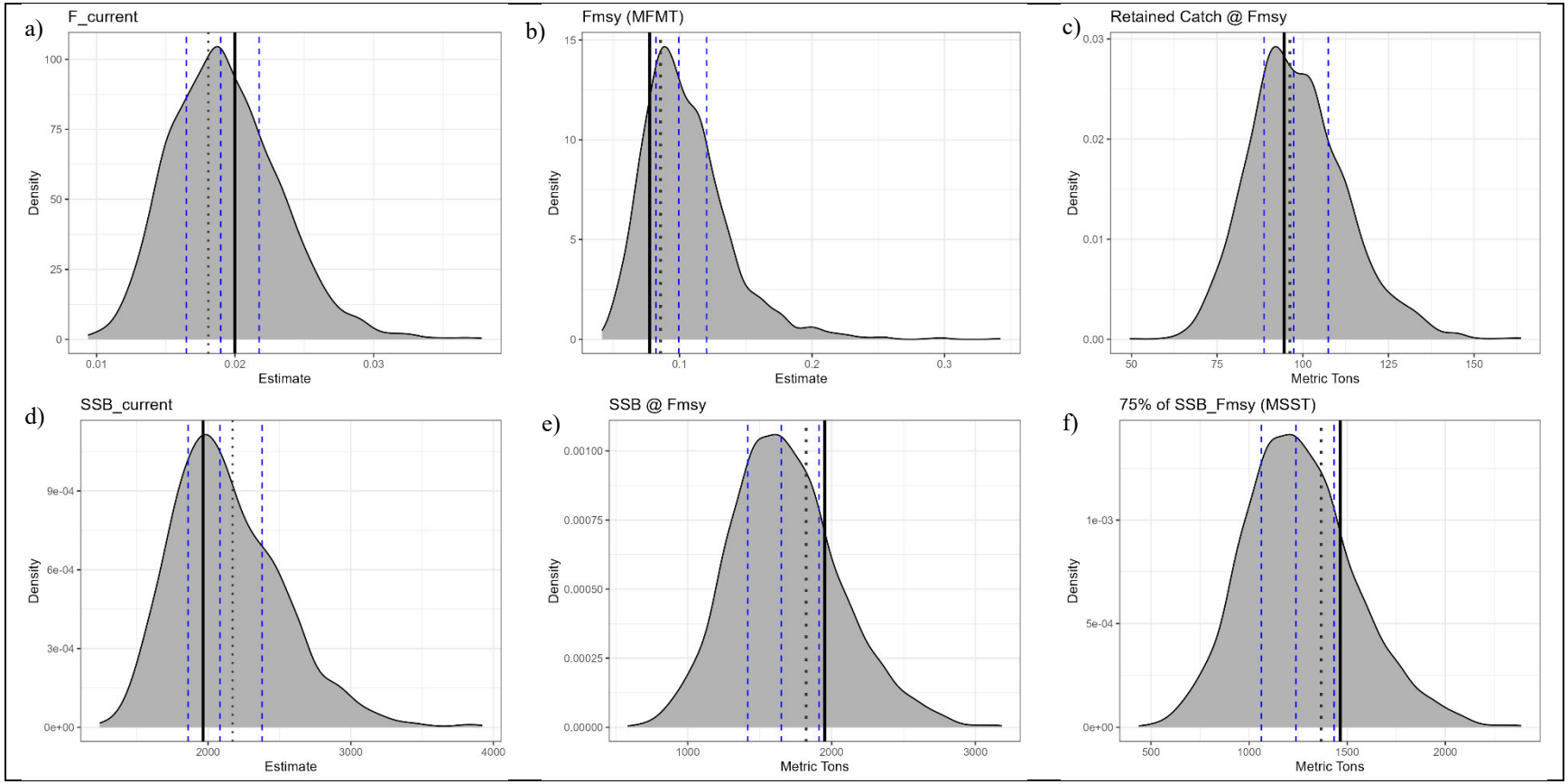


Figure 3.62. The posterior distributions for a) $F_{current}$ (i.e., geometric mean of F for years 2022 – 2024), b) F_{MSY} (i.e., MFMT), and c) the retained yield associated with F_{MSY}, d) $SSB_{current}$ (i.e., geometric mean of SSB for years 2022 – 2024), e) SSB at F_{MSY}, and f) 75% of SSB at F_{MSY} (i.e., MSST) from the combined six-chain MCMC of the MCMC 'proxy' model based on the SEDAR 94 KEYS base model. The blue dashed lines indicate the median and interquartile range, the black dotted line is the estimate from the MCMC 'proxy' model, and the solid black line is the estimate from the SEDAR 94 KEYS base model.

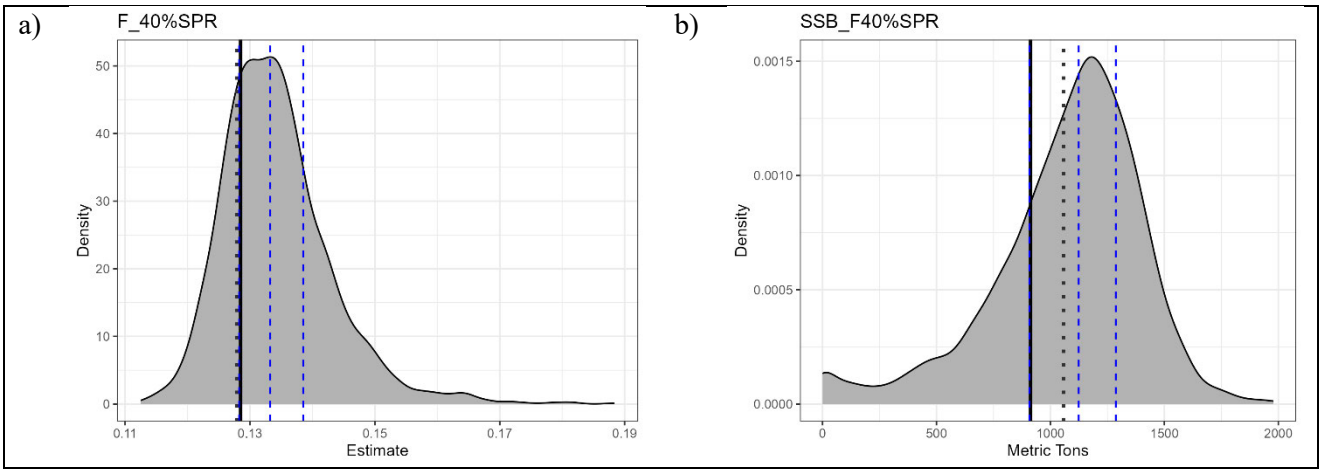


Figure 3.63. The posterior distribution for a) $F_{40\%SPR}$ and b) SSB at $F_{40\%SPR}$ values from the combined six-chain MCMC of the MCMC 'proxy' model based on the SEDAR 94 KEYS base model. The blue dashed lines indicate the median and interquartile range, the black dotted line is the estimate from the MCMC 'proxy' model, and the solid black line is the estimate from the SEDAR 94 KEYS base model.

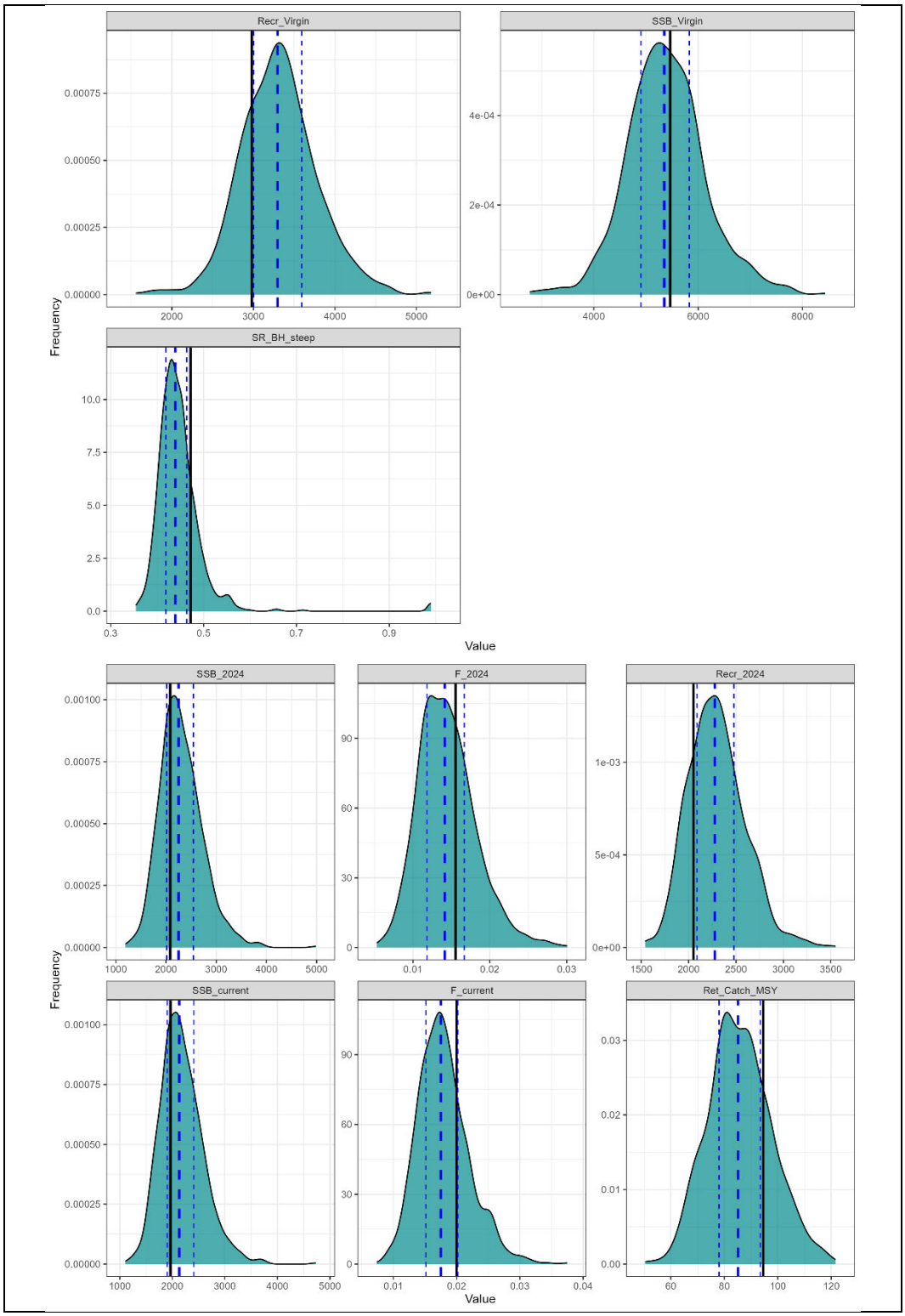


Figure 3.64. Distributions of selected parameter estimates and derived quantities from parametric bootstrapping the SEDAR 94 KEYS base model.

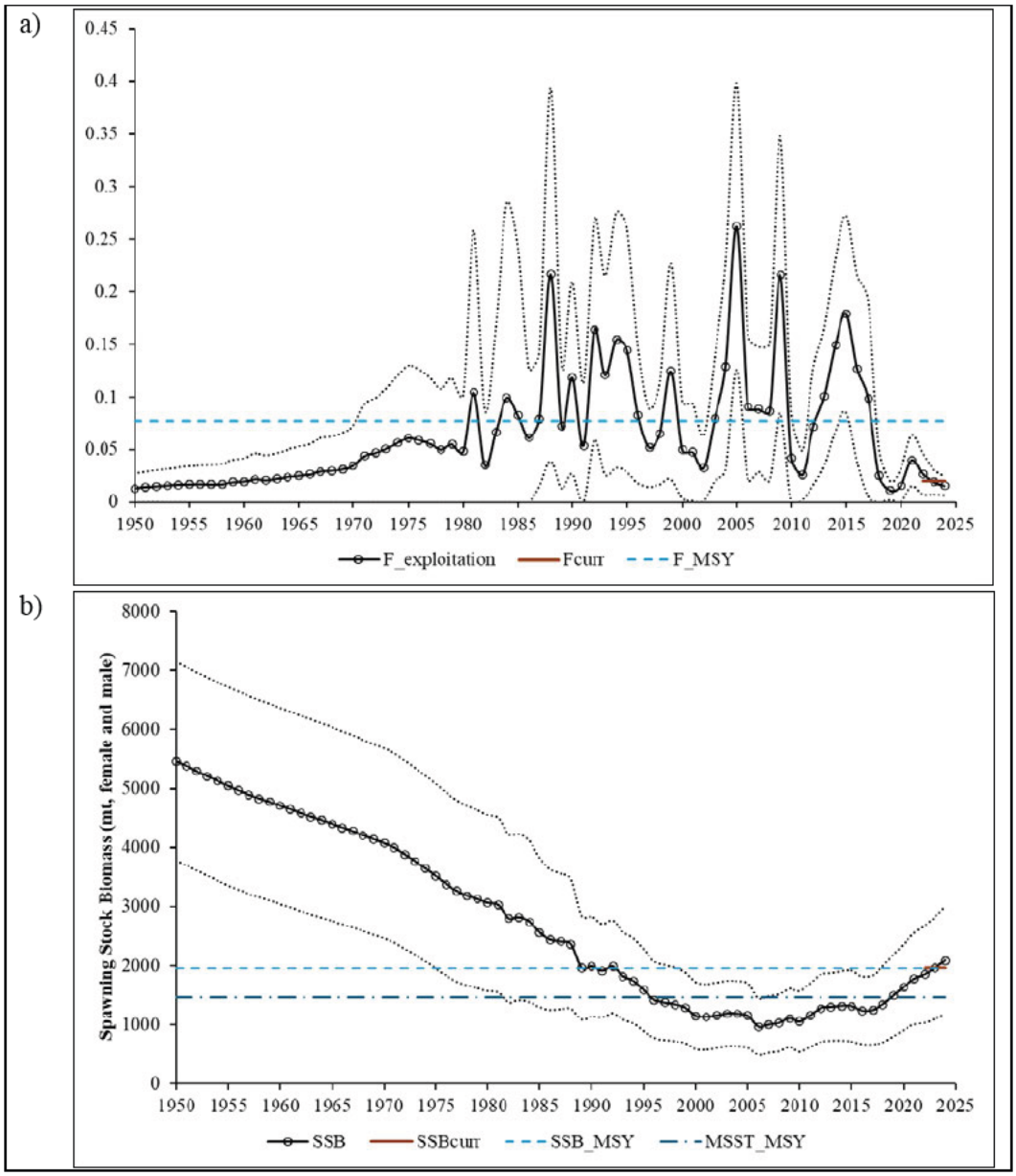


Figure 3.65. Annual estimates of a) exploitation relative to F_{MSY} and the geometric mean of exploitation in the last three years ($F_{current}$), and b) spawning stock biomass (SSB) relative to MSST (75% SSB_{MSY}), SSB_{MSY}, and the geometric mean of SSB in the last three years ($SSB_{current}$) by the SEDAR 94 KEYS base model. Dotted lines represent 95% confidence intervals.

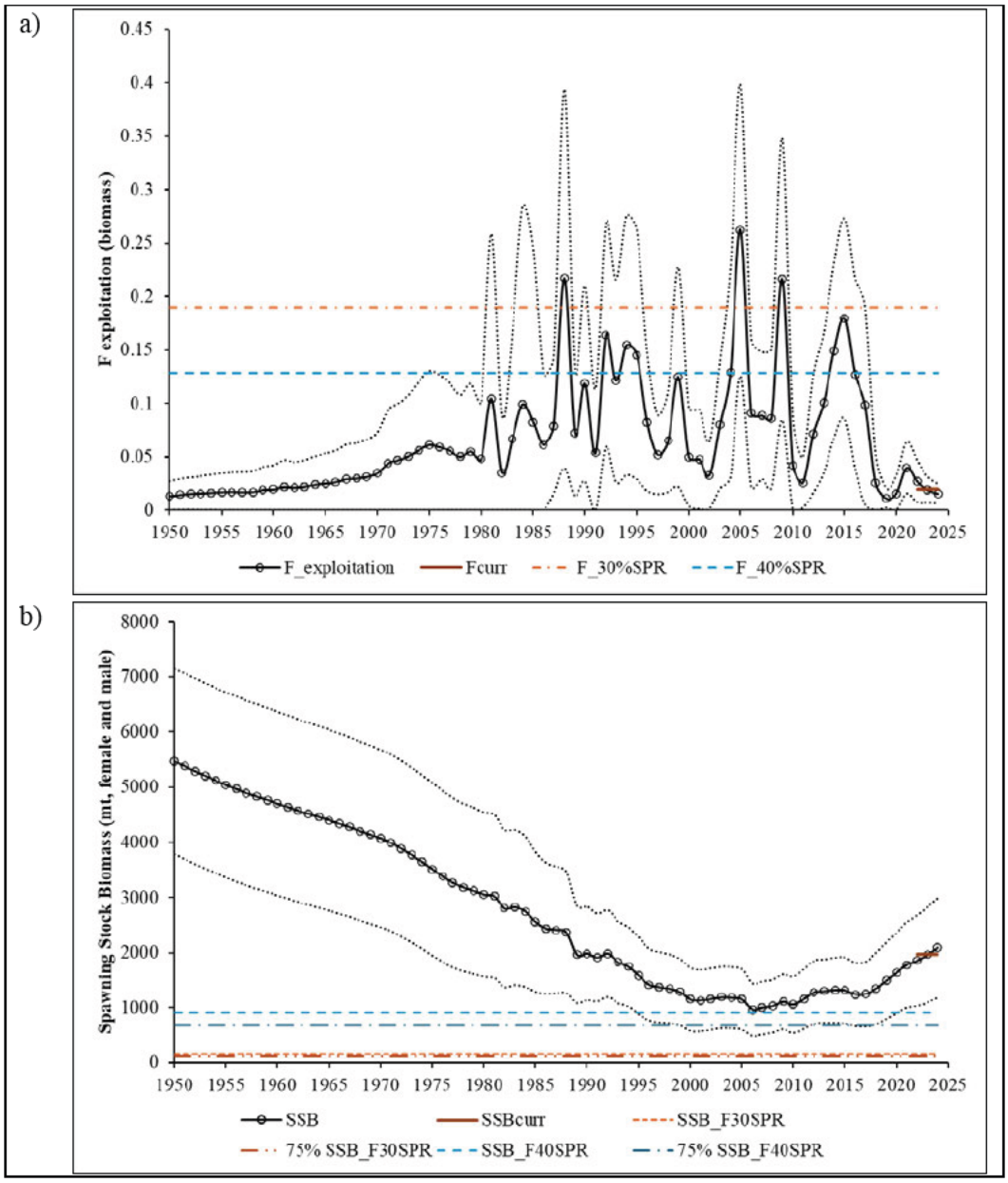


Figure 3.66. Annual estimates of a) exploitation relative to $F_{30\%SPR}$, $F_{40\%SPR}$, and the geometric mean of exploitation in the last three years ($F_{current}$), and b) spawning stock biomass (SSB) relative to 75% $SSB_{F40\%SPR}$, $SSB_{F40\%SPR}$, and the geometric mean of SSB in the last three years ($SSB_{current}$) by the SEDAR 94 KEYS base model. Dotted lines represent 95% confidence intervals.

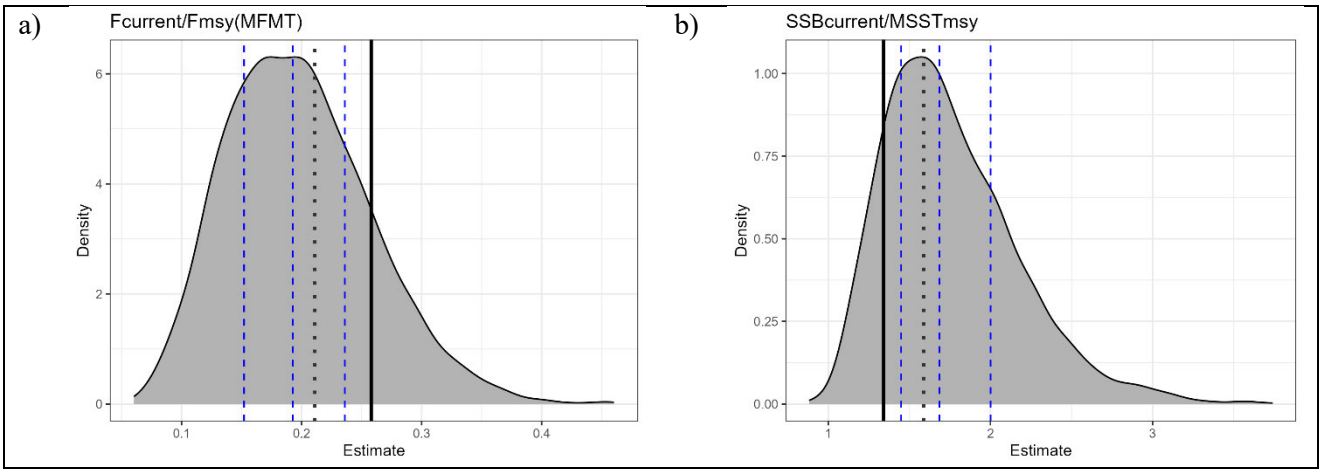


Figure 3.67. The posterior distribution for the F ratio ($F_{current}/F_{MSY}$) and SSB ratio ($SSB_{current}/MSST_{MSY}$) values from the combined six-chain MCMC of the MCMC 'proxy' model based on the SEDAR 94 KEYS base model. The blue dashed lines indicate the median and interquartile range, the black dotted line is the estimate from the MCMC 'proxy' model, and the solid black line is the estimate from the SEDAR 94 KEYS base model.

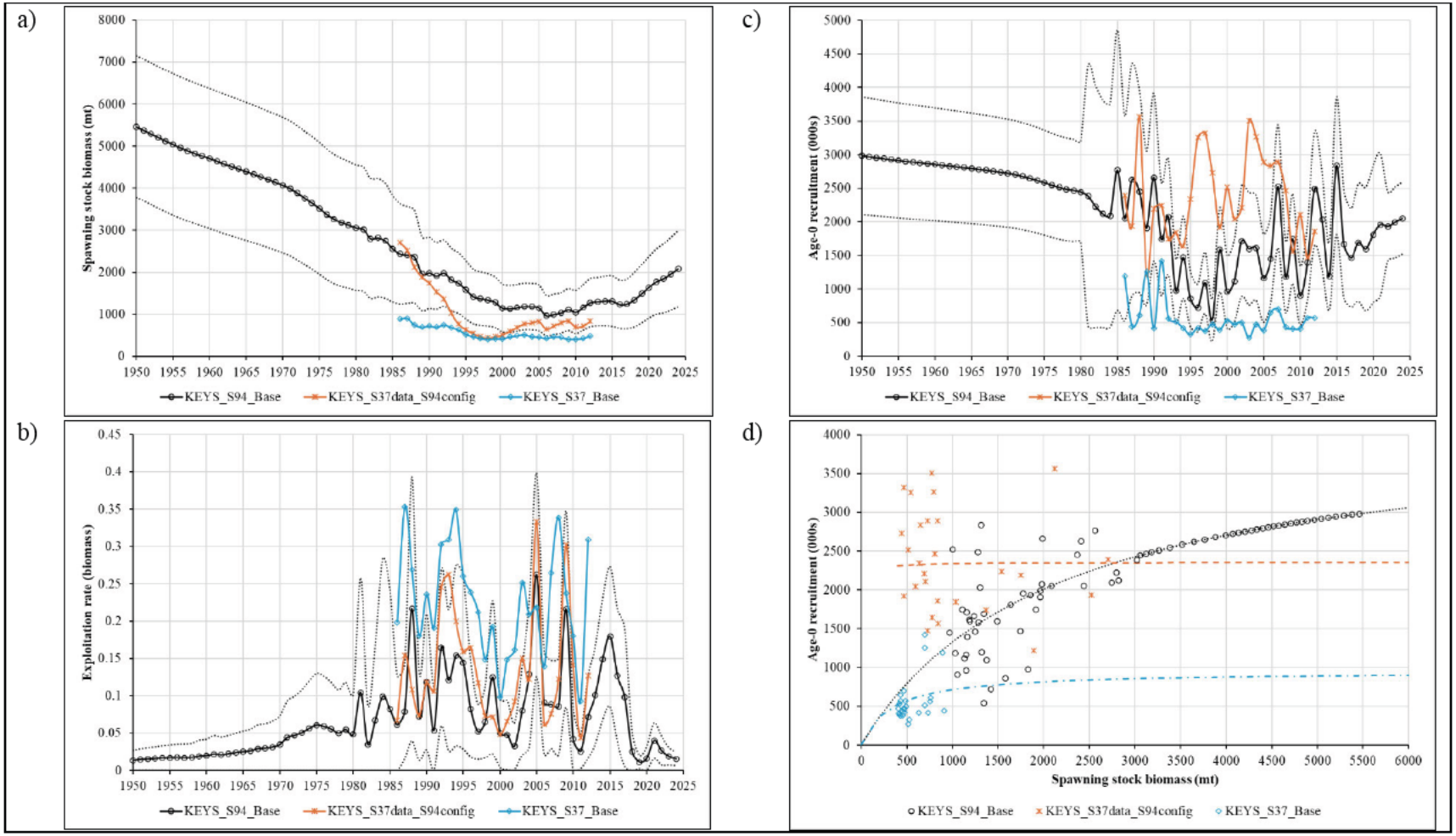


Figure 3.68. A comparison of the results between the SEDAR 94 KEYS base model (KEYS_S94_Base), the bridge building model (KEYS_S37data_S94config), and the SEDAR 37 base model (KEYS_S37_Base) for a) spawning stock biomass, b) exploitation rates, c) age-0 recruitment, and d) the estimated stock-recruitment relationship.

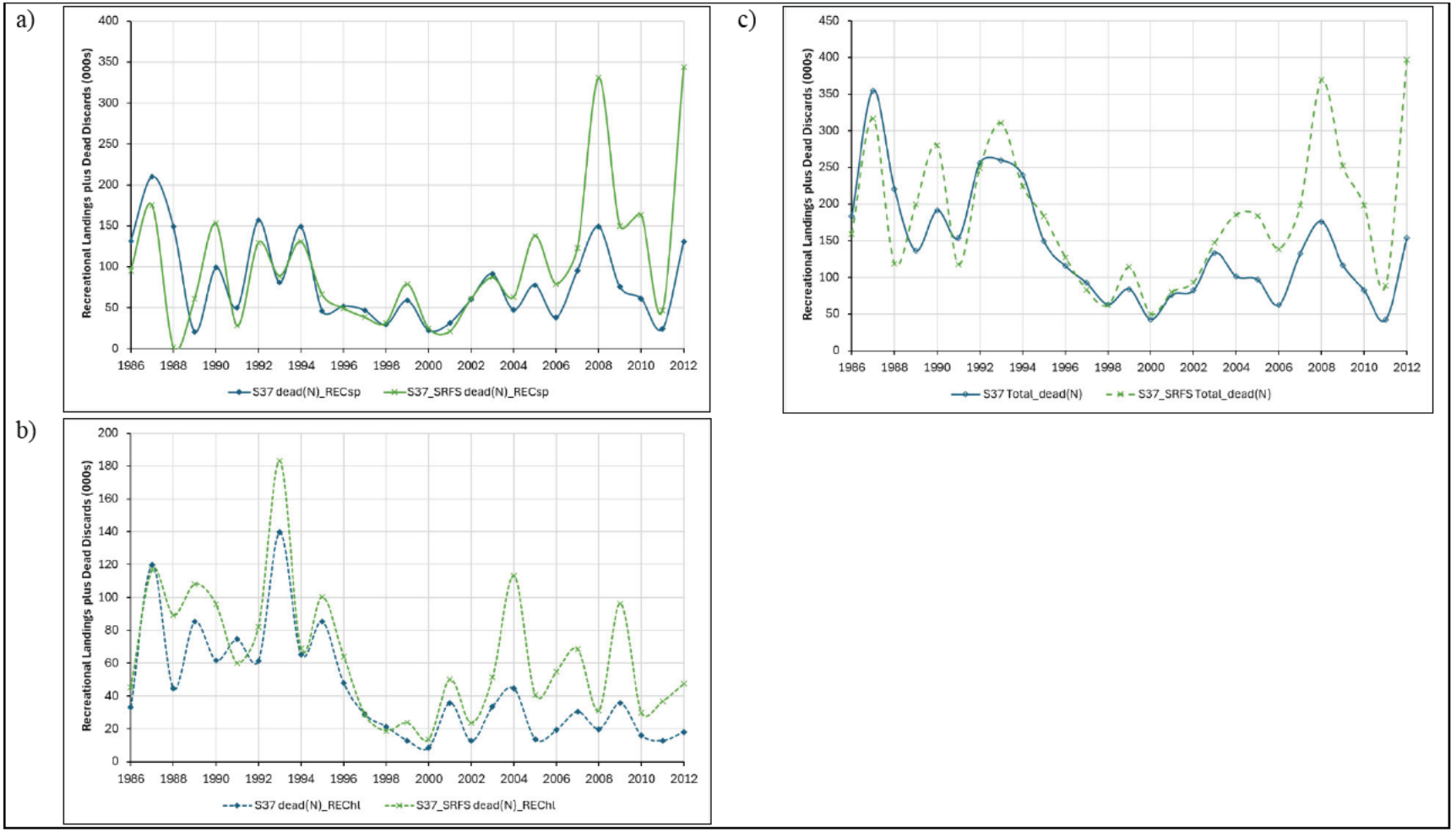


Figure 3.69. A comparison of the input recreational landings plus dead discards in numbers (dead[N]) between the SEDAR 37 base model (S37) and the SEDAR 37 base model containing the 'Full SRFS' (S37_SRFS) catch timeseries a) for the spear gear, b) for the hook-and-line gears, and c) when gears were combined as configured for the S94 KEYS base model.

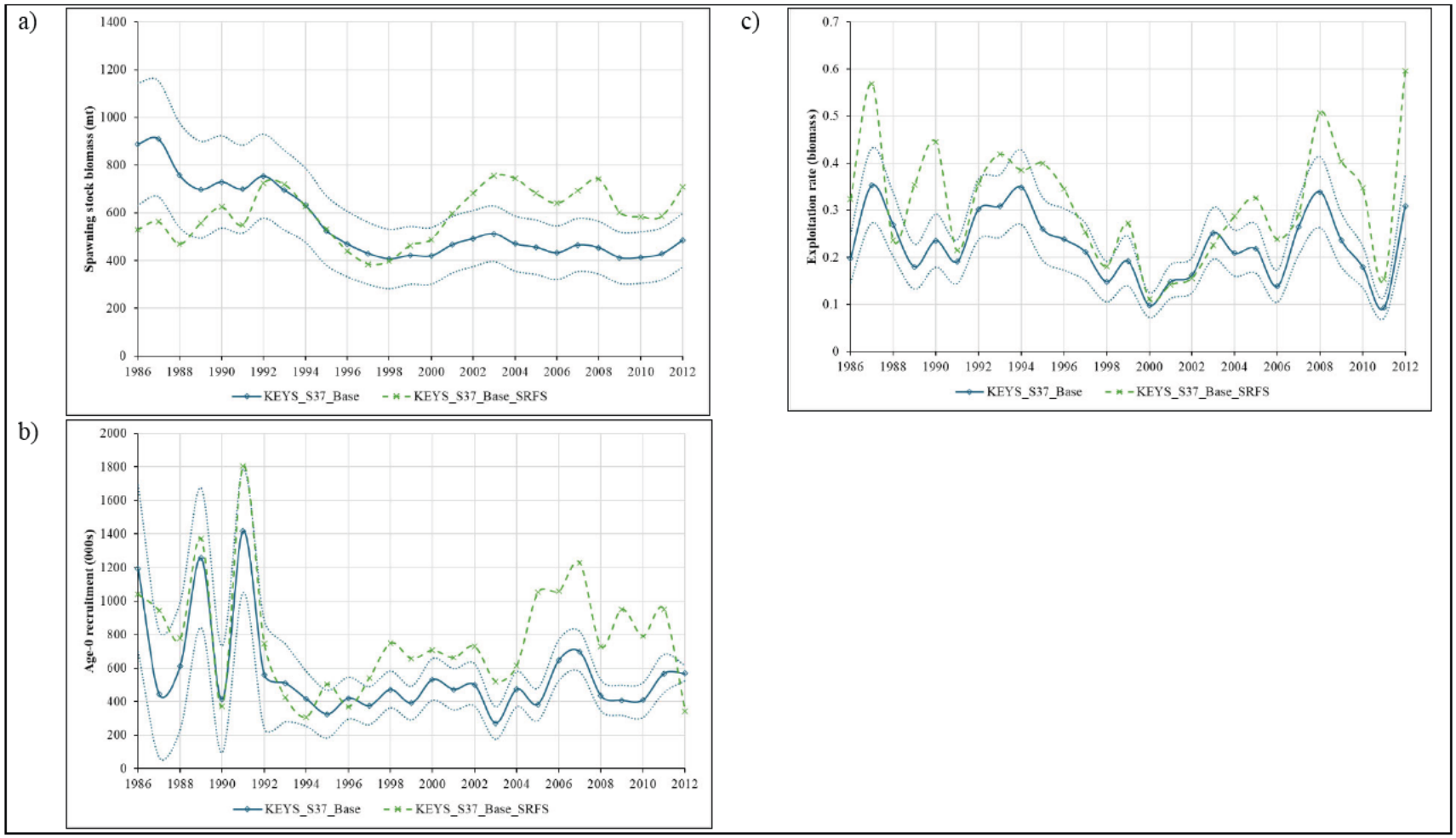


Figure 3.70. A comparison of the results between the SEDAR 37 base model (S37) and the SEDAR 37 base model containing the 'Full SRFS' catch timeseries (S37_SRFS) for a) spawning stock biomass, b) age-0 recruitment, and c) exploitation rates.

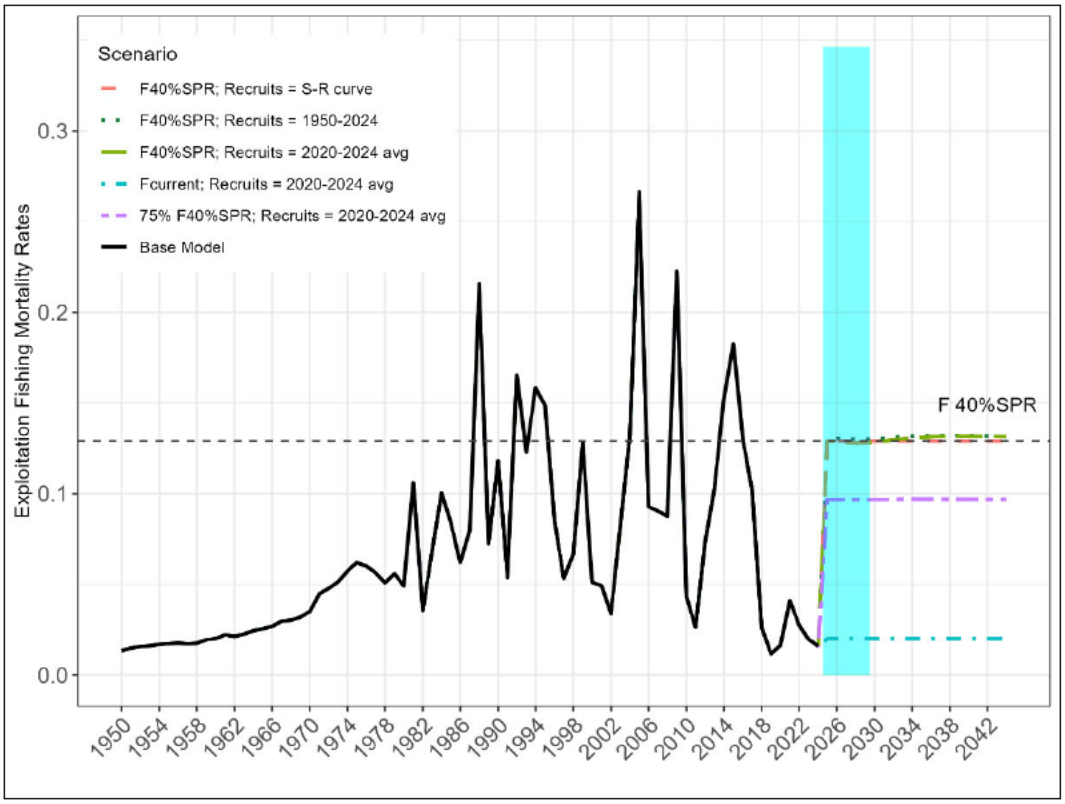


Figure 3.71. Exploitation rates based on projections under long-term equilibrium $F_{40\%SPR}$ using the stock-recruitment curve (red dashed line), long-term equilibrium $F_{40\%SPR}$ using average recruitment from the whole timeseries (dark green dotted line), short-term $F_{40\%SPR}$ (mustard dashed line), $F_{current}$ (teal dot-dashed line), 75% of short-term $F_{40\%SPR}$ (purple short-dash-long-dashed line), and as estimated by the SEDAR 94 KEYS base model (black solid line). The cyan region highlights the first five years of the projection (2025 – 2030).

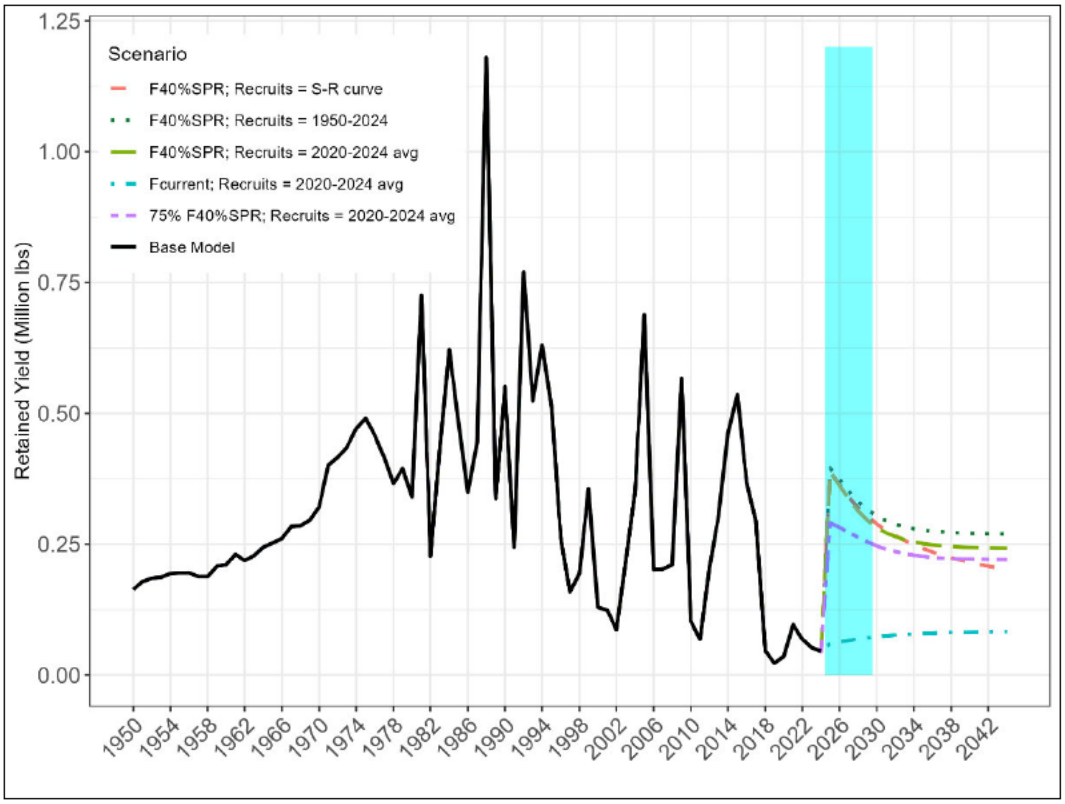


Figure 3.72. Retained yield (million pounds) based on projections under long-term equilibrium $F_{40\%SPR}$ using the stock-recruitment curve (red dashed line), long-term equilibrium $F_{40\%SPR}$ using average recruitment from the whole timeseries (dark green dotted line), short-term $F_{40\%SPR}$ (mustard dashed line), $F_{current}$ (teal dot-dashed line), 75% of short-term $F_{40\%SPR}$ (purple short-dash-long-dashed line), and as estimated by the SEDAR 94 KEYS base model (black solid line). The cyan region highlights the first five years of the projection (2025 – 2030).

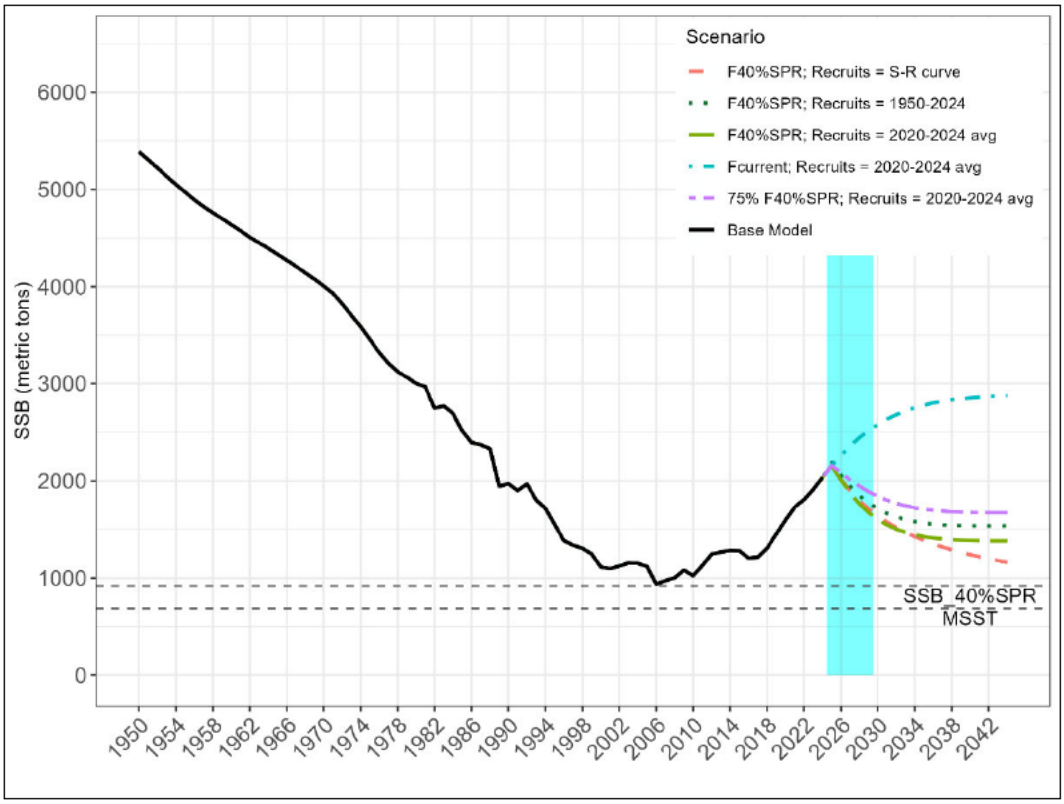


Figure 3.73. Spawning stock biomass (metric tons) based on projections under long-term equilibrium $F_{40\%SPR}$ using the stock-recruitment curve (red dashed line), long-term equilibrium $F_{40\%SPR}$ using average recruitment from the whole timeseries (dark green dotted line), short-term $F_{40\%SPR}$ (mustard dashed line), $F_{current}$ (teal dot-dashed line), 75% of short-term $F_{40\%SPR}$ (purple short-dash-long-dashed line), and as estimated by the SEDAR 94 KEYS base model (black solid line). The cyan region highlights the first five years of the projection (2025 – 2030).

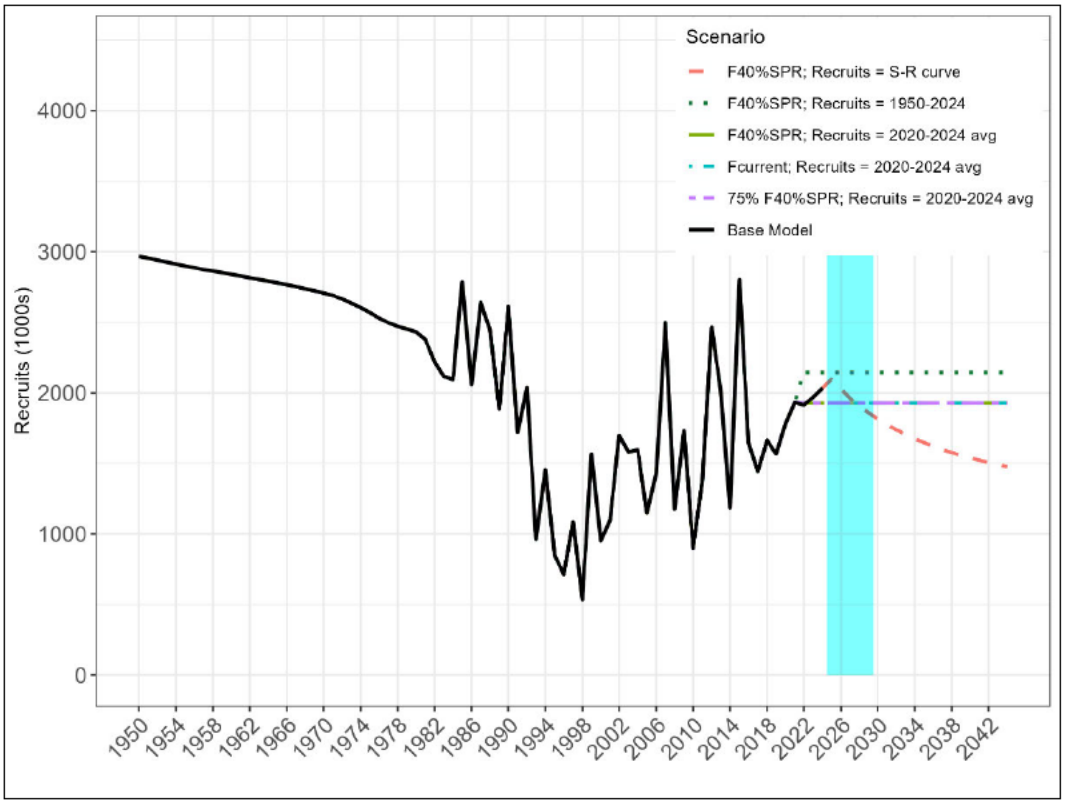


Figure 3.74. Age-0 recruits (in thousands) based on projections under long-term equilibrium $F_{40\%SPR}$ using the stock-recruitment curve (red dashed line), long-term equilibrium $F_{40\%SPR}$ using average recruitment from the whole timeseries (dark green dotted line), short-term $F_{40\%SPR}$ (mustard dashed line), $F_{current}$ (teal dot-dashed line), 75% of short-term $F_{40\%SPR}$ (purple short-dash-long-dashed line), and as estimated by the SEDAR 94 KEYS base model (black solid line). The cyan region highlights the first five years of the projection (2025 – 2030).

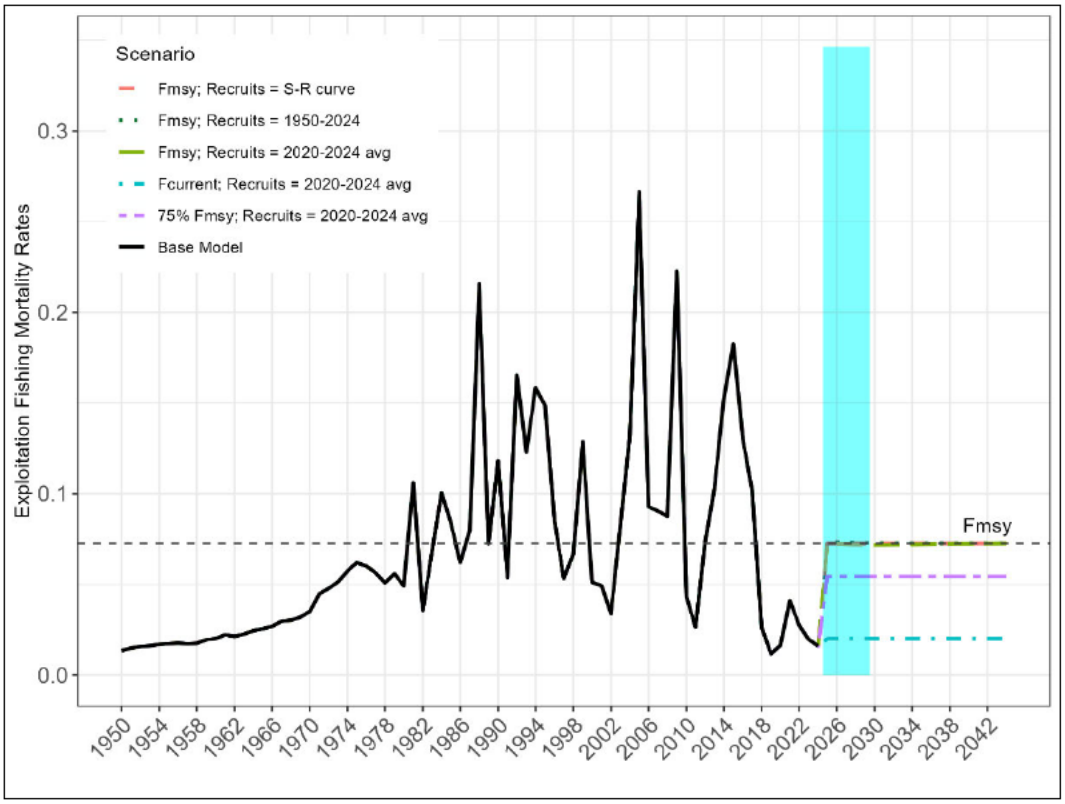


Figure 3.75. Exploitation rates based on projections under long-term equilibrium F_{MSY} using the stock-recruitment curve (red dashed line), long-term equilibrium F_{MSY} using average recruitment from the whole timeseries (dark green dotted line), short-term F_{MSY} (mustard dashed line), $F_{current}$ (teal dot-dashed line), 75% of short-term F_{MSY} (purple short-dash-long-dashed line), and as estimated by the SEDAR 94 KEYS base model (black solid line). The cyan region highlights the first five years of the projection (2025 – 2030).

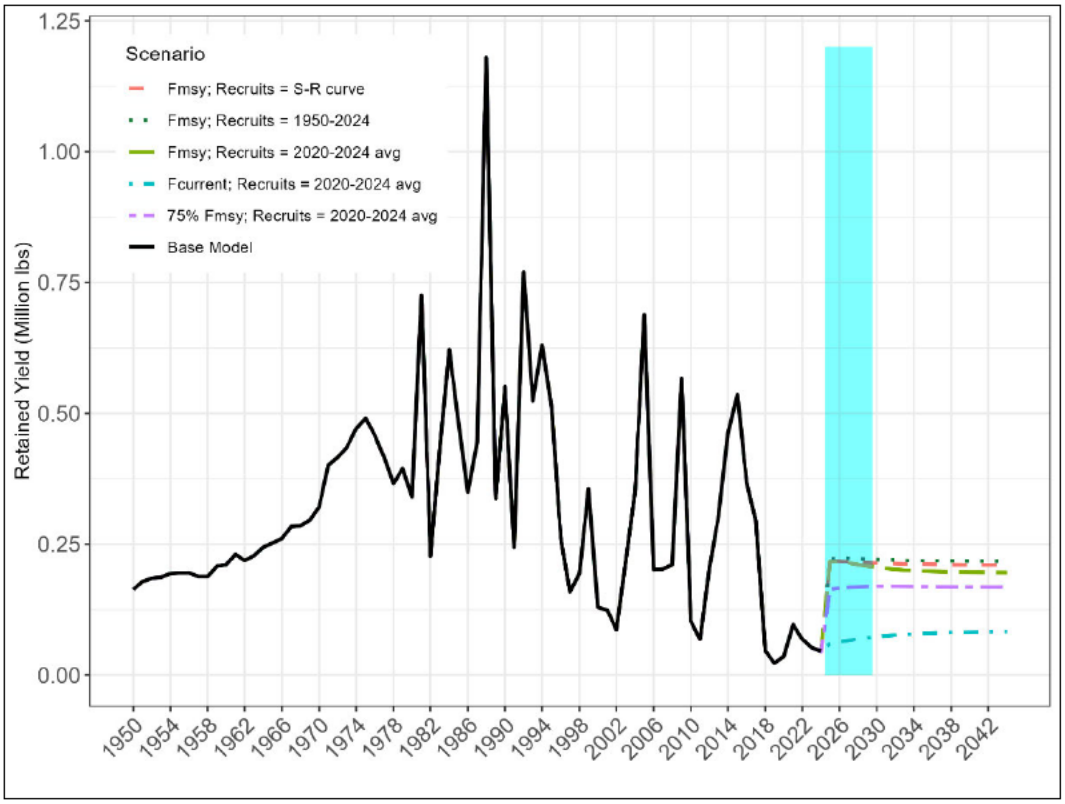


Figure 3.76. Retained yield (million pounds) based on projections under long-term equilibrium F_{MSY} using the stock-recruitment curve (red dashed line), long-term equilibrium F_{MSY} using average recruitment from the whole timeseries (dark green dotted line), short-term F_{MSY} (mustard dashed line), $F_{current}$ (teal dot-dashed line), 75% of short-term F_{MSY} (purple short-dash-long-dashed line), and as estimated by the SEDAR 94 KEYS base model (black solid line). The cyan region highlights the first five years of the projection (2025 – 2030).

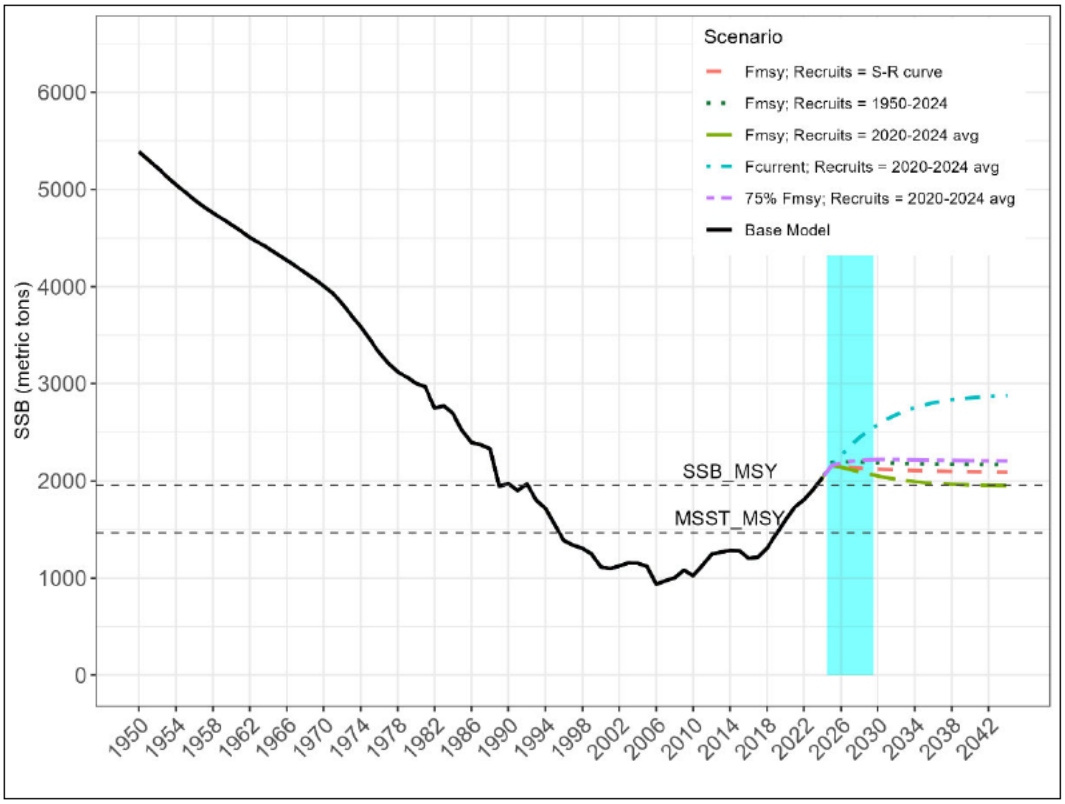


Figure 3.77. Spawning stock biomass (metric tons) based on projections under long-term equilibrium F_{MSY} using the stock-recruitment curve (red dashed line), long-term equilibrium F_{MSY} using average recruitment from the whole timeseries (dark green dotted line), short-term F_{MSY} (mustard dashed line), $F_{current}$ (teal dot-dashed line), 75% of short-term F_{MSY} (purple short-dash-long-dashed line), and as estimated by the SEDAR 94 KEYS base model (black solid line). The cyan region highlights the first five years of the projection (2025 – 2030).

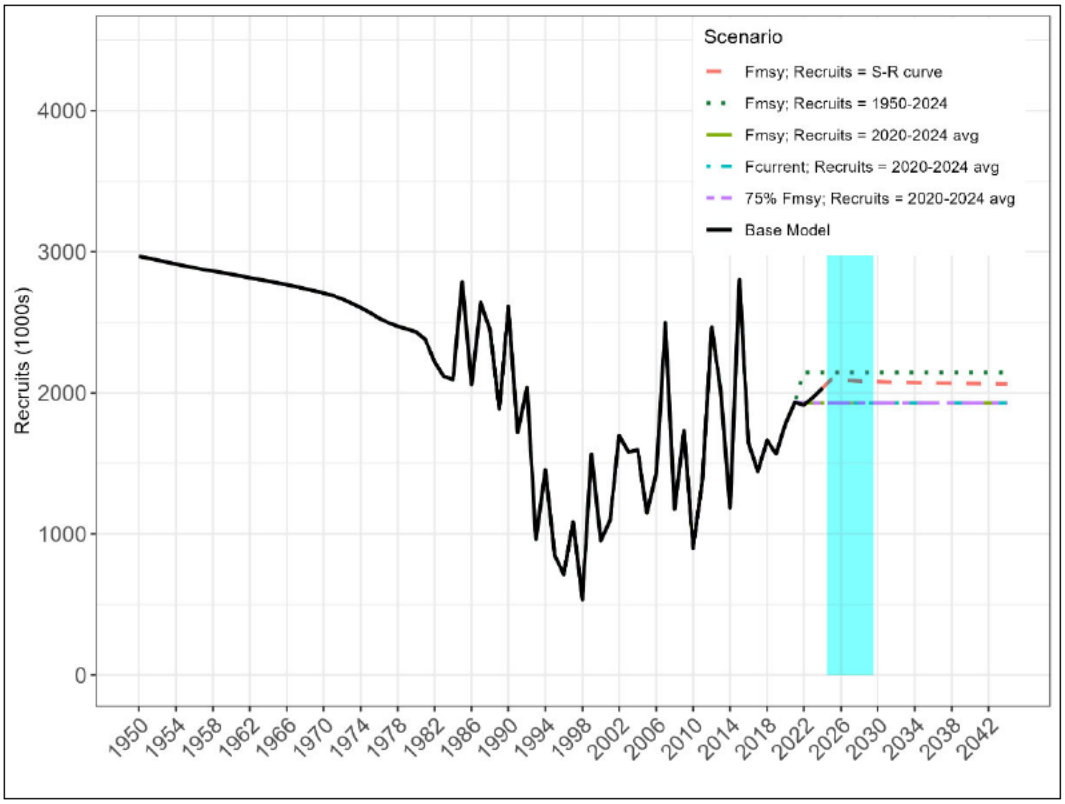


Figure 3.78. Age-0 recruits (in thousands) based on projections under long-term equilibrium F_{MSY} using the stock-recruitment curve (red dashed line), long-term equilibrium F_{MSY} using average recruitment from the whole timeseries (dark green dotted line), short-term F_{MSY} (mustard dashed line), $F_{current}$ (teal dot-dashed line), 75% of short-term F_{MSY} (purple short-dash-long-dashed line), and as estimated by the SEDAR 94 KEYS base model (black solid line). The cyan region highlights the first five years of the projection (2025 – 2030).

SEDAR

Southeast Data, Assessment, and Review

SEDAR 94

Florida Hogfish

SECTION IV: Research Recommendations

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

Table of Contents

1. DATA WORKSHOP RESEARCH RECOMMENDATIONS 2
1.1 LIFE HISTORY RESEARCH RECOMMENDATIONS 2
1.1.1 Stock Definition 2
1.1.2 Age and Growth 3
1.1.3 Natural Mortality 3
1.1.4 Reproduction 3
1.2 COMMERCIAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS 4
1.3 RECREATIONAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS 4
1.3.1 Research Recommendations 4
1.3.2 Other Recommendations 5
1.4 MEASURES OF POPULTAION ABUNDANCE RESEARCH RECOMMENDATIONS 5
2. ASSESSMENT PROCESS RESEARCH RECOMMENDATIONS 6
No consolidated research recommendations section was included in the assessment report. 6
3. REVIEW PANEL RESEARCH RECOMMENDATIONS 6

1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

1.1 LIFE HISTORY RESEARCH RECOMMENDATIONS

1.1.1 Stock Definition

The LHWG recommended expanding genetic sampling in the currently defined unit stocks for Hogfish to reinforce or challenge respective boundaries. In the FLK/EFL stock, sampling does not exist from central (e.g., Cape Canaveral area) and northeastern Florida; investigating this could provide insight into the assumed connection with southeastern Florida as well as any potential source and sink dynamics. Furthermore, no Hogfish have been sampled in GA or SC; any fish here are currently assumed to be defined with the stock sampled off NC, but uncertainty in that boundary exists and whether portions may be further spillover from south Florida. The group also recommends the use of updated genetic methods (e.g., RADseq derived genomic data, SNPS; see Wallace et al. *in prep*. for Spotted Seatrout in Florida) to better inform these biological and managerial boundaries. Lastly, there is no genetic data published from Hogfish in the Caribbean, but preliminary results from mitochondrial DNA samples in Puerto Rico and St. Thomas indicate some degree of genetic connectivity exists with those from the WFS and southeast FL (A. Janosik, *pers. comm*. 5/15/25).

1.1.2 Age and Growth

The LHWG expressed the need to increase the annual fishery-dependent and -independent age sampling of Hogfish. Current sample sizes make detecting and tracking year classes difficult or inadequate in most years without the reliance on data from life history studies. However, the LHWG recognizes the challenge of this as the fisheries tend to be more opportunistic for Hogfish. For the FLK/EFL stock, sampling also needs to expand to include more areas of refuge (e.g., marine no-take reserves; Muñoz et al. 2010) and areas currently unsampled (e.g., northeast FL) to better inform population demographics. Hogfish in both the heavily fished areas of the FLK/EFL and the nearshore areas of the WFS where fishing predominantly occurs exhibit truncated age-at-length data but can grow larger and live longer when able to escape to refuge.

1.1.3 Natural Mortality

The field of natural mortality is not yet in a position to establish 'best practices' (Maunder et al. 2023) and suggested 'good practices' are often trade-offs between reliability and availability of the data. More direct methods of estimating mortality, such as mark-recapture or acoustic telemetry tagging, are generally recommended over empirical methods but have largely been unavailable for Hogfish until recently. Ellis et al. (2025) conducted a pilot study to estimate discard mortality and successfully tagged 42 Hogfish (including 38 tagged with acoustic tags) from 45 trips on the WFS between May 2019 and February 2025, showing the viability for a larger scale study. Effort into acoustic telemetry tagging requires a large enough array of detectors to minimize incomplete detections, but the high site fidelity of Hogfish seem to make it a good candidate as movement out of the array area for extended periods (i.e., are the change in numbers due to mortality or migration) may be minimized. Ellis et al. (2025) also reported 3 re-captured individuals, but none were reported by recreational anglers; rather, they were determined via acoustic detection which alleviates human reporting issues common in conventional tagging.

1.1.4 Reproduction

The LHWG commends the amount of histological data that has been available for Hogfish from life history research studies but also notes that all reproductive data used here were at least 18 years old. If the original histology slides are still available, it is recommended to re-analyze them

following current best practices (Lowerre-Barbieri et al. 2022, Lowerre-Barbieri and Friess 2023) which would also allow comparison with any reproductive data collected in the future for determining size- and age-at-maturity and spawning seasonality. The LHWG also notes the impact of top-down size selective fishing mortality on harem-disruption, social breakdown, reproduction, and possible sperm limitation for Hogfish and recommends additional *in situ* sampling (e.g., diver surveys; Muñoz et al. 2010) to help evaluate recovery of these from the impacts of fishing.

1.2 COMMERCIAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

Landings

- Improve gear, area, and effort data reported for each trip on state Trip Ticket programs to ensure more accurate data for future assessments.

Discards

- Continue to research alternative methods and analyses for estimating total effort during the closed season of a fishery.

- Recommend the observer program investigate the allocation of some observer coverage for focused trips to aid in future SEDARs as a subset of existing strata.
    - For Hogfish, this may include allocating addition effort to increase the probability of Hogfish encounters in areas of higher population density (SE FL, FL Keys, West Florida)

Biosampling

- Hold more frequent TIP trainings and increase port agent buy-in through information exchange with assessment and SEDAR staff focused on the usage of data collected by TIP staff to continue to refine data quality.
- Increase the priority of Hogfish sampling throughout its' distribution (potentially allocating funds to purchase landed Hogfish to increase the number of aged fish)

1.3 RECREATIONAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

1.3.1 Research Recommendations

- Additional release mortality research specially investigating mortality of surface released fish and/or vented fish caught by hook and line in the recreational fishery. This should include research into the incidence of barotrauma, its causes, and its relationship to release mortality.

- Improve precision of MRIP and SRFS estimates for all modes through increased sampling
- Additional age data collection from all recreational sources by region (WFS, FLK/Keys), by gear (spear, hook and line), and by fishing area
- Increasing sampling to intercept and collect biological information from private recreational Hogfish anglers
- Explore methods to acquire catch information from private boat anglers returning to private docks in addition to public access points

1.3.2 Other Recommendations

Issue: Providing a potential model start year recommendation according to recreational data availability and uncertainty. The RWG discussed a potential recommendation to start the assessment model in 1986, as has been done in the previous Hogfish assessment (SEDAR 37) and other SEDAR stock assessments for reef fishes.

Recommendation: Catch estimates from the early years of the MRIP survey (e.g., 1981-1985) are highly variable and tend to result in higher CVs than those estimated in subsequent years. Additionally, some early years (1984-1985) in the WFS have zero estimated landings. The group has no particular concerns with retaining and using the recreational data in these early years as inputs into the assessment model but recognizes the above reasons could be used for justification of removal. The RWG concluded that both options are valid and supported and recommends this decision be made during the assessment process based on other aspects of data availability and modeling needs.

1.4 MEASURES OF POPULTAION ABUNDANCE RESEARCH RECOMMENDATIONS

- **Evaluate the Integration of Supplemental SRFS Intercept Data:** The IWG recommends investigating the feasibility and utility of incorporating supplemental SRFS intercept data into MRIP indices of abundance to improve precision.
- **Expand Length Data Collection through REEF/SMILE:** Continue collecting additional length-frequency data via the SMILE project for consideration in future stock assessments.

- **Collect Genetic Data to Assess Stock Mixing:** Obtain genetic samples from broad-scale fishery-independent surveys (e.g., SEAMAP trawl) that encompass both the West Florida Shelf (WFS) and the Keys-East Florida (Keys-EFL) stocks to evaluate mixing rates between the two.
- **Assess Environmental Stressors:** Investigate the impacts of seagrass habitat decline in the Indian River Lagoon and the effects of red tide events on Hogfish population dynamics and distribution.
- **Develop a Juvenile Abundance Survey in the Keys-EFL Region:** Design and implement a fishery-independent survey targeting juvenile Hogfish to generate indices of abundance for the Keys-EFL stock, addressing a current data gap in early life history stages.
- **Examine Migration Patterns:** Study the seasonal and spatial timing of inshore and offshore migrations to better understand life history patterns and inform management strategies.

2. ASSESSMENT PROCESS RESEARCH RECOMMENDATIONS

No consolidated research recommendations section was included in the assessment report.

3. REVIEW PANEL RESEARCH RECOMMENDATIONS

The Review Panel supports the research recommendations developed during the Data and Assessment Workshops and identified several additional priorities that could improve future hogfish assessments.

1. Improve understanding and modeling of protogynous hermaphroditic population dynamics.
    - This represents a high research priority. Future work should investigate the recruitment and reproductive dynamics of protogynous, harem-forming species and evaluate how social structure affects sex transition. The current assessment represents sex transition primarily as an age-dependent process, whereas hogfish sex change may also depend strongly on the local abundance or density of males. Research should evaluate whether the probability of female-to-male transition changes with male density and how fishing-induced changes in population sex ratio affect reproductive output. Simulation studies and explicitly sex-structured population models could be particularly useful for evaluating these processes and the implications of size-selective harvest regulations for protogynous species.

- Related work should investigate the potential for sperm limitation or male limitation and the prevalence of skip spawning. These processes could influence the relationship between conventional measures of spawning biomass and realized reproductive output and may help explain why a conventional stock-recruit relationship is difficult to estimate for this species.

2. Improve recreational spearfishing information.

   - Uncertainty in recreational spear landings remains one of the more important data limitations for the WFS assessment. Existing intercept designs may inadequately sample portions of the spearfishing fleet, particularly fishers operating from private access points. Targeted survey designs should be considered to evaluate the magnitude and potential bias of recreational spear removals and to determine whether existing CPUE observations adequately represent the broader spearfishing population. Improvements in this area would increase confidence in historical fishing pressure, current stock status, and sustainable harvest reference points.

3. Evaluate fishery-independent survey coverage and data gaps.

   - Available fishery-independent indices, including those excluded during the DW, should be systematically evaluated with respect to geographic coverage of hogfish habitat, sample size, and availability of age and length information. This could identify important spatial or temporal gaps and help prioritize future monitoring.

4. Evaluate alternative assessment and uncertainty methods.

   - Future methodological work should compare uncertainty estimates derived from MCMC, parametric bootstrap, and asymptotic normal approximations. Comparisons on both normal and log scales could help determine circumstances in which conventional asymptotic approximations provide sufficiently reliable inference and when more computationally intensive MCMC or bootstrap procedures are warranted.

   - Alternative MCMC algorithms, including Hamiltonian Monte Carlo and related approaches, should be investigated where feasible to determine whether they improve convergence and posterior exploration relative to the current Metropolis-Hastings implementation.

   - Additional consideration should also be given to assessment frameworks capable of incorporating random effects or state-space processes, including time-varying fishing mortality where appropriate.

5. Evaluate Stock Synthesis implementation choices that are not well understood.

   - Additional research should examine the statistical properties and consequences of using super-periods to address sparse composition data. Sensitivity analyses should also evaluate the specification of growth platoons, given the limited experience of many assessment practitioners and reviewers with this feature.

   - The implications of removing the recruitment-deviation sum-to-zero constraint for MCMC proxy models should also be examined further. The current workaround

was considered acceptable for the WFS assessment, but a better understanding of the statistical consequences would benefit future applications.

6. Investigate sex-specific growth.
    - Although residual diagnostics supported the assumption of equal growth rates for males and females in the current assessment, additional biological and modeling work should evaluate whether sex-specific growth differences are important enough to affect future assessment results.
7. Evaluate environmental effects on hogfish population dynamics.
    - Future research should consider the effects of environmental disturbances and stressors, including red tides and other harmful algal blooms, cold events, and oil spills. Potential environmental effects on natural mortality, recruitment, movement, and habitat use could be important sources of temporal variability not explicitly represented in the current assessment.
8. Develop stochastic projections that propagate assessment uncertainty.
    - The MCMC framework provides an opportunity to propagate parameter uncertainty into future projections. Stochastic projections could quantify probabilities of SSB falling below biomass thresholds or fishing mortality exceeding applicable reference points under alternative management scenarios. Incorporating such approaches more routinely into the SEDAR process could improve communication of management risk and make fuller use of the uncertainty analyses already conducted as part of the assessment.

- **Provide recommendations on possible ways to improve the SEDAR process**

  The Review Panel commented that some TORs may need to be revisited or clarified. For example, the text on BSIA may need updating, and the evaluation of the projection results may be a task for the SSC, rather than a Review Panel. Also, the Review Panel noted that the bridging analysis (see TORs for the assessment phase) was not very informative given the length between assessments and resulting changes in the data and the model. It was therefore not evaluated by the Review Panel.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 94

Florida Hogfish:

West Florida Shelf and East Florida/Florida Keys

SECTION V: Review Workshop Report

July 2026

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

1. INTRODUCTION 2
1.1 WORKSHOP TIME AND PLACE 2
1.2 TERMS OF REFERENCE 2
1.3 LIST OF PARTICIPANTS 3
1.4 LIST OF REVIEW WORKSHOP REFERENCE DOCUMENTS 5
2. REVIEW PANEL REPORT 5

1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 94 Florida Hogfish Review Workshop was held in Charleston, SC July 14-17, 2026.

1.2 TERMS OF REFERENCE

1. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:
   a) Are data decisions made by the DW and AW panels sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are input data series reliable and applied properly within the assessment model?
2. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and considering the following:
   a) Are methods scientifically sound and robust?
   b) Are assessment models configured properly and consistent with standard practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings and consider the following:
   a) Are population estimates (model output – e.g. abundance, exploitation, biomass) reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   b) Is the stock overfished? What information helps you reach this conclusion?
   c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
   d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

4. Evaluate the stock projections, including discussing strengths and weaknesses, and consider the following:
   a) Are the methods consistent with accepted practices and available data?
   b) Are the methods appropriate for the assessment model and outputs?
   c) Are the results informative and robust, and useful to support inferences of probable future conditions?
   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
   - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
   - Ensure that the implications of uncertainty in technical conclusions are clearly stated
6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.
   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments
   - Provide recommendations on possible ways to improve the SEDAR process
7. Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation, and peer review of fishery management information.
8. Provide suggestions on key improvements in data or modeling approaches that should be considered when scheduling the next assessment.
9. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Peer Review Summary Report in accordance with the project guidelines.

1.3 LIST OF PARTICIPANTS

Review Panel

Luiz Barbieri (Chair)	SAFMC/GFMC SSC
Lisa Chong	CIE Reviewer
Noel Cadigan	CIE Reviewer
A. Challen Hyman	GFMC SSC

Joe Powers	CIE Reviewer
Marcel Reichert	SAFMC SSC
Alexei Sharov	SAFMC SSC
Steve Saul (via webinar)	GFMC SSC

Analytic Team

Chris Swanson	USF/FWC-FWRI
Dustin Addis	FWC-FWRI
Heather Christiansen	FWC-FWRI

Staff

Julie A Neer	SEDAR
Chip Collier	SAFMC Staff
Leonardo Eguia	GFMCC Staff
Emily Ott	SEDAR
Ryan Rindone	GFMC Staff
Rachael Silvas	SAFMC Staff

Council Representative

CJ Sweetman	Gulf & South Atlantic Council

Workshop Observers

Chris Bradshaw	FWC-FWRI

Workshop Observers via Webinar

Shanae Allen	USF/FWC-FWRI
Manuel Coffill-Rivera	
Alena Figueroa	FWC-FWRI
Sarah Gardiner	GFMC Staff
Bob Hillard	Recreational Fisherman
Jennifer Loch	REEF
Danielle Morley	FWC-FWRI
Robert Muller	FWC-FWRI
Roldan Muñoz	NOAA
Hallie O'Farrell	FWC-FWRI
Tia Offner	FWC-FWRI
Jack Olsen	FWC-FWRI
Chloe Ramsay	FWC-FWRI
Ted Switzer	FWC-FWRI

1.4 LIST OF REVIEW WORKSHOP REFERENCE DOCUMENTS

Reference Documents		
SEDAR94-RD03	Modeling protogynous hermaphrodite fishes workshop	Gary Shepherd, Kyle Shertzer, Jessica Coakley, Megan Caldwell
SEDAR94-RD04	Stock assessment of protogynous fish: evaluating measures of spawning biomass used to estimate biological reference points	Elizabeth N. Brooks, Kyle W. Shertzer, Todd Gedamke, and Douglas S. Vaughan

2. REVIEW PANEL REPORT

Introduction

An independent peer review of the SEDAR 94 Hogfish (*Lachnolaimus maximus*) Stock Assessment was conducted during an in-person Review Workshop on July March 14-17, 2026, in Charleston, SC. The Review Panel consisted of Luiz Barbieri (Chair), Noel Cadigan (CIE), Joe Powers (CIE), Lisa Chong (CIE), Steven Saul (Gulf SSC), A. Challen Hyman (Gulf SSC), Alexei Sharov (SA SSC), and Marcel Reichert (SA SSC). The Review Panel was able to conduct a thorough review of two hogfish assessments: An East Florida/Florida Keys stock and a West Florida Shelf stock. The Review Panel thanks the Assessment Team for the significant amount of work involved and for the reports and presentations detailing the data, analyses, exploration, and modeling. In particular, the panel acknowledges Chris Swanson, Heather Christiansen, and Dustin Addis (Assessment Leads) who presented overviews of the assessments. The Review Panel appreciated the collegial nature of the review deliberations and Assessment Team's positive responsiveness to the Review Panel's comments, questions, and requests for additional information and analyses. The Review Panel also thanks SEDAR, South Atlantic Fisheries Management Council, and Gulf Council Staff for their invaluable assistance during the review process.

This report summarizes the Review Panel's findings and recommendations. Section 2.1 details the review for the West Florida Shelf stock, while 2.2 reports on the review of the East Florida-Florida Keys stock (2.2). Each follows the Terms of Reference provided to the Review Panel.

2.1 WEST FLORIDA SHELF STOCK

Executive Summary

SEDAR 94 developed a stock assessment of the West Florida Shelf (WFS) hogfish (*Lachnolaimus maximus*) stock using Stock Synthesis 3 (SS3). The assessment model

incorporated commercial and recreational removals, fishery-independent indices of abundance, length-composition and conditional age-at-length data, and biological information appropriate for the protogynous life history of hogfish. Model performance was evaluated using an extensive suite of diagnostics and sensitivity analyses. The Review Panel concluded that the assessment model was appropriately configured and applied, and the resulting population estimates were sufficiently reliable and consistent with the available fishery-dependent and fishery-independent data, and the known biology of hogfish. The WFS hogfish stock was found not to be overfished nor undergoing overfishing. Recent spawning stock biomass was estimated to be well above the minimum stock size threshold (MSST), and recent fishing mortality was estimated to be below the maximum fishing mortality threshold (MFMT). Although the Panel identified several important sources of uncertainty, it concluded that none were sufficient to alter acceptance of the assessment or its principal findings. An informative stock-recruitment relationship could not be estimated from the available data. Steepness (*h*) was fixed at 0.99, effectively representing average recruitment (with annual deviations) and SPR-based proxies (SPR30%) were used as the basis for stock-status reference points. The methodology used for stock projections were considered appropriate, informative, and suitable for management consideration. The Panel identified several research priorities that could improve future WFS hogfish assessments. In particular, it noted that the reproductive dynamics of hogfish—including protogynous sex change, haremic behavior, possible male limitation, and potential skip spawning—may complicate the relationship between conventional measures of spawning biomass and subsequent recruitment and remain important areas for future research. Overall, the Review Panel concluded that the SEDAR 94 West Florida Shelf hogfish assessment is scientifically sound, uses the available data appropriately, and provides a suitable basis for management advice. However, the uncertainties and research needs identified during the review should be considered in interpreting management quantities and in planning future assessments, but they do not materially change the Panel's conclusions regarding the current status of the WFS hogfish stock.

The Review Panel discussions and deliberations are summarized below for each of the Terms of Reference

1. **Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:**

   a) Are data decisions made by the DW and AW panels sound and robust?

   The Review Panel concluded that, overall, the data decisions made by the Data Workshop (DW) and Assessment Workshop (AW) for the West Florida Shelf (WFS) stock were sound and robust given the available information and the data limitations associated with this stock. The assessment incorporated the principal data streams typically available for Gulf reef fish assessments, including commercial and recreational landings, reconstructed historical landings, fishery-independent abundance indices, length compositions, and conditional age-at-length (CAAL) data. Fishery-dependent indices, including the MRIP hook-and-line CPUE index, were explored during assessment development but were not

recommended for inclusion in the final model. The rationale for major data inclusion and exclusion decisions was adequately considered and documented.

The Review Panel considered aggregation of commercial gears into a single commercial fleet to be appropriate. Commercial landings represented a relatively small proportion of total WFS removals, and annual length and CAAL sample sizes were limited and variable among gears. Separating these gears would, therefore, have increased model complexity and the number of estimated parameters without a corresponding increase in information. Similarly, combining the relatively small SRHS landings and discards with SRFS hook-and-line estimates was considered reasonable.

The treatment of the recreational fishery warrants somewhat greater consideration. The WFS assessment retained separate recreational spear and hook-and-line fleets, in part because the hook-and-line component has continued to develop and has recently become an increasingly important source of removals. The Panel noted, however, that recreational composition data for the WFS are relatively sparse and that this decision differs from the aggregation approach applied to the Florida Keys hogfish stock (see below). Although the retained fleet structure was accepted for the current assessment, future assessments should continue to evaluate whether the available data adequately support separate recreational fleet parameterizations.

The Review Panel also discussed the natural mortality-at-age vector, particularly the relatively high mortality estimates for younger ages compared with those used in the Florida Keys assessment. This was considered in conjunction with the relatively young terminal age represented in the KEYS model compared to the WFS model (16 vs 23 years). Following discussion, the Panel accepted the natural mortality vector used in the base model.

b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

The assessment adequately acknowledged the major sources of data uncertainty. The Review Panel considered these uncertainties generally within the range expected for the available information for this species and region, recognizing that hogfish can be a relatively rare-event species in several sampling programs. A principal concern involves recreational spearfishing data. Recreational spear landings are relatively uncertain because spearfishers are infrequently encountered by conventional dockside surveys at public-access boat ramps.The Panel also discussed whether CPUE information obtained from these intercepts is representative of spearfishers operating from private access points, who may differ in fishing behavior or efficiency. The same is true for the sector of the recreational fisheries that leave from and return to private docks. These limitations create uncertainty regarding both historical and current recreational spear removals.

Discard mortality, particularly for hook-and-line-caught hogfish, is another source of considerable uncertainty. Available information suggests that hogfish are highly susceptible

to barotrauma even at relatively shallow depths. However, sensitivity analyses using alternative discard mortality rates produced relatively small changes in spawning stock biomass (SSB) and fishing mortality trajectories. Thus, although discard mortality remains biologically uncertain, this uncertainty did not appear to have a substantial influence on the principal stock-status conclusions of the current assessment. This result may partly reflect the relatively low level of WFS discarding and the comparatively recent development of the recreational hook-and-line fishery. Consequently, accurate estimation of this probability may become increasingly important if the magnitude of hook-and-line discards continues to increase.

The catch and index time series provided limited contrast with respect to the stock-recruit relationship (i.e., estimate steepness). Notably, the fishery-independent indices showed no clear response to long-term increase in removals. The inclusion of reconstructed recreational catch data was also reported to be uninformative to the estimation of steepness. The Assessment Team acknowledged this limitation, and therefore fixed steepness to 0.99 in the model.

c) Are input data series reliable and applied properly within the assessment model?

The Review Panel concluded that the input data series were appropriately applied within the assessment model and were sufficiently reliable to support the assessment conclusions, subject to the qualifications described above. The fishery-independent indices provide an important independent perspective on stock trends and did not indicate a declining trend over the assessment period despite increases in removals. This pattern is broadly consistent with the population trajectory estimated by the assessment and provides additional support for the conclusion that the stock is not currently overfished. Overall, the Panel accepted the data inputs and their treatment in the WFS assessment, while identifying recreational spear removals and sampling as an important area for future improvement.

2. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and considering the following:

a) Are methods scientifically sound and robust?

The Review Panel concluded that the methods used to assess the WFS hogfish stock were scientifically sound and robust. Stock Synthesis 3 (SS3; version 3.30.24) is a widely used and extensively tested integrated stock assessment framework capable of incorporating the diverse and intermittent data streams available for the WFS hogfish stock. Its application to this assessment was considered appropriate. The Assessment Team conducted an extensive suite of diagnostics and sensitivity analyses. Model convergence was evaluated using final gradients, Hessian properties, parameter-bound checks, and jitter analyses from dispersed starting values. One hundred jitter runs using a relatively broad jitter magnitude did not identify a lower likelihood solution. Likelihood profiles, retrospective analyses, sensitivity runs, parametric bootstrap analyses, and Markov Chain Monte Carlo (MCMC) analyses

provided additional evaluation of model behavior and uncertainty. The Panel therefore considered the model to have been competently implemented and adequately diagnosed.

One qualification concerns the MCMC implementation. Two of eight MCMC chains did not satisfy convergence diagnostics and were excluded from posterior inference. The remaining chains provided broadly consistent results, but the cause of the failed chains was not fully understood and diagnosed. Future assessments should consider whether alternative sampling approaches, including Hamiltonian Monte Carlo or the No-U-Turn Sampler (NUTS), could improve sampling efficiency and convergence for complex SS models.

b) Are assessment models configured properly and consistent with standard practices?

The Review Panel concluded that the WFS model was properly configured and generally consistent with accepted stock assessment practices. The model appropriately accounted for the protogynous hermaphroditic life history of hogfish within the capabilities of SS3. Steepness was fixed at 0.99 because an informative stock-recruit relationship could not be estimated from the available data. The consequences of this assumption are considered further under TOR 3. The assessment used super-periods for commercial and recreational length-frequency data to address sparse sampling. Although this provided a practical means of reducing estimation problems associated with limited annual samples, the Panel noted that the statistical properties and potential consequences of using super-periods are not well understood by many practitioners and reviewers. Further evaluation of this approach is recommended.

A sum-to-zero constraint was applied to recruitment deviations in the base assessment model. Although initially motivated primarily by reducing retrospective behavior in the Florida Keys model, retaining the constraint in the WFS model was considered reasonable because removing it did not improve model fit and the constraint resolves potential indeterminacy between the scale of the stock-recruit relationship and the mean recruitment deviations. The sum-to-zero constraint, however, created difficulties for ADMB MCMC sampling and therefore was removed in a proxy model used for MCMC analyses. Estimates from the maximum-likelihood WFS model generally fell within the interquartile ranges of the posterior distributions from the proxy MCMC model, providing reassurance that this workaround did not materially alter the major assessment conclusions. Nevertheless, the need to use a modified proxy model for uncertainty analysis deserves additional methodological investigation.

c) Are the methods appropriate for the available data?

The Review Panel concluded that the assessment methods were appropriate for the available data. The age- and size-structured SS3 model accommodated the available length compositions, CAAL observations, abundance indices, uncertain catch information, and

historical changes in fishery regulations. Estimating growth internally within the model was considered a strength because this approach can account for interactions among growth, length-based selectivity, and size truncation in sampled fish. Use of CAAL information also helps address growth model biases associated with length-stratified and other size-selective sampling.

The model further incorporated the SS3 growth-platoon feature to represent and account for the effects of size-selective mortality on the distribution of size at age. Sensitivity analyses of this feature would nevertheless be useful because its consequences for estimation of major assessment quantities are not as well understood as many other components of SS3.

The model assumed equivalent growth rates for males and females. Available residual diagnostics (*see Addendum Section below*) supported this assumption for the current assessment, although further investigation of sex-specific growth is warranted.

3. Evaluate the assessment findings and consider the following:

a) Are population estimates (model output – e.g. abundance, exploitation, biomass) reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

The Review Panel concluded that the population estimates generated by the WFS base model were sufficiently reliable, consistent with the available data and known biology, and appropriate for supporting stock-status inferences.

The base model converged successfully and exhibited generally acceptable diagnostics. The retrospective analysis showed a modest retrospective pattern, with Mohn's rho values of approximately -0.15 for SSB and 0.19 for fishing mortality. These values were near the range generally considered acceptable for a relatively long-lived species and therefore warrant recognition but did not invalidate the assessment results. The retrospective patterns likely reflect the recent increase and development of the recreational hook-and-line fishery. Importantly, the direction of the retrospective pattern suggests that terminal-year biomass historically tended to be underestimated, and fishing mortality overestimated. As additional data were incorporated, estimates therefore tended to become somewhat more favorable rather than indicating previously undetected depletion. The absence of a declining trend in the fishery-independent indices provides additional support for the estimated population trajectory.

b) Is the stock overfished? What information helps you reach this conclusion?

The Review Panel agreed with the assessment conclusion that the WFS hogfish stock is not overfished. Current spawning stock biomass, defined using the geometric mean for 2022–2024, was estimated at approximately 1,086 mt, substantially greater than the minimum stock size threshold (MSST) of approximately 259 mt based on the SPR30% reference point. The uncertainty analysis strongly supported this conclusion. The posterior distribution from the MCMC analysis for the ratio of current SSB to MSST was entirely

above 1. Thus, the conclusion that the stock is not overfished was robust to the parameter uncertainty represented by the MCMC analysis. This conclusion is also consistent with the lack of a declining trend in the available fishery-independent abundance indices.

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

The Review Panel agreed with the assessment conclusion that the WFS hogfish stock is not undergoing overfishing. The posterior distribution of the fishing mortality status ratio was entirely below 1, with a posterior median of approximately 0.28, also based on the SPR30% reference point. The available uncertainty analyses therefore provide strong evidence that recent fishing mortality is below the applicable maximum fishing mortality threshold ($F_{30\%SPR}$).

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

An informative stock-recruit relationship could not be estimated for the WFS hogfish stock. Attempts to estimate steepness (h) resulted in estimates near 0.99, effectively indicating little information in the available data regarding the shape of the stock-recruit relationship. Steepness was therefore fixed at 0.99 and recruitment was represented primarily through average recruitment and annual recruitment deviations. This should not be interpreted as evidence that the biological stock-recruit relationship has an h of 0.99. Rather, it reflects the Panel's conclusion that the relationship cannot be reliably estimated with the available information. The Review Panel considered this approach appropriate given the available information. Consequently, SPR-based proxies rather than conventional MSY estimates derived from an estimated stock-recruit curve were deemed appropriate for determining stock status. The Panel supported use of the SPR30% reference point for this purpose, which was used in the previous SEDAR 94 assessment. The difficulty in estimating recruitment dynamics may be particularly relevant for hogfish because of their protogynous hermaphroditic life history and haremic spawning system. Sex change, population sex ratio, potential male limitation, and possible skip spawning could complicate the relationship between conventional measures of spawning biomass and subsequent recruitment.

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?

The Review Panel concluded that the SPR-based status determination criteria were appropriate and sufficiently reliable for management use. Use of proxies is warranted because the data do not support estimation of a sufficiently informative stock-recruit relationship for calculation of conventional MSY-based reference points. Nevertheless, uncertainty in recreational spear removals complicates inference regarding the absolute level of fishing pressure the stock can sustainably support. Managers should recognize this

uncertainty when developing management quantities derived from the assessment. Appropriate management buffers, including those considered in setting OFL and ABC, provide one mechanism for accounting for uncertainty that cannot be fully represented in the assessment itself.

4. Evaluate the stock projections, including discussing strengths and weaknesses, and consider the following:

a) Are the methods consistent with accepted practices and available data?

The Review Panel concluded that the projection methods were consistent with accepted practices and the available data.

Projections were conducted externally to SS3 using a projection tool developed by the Southeast Fisheries Science Center (SEFSC) that has been used in previous assessments and reviewed through the regional management process. The assessment presented deterministic projections under multiple fishing mortality/reference-point scenarios. Long-term equilibrium projections used average recruitment over 1986–2024, whereas short-term projections used the more recent 2020–2024 average. Given the inability to estimate an informative stock-recruit relationship and the fixed steepness value of 0.99, the Panel considered the use of empirical average recruitment appropriate. With steepness near 1, recruitment varies relatively little with spawning biomass except at very low stock sizes; consequently, constant average recruitment provides a reasonable practical approximation for the WFS projections.

b) Are the methods appropriate for the assessment model and outputs?

The Review Panel concluded that the projection methods were appropriate for the WFS assessment model and its outputs. The projections were based on accepted model estimates and reference points and appropriately reflected the recruitment assumptions required by the WFS model configuration. The Panel therefore accepted the projections as a suitable basis for subsequent consideration by the SSC and Council.

c) Are the results informative and robust, and useful to support inferences of probable future conditions?

The projections were considered informative and sufficiently useful for evaluating probable future stock conditions and developing management advice. However, the degree of robustness to alternative biological assumptions could not be fully evaluated because projections were not accompanied by sensitivity analyses for all potentially important inputs, such as natural mortality, discard mortality, and other externally specified parameters. Such analyses are not necessarily standard components of the projection process, and their absence does not invalidate the projections. Nevertheless, sensitivity analyses could provide useful information regarding the dependence of projected outcomes on key fixed assumptions.

d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Important projection assumptions and uncertainties were acknowledged, including assumptions of constant fleet selectivity and allocation, growth, natural mortality, stock-recruitment parameters, other fixed quantities, terminal-year recruitment, and future recruitment. A limitation is that the projections were deterministic and therefore did not propagate parameter uncertainty forward through time. Although multiple management scenarios were considered, the projections did not directly estimate probabilities of future biomass or fishing mortality crossing management reference points.

The MCMC analyses provide a potential mechanism for incorporating this uncertainty. Future assessments should consider propagating posterior parameter draws through projections to estimate the probability of future stock conditions under alternative fishing scenarios. Such stochastic projections could provide managers with a more explicit representation of risk.

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- **Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods**
- **Ensure that the implications of uncertainty in technical conclusions are clearly stated**

The Review Panel concluded that uncertainty was evaluated extensively in the WFS assessment and that the analyses captured many of the important sources of parameter, data, and model uncertainty. The WFS model estimated a large number of biological, recruitment, catchability, selectivity, and retention parameters. Variance estimates associated with input data were incorporated into SS as appropriate, and alternative model configurations and parameter assumptions were evaluated through sensitivity analyses, likelihood profiles, and retrospective analyses. Jitter analyses and other standard model diagnostics were examined to assess estimation convergence.

The Assessment Team explored uncertainty of M through a set of sensitivity runs (alternative formulations and freely estimated M). This exploration demonstrated that the assessment is sensitive to M as the growth estimates, ln(R0), and reference points varied substantially across the different configurations. The Assessment Team acknowledged this sensitivity in the AW report and during the RW, noting that estimating M freely added considerable uncertainty to key assessment outputs (SSB, recruitment, exploitation rates). The sensitivity analysis on discard mortality showed that discard mortality had minimal influence on model outputs. High (59%) and low (23%) discard mortality rates produced outputs that closely tracked with the based model (41.1%), indicating that discard mortality is not a significant source of uncertainty for the WFS model.

The Assessment Team conducted ln(R0) likelihood profiles, and the total likelihood profile showed a single minimum, indicating identifiability of the ln(R0) parameter from the data. The data components profiles revealed directional conflict among data types, where the length and age composition pulled toward a lower ln(R0) and the survey indices pulled towards a higher ln(R0). The base ln(R0) estimate is largely informed by the composition (age and length) data, with some influence from the survey indices.

In addition to asymptotic uncertainty estimates derived from the covariance matrix, the Assessment Team conducted both MCMC and parametric bootstrap analyses. These analyses represented a substantial strength of the assessment because they provided alternative means of characterizing uncertainty beyond standard asymptotic Normal approximations.

The MCMC analysis produced posterior distributions for model parameters and important derived quantities, including current SSB and fishing mortality relative to their respective status thresholds. This permitted direct probabilistic evaluation of stock status and clearly demonstrated the strength of evidence supporting the conclusions that the stock is neither overfished nor undergoing overfishing.

Some qualifications apply to the MCMC analysis. Two of eight chains did not satisfy the selected convergence diagnostic and were excluded from inference. The six retained chains showed acceptable convergence according to other diagnostics, but the reason for failure of the two excluded chains was not fully determined. Further investigation of trace behavior, posterior geometry, and alternative sampling algorithms would help distinguish between inefficient sampling and more substantive features such as posterior multimodality.

The parametric bootstrap provided an additional evaluation of uncertainty associated with the observed data and potential model instability. A substantial fraction of bootstrap replicates produced at least one parameter estimate at a parameter-space bound, indicating that model behavior under resampled datasets was less stable than suggested by the convergence characteristics of the base model alone. However, the resulting distributions of key parameters and derived quantities were generally consistent with the base-model and MCMC estimates. The different uncertainty approaches therefore did not indicate materially different conclusions regarding stock status.

The Review Panel considered the implications of parameter uncertainty to have been clearly communicated, particularly for the stock-status criteria. The posterior distributions associated with current biomass and fishing mortality effectively conveyed the degree of risk relative to the management thresholds. Nevertheless, not all forms of uncertainty were propagated through every component of the analysis. In particular, the deterministic projections did not propagate parameter uncertainty into future stock trajectories. However, conducting stochastic projections were not in the TORs of the AW, which is why the Assessment Team did not consider uncertainty in the projections. Future assessments should

consider whether stochastic projections based on posterior parameter distributions could provide a more complete characterization of management risk.

6. **Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.**

- **Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments**

The Review Panel supports the research recommendations developed during the Data and Assessment Workshops and identified several additional priorities that could improve future hogfish assessments.

1. Improve understanding and modeling of protogynous hermaphroditic population dynamics.
    - This represents a high research priority. Future work should investigate the recruitment and reproductive dynamics of protogynous, harem-forming species and evaluate how social structure affects sex transition. The current assessment represents sex transition primarily as an age-dependent process, whereas hogfish sex change may also depend strongly on the local abundance or density of males. Research should evaluate whether the probability of female-to-male transition changes with male density and how fishing-induced changes in population sex ratio affect reproductive output. Simulation studies and explicitly sex-structured population models could be particularly useful for evaluating these processes and the implications of size-selective harvest regulations for protogynous species.
    - Related work should investigate the potential for sperm limitation or male limitation and the prevalence of skip spawning. These processes could influence the relationship between conventional measures of spawning biomass and realized reproductive output and may help explain why a conventional stock-recruit relationship is difficult to estimate for this species.
2. Improve recreational spearfishing information.
    - Uncertainty in recreational spear landings remains one of the more important data limitations for the WFS assessment. Existing intercept designs may inadequately sample portions of the spearfishing fleet, particularly fishers operating from private access points. Targeted survey designs should be considered to evaluate the magnitude and potential bias of recreational spear removals and to determine whether existing CPUE observations adequately represent the broader spearfishing population. Improvements in this area would increase confidence in historical fishing pressure, current stock status, and sustainable harvest reference points.
3. Evaluate fishery-independent survey coverage and data gaps.
    - Available fishery-independent indices, including those excluded during the DW, should be systematically evaluated with respect to geographic coverage of hogfish habitat, sample size, and availability of age and length information. This could identify important spatial or temporal gaps and help prioritize future monitoring.

4. Evaluate alternative assessment and uncertainty methods.
    - Future methodological work should compare uncertainty estimates derived from MCMC, parametric bootstrap, and asymptotic normal approximations. Comparisons on both normal and log scales could help determine circumstances in which conventional asymptotic approximations provide sufficiently reliable inference and when more computationally intensive MCMC or bootstrap procedures are warranted.
    - Alternative MCMC algorithms, including Hamiltonian Monte Carlo and related approaches, should be investigated where feasible to determine whether they improve convergence and posterior exploration relative to the current Metropolis-Hastings implementation.
    - Additional consideration should also be given to assessment frameworks capable of incorporating random effects or state-space processes, including time-varying fishing mortality where appropriate.
5. Evaluate Stock Synthesis implementation choices that are not well understood.
    - Additional research should examine the statistical properties and consequences of using super-periods to address sparse composition data. Sensitivity analyses should also evaluate the specification of growth platoons, given the limited experience of many assessment practitioners and reviewers with this feature.
    - The implications of removing the recruitment-deviation sum-to-zero constraint for MCMC proxy models should also be examined further. The current workaround was considered acceptable for the WFS assessment, but a better understanding of the statistical consequences would benefit future applications.
6. Investigate sex-specific growth.
    - Although residual diagnostics supported the assumption of equal growth rates for males and females in the current assessment, additional biological and modeling work should evaluate whether sex-specific growth differences are important enough to affect future assessment results.
7. Evaluate environmental effects on hogfish population dynamics.
    - Future research should consider the effects of environmental disturbances and stressors, including red tides and other harmful algal blooms, cold events, and oil spills. Potential environmental effects on natural mortality, recruitment, movement, and habitat use could be important sources of temporal variability not explicitly represented in the current assessment.
8. Develop stochastic projections that propagate assessment uncertainty.
    - The MCMC framework provides an opportunity to propagate parameter uncertainty into future projections. Stochastic projections could quantify probabilities of SSB falling below biomass thresholds or fishing mortality exceeding applicable reference points under alternative management scenarios. Incorporating such approaches more routinely into the SEDAR process could

improve communication of management risk and make fuller use of the uncertainty analyses already conducted as part of the assessment.

- **Provide recommendations on possible ways to improve the SEDAR process**

  The Review Panel commented that some TORs may need to be revisited or clarified. For example, the text on BSIA may need updating, and the evaluation of the projection results may be a task for the SSC, rather than a Review Panel. Also, the Review Panel noted that the bridging analysis (see TORs for the assessment phase) was not very informative given the length between assessments and resulting changes in the data and the model. It was therefore not evaluated by the Review Panel.

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 the SEDAR 94 West Florida Shelf hogfish assessment is scientifically sound, uses the available data appropriately, and provides a suitable basis for management advice.

8. **Provide suggestions on key improvements in data or modeling approaches that should be considered when scheduling the next assessment.**

Completion of any of the research recommendations provided for ToR 6 is not required before scheduling the next assessment.

Revisions and recalibration of MRIP fishing effort may warrant a new assessment.

9. **Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Peer Review Summary Report in accordance with the project guidelines.**

This report represents the Peer Review Summary summarizing the Panel's evaluation of the SEDAR 94 West Florida Shelf hogfish stock assessment and addressing each Term of Reference.

2.2 EAST FLORIDA-FLORIDA KEYS STOCK

Executive Summary

SEDAR 94 developed a stock assessment of the East Florida-Florida Keys (KEYS) hogfish (*Lachnolaimus maximus*) stock using Stock Synthesis 3 (SS3). The assessment model

incorporated commercial and recreational removals, fishery-independent indices of abundance, length-composition and conditional age-at-length data, and biological information appropriate for the protogynous life history of hogfish. Model performance was evaluated using an extensive suite of diagnostics and sensitivity analyses. The Review Panel concluded that the assessment model was appropriately configured and applied, and the resulting population estimates were sufficiently reliable and consistent with the available fishery-dependent and fishery-independent data, and the known biology of hogfish. A main outcome of the review was the Review Panel's recommendation to replace the Assessment Workshop base model with a revised Review Workshop base model (KEYS_RW_Base model) based on the high uncertainty in the reconstructed landings for the period 1950-198 . This revised 1986–2024 model could not reliably estimate steepness (*h*) of the stock-recruitment relationship from the available data. Therefore, *h* was fixed at 0.99, effectively representing average recruitment (with annual deviations) and SPR-based proxies (SPR30%) were used as the basis for stock-status reference points. Based on this revised model and associated SPR-based reference points the Review Panel agreed with the conclusion that the East Florida–Florida Keys hogfish stock is not overfished nor undergoing overfishing. The Panel concluded that the projection methodology was consistent with accepted practices and appropriate for the SS3 assessment framework. However, Markov Chain Monte Carlo (MCMC) analyses and parametric bootstrap analyses corresponding specifically to the KEYS_RW_Base model were not available for Review Panel evaluation during the Review Workshop. Consequently, although the Panel accepted the deterministic stock-status conclusions, it was not able to evaluate their probabilistic robustness using posterior distributions or bootstrap results for the final revised model during the workshop . The Review Panel also identified several research priorities that could improve future KEYS Hogfish assessments. High priorities include improving understanding and modeling of recruitment and reproductive dynamics in protogynous and haremic species; improving recreational harvest, discard, life-history, age, and length information; obtaining a more reliable estimate of maximum age to better inform natural mortality; and evaluating fishery-independent survey coverage and data gaps. Overall, the Review Panel concluded that the SEDAR 94 East Florida–Florida Keys hogfish assessment, as modified during the Review Workshop, provides an appropriate scientific basis for stock-status determination and management consideration. However, important uncertainties remain regarding stock productivity, the stock-recruit relationship, and several data sources. These qualifications should accompany interpretation and use of the assessment results but do not alter the Review Panel's acceptance of the revised model for determining current stock status and providing management advice.

The Review Panel discussions and deliberations are summarized below for each of the Terms of Reference

1. **Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:**
    a) **Are data decisions made by the DW and AW panels sound and robust?**

The Review Panel concluded that most data decisions made during the Data Workshop (DW) and Assessment Workshop (AW) were well documented and appropriate. Decisions to aggregate commercial gears into a single commercial fleet, combine SRHS landings and discards with SRFS hook-and-line estimates, and aggregate the recreational fishery into a single fleet were considered reasonable given the available data and assessment objectives.

The principal exception concerned reconstruction of historical removals prior to 1986. The Assessment Workshop base model began in 1950 and incorporated reconstructed recreational catches for the period preceding the availability of more reliable recreational fishery data. The Review Panel recognized the value of the reconstruction as an attempt to characterize the historical development of the fishery and inform initial stock conditions. However, the Panel did not consider the reconstructed recreational removals sufficiently reliable for inclusion in the model used for management advice. In particular, recreational catch during the historical period was reconstructed using effort information from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation together with CPUE inferred from recreational data available for 1982, 1983, and 1985. This approach effectively required assumptions regarding the applicability of catch rates observed during those years to much earlier periods. Because the reconstructed removals substantially influenced estimates of historical stock size and the apparent stock-recruit relationship, the Panel concluded that uncertainty in the reconstruction had potentially important consequences for model results. Accordingly, the Panel recommended that the model used as the Review Workshop base model begin in 1986, when recreational catch information becomes more reliable. The resulting 1986–2024 model is referred to here as the KEYS_RW_Base model.

The Panel also discussed differences in estimated selectivity among fishery-independent surveys. In particular, the Reef Visual Census (RVC) exhibited dome-shaped selectivity, whereas the video survey exhibited a more flat-topped selectivity pattern. These differences were considered biologically and operationally plausible because the surveys differ in depth coverage, gear characteristics, availability of fish to the survey, fishing pressure, and the degree to which surveyed areas are protected from fishing. The Panel accepted the explanation that larger fish occurring in deeper waters may be less available to the shallower RVC survey than to video sampling conducted across a broader depth range.

The Review Panel also discussed the natural mortality-at-age vector, particularly the lower mortality estimates for younger ages compared with those used in the WFS assessment. This was considered in conjunction with the relatively young terminal age represented in the KEYS model compared to the WFS model (16 vs 23 years). Following discussion, the Panel accepted the natural mortality vector used in the base model.

b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

The Review Panel concluded that important data uncertainties were acknowledged and adequately reported. Overall, uncertainty in the KEYS assessment was considered relatively high, reflecting limitations in several data streams. Recreational removals are an important source of uncertainty, in particular due to recreational fishers that leave from and return to private docks. This is particularly true for recreational spearfishing because relatively few positive trips are encountered through conventional intercept surveys. Consequently, MRIP estimates of recreational harvest and discards can have high coefficients of variation.

Discard information is also limited. Sensitivity analyses conducted during assessment development suggested that alternative discard assumptions had relatively little influence on major model results, but the Review Panel noted that the consequences of sparse discard information remain poorly understood. The historical recreational catch reconstruction represents a more consequential source of uncertainty because it influenced estimated initial stock conditions and the apparent stock-recruit relationship. Rather than accepting this uncertainty within the final model configuration, the Panel addressed it by recommending exclusion of the reconstructed period and adoption of 1986 as the starting year for the KEYS_RW_Base model.

With the reconstructed recreational landings included (in addition to the commercial landings), the catch series from 1950-1980 provided enough contrast to inform the stock-recruit relationship and steepness. However in the KEYS_RW_BASE model once the reconstructed time series was excluded, the shortened time series (1986-2024) no longer supported a reliable estimate of steepness (see TOR 3d).

c) Are input data series reliable and applied properly within the assessment model?

The Review Panel concluded that the data series retained in the KEYS_RW_Base model were appropriately applied and sufficiently reliable for assessment purposes, given the acknowledged uncertainties.

2. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and considering the following:

a) Are methods scientifically sound and robust?

The Review Panel concluded that Stock Synthesis 3 (SS3; version 3.30.24) is a scientifically sound and robust framework for assessing the East Florida–Florida Keys Hogfish stock. SS3 has been extensively applied and tested in U.S. and international stock assessments and can integrate the mixture of catch, abundance-index, length-composition, age, and biological information available for this stock.

The Assessment Team applied an extensive suite of diagnostics during model development. Model convergence was evaluated using final gradients, Hessian properties, parameter-bound checks, and jitter analyses. One hundred jittered starting values were evaluated over a broad range, and no lower-likelihood solution was identified. Sensitivity analyses and likelihood profiles were also used extensively to examine important model assumptions.

These analyses were particularly important for evaluating the influence of the reconstructed historical catches and assumptions regarding initial conditions and stock-recruit dynamics. The Panel concluded that the assessment framework itself was scientifically appropriate and competently applied, while recommending an alternative base-model configuration based on the results of those evaluations.

b) Are assessment models configured properly and consistent with standard practices?

The Review Panel concluded that the revised KEYS_RW_Base model was appropriately configured and consistent with accepted assessment practices.

The Panel also examined the treatment of the stock-recruit relationship. When the model began in 1986 and initial depletion was freely estimated, steepness and unfished recruitment were poorly identified and traded off against one another. Alternative assumptions regarding initial conditions produced substantially different steepness (h) estimates, and likelihood profiling indicated that the available data could not reliably identify h. Consequently, the Panel recommended fixing steepness at 0.99 in the KEYS_RW_Base model, effectively removing an informative stock-recruit relationship from the assessment and allowing average recruitment and recruitment deviations to describe recruitment dynamics.

Super-periods were used for commercial and recreational length-frequency data to reduce estimation difficulties caused by sparse annual sampling. The Panel accepted this treatment for the current assessment but noted that the strengths and weaknesses of super-periods are not sufficiently understood and recommended additional methodological research.

The model also used a sum-to-zero constraint on recruitment deviations, in part to reduce retrospective patterns and remove indeterminacy between the scale of the stock-recruit relationship and the mean recruitment deviations. This constraint created difficulties for ADMB MCMC sampling because it restricted efficient exploration of the parameter space. Consequently, MCMC analyses required a proxy model in which the sum-to-zero constraint was removed. This issue was particularly important because the proxy model produced some differences in estimated stock size relative to the corresponding base model. Moreover, an MCMC analysis for the final KEYS_RW_Base model was not available at the conclusion of the Review Workshop. The Panel considered the proxy approach an acceptable methodological workaround for investigating uncertainty but recommended further research into the issue.

c) Are the methods appropriate for the available data?

The Review Panel concluded that the methods were appropriate for the available data.

The age- and size-structured SS3 framework appropriately accommodated the available catch data, intermittent length compositions, conditional age-at-length observations, abundance indices, and changes in fishery size limits and other regulations.

Growth was estimated internally within the model, which provides an effective means of accounting for interactions among growth, length selectivity, and size truncation. Conditional age-at-length information was incorporated to improve estimation of growth and selectivity while reducing biases associated with length-stratified or otherwise size-selective sampling.

The assessment also used the SS3 growth-platoon feature to represent effects of size-selective mortality on the distribution of size at age. Additional sensitivity analyses of growth-platoon assumptions are recommended because this component of SS3 is less familiar to many assessment practitioners and reviewers.

The model assumed equivalent growth rates for males and females. Available external residual analyses supported this assumption for the current assessment, although further investigation of sex-specific growth is recommended.

3. Evaluate the assessment findings and consider the following:

The Review Panel's evaluation of the assessment findings resulted in an important change from the Assessment Workshop model. The Panel did not recommend carrying forward the proposed 1950-start model containing reconstructed historical recreational catches. Instead, the Panel recommended the KEYS_RW_Base model beginning in 1986 with steepness fixed at 0.99.

a) Are population estimates (model output – e.g. abundance, exploitation, biomass) reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

The Panel concluded that the population estimates from the KEYS_RW_Base model were sufficiently reliable and useful for stock-status inference, subject to important qualifications regarding initial conditions, historical catches, and the stock-recruit relationship. The Panel's recommendation to replace the Assessment Workshop base model with the KEYS_RW_Base model was itself intended to improve reliability by preventing highly uncertain reconstructed historical catches from exerting substantial influence on estimates of historical population size and productivity.

Despite the substantial difference in starting years between the original 1950–2024 model and the revised 1986–2024 model, the two configurations produced broadly similar temporal trends in spawning stock biomass and fishing mortality. This consistency provided some reassurance that the principal recent stock trajectory was not solely an artifact of the historical reconstruction. The Panel therefore considered the KEYS_RW_Base model suitable for evaluating current stock status, while recognizing greater uncertainty regarding absolute population scale and productivity than would be desirable.

b) Is the stock overfished? What information helps you reach this conclusion?

Based on the KEYS_RW_Base model and the applicable SPR-based biomass reference point (SPR30%), the Review Panel agreed with the conclusion that the East Florida–Florida Keys Hogfish stock is not overfished.

Although the Panel considered the revised model suitable for this determination, MCMC and parametric bootstrap analyses corresponding specifically to the final KEYS_RW_Base configuration were not available for Panel evaluation during the Review Workshop. Consequently, the Panel could not evaluate the probabilistic robustness of this status determination using posterior distributions for the final revised model during the workshop.

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

Based on the KEYS_RW_Base model and applicable SPR-based fishing mortality reference point, the Panel agreed with the conclusion that the East Florida–Florida Keys Hogfish stock is not undergoing overfishing. As with the biomass determination, this conclusion is based on the selected SPR proxy (SPR30%) and did not rely on MCMC and bootstrap analyses. Therefore, although the Panel accepted the deterministic stock-status determination, the associated probabilistic characterization of uncertainty for the revised model remained to be completed before subsequent consideration by the SSC.

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 Review Panel concluded that the available data did not support reliable estimation of an informative stock-recruit relationship for the KEYS stock. This conclusion emerged from extensive consideration of both the original AW Base model and alternative model configurations. The original model beginning in 1950 appeared capable of estimating steepness, but the result was strongly influenced by reconstructed historical catches and recruitment estimates associated with the reconstructed period. Because the Panel did not consider those historical removals sufficiently reliable, it did not consider the resulting stock-recruit relationship sufficiently robust for management use.

Models beginning in 1986 also provided indications that *h* might be considerably below 0.99, but estimates were highly sensitive to assumptions regarding initial stock conditions and the estimation of R0. Likelihood profiles similarly indicated information favoring lower *h* but did not provide a sufficiently stable basis for estimating the parameter. The Panel therefore recommended fixing *h* at 0.99 in the KEYS_RW_Base model. This should not be interpreted as evidence that the biological stock-recruit relationship has an *h* of 0.99. Rather, it reflects the Panel's conclusion that the relationship cannot be reliably estimated with the available information.

This distinction has management implications. Analyses conducted during the review suggested that reference points derived under a lower-steepness stock-recruit relationship

could be more conservative than the SPR30% proxy used after fixing *h* at 0.99. Thus, although the evidence was insufficient to support an estimated stock-recruit relationship, the possibility of stronger density dependence than represented by the final model remains an important source of uncertainty.

The unusual reproductive biology of hogfish may further complicate recruitment dynamics. Protandry is not involved; rather, hogfish are protogynous hermaphrodites in which females transition to males, with sex change influenced by social and haremic dynamics. Changes in sex ratio, male abundance, or reproductive behavior could affect the relationship between conventional spawning biomass and effective reproductive output.

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?

The Review Panel considered SPR-based status determination criteria appropriate for the KEYS_RW_Base model because an informative stock-recruit relationship could not be reliably estimated. The Panel nevertheless emphasized that the choice of SPR proxies does not eliminate uncertainty regarding underlying stock productivity. Model explorations provided some evidence consistent with lower *h*, and reference points calculated under such assumptions could differ from those obtained using conventional SPR proxies. The SSC and Council should therefore recognize this structural uncertainty when interpreting assessment-derived management quantities.

4. Evaluate the stock projections, including discussing strengths and weaknesses, and consider the following:

a) Are the methods consistent with accepted practices and available data?

The Review Panel concluded that the projection methodology was consistent with accepted practices and appropriate for the available data. The projection framework is designed to operate with SS outputs and can evaluate future stock trajectories under alternative fishing mortality or catch scenarios. The Allocation Forecasting framework developed by the SEFSC provides an established mechanism for conducting forecasts using SS3 assessment results and allocating catches among fleets. The methodology can accommodate alternative recruitment assumptions, fishing mortality targets, catch limits, and fleet allocations and can provide projected SSB, allowable catches, and stock-status metrics.

b) Are the methods appropriate for the assessment model and outputs?

The Panel concluded that the projection methodology was appropriate for the assessment model and its outputs. The forecasting framework was developed specifically for use with SS and therefore provides an internally consistent means of projecting assessment results. The Assessment Team appropriately acknowledged several important caveats and advised that projection results be interpreted carefully.

c) Are the results informative and robust, and useful to support inferences of probable future conditions?

Final projections corresponding to the KEYS_RW_Base model were not available for evaluation by the Panel during the Review Workshop. The Panel therefore could not reach a conclusion regarding the informativeness or robustness of the projection results for the revised model.

The Panel requested that projections for the KEYS_RW_Base model be completed following the Review Workshop and prior to presentation of the assessment to the SAFMC's SSC. Accordingly, the Panel's endorsement under TOR 4 applies to the projection methodology, not to projection results that were unavailable for review.

d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

The Review Panel identified an important limitation of the projection framework: projections are deterministic and do not propagate assessment uncertainty from the terminal year into future stock trajectories. Likewise, using average recruitment in future years does not represent interannual recruitment variability. Although selection of long-term or recent average recruitment is a standard forecasting approach, actual future recruitment will vary around those expectations. However, conducting stochastic projections were not in the TORs of the AW, which is why the Assessment Team did not consider uncertainty in the projections.

The Panel therefore recommends development and evaluation of probabilistic projections that propagate relevant parameter and state uncertainty and, where appropriate, future recruitment variability. Such projections could provide explicit probabilities of future biomass falling below applicable thresholds or fishing mortality exceeding reference points. Because final projections from the KEYS_RW_Base model were not available during the workshop, the extent to which uncertainties are reflected in those specific projection results could not be evaluated.

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- **Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods**
- **Ensure that the implications of uncertainty in technical conclusions are clearly stated**

The Panel concluded that the assessment employed an extensive and generally appropriate suite of methods for evaluating uncertainty. These included variance estimates associated with input data, likelihood profiles, sensitivity analyses, jitter analyses, retrospective analyses, asymptotic standard errors, MCMC analyses, and parametric bootstrap analyses.

The assessment estimated a large number of biological, recruitment, catchability, selectivity, and retention parameters. Uncertainty associated with input datasets was incorporated into SS3 as appropriate, and likelihood profiles and sensitivity analyses were used to evaluate influential assumptions and model configurations. However, the MCMC and bootstrap analyses available in preparation for the Review Workshop corresponded to the Assessment Workshop model beginning in 1950. During the Review Workshop, the Panel recommended replacing that configuration with the 1986-start KEYS_RW_Base model. It was not possible to complete corresponding MCMC and bootstrap analyses for the revised model during the workshop. Consequently, although the Panel considered MCMC,bootstrap methods, sensitivity analyses, and R0 and steepness likelihood profiles appropriate and useful for characterizing assessment uncertainty, the Panel did not review completed full diagnostics for the final KEYS_RW_Base model during the Review Workshop. Those analyses were requested for completion before subsequent SSC consideration.

The need to use a proxy model for MCMC analysis introduces an additional methodological qualification. The sum-to-zero constraint on recruitment deviations used in the base assessment interferes with efficient MCMC exploration and therefore must be removed in the proxy configuration. Because the proxy model produced some differences in estimated stock size additional research is warranted to understand the consequences of this modification and to evaluate alternative approaches to posterior sampling.

6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.

- **Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments**

The Review Panel supports the research recommendations developed during the Data and Assessment Workshops and identified several additional priorities that could improve future assessments of the East Florida–Florida Keys Hogfish stock.

1. Improve understanding and modeling of protogynous hermaphroditic population dynamics.

    - This represents a high research priority. Future work should investigate the recruitment and reproductive dynamics of protogynous, harem-forming species and evaluate how social structure affects sex transition. The current assessment represents sex transition primarily as an age-dependent process, whereas hogfish sex change may also depend strongly on the local abundance or density of males. Research should evaluate whether the probability of female-to-male transition changes with male density and how fishing-induced changes in population sex ratio affect reproductive output. Simulation studies and explicitly sex-structured population models could be particularly useful for evaluating these processes and the implications of size-selective harvest regulations for protogynous species.

- Related work should investigate the potential for sperm limitation or male limitation and the prevalence of skip spawning. These processes could influence the relationship between conventional measures of spawning biomass and realized reproductive output and may help explain why a conventional stock-recruit relationship is difficult to estimate for this species.

2. Improve life-history, age, length, and discard information.

   - Improving and updating basic biological and fishery information should remain a high priority. Better age and length information would strengthen estimation of growth, selectivity, mortality, and population age structure.
   - For the KEYS stock specifically, obtaining a more reliable estimate of maximum age is recommended. Maximum age provides important information for evaluating natural mortality-at-age assumptions, and improved information would help validate the natural mortality vector used in future assessments.
   - Discard information also remains limited and should be improved, particularly where sample sizes are insufficient to characterize discard magnitude, composition, and mortality reliably.

3. Improve recreational fishery information.

   - Recreational harvest and discard estimates, particularly for the spear sector, remain relatively uncertain because of low positive-trip interception rates and correspondingly high sampling variability. Improved sampling approaches or supplemental data collection could reduce uncertainty in these removals.
   - The historical catch reconstruction considered during SEDAR 94 also demonstrates the importance of developing and maintaining reliable recreational fishery information. Future historical reconstructions should explicitly characterize uncertainty in both effort and CPUE assumptions and evaluate how those uncertainties affect population-scale and productivity estimates before such data are used to inform initial stock conditions.

4. Evaluate fishery-independent survey coverage and data gaps.

   - All available fishery-independent indices, including those excluded during the DW, should be evaluated systematically for geographic and habitat coverage, sample size, and availability of age and length information.
   - The differences in selectivity among surveys considered during SEDAR 94 illustrate the importance of understanding survey depth distributions, habitat coverage, fish availability, and spatial patterns of fishing pressure when interpreting fishery-independent indices. The Review Panel noted that two of the three fisheries independent surveys occurred in a region where fishing pressure was minimal and thus may not be reflective of the stock status in regions where fishing is actively occurring.

5. Evaluate uncertainty estimation methods.

   - Future research should compare uncertainty distributions obtained from MCMC, parametric bootstrap, and asymptotic normal approximations. Comparisons on

both arithmetic and log scales could help determine when conventional covariance-based uncertainty estimates provide adequate inference and when computationally intensive MCMC or bootstrap methods materially improve characterization of uncertainty.

- Alternative MCMC algorithms and assessment frameworks capable of incorporating random effects or state-space processes should also be evaluated where appropriate.
- Particular attention should be given to the MCMC proxy-model issue identified during SEDAR 94. The statistical consequences of removing the recruitment-deviation sum-to-zero constraint should be investigated, as should alternative methods that permit posterior sampling without requiring changes to the base-model configuration.

6. Evaluate super-period and growth-platoon assumptions.
    - Additional research should examine the statistical properties of super-periods used to address sparse composition data. The approach was accepted for the current assessment, but its potential effects on parameter estimation and uncertainty are not well understood.
    - Sensitivity analyses should also be conducted for the SS3 growth-platoon specification to identify whether alternative platoon assumptions materially influence growth, selectivity, population scale, or status estimates.
7. Investigate sex-specific growth.
    - Although available residual diagnostics supported the assumption of equal male and female growth for the current assessment, further biological and modeling work should evaluate whether sex-specific growth differences are important for hogfish assessment results.
8. Evaluate environmental effects and stressors.
    - Future research should investigate environmental influences on natural mortality, recruitment, movement, and habitat use. Potential factors include red tides and other harmful algal blooms, cold events, oil spills, and other disturbances that could affect hogfish population dynamics independently of fishing.
9. Revisit the Review Workshop Terms of Reference and alignment among SEDAR stages.
    - The Panel recommended reviewing the structure and wording of the Review Workshop TORs to improve clarity regarding the Panel's expected role. In particular, TORs requiring evaluation of the robustness of projection results may be difficult to address when final projections change following Review Workshop recommendations or when the SSC is expected to request alternative projection scenarios.
    - Greater alignment among Data Workshop, Assessment Workshop, and Review Workshop TORs would also be beneficial. Important Assessment Workshop

tasks, such as bridge analyses between previous and current assessments, should be reflected explicitly in Review Workshop TORs when evaluation of those analyses is expected.

- **Provide recommendations on possible ways to improve the SEDAR process**

  The RP commented that some TORs may need to be revisited or clarified. E.g., the text on BSIA may need updating, and the evaluation of the projection results may be a task for the SSC, rather than a RP. Also, the RP noted that the bridging analysis (see TORs for the assessment phase) was not very informative given the length between assessments and resulting changes in the data and the model. It was therefore not evaluated by the RP.

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 the SEDAR 94 East Florida-Florida Keys hogfish stock assessment is scientifically sound, uses the available data appropriately, and provides a suitable basis for management advice.

8. **Provide suggestions on key improvements in data or modeling approaches that should be considered when scheduling the next assessment.**

Completion of any of the research recommendations provided for ToR 6 is not required before scheduling the next assessment.

Revisions and recalibration of MRIP fishing effort may warrant a new assessment.

9. **Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Peer Review Summary Report in accordance with the project guidelines.**

This report represents the Peer Review Summary summarizing the Panel's evaluation of the SEDAR 94 East Florida-Florida Keys hogfish stock assessment and addressing each Term of Reference.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 94

Florida Hogfish

SECTION VI: Addenda and Post-Review Workshop Report

July 2026

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

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

Table of Contents

Table of Contents....2
1 Introduction....3
2 Additional Data Requests....3
2.1 Data Plots....3
3 Additional Requests for Base Model Results....3
3.1 Florida Keys/East Florida....3
3.1.1 Stock-Recruitment....4
3.2 West Florida Shelf....5
4 FL KEYS/EFL Stock Synthesis Model Results: KEYS RW Base Model....5
4.1 Life History....5
4.2 Landings and Discards....6
4.3 Indices....6
4.4 Length and Age Composition....6
4.4.1 Data Weighting....6
4.4.2 Length Composition....7
4.4.3 Conditional Age-at-Length....7
4.5 Estimated Parameters and Derived Quantities....7
4.5.1 Stock Biomass (Total and Spawning)....7
4.5.2 Recruitment....7
4.5.3 Fishing Mortality....8
4.5.4 Selectivity and Retention....9
4.6 Model Diagnostics....9
4.6.1 Convergence....9
4.6.2 Goodness of fit....10
4.6.3 Model Consistency....10
4.6.4 Model Validation (Prediction Skill)....12
4.7 Per-recruit Analyses....12
4.8 Uncertainty in Parameters and Derived Quantities....13
4.8.1 MCMC Analysis....13
4.8.2 Parametric Bootstrap....13
4.9 Stock Status Determination Criteria....13
4.10 Projections....14
4.10.1 Results....15
5 Tables....17
6 Figures....36

1 Introduction

The SEDAR 94 Florida Hogfish Assessment Review Workshop (RW) took place July 14 – 17, 2026, in Charleston, SC. During the RW, the SEDAR 94 RW Panel requested additional details or analyses from the analytical team, which are summarized below.

2 Additional Data Requests

2.1 Data Plots

Residual plots from the external growth models for each stock were developed during the Data Workshop (DW) and are presented in the DW Report at Figure 2.13.31 for the Florida Keys/East Florida stock and Figure 2.13.38 for the West Florida Shelf stock. Figures 2.13.31g and 2.13.38g showed the residuals by age while Figures 2.13.31e and 2.13.38e showed the residuals by sex aggregated across ages. The RW Panel requested additional residual plots by age but separated by sex to further explore whether Hogfish exhibited sexual dimorphism. Here, Figure 1 and Figure 2 show the residuals by age and separated by sex from the Florida Keys/East Florida and West Florida Shelf external growth models, respectively.

The RW Panel wanted to further understand, for each stock, the contribution of each fleet to the total dead catch (i.e., retained landings plus dead discards), particularly in the post-2017 regulatory time block when discards were increasing in trend. Figures 3a and Figures 3b illustrate the proportion of total dead catch (in numbers) per fleet for the Florida Keys/East Florida stock and West Florida Shelf, respectively.

During the Assessment Workshop (AW) process, the AW panel determined for the WFS model to remove the conditional age-at-length data from the commercial, recreational hook-and-line, recreational spear, and fishery-independent trawl sources. The WFS base model, therefore, retained only the SEAMAP and fishery-independent spear conditional age-at-length data as the most reliable data sources to inform the internal estimation of growth and in effort to remove conflicting data sources in a model already relying primarily on composition data to inform population scale. The RW panel wished to see those age data, and they are presented in Figures 4 – 7.

3 Additional Requests for Base Model Results

3.1 Florida Keys/East Florida

In Figure 3.34b of the AW Report, estimates of spawning stock biomass separated by sex were presented which indicated trends in biomass were largely influenced by male biomass. Within the KEYS base model, male Hogfish are generally larger and heavier than females due to the combination of the length-weight and hermaphroditism functions input to the model. The RW panel wished to see the total abundance (in numbers) separated by sex to verify the model was estimating more numbers of females and that the trend in abundance was influenced more by the numbers of females within the population. This is presented in Table 1 and Figure 8.

Discussion arose over the retrospective analysis and why a pattern was presenting itself during model development in the AW process. The RW panel discussed treatment of the recruitment deviations in the terminal years, data weighting (whether using the Dirichlet-multinomial or Francis) and the use of lambdas, as well as catchability of the indices across retrospective peels. The RW panel requested to see

how estimates of catchability for the three indices, particularly for the RVC Dry Tortugas index, changed across the six retrospective peels. They are presented in Table 2 and Figure 9 and show that estimates of catchability for the RVC Dry Tortugas index generally increased with more successive peels while the RVC Florida Keys and combined video indices were more consistent across peels.

The RW panel wished to see how changes in assumptions of natural mortality impacted various parameter estimates and model derived quantities. Specifically, they were interested in seeing how model likelihood, growth and stock-recruitment parameters, as well as MSY- and SPR-based reference points responded. These results from the three natural mortality scenario sensitivity runs are presented in Table 3. The "HamelCope_age3" and "est_HamelCope_age3_noprior" scenarios showed similar estimates of model fit via total log likelihood, growth and stock-recruitment parameters, and F_{MSY}; however, they differed slightly in remaining reference point values. In contrast, the "est_HamelCope_age3" scenario estimated a larger asymptotic size, a larger virgin population size, worsened fits to the data via total log likelihood, and different reference point values.

3.1.1 Stock-Recruitment

During the RW, lengthy discussion occurred regarding the uncertainty of the stock-recruitment relationship within the KEYS base model. Of particular concern was the reliance of the reconstructed recreational landings data to inform the *steepness* parameter (h) and to better inform the *ln(R0)* parameter (i.e., create an 'anchor point') and the uncertainty surrounding those reconstructed landings data. Discussion was also brought up about the results of the "1986 Start Year" sensitivity run described in the AW Report (Sections 2.12.5.1 and 3.6.5.1) which assumed recruitment deviated around an average, yet showed a *steepness* parameter profile indicating the data were informing a value much lower than 0.99 (Figure 3.55g in the AW Report). However, upon further investigation during the RW, it was uncovered that when the "1986 Start Year" model was allowed to estimate the *steepness* parameter, it could no longer reliably estimate the *ln(R0)* parameter (i.e., it chased the upper bound at $ln(14)$), thereby making the profile plot misleading.

Further discussion occurred regarding how the results of the KEYS base model and the "1986 Start Year" sensitivity run were largely similar (see Section 3.6.5.1 in the AW Report), despite significantly different assumptions about the relationship between spawning stock size and recruitment. The RW panel requested whether any model diagnostics for the "1986 Start Year" sensitivity model had been conducted. As noted in Section 2.12.5.1 in the AW Report, this model was developed during the AW process alongside what would become the KEYS base model (indeed, it was the original preliminary base model) and was deliberated over by the AW panel. Therefore, model diagnostics (e.g., residual analyses, retrospective analyses, jitter analysis, and parameter profiling) were already completed and compiled within an AW presentation and shared with the RW panel.

Ultimately, the RW panel concluded that while the stock-recruitment relationship as estimated by the KEYS base model was informative, it was not reliable and useful for management. This was primarily due to the uncertainty of and the reliance on the reconstructed recreational landings data as well as the sensitivity of the *steepness* estimate to initial model conditions. The RW panel consented to reject the KEYS base model in favor of the "1986 Start Year" model which they concluded to also be stable, pass model diagnostics, but did not make the same assumptions for the stock-recruitment relationship. However, no uncertainty analyses (i.e., MCMC or bootstrapping) nor any projections were performed for this model given its rejection during the AW process. Therefore, the analytical team were tasked by the

RW panel with conducting these analyses post-RW. Furthermore, since the results of the "1986 Start Year" model were not presented in detail in the AW Report, but only as a comparative sensitivity run, the results will be presented in detail below in Section 4. The "1986 Start Year" sensitivity model for the Florida Keys/East Florida stock will, hereafter, be referred to as the "**KEYS RW base model**" and the original KEYS base model will, hereafter, be referred to as the "AW KEYS base model".

3.2 West Florida Shelf

As requested for the AW KEYS base model, the RW panel wished to see how changes to assumptions of natural mortality impacted various parameter estimates and model derived quantities for the WFS base model. These results from the three natural mortality scenario sensitivity runs are presented in Table 4 and show how the WFS base model compensates between mortality, growth, and recruitment to estimate population size, as noted in Section 4.6.5.1 in the AW Report.

The WFS base model was configured such that landings for all three fleets (COM, REChl, RECsp) were fit near exact within the model. This was accomplished using the F_{hybrid} configuration and was explored during the model development process of the AW. Since recreational landings for Hogfish were highly uncertain, the RW panel requested to see how the WFS base model incorporated that uncertainty for the REChl fleet by configuring it with F as a parameter (F_{par}). When annual fishing mortality rate parameters are estimated for any given fleet, estimated landings are not an exact fit to the observed landings and account for associated error in the landings data. Estimates of spawning stock biomass (Figure 10a) and exploitation rates (Figure 10b) were found to be relatively insensitive; however, the uncertainty surrounding these estimates, represented by the annual CVs, increased by 9.2% for spawning stock biomass (Figure 10c) and by 15.4% for exploitation rates (Figure 10d).

4 FL KEYS/EFL Stock Synthesis Model Results: KEYS RW Base Model

The KEYS RW base model was developed in Stock Synthesis (SS) version 3.30.24.1 and was largely identical in configuration to the AW KEYS base model apart from a few key model assumptions. First, the KEYS RW base model started in 1986 which therefore removed the influence of both the historic commercial landings data as well as the reconstructed recreational landings data for years 1950 – 1985. Secondly, it assumed that annual recruitment deviated around a long-term average (i.e., *steepness* = 0.99) rather than assuming a stock-recruitment relationship.

4.1 Life History

The KEYS RW base model internally estimated growth where asymptotic length (L_{inf}) was estimated at 51.9 cm FL and the growth coefficient (k) was estimated at 0.173. Using the platoons feature within SS, this corresponded to the 3rd platoon (of the 5 total platoons) which was apportioned 46.4% of annual recruitment. The estimated mean length-at-age was found similar to the results of the external growth model developed during the Data Workshop (Figure 11; see Section 2.3.5 in the Data Workshop Report) and the additional platoons allowed fish to grow faster (i.e., larger) and slower (i.e., smaller). For example, in the fourth platoon, where 23.7% of annual recruitment was apportioned, mean fish size was as large as 63.6 cm FL; but in the second platoon, also receiving 23.7% of recruitment, mean fish size was as large as 34.4 cm FL. These faster growing fish became vulnerable to the fisheries sooner whereas the

slower growing fish encountered the fisheries much less, helping to mimic the "Lee phenomenon" hypothesized to be occurring in this stock. Furthermore, the platoon within/between standard deviation ratio parameter was estimated at 0.77, suggesting a shift to lower mean size-at-age has been occurring for this population.

4.2 Landings and Discards

Fits to the landings data for the commercial and recreational fleets are presented in Figures 12 – 13. The fits to the commercial landings were nearly exact (total negative log-likelihood = 3.46e-05) while the recreational landings were allowed more flexibility given their higher observation error (total negative log-likelihood = 15.896). The KEYS RW base model generally fit the observed recreational landings well except in 1988 and 2005, which expected much higher landings, and in years 2008, 2012, and 2015, which expected lower landings. Figure 14a and Figure 14b compares model estimated landings across fleets in biomass and numbers of fish, respectively.

Fits to the recreational discard data were well (total negative log-likelihood = -0.169) as most estimates were close to the observed values and within the 95% confidence intervals (Figure 15) except for year 2009 which estimated higher numbers of fish discarded.

4.3 Indices

The KEYS RW base model fits to the three fishery-independent indices (RVC Florida Keys, RVC Dry Tortugas, and combined video) are presented in Figures 16 – 18. Model fits to the indices were overall well (total negative log-likelihood = 9.157) and seemed to follow a similar common trend.

Model fits to the RVC Florida Keys index were fair (RMSE = 0.2590), but misfit in certain years contributed the most to the model's overall total negative log-likelihood for the index component (Figure 16). The observed trend started very low and gradually increased through time until the series high in 2024. But the model expected higher abundances in those first two years before becoming more aligned through 2018. Fits to years 2022 and 2024 behaved as a flat average between the two observed values for two primary reasons: 1) the model balanced fitting the other two indices, and 2) the model's main recruitment deviations for 2022 – 2024 were configured to follow average recruitment (see Section 2.6 in the AW Report).

Fits to the RVC Dry Tortugas index were closest (RMSE = 0.1570) and the observed trend was similar to the RVC Florida Keys index. The fitted values followed the observed stable but variable trend through the 2000s and then increased from 2018 – 2024 (Figure 17).

Lastly, model fits to the combined video index were the worst of the three (RMSE = 0.3730), but this index also contained the greatest amount of observed error. The fitted values generally followed the observed trend which began as an initial high in 1993 and gradually decreased though 1997, became stable but variable through 2017, then began gradually increasing again (Figure 18).

4.4 Length and Age Composition

4.4.1 Data Weighting

Weighting of the length composition data using the Dirichlet-multinomial distribution resulted in $ln(\theta)$ parameters < 5 with most close to 0 (commercial landings: $\theta = 2.167$, recreational discards: $\theta = 1.052$, recreational landings: $\theta = -0.572$, combined video: $\theta = 0.434$, RVC indices: $\theta = -0.373$; Table 5). Thus,

theta ratios were all below 1.0 (commercial landings: 0.897, recreational discards: 0.741, recreational landings: 0.361, combined video: 0.607, RVC indices: 0.408).

4.4.2 Length Composition

The KEYS RW base model fits to the length composition data along with the Pearson residuals associated with the landings, discards, and indices are presented in Figures 19 – 23. The quality of the fit varied among fleets and indices and fits aggregated across time were reasonable (length component: total negative log-likelihood = 521.906; size component: total negative log-likelihood = 1103.6). Fits to these data were largely identical to the fits by the AW KEYS base model (see Section 3.4.2 of the AW Report) and therefore will not be repeated in description here.

4.4.3 Conditional Age-at-Length

The KEYS RW base model fits to the CAAL data associated with the landings as well as fishery-independent spear and trawl data are presented in Figures 24 – 28. The quality of the fit varied among data sources and fits to their aggregated mean ages were generally acceptable (total negative log-likelihood = 620.211). As with the length composition data, fits to the CAAL data were largely identical to the fits by the AW KEYS base model (see Section 3.4.3 of the AW Report) and will not be repeated here.

4.5 Estimated Parameters and Derived Quantities

The SEDAR 94 KEYS RW base model estimated most parameters reasonably well (i.e., $|CV| < 1$; Table 6). Of the 130 active parameters, 19 exhibited poor estimation (i.e., $|CV| > 1$); including 14 recruitment deviations and 5 parameters describing selectivity (mostly commonly the top logit and/or end logit parameters). No parameters were estimated near bounds.

4.5.1 Stock Biomass (Total and Spawning)

The predicted total biomass and spawning stock (mature female plus male) biomass are summarized in Table 7 and Figure 29a-b. Both trends in biomasses gradually decreased through time from 1986 until about the year 2000, then became stable but variable through 2017, then began increasing again through 2024 (Figure 29a-b).

The unfished spawning stock biomass (SSB_0) was estimated at 3,316.51 mt (Table 7, Figure 29b) where the estimated female spawning biomass was 831 mt and the male biomass was 2,485 mt (Table 8). In 1986, the depletion ratio (SSB/ SSB_0) was 0.786 and decreased to an average 0.406 from 1995 – 2017; it was lowest from 2006 – 2010 (avg. ratio = 0.337) but since 2018 has increased in trend from 0.435 to 0.674 in 2024 (Table 7). Temporal trends in the population reflected the model's configuration of the length-weight relationship as well as the hermaphroditism function. That is, trends in spawning biomass appeared to be influenced predominantly by changes in the male (i.e., larger and heavier) biomass (Table 8, Figure 30a), while the estimated numbers of the population were primarily influenced by changes to the females (i.e., smaller but more numerous; Table 8, Figure 30b).

4.5.2 Recruitment

The relationship between spawning stock biomass and age-0 fish was parameterized within SS using the Beverton-Holt stock-recruitment model and is presented in Figure 31. However, the *steepness* parameter was fixed at 0.99, thereby configuring recruitment to deviate annually around a long-term average. The

sigmaR parameter was estimated at 0.411, and the *ln(R0)* parameter was estimated at 7.484 (Table 6), which equates to 1,778,579 age-0 Hogfish.

Simple annual deviations from the stock-recruitment function, which were constrained to sum to zero, were estimated assuming a lognormal error structure. Main recruitment deviations were estimated for years of greater data-richness (1981 – 2021) and corresponded to when the length and age composition data for the fleets began to become available. Values were slightly above average from 1981 – 1992, below average from 1993 – 2001, then oscillated above and below through 2021 (Figure 31b). As observed during the AW model development process, estimated recruitment in the last three years (2022 – 2024) was highly elevated, following the index of abundance trends and corresponded to the stock continuing to recover after management intervention beginning in 2017. But this configuration also produced a retrospective pattern due to the model's inability to predict that recovery trend as the terminal years of the model withdraw. As with the AW KEYS base model (see Section 2.6 and Section 2.14.1.1 in the AW Report), introducing process error by removing the deviations for years 2022 – 2024 (i.e., recruitment followed the long-term average recruitment instead) eliminated the retrospective pattern for the KEYS RW base model.

The estimated annual recruitment of age-0 Hogfish to the biological population in the Florida Keys/East Florida is summarized in Table 7 and Figure 31a-b. Recruitment was above average from 1986 – 1992 (avg. 2.188 million fish), diminished considerably from 1993 – 1998 (avg. 0.995 million fish), then became stable but variable through 2021 to 2.319 million fish (Figure 31a). From 2022 – 2024, recruitment was 1.776 million fish. Recent notably high years of recruitment were estimated to be in 2007 (2.591 million fish), 2012 (2.580 million fish), 2013 (2.113 million fish), and 2015 (2.921 million fish).

The estimated (and applied) recruitment bias adjustment ramp as recommended by Methot and Taylor (2011) is shown in Figure 32. However, the recommended bias adjustment showed some instability in the KEYS RW base model, which was observed and discussed during the AW process. The recommended values tended to oscillate between two different vectors, rather than converge on a single solution, and may have been influenced by the recruitment deviation's sum-to-zero constraint.

4.5.3 Fishing Mortality

The annual exploitation fishing mortality rates on Florida Keys/East Florida Hogfish are presented in Table 9 and Figure 33. Exploitation rates generally followed the trend in catch; between 1986 and 1994 exploitation averaged 0.095 yr^{-1} with a high in 1988 (0.165 yr^{-1}). From 1995 – 2017, exploitation rates were variable with notable highs in 2005 (F = 0.262 yr^{-1}), 2009 (F = 0.209 yr^{-1}), and 2015 (F = 0.174 yr^{-1}; Table 9, Figure 33). After new regulations (SAFMC Snapper Grouper Amendment 37) were implemented near the end of 2017, exploitation averaged 0.021 yr^{-1} for years 2018 – 2024.

Fleet-specific fishing mortality rates (i.e., instantaneous apical rates representing the fishing mortality level on the most vulnerable age class) are also provided in Table 9 and Figure 34. Apical fishing mortality rates were considerably higher for the recreational fleet and, like the exploitation rates above, followed the trend in annual catch. In contrast, commercial fishing mortality rates were very low but were highest between 1986 – 2005 (Table 9, Figure 34).

4.5.4 Selectivity and Retention

Selectivity for all fleets and indices was estimated using length-based selectivity functions which the KEYS RW base model used to further derive age-based selectivity (Figures 35 – 39).

Selectivity of Hogfish for the commercial fleet was time-varying to follow changes in minimum size regulations; without discard estimates (which must be assumed negligible) or discard length composition data, selectivity here functioned as retention. Selectivity was dome-shaped generally between 27 – 41 cm FL from 1986 – 1994, 29 – 41 cm FL from 1995 – 2017, and 39 – 53 cm FL from 2018 – 2024; an asymptote of 55% was reached in all three time blocks (Figure 35). In the first two time blocks, fish became vulnerable beginning at age-2 before becoming more fully selected by ages 5 and 6; age-derived selectivity of fish in the 2018 – 2024 time block was more gradual due to the increase in minimum size, beginning around age-3 and continuing to age-16 (Figure 38).

Dome-shaped selectivity of Hogfish by the recreational fleet was generally between 23 – 54 cm FL, reaching an asymptote of 7% by 55 cm FL (Figure 36a-c). Age-derived selectivity was primarily across ages 2+ with fuller selectivity occurring between ages 4 – 6 (Figure 39). Retention was time-varying and fish were fully retained by 9 cm FL from 1986 – 1994 (Figure 36a), 33 cm FL from 1995 – 2017 (Figure 36b), and 55 cm from 2018 – 2024 (Figure 36c). Note that where retention was estimated to occur well below 23 cm FL from 1986 – 1994, it meant fish vulnerability still followed the estimated selectivity curve and that, given the absence of minimum size limits, whatever negligible number of fish were encountered were retained. Furthermore, this time period contained no discard length composition data; thus, discards-at-length from 1986 – 1994 followed selectivity and the additive inverse of retention. From 1995 – 2017, Hogfish were discarded largely between 21 – 33 cm FL (Figure 36b), whereas fish from 2018 – 2024 were discarded in greater proportion across a wider range from 21 – 51 cm FL due to the increased minimum size limit and reduction in daily bag limit (Figure 36c).

The selectivity (vulnerability to observations by divers) of Hogfish by the RVC Florida Keys index was dome-shaped, occurring mostly between 11 – 53 cm FL and reached an asymptote of 11% by 55 cm FL (Figure 37). Juvenile fish started to become vulnerable at about 9 cm and individuals became fully selected between 21 – 29 cm FL (Figure 37). Age-derived selectivity occurred across all ages with fish becoming more fully selected at ages 2 – 3 (Figure 39). In the RVC Dry Tortugas index, selectivity was dome-shaped and primarily occurred on larger individuals between 29 – 87 cm FL (Figure 37). As a result, age-derived selectivity appeared more flat-topped by gradually increasing from age 1 to the maximum age (Figure 39). Fish observed by the combined video index, which operated near and north of the Dry Tortugas but sampled deeper waters, began to be selected around 11 cm FL and became fully selected by 41 cm FL (Figure 37). Age-derived selectivity of this index started at age-1 and became more fully selected by ages 10+ (Figure 39).

4.6 Model Diagnostics

4.6.1 Convergence

The SEDAR 94 KEYS RW base model converged with a total objective function of 2253.57. The model contained no parameters on the bounds, had a small final gradient <0.0001, and had a positive definite Hessian matrix. Highly correlated parameters were inspected, but all were found to be structurally correlated and therefore left as-is estimated in their different model phases.

The results of the jitter analysis, where initial values for each parameter were jittered by 20%, found that no jittered runs contained a total likelihood lower than the KEYS RW base model and suggested that the base model had converged on a global solution (Figure 40). Furthermore, 91 jittered runs were found within 2 total likelihood units of the KEYS RW base model. All 100 jittered runs converged where 71% had a low gradient (<0.0001) and the maximum gradient observed was 0.0008605.

4.6.2 Goodness of fit

The residuals from the various data components of the KEYS RW base model were very similar to the residuals observed by the AW KEYS base model. Therefore, discussion will be more abbreviated here.

The joint residual plots for the indices (Figure 41a), mean length composition data (Figure 41b), the conditional age-at-length data (Figure 41c), and the mean general size composition data (Figure 41d) indicated reasonable fits to the data as combined RMSE values were 0.298, 0.023, 0.316, and 0.105 respectively. As illustrated by the loess-smoother and size of the boxplots, residual variability of the indices was more positively biased at the beginning of the timeseries due to the more poorly fit combined video index (RMSE = 0.373). When the RVC indices became available in 1999, the overall trend centered around zero through 2009 then became more negatively deviated until reaching near zero again in the terminal years (Figure 41a). Due to the application of super-periods, the frequency of mean length residuals was only during the start of those periods; residuals and interquartile ranges of these data were small and consistent across time, indicating general agreement with the fisheries and index data (Figure 41b). In the conditional age-at-length data, residuals were more negatively biased in the beginning and end of the timeseries as influenced by the poorer-fitting fishery-independent trawl ages (RMSE = 0.666) and, to a lesser extent, the recreational ages (RMSE = 0.235; Figure 41c). Lastly, the fits to the mean size data for the RVC indices were well and mostly centered around zero across the timeseries (Figure 41d).

The residual series of all three indices passed the runs test, indicating residuals were sufficiently random and without significant autocorrelation (Figure 42). Only the recreational length composition data had sufficient observations for the runs test and passed (Figure 43a). As was observed in the AW KEYS base model, the size composition data for both indices failed due to each having two years of residuals greater than three standard deviations with some possible temporal autocorrelation (Figure 43b). The conditional age-at-length residuals for the commercial landings and both fishery independent fleets passed the runs test, but the residuals for the recreational landings failed by showing some positive temporal autocorrelation from 2009 – 2016 as well as a residual in 2004 greater than three standard deviations (Figure 44).

4.6.3 Model Consistency

4.6.3.1 Likelihood Profiles

The likelihood profile on the *ln(R0)* parameter revealed that the parameter was influenced by the index and length composition components as well as by the recruitment and age data components, behaving as a middle-ground between these two sets of data components (Figure 45a). The profile minimum agreed with the KEYS RW base model estimate of 7.48, but also indicated a parameter estimate between ~7.3 – 7.7 would not produce a significantly worse fit to the data (i.e., change in log-likelihood <2 units).

The profile of the *steepness* parameter indicated that a substantially better model fit could be achieved at a value of approximately 0.35 (Figure 45b). This result was driven primarily by the recruitment component and both RVC size composition components, which consistently favored steepness values between 0.30

and 0.35. In contrast, the index component—particularly the RVC Dry Tortugas and combined video indices—supported substantially higher values (>0.6).

Figure 46 shows the relationship between the two correlated parameters, *steepness* and *ln(R0)*, during the *steepness* profiling exercise. As *steepness* decreased from 0.99, the freely estimated *ln(R0)* parameter became increasingly unstable. This instability was most pronounced at the lower *steepness* values identified by the profile, where *ln(R0)* approached its upper parameter bound of *ln*(14). This behavior motivated the inclusion of the historical and reconstructed landings time series during the AW process, as these data provided an important "anchor point" for estimating *ln(R0)*. Without these data, neither *steepness* nor *ln(R0)* was well informed at these lower values, causing the *steepness* profile to produce misleading results.

4.6.3.2 Age-structured Production Models

The results from the ASPM indicate that there is enough information in both the catch and index data for the production function to largely drive the stock dynamics and for the model to be adequately informed about scale (Figures 47 – 48). Catches were high in the mid-1980s through early 1990s, when the combined video index showed a decline in abundance, then catches and indices became stable but variable through 2017, then catches further declined while indices increased in trend through 2024. As seen in the AW KEYS base model diagnostic, the ASPM greatly benefited from the F as a parameter configuration (process error) which allowed the model to access the observational error of the catch in order to compensate for the lack of recruitment deviations. Here, the ASPM was able to artificially estimate significantly higher exploitation rates in 1999 and 2001 (Figure 47b), when all three indices become available, in order obtain a close enough estimate of absolute scale in which to adequately fit those indices (Figure 48b-d) and continue following the population trends of the KEYS RW base model.

The estimate of *ln(R0)* by all three models generally overlapped in distribution; however, the KEYS RW base model had the highest *ln(R0)* estimate, indicating the composition data contained some information on unfished population scale (Figure 48a). The ASPM with recruitment deviations (ASPMdev) estimated the lowest population scale (Figure 47a) with correspondingly larger exploitation rates, especially from 2012 – 2017 (Figure 47b), and followed the same trends as the KEYS RW base model and the ASPM, further indicating the inclusion of length and age composition data in the KEYS RW base model is still informative to estimates of population scale. The trend in age-0 recruitment and recruitment deviations of the ASPMdev was also very similar to the KEYS RW base model (Figure 47c-d), suggesting the model needed that process error in order to better fit the trends in the indices. Indeed, without the influence of the composition data, fits to all three indices by the ASPMdev were improved.

Fits to the RVC Dry Tortugas index ($RMSE_{ASPMdev}$ = 0.102; $RMSE_{ASPM}$ = 0.142; Figure 48c; Table 10) were the best, followed by the RVC Florida Keys index ($RMSE_{ASPMdev}$ = 0.208; $RMSE_{ASPM}$ = 0.339; Figure 48a; Table 10). The combined video survey was the worse fitting of the three indices ($RMSE_{ASPMdev}$ = 0.347; $RMSE_{ASPM}$ = 0.397; Figure 48d; Table 10).

4.6.3.3 Retrospective Analysis

The retrospective analysis showed a slight pattern in estimates of spawning stock biomass and exploitation after removing six successive years from the terminal year. Spawning stock biomass tended to decrease in trend while exploitation tended to increase in trend (Figure 49a-b). All runs were within the 95% confidence interval of the KEYS RW base model, converged, and contained no parameters on the bounds. Furthermore, the calculated values for Mohn's rho for SSB (ρ_M = -0.090; Table 11) and

exploitation (ρ_M = 0.076; Table 11) were within the "acceptable" range for longer-lived species according to Hurtado-Ferro et al. (2015). As observed in the AW KEYS base model, the KEYS RW base model needed the inclusion of process error in the form of recruitment deviations ending in 2021 and the sum-to-zero constraint to eliminate the stronger retrospective pattern observed in earlier developed models.

4.6.4 Model Validation (Prediction Skill)

Retrospective forecasting showed that the one year forward projections were largely consistent with the overall estimated trend in the reference model and were similar in trend to the results of the retrospective analysis (Figure 49a-b). All retrospective forecasts fell within the 95% confidence interval of the KEYS RW base model. The forecast rho value for spawning stock biomass increased slightly to ρ_F = -0.085 and exploitation decreased to ρ_F = -0.096 (Table 11), suggesting model stability as well as consistency when successive data became available.

A hindcast with cross-validation of the terminal seven years of data was performed to gauge predictive capacity of the KEYS RW base model. From the indices, eleven total observations were available, and a joint MASE score of 0.655 indicated the KEYS RW base model predicted these indices almost twice as accurately as a naïve forecast (Table 12). All three indices scored similar MASE values; the RVC Dry Tortugas index was the lowest (MASE = 0.552, Table 12), followed by the combined video survey (MASE = 0.632, Table 12), and the Florida Keys index (MASE = 0.750, Table 12). Only the RVC Dry Tortugas mean size data indicated predictive capacity (MASE = 0.597, Table 12) while the number of super-period observations for commercial, recreational, and combined video mean length data precluded computing of prediction residuals. The MASE values for the conditional age-at-length (CAAL) data demonstrated low mean absolute errors and all CAAL data sources were better predicted by the KEYS RW base model than a naïve baseline prediction (joint MASE = 0.170; Table 12).

4.7 Per-recruit Analyses

The yield-per-recruit (YPR), spawner-per-recruit (SSB/R), static spawning potential ratio (SPR), and equilibrium yield analyses were computed as a function of the instantaneous exploitation rate on Florida Keys/East Florida Hogfish and are presented in Table 13 and Figures 50 – 51a. The retained yield at $F_{30\%SPR}$ for Florida Keys/East Florida Hogfish was estimated to be 106.702 mt (235,238 lbs.; Figure 50d) while the total yield (retained yield plus dead discards) at $F_{30\%SPR}$ was estimated at 212.250 mt (467,931 lbs.; Figure 50c). At exploitation rates greater than 0.30, corresponding to a 20% SPR and below (Figure 51a), the retained yield declines (Figure 50d). In contrast, total yield remains relatively constant (Figure 50c), indicating that any additional catch is offset by increasing dead discards. The retained yield associated with $F_{40\%SPR}$ was estimated at 98.714 mt (217,628 lbs.; Figure 50d), marking that a 7.5% decrease in retained landings produces a 10% increase to SPR.

The SPR values by year were calculated and are presented in Figure 51b. The average SPR from 1986 – 1994 was 0.458, then increased slightly to an average value of 0.498 from 1995 – 2017, then increased again from 2018 – 2024 to an average value of 0.843. The KEYS RW base model indicated that SPR had declined below 30% in 4 years of the timeseries (1988, 2005, 2009, and 2015) but had declined below 40% in 11 years of the timeseries (Figure 51b).

4.8 Uncertainty in Parameters and Derived Quantities

4.8.1 MCMC Analysis

An MCMC 'proxy' model was developed from the KEYS RW base model using the same methodology as was performed for the AW KEYS base model (see Section 2.14.1.1 in the AW Report) and as supported for use by the RW panel.

Four MCMC chains were produced based on this MCMC 'proxy' model. For each chain, a total of 5,000,000 iterations were performed but only one out of every 1,000 iterations were saved, resulting in 5,000 potential iterations used to generate estimates of uncertainty in parameters and derived quantities. Visual inspection of trace plots to adjust appropriate levels of burn-in and thinning as well as to address any autocorrelation in the iterations led to a burn-in of 1,000 with further thinning of every 4, resulting in 1,000 samples per chain. Each chain was found to have converged based on Geweke's diagnostic and a total of 4,000 iterations were utilized. The four chains were combined, and convergence was evaluated using trace plots (Figure 52) and the Gelman and Rubin's (1992) potential scale reduction factor (PSRF) for selected model parameters (*ln(R0)*, SSB_0, and *steepness*) and derived quantities (exploitation in 2024, SSB in 2024, $F_{30\%SPR}$, SSB at $F_{30\%SPR}$, and the retained yield at $F_{30\%SPR}$). PSRF values for all selected parameters and stock status criteria were close to 1 and since none of the PSRF upper confidence intervals exceeded the 'rule of thumb' value of 1.1, it was concluded that the final combined MCMC converged (Table 14).

Posterior distributions from the MCMC 'proxy' model were produced for stock-recruitment parameters (Figure 53) as well as the derived quantities of $F_{current}$ (Figure 54a), $F_{30\%SPR}$ (Figure 54b), the retained yield associated with $F_{30\%SPR}$ (Figure 54c), $SSB_{current}$ (Figure 54d), SSB at $F_{30\%SPR}$ (Figure 54e), and 75% of the SSB at $F_{30\%SPR}$ (Figure 54f). Estimated values of the KEYS RW base model were generally found to fall within the interquartile ranges of these posterior distributions (Figures 53 – 53) which further evidenced the MLE values were not "captured in a strange neighborhood".

4.8.2 Parametric Bootstrap

Five hundred bootstrapped datasets were produced from the KEYS RW base model by randomly drawing datasets according to assumed error distributions centered on fitted values. Results of the bootstrap analysis indicated that the model exhibited a measure of instability when fitting to the randomly generated data sets. From the 500 bootstrapped data sets, 330 runs (66%) had a gradient >0.0001 yet the maximum gradient observed was still relatively low at 0.5489. A total of 345 runs (69%) had at least one parameter on the bounds. However, distributions of selected parameter estimates and derived quantities were largely consistent with those observed in the posterior distributions from the MCMC 'proxy' model and the KEYS RW base model estimates generally fell within the interquartile ranges (Figure 55).

4.9 Stock Status Determination Criteria

A summary of the Florida Keys/East Florida Hogfish stock status determination criteria and their values according to the SAFMC from the SEDAR 94 KEYS RW base model is presented in Table 15.

The Maximum Fishing Mortality Threshold (MFMT) for Florida Keys/East Florida Hogfish is currently defined by the SAFMC Snapper Grouper Amendment 37 as $F_{30\%SPR}$ and overfishing is occurring if the recent average of fishing mortality rates ($F_{current}$) exceeds the MFMT. $F_{current}$ is calculated as the geometric

mean of exploitation rates for 2022 – 2024. Based on this, the MFMT was estimated by the KEYS RW base model to be 0.186 yr^{-1}, $F_{current}$ was estimated to be 0.018 yr^{-1}, and F_{2024} was estimated to be 0.014 yr^{-1} (Figure 56a). The $F_{40\%SPR}$ was estimated to be 0.125 yr^{-1} (Figure 56a). Using either of these reference points, the Florida Keys/East Florida Hogfish stock was not found to be experiencing overfishing ($F_{current}/F_{30\%SPR}$ = 0.099; $F_{current}/F_{40\%SPR}$ = 0.147).

The minimum stock size threshold (MSST) for Florida Keys/East Florida Hogfish is currently defined as 75 percent of the spawning stock biomass associated with $F_{30\%SPR}$ (i.e., 0.75* $SSB_{F30\%SPR}$). The stock is overfished if the recent average spawning stock biomass ($SSB_{current}$) is less than MSST. The $SSB_{current}$ is calculated as the geometric mean of the spawning stock biomass for 2022 – 2024 and was estimated to be 2,098.706 mt (4,626,855 lbs.) with SSB_{2024} estimated to be 2,236.94 mt (4,931,609 lbs.). The $SSB_{F30\%SPR}$ was estimated by the KEYS RW base model at 989.077 mt (2,180,542 lbs.) and MSST was therefore defined as 741.808 mt (1,635,406 lbs.; Figure 56b). The $SSB_{F40\%SPR}$ was estimated at 1,321.570 mt (2,913,563 lbs.; Figure 56b). Based on either of these results, the Florida Keys/East Florida Hogfish stock was not found to be overfished ($SSB_{current}/SSB_{F30\%SPR}$ = 2.829; $SSB_{current}/SSB_{F40\%SPR}$ = 2.117).

From the posterior distributions of the MCMC 'proxy' model, the median value for $F_{current}$ was estimated to be 0.018 yr^{-1} (Figure 54a), $F_{30\%SPR}$ was estimated to be 0.193 yr^{-1} (Figure 54b), $SSB_{F30\%SPR}$ was estimated to be 1,023.120 mt (2,255,593 lbs.; Figure 54e), MSST was 767.340 mt (1,691,695 lbs.; Figure 54f), and $SSB_{current}$ was estimated to be 2,130.268 mt (4,696,437 lbs.; Figure 54d). The MCMC distribution of the retained yield at $F_{30\%SPR}$ had a median value of 112.526 mt (248,077 lbs.; Figure 54c). Additional posterior distributions of the F_{ratio} ($F_{current}$/ MFMT) and SSB_{ratio} ($SSB_{current}$/MSST) are presented in Figure 57 where median values were 0.093 and 2.776, respectively. The estimates for these reference points as derived by the KEYS RW base model were also within the interquartile ranges of these posterior distributions. The distribution of the F_{ratio} was entirely below one, indicating a high probability that overfishing is currently not occurring and the distribution for the SSB_{ratio} was entirely above one, indicating a high probability that the stock is not currently overfished.

4.10 Projections

Short- and long-term deterministic projections were conducted to estimate Florida Keys/East Florida Hogfish spawning stock biomass and yield under a range of harvest scenarios. These were performed under several assumed conditions: growth, and stock-recruitment parameters were kept constant (at values estimated by the SEDAR 94 KEYS RW base model) while relative apical F, selectivity, and discarding and retention associated with the terminal three years (2022 – 2024) would remain the same into the future. The average relative apical F values from 2022 – 2024 as estimated by the base model were used to determine the fleet allocations in the projection scenarios. These were 1.43% for the commercial fleet and 98.57% for the recreational fleet. The method to project the assessment results was developed in the R statistical computing environment by SEFSC assessment scientists (https://github.com/SEFSC/SFD-AllocationForecasting).

First, long-term deterministic projections were conducted to determine the equilibrium fishing mortality rate that achieves $F_{30\%SPR}$ (or $F_{40\%SPR}$) as well as the associated spawning stock biomass, $SSB_{F30\%SPR}$ (or $SSB_{F40\%SPR}$), by using an iterative process to set exploitation rates each year that ensures 1) the MSY_{proxy} (i.e. SPR 30% or 40%) is achieved at equilibrium, and 2) annual relative apical fishing mortality between fleets is maintained at the average of the base model's terminal three years (2022 – 2024). Projections were for 100 years (2025 – 2124) where recruitment was held constant at the long-term (1986 – 2024)

average; equilibrium was assumed to have been obtained in the final 10 years of the projection (i.e., 2115 – 2124) as recommended by Van Beveren et al. (2021). Please note, however, that due to the configuration of the KEYS RW base model where main recruitment deviations ended in 2021, projected recruitment within all scenarios began in 2022. This was a limitation imposed by the structural framework of SS and could not be changed.

Next, short-term deterministic projections, which used a similar iterative process as the long-term projections, were conducted under a range of harvest scenarios and assumed age-0 recruitment remained constant at the recent 5-year average (2020 – 2024) estimated by the KEYS RW base model (Schueller et al. 2022; Van Beveren et al. 2021). Per the TORs, short-term projections explored the effects of holding fishing mortality rates constant at the equilibrium $F_{30\%SPR}$ or $F_{40\%SPR}$ (as determined via the long-term projection above), at 75% of that equilibrium $F_{30\%SPR}$ or $F_{40\%SPR}$, and at $F_{current}$ in order to produce annual yield values. Reported short-term projections extend until 2034 but only the first 5 years are recommended for use.

4.10.1 Results

The projection results for the constant F scenarios including the associated fishing mortality rates, retained landings (in pounds and numbers), spawning stock biomass (mt), and age-0 recruitment (in numbers) as estimated for assessment years (1986 – 2024) and forecast years (2025 – 2044) are presented in Figures 58 – 65 and Tables 16 – 19. The equilibrium fishing mortality rate that achieved 30% SPR ($F_{30\%SPR}$) in the long-term projections was 0.185 yr^{-1} (Figure 58, Table 16) and was near exact to the KEYS RW base model estimate (0.186 yr^{-1}). Likewise, the equilibrium $F_{40\%SPR}$ in the long-term projection was 0.125 yr^{-1} (Figure 62, Table 18) and was identical the KEYS RW base model.

Retained landings from the long-term constant $F_{30\%SPR}$ projection scenario initially increased to values similar to yields prior to 2018, then quickly declined through the 5-yr projection period from 583,898 lbs. in 2025 to 320,222 lbs. in 2029 (Table 16, Figure 59). Spawning stock biomass immediately declined in response to the higher exploitation rates, becoming more like the mid-2000s years (Table 16, Figure 60). Projected recruitment based on the whole time series average (1.698 million fish) began in 2022 (Table 16, Figure 61) but was lower than recruitment in the terminal three years of the KEYS RW base model (1.776 million fish).

In the short-term projection scenarios, $F_{30\%SPR}$ (0.185 yr^{-1}; Table 16, Figure 58) is higher than nearly all exploitation rates estimated throughout the KEYS RW base model's timeseries and was ten times higher than recent exploitation rates ($F_{30\%SPR}/F_{current}$ = 10.12). When exploitation rates were held at 75% $F_{30\%SPR}$ (0.139 yr^{-1}; Table 17, Figure 58), they were still higher than the whole timeseries (1986 – 2024) average of 0.083 yr^{-1} and were seven-and-a-half times higher than recent exploitation rates (75% $F_{30\%SPR}/F_{current}$ = 7.59). In the short-term $F_{30\%SPR}$ scenario, retained landings were 589,100 lbs. (177,234 fish) in 2025 and 340,462 lbs. (106,330 fish) in 2029 (Table 16, Figure 59). In the 75% $F_{40\%SPR}$ scenario, retained landings were 441,788 lbs. (133,099 fish) in 2025 and 311,748 lbs. (95,121 fish) in 2029 (Table 17, Figure 59). In both scenarios, projected SSB immediately declined (Tables 16 – 17, Figure 60) but remained above the $SSB_{F30\%SPR}$ target due to the above-average assumptions on recruitment (Tables 16 – 17, Figure 61).

Short-term projections for the $F_{current}$ scenario estimated comparatively lower F values (0.018 yr^{-1}; Table 17, Figure 58) and resulted in retained landings increasing to 57,954 lbs. (17,525 fish) in 2025 and 67,730 lbs. (19,735 fish) in 2029 (Table 17, Figure 59). Projected SSB continued to increase to values estimated

similar to the beginning of the KEYS RW base model time series, reaching 2,661.45 mt in 2029 (Table 17, Figure 60).

The exploitation rate at $F_{40\%SPR}$ (Table 18, Figure 62) was nearly seven times greater than the current exploitation rate ($F_{40\%SPR}/F_{current} = 6.82$) and higher than most years across the KEYS RW base model's timeseries. The 75% $F_{40\%SPR}$ (0.094 yr^{-1}; Table 19, Figure 63) was five times greater (75% $F_{40\%SPR}/F_{current} = 5.12$) but closer to the average exploitation rate across the whole timeseries (1986 – 2024). Retained landings from the short-term constant $F_{40\%SPR}$ scenario were 397,607 lbs. (119,842 fish) in 2025 and 297,722 lbs. (90,271 fish) in 2029 (Table 18, Figure 63). In the 75% $F_{40\%SPR}$ scenario, retained landings were 298,150 lbs. (89,955 fish) in 2025 and 254,879 lbs. (76,270 fish) in 2029 (Table 19, Figure 63). Since recruitment in the short-term is held constant at values higher than the long-term average (Tables 18 – 19, Figure 65), SSB under the constant $F_{40\%SPR}$ scenario declined to values just above the $SSB_{F40\%SPR}$ target (Table 18, Figure 64); however, SSB under the constant 75% $F_{40\%SPR}$ scenario declined slightly values similar to the terminal three years of the KEYS RW base model's timeseries (Table 19, Figure 64).

5 Tables

Table 1. Predicted spawning stock biomass (SSB; metric tons, pounds) by sex, total female abundance (1000s of fish), male age 1+ abundance (1000s of fish), and total abundance (1000s of fish) as estimated by the KEYS base model for Florida Keys/East Florida Hogfish. Virgin is the estimated unfished condition while Initial is the estimated initial conditions of the stock before the model start year.

Year	Female SSB (mt)	Female SSB (lbs)	Male SSB (mt)	Male SSB (lbs)	Total Female Abundance (000s)	Male Age 1+ Abundance (000s)	Total Abundance (000s)
Virgin	1,391	3,066,167	4,071	8,975,790	7,513	2,057	9,570
Initial	1,391	3,066,167	4,071	8,975,790	7,513	2,057	9,570
1950	1,391	3,066,167	4,071	8,975,790	7,513	2,057	9,570
1951	1,364	3,007,745	4,016	8,852,816	7,469	2,023	9,491
1952	1,340	2,955,142	3,952	8,712,073	7,426	1,986	9,413
1953	1,322	2,914,467	3,884	8,561,762	7,387	1,950	9,337
1954	1,308	2,884,683	3,814	8,408,453	7,350	1,915	9,265
1955	1,298	2,861,027	3,744	8,253,490	7,314	1,882	9,196
1956	1,289	2,840,965	3,676	8,104,788	7,278	1,852	9,130
1957	1,280	2,822,292	3,613	7,965,632	7,243	1,825	9,068
1958	1,273	2,805,713	3,557	7,841,358	7,211	1,801	9,012
1959	1,265	2,789,377	3,505	7,726,695	7,180	1,780	8,959
1960	1,255	2,766,735	3,450	7,606,852	7,145	1,756	8,900
1961	1,245	2,744,821	3,398	7,492,145	7,111	1,732	8,844
1962	1,233	2,717,550	3,343	7,369,613	7,073	1,707	8,780
1963	1,224	2,698,943	3,294	7,261,608	7,042	1,685	8,727
1964	1,216	2,680,182	3,245	7,153,185	7,010	1,663	8,673
1965	1,206	2,658,091	3,193	7,040,110	6,975	1,640	8,615
1966	1,195	2,634,612	3,142	6,927,828	6,939	1,617	8,556
1967	1,184	2,610,868	3,091	6,815,238	6,902	1,593	8,495
1968	1,171	2,580,996	3,035	6,691,360	6,860	1,567	8,426
1969	1,159	2,554,651	2,981	6,571,230	6,819	1,541	8,361
1970	1,146	2,527,357	2,925	6,448,698	6,777	1,515	8,292
1971	1,131	2,493,781	2,864	6,313,554	6,728	1,486	8,214
1972	1,103	2,432,382	2,779	6,127,219	6,653	1,442	8,095
1973	1,077	2,373,739	2,691	5,931,559	6,576	1,396	7,973
1974	1,051	2,316,507	2,597	5,724,391	6,494	1,349	7,843
1975	1,022	2,253,918	2,493	5,497,006	6,401	1,297	7,698
1976	994	2,191,393	2,386	5,261,133	6,301	1,244	7,545
1977	975	2,149,068	2,293	5,054,296	6,214	1,201	7,415
1978	965	2,128,153	2,216	4,885,311	6,145	1,170	7,315
1979	964	2,124,857	2,161	4,763,175	6,096	1,151	7,247
1980	954	2,103,045	2,104	4,638,129	6,036	1,128	7,165
1981	954	2,102,553	2,068	4,559,556	5,953	1,119	7,072
1982	877	1,933,009	1,925	4,244,273	5,652	1,035	6,686
1983	902	1,988,391	1,920	4,233,779	5,489	1,045	6,533
1984	881	1,941,691	1,863	4,107,410	5,313	1,017	6,330
1985	810	1,786,558	1,751	3,859,677	5,829	951	6,780

Table 1 continued. Predicted spawning stock biomass (SSB; metric tons, pounds) by sex, total female abundance (1000s of fish), male age 1+ abundance (1000s of fish), and total abundance (1000s of fish) as estimated by the KEYS base model for Florida Keys/East Florida Hogfish. Virgin is the estimated unfished condition while Initial is the estimated initial conditions of the stock before the model start year.

Year	Female SSB (mt)	Female SSB (lbs)	Male SSB (mt)	Male SSB (lbs)	Total Female Abundance (000s)	Male Age 1+ Abundance (000s)	Total Abundance (000s)
1986	767	1,690,946	1,671	3,683,638	5,428	908	6,336
1987	783	1,726,138	1,629	3,591,308	5,827	895	6,722
1988	801	1,766,375	1,567	3,453,784	5,861	869	6,729
1989	657	1,449,445	1,306	2,879,502	5,134	710	5,844
1990	721	1,588,539	1,266	2,791,978	5,702	712	6,414
1991	720	1,587,571	1,193	2,630,005	5,041	687	5,729
1992	775	1,707,513	1,208	2,662,170	5,079	723	5,802
1993	710	1,565,275	1,114	2,456,721	3,849	671	4,520
1994	669	1,473,997	1,074	2,367,632	3,702	654	4,356
1995	581	1,280,101	1,001	2,207,158	2,945	606	3,551
1996	490	1,079,330	932	2,054,761	2,398	562	2,961
1997	459	1,010,901	916	2,020,329	2,500	555	3,054
1998	422	931,241	921	2,030,537	2,009	557	2,566
1999	382	843,215	905	1,994,987	2,763	540	3,302
2000	324	715,314	825	1,818,624	2,530	477	3,007
2001	327	721,884	803	1,771,386	2,610	461	3,071
2002	374	823,658	783	1,725,968	3,269	448	3,717
2003	410	904,991	778	1,715,765	3,540	450	3,990
2004	435	958,610	750	1,652,515	3,693	438	4,131
2005	453	997,649	700	1,542,305	3,306	413	3,719
2006	392	863,377	575	1,268,123	3,274	339	3,613
2007	430	947,937	571	1,258,831	4,457	352	4,810
2008	452	995,619	579	1,277,365	3,787	373	4,159
2009	510	1,123,551	600	1,322,379	3,995	400	4,396
2010	496	1,093,707	557	1,227,779	3,170	375	3,545
2011	550	1,212,953	610	1,345,230	3,317	423	3,740
2012	593	1,307,901	688	1,516,256	4,488	481	4,969
2013	555	1,222,770	747	1,646,425	4,643	513	5,156
2014	543	1,196,859	776	1,711,268	3,897	519	4,416
2015	562	1,238,639	755	1,663,699	5,095	493	5,588
2016	535	1,179,978	705	1,554,916	4,573	456	5,028
2017	555	1,224,527	694	1,529,977	4,136	456	4,592
2018	631	1,391,410	715	1,576,217	4,143	482	4,625
2019	695	1,531,225	798	1,758,528	4,100	549	4,649
2020	730	1,609,507	910	2,007,223	4,284	626	4,911
2021	741	1,634,207	1,035	2,280,682	4,522	698	5,220
2022	720	1,587,935	1,134	2,500,659	4,609	740	5,349
2023	729	1,606,795	1,232	2,716,977	4,739	778	5,517
2024	763	1,681,477	1,322	2,914,467	4,896	813	5,710

Table 2. Estimates of catchability by the KEYS base model across six retrospective peels for the three indices of abundance. Retro-0 is the KEYS base model reference run.

	RVC Florida Keys	RVC Dry Tortugas	Combined Video
Retro-0	0.000741311	0.001700624	0.000979577
Retro-1	0.000713905	0.002043523	0.001122014
Retro-2	0.000680624	0.001969629	0.001006506
Retro-3	0.000719424	0.002388475	0.001163561
Retro-4	0.000738042	0.00271197	0.001253419
Retro-5	0.000746489	0.002824398	0.001266029
Retro-6	0.000743821	0.002917962	0.001335299

Table 3. Comparison of the total log-likelihood, selected parameters, and derived quantities as estimated by the KEYS base model ('KEYS Base Model') against sensitivity runs exploring assumptions on natural mortality for Florida Keys/East Florida Hogfish. 'HamelCope_age3' uses the Hamel and Cope (2022) longevity-based estimate (M=0.338 yr^{-1}) for age-3 fish, 'est_HamelCope_age3' estimates M using the standard deviation (0.31) prior in log-space, and 'est_HamelCope_age3_noprior' removes the standard deviation prior to freely estimate.

Label	KEYS Base Model	HamelCope_age3	est_HamelCope_age3	est_HamelCope_age3_noprior
TOTAL like	2314.27	2315.13	2324.79	2315.2
SR_LN(R0)	8.000	8.472	9.356	8.135
Steepness (h)	0.472	0.439	0.404	0.463
L_{inf}	51.2	54.0	64.2	52.5
SSB_MSY	1952.40	1925.45	1888.75	1937.46
F_MSY	0.077	0.077	0.077	0.078
SSB_SPR	912.573	616.930	251.990	834.452
F_40%SPR	0.128	0.146	0.169	0.133

Table 4. Comparison of the total log-likelihood, selected parameters, and derived quantities as estimated by the WFS base model ('WFS Base Model') against sensitivity runs exploring assumptions on natural mortality for West Florida Shelf Hogfish. Sensitivity runs included the Lorenzen (1996) mortality-at-weight, Hamel and Cope (2022) longevity-based estimate (M=0.235 yr^{-1}) for age-3 fish, and Hamel and Cope (2022) longevity-based M as freely estimable.

Label	WFS Base Model	Lorenzen96	HamelCope_age3	est_HamelCope_age3_23_noprior
TOTAL like	916.605	941.65	945.112	914.294
SR_LN(R0)	7.65708	5.89814	5.76754	8.95173
Steepness (h)	0.99	0.99	0.99	0.99
L_{inf}	89.5804	114.728	54.1924	86.5378
SSB_SPR	518.9	844.481	377.638	712.598
F_30%SPR	0.229282	0.0694546	0.167258	0.394587

Table 5. Dirichlet-multinomial weights applied to length and size composition data of the SEDAR 94 KEYS RW base model. Theta ratios are calculated as theta/(1+theta).

Data Type	Fleet/Index	*ln(theta)*	*theta*	*theta ratio*
Length Composition	Commercial landings	2.167	8.734	0.897
	Recreational discards	1.052	2.862	0.741
	Recreational landings	-0.572	0.564	0.361
	Combined video index	0.434	1.543	0.607
Size Composition	RVC Florida Keys and RVC Dry Tortugas indices	-0.373	0.689	0.408

Table 6. List of Stock Synthesis parameters for the SEDAR 94 KEYS RW base model. The list includes expected parameter values (Value), lower (Min) and upper (Max) bounds of the parameters, associated standard deviation (Std Dev) and coefficients of variation (CV), prior type (Prior), prior standard deviation (Prior Std Dev), and the phase (Phase) of estimation. Parameters designated as fixed were held at their initial values and have no associated range or SE.

	Parameter Label	Value	Min	Max	Std Dev	CV	Prior	Prior Std Dev	Phase
1	LatAminFemGP1	6.546	2	20	0.743	0.113			3
2	LatAmaxFemGP1	51.870	30	80	3.618	0.070			3
3	VonBertKFemGP1	0.173	0.05	0.4	0.025	0.144			4
4	CVyoungFemGP1	0.481	0.05	0.9	0.052	0.108			7
5	CVoldFemGP1	0.369	0.05	0.9	0.046	0.125			7
6	Wtlen1FemGP1	2.55E-05	-3	3					Fixed
7	Wtlen2FemGP1	2.927	-3	4					Fixed
8	Mat50%FemGP1	2.080	1	4					Fixed
9	MatslopeFemGP1	-3.034	-4	-0.1					Fixed
10	EggsscalarFemGP1	1.000	-3	3					Fixed
11	EggsexpwtFemGP1	1.000	-3	3					Fixed
12	LatAminMalGP1	0.000	-1	1					Fixed
13	LatAmaxMalGP1	0.000	-1	1					Fixed
14	VonBertKMalGP1	0.000	-1	1					Fixed
15	CVyoungMalGP1	0.000	-1	1					Fixed
16	CVoldMalGP1	0.000	-1	1					Fixed
17	Wtlen1MalGP1	2.55E-05	-3	3					Fixed
18	Wtlen2MalGP1	2.927	-3	4					Fixed
19	HermInflage	6.080	1	11					Fixed
20	Hermstdev	2.330	1	5					Fixed
21	Hermasymptote	0.999	0.01	1					Fixed
22	CohortGrowDev	1.000	0	1					Fixed
23	PlatoonSDRatio	0.772	0.1	3	0.308	0.399			1
24	FracFemaleGP1	1.000	0	1					Fixed
25	SRLN(R0)	7.484	6	14	0.136	0.018			1
26	SRBHsteep	0.990	0.2	0.99					Fixed
27	SRsigmaR	0.411	0.1	2	0.095	0.230			7
28	SRregime	0.000	-5	5					Fixed
29	SRautocorr	0.000	0	0					Fixed
30	MainInitAge5	0.167	-4	4	0.401	2.406			3
31	MainInitAge4	0.154	-4	4	0.397	2.578			3
32	MainInitAge3	0.139	-4	4	0.392	2.823			3
33	MainInitAge2	0.127	-4	4	0.388	3.059			3
34	MainInitAge1	0.408	-4	4	0.391	0.959			3
35	MainRecrDev1986	0.138	-4	4	0.361	2.610			3
36	MainRecrDev1987	0.406	-4	4	0.339	0.834			3
37	MainRecrDev1988	0.361	-4	4	0.312	0.863			3
38	MainRecrDev1989	0.166	-4	4	0.290	1.747			3
39	MainRecrDev1990	0.496	-4	4	0.227	0.457			3
40	MainRecrDev1991	0.090	-4	4	0.217	2.417			3
41	MainRecrDev1992	0.259	-4	4	0.174	0.672			3
42	MainRecrDev1993	-0.463	-4	4	0.208	-0.448			3
43	MainRecrDev1994	-0.065	-4	4	0.159	-2.448			3
44	MainRecrDev1995	-0.588	-4	4	0.193	-0.329			3
45	MainRecrDev1996	-0.755	-4	4	0.200	-0.265			3
46	MainRecrDev1997	-0.363	-4	4	0.161	-0.444			3
47	MainRecrDev1998	-1.018	-4	4	0.250	-0.246			3
48	MainRecrDev1999	-0.010	-4	4	0.148	-14.656			3
49	MainRecrDev2000	-0.455	-4	4	0.228	-0.500			3
50	MainRecrDev2001	-0.303	-4	4	0.221	-0.730			3
51	MainRecrDev2002	0.079	-4	4	0.197	2.479			3
52	MainRecrDev2003	0.028	-4	4	0.216	7.739			3
53	MainRecrDev2004	0.025	-4	4	0.198	7.844			3
54	MainRecrDev2005	-0.269	-4	4	0.227	-0.846			3
55	MainRecrDev2006	-0.049	-4	4	0.176	-3.560			3
56	MainRecrDev2007	0.463	-4	4	0.119	0.257			3
57	MainRecrDev2008	-0.249	-4	4	0.169	-0.677			3
58	MainRecrDev2009	0.093	-4	4	0.131	1.410			3
59	MainRecrDev2010	-0.498	-4	4	0.185	-0.371			3
60	MainRecrDev2011	-0.113	-4	4	0.142	-1.256			3
61	MainRecrDev2012	0.457	-4	4	0.101	0.222			3

62	MainRecrDev2013	0.257	-4	4	0.112	0.434	3
63	MainRecrDev2014	-0.247	-4	4	0.156	-0.631	3
64	MainRecrDev2015	0.581	-4	4	0.118	0.203	3
65	MainRecrDev2016	0.067	-4	4	0.191	2.835	3
66	MainRecrDev2017	-0.056	-4	4	0.196	-3.510	3
67	MainRecrDev2018	0.053	-4	4	0.203	3.810	3
68	MainRecrDev2019	-0.003	-4	4	0.231	-78.771	3
69	MainRecrDev2020	0.143	-4	4	0.232	1.626	3
70	MainRecrDev2021	0.346	-4	4	0.212	0.612	3
71	InitFseas1flt1COM	0.004	1.00E-06	0.1	0.001	0.346	1
72	InitFseas1flt2REC	0.076	1.00E-06	0.3	0.046	0.599	1
73	Ffleet1YR1986s1	0.010					
74	Ffleet1YR1987s1	0.010					
75	Ffleet1YR1988s1	0.010					
76	Ffleet1YR1989s1	0.010					
77	Ffleet1YR1990s1	0.010					
78	Ffleet1YR1991s1	0.010					
79	Ffleet1YR1992s1	0.010					
80	Ffleet1YR1993s1	0.010					
81	Ffleet1YR1994s1	0.010					
82	Ffleet1YR1995s1	0.010					
83	Ffleet1YR1996s1	0.010					
84	Ffleet1YR1997s1	0.010					
85	Ffleet1YR1998s1	0.010					
86	Ffleet1YR1999s1	0.010					
87	Ffleet1YR2000s1	0.010					
88	Ffleet1YR2001s1	0.010					
89	Ffleet1YR2002s1	0.010					
90	Ffleet1YR2003s1	0.010					
91	Ffleet1YR2004s1	0.010					
92	Ffleet1YR2005s1	0.010					
93	Ffleet1YR2006s1	0.010					
94	Ffleet1YR2007s1	0.010					
95	Ffleet1YR2008s1	0.010					
96	Ffleet1YR2009s1	0.010					
97	Ffleet1YR2010s1	0.010					
98	Ffleet1YR2011s1	0.010					
99	Ffleet1YR2012s1	0.010					
100	Ffleet1YR2013s1	0.010					
101	Ffleet1YR2014s1	0.010					
102	Ffleet1YR2015s1	0.010					
103	Ffleet1YR2016s1	0.010					
104	Ffleet1YR2017s1	0.010					
105	Ffleet1YR2018s1	0.010					
106	Ffleet1YR2019s1	0.010					
107	Ffleet1YR2020s1	0.010					
108	Ffleet1YR2021s1	0.010					
109	Ffleet1YR2022s1	0.010					
110	Ffleet1YR2023s1	0.010					
111	Ffleet1YR2024s1	0.010					
112	Ffleet2YR1986s1	0.149	0	3	0.093	0.621	2
113	Ffleet2YR1987s1	0.189	0	3	0.090	0.476	2
114	Ffleet2YR1988s1	0.523	0	3	0.249	0.476	2
115	Ffleet2YR1989s1	0.147	0	3	0.078	0.530	2
116	Ffleet2YR1990s1	0.254	0	3	0.116	0.456	2
117	Ffleet2YR1991s1	0.094	0	3	0.072	0.764	2
118	Ffleet2YR1992s1	0.350	0	3	0.131	0.373	2
119	Ffleet2YR1993s1	0.242	0	3	0.118	0.489	2
120	Ffleet2YR1994s1	0.338	0	3	0.155	0.458	2
121	Ffleet2YR1995s1	0.380	0	3	0.180	0.473	2
122	Ffleet2YR1996s1	0.203	0	3	0.096	0.475	2
123	Ffleet2YR1997s1	0.106	0	3	0.050	0.474	2
124	Ffleet2YR1998s1	0.168	0	3	0.076	0.453	2
125	Ffleet2YR1999s1	0.397	0	3	0.200	0.504	2
126	Ffleet2YR2000s1	0.121	0	3	0.072	0.596	2
127	Ffleet2YR2001s1	0.121	0	3	0.073	0.608	2
128	Ffleet2YR2002s1	0.070	0	3	0.045	0.643	2
129	Ffleet2YR2003s1	0.210	0	3	0.090	0.428	2
130	Ffleet2YR2004s1	0.356	0	3	0.158	0.445	2
131	Ffleet2YR2005s1	0.882	0	3	0.266	0.302	2
132	Ffleet2YR2006s1	0.241	0	3	0.102	0.423	2

133	Ffleet2YR2007s1	0.224	0	3	0.083	0.369			2
134	Ffleet2YR2008s1	0.217	0	3	0.092	0.424			2
135	Ffleet2YR2009s1	0.590	0	3	0.202	0.343			2
136	Ffleet2YR2010s1	0.093	0	3	0.054	0.582			2
137	Ffleet2YR2011s1	0.051	0	3	0.028	0.546			2
138	Ffleet2YR2012s1	0.177	0	3	0.075	0.427			2
139	Ffleet2YR2013s1	0.260	0	3	0.094	0.359			2
140	Ffleet2YR2014s1	0.404	0	3	0.124	0.307			2
141	Ffleet2YR2015s1	0.491	0	3	0.145	0.295			2
142	Ffleet2YR2016s1	0.339	0	3	0.131	0.387			2
143	Ffleet2YR2017s1	0.258	0	3	0.134	0.519			2
144	Ffleet2YR2018s1	0.091	0	3	0.051	0.557			2
145	Ffleet2YR2019s1	0.040	0	3	0.017	0.420			2
146	Ffleet2YR2020s1	0.058	0	3	0.031	0.534			2
147	Ffleet2YR2021s1	0.155	0	3	0.047	0.304			2
148	Ffleet2YR2022s1	0.102	0	3	0.038	0.369			2
149	Ffleet2YR2023s1	0.073	0	3	0.023	0.318			2
150	Ffleet2YR2024s1	0.060	0	3	0.018	0.298			2
151	LnQbaseRVCKEYS(3)	-7.236	-18	5					Fixed
152	LnQbaseRVCDRTO(4)	-6.474	-18	5					Fixed
153	LnQbaseCOMBVIDEO(5)	-6.999	-18	5					Fixed
154	SizeDblNpeakCOM(1)	29.939	15	60	2.730	0.091			3
155	SizeDblNtoplogitCOM(1)	-9.919	-15	15	71.224	-7.181			4
156	SizeDblNascendseCOM(1)	3.188	0.01	15	0.860	0.270			5
157	SizeDblNdescendseCOM(1)	3.183	0.01	5	0.687	0.216			5
158	SizeDblNstartlogitCOM(1)	-999	-15	15					Fixed
159	SizeDblNendlogitCOM(1)	0.216	-15	15	0.384	1.779			3
160	SizeDblNpeakREC(2)	32.722	15	50	0.660	0.020			3
161	SizeDblNtoplogitREC(2)	-12.129	-15	15	47.996	-3.957			4
162	SizeDblNascendseREC(2)	3.874	0.1	15	0.151	0.039			5
163	SizeDblNdescendseREC(2)	4.663	0.1	15	0.207	0.044			5
164	SizeDblNstartlogitREC(2)	-999	-15	7					Fixed
165	SizeDblNendlogitREC(2)	-2.647	-15	15	0.356	-0.134			3
166	RetainLinflREC(2)	6.272	4	50	46.983	7.491			3
167	RetainLwidthREC(2)	0.680	0.01	10	12.960	19.053			4
168	RetainLasymptotelogitREC(2)	2.604	-15	15	0.349	0.134			5
169	RetainLmaleoffsetREC(2)	0.000	-1	1					Fixed
170	DiscMortLinflREC(2)	0.100	0	1					Fixed
171	DiscMortLwidthREC(2)	0.100	0	1					Fixed
172	DiscMortLleveloldREC(2)	0.414	0.01	1					Fixed
173	DiscMortLmaleoffsetREC(2)	0.000	-1	2					Fixed
174	SizeDblNpeakRVCKEYS(3)	22.088	5	50	0.673	0.030			3
175	SizeDblNtoplogitRVCKEYS(3)	-2.765	-15	15	0.602	-0.218			4
176	SizeDblNascendseRVCKEYS(3)	3.795	0.1	15	0.129	0.034			3
177	SizeDblNdescendseRVCKEYS(3)	4.951	0.1	15	0.353	0.071			5
178	SizeDblNstartlogitRVCKEYS(3)	-999	-15	15					Fixed
179	SizeDblNendlogitRVCKEYS(3)	-2.113	-15	15	0.342	-0.162			3
180	SizeDblNpeakRVCDRTO(4)	54.390	30	70	3.111	0.057			3
181	SizeDblNtoplogitRVCDRTO(4)	-1.954	-15	15	2.297	-1.176			4
182	SizeDblNascendseRVCDRTO(4)	6.151	0.1	15	0.115	0.019			3
183	SizeDblNdescendseRVCDRTO(4)	6.473	0.1	15	3.292	0.509			5
184	SizeDblNstartlogitRVCDRTO(4)	-999	-5	5					Fixed
185	SizeDblNendlogitRVCDRTO(4)	-1.213	-15	15	1.528	-1.260			3
186	SizeinflectionCOMBVIDEO(5)	27.316	15	40	2.952	0.108			3
187	Size95%widthCOMBVIDEO(5)	11.197	0.1	15	2.814	0.251			4
188	ln(DMtheta)LenP1	2.167	-5	20	0.840	0.387	0	1.813	2
189	ln(DMtheta)LenP2	1.052	-5	20	0.910	0.865	0	1.813	2
190	ln(DMtheta)LenP3	-0.572	-5	20	0.221	-0.387	0	1.813	2
191	ln(DMtheta)LenP4	0.434	-5	20	0.612	1.410	0	1.813	2
192	ln(DMtheta)SzP5	-0.373	-5	20	0.138	-0.370	0	1.813	2
193	SizeDblNpeakCOM(1)BLK1repl1995	31.016	15	60	0.452	0.015			3
194	SizeDblNpeakCOM(1)BLK1repl2018	41.784	15	60	1.173	0.028			3
195	SizeDblNascendseCOM(1)BLK1repl1995	1.875	0.01	15	0.295	0.157			5
196	SizeDblNascendseCOM(1)BLK1repl2018	1.452	0.01	6	0.775	0.533			5
197	RetainLinflREC(2)BLK1repl1995	28.577	6	50	0.303	0.011			3
198	RetainLinflREC(2)BLK1repl2018	42.594	6	50	2.080	0.049			3
199	RetainLwidthREC(2)BLK1repl1995	1.273	0.1	10	0.178	0.139			4
200	RetainLwidthREC(2)BLK1repl2018	4.947	0.1	10	1.236	0.250			4
201	RetainLasymptotelogitREC(2)BLK1repl1995	3.205	-15	15	0.568	0.177			5
202	RetainLasymptotelogitREC(2)BLK1repl2018	9.579	-15	15	74.635	7.791			5

Table 7. Predicted total biomass (metric tons, pounds), spawning stock biomass (SSB; metric tons, pounds), age-0 recruits (1000s of fish), age 1+ abundance (1000s of fish), and depletion (SSB/SSB0) for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model. Virgin is the estimated unfished condition while Initial is the estimated initial conditions of the stock before the model start year.

Year	Biomass (mt)	Biomass (lbs.)	SSB (mt)	SSB (lbs.)	Age-0 Recruits (000s)	Age-1+ Abundance (000s)	B/B0	SSB/SSB0
Virgin	3,496	7,706,986	3,317	7,311,653	1,779	3,929	1.000	1.000
Initial	2,705	5,962,953	2,527	5,571,566	1,777	3,553	0.774	0.762
1986	2,823	6,224,069	2,606	5,745,864	1,917	4,142	0.808	0.786
1987	2,785	6,139,389	2,564	5,651,660	2,492	3,945	0.797	0.773
1988	2,717	5,989,210	2,496	5,502,959	2,368	4,118	0.777	0.753
1989	2,386	5,261,288	2,162	4,766,041	1,935	3,895	0.683	0.652
1990	2,388	5,264,837	2,169	4,781,826	2,689	3,763	0.683	0.654
1991	2,319	5,113,247	2,098	4,625,254	1,791	4,038	0.663	0.633
1992	2,381	5,249,096	2,161	4,764,520	2,121	3,810	0.681	0.652
1993	2,213	4,878,742	2,029	4,473,179	1,030	3,674	0.633	0.612
1994	2,112	4,656,185	1,957	4,315,527	1,533	3,034	0.604	0.590
1995	1,940	4,277,629	1,815	4,002,118	909	2,870	0.555	0.547
1996	1,759	3,877,248	1,645	3,626,626	769	2,404	0.503	0.496
1997	1,676	3,694,198	1,586	3,496,333	1,137	2,111	0.479	0.478
1998	1,636	3,606,741	1,545	3,406,054	591	2,164	0.468	0.466
1999	1,566	3,453,475	1,473	3,247,894	1,618	1,850	0.448	0.444
2000	1,409	3,105,233	1,301	2,868,126	1,036	2,145	0.403	0.392
2001	1,400	3,085,678	1,273	2,805,779	1,207	2,074	0.400	0.384
2002	1,410	3,108,937	1,289	2,842,199	1,768	2,142	0.403	0.389
2003	1,467	3,234,446	1,319	2,908,228	1,680	2,522	0.420	0.398
2004	1,478	3,258,829	1,311	2,889,885	1,675	2,657	0.423	0.395
2005	1,432	3,155,961	1,271	2,802,582	1,248	2,687	0.409	0.383
2006	1,190	2,622,597	1,050	2,314,347	1,552	2,277	0.340	0.317
2007	1,234	2,720,526	1,083	2,386,857	2,591	2,421	0.353	0.326
2008	1,309	2,884,749	1,117	2,461,549	1,272	3,104	0.374	0.337
2009	1,388	3,059,002	1,200	2,645,062	1,791	2,788	0.397	0.362
2010	1,285	2,833,910	1,138	2,508,618	991	2,748	0.368	0.343
2011	1,390	3,064,756	1,251	2,757,696	1,458	2,476	0.398	0.377
2012	1,517	3,343,994	1,377	3,035,920	2,580	2,612	0.434	0.415
2013	1,596	3,518,159	1,400	3,087,001	2,113	3,267	0.456	0.422
2014	1,637	3,609,673	1,422	3,134,312	1,276	3,366	0.468	0.429
2015	1,599	3,525,699	1,417	3,123,818	2,921	2,899	0.457	0.427
2016	1,536	3,387,226	1,336	2,944,340	1,747	3,504	0.440	0.403
2017	1,561	3,440,953	1,346	2,966,739	1,545	3,271	0.446	0.406
2018	1,611	3,552,507	1,442	3,178,426	1,723	3,075	0.461	0.435
2019	1,760	3,880,114	1,596	3,517,519	1,630	3,173	0.503	0.481
2020	1,921	4,235,411	1,751	3,860,426	1,887	3,212	0.550	0.528
2021	2,072	4,568,044	1,890	4,166,649	2,319	3,390	0.593	0.570
2022	2,176	4,797,457	1,972	4,347,824	1,776	3,715	0.622	0.595
2023	2,297	5,064,128	2,095	4,619,522	1,776	3,639	0.657	0.632
2024	2,418	5,331,681	2,237	4,931,609	1,776	3,630	0.692	0.674

Table 8. Predicted female spawning stock biomass (SSB; metric tons, pounds), male spawning stock biomass (SSB; metric tons, pounds), Female age 1+ abundance (1000s of fish), and Male age 1+ abundance (1000s of fish) for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model. Virgin is the estimated unfished condition while Initial is the estimated initial conditions of the stock before the model start year.

Year	Female SSB (mt)	Female SSB (lbs)	Male SSB (mt)	Male SSB (lbs)	Female Age 1+ Abundance (000s)	Male Age 1+ Abundance (000s)
Virgin	831	1,832,881	2,485	5,478,774	2,703	1,227
Initial	744	1,639,902	1,783	3,931,680	2,624	930
1986	810	1,784,653	1,797	3,961,222	3,195	947
1987	803	1,770,998	1,760	3,880,665	3,017	928
1988	795	1,752,582	1,701	3,750,372	3,222	896
1989	678	1,493,656	1,484	3,272,387	3,129	766
1990	726	1,601,597	1,443	3,180,212	3,002	761
1991	731	1,610,739	1,367	3,014,513	3,303	735
1992	788	1,736,542	1,373	3,027,983	3,046	764
1993	745	1,643,330	1,284	2,829,832	2,953	720
1994	713	1,572,965	1,244	2,742,573	2,326	708
1995	636	1,401,571	1,180	2,600,551	2,200	670
1996	539	1,187,291	1,106	2,439,327	1,778	626
1997	499	1,101,059	1,086	2,395,278	1,496	615
1998	457	1,007,832	1,088	2,398,233	1,549	615
1999	411	905,278	1,063	2,342,610	1,257	593
2000	343	755,855	958	2,112,264	1,627	518
2001	345	760,562	928	2,045,220	1,576	498
2002	392	863,315	898	1,978,889	1,659	483
2003	433	955,047	886	1,953,172	2,039	483
2004	461	1,016,959	850	1,872,937	2,188	470
2005	480	1,057,436	792	1,745,142	2,244	443
2006	406	895,513	644	1,418,825	1,919	358
2007	448	986,976	635	1,399,878	2,050	371
2008	476	1,048,371	641	1,413,185	2,711	393
2009	539	1,188,082	661	1,456,971	2,366	422
2010	524	1,154,393	614	1,354,218	2,352	396
2011	580	1,279,523	670	1,478,173	2,030	446
2012	624	1,376,478	753	1,659,453	2,105	507
2013	585	1,290,050	815	1,796,948	2,726	541
2014	573	1,263,855	848	1,870,453	2,817	549
2015	591	1,302,335	826	1,821,492	2,377	522
2016	562	1,239,417	773	1,704,914	3,022	482
2017	584	1,287,085	762	1,679,651	2,788	482
2018	660	1,454,524	782	1,723,896	2,568	507
2019	727	1,602,776	869	1,914,732	2,596	576
2020	764	1,684,984	987	2,175,431	2,556	657
2021	773	1,703,993	1,117	2,462,652	2,660	730
2022	749	1,651,231	1,223	2,696,584	2,940	774
2023	767	1,691,605	1,328	2,927,915	2,824	815
2024	813	1,792,197	1,424	3,139,405	2,777	853

Table 9. Annual exploitation rates on Florida Keys/East Florida Hogfish combined across all fleets as well as annual estimates of instantaneous apical fishing mortality rates by fleet from the SEDAR 94 KEYS RW base model. Apical fishing mortality rates represent the instantaneous fishing mortality level on the most vulnerable age class for each fleet.

Year	Exploitation (Biomass)	Commercial (Biomass)	Recreational (Numbers)
InitF	_	0.0041	0.0764
1986	0.0548	0.0136	0.1490
1987	0.0702	0.0185	0.1890
1988	0.1648	0.0203	0.5225
1989	0.0618	0.0265	0.1473
1990	0.0967	0.0260	0.2541
1991	0.0456	0.0238	0.0939
1992	0.1333	0.0320	0.3501
1993	0.1000	0.0345	0.2416
1994	0.1242	0.0243	0.3382
1995	0.1261	0.0214	0.3801
1996	0.0738	0.0209	0.2030
1997	0.0458	0.0234	0.1061
1998	0.0601	0.0177	0.1682
1999	0.1227	0.0193	0.3971
2000	0.0450	0.0187	0.1210
2001	0.0443	0.0143	0.1205
2002	0.0299	0.0142	0.0696
2003	0.0742	0.0153	0.2099
2004	0.1209	0.0169	0.3559
2005	0.2625	0.0112	0.8816
2006	0.0855	0.0103	0.2409
2007	0.0830	0.0101	0.2241
2008	0.0811	0.0087	0.2169
2009	0.2088	0.0093	0.5899
2010	0.0394	0.0075	0.0933
2011	0.0241	0.0072	0.0515
2012	0.0692	0.0078	0.1765
2013	0.0950	0.0093	0.2603
2014	0.1437	0.0115	0.4040
2015	0.1737	0.0122	0.4908
2016	0.1212	0.0101	0.3385
2017	0.0967	0.0058	0.2578
2018	0.0242	0.0031	0.0910
2019	0.0106	0.0014	0.0397
2020	0.0151	0.0016	0.0581
2021	0.0375	0.0017	0.1547
2022	0.0245	0.0014	0.1021
2023	0.0176	0.0011	0.0730
2024	0.0144	0.0010	0.0601

Table 10. Index root mean square error (RMSE) values from the SEDAR 94 KEYS RW base model (RW Base), the age-structured production model (ASPM), and the ASPM with estimated recruitment deviations (ASPMdev).

Index	RW Base	ASPM	ASPMdev
RVC Florida Keys	0.2590	0.3388	0.2076
RVC Dry Tortugas	0.1570	0.1416	0.1015
Combined Video	0.3730	0.3970	0.3467

Table 11. Mohn's rho (ρ_M) and forecast Mohn's rho (ρ_F) values calculated from the retrospective and retrospective forecasting analyses, respectively, on estimates of spawning stock biomass (SSB) and exploitation fishing mortality rates (F) from the SEDAR 94 KEYS RW base model. Analyses were performed across 6 successive years of removal from the terminal year 2024.

Quantity	Year Peel	Mohn's Rho (ρ_M)	Forecast Mohn's Rho (ρ_F)
SSB	2023	-0.065	-0.080
SSB	2022	-0.006	-0.029
SSB	2021	-0.084	-0.069
SSB	2020	-0.101	-0.076
SSB	2019	-0.135	-0.116
SSB	2018	-0.149	-0.140
SSB	Combined	-0.090	-0.085
F	2023	0.089	0.137
F	2022	0.068	-0.377
F	2021	0.043	-0.158
F	2020	0.058	0.253
F	2019	0.036	-0.163
F	2018	0.165	-0.269
F	Combined	0.076	-0.096

Table 12. Hindcast cross-validation summary statistics for the SEDAR 94 KEYS RW base model. N = number of observations to compute each statistic. MASE = mean absolute scaled error, with values < 1 (in green) indicative of superior prediction skill over a naïve baseline forecast (random walk) and values > 1 (in red) indicative of poor prediction skill. Model MAE = mean absolute error of model prediction residuals. Naïve MAE = mean absolute error of naïve predictions.

Model Component	Data Source	MASE	Model MAE	Naïve MAE	N
Index of Abundance	RVC_KEYS	0.750	0.336	0.448	2
	RVC_DRTO	0.552	0.098	0.177	3
	COMB_VIDEO	0.632	0.140	0.221	6
	joint	0.655	0.164	0.250	11
Conditional Age-at-Length	REC	0.321	0.096	0.298	3
	FI_LHR_SP	0.178	0.024	0.134	1
	FI_LHR_TW	0.026	0.024	0.944	1
	joint	0.170	0.067	0.395	5
Size Composition	RVC_KEYS	1.984	0.120	0.060	2
	RVC_DRTO	0.597	0.038	0.064	3
	joint	1.132	0.071	0.063	5

Table 13. The yield-per-recruit (YPR), spawner-per-recruit (SSB/R), static spawning potential ratio (SPR), and total equilibrium yield in metric tons computed over a range of exploitation rates on Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model.

Exploitation	YPR	SSB/R	SPR	Total Yield (mt)
0.000	0.000	1.864	1.000	0.070
0.039	0.054	1.306	0.700	95.940
0.082	0.086	0.961	0.516	151.843
0.128	0.105	0.737	0.395	186.427
0.176	0.118	0.584	0.313	208.798
0.226	0.127	0.476	0.255	223.798
0.275	0.133	0.398	0.213	234.163
0.324	0.137	0.340	0.182	241.507
0.371	0.141	0.295	0.158	246.824
0.417	0.143	0.261	0.140	250.744
0.460	0.145	0.233	0.125	253.676
0.502	0.147	0.211	0.113	255.895
0.541	0.148	0.192	0.103	257.587
0.579	0.149	0.177	0.095	258.885
0.614	0.150	0.164	0.088	259.880
0.648	0.151	0.153	0.082	260.641
0.680	0.151	0.144	0.077	261.216
0.711	0.152	0.135	0.073	261.643
0.740	0.153	0.128	0.069	261.951
0.768	0.153	0.122	0.065	262.160
0.795	0.153	0.116	0.062	262.288
0.821	0.154	0.111	0.059	262.347
0.846	0.154	0.106	0.057	262.350
0.870	0.154	0.102	0.054	262.304
0.894	0.155	0.098	0.052	262.217
0.916	0.155	0.094	0.050	262.093
0.938	0.155	0.091	0.049	261.939
0.959	0.155	0.088	0.047	261.758
0.980	0.155	0.085	0.046	261.554
1.000	0.155	0.082	0.044	261.328
1.019	0.156	0.080	0.043	261.085
1.038	0.156	0.077	0.042	260.825
1.056	0.156	0.075	0.040	260.552
1.074	0.156	0.073	0.039	260.265
1.092	0.156	0.071	0.038	259.968
1.109	0.156	0.070	0.037	259.660
1.126	0.156	0.068	0.036	259.343
1.142	0.156	0.066	0.036	259.018
1.158	0.156	0.065	0.035	258.685
1.174	0.157	0.063	0.034	258.346

Table 14. Gelman and Rubin's (1992) potential scale reduction factor (PSRF) values from the combined four MCMC chains for selected model parameters (*ln(R0)*) and derived quantities (SSB_0, SSB in 2024, F exploitation in 2024, $F_{30\%SPR}$, SSB at $F_{30\%SPR}$, and the retained yield at $F_{30\%SPR}$) of the SEDAR 94 KEYS RW base model.

PSRF	PSRF Upper CI	Parameter or Derived Quantity
1.005	1.012	*ln(R0)*
1.013	1.035	SSB_0
1.024	1.059	SSB_{2024}
1.014	1.043	F_{2024}
1.008	1.027	$F_{30\%SPR}$
1.013	1.035	$SSB_{F30\%SPR}$
1.022	1.066	Retained yield at $F_{30\%SPR}$

Table 15. The stock status determination criteria for Florida Keys/East Florida Hogfish according to the South Atlantic Fishery Management Council (SAFMC). All SPR proxy values of 30%SPR and 40%SPR were derived from the SEDAR 94 KEYS RW base model.

South Atlantic Fishery Management Council			
Criteria	Definition	30% SPR	40% SPR
MSY	The retained yield at F_{MSY} or $F_{SPRproxy}$	106.702 mt (235,238 lbs.)	98.714 mt (217,628 lbs.)
$F_{MSY\ or\ proxy}$	The fishing mortality rate associated with MSY or SPR proxy	0.186 yr^{-1}	0.125 yr^{-1}
MFMT (Maximum Fishing Mortality Threshold)	$F_{MSY\ or\ SPR\ proxy}$	0.186 yr-1	0.125 yr-1
$F_{current}$ (recent average fishing mortality rate)	The geometric mean of F exploitation for 2022 – 2024	0.018 yr^{-1}	
$SSB_{MSY\ or\ SPRproxy}$	The estimated spawning stock biomass associated with F_{MSY} or $F_{SPRproxy}$	989.077 mt (2,180,542 lbs.)	1,321.570 mt (2,913,563 lbs.)
MSST (Minimum Stock Size Threshold)	$0.75*SSB_{MSY\ or\ SPRproxy}$	741.808 mt (1,635,406 lbs.)	991.178 mt (2,185,172 lbs.)
$SSB_{current}$ (recent average of SSB)	The geometric mean of SSB for 2022 – 2024	2,098.706 mt (4,626,855 lbs.)	

Table 16**.** Projection results when exploitation rates = $F_{30\%SPR}$ (0.185) for Florida Keys/East Florida Hogfish. Equilibrium projections assume predicted recruitment follows the long-term average from 1986 – 2024 (1.698 million fish) while short-term projections assume predicted age-0 recruitment is equal to the average from 2020 to 2024 (1.906 million). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	$F_{30\%SPR}$ Equilibrium Long-Term Projections					**$F_{30\%SPR}$ Short-Term Projections**				
Year	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2025	1,698.40	0.185	2,295.34	583,898	174,020	1,906.89	0.185	2,323.28	589,100	177,234
2026	1,698.40	0.185	1,956.68	501,183	147,446	1,906.89	0.185	2,005.20	510,561	152,211
2027	1,698.40	0.185	1,673.27	426,677	126,007	1,906.89	0.185	1,739.11	440,246	132,088
2028	1,698.40	0.185	1,452.93	366,147	109,961	1,906.89	0.185	1,532.58	383,417	117,062
2029	1,698.40	0.185	1,288.80	320,222	98,485	1,906.89	0.185	1,378.95	340,462	106,330
2030	1,698.40	0.185	1,170.41	286,955	90,528	1,906.89	0.185	1,268.32	309,433	98,902
2031	1,698.40	0.185	1,087.38	263,685	85,170	1,906.89	0.185	1,190.94	287,788	93,916
2032	1,698.40	0.185	1,030.14	247,747	81,624	1,906.89	0.185	1,137.76	272,996	90,630
2033	1,698.40	0.185	992.12	237,231	79,377	1,906.89	0.185	1,102.63	263,286	88,565
2034	1,698.40	0.185	967.83	230,546	78,024	1,906.89	0.185	1,080.37	257,150	87,336

Table 17. Projection results when exploitation rates 75% $F_{30\%SPR}$ (0.139) and $F_{current}$ (0.018) for Florida Keys/East Florida Hogfish. Short-term projections assume predicted age-0 recruitment is equal to the average from 2020 to 2024 (1.906 million). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	0.75 * $F_{30\%SPR}$ Short-Term Projections					**$F_{current}$ Short-Term Projections**				
Year	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2025	1,906.89	0.139	2,323.28	441,788	133,099	1,906.89	0.018	2,323.28	57,954	17,525
2026	1,906.89	0.139	2,121.83	405,518	120,971	1,906.89	0.018	2,427.87	60,963	18,229
2027	1,906.89	0.139	1,938.41	369,662	110,373	1,906.89	0.018	2,518.58	63,587	18,823
2028	1,906.89	0.139	1,783.98	337,942	101,787	1,906.89	0.018	2,596.21	65,837	19,322
2029	1,906.89	0.139	1,659.37	311,748	95,121	1,906.89	0.018	2,661.45	67,730	19,735
2030	1,906.89	0.139	1,562.11	291,121	90,102	1,906.89	0.018	2,715.95	69,314	20,075
2031	1,906.89	0.139	1,488.33	275,432	86,426	1,906.89	0.018	2,761.54	70,640	20,359
2032	1,906.89	0.139	1,432.95	263,679	83,755	1,906.89	0.018	2,798.08	71,704	20,585
2033	1,906.89	0.139	1,392.78	255,173	81,878	1,906.89	0.018	2,828.15	72,582	20,770
2034	1,906.89	0.139	1,364.42	249,184	80,599	1,906.89	0.018	2,853.01	73,309	20,922

Table 18. Projection results when exploitation rates = $F_{40\%SPR}$ (0.125) for Florida Keys/East Florida Hogfish. Equilibrium projections assume predicted recruitment follows the long-term average from 1986 – 2024 (1.698 million fish) while short-term projections assume predicted age-0 recruitment is equal to the average from 2020 to 2024 (1.906 million). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

	$F_{40\%SPR}$ Equilibrium Long-Term Projections					**$F_{40\%SPR}$ Short-Term Projections**				
Year	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age-0 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2025	1,698.40	0.125	2,295.34	394,067	117,670	1,906.89	0.125	2,323.28	397,607	119,842
2026	1,698.40	0.125	2,106.38	364,469	107,387	1,906.89	0.125	2,156.88	371,078	110,726
2027	1,698.40	0.125	1,929.17	333,832	98,104	1,906.89	0.125	2,000.65	343,802	102,528
2028	1,698.40	0.125	1,775.63	305,696	90,358	1,906.89	0.125	1,865.48	318,895	95,707
2029	1,698.40	0.125	1,648.32	281,684	84,178	1,906.89	0.125	1,753.52	297,722	90,271
2030	1,698.40	0.125	1,546.30	262,187	79,395	1,906.89	0.125	1,663.90	280,581	86,071
2031	1,698.40	0.125	1,466.85	246,930	75,795	1,906.89	0.125	1,594.22	267,200	82,915
2032	1,698.40	0.125	1,405.59	235,176	73,104	1,906.89	0.125	1,540.52	256,897	80,559
2033	1,698.40	0.125	1,359.85	226,412	71,150	1,906.89	0.125	1,500.51	249,228	78,853
2034	1,698.40	0.125	1,326.48	220,036	69,765	1,906.89	0.125	1,471.45	243,670	77,651

Table 19. Projection results when exploitation rates = 75% $F_{40\%SPR}$ (0.094) for Florida Keys/East Florida Hogfish. Short-term projections assume predicted age-0 recruitment is equal to the average from 2020 to 2024 (1.906 million). Recruitment (Recruits) is in thousands of age-0 fish, F is the exploitation rate, SSB is in metric tons (female plus male SSB), Retained Yield is in pounds (whole weight), and Retained Num is in numbers of fish.

0.75 * $F_{40\%SPR}$ Short-Term Projections

Year	Age-0 Recruits	F	SSB	Retained Yield	Retained Num
2025	1,906.89	0.094	2,323.28	298,150	89,955
2026	1,906.89	0.094	2,235.95	288,580	86,163
2027	1,906.89	0.094	2,145.08	277,119	82,437
2028	1,906.89	0.094	2,059.99	265,550	79,106
2029	1,906.89	0.094	1,984.30	254,879	76,270
2030	1,906.89	0.094	1,919.64	245,608	73,937
2031	1,906.89	0.094	1,866.24	237,871	72,074
2032	1,906.89	0.094	1,822.26	231,499	70,591
2033	1,906.89	0.094	1,787.42	226,440	69,443
2034	1,906.89	0.094	1,760.47	222,523	68,576

6 Figures

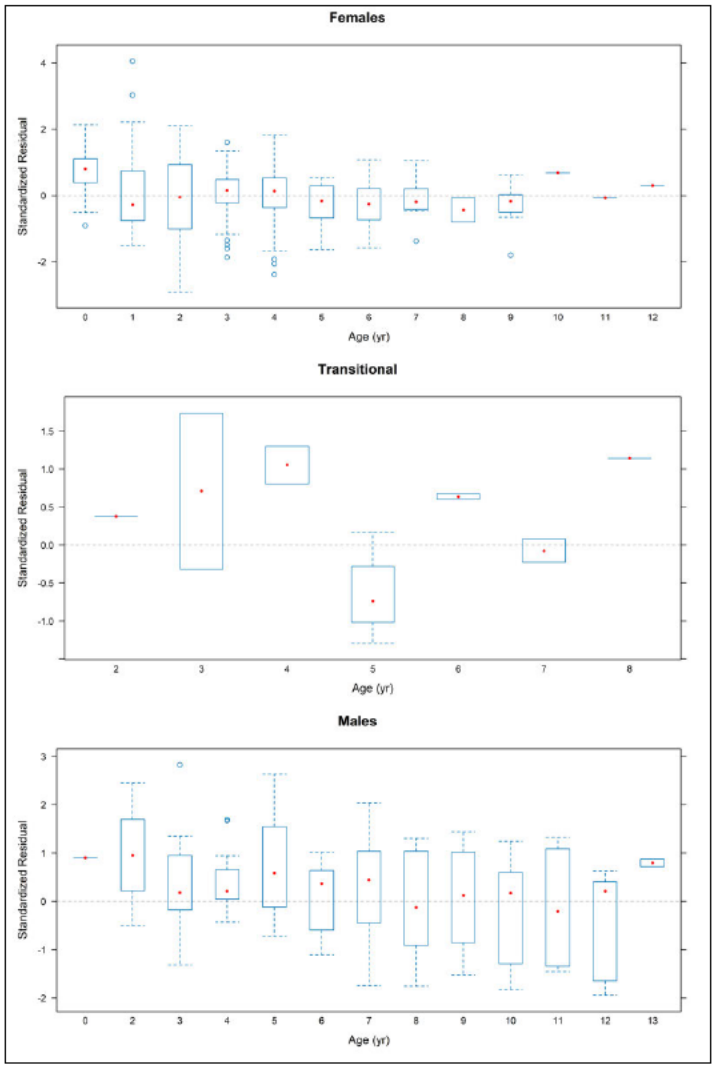


Figure 1. Boxplots of standardized residuals by age and sex from the Florida Keys/East Florida size-truncated von Bertalanffy growth model applied to inverse-weighted data where CV was constant across age. Boxplots include the median (red dots), upper and lower quartiles, and outliers (open circles).

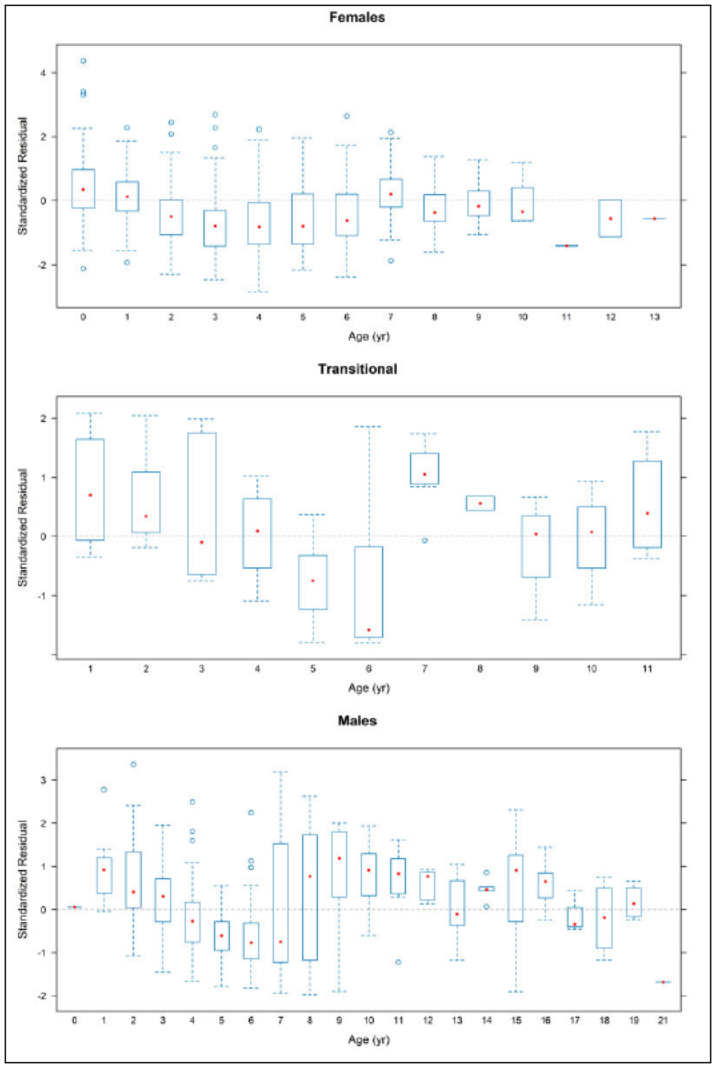
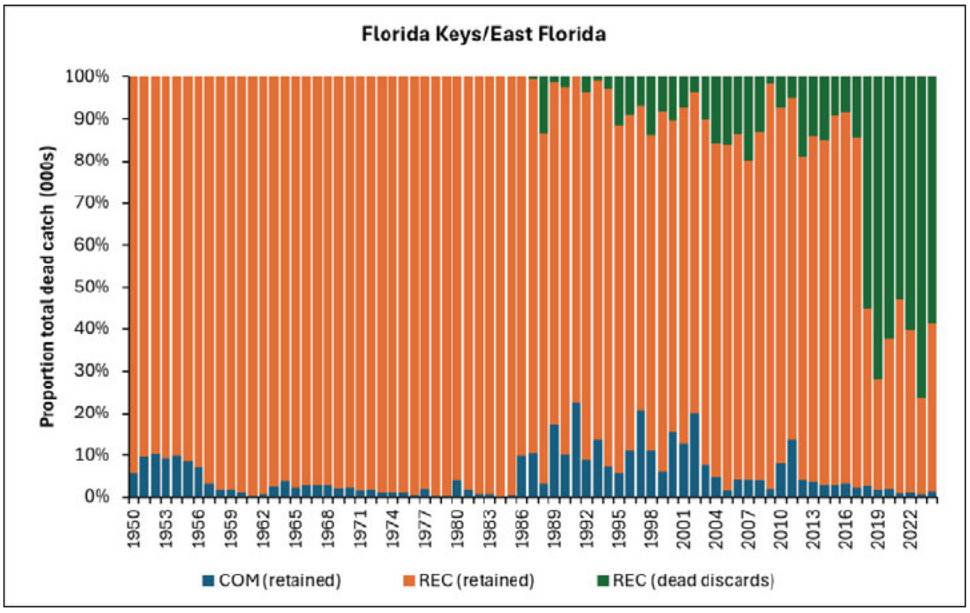


Figure 2. Boxplots of standardized residuals by age and sex plots from the West Florida Shelf size-truncated von Bertalanffy growth model applied to inverse-weighted data where CV changed linearly with age. Boxplots include the median (red dots), upper and lower quartiles, and outliers (open circles).

a)



b)

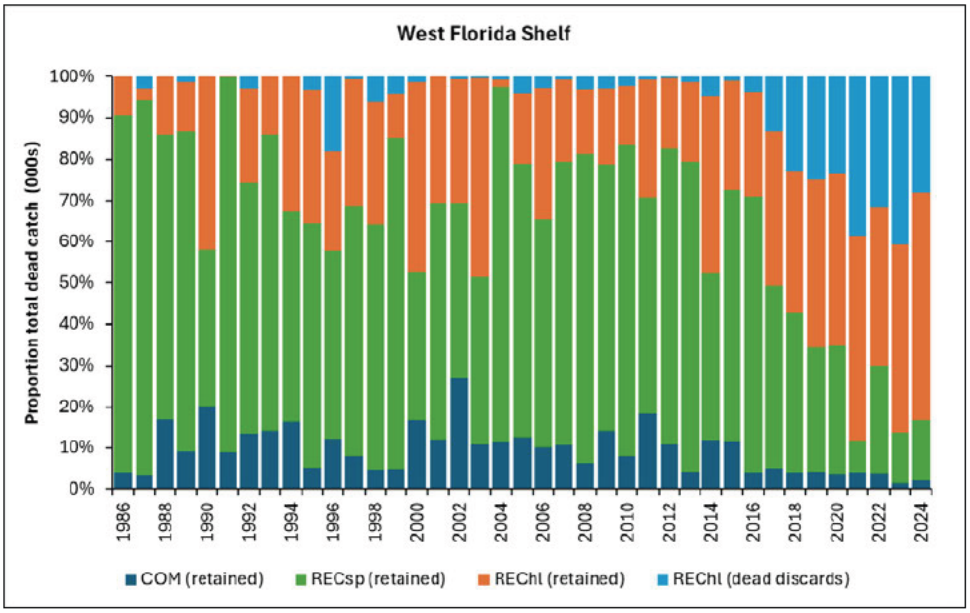


Figure 3. The proportion of total dead catch (in numbers) of Hogfish for (a) the Florida Keys/East Florida stock and (b) the West Florida Shelf stock. Recreational dead discards assumed a discard mortality rate of 41.4%.

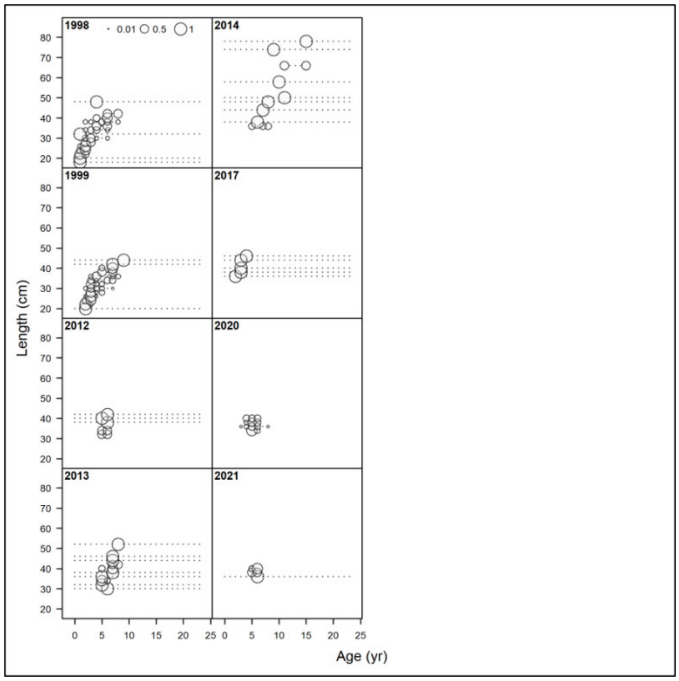


Figure 4. Observed conditional age-at-length in 2 cm FL bins of West Florida Shelf Hogfish for the commercial fleet during years 1998 – 2021.

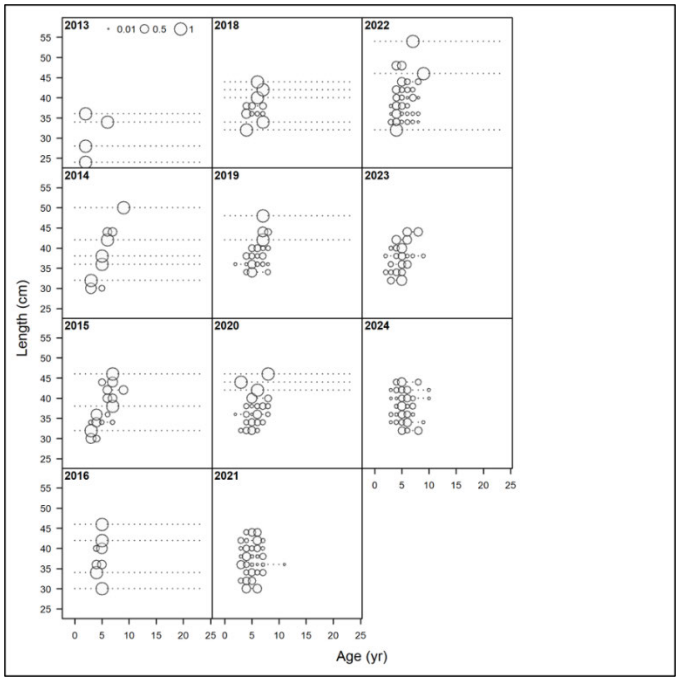


Figure 5. Observed conditional age-at-length in 2 cm FL bins of West Florida Shelf Hogfish for the recreational hook-and-line fleet during years 2013 – 2024.

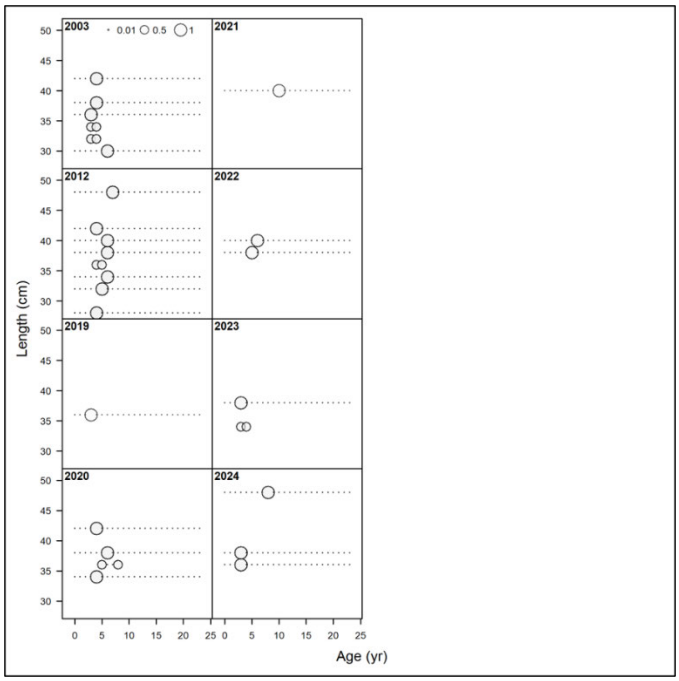


Figure 6. Observed conditional age-at-length in 2 cm FL bins of West Florida Shelf Hogfish for the recreational spear fleet during years 2003 – 2024.

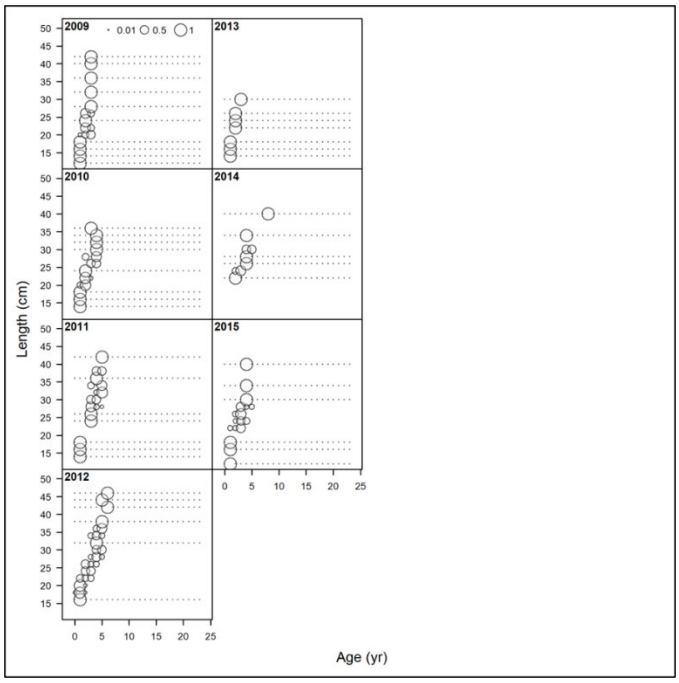


Figure 7. Observed conditional age-at-length in 2 cm FL bins of West Florida Shelf Hogfish from fishery-independent trawl sources during years 2009 – 2015.

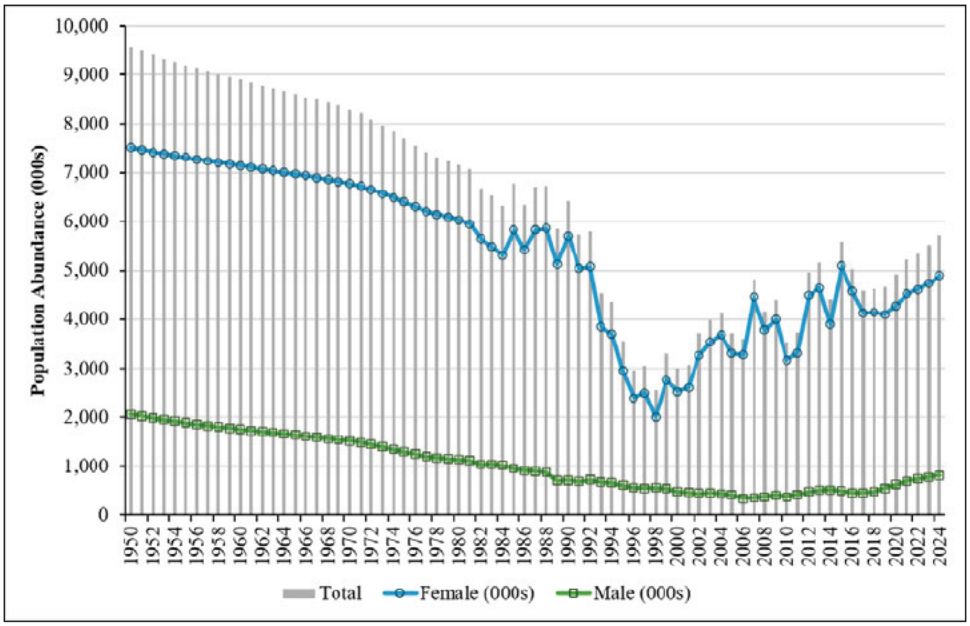


Figure 8. Estimates of total abundance separated by sex (female = blue circles, male = green squares, combined = grey bars) for Florida Keys/East Florida Hogfish from 1950 – 2024.

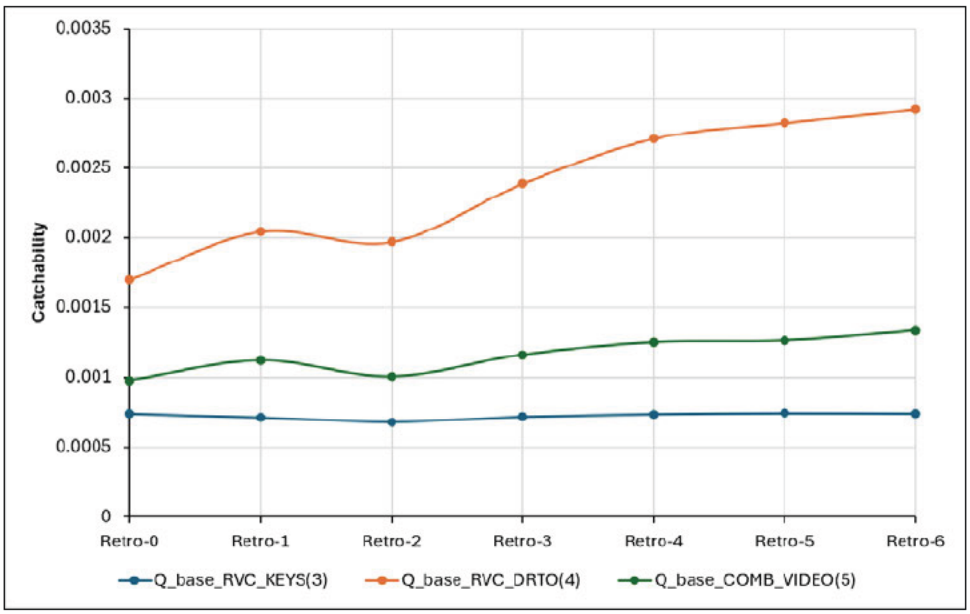


Figure 9. Estimates of catchability (Q_base) by the KEYS base model across six retrospective peels for the three indices of abundance. Retro-0 is the KEYS base model reference run.

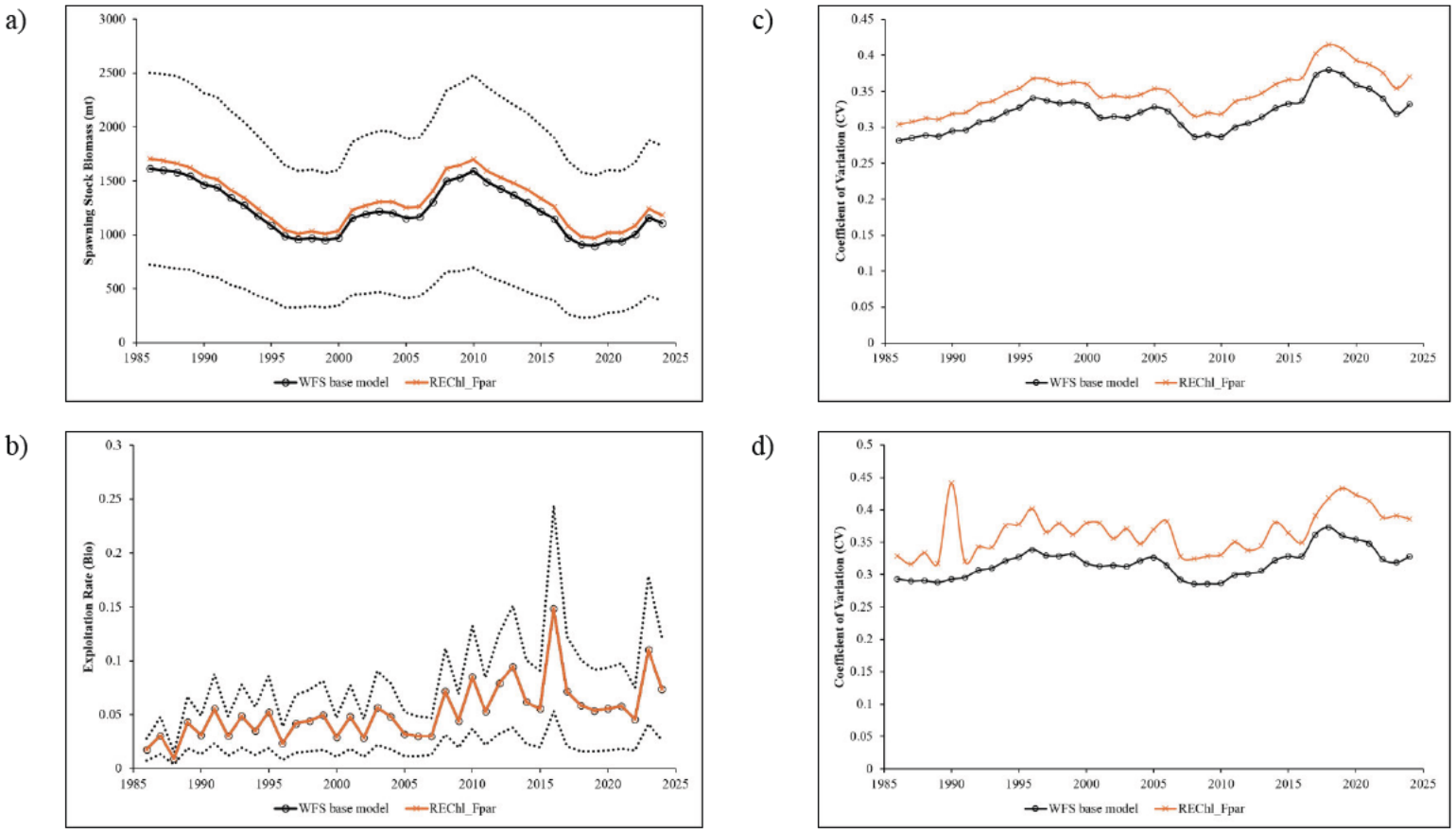


Figure 10. The a) spawning stock biomass, b) exploitation rate, c) annual CV estimates for spawning stock biomass, and d) annual CV estimates for exploitation rates from the WFS base compared to a sensitivity run where the Recreational hook-and-line (REChl) fleet was configured using F as parameter (Fpar).

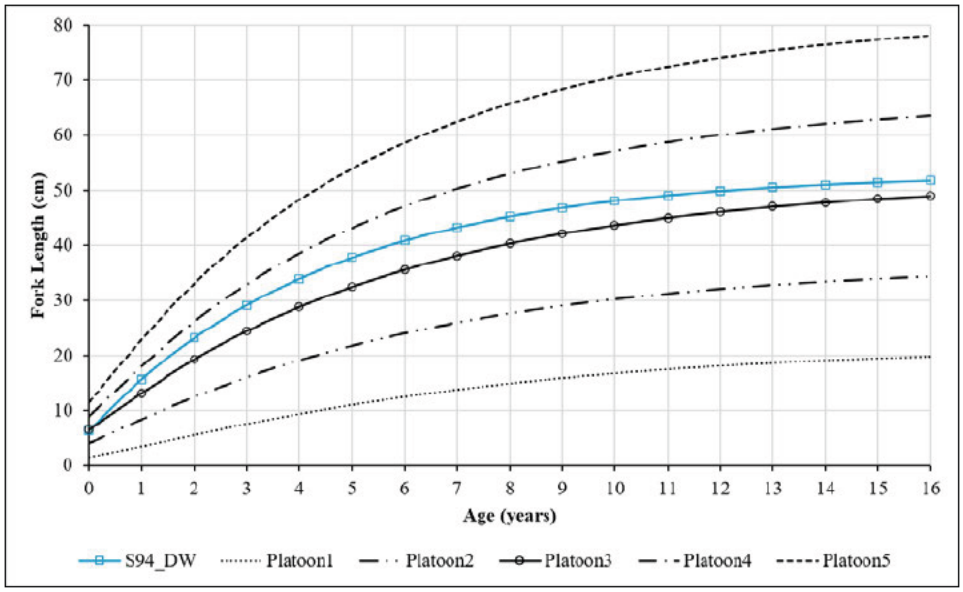


Figure 11. Mean size-at-age across 5 platoons for Florida Keys/East Florida Hogfish as estimated by the SEDAR 94 KEYS RW base model. Distribution of recruitment among platoons approximated a normal distribution (0.031, 0.237, 0.464, 0.237, 0.031) and the 3rd platoon (black circles) followed the L_{inf} (51.9 cm FL) and k (0.173) parameters estimated by the SEDAR 94 KEYS RW base model. A comparison with the external growth model developed during the Data Workshop is shown by the blue squares.

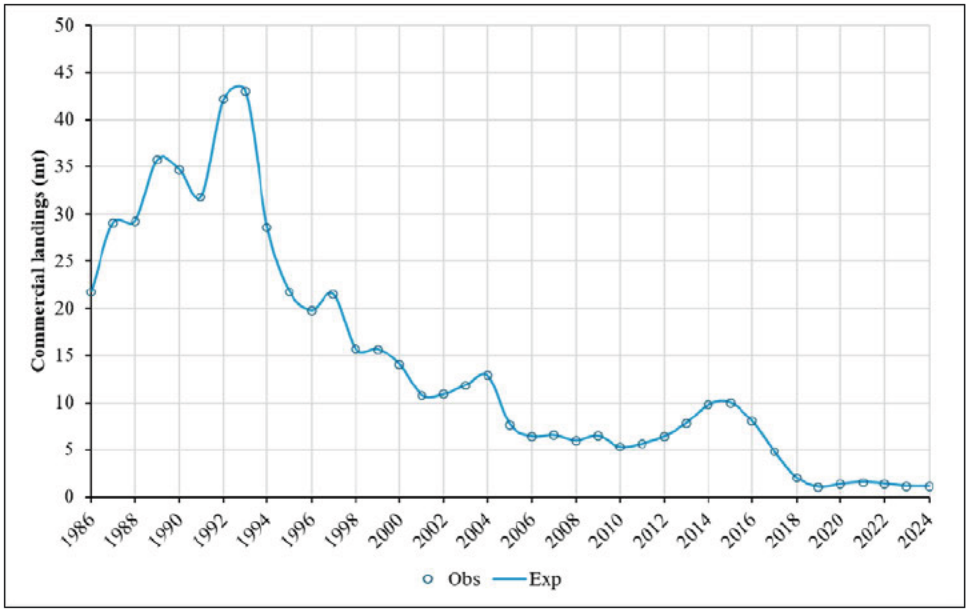


Figure 12. Florida Keys/East Florida Hogfish observed (dots) and expected (solid line) landings by the commercial fleet (in metric tons) from the SEDAR 94 KEYS RW base model.

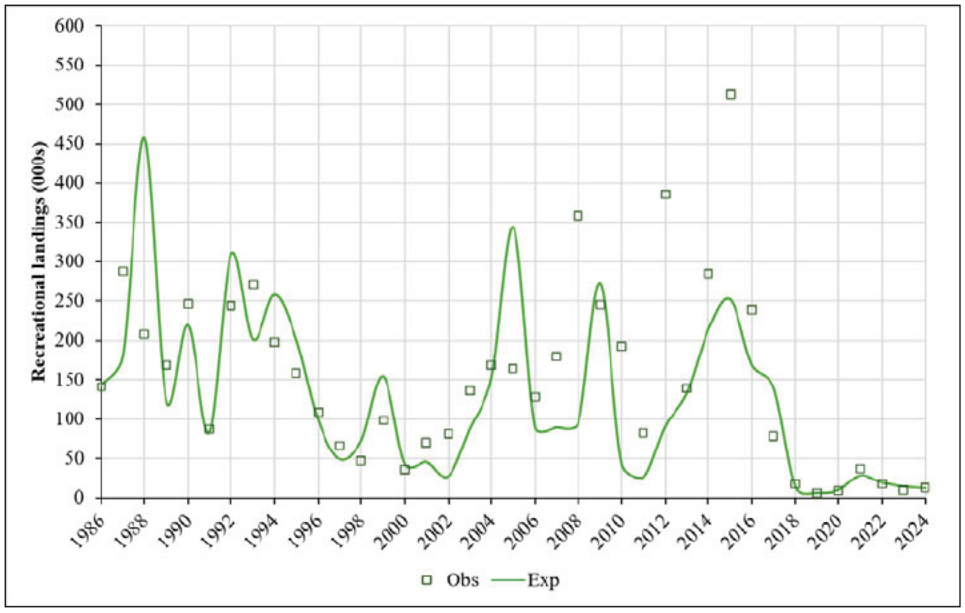
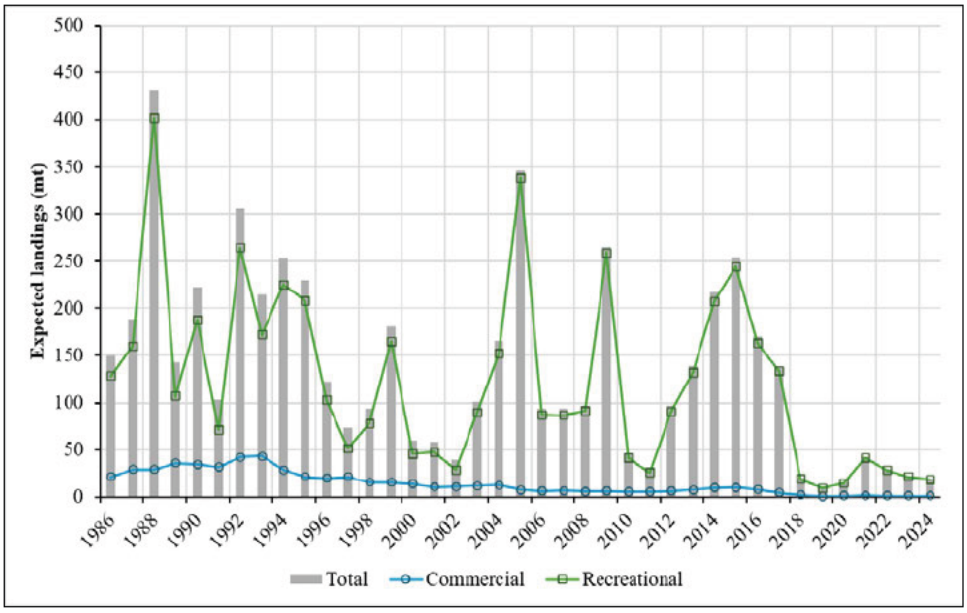


Figure 13. Florida Keys/East Florida Hogfish observed (squares) and expected (solid line) landings by the recreational fleet (in thousands of fish) from the SEDAR 94 KEYS RW base model.

a)



b)

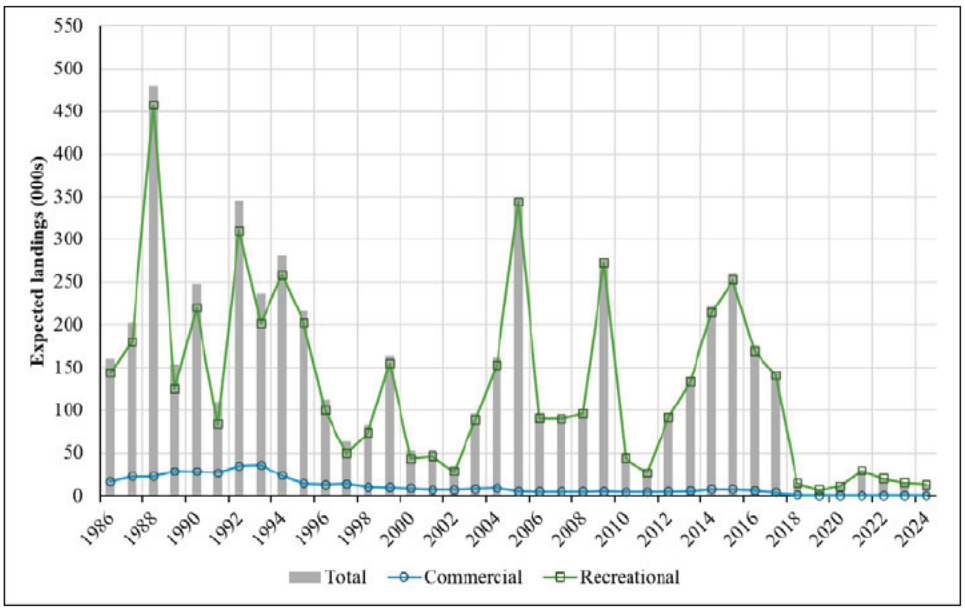


Figure 14. Expected landings of Florida Keys/East Florida Hogfish by fleet a) in metric tons, and b) in thousands of fish, as estimated from the SEDAR 94 KEYS RW base model.

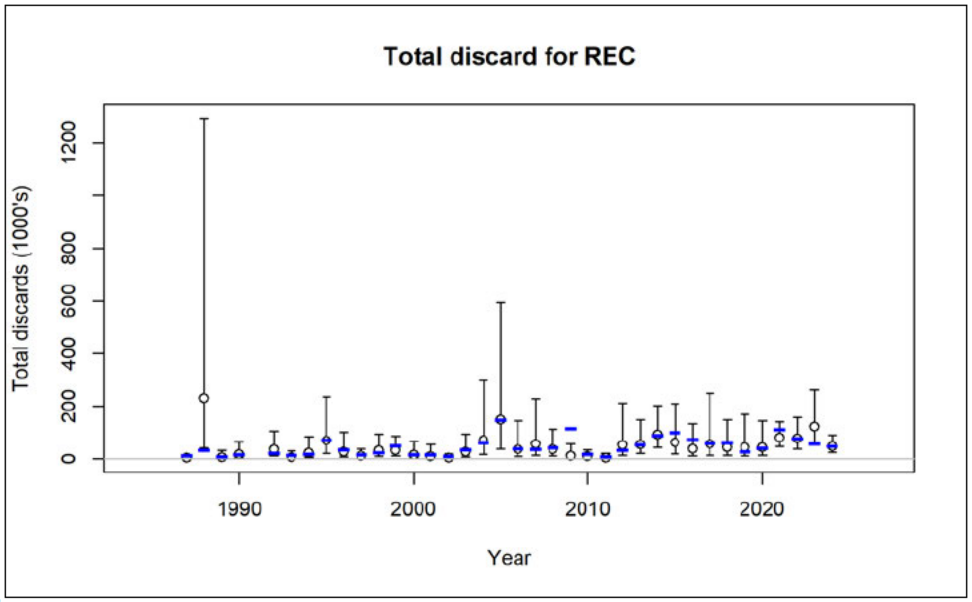


Figure 15. Florida Keys/East Florida Hogfish observed (dots with 95% confidence intervals) and expected (blue dashes) discards (i.e., before applying the discard mortality rate for each fleet) by the recreational fleet (in thousands of fish) from the SEDAR 94 KEYS RW base model.

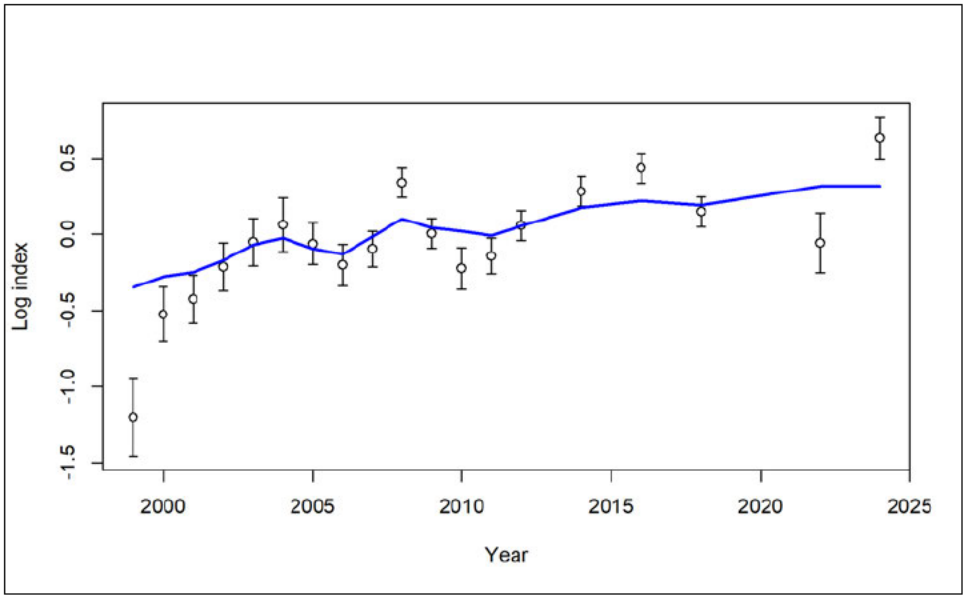


Figure 16. The Florida Keys/East Florida Hogfish observed (dots with 95% confidence intervals) and predicted (blue line) RVC Florida Keys index of relative abundance (log-transformed) from the SEDAR 94 KEYS RW base model.

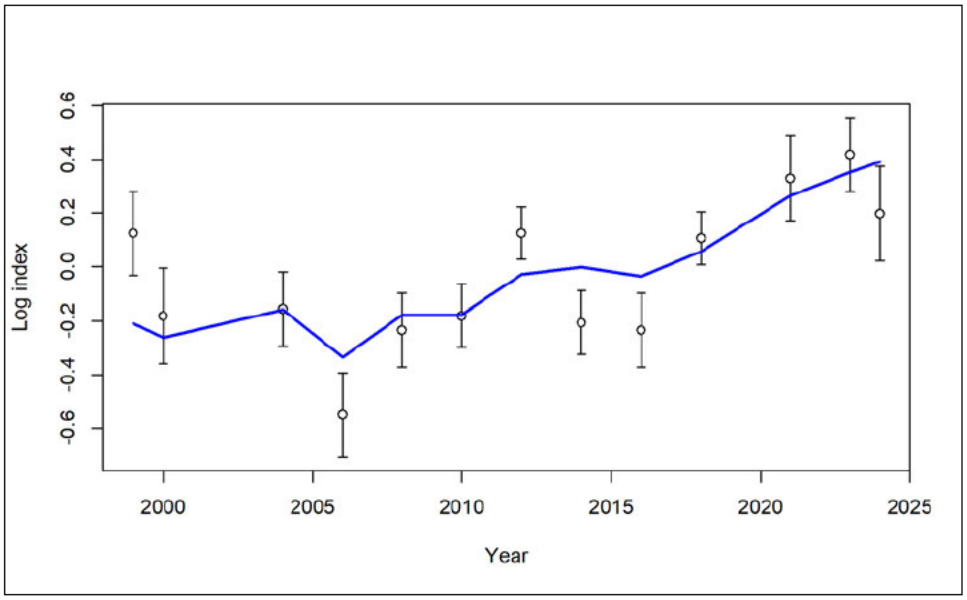


Figure 17. The Florida Keys/East Florida Hogfish observed (dots with 95% confidence intervals) and predicted (blue line) RVC Dry Tortugas index of relative abundance (log-transformed) from the SEDAR 94 KEYS RW base model.

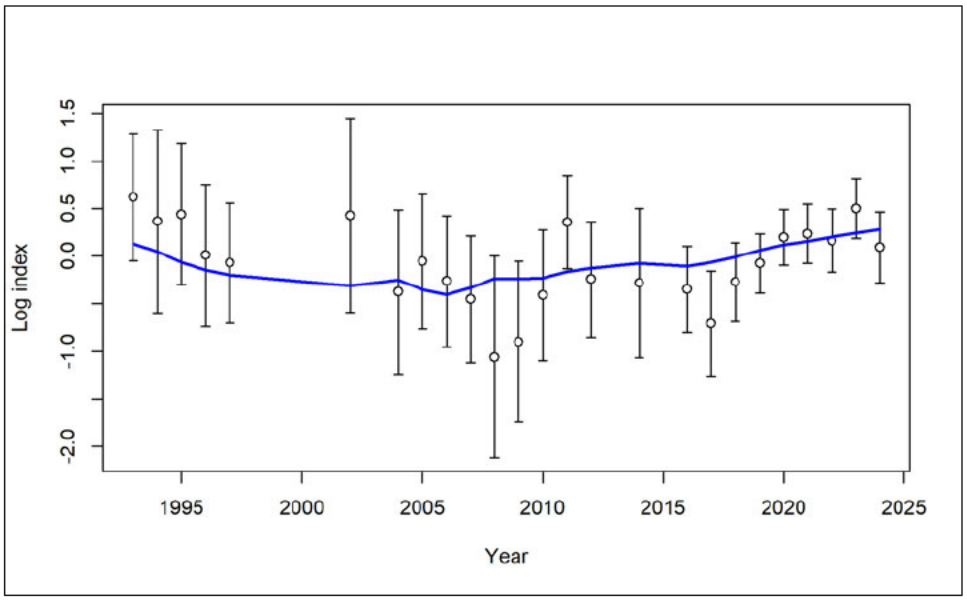


Figure 18. The Florida Keys/East Florida Hogfish observed (dots with 95% confidence intervals) and predicted (blue line) combined video index of relative abundance (log-transformed) from the SEDAR 94 KEYS RW base model.

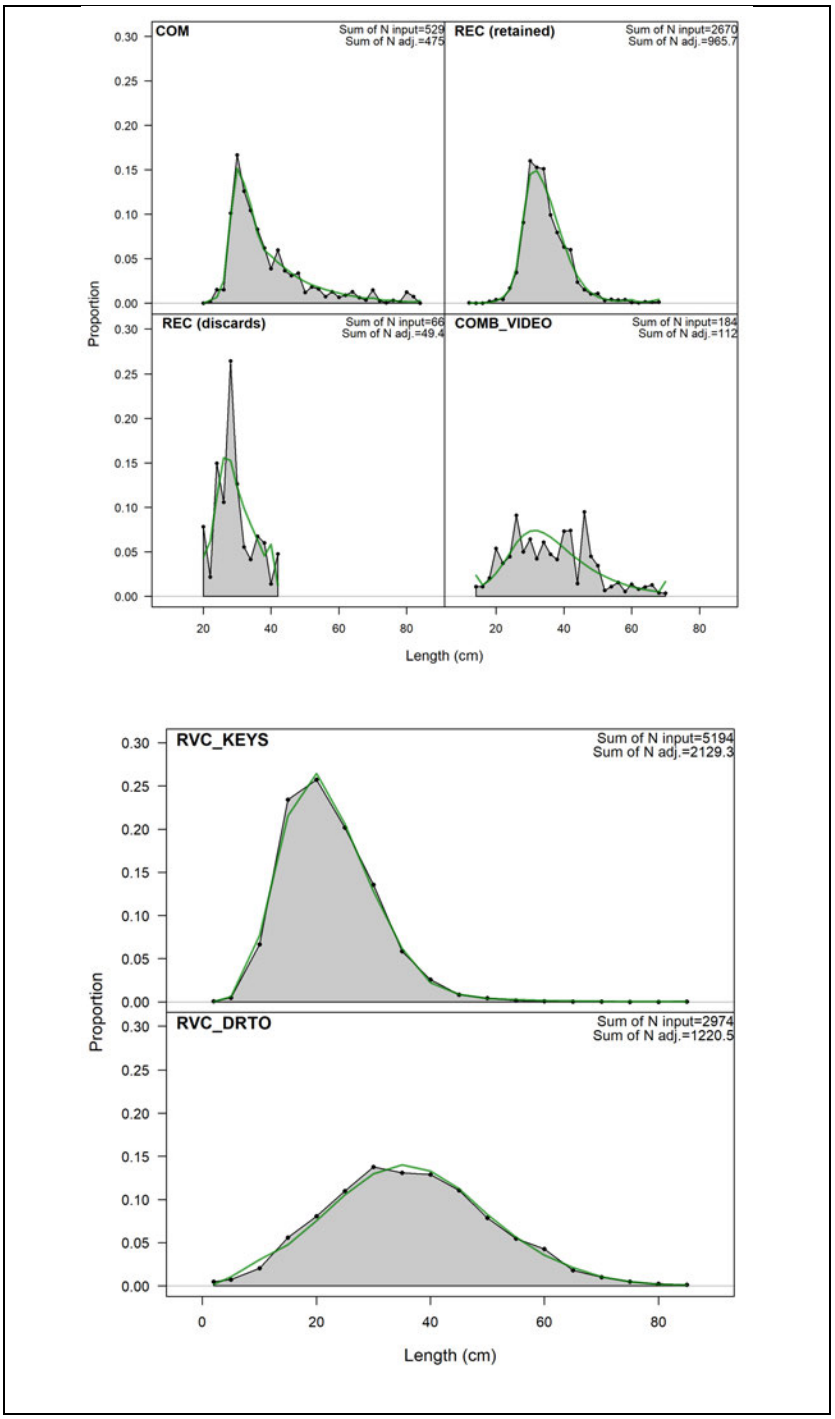


Figure 19. Model fits to the length composition of retained and discarded catch within a given fleet or survey aggregated across years for Florida Keys/East Florida Hogfish. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. In the upper right hand corners, 'N input.' is the input sample size while 'N adj.' is the effective sample size calculated using the Dirichlet-Multinomial data-weighting adjustment.

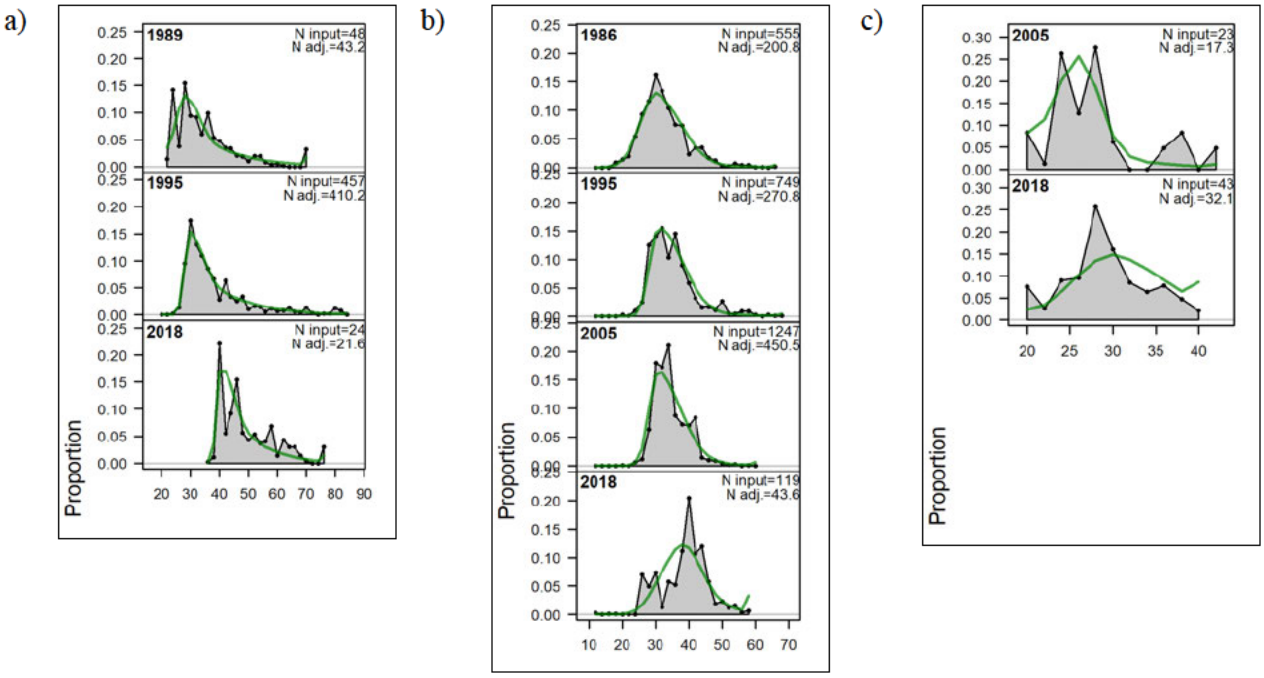


Figure 20. Model fits to the length composition of a) retained catch by the commercial fleet, b) retained catch by the recreational fleet, and c) discards for the recreational fleet by super-period for Florida Keys/East Florida Hogfish. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. In the upper right hand corners, 'N input.' is the input sample size while 'N adj.' is the effective sample size calculated using the Dirichlet-Multinomial data-weighting adjustment. Data are in 2 cm fork length bins.

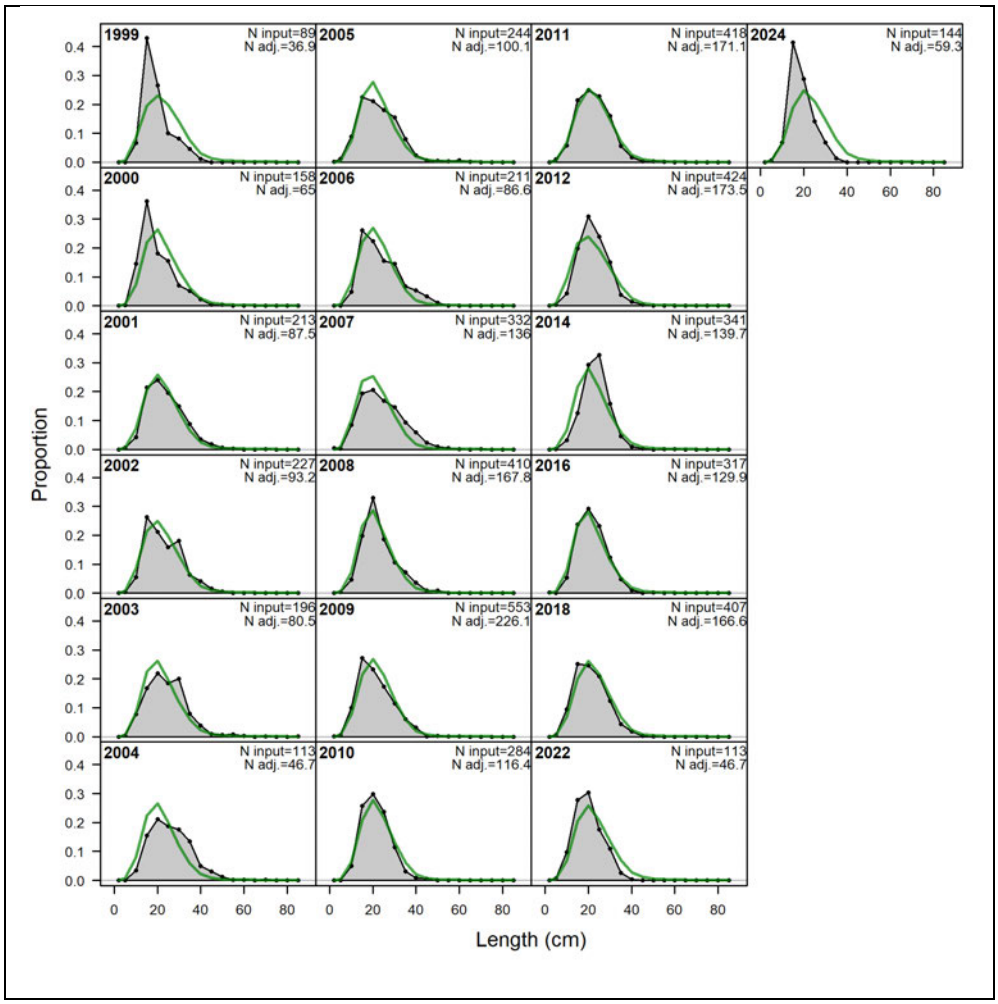


Figure 21. Model fits to the length composition data by the RVC Florida Keys index for Florida Keys/East Florida Hogfish. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. In the upper right hand corners, 'N input.' is the input sample size while ‘N adj.’ is the effective sample size calculated using the Dirichlet-Multinomial data-weighting adjustment. Data are in 5 cm fork length bins.

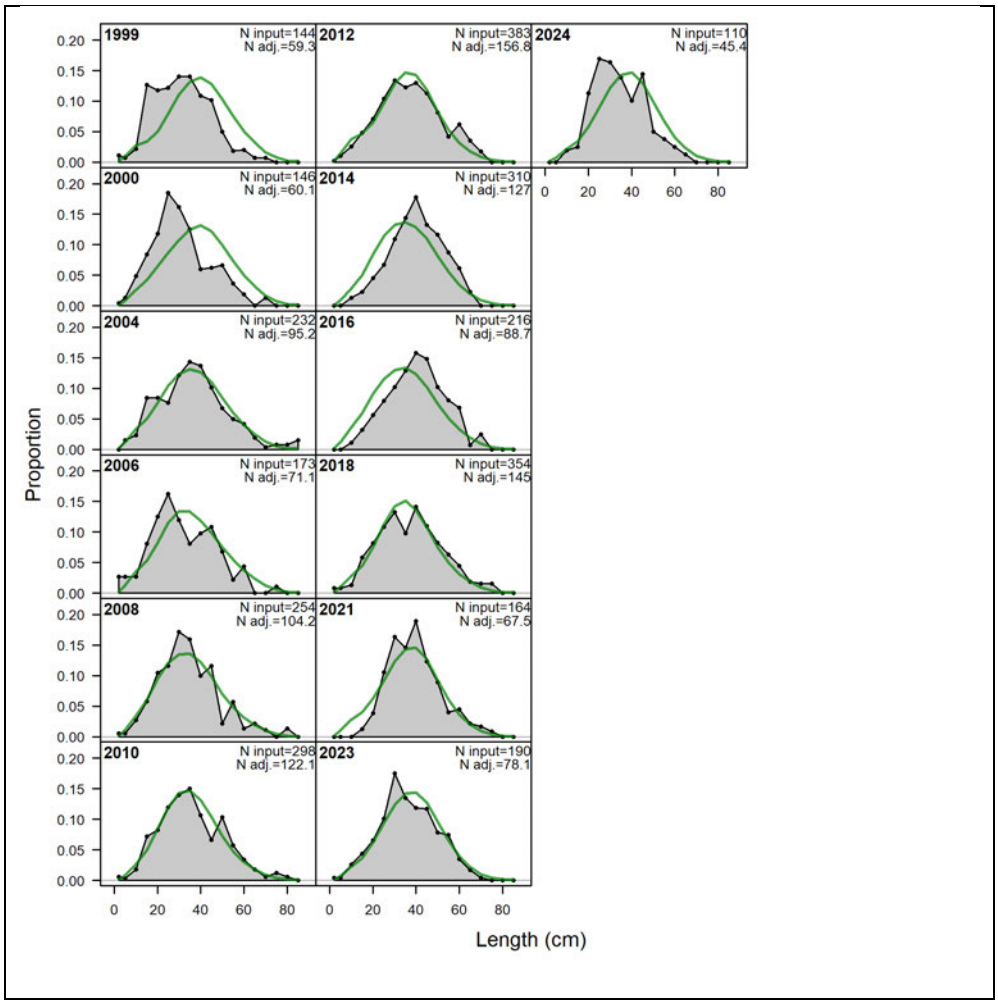


Figure 22. Model fits to the length composition data by the RVC Dry Tortugas index Florida Keys/East Florida Hogfish. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. In the upper right hand corners, 'N input.' is the input sample size while 'N adj.' is the effective sample size calculated using the Dirichlet-Multinomial data-weighting adjustment. Data are in 5 cm fork length bins.

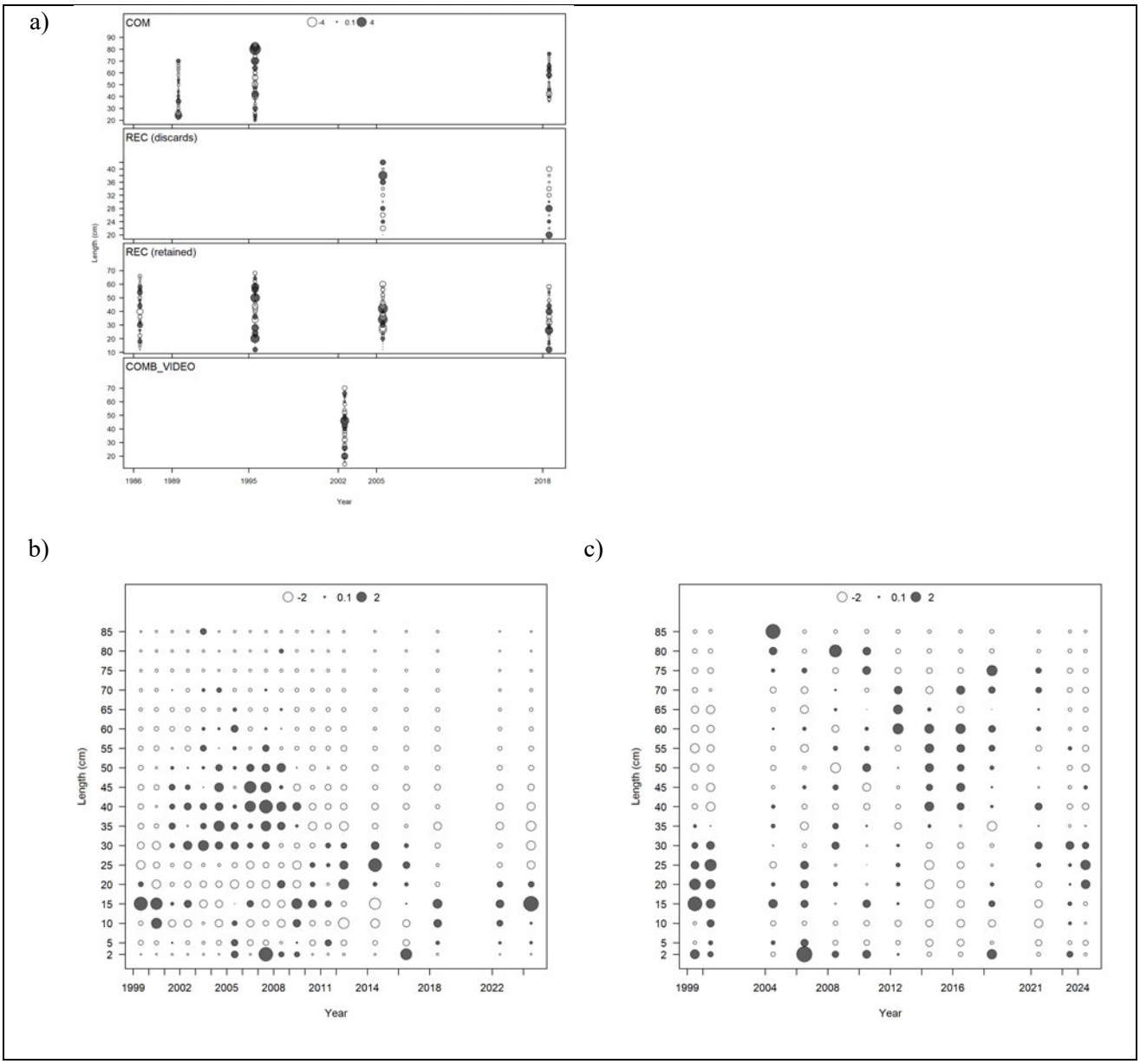


Figure 23. Pearson residuals for length composition data for a) the commercial and recreational fleets as well as the combined video index by super-period, b) the RVC Florida Keys index by year, and c) the RVC Dry Tortugas index by year for Florida Keys/East Florida Hogfish. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

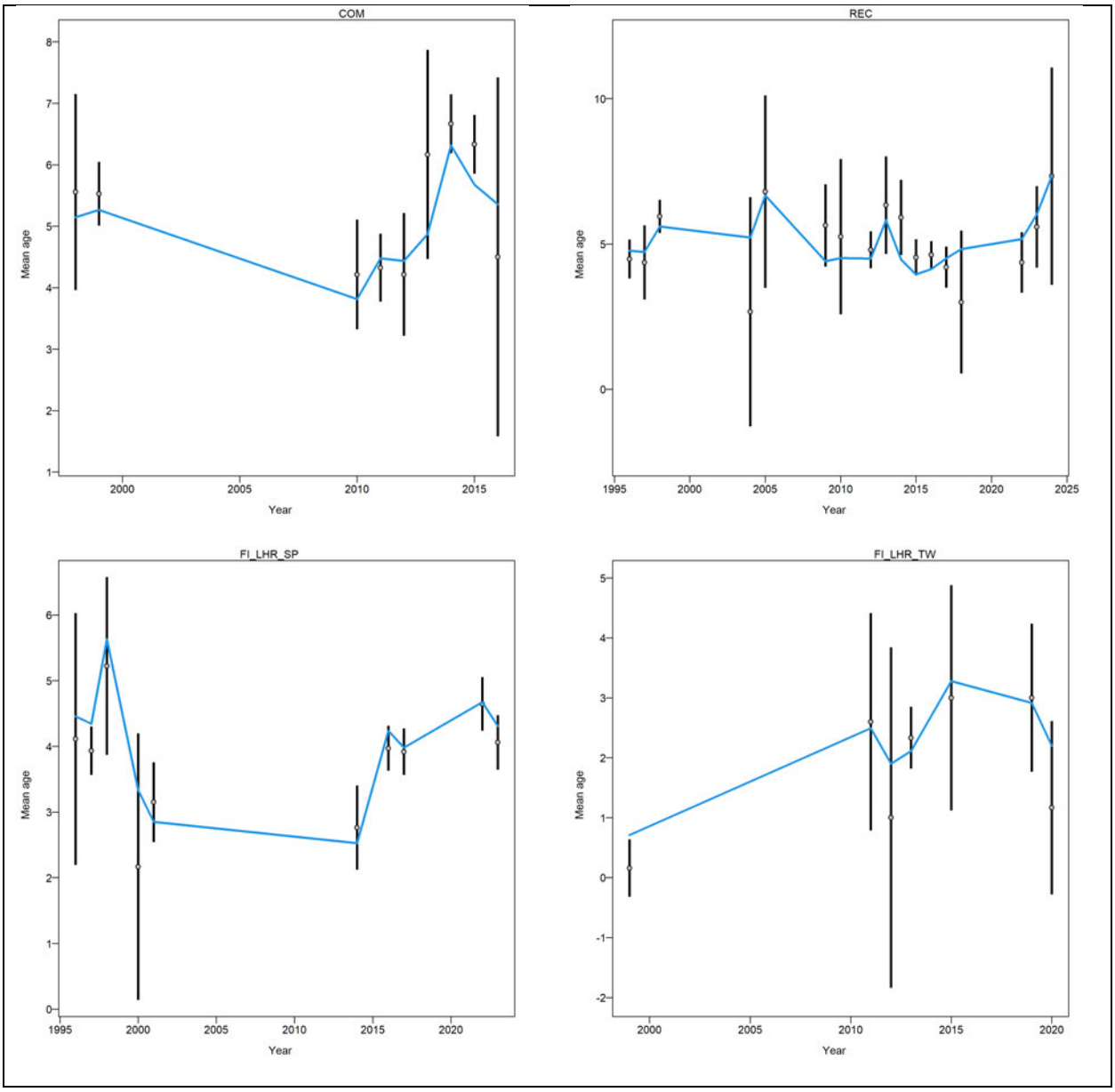


Figure 24. Mean ages of Florida Keys/East Florida Hogfish from conditional age-at-length data (commercial retained catch, recreational retained catch, fishery-independent spear, and fishery-independent trawl) aggregated across length bins. Observed values are dots with 95% confidence intervals and predicted values are the blue lines).

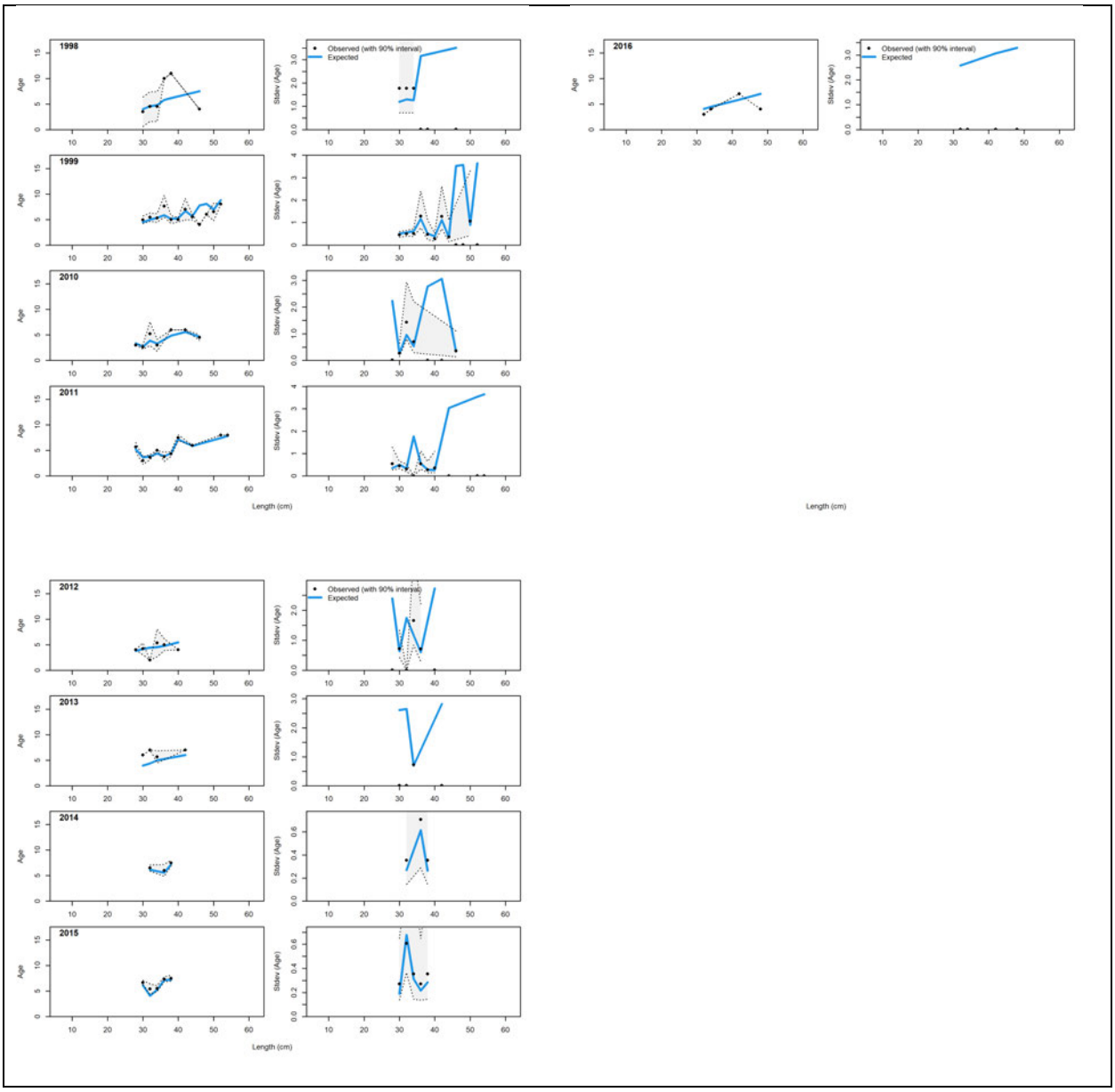


Figure 25. Model fits to the annual conditional age-at-length data from retained catch by the commercial fleet for Florida Keys/East Florida Hogfish. In the left plots, the blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals. In the right plots, the blue lines represent predicted standard error of mean age-at-length by size class while the black dots and grey shaded regions represent the observed standard error of mean age-at-length by size class with 90% confidence intervals.

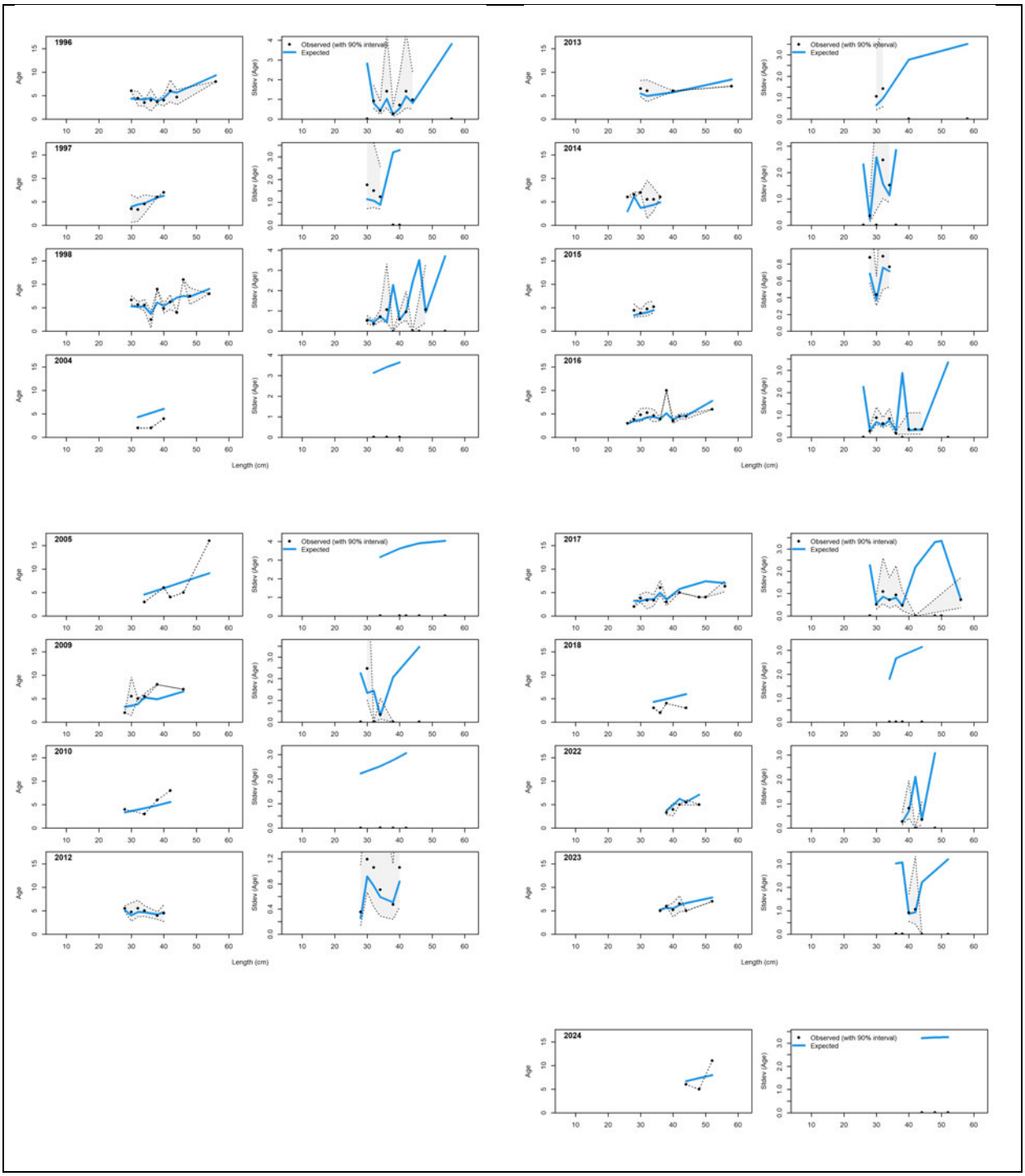


Figure 26. Model fits to the annual conditional age-at-length data from retained catch by the recreational fleet for Florida Keys/East Florida Hogfish. In the left plots, the blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals. In the right plots, the blue lines represent predicted standard error of mean age-at-length by size class while the black dots and grey shaded regions represent the observed standard error of mean age-at-length by size class with 90% confidence intervals.

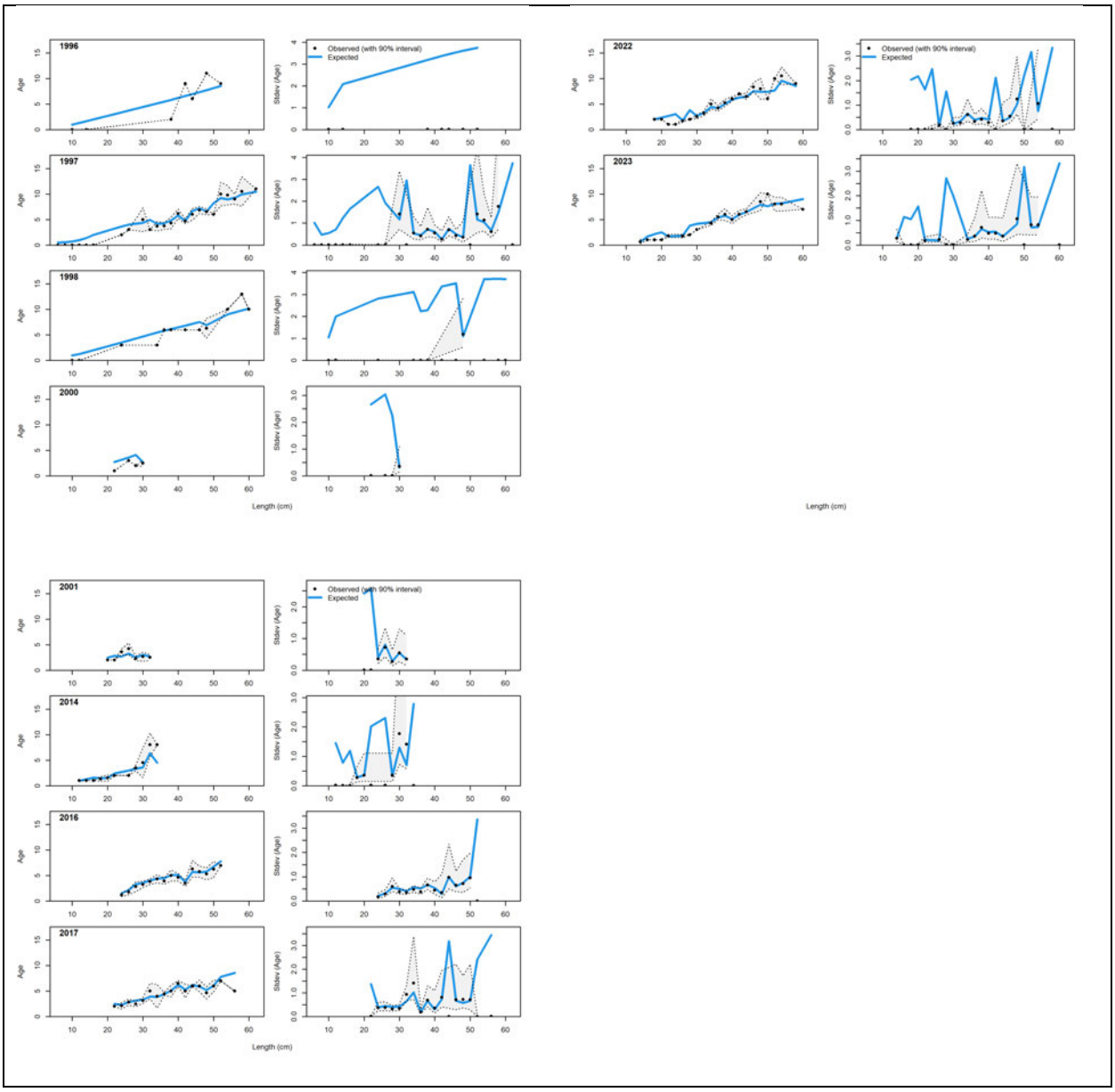


Figure 27. Model fits to the annual conditional age-at-length data from fishery-independent spear data sources for Florida Keys/East Florida Hogfish. In the left plots, the blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals. In the right plots, the blue lines represent predicted standard error of mean age-at-length by size class while the black dots and grey shaded regions represent the observed standard error of mean age-at-length by size class with 90% confidence intervals.

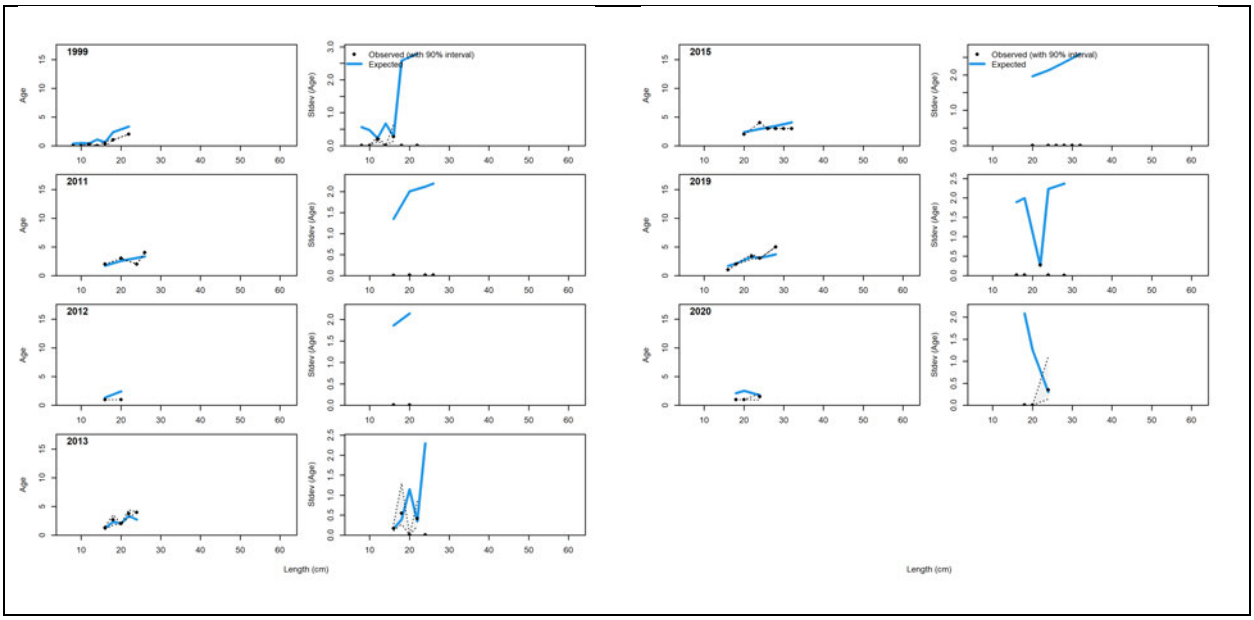
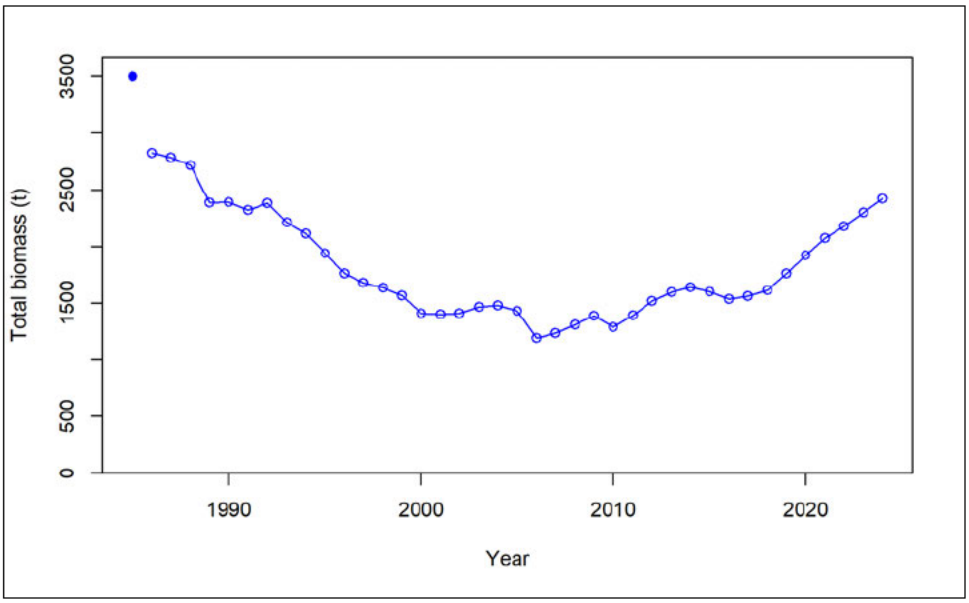


Figure 28. Model fits to the annual conditional age-at-length data from fishery-independent trawl data sources for Florida Keys/East Florida Hogfish. In the left plots, the blue lines represent predicted mean age-at-length by size class while the black dots and grey shaded regions represent the observed mean age-at-length by size class with 90% confidence intervals. In the right plots, the blue lines represent predicted standard error of mean age-at-length by size class while the black dots and grey shaded regions represent the observed standard error of mean age-at-length by size class with 90% confidence intervals.

a)



b)

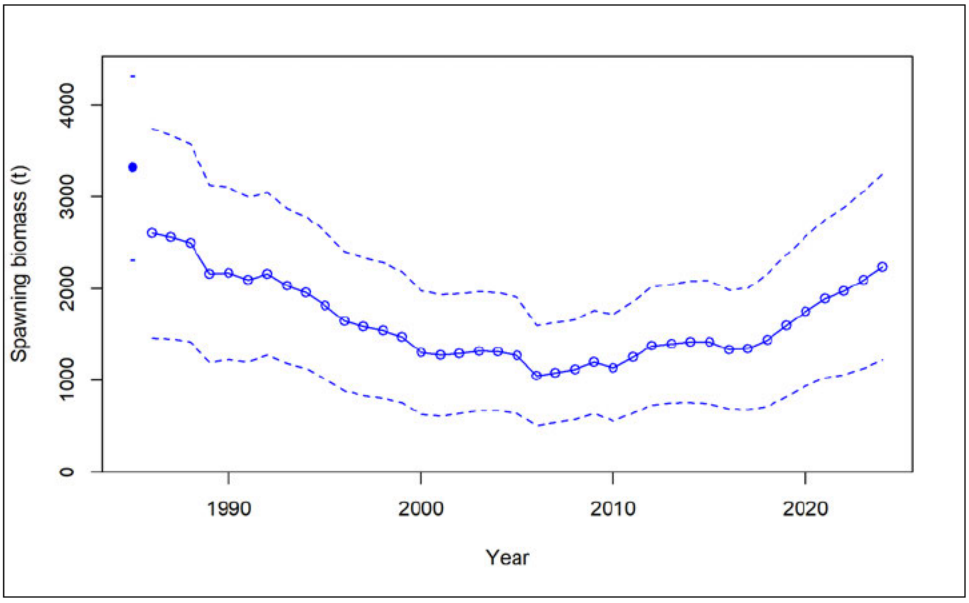
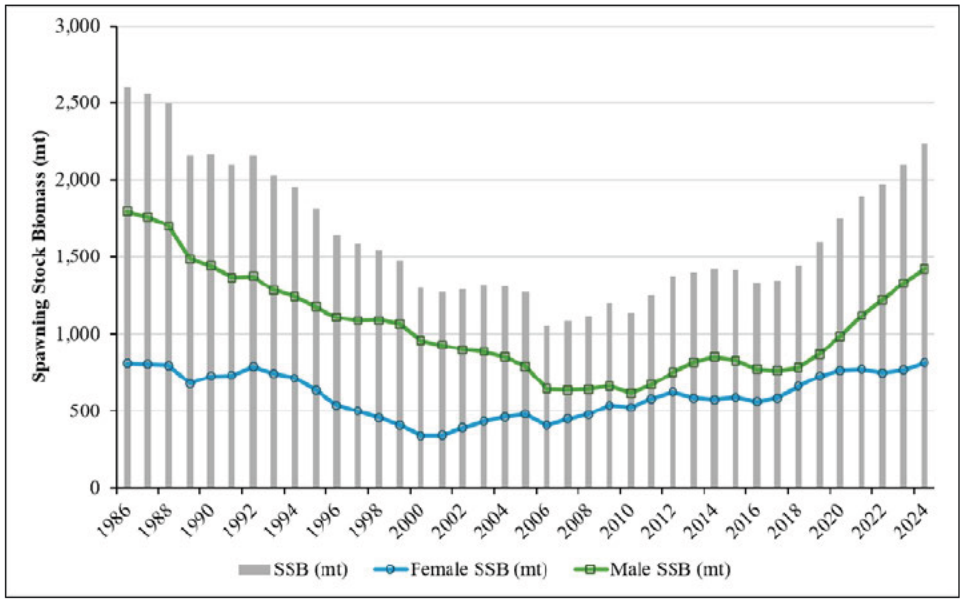


Figure 29. Estimates of a) total biomass and b) mature female and male spawning stock biomass (in metric tons) of Florida Keys/East Florida Hogfish (open circles) from 1986 – 2024. The solid blue circles are the estimated unfished biomasses.

a)



b)

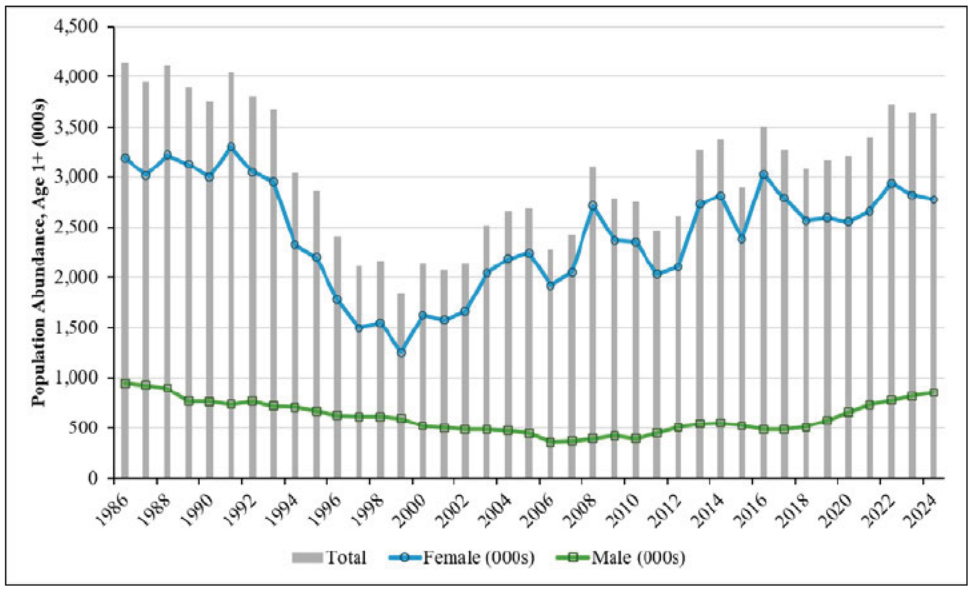


Figure 30. Estimates of a) mature female and male spawning stock biomass (in metric tons), and b) population abundance for age 1+ fish (in thousands), separated by sex (female = blue circles, male = green squares, combined = grey bars) for Florida Keys/East Florida Hogfish from 1986 – 2024.

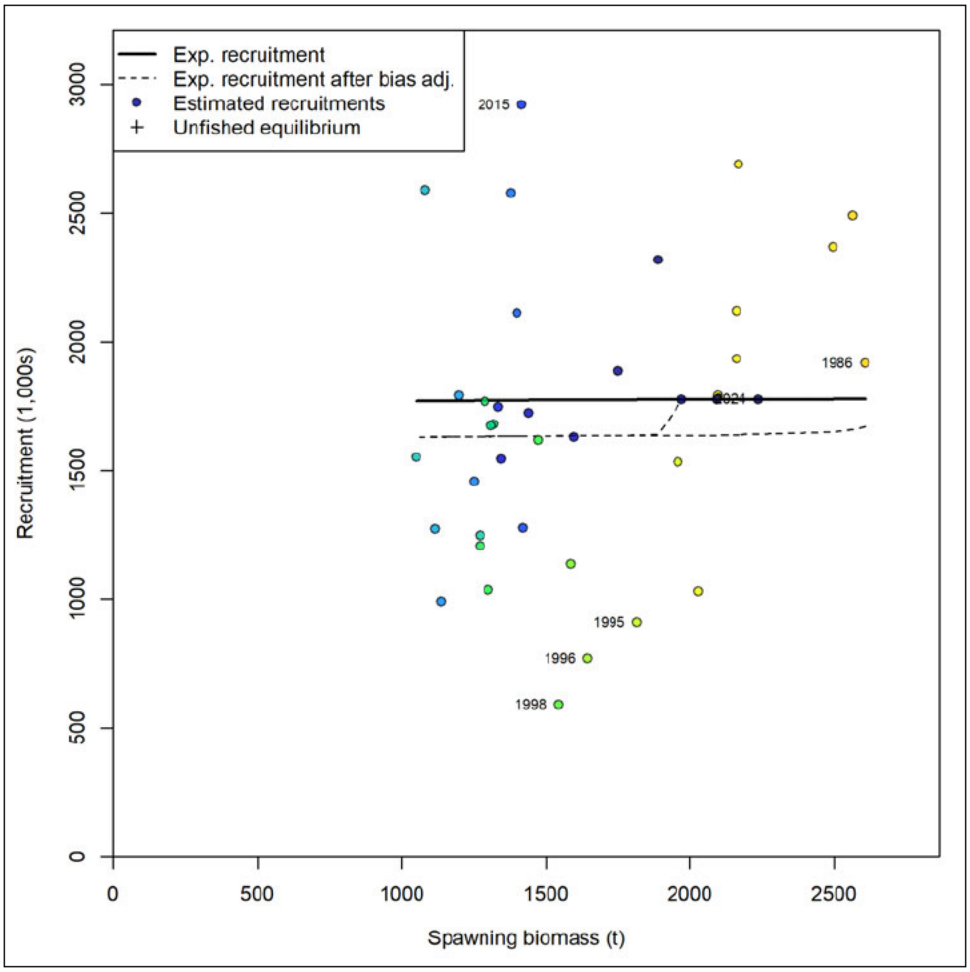


Figure 31. Expected stock-recruitment relationship for Florida Keys/East Florida Hogfish. Steepness was fixed at 0.99 and sigmaR was estimated at 0.411. Plotted are expected annual recruitments from the SEDAR 94 KEYS RW base model (circles), expected recruitment from the stock-recruitment relationship (black line), and bias adjusted recruitment from the stock-recruit relationship (dashed line). Point colors indicate year, with warmer colors indicating earlier years and cooler colors showing later years.

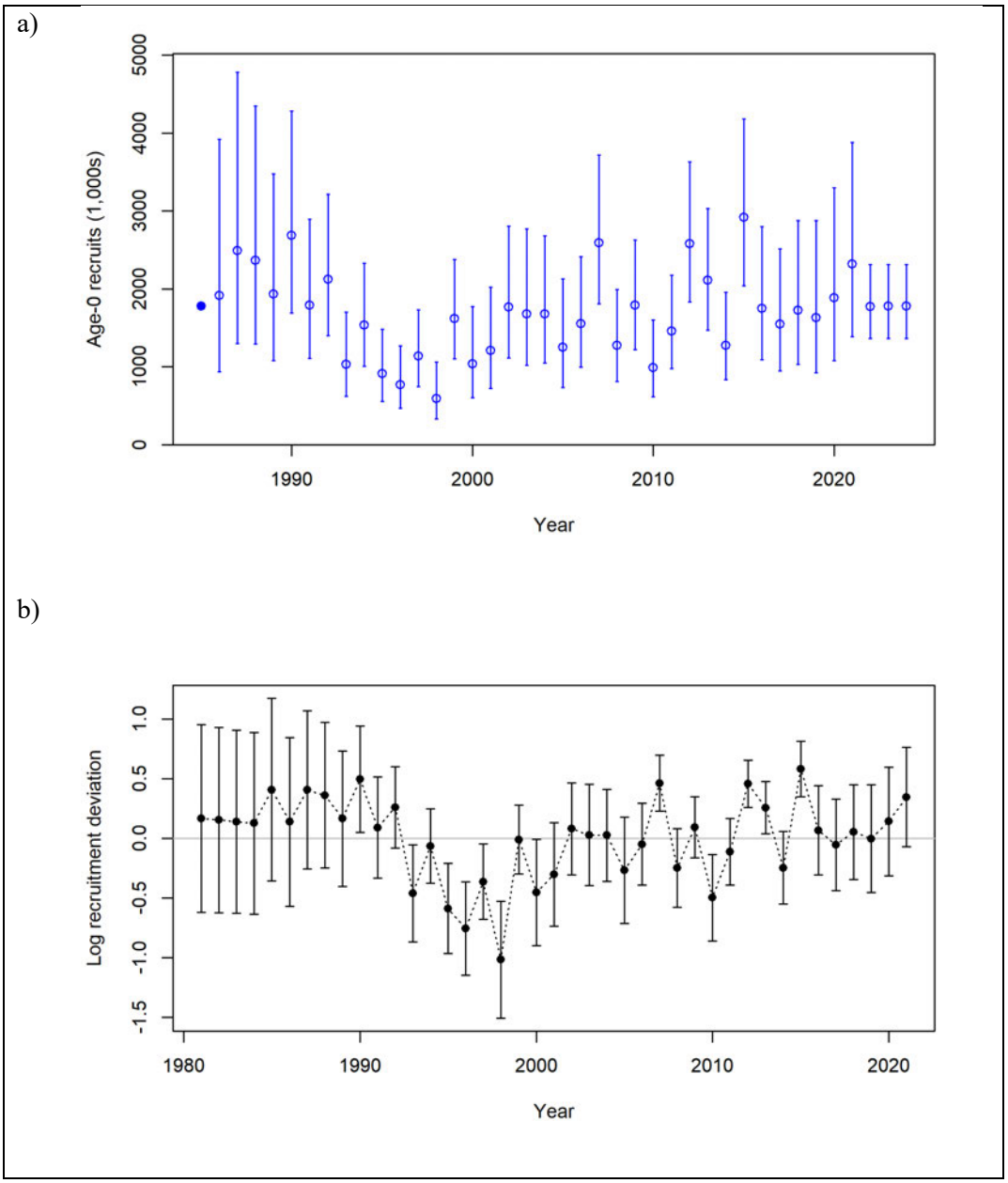


Figure 31. Estimated recruitment for Florida Keys/East Florida Hogfish. a) Annual estimated age-0 recruitment (open circles) with 95% confidence intervals (lines) as well as estimated initial equilibrium recruitment (blue dot). b) Log-scaled main recruitment deviations (dots) with 95% confidence intervals (lines) from 1981 – 2021. Recruitment for years 2022 – 2024 was estimated following the expected stock-recruitment curve (i.e., average recruitment).

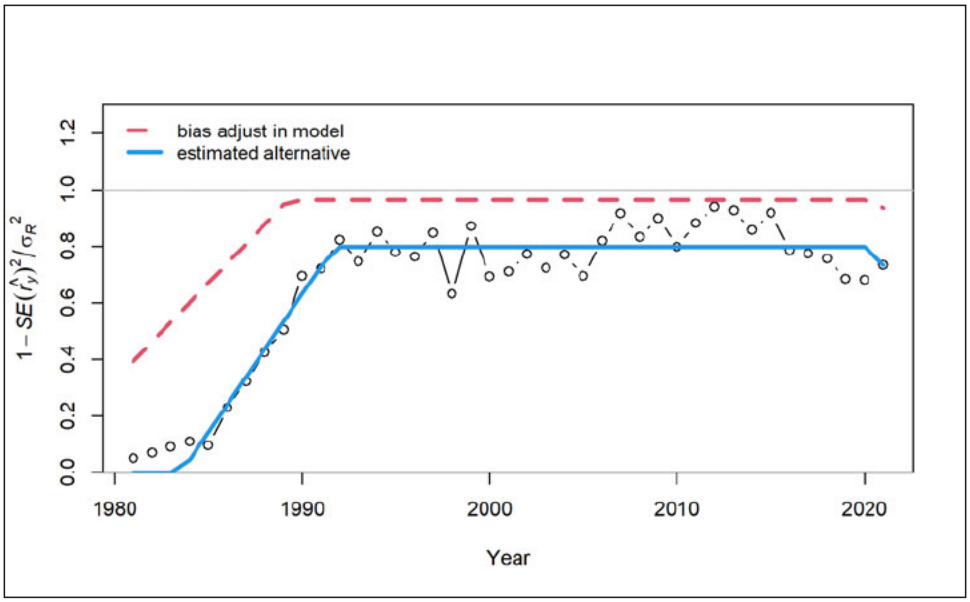


Figure 32. Recommended bias adjustment for recruitment deviations. The red dashed line shows the bias adjustment specified for the SEDAR 94 KEYS RW base model, which deviated from the least squares estimate of an alternative bias adjustment relationship for recruitment deviations (blue line). Points are transformed variances. For more information, see Methot and Taylor (2011).

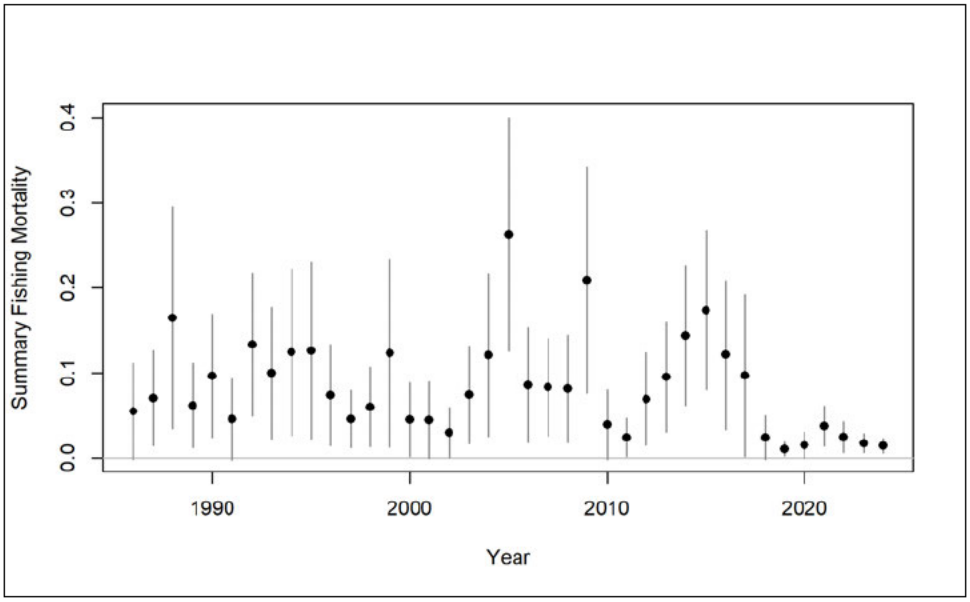


Figure 33. Annual exploitation fishing mortality rates, calculated as the ratio of the total annual catch in biomass to the age 1+ biomass at the beginning of the year, for Florida Keys/East Florida Hogfish with 95% confidence intervals from the SEDAR 94 KEYS RW base model.

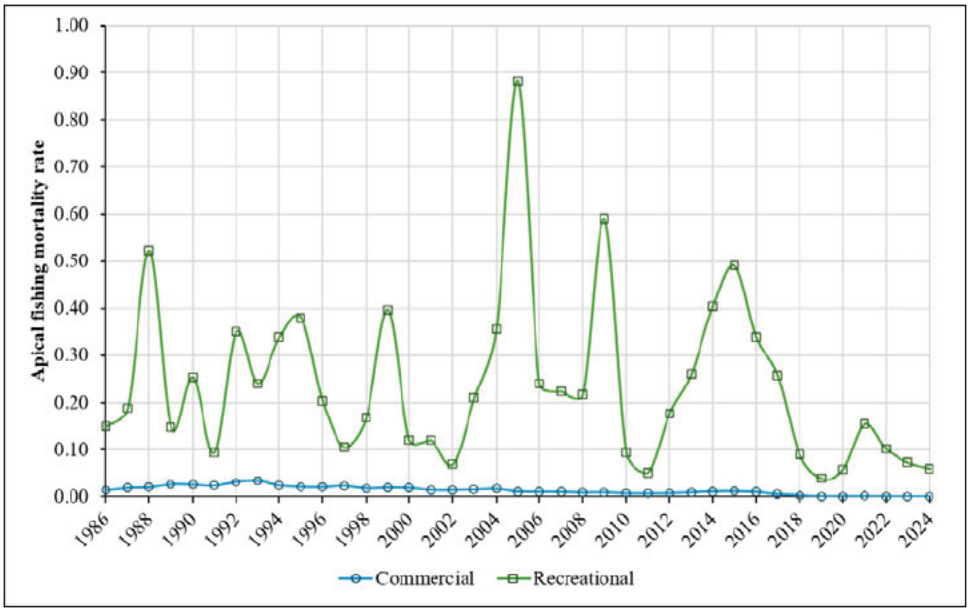


Figure 34. Annual fleet-specific instantaneous apical fishing mortality rates for Florida Keys/East Florida Hogfish for years 1986 – 2024 from the SEDAR 94 KEYS RW base model. This represents the instantaneous fishing mortality level on the most vulnerable (i.e., selectivity = 1) age class for each fleet.

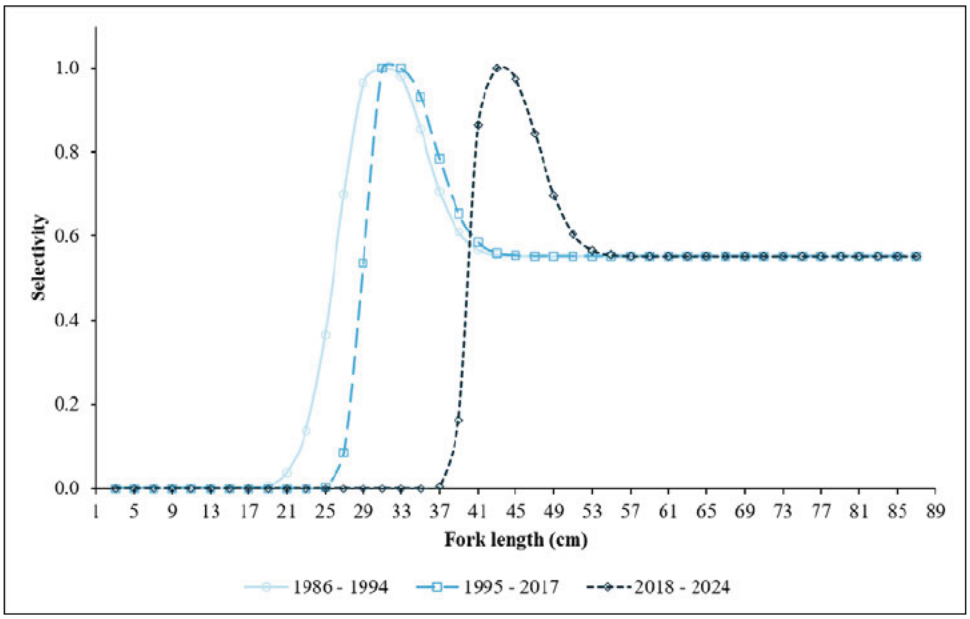


Figure 35. Length-based selectivity of the commercial fleet by time block for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model.

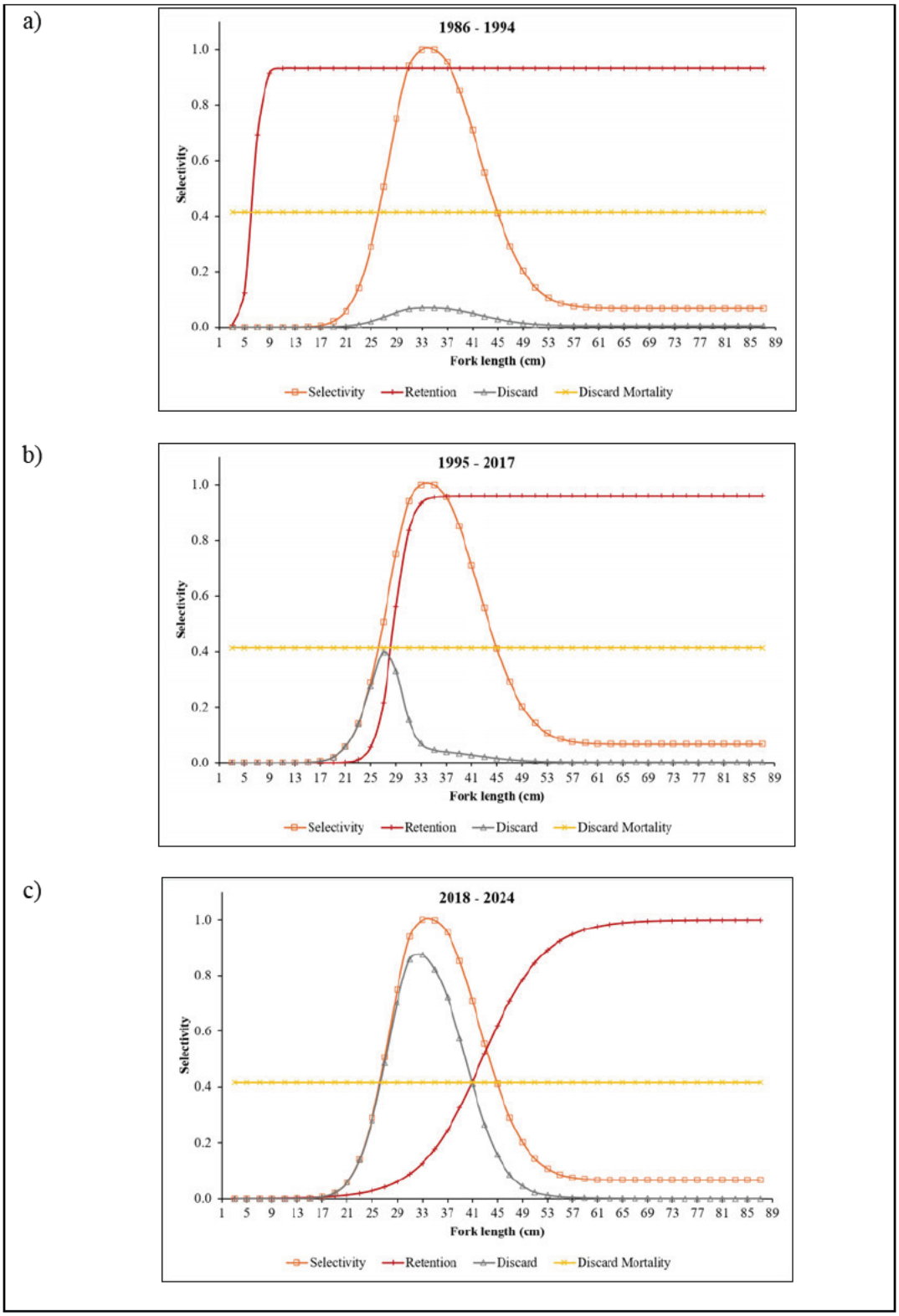


Figure 36. Length-based selectivity, retention, discard, and discard mortality (41.4%) patterns of the recreational fleet by time block a) 1986 – 1994, b) 1995 – 2017, and c) 2018 – 2024 for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model.

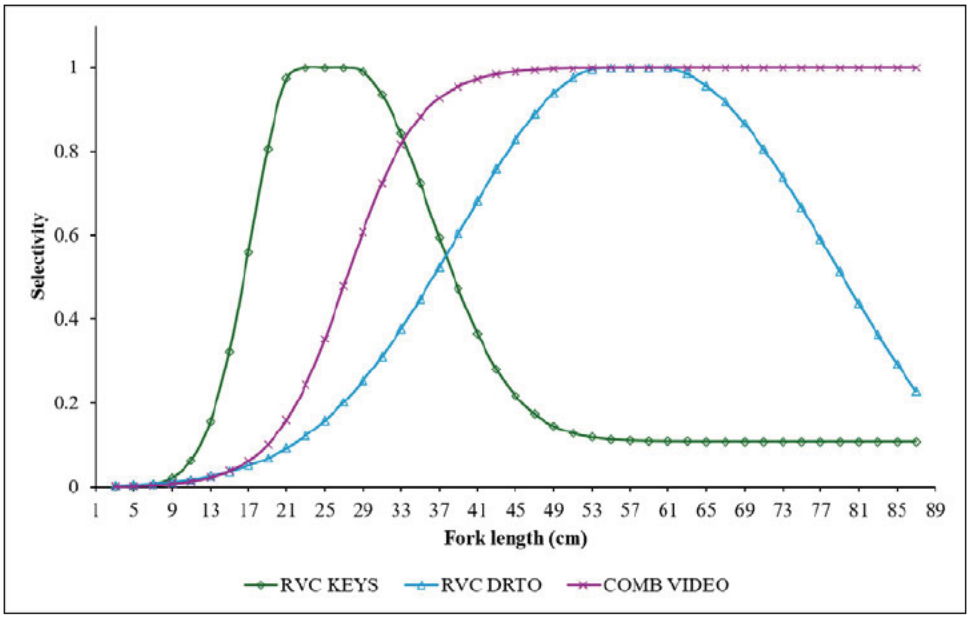


Figure 37. Length-based selectivity of the RVC Florida Keys index (green diamonds), RVC Dry Tortugas index (blue triangles), and combined video index (purple x's) for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model.

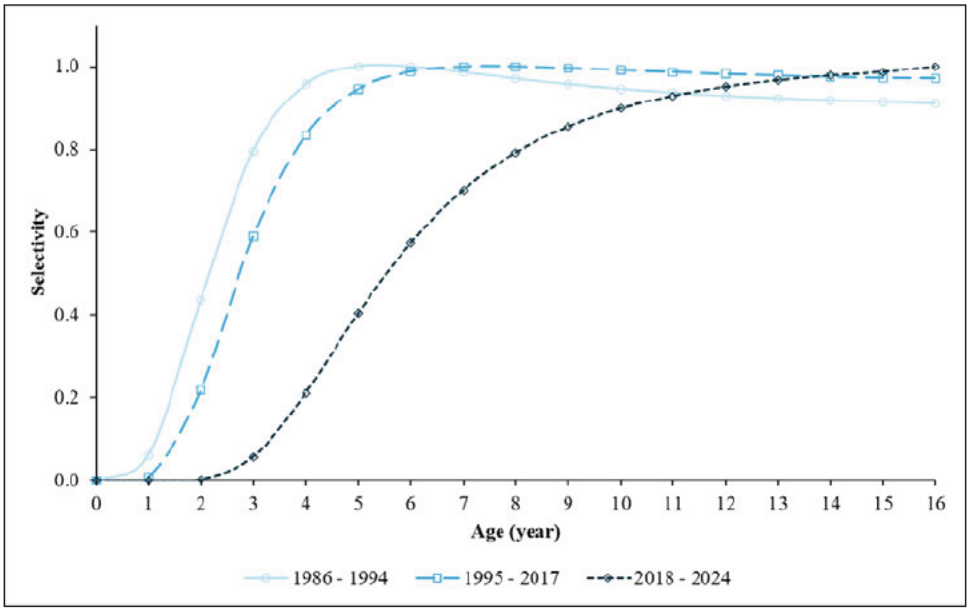


Figure 38. Age-derived selectivity of the commercial fleet by time block for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model.

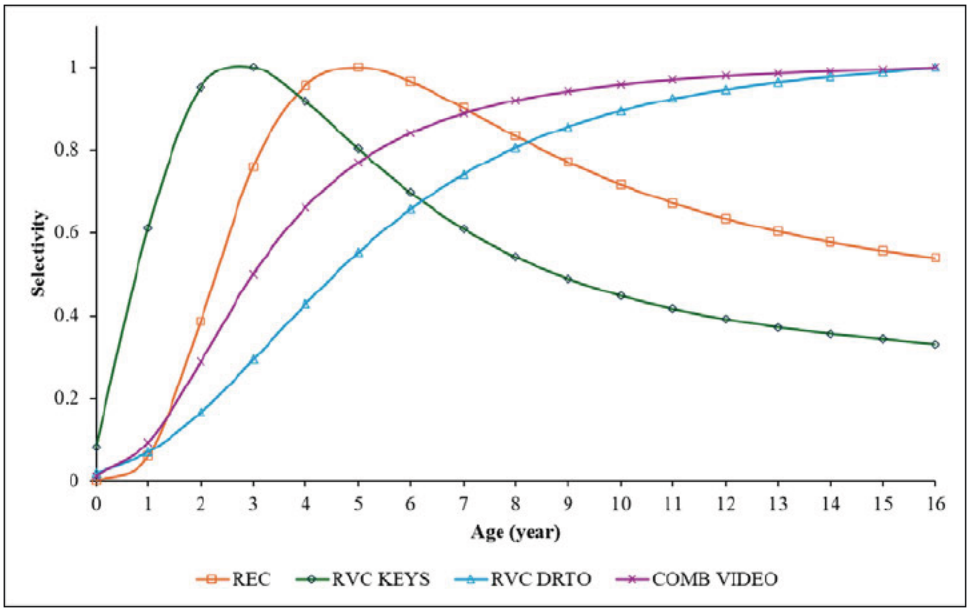


Figure 39. Age-derived selectivity of the recreational fleet (orange square), RVC Florida Keys index (green diamonds), RVC Dry Tortugas index (blue triangles), and combined video index (purple x's) for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model.

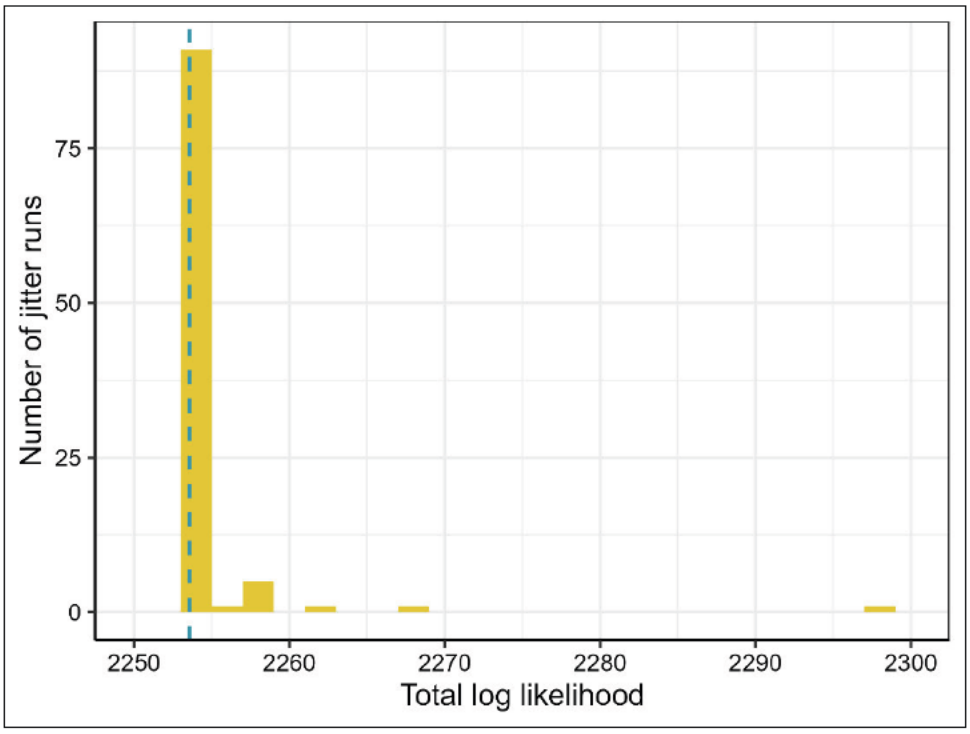


Figure 40. Total log-likelihood values of model runs performed by the jitter analysis (yellow bars) and the SEDAR 94 KEYS RW base model (blue dashed line).

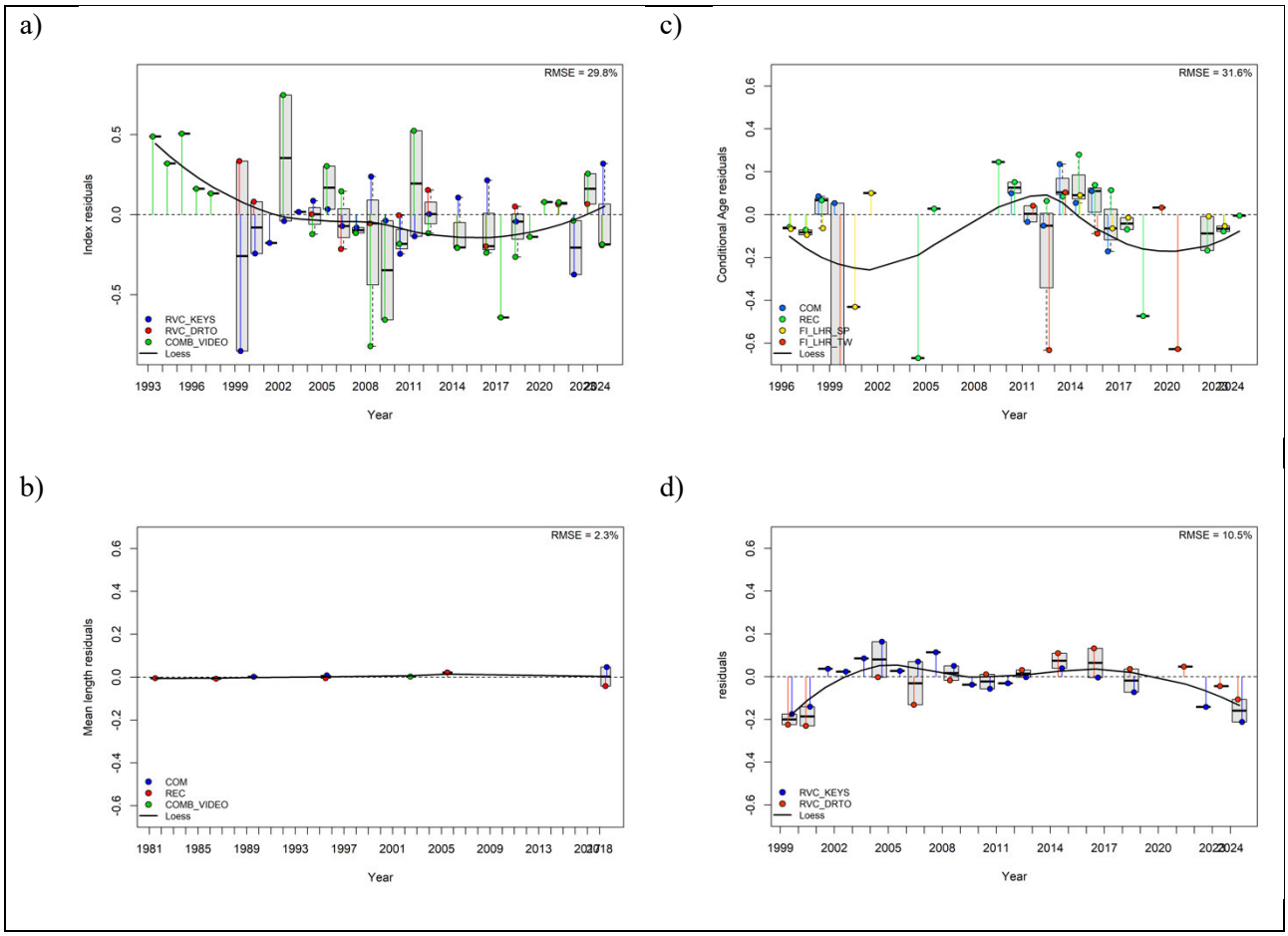


Figure 41. Joint residual plots for a) the indices of abundance, b) the annual mean length estimates, and c) the annual conditional age-at-length estimates, and d) the annual mean general size composition (i.e., RVC lengths) of available fleets and indices from the SEDAR 94 KEYS RW base model. Vertical lines with points show the residuals, boxplots show residual medians and quantiles, and solid black lines are a loess smoother. Root-mean squared errors (RMSE) are included in the upper right-hand corner of each plot.

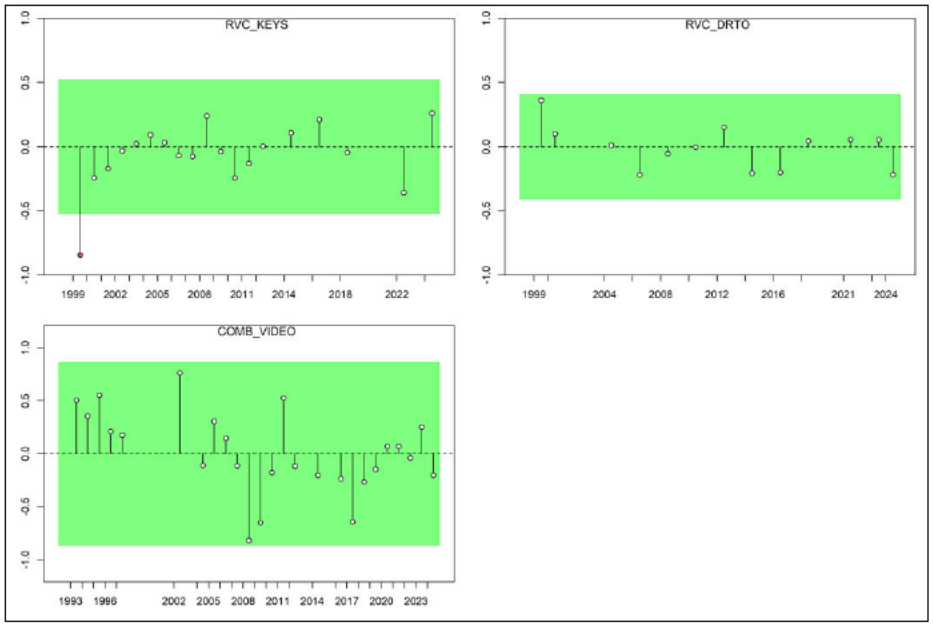


Figure 42. Runs tests results for the indices of abundance from the SEDAR 94 KEYS RW base model. Green shading indicates no evidence ($p \geq 0.05$) and red shading evidence ($p < 0.05$) to reject the hypothesis of a randomly distributed time-series of residuals, respectively. Shaded regions span three residual standard deviations to either side from zero and red points outside of the shading indicate a violation of that 'three-sigma limit'.

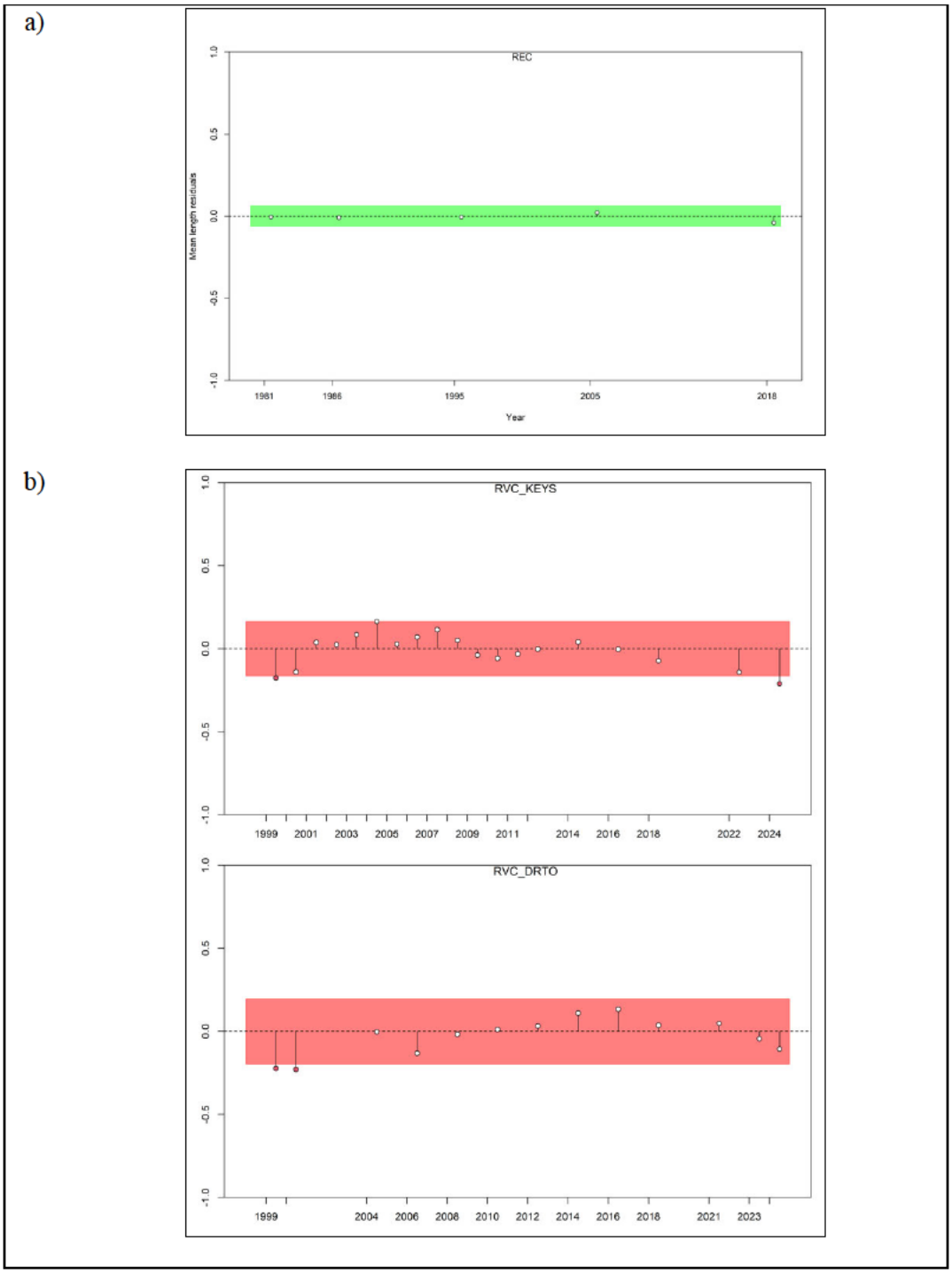


Figure 43. Runs tests results for a) the annual mean length estimates of the recreational fleet and b) the annual mean general size composition (i.e., RVC lengths) from the SEDAR 94 KEYS RW base model. Green shading indicates no evidence ($p \geq 0.05$) and red shading evidence ($p < 0.05$) to reject the hypothesis of a randomly distributed time-series of residuals, respectively. Shaded regions span three residual standard deviations to either side from zero and red points outside of the shading indicate a violation of that 'three-sigma limit'.

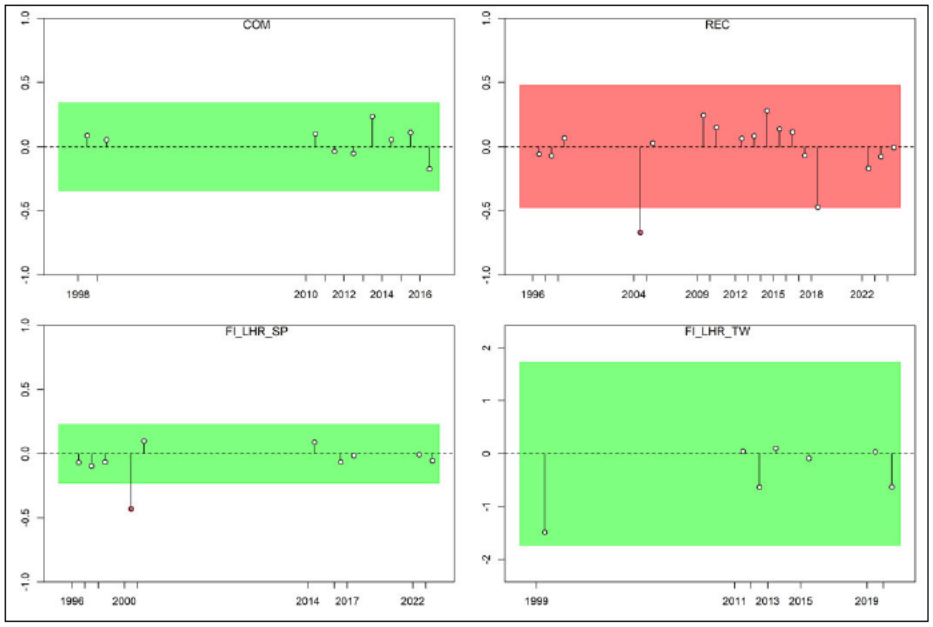
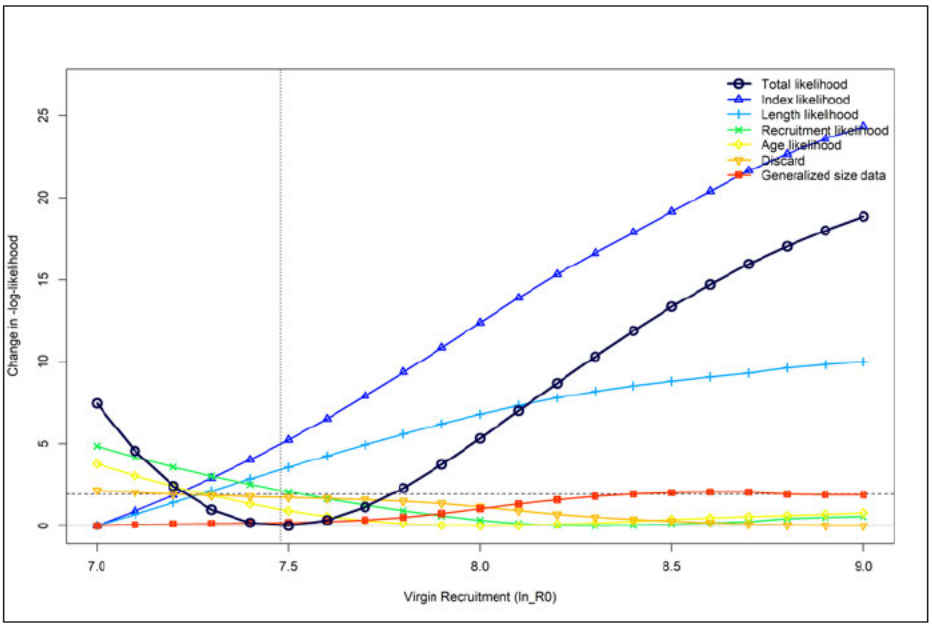


Figure 44. Runs tests results for the conditional age-at-length estimates from the SEDAR 94 KEYS RW base model. Green shading indicates no evidence ($p \geq 0.05$) and red shading evidence ($p < 0.05$) to reject the hypothesis of a randomly distributed time-series of residuals, respectively. Shaded regions span three residual standard deviations to either side from zero and red points outside of the shading indicate a violation of that 'three-sigma limit'.

a)



b)

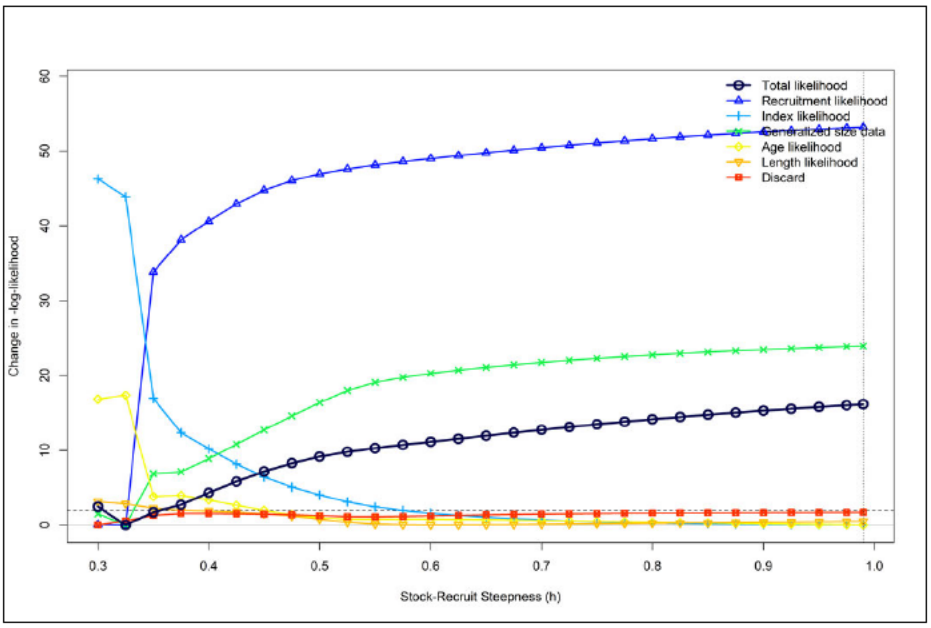


Figure 45. Log-likelihood profiles of a) the unfished (i.e., virgin) recruitment (*ln(R0)*) parameter, and b) the *steepness (h)* parameter for various data components in the SEDAR 94 KEYS RW base model. The horizontal dashed line indicates a 2 unit difference in log-likelihood while the vertical dotted line is the estimate from the SEDAR 94 KEYS RW base model.

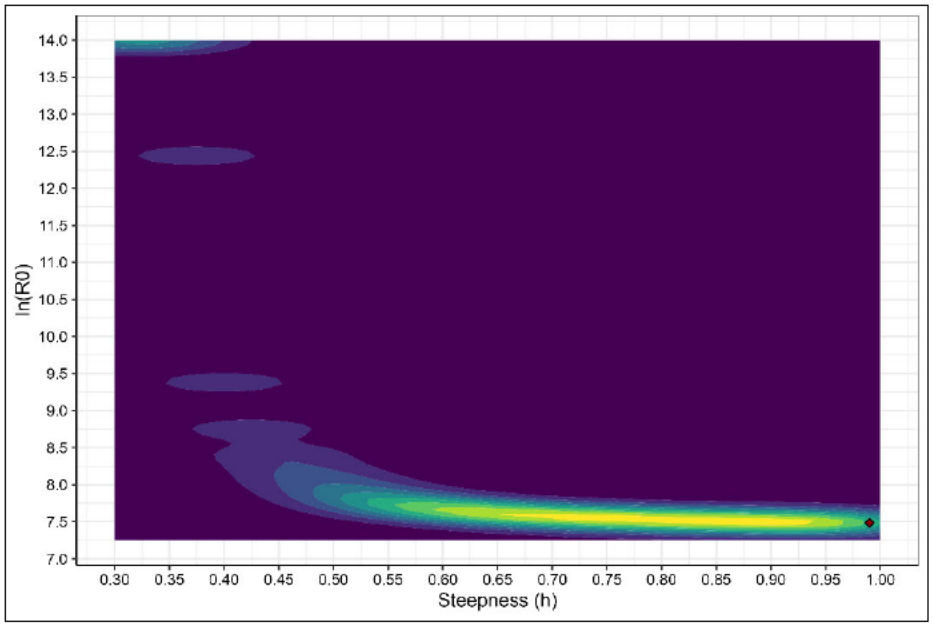


Figure 46. Contour plot showing corresponding estimates of the unfished (i.e., virgin) recruitment (*ln(R0)*) parameter to the profiled *steepness (h)* parameter from the SEDAR 94 KEYS RW base model. The *steepness (h)* parameter was profiled (i.e., fixed) on values from 0.3 – 0.99; the *ln(R0)* parameter was estimated during each profile iteration but bound between values from 6 – 14. The red diamond is the value used in the KEYS RW base model.

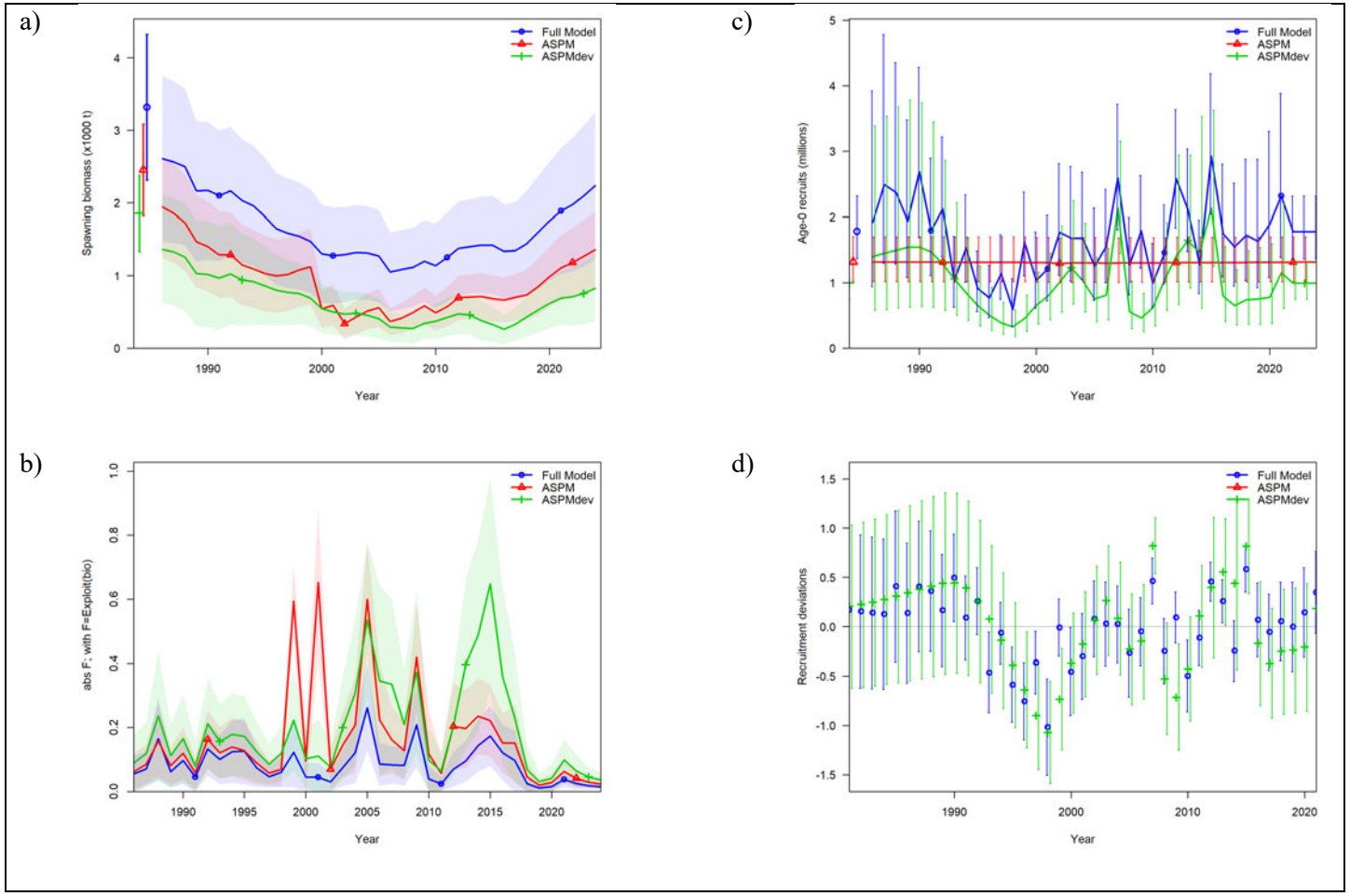


Figure 47. Results comparison between the SEDAR 94 KEYS RW base model (Full Model), the deterministic Age-Structured-Production Model (ASPM), and the ASPM with recruitment deviations (ASPMdev) showing a) spawning stock biomass, b) exploitation rates, c) estimates of age-0 recruitment, and d) estimates of recruitment deviations.

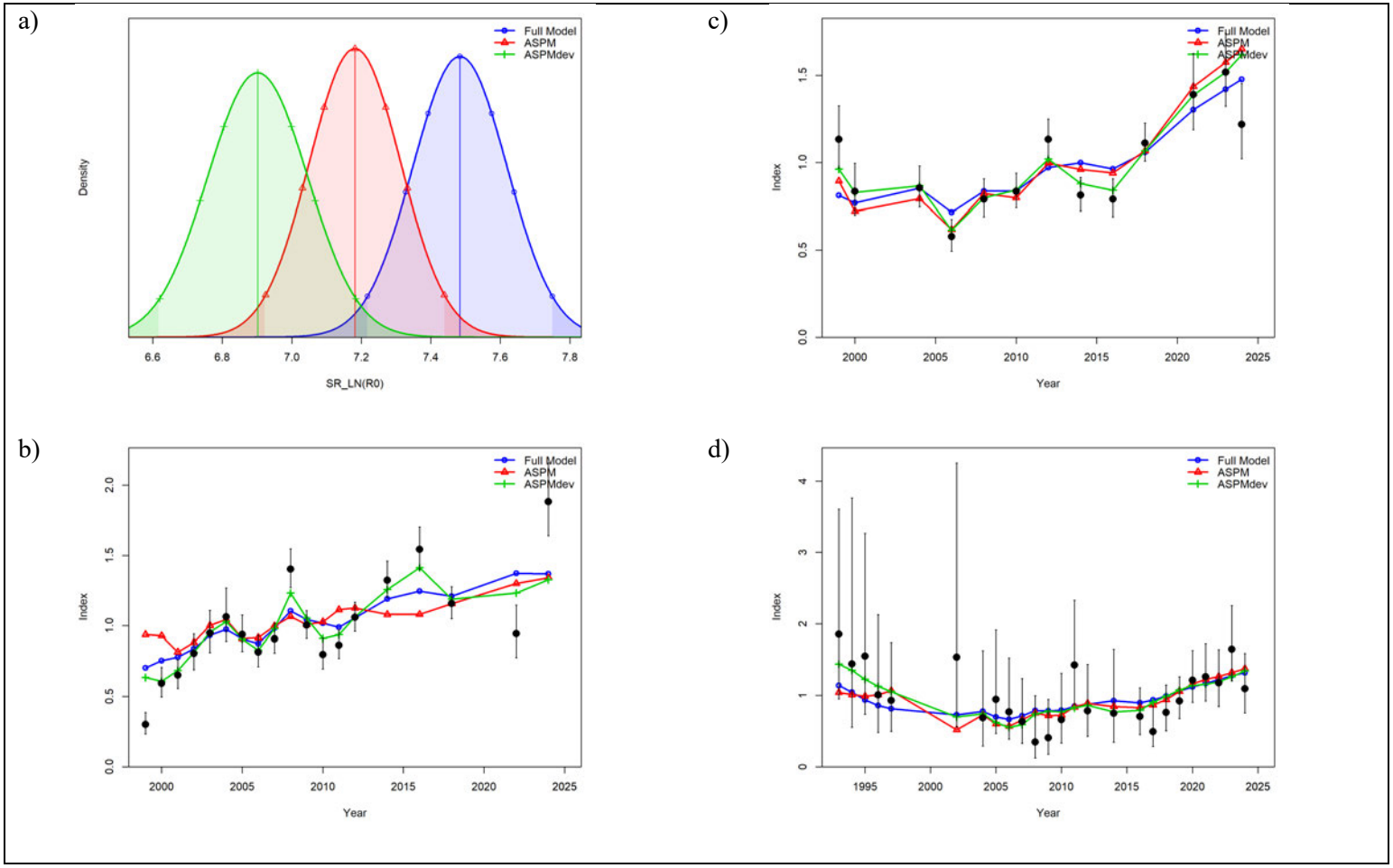


Figure 48. Results comparison between the SEDAR 94 KEYS RW base model (Full Model), the deterministic Age-Structured-Production Model (ASPM), and the ASPM with recruitment deviations (ASPMdev) showing a) estimates of the virgin recruitment parameter in log-space *ln(R0)*, b) observed and predicted values for the RVC Florida Keys index, c) observed and predicted values for the RVC Dry Tortugas index., and d) observed and predicted values for the combined video index.

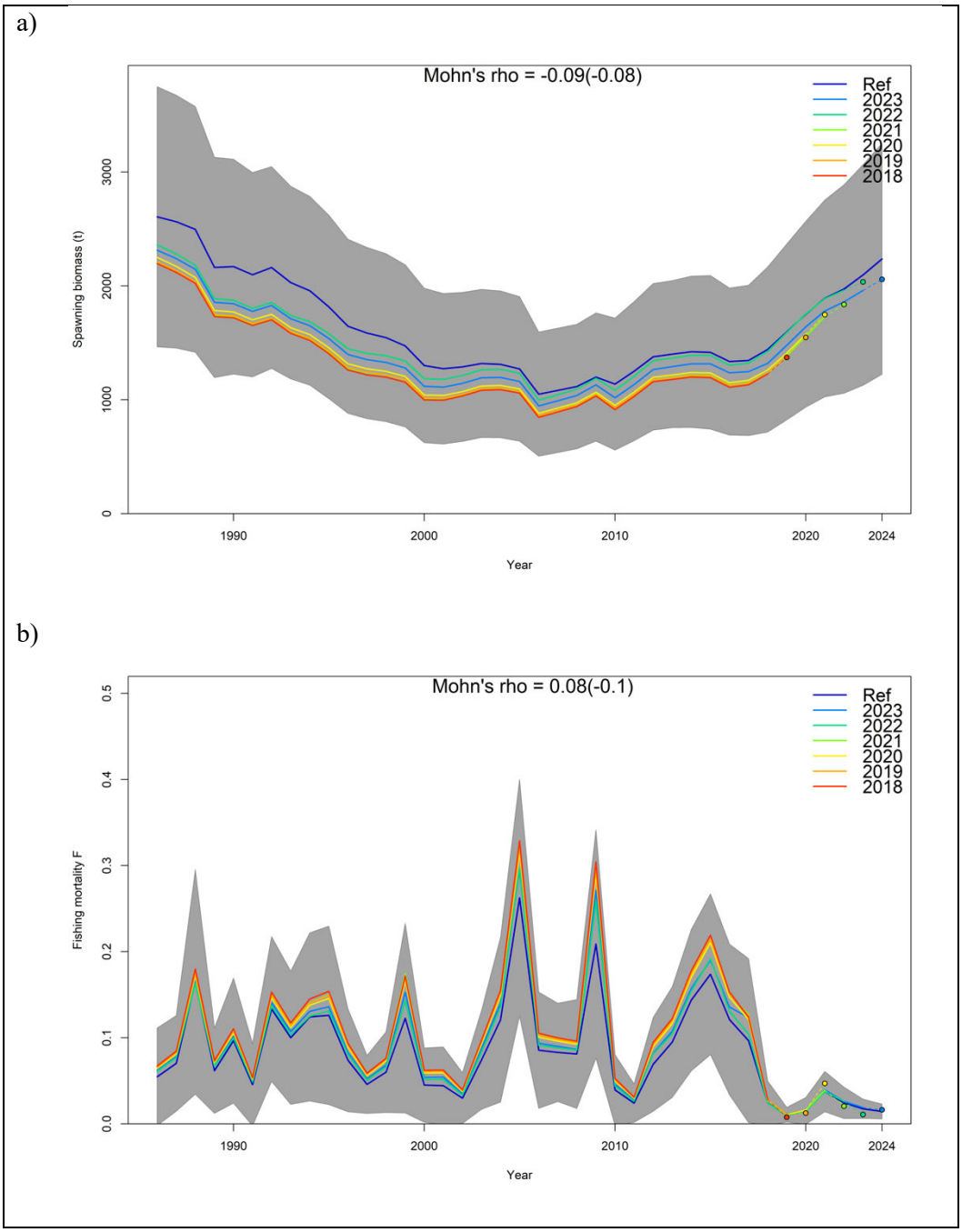


Figure 49. Retrospective forecast results of a) spawning stock biomass and b) exploitation rates conducted by re-fitting the SEDAR 94 KEYS RW base model (Ref) after sequentially removing seven years of observations. The Mohn's rho (ρ_M) statistic and corresponding forecast rho (ρ_F) values (in parenthesis) are provided at the top of each panel. One-year-ahead projections denoted by color-coded dashed lines with terminal points are shown for each peel. Grey shaded areas are the 95 % confidence intervals from the SEDAR 94 KEYS RW base model.

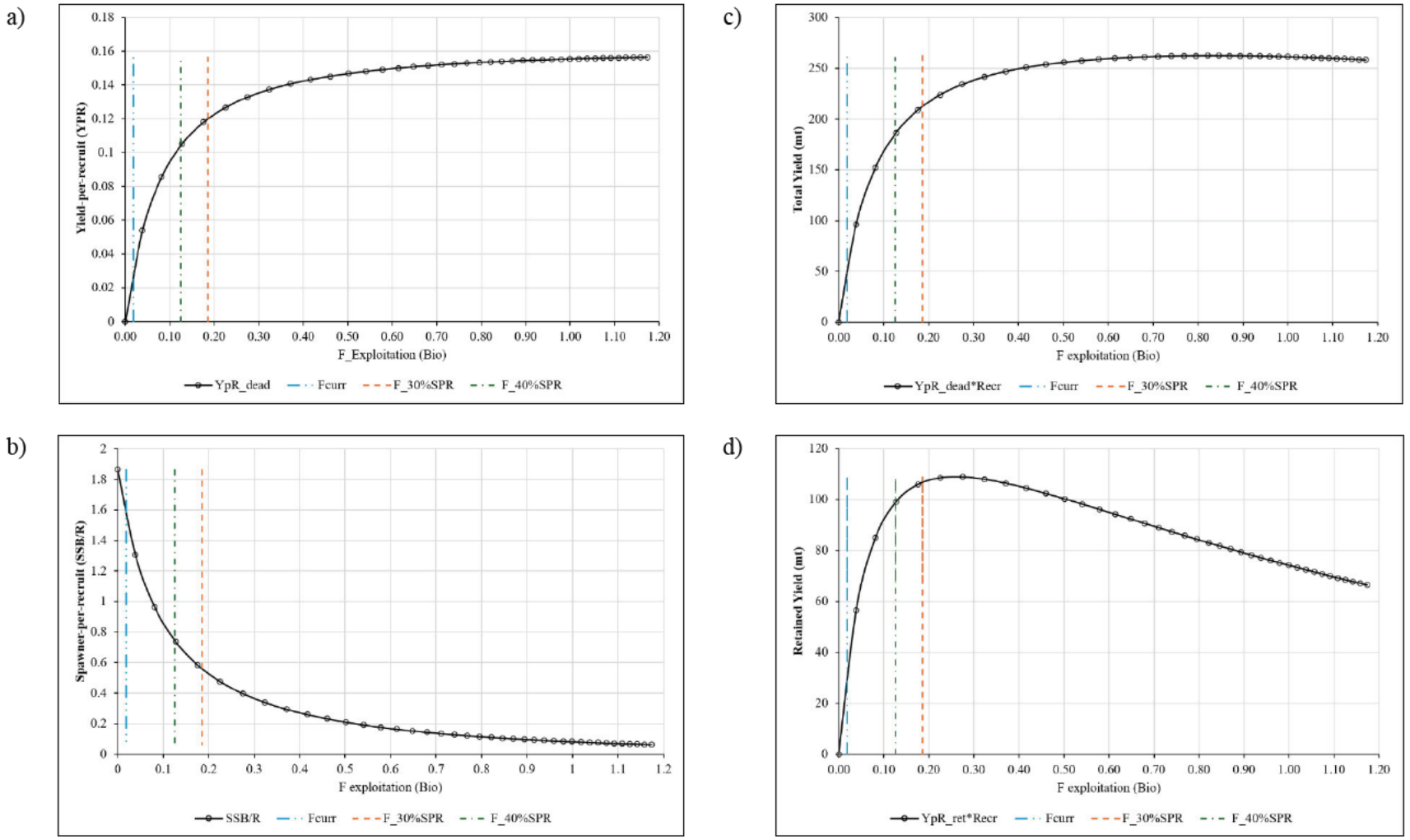
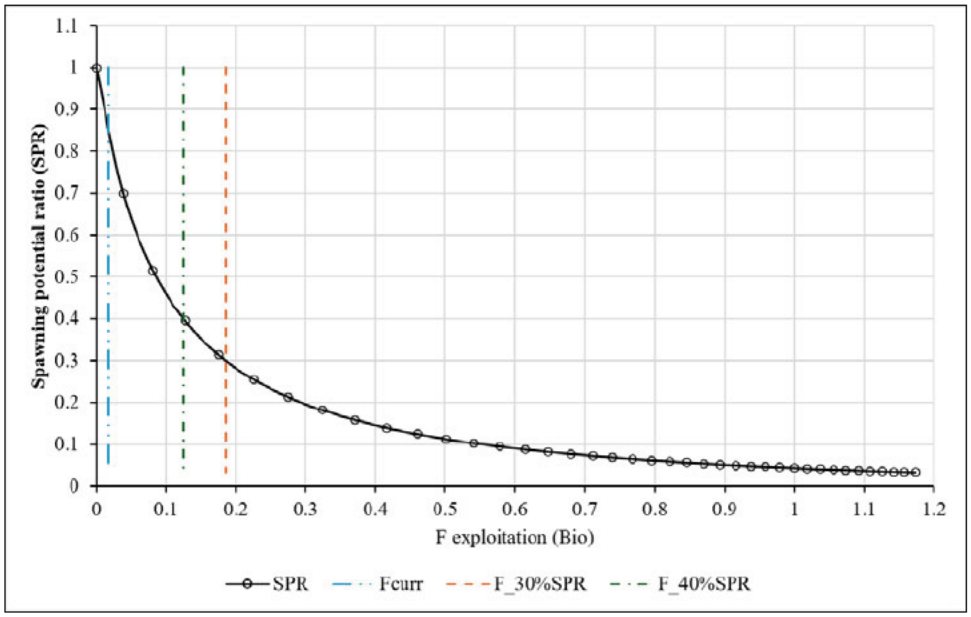


Figure 50. The a) yield-per-recruit, b) spawner-per-recruit, c) total equilibrium yield, and d) retained equilibrium yield computed as a function of the instantaneous exploitation rate on Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model.

a)



b)

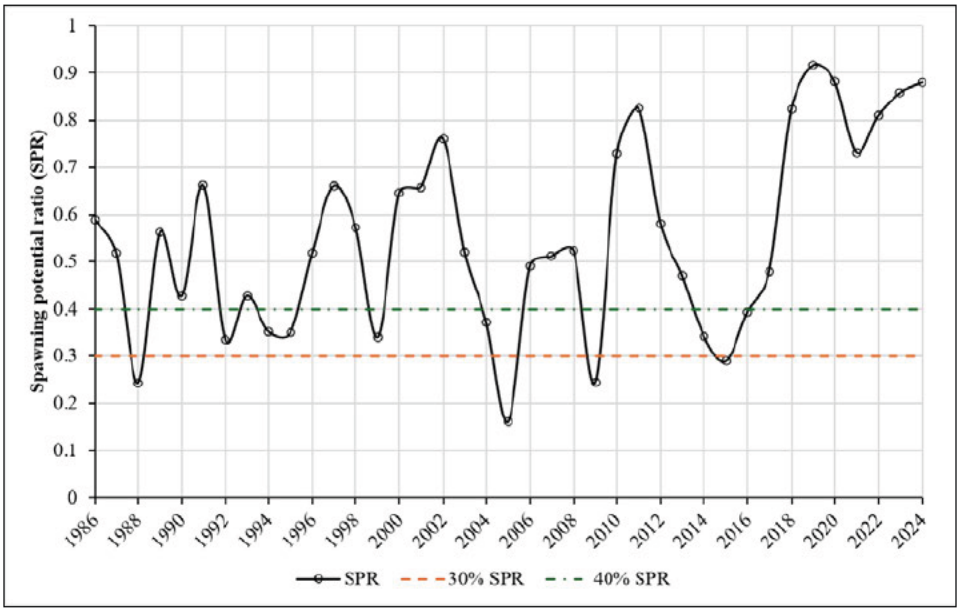


Figure 51. The a) static spawning potential ratio (SPR) computed as a function of the instantaneous exploitation rate, and b) static spawning potential ratio (SPR) by year for Florida Keys/East Florida Hogfish from the SEDAR 94 KEYS RW base model.

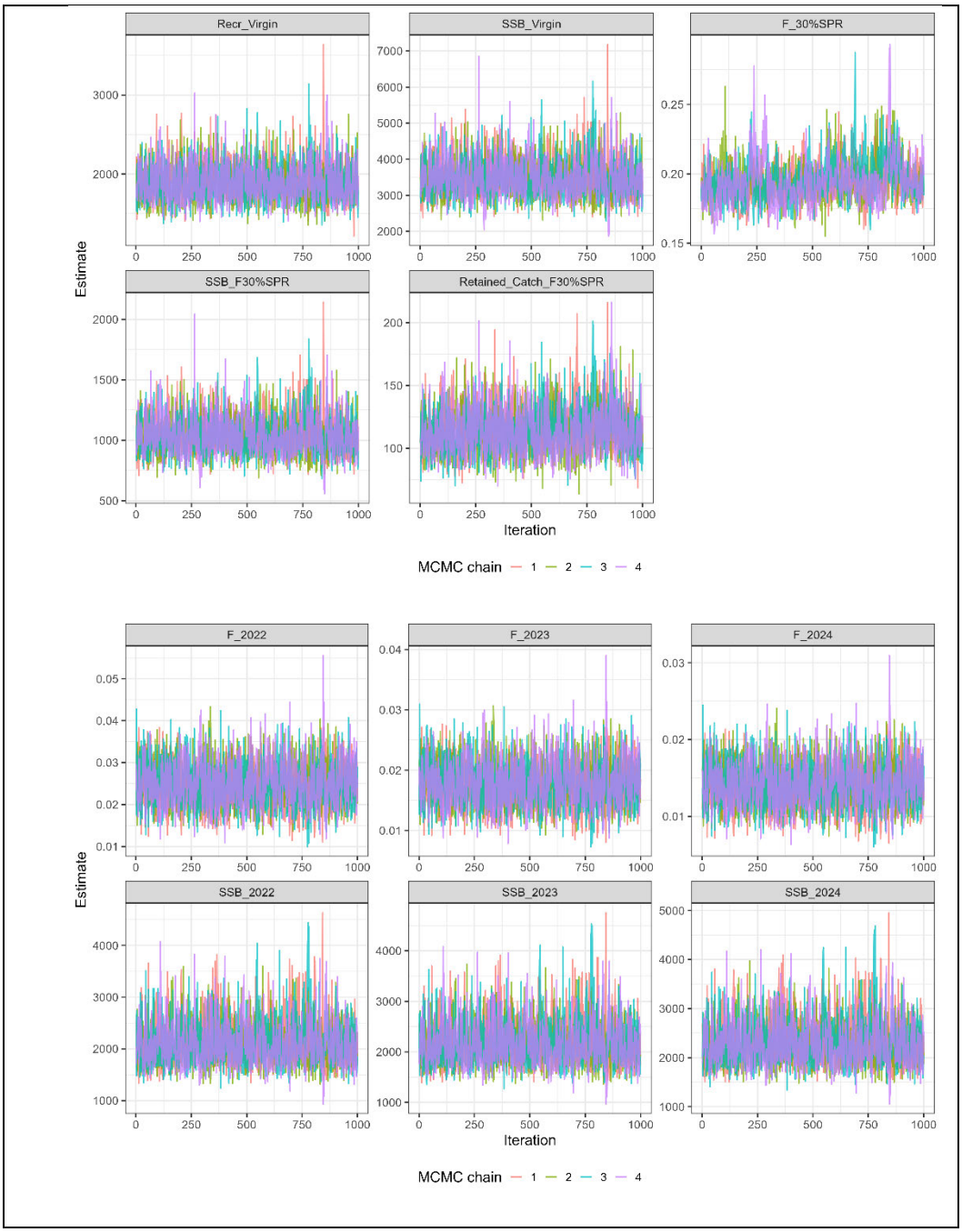


Figure 52. Combined trace plots of the four MCMC chains for selected parameters and derived quantities from the MCMC 'proxy' model based on the SEDAR 94 KEYS RW base model.

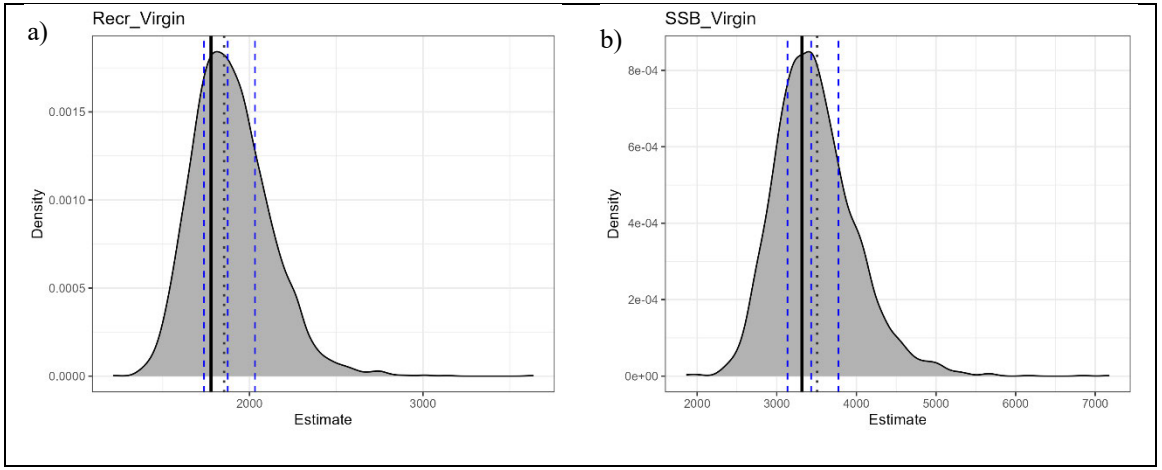


Figure 53. The posterior distributions for a) R_0 (i.e., virgin recruitment), and b) SSB_0 (i.e., virgin spawning stock biomass) from the combined four-chain MCMC of the MCMC 'proxy' model based on the SEDAR 94 KEYS RW base model. The blue dashed lines indicate the median and interquartile range, the black dotted line is the estimate from the MCMC 'proxy' model, and the solid black line is the estimate from the SEDAR 94 KEYS RW base model.

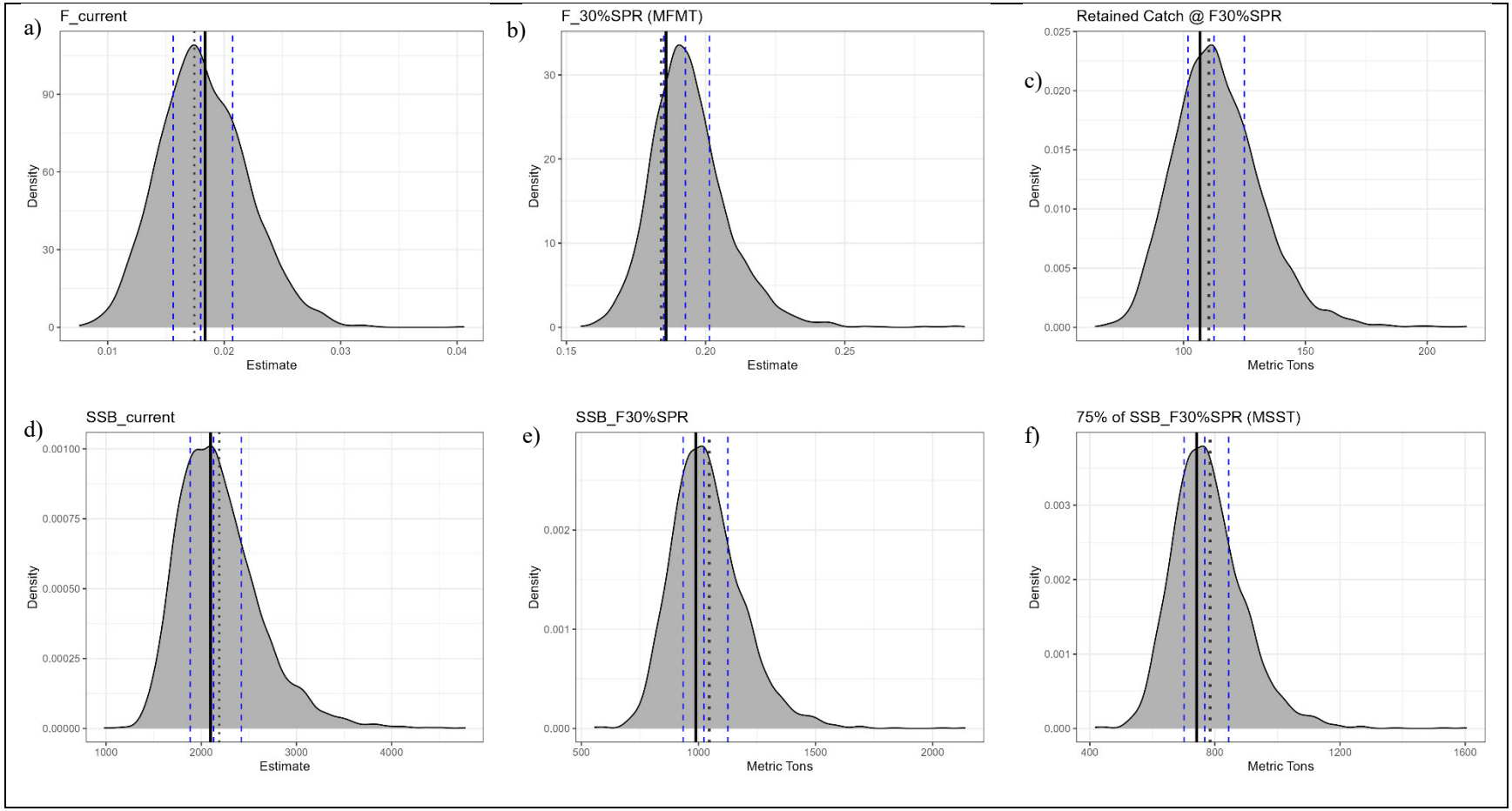


Figure 54. The posterior distributions for a) $F_{current}$ (i.e., geometric mean of F for years 2022 – 2024), b) $F_{30\%SPR}$ (i.e., MFMT), and c) the retained yield associated with $F_{30\%SPR}$, d) $SSB_{current}$ (i.e., geometric mean of SSB for years 2022 – 2024), e) SSB at $F_{30\%SPR}$, and f) 75% of SSB at $F_{30\%SPR}$ (i.e., MSST) from the combined four-chain MCMC of the MCMC 'proxy' model based on the SEDAR 94 KEYS RW base model. The blue dashed lines indicate the median and interquartile range, the black dotted line is the estimate from the MCMC 'proxy' model, and the solid black line is the estimate from the SEDAR 94 KEYS RW base model.

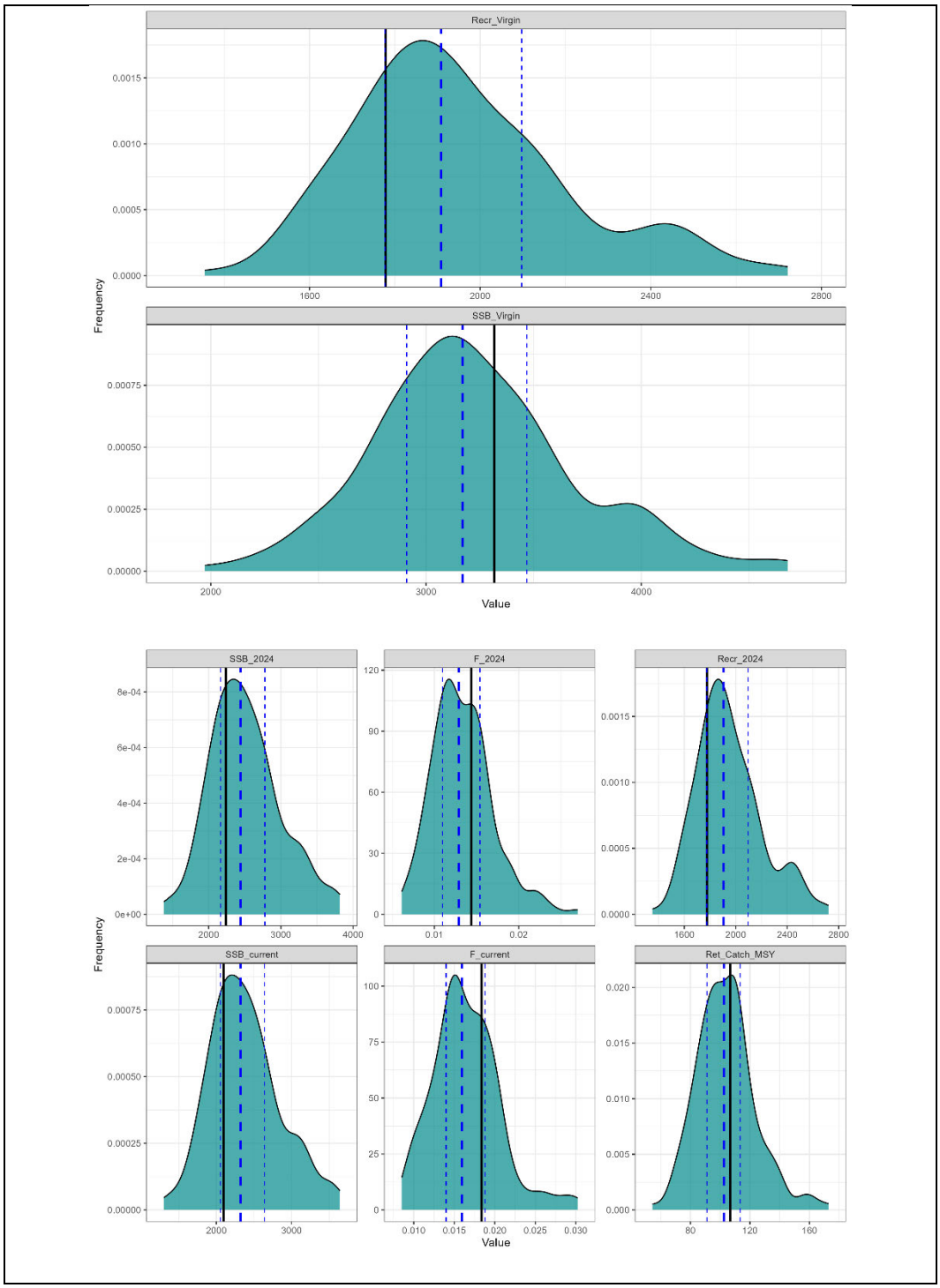


Figure 55. Distributions of selected parameter estimates and derived quantities from the parametric bootstrapping analysis. The blue dashed lines indicate the median and interquartile range and the solid black line is the estimate from the SEDAR 94 KEYS base model.

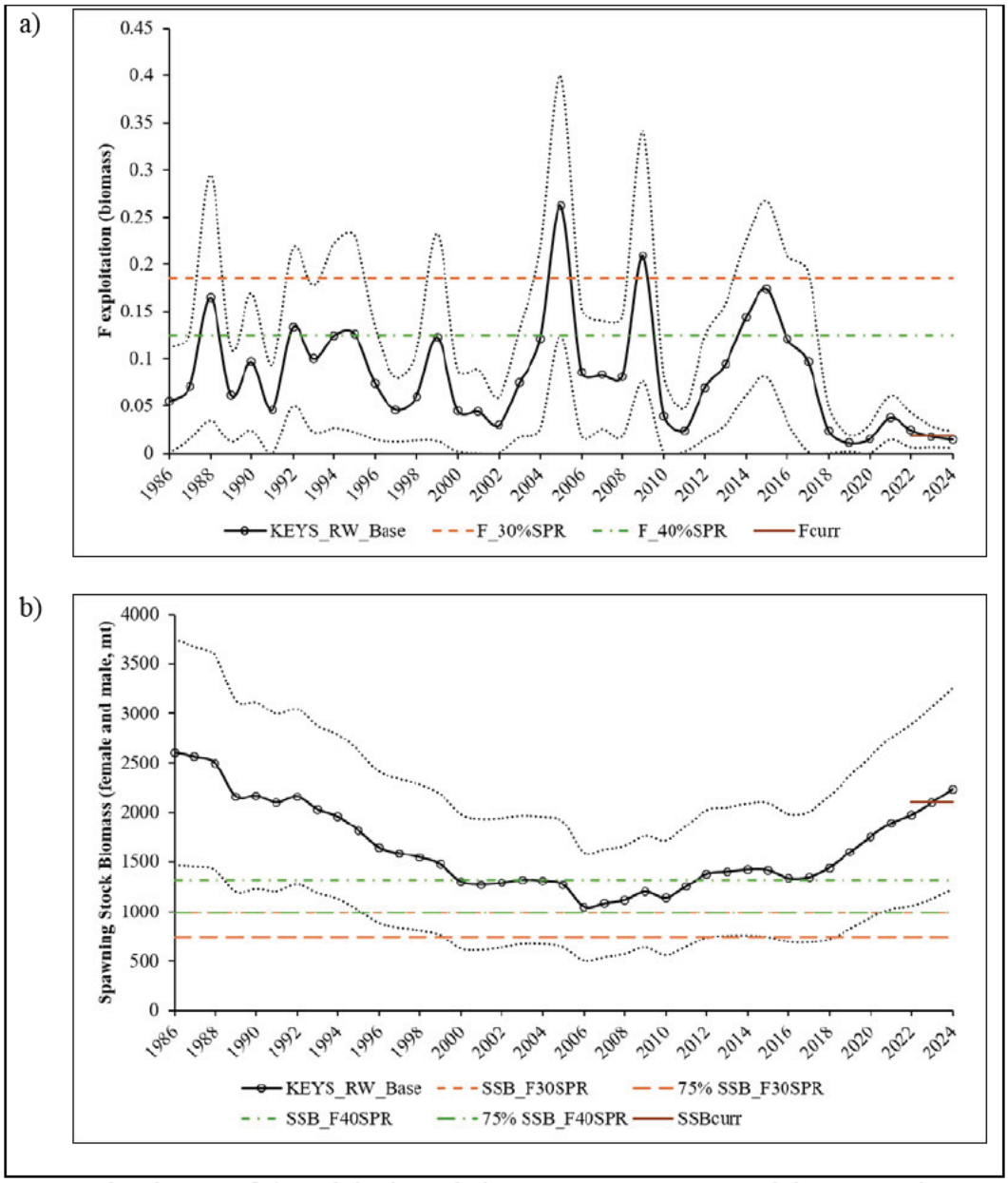


Figure 56. Annual estimates of a) exploitation relative to $F_{30\%SPR}$, $F_{40\%SPR}$, and the geometric mean of exploitation in the last three years ($F_{current}$), and b) spawning stock biomass (SSB) relative to 75% $SSB_{F30\%SPR}$, $SSB_{F40\%SPR}$, and the geometric mean of SSB in the last three years ($SSB_{current}$) by the SEDAR 94 KEYS RW base model. Dotted lines represent 95% confidence intervals.

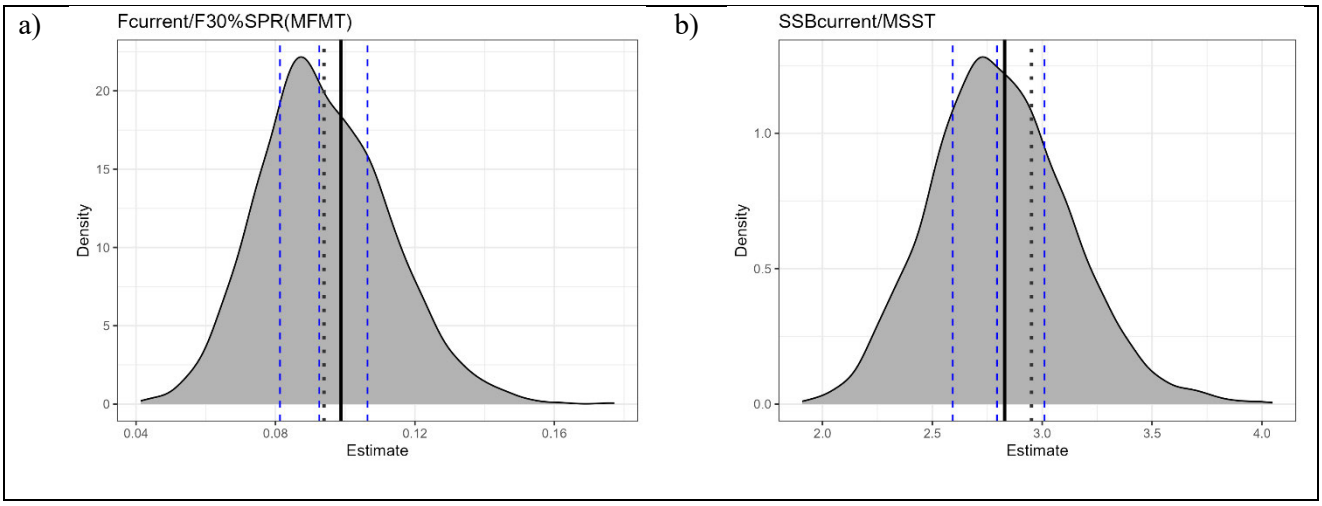


Figure 57. The posterior distribution for the F ratio ($F_{current}/F_{30\%SPR}$) and SSB ratio ($SSB_{current}/MSST$) values from the combined four-chain MCMC of the MCMC 'proxy' model based on the SEDAR 94 KEYS RW base model. The blue dashed lines indicate the median and interquartile range, the black dotted line is the estimate from the MCMC 'proxy' model, and the solid black line is the estimate from the SEDAR 94 KEYS RW base model.

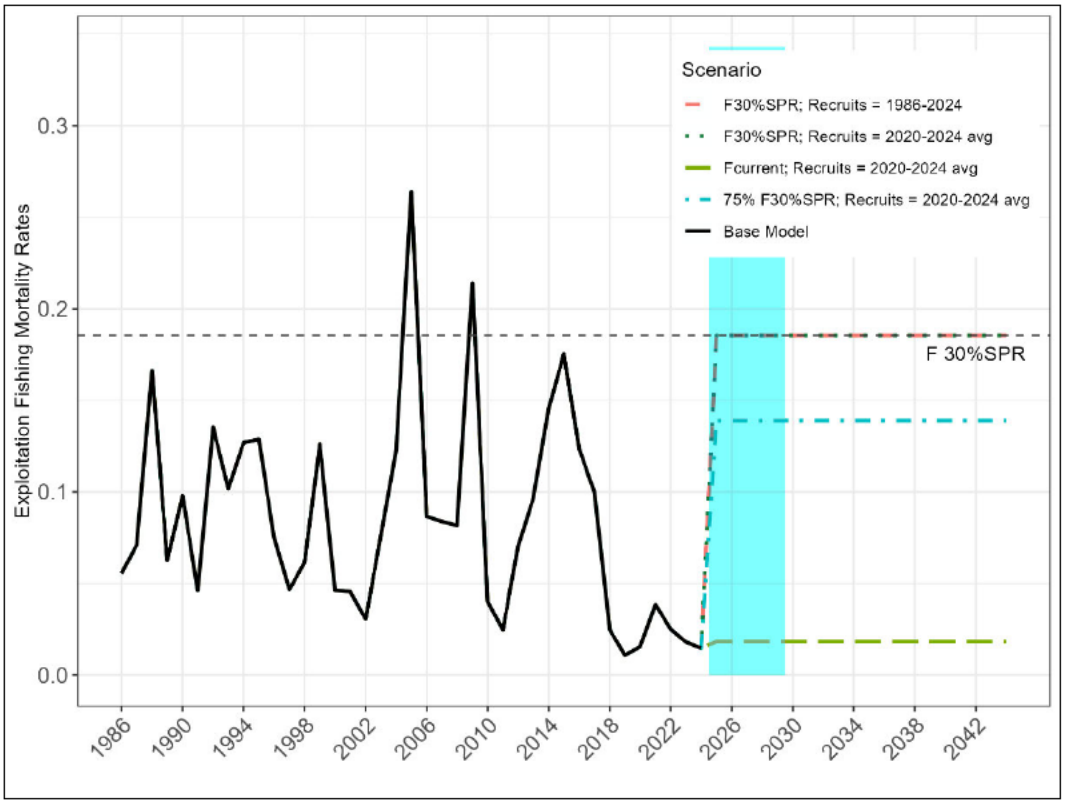


Figure 58. Projected exploitation rates under various constant F scenarios as estimated by the SEDAR 94 KEYS RW base model (black solid line). Long-term equilibrium $F_{30\%SPR}$ used average recruitment from 1986 – 2024 (red dashed line) while short-term $F_{30\%SPR}$ (dark green dotted line), $F_{current}$ (mustard dashed line), and 75% of short-term $F_{30\%SPR}$ (teal dot-dashed line) used average recruitment from 2020 – 2024. The cyan region highlights the first five years of the projection (2025 – 2030).

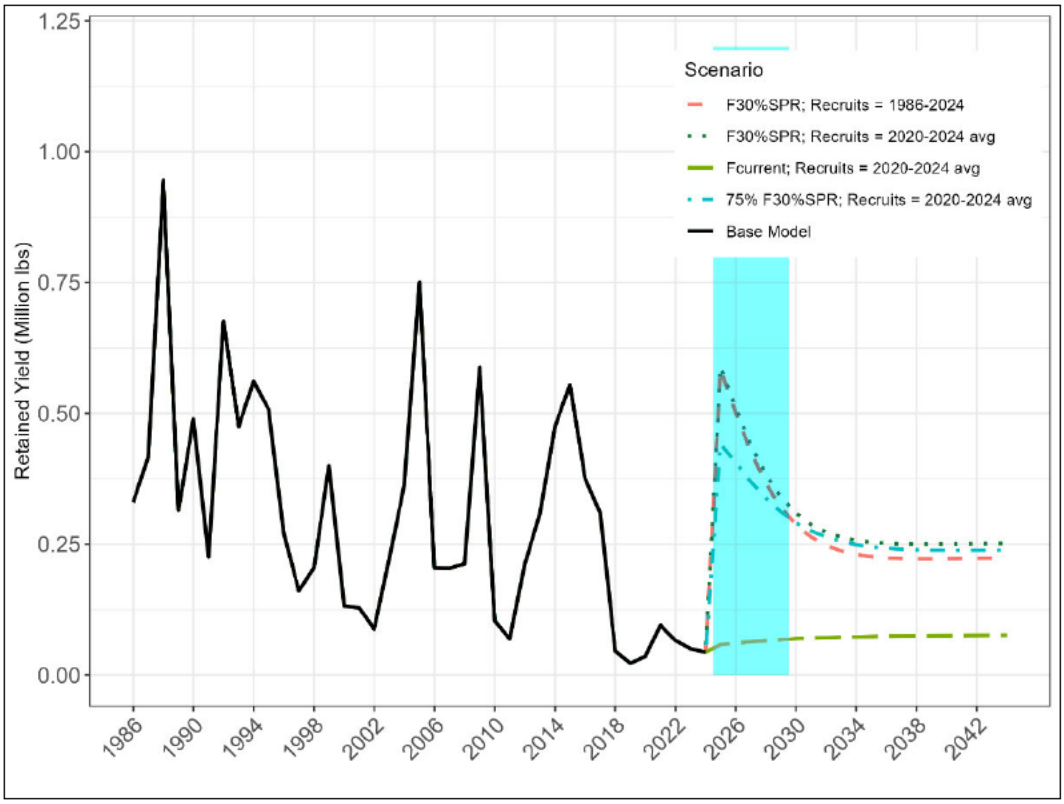


Figure 59. Projected retained yield (million pounds) under various constant F scenarios as estimated by the SEDAR 94 KEYS RW base model (black solid line). Long-term equilibrium $F_{30\%SPR}$ used average recruitment from 1986 – 2024 (red dashed line) while short-term $F_{30\%SPR}$ (dark green dotted line), $F_{current}$ (mustard dashed line), and 75% of short-term $F_{30\%SPR}$ (teal dot-dashed line) used average recruitment from 2020 – 2024. The cyan region highlights the first five years of the projection (2025 – 2030).

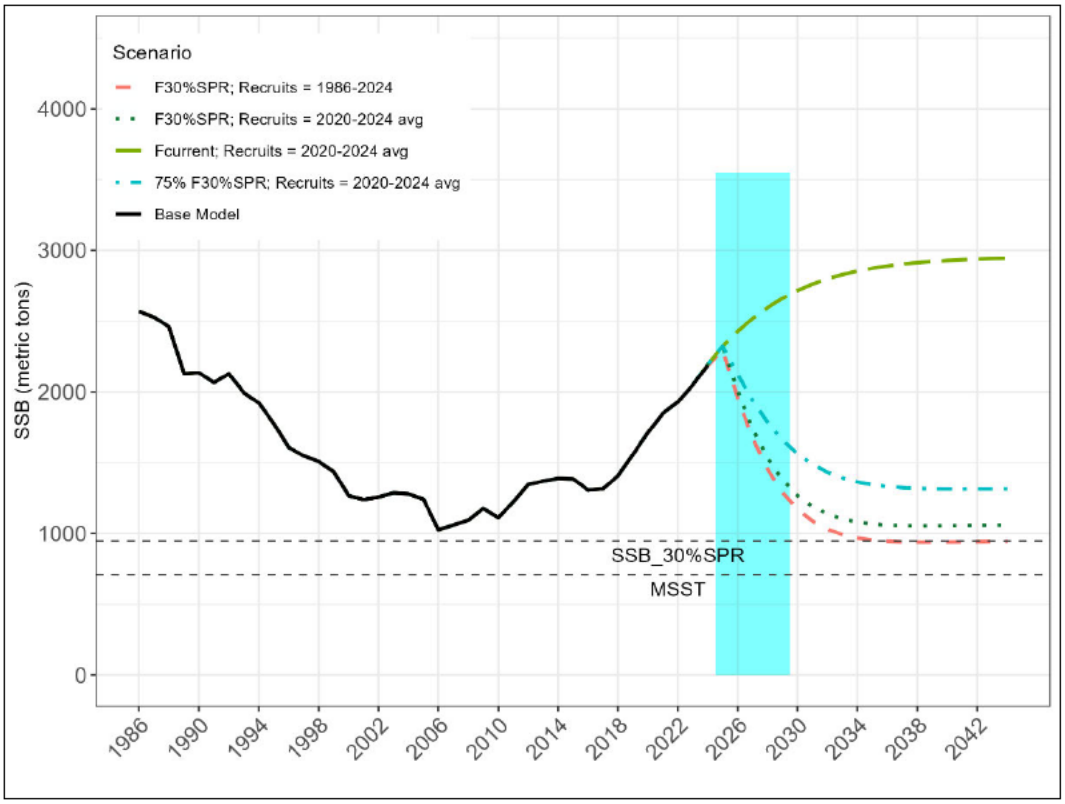


Figure 60. Projected spawning stock biomass (SSB, metric tons) under various constant F scenarios as estimated by the SEDAR 94 KEYS RW base model (black solid line). Long-term equilibrium $F_{30\%SPR}$ used average recruitment from 1986 – 2024 (red dashed line) while short-term $F_{30\%SPR}$ (dark green dotted line), $F_{current}$ (mustard dashed line), and 75% of short-term $F_{30\%SPR}$ (teal dot-dashed line) used average recruitment from 2020 – 2024. The cyan region highlights the first five years of the projection (2025 – 2030).

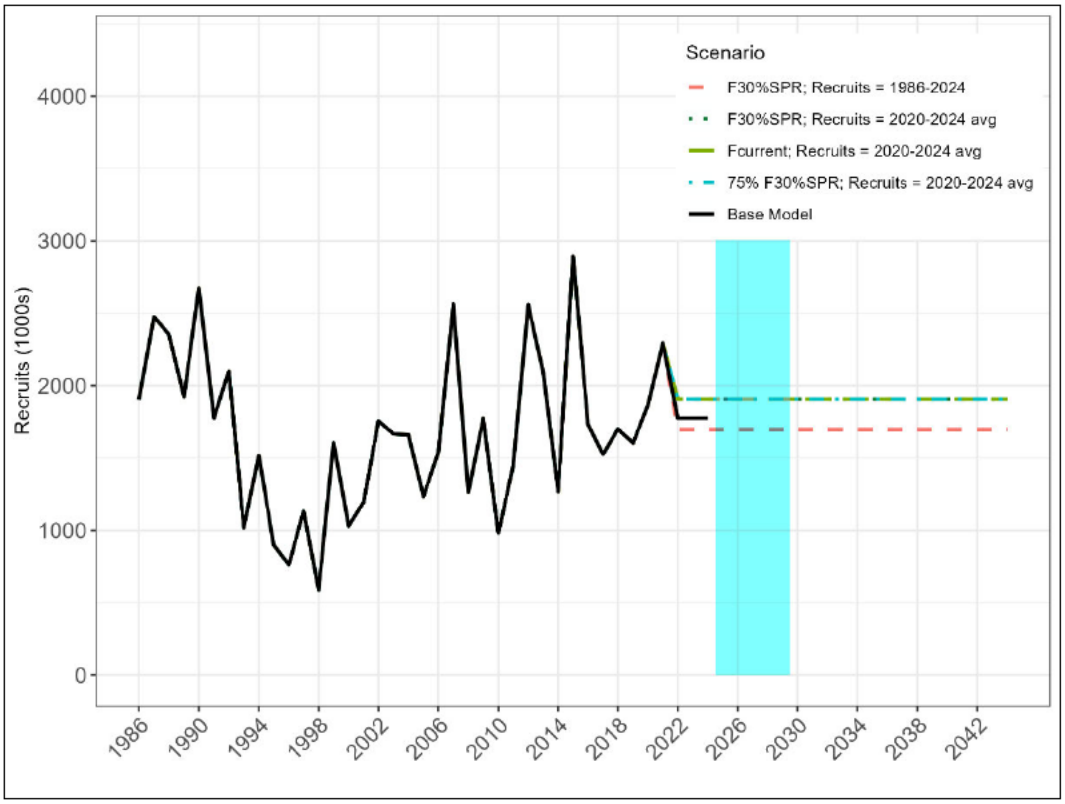


Figure 61. Projected age-0 recruitment (in thousands) under various constant F scenarios as estimated by the SEDAR 94 KEYS RW base model (black solid line). Long-term equilibrium $F_{30\%SPR}$ used average recruitment from 1986 – 2024 (red dashed line) while short-term $F_{30\%SPR}$ (dark green dotted line), $F_{current}$ (mustard dashed line), and 75% of short-term $F_{30\%SPR}$ (teal dot-dashed line) used average recruitment from 2020 – 2024. The cyan region highlights the first five years of the projection (2025 – 2030).

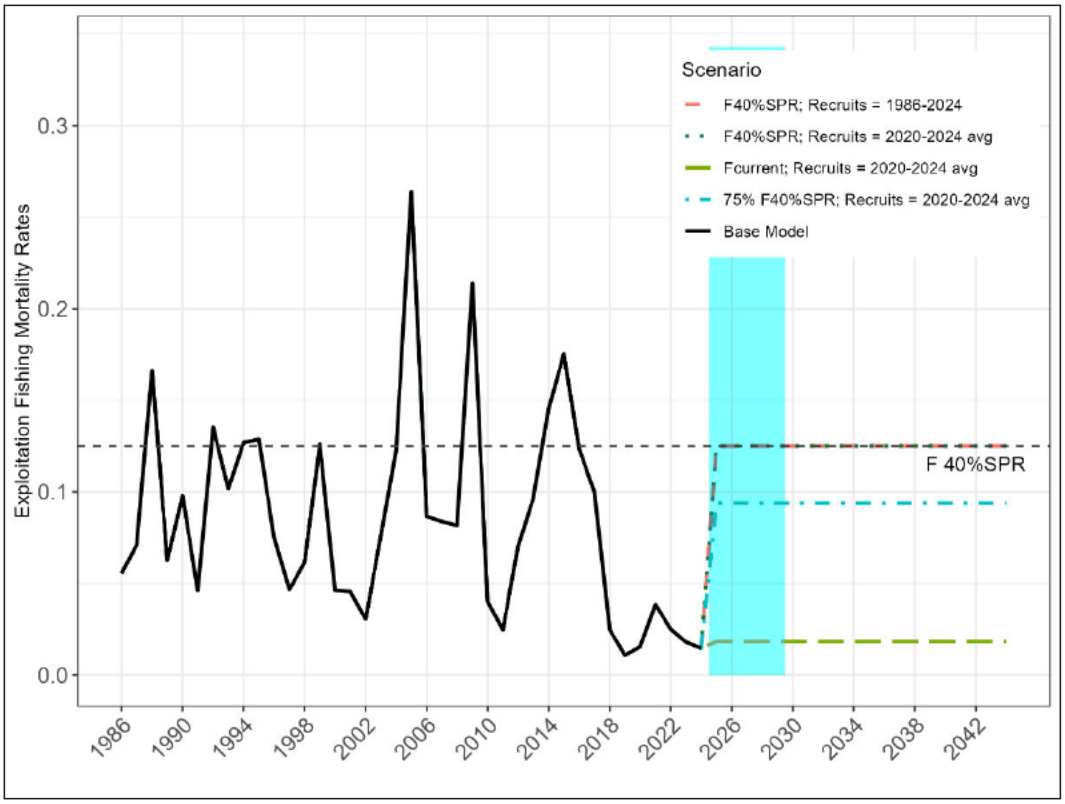


Figure 62. Projected exploitation rates under various constant F scenarios as estimated by the SEDAR 94 KEYS RW base model (black solid line). Long-term equilibrium $F_{40\%SPR}$ used average recruitment from 1986 – 2024 (red dashed line) while short-term $F_{40\%SPR}$ (dark green dotted line), $F_{current}$ (mustard dashed line), and 75% of short-term $F_{40\%SPR}$ (teal dot-dashed line) used average recruitment from 2020 – 2024. The cyan region highlights the first five years of the projection (2025 – 2030).

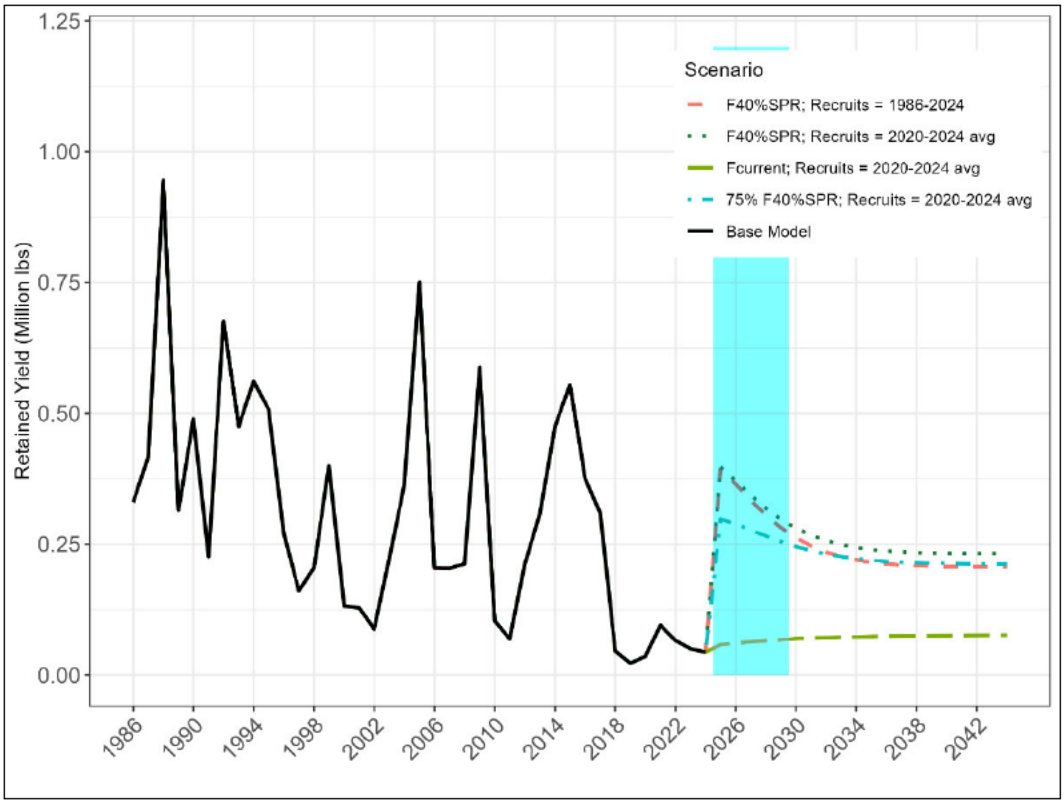


Figure 63. Projected retained yield (million pounds) under various constant F scenarios as estimated by the SEDAR 94 KEYS RW base model (black solid line). Long-term equilibrium $F_{40\%SPR}$ used average recruitment from 1986 – 2024 (red dashed line) while short-term $F_{40\%SPR}$ (dark green dotted line), $F_{current}$ (mustard dashed line), and 75% of short-term $F_{40\%SPR}$ (teal dot-dashed line) used average recruitment from 2020 – 2024. The cyan region highlights the first five years of the projection (2025 – 2030).

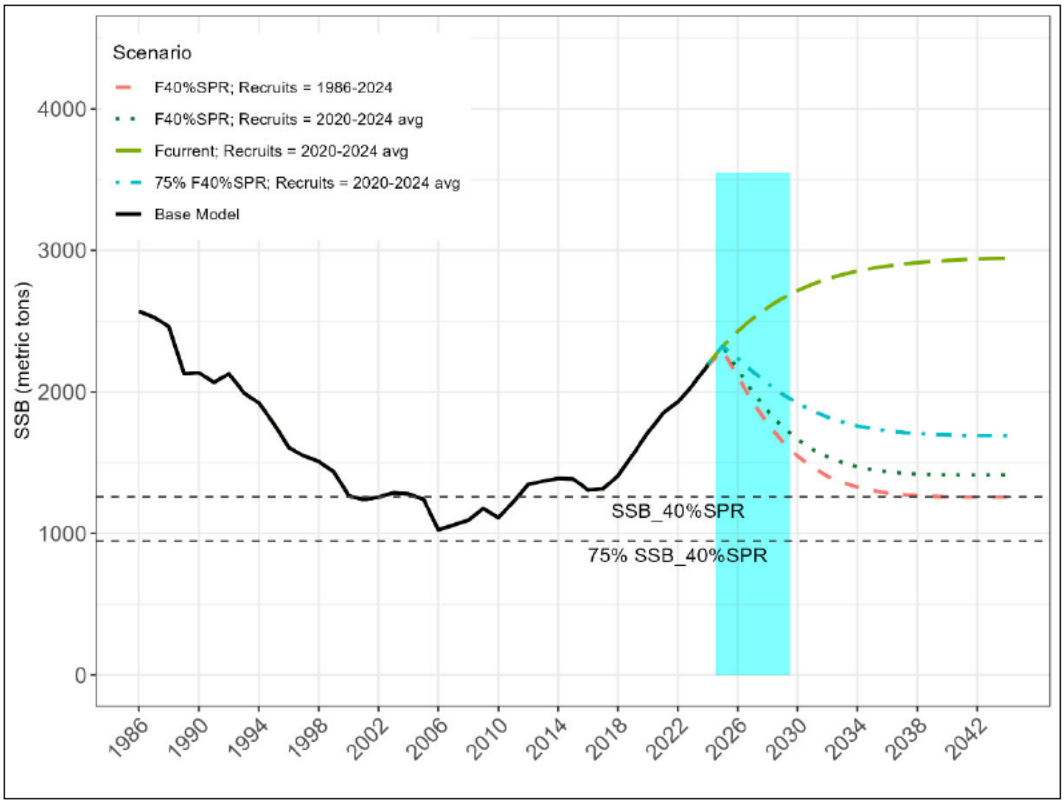


Figure 64. Projected spawning stock biomass (SSB, metric tons) under various constant F scenarios as estimated by the SEDAR 94 KEYS RW base model (black solid line). Long-term equilibrium $F_{40\%SPR}$ used average recruitment from 1986 – 2024 (red dashed line) while short-term $F_{40\%SPR}$ (dark green dotted line), $F_{current}$ (mustard dashed line), and 75% of short-term $F_{40\%SPR}$ (teal dot-dashed line) used average recruitment from 2020 – 2024. The cyan region highlights the first five years of the projection (2025 – 2030).

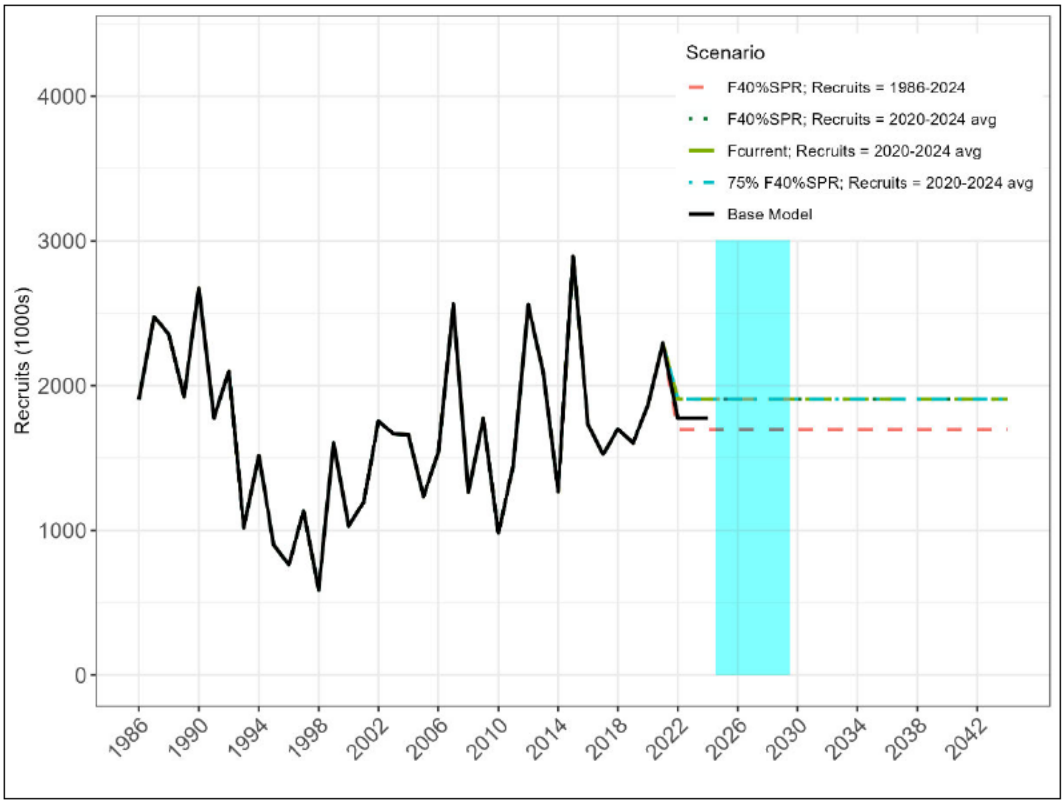


Figure 65. Projected age-0 recruitment (in thousands) under various constant F scenarios as estimated by the SEDAR 94 KEYS RW base model (black solid line). Long-term equilibrium $F_{40\%SPR}$ used average recruitment from 1986 – 2024 (red dashed line) while short-term $F_{40\%SPR}$ (dark green dotted line), $F_{current}$ (mustard dashed line), and 75% of short-term $F_{40\%SPR}$ (teal dot-dashed line) used average recruitment from 2020 – 2024. The cyan region highlights the first five years of the projection (2025 – 2030).