2024 Southeastern US Mutton Snapper (Lutjanus analis)
CIE Review

Southeast Science Center
National Oceanic and Atmospheric Association (NOAA)
September 10-12, 2024
St. Petersburg, FL

Prepared by:

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Image Credit: Florida Fish and Wildlife

Executive Summary

An in-person CIE review of the Benchmark Stock Assessment for Southeastern US Mutton Snapper (*Lutjanus analis*) was held 10-12 September 2024 in St. Petersburg, Florida. The data, analyses, and stock modeling presented were part of a Benchmark Stock Assessment (called "assessment" in this report).

CIE panelists were asked to become familiar with the results of the 2023 Data Workshop, as well as relevant reference documents. About a week prior to the meeting, they were also provided with the draft assessment report. During the course of the review, the assessment team responded quickly and effectively to the questions raised by the review panel.

The CIE reviewers and other members of the review panel provided specific guidance on all of the Terms of Reference, which are reviewed in more detail in this report. Concerning the adequacy of the data, I agreed that the data decisions made by the assessment team were appropriate. However, an area for further research is the current assumption of a single population, with minimal connectivity with other mutton snapper stocks. The reporting of recreational fishery landings was also a challenging aspect of the assessment, but the uncertainty was well-acknowledged and some sensitivity analyses were undertaken to investigate the impact of the assumptions made. The longline CPUE series could be an influential area for further work, as it provides indices of abundance for older ages than those contained in the other indices of abundance, and the indices are not well fit in the current model formulation. I agreed that given the diagnostics completed for mutton snapper, the models were configured appropriately and are consistent with standard practices.

Given the base model and the sensitivity analyses attempted during the meeting, I agreed that the stock is not overfished, nor is overfishing occurring. The quantitative estimates of relative stock status appear reliable and useful for resource managers. Similarly, the projection methods and results seem reasonable and appropriate. However, the projections of future yield and stock status included deterministic results only, as MCMC results were deemed unreliable. The review panel made a short-term recommendation to continue efforts to resolve the issues with the projection MCMC results, so that stochastic projections may be provided.

Longer term recommendations included increasing the frequency of stock assessments, obtaining length composition (and other biological data) from a broader range of gear types in the recreational fishery, a study of the size/age based vertical distribution to better understand availability to fishing/sampling gear and alternative treatments of the longline CPUE data. Post-release and delayed mortality estimates are provided by a proxy species (red snapper). Given the scale of this type of mortality, providing post-release estimates of mortality specifically for the mutton snapper fishery is a high priority, in my opinion.

While the review panel identified some significant sources of uncertainty and had some important suggestions for future work, the assessment was conducted thoroughly and the conclusions reached appear to be robust. I have confidence that the work presented is the best available science at this time, and future studies will further strengthen the assessment.

Background

Three CIE independent scientists participated in a review of the 2024 Mutton Snapper Research Stream Stock Assessment, held in St. Petersburg, Florida Sept. 10-12. A list of participants in the review may be found in Appendix 3.

The CIE reviewers were also asked to participate in a pre-assessment virtual meeting September 3. The webinar was organized by Dr. Julie Neer, (SEDAR Program Manager). The purpose of the webinar was to discuss initial impressions of the stock assessment and for the reviewers to make requests for further analyses prior to the review workshop. I had two requests for the assessment team: a) to run the base model without two indices of abundance (the longline CPUE index, and the young of the year index from Indian River) and b) to run the base model starting at 1986, excluding the recreational data from 1981 to 1985, a period which was known to include highly imprecise recreational landings data.

My role in the review was to contribute to the Review Panel's Summary Report, as well as prepare an individual report containing my views on how well the assessment meets the Terms of Reference (Annex 2), presented below.

Responses to the Terms of Reference

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

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

Overall, I concluded that the data decisions made by the Data Workshop and Assessment Workshop panels were sound and robust. Southeastern U.S. Mutton Snapper was treated as a single population based on a combination of genetic and biological evidence, although the data available are not comprehensive. Moreover, the inferences of low levels of connectivity between Cuba and southeast Florida seem to be based on somewhat weak data. The D'Allessandro et al. paper was given as a key reference on larval distributions. But on checking the original work, I found it represented monthly sampling of only 17 stations yielding just 114 larvae in the two-year long study. The stations were along a linear transect from the 100 m contour off FL to the Grand Bahamas Bank. To me, there seem to be a lot of inferences made concerning larval distributions based on this quite constrained data set.

The stock definition used in the assessment seems to be an administrative convenience rather than reflecting biological reality. There are some observations within the assessment documents that could be consistent with finer scale structuring of the population. For example, fish landed in a certain area are known to be somewhat smaller than elsewhere. Application of exploitation rate suitable for the entire management unit might not be optimal for that group, if snapper are of lower productivity in such areas.

The description of the precision of age estimates was very comprehensive. However, not much was reported on accuracy considerations. Still, on age determinations, given that more than one lab provided ageing services, there was no discussion of inter-lab calibration exercises that might have been undertaken.

Species identification appears to be unambiguous, at least for the larger fish caught in the commercial fishery. But there was a suggestion in the data report that lane snappers might be misidentified as mutton snappers in the recreational fishery. The implications of this source of uncertainty were not discussed.

Finally, I was curious about fishers' experiences with this apparently growing resource, and raised the point during the assessment meeting. A meeting participant responded that there were recent surveys of commercial fishers and anglers' experiences with the mutton snapper fishery, and participants were generally positive about resource status. Such information would have been a good addition to the documentation for the assessment.

The use of the available recreational fishery catch data was discussed extensively by the Review Panel. The assessment team evaluated estimates from the Marine Recreational Information Program (MRIP) and the State Reef Fish Survey (SRFS) from Florida. Ultimately, SRFS estimates were deemed more reliable for the Florida private boat mode, as the survey is better suited for rare-event species like Mutton Snapper, and the sampling effort was higher and more consistent. However, the decision to use the SRFS series was conditional on a sensitivity test to assess the impact of this decision.

I agreed with the Panel that another important data decision involved the treatment of the combined Gulf video survey, which has evolved over time and expanded into sub-optimal Mutton Snapper habitat. Recent declines in the index could therefore be artifacts of these changes in survey design. Rather than creating a new index based solely on core habitat, the team chose to use the existing index while allowing the catchability coefficient (q) to adjust in the model to reflect the survey changes. This was a reasonable choice, allowing the model to internally calibrate the survey, but it effectively down-weighted the survey's contribution to recent trends. In the future, alternative analytical approaches incorporating spatiotemporal considerations could be useful for monitoring range expansions and producing a more accurate time series of population trends.

Overall, I agreed that the assessment team's approach to data decisions was appropriate and supported by the available evidence.

Data uncertainties were acknowledged and reported throughout the assessment process. This assessment lies within the data-moderate to data-rich spectrum, and the team integrated a wide range of fishery-dependent and fishery-independent data to inform trends in the stock using a conditional age-at-length model. Such approaches also allowed considerations of various forms of statistical uncertainty.

A significant area of uncertainty concerns discard mortality of undersized Mutton Snapper. Due to a lack of species-specific data, Mutton Snapper were assumed to experience a similar release mortality as Red Snapper which, according to a recent meta-analysis, was roughly 30%. This was considered a coarse approximation, and sensitivity tests using higher and lower rates were conducted to assess the impact of this assumption. I consider this to be an important source of uncertainty that is also suited for further study (see research recommendations later).

Six fishery-independent indices of abundance and one fishery-dependent index of biomass were used in the assessment. Uncertainty levels were estimated for each index on an annual basis and these estimates were provided to the model. The longline CPUE series also presented some challenges. Considering recent significant management changes that could impact commercial fishery catch rates, the decision was made to truncate the series in 2010. The resulting index series was not fit well by the model, with runs of positive or negative residuals. It was acknowledged that this index may be hyperstable and the reliability of this series was discussed. I consider this to be an important source of uncertainty, as this index provides information on the larger/older year-classes. Later, I provide some suggestions on alternative methods for catch rate standardization that could be helpful in the next assessment.

Data uncertainties were appropriately addressed, with key uncertainties regarding survey estimates, connectivity, and anomalous data points explicitly recognized and accounted for in the model. With the caveats already identified, I agreed that input data series were applied correctly and contributed meaningfully to the overall assessment.

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

a) Are the methods sound and robust?
b) Are assessment models configured properly and consistent with standard practices?
c) Are the methods appropriate for the available data?

I agree that the methods used in the stock assessment are sound and robust. Comparing the methods and models to recent recommendations in the literature (in particular, Punt 2023), I concluded that the Mutton Snapper assessment was well done both for the methods and models used. The integrated stock assessment model used in the assessment is a well-accepted state of the art approach (Stock Synthesis V. 3).

A comprehensive suite of diagnostic tests was presented to demonstrate the robustness of the model, including residual diagnostics, retrospective analyses, hindcast cross-validation, jitter analysis, likelihood profiling, and comparison with age-structured production analyses. The base case model produced satisfactory results for most of these diagnostics. The assessment report also included various sensitivity runs to evaluate the impact of different assumptions.

Biological parameters, such as natural mortality, were configured using the best available information and following the latest best practices. A Beverton-Holt curve was chosen as the stock-recruitment relationship and recruitment-deviations were estimated, which allowed large deviations from mean levels of recruitment. The model was configured to estimate recruitment at age 1, following recent recommendations from the literature.

The assumed shape of the selectivity curves for the fisheries and survey indices were discussed at length. I questioned the validity of the dome-shape assumption applied to the reef visual surveys; however, some evidence was provided to support the conclusion that larger and older snapper are less available to these surveys. Note that this assumption should be further evaluated with targeted field studies, as noted later. The flat-top assumption for the combined Gulf and SERFS video surveys was also justified by their spatial extent and depth-coverage. The dome-shape assumption for the recreational west and east fisheries were also questioned and sensitivity tests showed that stock size estimates decrease when a flat-top shape is assumed; however, this comes at a cost of fitting the length-composition data poorly. I agreed that the dome-shape provides the best explanation of the data, but cautioned that the assessment and projection may overestimate stock size if larger snapper are under-represented in the recreational fishery monitoring programs. I later highlight the need for more investigation of ontogenetic studies of the distribution of Mutton Snapper to provide validation of these assumptions.

Like the rest of the Review Panel, I was somewhat surprised at the use of age 40 as the plus group. Given the limited portion of data available for these larger ages, a younger-aged plus group would be more appropriate. However, my view was that the plus group configuration would be more of a concern if it were too young of an age, such as 10+. The base model configuration of 40+ was retained to capture the little information available out to these older ages, and to better reflect the expected progression of recent strong year-classes in an environment of relatively low fishing mortality.

I conclude that the methods were appropriate for the available data. Instead of using an age-structured model, which would have required extensive data pre-processing, the team opted for a conditional age-at-length approach. This method allowed them to incorporate length and age data whenever available, minimizing the number of assumptions and maximizing the use of raw, unprocessed information. This approach aligns with best practices in stock assessment.

As I mentioned earlier, there could be more scope for exploration of the commercial fishery CPUE data, possibly using methods for filtering the data for index fishermen that have an established history of fishing mutton snapper.

Tor 3. Evaluate the assessment findings and consider the following:

a) Are population estimates reliable, consistent with input data, 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?

I agreed that the population estimates were generally consistent with the input data. The majority of the fisheries-independent indices indicated that the population is increasing and those trends are reflected in the base-case model, and the majority of sensitivity runs that were completed. The production models that formed part of the continuity analyses (but not used for management advice) also indicated that the population was increasing. Retrospective estimates were consistent, showing no patterns or bias over years. The convergence of the base model was acceptable.

Given such analyses, there is confidence that the stock is neither overfished nor is not undergoing overfishing. The increasing trend of the population in relation to management targets is shown in Fig. 1 below, and the trend of fishing mortality with respect to management targets is shown in Fig. 2 (both figures supplied by the assessment team):

Figure 1. SEDAR 79 Final Model Formulation, mutton snapper trend in relative biomass in relation to several management targets.

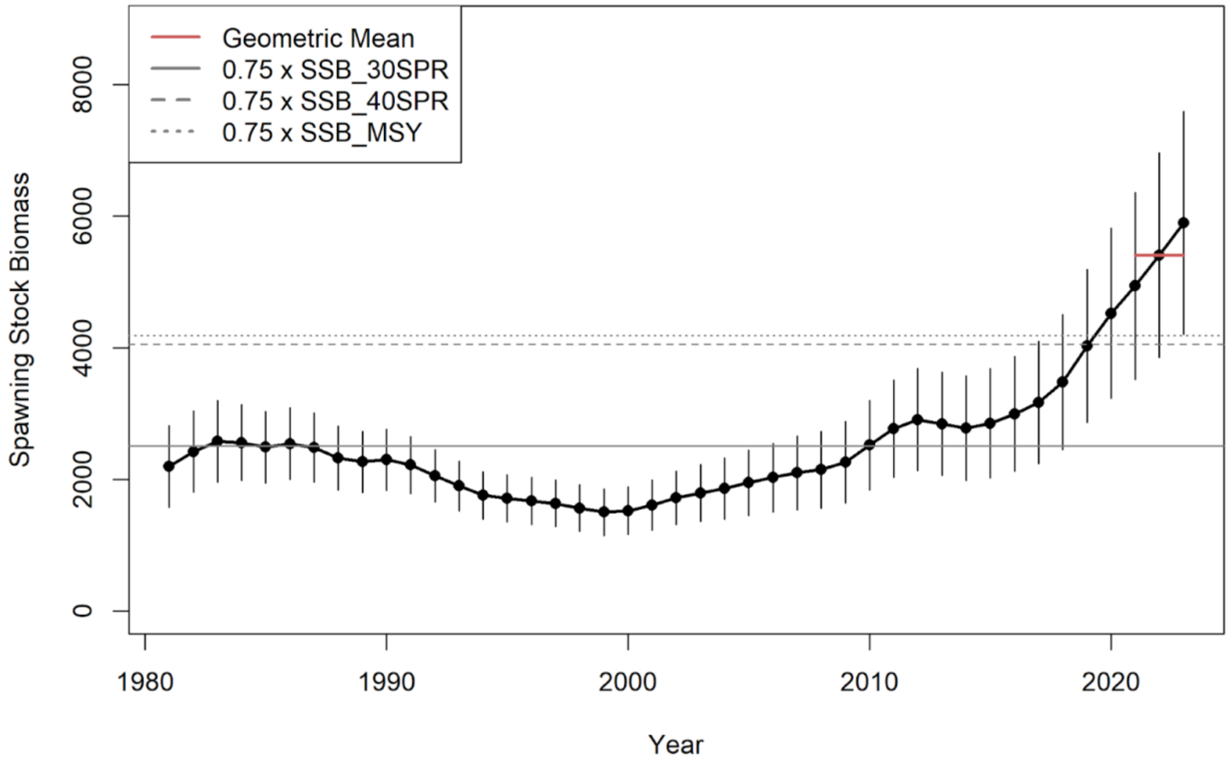
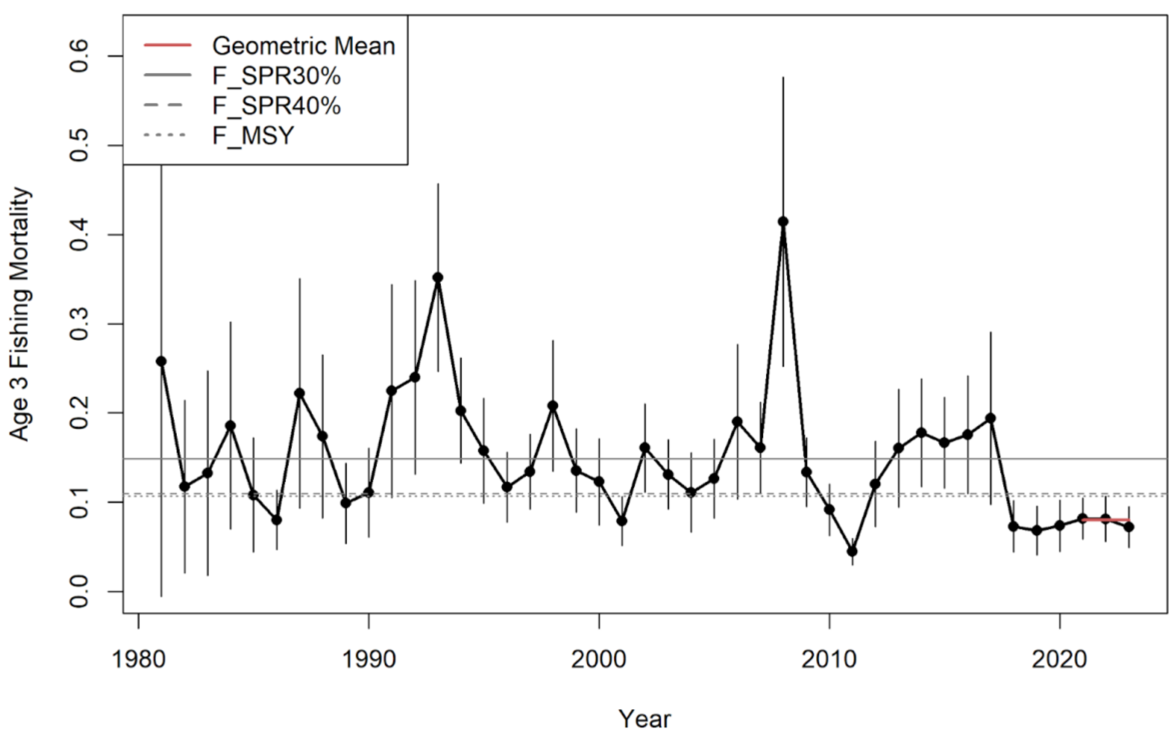


Figure 2. SEDAR 79 Final Model. Trend in age-3 fishing mortality in relation to management targets.



I agreed that there was an informative stock-recruitment relationship, although the form of the relationship is heavily influenced by the three most recent years of data. A Beverton-Holt curve was selected as the stock-recruitment relationship, and recruitment deviations were estimated. Steepness was estimated within the model to be 0.63. When fixing steepness to unity, the model estimated a sharp decrease in virgin recruits and SSB. However, this adjustment did not significantly change the overall population dynamics estimates (SSB and fishing mortality). As is usual, there is considerable uncertainty in the stock and recruitment relationship.

Tor 4. Evaluate the stock projections, including discussion of the strengths and weaknesses of data sources and decisions, 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?

I agreed with the Panel's conclusion that robust methods were used for projections. The recent recruitment deviations were higher than average values predicted from the stock-recruit curve. Projections of future stock status should not assume such high recruitments will continue into the future. The alternate approach of using the stock recruit curve with estimated steepness predicts much lower recruitment than the recent average, leading to more conservative projections. I feel that representing both scenarios is helpful for fisheries managers, as these are deterministic projections and do not account for any of the uncertainties estimated by the model.

Projection methods in future assessments could include recruitment uncertainty. The assessment team was hoping to use the Markov Chain Monte Carlo (MCMC) to do this, but as of this report the MCMC was not yet reliable.

I suggested that the projection tables include projected discards, so that fisheries managers are better aware of the significant quantities of discarded fish. Such estimates could also support investment in research to better quantify documentation of discard mortality and methods to reduce quantities discarded. These quantities were added to the projection tables, along with the usual F, yield, and SSB estimates.

In my view, the projection methods used and the base model were fully appropriate. The results were robust and could be used for management purposes. However, it would have been appropriate to acknowledge that the role of the changing ocean environment is a considerable source of uncertainty in future projections of stock status.

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

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

As I noted earlier, the SEDAR 79 assessment of Mutton Snapper was based on the Stock Synthesis (SS3) model (Methot and Wentzel, 2013). This approach supports numerous approaches to investigating uncertainty. The tools used in SEDAR 79 included examination of residual plots, likelihood profiles, sensitivity runs, retrospective analyses, and jitter analyses.

As noted in the Review Panel's Summary Report, uncertainty in input data were specified through reported estimates of standard errors and CVs for the annual estimates of catch (both commercial and recreational), discards and fishery dependent and fishery independent indices of abundance. Standard errors or coefficients of variation of landings and indices are a necessary model input. However, the uncertainty in commercial fishery landings in the end was effectively ignored because the model was configured to fit the commercial landings exactly. Furthermore, commercial discard estimates in the South Atlantic were deemed unreliable and base model was configured to essentially ignore the fit to the commercial discards. Given these considerations, the uncertainty in commercial landings and discards was under-represented in the assessment, but is thought to have a relatively insignificant impact, due to the relatively low and declining contribution of the commercial fishery to total removals.

Estimates of uncertainty in recreational landings and releases estimated by MRIP and SRFS were based on standard probability-based survey methods. Uncertainty in the index observations was estimated through the standardization techniques used to determine the final observed index values. Index values and their CVs were reported.

Process and model uncertainty in SEDAR 79 Base model within SS3 were considered through the growth, natural mortality, fishing mortality, survey catchability and stock-recruitment relationship. Estimation uncertainty is included as part of the fitting process. SS3 model output provided estimated parameter values (202), the range of values a parameter could take, their initial starting values, their associated standard deviations and CVs, the prior type and its standard deviation (where applicable), and the phase the parameter was either estimated (positive phase) or fixed (negative phase). I agree with the approach taken in the estimation of model parameters.

Approximate uncertainty estimates for estimated and derived quantities based on the asymptotic standard errors from the covariance matrix provide a minimum estimate of uncertainty in parameter values and derived quantities. To better characterize the uncertainty, MCMC analyses were run to provide posterior distributions of model parameters and selected derived quantities. Other analyses included a jitter analysis to determine if the choice of starting year influences the technical advice (it did not, indicating that local minima in model solutions were not an issue), inspection of residuals, and goodness of fit. As was done in previous SEDAR reviews, the assessment team also presented results of age-structured production models. In general, those results support the trends in biomass and fishing mortality derived from the current SEDAR 79 model.

I agreed that the uncertainty in the data and the assessment model was extensively explored and quantified where possible. The assessment results with respect to the status of the stock appear to be generally robust relative to the range of uncertainties considered in the assessment. An exception is the sensitivity run that considered the impacts of excluding the commercial longline CPUE and the Indian River Young of the Year indices. In that case, the trend of relative biomass, while tracking the base model results, was displaced lower so that the stock remained in an overfished condition until 2017 (compared with 2010 in the base model) and the current status was somewhat less optimistic. Other exceptions were the runs requested by the review panel regarding the selectivity configuration of the recreational east and west fleets. Using a selectivity that is less dome-shaped led to less optimistic stock assessment outcomes.

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

1. Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments
2. Provide recommendations on possible ways to improve the SEDAR process.

I support the research recommendations identified by the Data and Assessment stages for the Southeastern US Mutton Snapper assessment process. In particular, I noted that the Data Workshop recommended a study of depredation in the commercial longline fishery. I support that recommendation. It was also highlighted in the Data Workshop that reproductive data used in the 2024 stock assessment was more than 10 years old. Given the possible impacts of climate change on size/age at maturity and duration of spawning season, I agree that effort should be devoted to obtain more current information.

I also strongly recommend that this stock is next assessed sooner than 10 years given the uncertainties associated with the scale of the population. I also endorse recommendations of the Review Team, and add some additional considerations from my perspective below.

I feel that the assumptions in the form of the selection curve need further investigation, and probably includes a field program with experimental fishing to determine size and age-related components of the vertical distribution of Mutton Snapper. The alternative explanation that sampling deficiencies have caused the apparent absence of older individuals in the recreational fishery data also needs to be examined carefully.

I also would strongly support continued investigation of alternative approaches for longline catch rate standardization, ideally allowing the most recent (2011-2023) data to be included. the analysts could have a look at Maunder and Punt (2004) for suggestions on how to subset the available data to identify vessels/skippers that have a long-running history of involvement with the mutton snapper fishery.

Concerning options for improving the SEDAR review process, the Panel noted that the data review and assessment review processes are closely linked and data decisions affect model choices. Having at least one of the review panel members present at the data meeting may be useful for guiding discussions at the assessment review meeting. While I agree with the Panel's intent, I suspect that will be difficult to implement practically. I also consider that there are some positive aspects in having the CIE reviewers removed from the earlier decisions, as it would potentially support a more independent review.

The draft report was provided to the CIE reviewers August 27, about 10 business days prior to the meeting. While this is consistent with the contract specifications, having the documents earlier would facilitate a more thorough review. I realize the pressures of providing these comprehensive reviews, so please consider this an area for possible improvement rather than a serious issue. Otherwise, it was difficult to fault this SEDAR process. The review was handled professionally by all involved, and the atmosphere was collegial and constructive. The analytic team, in particular, was very responsive to the review panel's requests and suggestions. I would like to pass along sincere thanks to them, and the hosting organizations for their hospitality.

Tor 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.

Consistent with the Review Panel's conclusion, my review indicates that the assessment was appropriate, well-documented and completed with care and diligence. The approaches, results and conclusions are well supported with comprehensive analyses that follow published best practices for stock assessments. Given such attributes, I could not identify any critical data or analytical approaches that would improve the existing assessment, and the current assessment constitutes the best scientific information available.

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

While all the research recommendations in TOR 6 are also relevant for this TOR, special consideration data improvements include *development* of the longline catch rate series (not exclusion as suggested in the Panel Summary Report), more incorporation of spatial-temporal models incorporating movement, and continued investment into obtaining quality recreational landings data. Obtaining species-specific discard mortality rates for Mutton Snapper would also be helpful and important.

Improved modeling approaches would include explorations of the fleet and area specific selectivity patterns, and incorporation of uncertainty into the projections of future stock status.

Tor 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.

The Peer Review Summary Report was prepared and submitted by the Review Panel according with the project guidelines.

Conclusions

My independent review of the 2024 mutton snapper was in good concurrence with the conclusions of the summary report prepared by the review panel. This was a comprehensive and well-executed stock assessment using state of the art methods. The results represent the best available science at this time.

In my view, the most influential research recommendations to pursue over the medium term (4-8 years) would be to investigate stock structure and connectivity with adjacent mutton snapper stocks, such as in Cuba. As I explained earlier, the evidence suggesting an absence of mixing seems insufficient. There also seems to be a lack of certain important life history information, including depth-related distributions of adult fish. Such data would help the assessment team understand patterns of selectivity in the fishery. I would also recommend that the possible impacts of climate change on size/age at maturity and duration of spawning season be given more consideration in future assessments. Finally, I believe there is more information that could be extracted from the fishery-dependent indices of abundance that could be consequential for the stock assessment, and I provider some starting points to consider.

Appendix One

Literature Provided for the Review, and Additional Material Cited by the CIE Reviewer

A complete list of the documents available from the Data and Assessment Workshops may be found here:
https://sedarweb.org/documents/sedar-79-se-us-mutton-snapper-document-list-8-march-2022/

References for this CIE Report

Felipe Carvalho, Henning Winker, Dean Courtney, Maia Kapur, Laurence Kell, Massimiliano Cardinale, Michael Schirripa, Toshihide Kitakado, Dawit Yemane, Kevin R. Piner, Mark N. Maunder, Ian Taylor, Chantel R. Wetzel, Kathryn Doering, Kelli F. Johnson, Richard D. Methot. 2021. A cookbook for using model diagnostics in integrated stock assessments. Fisheries Research. 240: 1-18.

D'Alessandro, E.K., Sponaugle, S., and J.E. Serafy. 2010. Larval ecology of a suite of snappers (family Lutjanidae) in the Straits of Florida, western Atlantic Ocean. Mar. Ecol. Prog. Ser. 410: 159-175.

Maunder, M.N. and A. Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fish. Res. 70: 141-159.

Punt, A. 2023. Those who fail to learn from history are condemned to repeat it: A perspective on current stock assessment good practices and the consequences of not following them. Fish. Res. 261: 1-15.

Winker, H., Carvalho, F., and M. Kapur. 2018. JABBA: Just Another Bayesian Biomass Assessment. Fish. Res. 204:275-288.

Appendix Two

Performance Work Statement (PWS)
National Oceanic and Atmospheric Administration
(NOAA) NOAA Fisheries
Center for Independent Experts (CIE)
Program External Independent Peer Review
SouthEast Data, Assessment, and Review (SEDAR 79) Southeastern Mutton Snapper Assessment Review

Background

NOAA Fisheries is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NOAA Fisheries science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination. Specifically, science products that the agency can reasonably determine that will have, when disseminated*, "a clear and substantial impact on important public policies or private sector decisions*." Additionally, peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards[1].

Scope

The SEDAR is the cooperative process by which stock assessment projects are conducted in NOAA Fisheries' Southeast Region. SEDAR was initiated to improve planning and coordination of stock assessment activities and to improve the quality and reliability of assessments.

SEDAR 79 will be a CIE assessment review conducted for Southeastern Mutton Snapper. The review workshop provides an independent peer review of SEDAR stock assessments. The term review is applied broadly, as the review panel may request additional analyses, error corrections and sensitivity runs of the assessment models provided by the assessment panel. There will be one model to be reviewed during the workshop. The review panel is ultimately

[1] https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/memoranda/2005/m05-03.pdf

responsible for ensuring the scientific basis of the assessment through the SEDAR process. The specified format and contents of the individual peer review reports are found in **Annex 1**. The Terms of Reference (ToR) of the peer review are listed in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3.**

Requirements

NOAA Fisheries requires three (3) reviewers to conduct an impartial and independent peer review in accordance with the PWS, OMB guidelines, and the ToR below. The reviewers shall have a working knowledge in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the primary task of providing peer-review advice in compliance with the workshop Terms of Reference fisheries stock assessment. Expertise the with Stock Synthesis modeling platform, and the associated model diagnostics would be helpful. The chair, who is in addition to the three reviewers, will not be provided by the CIE. Although the chair will be participating in this review, the chair's participation (e.g., labor and travel) is not covered by this contract.

Tasks for Reviewers

1) Two weeks before the peer review, the Project Contacts will send (by electronic mail) the necessary background information to the CIE reviewers and reports for the peer review. In the case where the documents need to be mailed, the Project Contacts will consult with the contractor on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance with the PWS scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

2) Attend and participate in an in-person review meeting. The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to answer any questions from the reviewers, and to provide any additional information required by the reviewers.

3) After the review meeting, reviewers shall conduct an independent peer review report in accordance with the requirements specified in this PWS, OMB guidelines, and ToR, in adherence with the required formatting and content guidelines. Reviewers are not required to reach a consensus.

4) Each reviewer shall assist the Chair of the meeting with contributions to the summary report.

5) Deliver their reports to the Government according to the specified milestones dates.

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NOAA Fisheries Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NOAA Fisheries Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Foreign National Guest website. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance

The places of performance shall be in St. Petersburg, FL.

Period of Performance

The period of performance shall be from the time of award through October 31, 2024. Each CIE reviewer's duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Within two weeks of award	Contractor selects and confirms reviewers
Two weeks prior to the panel review	Contractor provides the pre-review documents to the reviewers
September 10 – 12, 2024	Panel review meeting
Approximately three weeks later	Contractor receives draft reports
Within two weeks of receiving draft reports	Contractor submits final reports to the Government

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content; (2) The reports shall address each ToR as specified; and (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $13,000.00.

Restricted or Limited Use of Data

The contractors may be required to sign and adhere to a non-disclosure agreement.

Project Contacts:

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Annex 1: Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations and specify whether the science reviewed is adequate.

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each ToR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the ToR.

   a. Reviewers must describe in their own words the review activities completed during the panel review meeting, including a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, but especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the summary report they believe might require further clarification.

   d. Reviewers shall provide a critique of the NOAA Fisheries review process, including suggestions for improvements of both process and products.

   e. The report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The report shall represent the peer review of each ToR, and shall not simply repeat the contents of the summary report.

3. The report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of this Performance Work Statement
   Appendix 3: Panel membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review
SEDAR 79 Southeastern Mutton Snapper
Review Workshop Terms of Reference

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

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

Tor 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?

Tor 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?

Tor 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?

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

a) Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods

b) Ensure that the implications of uncertainty in technical conclusions are clearly stated

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

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

b) Provide recommendations on possible ways to improve the SEDAR process

Tor 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.

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

Tor 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.

Annex 3: Tentative Agenda - SEDAR 79 Southeastern Mutton Snapper Assessment Review

September 10-12, 2024
St. Petersburg, Florida

Monday - *Travel*

Tuesday

8:30 – 9:00 a.m.	**Introductions and Opening Remarks** *- Agenda Review, ToR, Task Assignments* *- Take Breaks as needed throughout*	**Coordinator**
9:00 a.m. – 12:00 p.m.	**Assessment Presentations**	**TBD**
12:00 p.m. – 1:30 p.m.	**Lunch Break**	
1:30 p.m. – 5:00 p.m.	**Panel Discussion** **-** *Assessment Data & Methods* *- Identify additional analyses, sensitivities, corrections* *- Review additional analyses*	**Chair**
5:00 p.m. – 5:30 p.m.	**ToR Review & Daily Wrap-Up**	**Chair**
5:30 p.m. - 6:00 p.m.	**Public Comment**	**Chair**

***Tuesday Goals*:** Initial presentations completed, sensitivities and modifications identified.

Wednesday

8:30 a.m. – 12:00 p.m.	**Panel Discussion** *- Review additional analyses, sensitivities* *- Consensus recommendations and comments*	**Chair**
12:00 p.m. – 1:30 p.m.	**Lunch Break**	
1:30 p.m. – 5:00 p.m.	**Panel Discussion / Work Session**	**Chair**
5:00 p.m. – 5:30 p.m.	**Daily Wrap-Up**	**Chair**
5:30 p.m. - 6:00 p.m.	**Public Comment**	**Chair**

Wednesday Goals: Final sensitivities identified, preferred models selected, projection approaches approved, begin summary report drafts.

Thursday

8:30 a.m. – 12:00 p.m.	**Panel Discussion** *- Final sensitivities reviewed.* *- Projections reviewed.*	**Chair**
12:00 p.m. – 1:30 p.m.	**Lunch Break**	
1:30 p.m. – 5:00 p.m.	**Panel Discussion / Work Session** *- Review Consensus Reports*	**Chair**
5:00 p.m. – 5:30 p.m.	**Daily Wrap-Up**	**Chair**
5:30 p.m. - 6:00 p.m.	**Public Comment**	**Chair**

Thursday Goals: Complete assessment work and discussions. Final results available. Draft Summary Report reviewed.

Friday - *Travel*

Appendix Three: Panel Membership, Attendees and Affiliations

Review Panel

Amy Schueller (Chair)	SAFMC SSC
Michael Allen	GMFMC SSC
Adriana Nogueira	CIE Reviewer
John Neilson	CIE Reviewer
Paul Regular	CIE Reviewer
Alexei Sharov	SAFMC SSC

Analytic Team

Shanae Allen	FWC
Bob Muller	FWC
Halie O'Farrell	FWC

Council Representation

Jessica McCawley	SAFMC
John Sanchez	GMFMC

Staff

Julie A Neer	SEDAR
Judd Curtis	SAFMC Staff
Ryan Rindone	SAFMC Staff
Emily Ott	SEDAR

Workshop Observers

NC State
NMFS SEFSC
NMFS SEFSC

Workshop Observers via Webinar

SAFMC Staff SAFMC Staff
NC DNR
NC DNR

Appendix Four
Additional Analyses Requested During the Review of the 2024 Mutton Snapper Assessment
(Provided by Lead Analyst Dr. Shanae Allen, Sept. 26 2024)

SEDAR

Southeast Data, Assessment, and Review

SEDAR 79

Southeastern US Mutton Snapper

SECTION VI: Post-Review Workshop Addenda

September 2024

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

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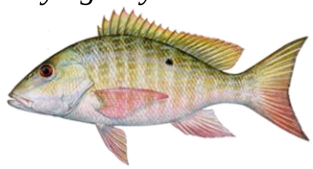

SEDAR 79 Southeastern US Mutton Snapper Benchmark Assessment Addendum

Fish and Wildlife Research Institute
Florida Fish and Wildlife Conservation Commission
September 2024

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1. INTRODUCTION

The SEDAR 79 Southeastern Mutton Snapper Assessment Review Workshop (RW) took place September 10-12, 2024, in St. Petersburg, FL. During the RW, the SEDAR 79 RW Panel requested additional details or analyses from the analytical team, which are summarized below.

2. ADDITIONAL DATA PLOTS

The RW Panel requested that landings per fleet be presented in the same figure to better understand the landings contribution of each fleet. **Figure 1a** illustrates landings in numbers per fleet while **Figure 1b** presents the proportion landed (in numbers) by fleet. Similarly, **Figure 2a** and **Figure 2b** present landings in pounds per fleet and the proportion landed (in weight) by fleet, respectively.

3. ADDITIONAL BASE MODEL RESULTS

The RW Panel wished to investigate additional results of the Base Model. First, numbers-at-age estimated by the Base Model are shown in **Figure 3**. This illustrates not only increases in age-1 recruits in recent years but also of older ages (ages 8+).

Second, the RW Panel questioned the age associated with the maximum fishing mortality rates by year and fleet. The maximum fishing mortality rate associated with the commercial longline fleet is age 17 in all years, while the maximum fishing mortality rate for both recreational fleets (Rec East and Rec West) occur at age 3 (**Table 1**). The commercial other fleet is the only fleet for which annual maximum fishing mortality rates vary across ages, ranging from age 10 to age 14 (**Table 1**).

This led to a discussion of alternative ages for the reported fishing mortality rates. The SEDAR 79 Base Model specifies age 3 as the basis of the reported fishing mortality rates and associated reference points. The RW Panel additionally requested estimates of fishing mortality rates associated with age 10 and as a weighted average of ages 3 – 5. The Base Model results under each of these scenarios are presented in **Figure 4** with 30% SPR reference points and **Figure 5** with 40% SPR reference points.

The RW Panel wanted to further explore the effects of removing the commercial longline index and requested additional plots of model fits. **Figure 6** presents the fits to all other indices when the commercial longline index is removed, as well as the estimated catchability over time for the Gulf Combined Video Index.

Lastly, the RW Panel requested that the projected number of live releases be added to the projection tables presented in the SAR in Tables 26 and 27 (**Table 2** and **Table 3** in this document).

4. ADDITIONAL REFERENCE POINTS

The RW Panel wished to consider additional reference points associated with maximum sustainable yield (MSY; based on maximizing dead catch biomass), maximum sustainable retained yield (MSRY; based on maximizing retained biomass), and 40%SPR for the Base Model.

The reference points were calculated in two ways; first, internally within the Stock Synthesis Base Model (**Table 4**) and then via long-term (100 year) projections assuming equilibrium was obtained in the final 10 years of the projection (2114-2123) and recruitment in the first year and every year thereafter follows the stock-recruit curve (**Table 5**). Note that Stock Synthesis only uses total dead catch biomass (retained and dead releases) as the quantity that is optimized when searching for F_{MSY}, therefore the MSRY (maximum sustainable retained yield) scenario is not shown for the SS internally calculated reference points.

From this analysis it was determined that F_{MSY} (0.107) is nearly equivalent to $F_{40\%SPR}$ (0.11), and corresponds to 75% of $F_{30\%SPR}$. While the F_{MSY} can be estimated, it is highly uncertain due to the uncertainty in the stock-recruit relationship. The estimated SPR associated with MSY is 0.409 and the approximate 95% confidence interval is 0.32 - 0.50. The fishing mortality rate that maximizes retained biomass (F_{MSRY}) was slightly less (estimated to be 0.10 via long term projections) and was associated with a slightly higher SPR (0.43).

4.1 Sensitivity Runs with 40%SPR Reference Points

The results of each sensitivity run that were described in the SEDAR 79 SAR (listed below) are presented in **Figures 7 – 10** with added reference points associated with 40%SPR.

1. Remove S-R curve (Steepness ≈ 1)

2. Release Mortality equal to 15% and 45%

3. MRIP-FES Private Mode Landings & Releases

4. Jack-Knife Analysis on Indices of Abundance

5. ADDITIONAL SENSITIVITY RUNS

Several additional sensitivity runs were requested by the RW Panel and the results of which are presented below. An additional sensitivity run investigated the effect of an erroneously omitted index value and related standard error for the RVC FL Keys survey in 1999. This was confirmed after the Review Workshop but was shared with the RW Panel shortly thereafter.

5.1 Start Year = 1986

The RW Panel was concerned with the high uncertainty associated with the recreational landings prior to 1986. To test the Base Model sensitivity to the inclusion of years 1981 – 1985, the start year was set to 1986, and all landings and release data were removed prior to 1986. **Figures 11-12** illustrate that there were minor differences in model results when the time series was truncated to 1986 – 2023.

5.2 Remove first 3 years from SERFS video index

Similarly, the uncertainty associated with the SERFS video index for the initial three years of the survey (2011-2013) was very high (CVs ranged from 0.46 – 0.58), but a sensitivity run removing these three years from index showed negligible deviations from the SEDAR 79 Base Model (**Figures 13 – 14**).

5.3 Estimate F parameters for all fleets

When annual fishing mortality rate parameters are estimated for all fleets, estimated landings are not an exact fit to the observed landings and account for associated error in the landings data. However, since the landings associated with the commercial fleets have such low standard errors on the log scale (ranging from 0.03 to 0.09 for the Commercial Longline fleet and from 0.02 to 0.07 for the Commercial Other fleet) and the commercial landings are very low relative to the recreational fleets (**Figure 1**), the results are virtually indistinguishable from the SEDAR 79 Base Model (**Figures 15 – 16**).

5.4 Alternative selectivity assumption for Rec fleets

Two sensitivity runs investigated the effect of alternative selectivity assumptions for the recreational fleets. The first sensitivity run assumed single logistic (i.e., flat topped) selectivity for both Rec East and Rec West fleets. The second sensitivity run fixed the Rec East selectivity to the less domed Rec West selectivity as estimated by the SEDAR 79 Base Model.

The impetus for exploring the alternative selectivity assumptions for the recreational fleets (i.e., 'less domed' compared to the Base Model) is the possibility that larger fish in the population are vulnerable to the recreational fishery but are under sampled to a large degree. Consistent under sampling of larger Mutton Snapper is plausible since fish landed on private property are not intercepted and therefore are not measured. Anglers that have access to a private dock may have boats with higher powered engines and may fish in areas further offshore, landing larger fish compared to anglers returning to public boat docks.

The overall log-likelihood increased since the fits to the recreational length comps deteriorated, especially for the Rec East fleet **(Figure 17**; **Table 6**). The effects on model results are shown in **Table 6 and Figures 18 - 19**. Compared to the Base Model, estimated fishing mortality rates, $F_{30\%SPR}/F_{40\%SPR}$, and annual estimated spawning stock biomasses all decreased markedly but the spawning stock biomass reference points only declined slightly leading differences in perceived stock status.

5.5 Include RVC FL Keys 1999 Data Point

It was discovered that a single data point from the RVC FL Keys index in 1999 was mistakenly omitted from the SEDAR 79 Base Model. When this data point (and related standard error on the log scale) is included, the observed and expected index values for the RVC FL Keys survey as well as the other indices show nearly identical fits as the SEDAR 79 Base Model (**Figure 20)**. This is expected as the omitted data point was consistent with neighboring years. Correspondingly, the results of this sensitivity run are equivalent to the SEDAR 79 Base Model results (**Figures 21-22**).

4. TABLES

Table 1. Fishing mortality rates by age (only ages 1 to 17 are shown), year, and fleet as estimated by the SEDAR 79 Base Model. Maximum fishing mortality rates (rounded to five decimal points) are highlighted in light red.

		Calendar Age																
Fleet	**Yr**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
COM_LL	1981	0.000	0.000	0.000	0.001	0.003	0.004	0.005	0.006	0.007	0.008	0.008	0.008	0.008	0.008	0.009	0.009	0.009
COM_LL	1982	0.000	0.000	0.001	0.002	0.004	0.006	0.008	0.009	0.010	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012
COM_LL	1983	0.000	0.000	0.000	0.001	0.003	0.005	0.006	0.007	0.008	0.008	0.009	0.009	0.009	0.009	0.010	0.010	0.010
COM_LL	1984	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006
COM_LL	1985	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
COM_LL	1986	0.000	0.000	0.001	0.002	0.004	0.006	0.008	0.010	0.011	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013
COM_LL	1987	0.000	0.000	0.001	0.003	0.006	0.010	0.013	0.016	0.017	0.018	0.019	0.020	0.020	0.021	0.021	0.021	0.021
COM_LL	1988	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.011	0.012	0.013	0.013	0.013	0.014	0.014	0.014	0.014
COM_LL	1989	0.000	0.000	0.001	0.003	0.006	0.010	0.013	0.015	0.017	0.018	0.019	0.020	0.020	0.020	0.021	0.021	0.021
COM_LL	1990	0.000	0.000	0.001	0.002	0.005	0.008	0.010	0.012	0.013	0.014	0.015	0.015	0.016	0.016	0.016	0.016	0.016
COM_LL	1991	0.000	0.000	0.001	0.003	0.006	0.009	0.012	0.014	0.015	0.016	0.017	0.018	0.018	0.018	0.019	0.019	0.019
COM_LL	1992	0.000	0.000	0.000	0.002	0.003	0.005	0.006	0.007	0.008	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.010
COM_LL	1993	0.000	0.000	0.001	0.002	0.003	0.005	0.007	0.008	0.009	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.011
COM_LL	1994	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008
COM_LL	1995	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008
COM_LL	1996	0.000	0.000	0.000	0.001	0.003	0.004	0.005	0.006	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009
COM_LL	1997	0.000	0.000	0.000	0.002	0.003	0.005	0.006	0.007	0.008	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.010
COM_LL	1998	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.012	0.012	0.013	0.013	0.014	0.014	0.014	0.014	0.014
COM_LL	1999	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.011	0.012	0.013	0.013	0.013	0.014	0.014	0.014	0.014
COM_LL	2000	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.011	0.012	0.013	0.013	0.013	0.013	0.014	0.014	0.014
COM_LL	2001	0.000	0.000	0.001	0.002	0.005	0.008	0.010	0.012	0.014	0.015	0.015	0.016	0.016	0.016	0.016	0.017	0.017
COM_LL	2002	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.011	0.012	0.013	0.013	0.013	0.014	0.014	0.014	0.014
COM_LL	2003	0.000	0.000	0.001	0.003	0.006	0.009	0.012	0.014	0.015	0.016	0.017	0.018	0.018	0.018	0.018	0.019	0.019
COM_LL	2004	0.000	0.000	0.002	0.005	0.010	0.015	0.020	0.023	0.026	0.028	0.029	0.030	0.031	0.031	0.031	0.032	0.032
COM_LL	2005	0.000	0.000	0.001	0.003	0.006	0.009	0.011	0.014	0.015	0.016	0.017	0.017	0.018	0.018	0.018	0.018	0.019
COM_LL	2006	0.000	0.000	0.001	0.004	0.009	0.014	0.018	0.021	0.024	0.025	0.026	0.027	0.028	0.028	0.029	0.029	0.029
COM_LL	2007	0.000	0.000	0.001	0.003	0.006	0.009	0.012	0.014	0.015	0.016	0.017	0.018	0.018	0.019	0.019	0.019	0.019
COM_LL	2008	0.000	0.000	0.001	0.002	0.003	0.005	0.007	0.008	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.011	0.011
COM_LL	2009	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
COM_LL	2010	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005
COM_LL	2011	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006
COM_LL	2012	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
COM_LL	2013	0.000	0.000	0.000	0.001	0.003	0.004	0.005	0.006	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.009
COM_LL	2014	0.000	0.000	0.001	0.002	0.004	0.006	0.008	0.009	0.010	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012

COM_LL	2015	0.000	0.000	0.001	0.002	0.003	0.005	0.007	0.008	0.009	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.011
COM_LL	2016	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
COM_LL	2017	0.000	0.000	0.000	0.001	0.003	0.004	0.006	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009
COM_LL	2018	0.000	0.000	0.000	0.001	0.003	0.005	0.006	0.007	0.008	0.009	0.009	0.009	0.010	0.010	0.010	0.010	0.010
COM_LL	2019	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004
COM_LL	2020	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004
COM_LL	2021	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
COM_LL	2022	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
COM_LL	2023	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
COM_LL	2024	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007
COM OTHER	1981	0.003	0.007	0.015	0.018	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
COM OTHER	1982	0.003	0.007	0.014	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
COM OTHER	1983	0.003	0.006	0.013	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
COM OTHER	1984	0.002	0.005	0.012	0.014	0.015	0.015	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
COM OTHER	1985	0.002	0.005	0.011	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
COM OTHER	1986	0.003	0.008	0.018	0.022	0.023	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
COM OTHER	1987	0.004	0.011	0.023	0.028	0.030	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
COM OTHER	1988	0.004	0.010	0.022	0.027	0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
COM OTHER	1989	0.005	0.012	0.025	0.031	0.033	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
COM OTHER	1990	0.004	0.010	0.021	0.027	0.028	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
COM OTHER	1991	0.005	0.011	0.023	0.029	0.031	0.031	0.031	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
COM OTHER	1992	0.005	0.012	0.025	0.031	0.033	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
COM OTHER	1993	0.006	0.014	0.031	0.038	0.040	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
COM OTHER	1994	0.005	0.013	0.027	0.034	0.036	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037
COM OTHER	1995	0.004	0.010	0.022	0.027	0.029	0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
COM OTHER	1996	0.004	0.011	0.023	0.028	0.030	0.030	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
COM OTHER	1997	0.004	0.011	0.023	0.028	0.030	0.030	0.030	0.030	0.030	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
COM OTHER	1998	0.005	0.013	0.028	0.034	0.037	0.037	0.037	0.037	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038
COM OTHER	1999	0.004	0.009	0.018	0.023	0.024	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
COM OTHER	2000	0.003	0.006	0.013	0.016	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
COM OTHER	2001	0.003	0.006	0.013	0.016	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
COM OTHER	2002	0.003	0.006	0.014	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
COM OTHER	2003	0.003	0.006	0.013	0.016	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
COM OTHER	2004	0.002	0.006	0.012	0.015	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
COM OTHER	2005	0.002	0.004	0.009	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
COM OTHER	2006	0.001	0.003	0.007	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
COM OTHER	2007	0.001	0.003	0.007	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009

COM OTHER	2008	0.001	0.003	0.006	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
COM OTHER	2009	0.001	0.003	0.006	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
COM OTHER	2010	0.001	0.003	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
COM OTHER	2011	0.001	0.003	0.006	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
COM OTHER	2012	0.001	0.003	0.006	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
COM OTHER	2013	0.001	0.002	0.005	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
COM OTHER	2014	0.001	0.003	0.006	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
COM OTHER	2015	0.001	0.003	0.006	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
COM OTHER	2016	0.001	0.002	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
COM OTHER	2017	0.001	0.002	0.004	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
COM OTHER	2018	0.001	0.003	0.005	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
COM OTHER	2019	0.001	0.002	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
COM OTHER	2020	0.001	0.002	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
COM OTHER	2021	0.001	0.001	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
COM OTHER	2022	0.000	0.001	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
COM OTHER	2023	0.000	0.001	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
COM OTHER	2024	0.001	0.002	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
REC EAST	1981	0.133	0.196	0.267	0.207	0.132	0.082	0.054	0.038	0.029	0.025	0.022	0.020	0.019	0.018	0.018	0.017	0.017
REC EAST	1982	0.045	0.066	0.089	0.069	0.044	0.028	0.018	0.013	0.010	0.008	0.007	0.007	0.006	0.006	0.006	0.006	0.006
REC EAST	1983	0.039	0.058	0.079	0.061	0.039	0.024	0.016	0.011	0.009	0.007	0.006	0.006	0.006	0.005	0.005	0.005	0.005
REC EAST	1984	0.027	0.040	0.055	0.042	0.027	0.017	0.011	0.008	0.006	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004
REC EAST	1985	0.039	0.057	0.078	0.061	0.039	0.024	0.016	0.011	0.009	0.007	0.006	0.006	0.006	0.005	0.005	0.005	0.005
REC EAST	1986	0.028	0.042	0.057	0.044	0.028	0.018	0.011	0.008	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004
REC EAST	1987	0.075	0.110	0.151	0.117	0.075	0.046	0.030	0.021	0.017	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
REC EAST	1988	0.029	0.043	0.059	0.045	0.029	0.018	0.012	0.008	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004
REC EAST	1989	0.029	0.042	0.058	0.045	0.029	0.018	0.012	0.008	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004
REC EAST	1990	0.022	0.032	0.044	0.034	0.022	0.014	0.009	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
REC EAST	1991	0.023	0.034	0.047	0.036	0.023	0.014	0.009	0.007	0.005	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003
REC EAST	1992	0.089	0.130	0.178	0.138	0.088	0.055	0.036	0.025	0.020	0.016	0.014	0.013	0.013	0.012	0.012	0.012	0.011
REC EAST	1993	0.113	0.166	0.227	0.176	0.112	0.070	0.046	0.032	0.025	0.021	0.018	0.017	0.016	0.016	0.015	0.015	0.015
REC EAST	1994	0.074	0.109	0.149	0.115	0.074	0.046	0.030	0.021	0.016	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
REC EAST	1995	0.055	0.080	0.109	0.085	0.054	0.034	0.022	0.016	0.012	0.010	0.009	0.008	0.008	0.007	0.007	0.007	0.007
REC EAST	1996	0.039	0.057	0.078	0.060	0.038	0.024	0.016	0.011	0.009	0.007	0.006	0.006	0.006	0.005	0.005	0.005	0.005
REC EAST	1997	0.047	0.069	0.094	0.073	0.046	0.029	0.019	0.013	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.006
REC EAST	1998	0.089	0.132	0.180	0.139	0.089	0.055	0.036	0.026	0.020	0.017	0.015	0.013	0.013	0.012	0.012	0.012	0.012

REC EAST	1999	0.059	0.086	0.118	0.091	0.058	0.036	0.024	0.017	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.008	0.008
REC EAST	2000	0.074	0.109	0.149	0.115	0.074	0.046	0.030	0.021	0.016	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
REC EAST	2001	0.043	0.063	0.086	0.067	0.043	0.027	0.017	0.012	0.010	0.008	0.007	0.006	0.006	0.006	0.006	0.006	0.006
REC EAST	2002	0.099	0.145	0.198	0.153	0.098	0.061	0.040	0.028	0.022	0.018	0.016	0.015	0.014	0.014	0.013	0.013	0.013
REC EAST	2003	0.059	0.087	0.119	0.092	0.059	0.037	0.024	0.017	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.008	0.008
REC EAST	2004	0.064	0.094	0.128	0.099	0.064	0.040	0.026	0.018	0.014	0.012	0.010	0.010	0.009	0.009	0.009	0.008	0.008
REC EAST	2005	0.075	0.110	0.150	0.116	0.075	0.046	0.030	0.021	0.017	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
REC EAST	2006	0.073	0.107	0.146	0.113	0.072	0.045	0.029	0.021	0.016	0.013	0.012	0.011	0.010	0.010	0.010	0.010	0.009
REC EAST	2007	0.072	0.106	0.144	0.112	0.072	0.044	0.029	0.021	0.016	0.013	0.012	0.011	0.010	0.010	0.010	0.009	0.009
REC EAST	2008	0.266	0.391	0.534	0.414	0.265	0.164	0.107	0.076	0.059	0.049	0.044	0.040	0.038	0.037	0.036	0.035	0.034
REC EAST	2009	0.081	0.118	0.162	0.125	0.080	0.050	0.032	0.023	0.018	0.015	0.013	0.012	0.011	0.011	0.011	0.011	0.010
REC EAST	2010	0.056	0.082	0.112	0.087	0.056	0.035	0.023	0.016	0.012	0.010	0.009	0.008	0.008	0.008	0.007	0.007	0.007
REC EAST	2011	0.022	0.032	0.044	0.034	0.022	0.013	0.009	0.006	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
REC EAST	2012	0.064	0.094	0.129	0.100	0.064	0.040	0.026	0.018	0.014	0.012	0.010	0.010	0.009	0.009	0.009	0.008	0.008
REC EAST	2013	0.080	0.118	0.161	0.125	0.080	0.050	0.032	0.023	0.018	0.015	0.013	0.012	0.011	0.011	0.011	0.011	0.010
REC EAST	2014	0.088	0.129	0.176	0.136	0.087	0.054	0.035	0.025	0.019	0.016	0.014	0.013	0.013	0.012	0.012	0.012	0.011
REC EAST	2015	0.092	0.135	0.185	0.143	0.091	0.057	0.037	0.026	0.020	0.017	0.015	0.014	0.013	0.013	0.012	0.012	0.012
REC EAST	2016	0.098	0.144	0.197	0.152	0.098	0.061	0.040	0.028	0.022	0.018	0.016	0.015	0.014	0.013	0.013	0.013	0.013
REC EAST	2017	0.125	0.183	0.250	0.194	0.124	0.077	0.050	0.036	0.028	0.023	0.020	0.019	0.018	0.017	0.017	0.016	0.016
REC EAST	2018	0.065	0.095	0.130	0.101	0.064	0.040	0.026	0.018	0.014	0.012	0.011	0.010	0.009	0.009	0.009	0.008	0.008
REC EAST	2019	0.055	0.081	0.111	0.086	0.055	0.034	0.022	0.016	0.012	0.010	0.009	0.008	0.008	0.008	0.007	0.007	0.007
REC EAST	2020	0.040	0.059	0.080	0.062	0.040	0.025	0.016	0.011	0.009	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.005
REC EAST	2021	0.072	0.105	0.144	0.111	0.071	0.044	0.029	0.020	0.016	0.013	0.012	0.011	0.010	0.010	0.010	0.009	0.009
REC EAST	2022	0.070	0.102	0.140	0.108	0.069	0.043	0.028	0.020	0.015	0.013	0.011	0.010	0.010	0.010	0.009	0.009	0.009
REC EAST	2023	0.058	0.085	0.117	0.090	0.058	0.036	0.023	0.017	0.013	0.011	0.009	0.009	0.008	0.008	0.008	0.008	0.008
REC EAST	2024	0.126	0.186	0.254	0.196	0.126	0.078	0.051	0.036	0.028	0.023	0.021	0.019	0.018	0.017	0.017	0.017	0.016
REC WEST	1981	0.014	0.019	0.023	0.022	0.020	0.018	0.016	0.015	0.013	0.012	0.011	0.011	0.010	0.009	0.009	0.009	0.008
REC WEST	1982	0.021	0.030	0.036	0.034	0.031	0.028	0.025	0.023	0.021	0.019	0.018	0.016	0.015	0.015	0.014	0.013	0.013
REC WEST	1983	0.041	0.057	0.068	0.065	0.059	0.053	0.048	0.043	0.040	0.036	0.034	0.031	0.030	0.028	0.027	0.026	0.025
REC WEST	1984	0.100	0.140	0.166	0.158	0.144	0.130	0.117	0.106	0.097	0.089	0.082	0.077	0.072	0.069	0.066	0.063	0.061
REC WEST	1985	0.025	0.034	0.041	0.039	0.035	0.032	0.029	0.026	0.024	0.022	0.020	0.019	0.018	0.017	0.016	0.015	0.015
REC WEST	1986	0.011	0.015	0.018	0.017	0.015	0.014	0.013	0.011	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.007	0.007
REC WEST	1987	0.056	0.078	0.093	0.088	0.081	0.073	0.066	0.059	0.054	0.050	0.046	0.043	0.040	0.038	0.037	0.035	0.034
REC WEST	1988	0.080	0.111	0.132	0.125	0.114	0.103	0.093	0.084	0.077	0.070	0.065	0.061	0.057	0.054	0.052	0.050	0.048
REC WEST	1989	0.019	0.026	0.031	0.030	0.027	0.024	0.022	0.020	0.018	0.017	0.015	0.014	0.013	0.013	0.012	0.012	0.011

REC WEST	1990	0.040	0.056	0.066	0.063	0.058	0.052	0.047	0.042	0.039	0.035	0.033	0.031	0.029	0.027	0.026	0.025	0.024
REC WEST	1991	0.126	0.176	0.209	0.199	0.181	0.164	0.147	0.133	0.121	0.111	0.103	0.096	0.091	0.086	0.082	0.079	0.077
REC WEST	1992	0.054	0.075	0.089	0.085	0.077	0.070	0.063	0.057	0.052	0.048	0.044	0.041	0.039	0.037	0.035	0.034	0.033
REC WEST	1993	0.105	0.147	0.174	0.166	0.152	0.137	0.123	0.111	0.101	0.093	0.086	0.080	0.076	0.072	0.069	0.066	0.064
REC WEST	1994	0.042	0.059	0.070	0.066	0.060	0.055	0.049	0.044	0.040	0.037	0.034	0.032	0.030	0.029	0.027	0.026	0.026
REC WEST	1995	0.062	0.086	0.102	0.097	0.089	0.080	0.072	0.065	0.059	0.055	0.050	0.047	0.044	0.042	0.040	0.039	0.038
REC WEST	1996	0.043	0.060	0.071	0.067	0.061	0.055	0.050	0.045	0.041	0.038	0.035	0.033	0.031	0.029	0.028	0.027	0.026
REC WEST	1997	0.049	0.068	0.081	0.077	0.070	0.063	0.057	0.052	0.047	0.043	0.040	0.037	0.035	0.033	0.032	0.031	0.030
REC WEST	1998	0.059	0.082	0.098	0.093	0.085	0.077	0.069	0.062	0.057	0.052	0.048	0.045	0.042	0.040	0.039	0.037	0.036
REC WEST	1999	0.037	0.052	0.062	0.059	0.054	0.049	0.044	0.040	0.036	0.033	0.031	0.029	0.027	0.026	0.024	0.023	0.023
REC WEST	2000	0.009	0.013	0.015	0.014	0.013	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.007	0.006	0.006	0.006	0.006
REC WEST	2001	0.008	0.011	0.012	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.005	0.005
REC WEST	2002	0.013	0.018	0.022	0.021	0.019	0.017	0.015	0.014	0.013	0.012	0.011	0.010	0.009	0.009	0.009	0.008	0.008
REC WEST	2003	0.036	0.051	0.060	0.057	0.052	0.047	0.043	0.038	0.035	0.032	0.030	0.028	0.026	0.025	0.024	0.023	0.022
REC WEST	2004	0.011	0.015	0.018	0.017	0.015	0.014	0.012	0.011	0.010	0.009	0.009	0.008	0.008	0.007	0.007	0.007	0.006
REC WEST	2005	0.014	0.020	0.024	0.023	0.021	0.019	0.017	0.015	0.014	0.013	0.012	0.011	0.010	0.010	0.009	0.009	0.009
REC WEST	2006	0.080	0.112	0.132	0.126	0.115	0.104	0.093	0.084	0.077	0.071	0.065	0.061	0.057	0.055	0.052	0.050	0.049
REC WEST	2007	0.054	0.075	0.089	0.085	0.077	0.070	0.063	0.057	0.052	0.048	0.044	0.041	0.039	0.037	0.035	0.034	0.033
REC WEST	2008	0.042	0.059	0.070	0.066	0.060	0.055	0.049	0.044	0.040	0.037	0.034	0.032	0.030	0.029	0.027	0.026	0.026
REC WEST	2009	0.017	0.024	0.029	0.027	0.025	0.022	0.020	0.018	0.017	0.015	0.014	0.013	0.012	0.012	0.011	0.011	0.011
REC WEST	2010	0.009	0.013	0.015	0.015	0.013	0.012	0.011	0.010	0.009	0.008	0.008	0.007	0.007	0.006	0.006	0.006	0.006
REC WEST	2011	0.009	0.013	0.015	0.014	0.013	0.012	0.011	0.010	0.009	0.008	0.007	0.007	0.007	0.006	0.006	0.006	0.005
REC WEST	2012	0.026	0.036	0.043	0.041	0.037	0.034	0.030	0.028	0.025	0.023	0.021	0.020	0.019	0.018	0.017	0.016	0.016
REC WEST	2013	0.044	0.061	0.072	0.069	0.063	0.057	0.051	0.046	0.042	0.039	0.036	0.033	0.031	0.030	0.029	0.027	0.027
REC WEST	2014	0.050	0.070	0.083	0.079	0.072	0.065	0.058	0.053	0.048	0.044	0.041	0.038	0.036	0.034	0.033	0.031	0.030
REC WEST	2015	0.033	0.047	0.055	0.053	0.048	0.043	0.039	0.035	0.032	0.029	0.027	0.025	0.024	0.023	0.022	0.021	0.020
REC WEST	2016	0.035	0.049	0.059	0.056	0.051	0.046	0.041	0.037	0.034	0.031	0.029	0.027	0.025	0.024	0.023	0.022	0.022
REC WEST	2017	0.018	0.025	0.030	0.028	0.026	0.023	0.021	0.019	0.017	0.016	0.015	0.014	0.013	0.012	0.012	0.011	0.011
REC WEST	2018	0.022	0.030	0.036	0.034	0.031	0.028	0.025	0.023	0.021	0.019	0.018	0.016	0.016	0.015	0.014	0.014	0.013
REC WEST	2019	0.026	0.037	0.044	0.041	0.038	0.034	0.031	0.028	0.025	0.023	0.022	0.020	0.019	0.018	0.017	0.017	0.016
REC WEST	2020	0.049	0.069	0.081	0.077	0.071	0.064	0.057	0.052	0.047	0.043	0.040	0.038	0.035	0.034	0.032	0.031	0.030
REC WEST	2021	0.028	0.039	0.046	0.043	0.040	0.036	0.032	0.029	0.027	0.024	0.023	0.021	0.020	0.019	0.018	0.017	0.017
REC WEST	2022	0.029	0.041	0.048	0.046	0.042	0.038	0.034	0.031	0.028	0.026	0.024	0.022	0.021	0.020	0.019	0.018	0.018
REC WEST	2023	0.029	0.041	0.048	0.046	0.042	0.038	0.034	0.031	0.028	0.026	0.024	0.022	0.021	0.020	0.019	0.018	0.018
REC WEST	2024	0.054	0.076	0.090	0.086	0.078	0.071	0.064	0.058	0.052	0.048	0.045	0.042	0.039	0.037	0.036	0.034	0.033

Table 2. Results of the projections when age-3 fishing mortality rates = $F_{30\%SPR}$ (0.149) for Southeastern US Mutton Snapper and either predicted age-1 recruitment follows the spawner-recruit curve or predicted age-1 recruitment is equal to the geometric mean from 2019 to 2023 (3.284 million). Recruitment (Recruits) is in millions of age-1 fish, F is age-3 instantaneous fishing mortality rate, SSB is in metric tons (female SSB), Retained Yield is in pounds (whole weight), and Retained and Released Num are in numbers of fish.

	Recruits = S-R Curve F = $F_{30\%SPR}$						Recruits = 2019-2023 avg F = $F_{30\%SPR}$					
Year	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Released Num**	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Released Num**
2024	1.966	0.149	6,488	3,278,980	627,789	1,224,767	3.284	0.149	6,488	3,280,143	628,742	1,844,997
2025	2.026	0.149	6,864	3,372,143	623,832	973,316	3.284	0.149	6,867	3,384,760	630,618	1,694,199
2026	2.061	0.149	6,974	3,249,912	564,280	816,997	3.284	0.149	7,029	3,363,706	605,530	1,635,621
2027	2.070	0.149	6,821	3,023,751	495,817	763,513	3.284	0.149	7,089	3,313,030	583,152	1,618,291
2028	2.057	0.149	6,584	2,814,305	446,663	748,840	3.284	0.149	7,118	3,270,355	568,844	1,613,371
2029	2.035	0.149	6,342	2,650,664	415,719	742,116	3.284	0.149	7,130	3,239,178	560,244	1,611,911
2030	2.012	0.149	6,109	2,523,697	395,653	735,257	3.284	0.149	7,130	3,216,409	554,984	1,611,442
2031	1.989	0.149	5,889	2,421,114	381,362	727,472	3.284	0.149	7,123	3,199,290	551,639	1,611,282
2032	1.965	0.149	5,682	2,335,047	370,254	719,230	3.284	0.149	7,112	3,186,071	549,426	1,611,220
2033	1.942	0.149	5,490	2,261,068	361,084	710,879	3.284	0.149	7,098	3,175,662	547,907	1,611,193

Table 3. Results of the projections when the number of recruits is equal to the recent (2019-2023) geometric mean and age-3 fishing mortality rates equal 75% $F_{30\%SPR}$ (0.112) and Fcurrent (0.08) for Southeastern US Mutton Snapper assuming predicted age 1 recruitment is equal to the geometric mean from 2019 to 2023 (3.284 million). Recruitment (Recruits) is in millions of age-1 fish, F is age-3 instantaneous fishing mortality rate, SSB is in metric tons (female SSB), Retained Yield is in pounds (whole weight), and Retained and Released Num are in numbers of fish.

	Recruits = 2019-2023 avg F = 75% F30%SPR						Recruits = 2019-2023 avg F = Fcurrent					
Year	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Released Num**	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Released Num**
2024	3.284	0.112	6,565	2,498,073	479,551	1,401,786	3.284	0.080	6,631	1,811,994	348,293	1,014,735
2025	3.284	0.112	7,160	2,662,320	497,423	1,307,562	3.284	0.080	7,419	1,985,255	371,812	959,507
2026	3.284	0.112	7,547	2,725,359	491,431	1,270,669	3.284	0.080	8,022	2,084,741	376,453	937,997
2027	3.284	0.112	7,822	2,752,377	483,445	1,259,725	3.284	0.080	8,512	2,151,561	377,279	931,733
2028	3.284	0.112	8,047	2,772,615	478,662	1,256,565	3.284	0.080	8,942	2,206,166	378,545	929,928
2029	3.284	0.112	8,233	2,791,436	476,385	1,255,608	3.284	0.080	9,319	2,253,469	380,361	929,379
2030	3.284	0.112	8,386	2,808,849	475,505	1,255,296	3.284	0.080	9,646	2,294,626	382,360	929,197
2031	3.284	0.112	8,513	2,824,461	475,332	1,255,184	3.284	0.080	9,930	2,330,278	384,303	929,135
2032	3.284	0.112	8,618	2,838,173	475,501	1,255,144	3.284	0.080	10,177	2,361,052	386,090	929,112
2033	3.284	0.112	8,705	2,850,076	475,824	1,255,129	3.284	0.080	10,389	2,387,571	387,685	929,104

Table 4. MSY (maximizing dead catch biomass), 40%SPR, and 30%SPR reference points for Southeastern U.S. Mutton Snapper calculated internally within the Stock Synthesis SEDAR 79 Base Model.

MSY (dead catch biomass)					**40% SPR**				
Derived Quantity	Estimate	SE	95% CI		Derived Quantity	Estimate	SE	95% CI	
SSB_{MSY}	5,583.61	1,722.63	2,207.26 -	8,959.96	$SSB_{40\%SPR}$	5,404.06	1,041.20	3,363.31 -	7,444.81
$75\%SSB_{MSY}$	4,187.71				$75\%SSB_{40\%SPR}$	4,053.05			
SPR	0.409	0.046	0.32 -	0.50	SPR	0.4			
F_MSY	0.107	0.015	0.08 -	0.14	F_40SPR	0.11	0.005	0.10 -	0.12
Dead Catch MSY (mt)	898.54	175.135	555.28 -	1,241.80	Dead Catch 40SPR (mt)	898.14	173.261	558.55 -	1,237.73
Retained Catch MSY (mt)	768	154.115	465.93 -	1,070.07	Retained Catch 40SPR (mt)	766.18	148.91	474.32 -	1,058.04

30% SPR				
Derived Quantity	Estimate	SE	95% CI	
$SSB_{30\%SPR}$	3,341.70	584.7	2,195.69 -	4,487.71
$75\%SSB_{30\%SPR}$	2,506.28			
SPR	0.3			
F_30SPR	0.149	0.006	0.14 -	0.16
Dead Catch 30SPR (mt)	819.98	144.62	536.53 -	1,103.44
Retained Catch 30SPR (mt)	680.57	121.7	442.03 -	919.11

Table 5. MSY (dead catch biomass), Maximum sustainable retained yield (MSRY), 40%SPR, and 30%SPR reference points for Southeastern U.S. Mutton Snapper calculated via long-term (100 year) projections assuming equilibrium was obtained in the final 10 years of the projection (2114-2123) and recruitment in the first year and every year thereafter follows the stock-recruit curve.

MSY (dead catch biomass)		**MSRY (retained biomass)**		**SPR 40%**	
Derived Quantity	Estimate	Derived Quantity	Estimate	Derived Quantity	Estimate
SSB_MSY	5,591.66	SSB_ MSRY	5,953.01	SSB_40SPR	5,406.25
75%SSB_MSY	4,193.74	75%SSB_ MSRY	4,464.76	75%SSB_40SPR	4,054.69
SPR	0.409	SPR	0.427	SPR	0.4
F_MSY	0.107	F_ MSRY	0.101	F_40SPR	0.11
Dead_Catch_MSY (mt)	898.77	Dead_Catch_MSRY (mt)	897.11	Dead_Catch_40SPR (mt)	898.4
Dead_Catch_MSY (num)	488,907	Dead_Catch_MSRY (num)	481,502	Dead_Catch_40SPR (num)	492,189
Ret_Catch_MSY (mt)	768.25	Ret_Catch_MSRY (mt)	769.67	Ret_Catch_40SPR (mt)	766.42
Ret_Catch_MSY (num)	275,918	Ret_Catch_MSRY (num)	274,034	Ret_Catch_40SPR (num)	276,528

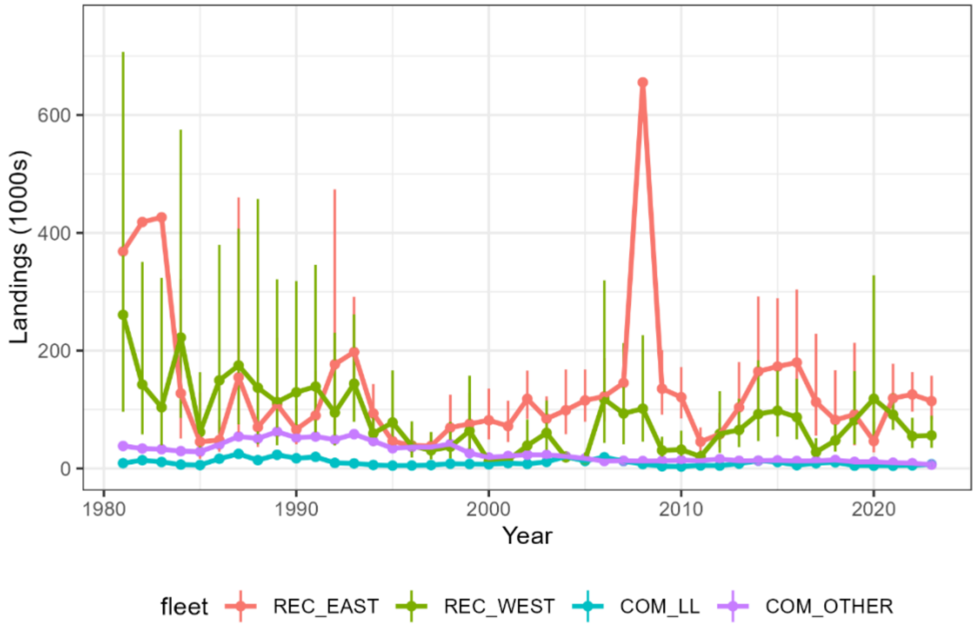
SPR 30%	
Derived Quantity	Estimate
SSB_30SPR	3,352.00
75%SSB_30SPR	2,514.00
SPR	0.3
F_30SPR	0.149
Dead_Catch_30SPR (mt)	821.28
Dead_Catch_30SPR (num)	492,834
Ret_Catch_30SPR (mt)	681.87
Ret_Catch_30SPR (num)	260,873

Table 6. Comparison of log-likelihoods, selected parameters, and derived quantities as estimated by the SEDAR 79 Base Model (‘Base Model’) and the Base Model when either flat-top selectivity is assumed for the Rec West and Rec East fleets (model = “Rec Flat Top”) or the Rec East selectivity is fixed at the Base Model estimates for Rec West (model=“Rec E equal Rec W_Base”).

	Base_Model	**Rec_Flat_Top**	**Rec_East = Rec_West_Base**
TOTAL_like	1488.01	1857.27	1687.85
Survey_like	55.285	56.871	60.085
Length_comp_like	519.391	722.314	658.537
Age_comp_like	803.328	937.915	845.27
Parm_priors_like	1.156	1.456	1.55
Recr_Virgin_millions	2.513	2.278	2.167
SR_LN(R0)	7.829	7.731	7.681
SR_BH_steep	0.644	0.757	0.759
L_at_Amax_Fem_GP_1	82.265	82.494	85.845
VonBert_K_Fem_GP_1	0.195	0.153	0.153
SSB_unfished_thousand_mt	17.778	15.005	14.812
SSB_2023_thousand_mt	5.898	4.306	3.885
F_2023	0.072	0.041	0.056
Ret_Catch_30SPR_mt	680.57	1066.45	897.427
Ret_Catch_40SPR_mt	767.994	1078.21	894.937
F_30SPR	0.149	0.067	0.083
F_40SPR	0.110	0.046	0.059
SSB_30SPR_thousand_mt	3.342	3.586	3.55
SSB_40SPR_thousand_mt	5.404	5.217	5.159

5. FIGURES

a)



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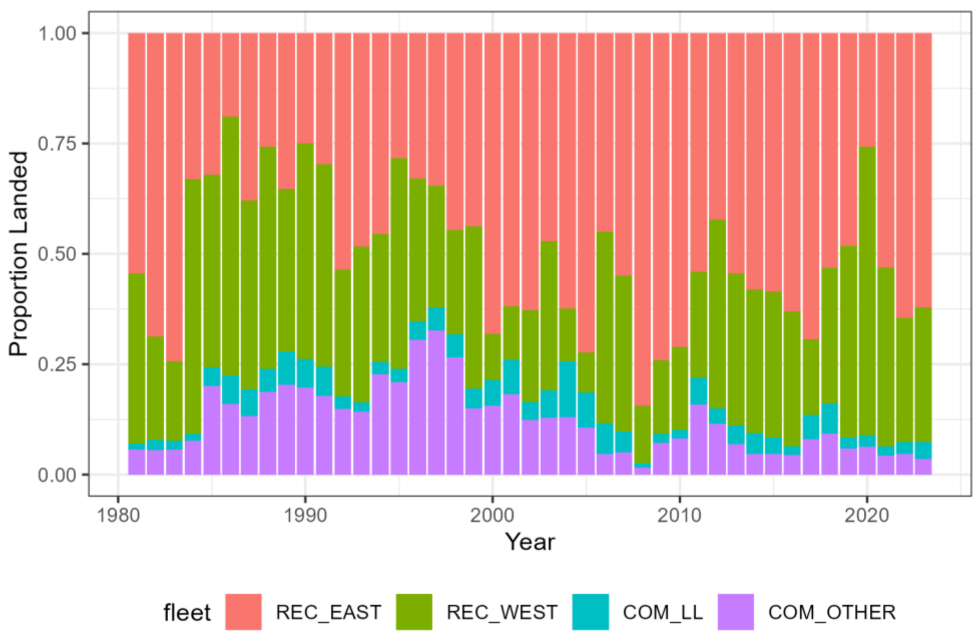
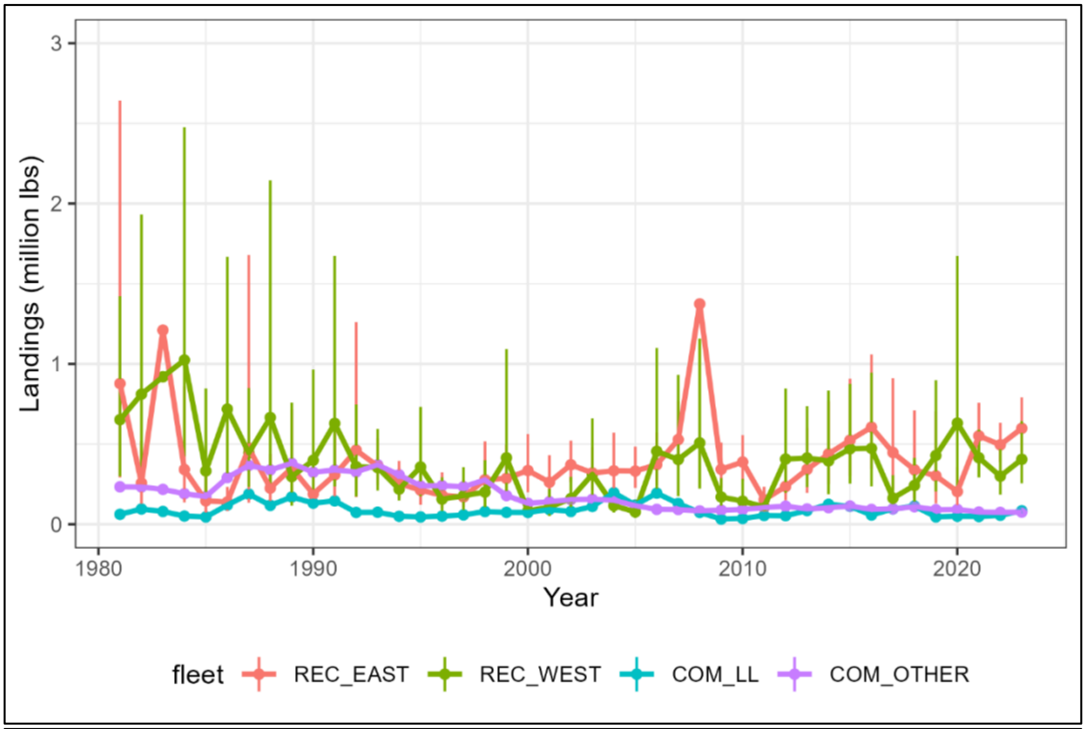


Figure 1. Landings in numbers (a) and proportion landed (b) by fleet for Southeastern Mutton Snapper. Recreational landings include Florida private-mode landings from the State Reef Fish Survey (SRFS). Approximate 95% confidence intervals (CI) are shown in Figure 1a, unless the CI exceeds the plot bounds.

a)



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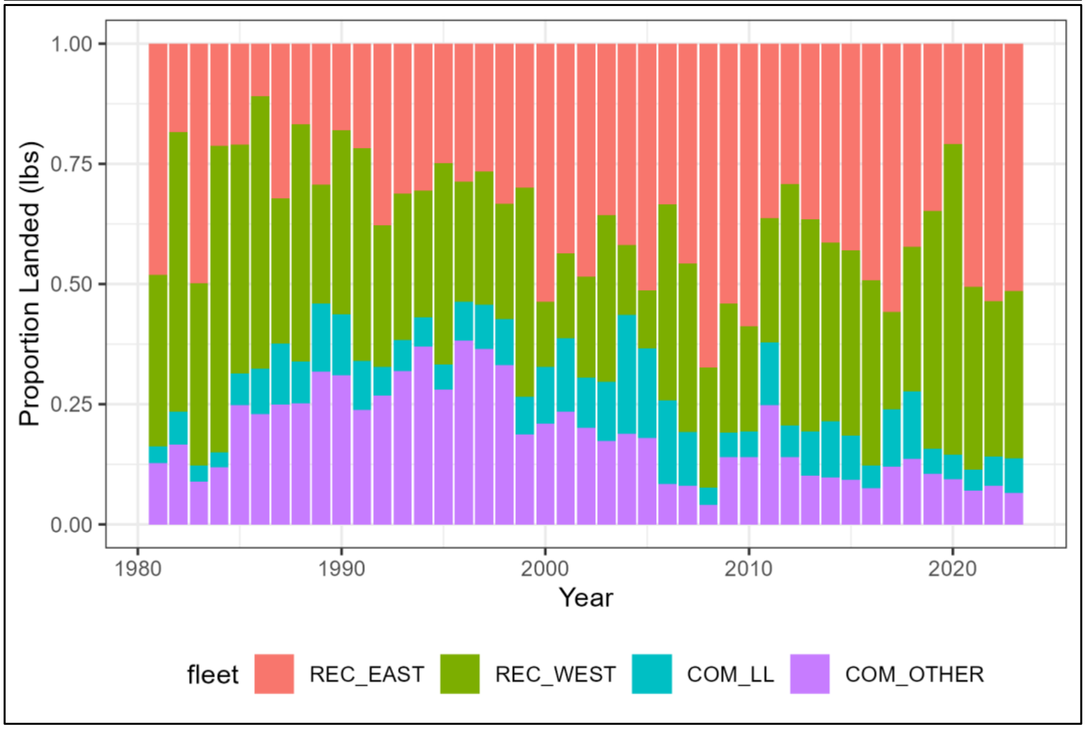


Figure 2. Landings in pounds (a) and proportion landed (b) by fleet for Southeastern Mutton Snapper. Recreational landings include Florida private-mode landings from the State Reef Fish Survey (SRFS). Approximate 95% confidence intervals (CI) are shown in Figure 2a, unless the CI exceeds the plot bounds.

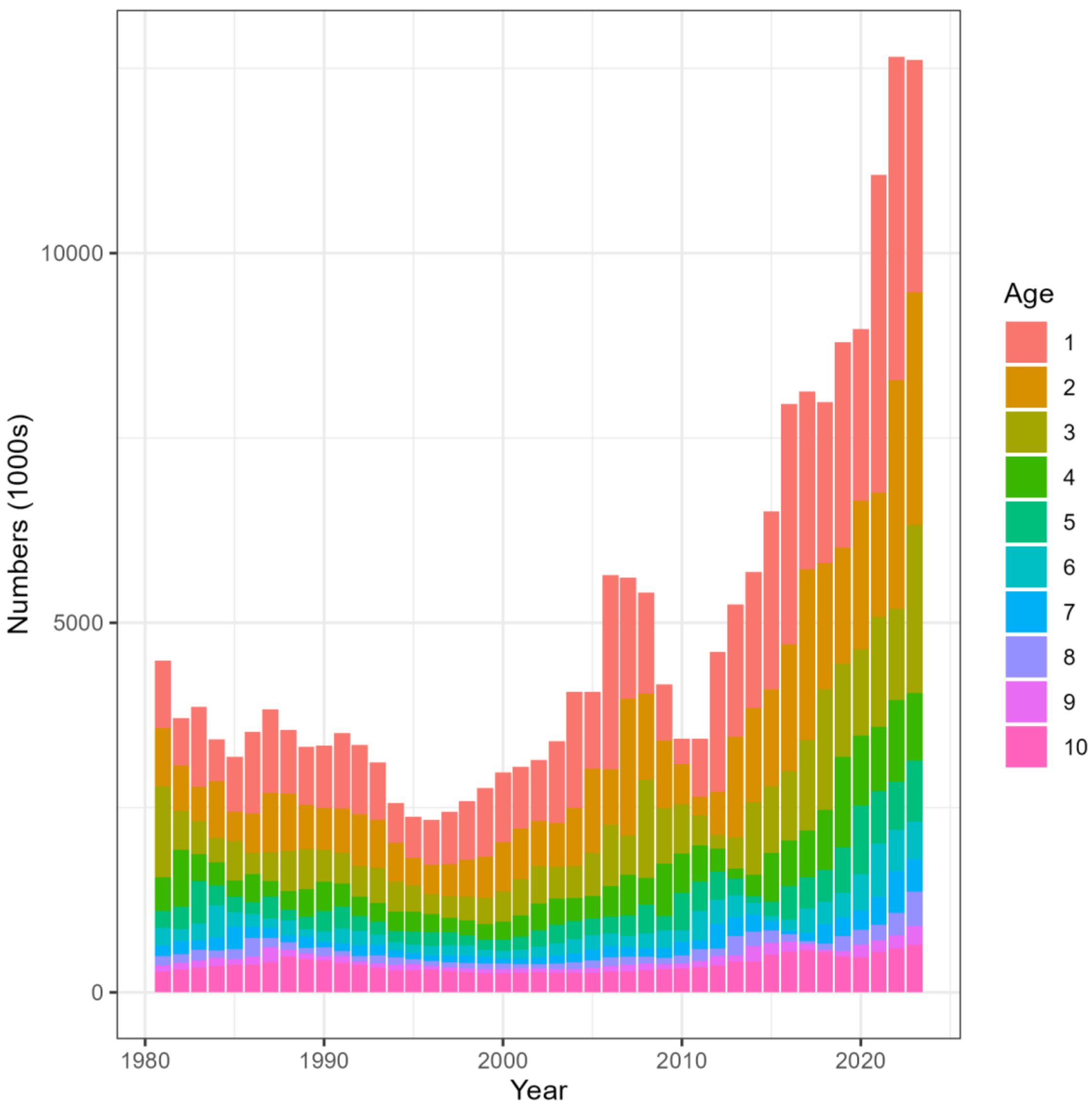


Figure 3. Stacked bar plot of the estimated numbers-at-age by year according to the SEDAR 79 Base Model.

a)

b)

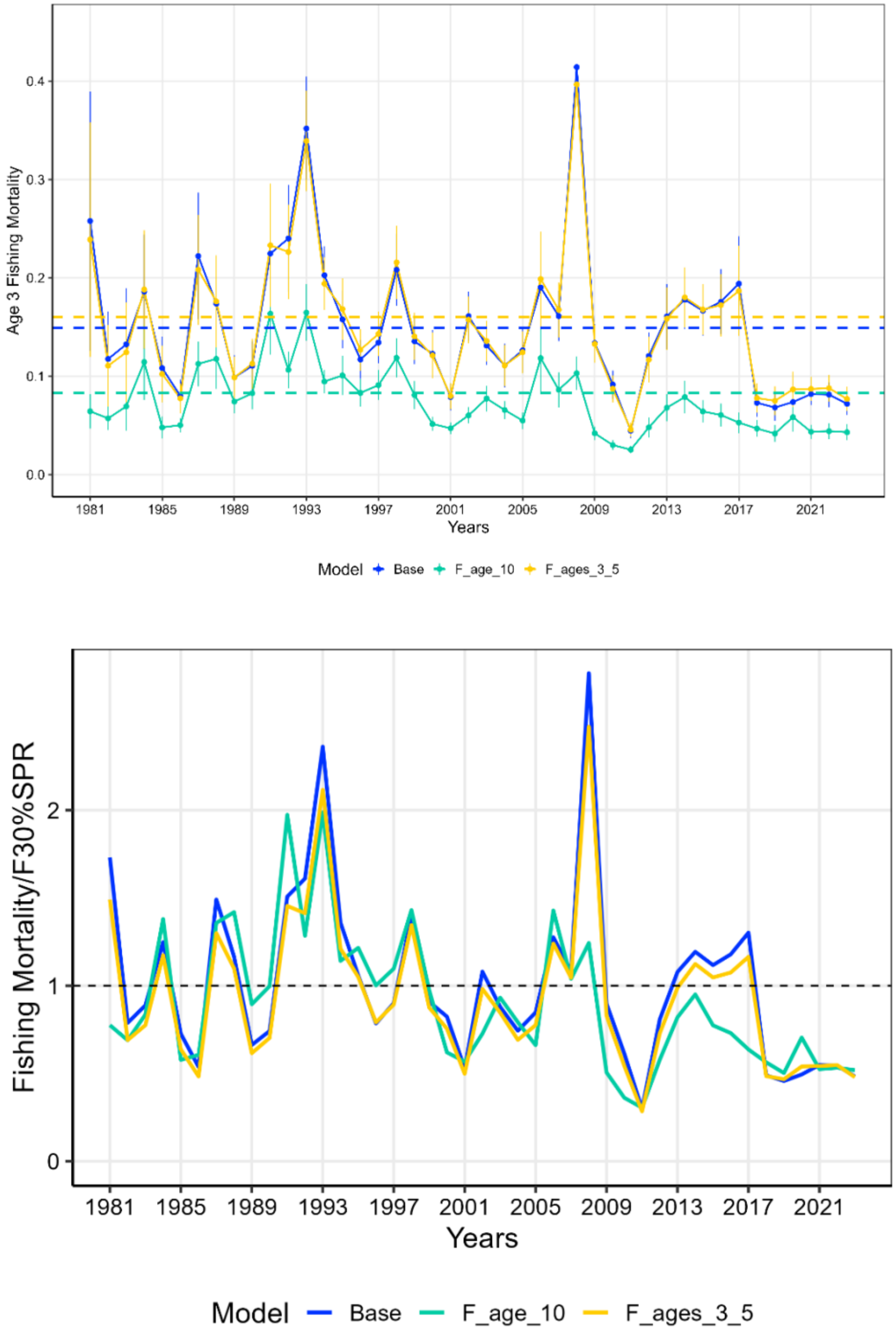
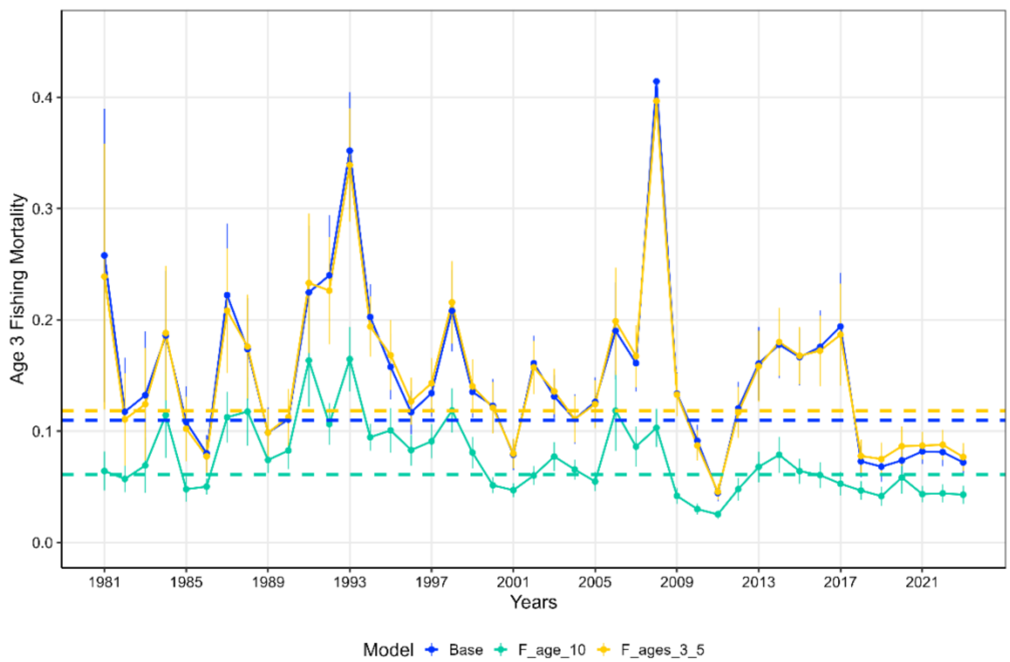


Figure 4. Comparison of fishing mortality rates with $F_{30\%SPR}$ for age 3, age 10, and ages 3 -5 (weighted average by the numbers at age) and as a ratio (b) as estimated by the SEDAR 79 Base Model.

a)



b)

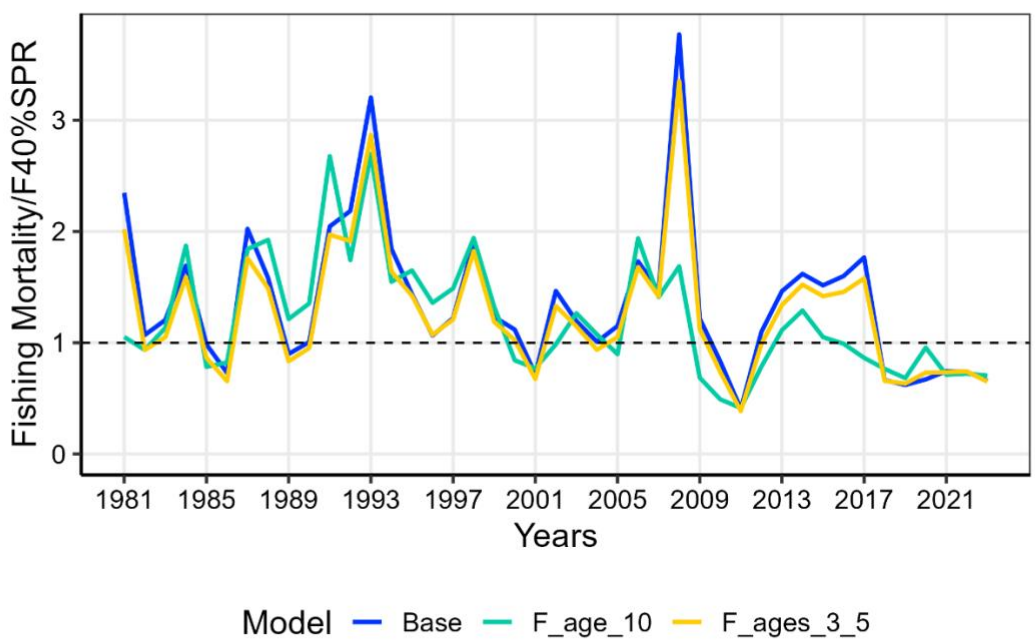
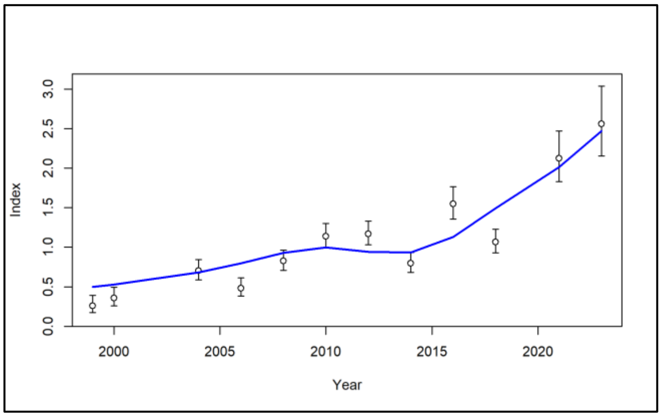
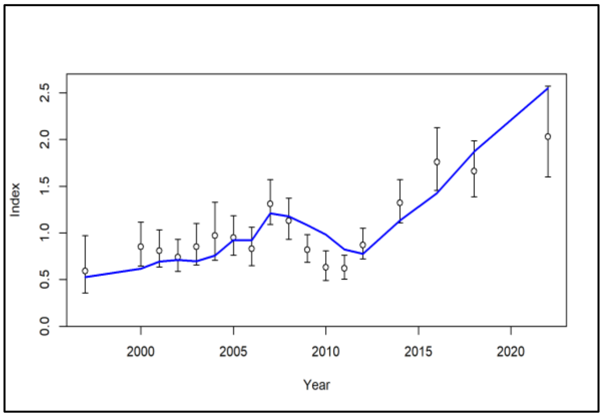


Figure 5. Comparison of fishing mortality rates with $F_{40\%SPR}$ for age 3, age 10, and ages 3 -5 (weighted average by the numbers at age) and as a ratio (b) as estimated by the SEDAR 79 Base Model.

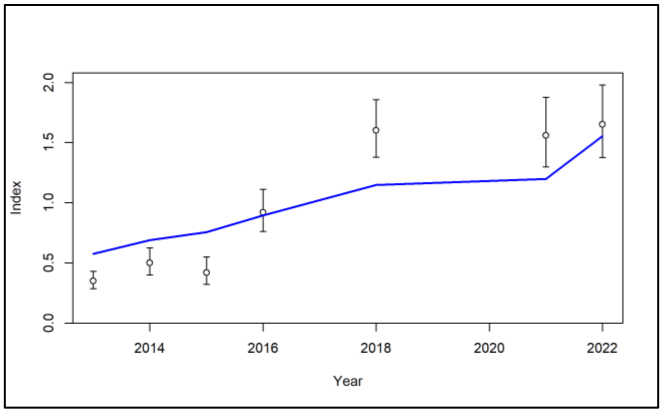
a) RVC Dry Tortugas Index



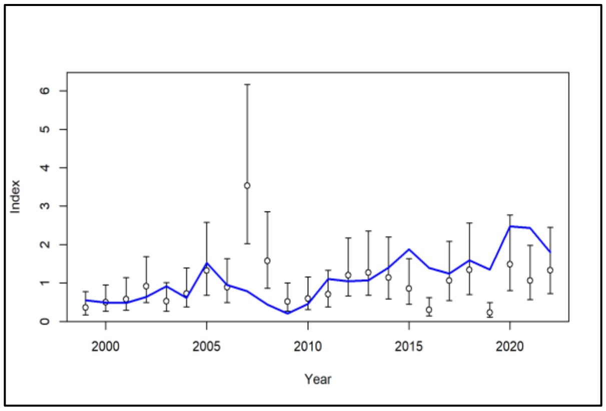
b) RVC FL Keys Index



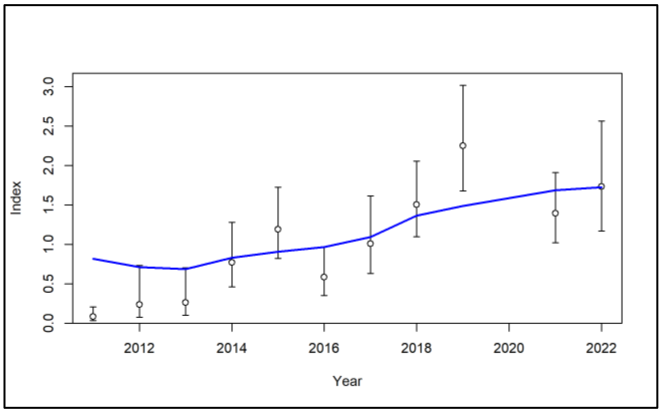
c) RVC SE FL Index



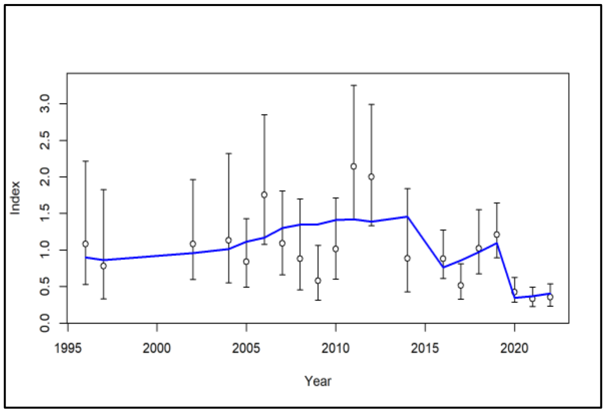
d) FIM YOY Index



e) SERFS Video Index



f) Gulf Combined Video Index



g) Estimated Catchability for the Gulf Combined Video Index

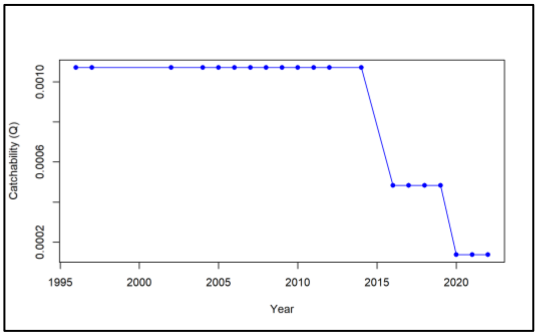
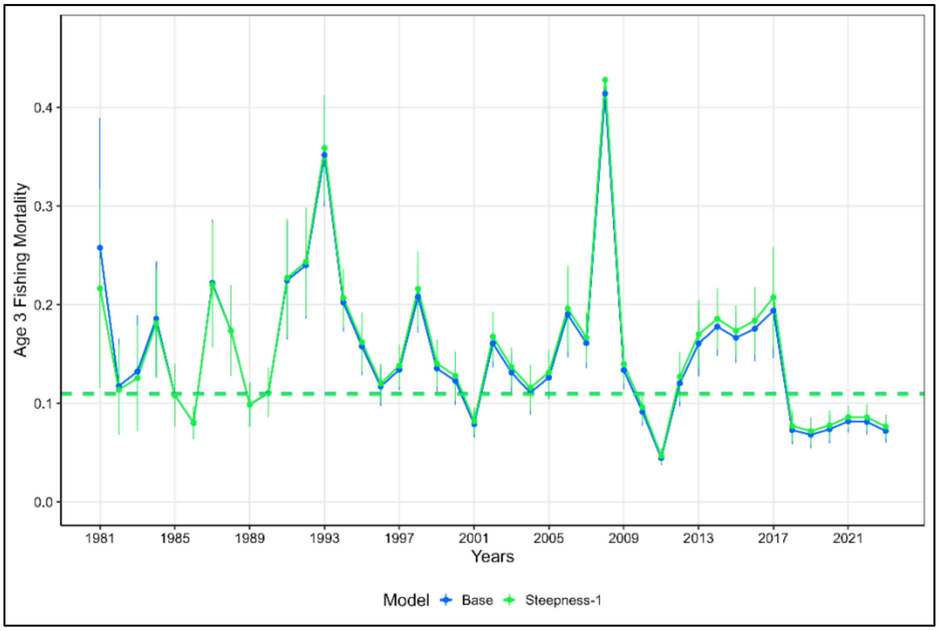
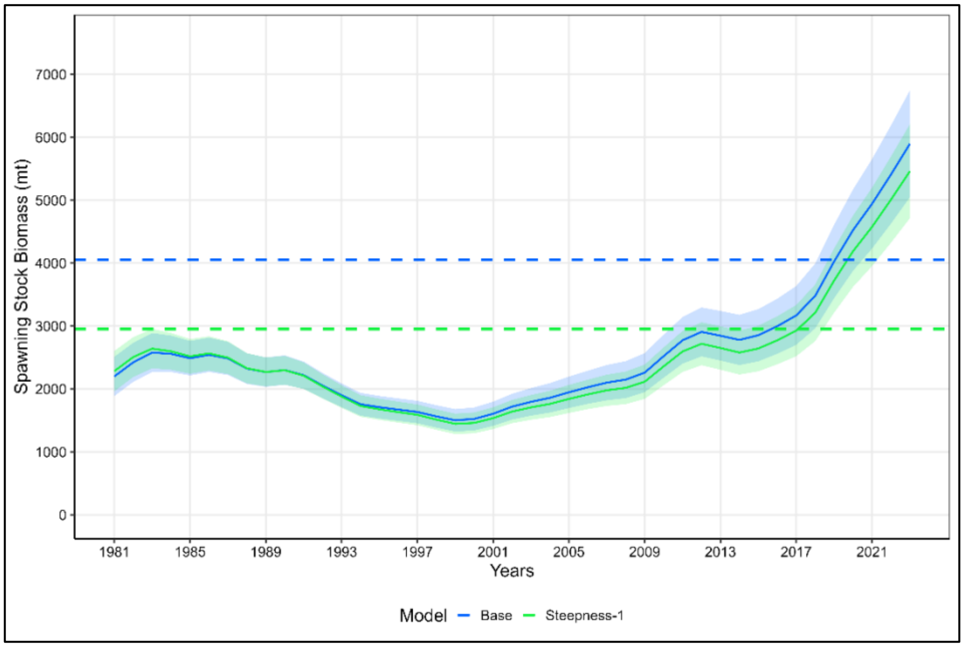


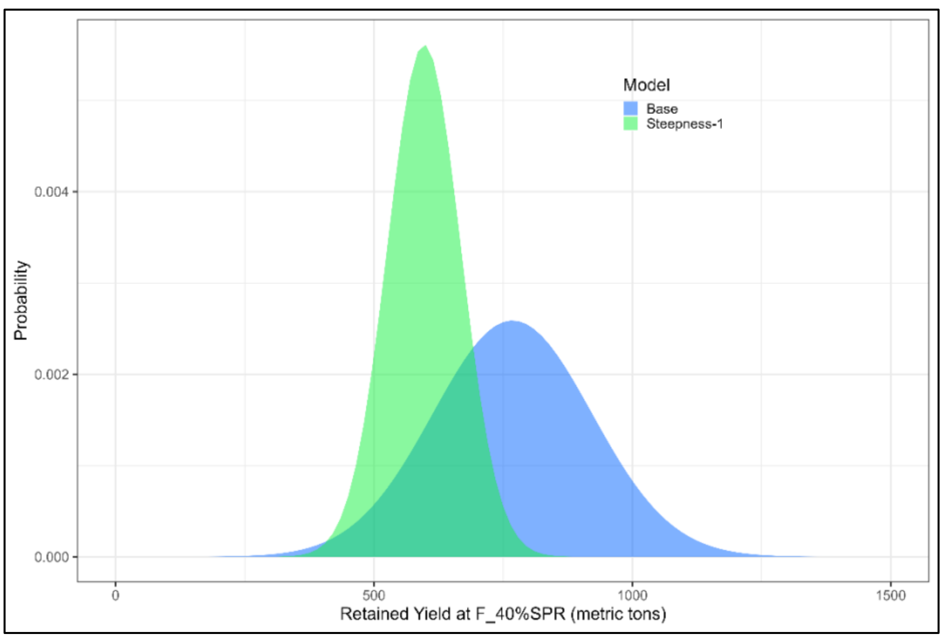
Figure 6. SEDAR 79 Base Model fits to indices when the Commercial Longline Index was removed.



a)

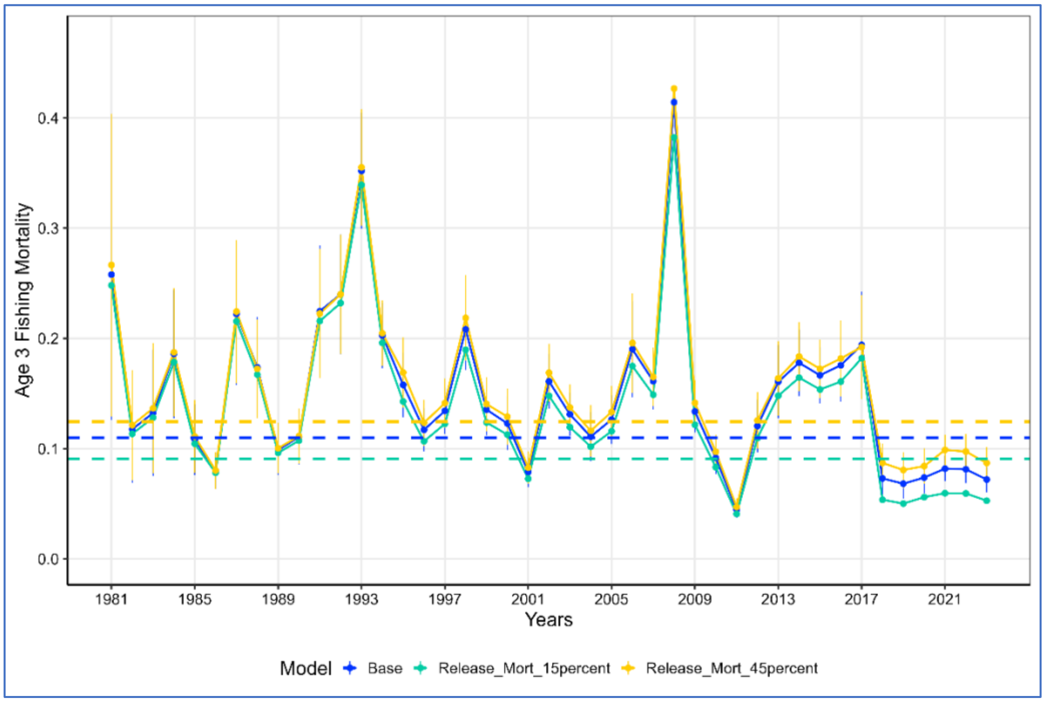


b)

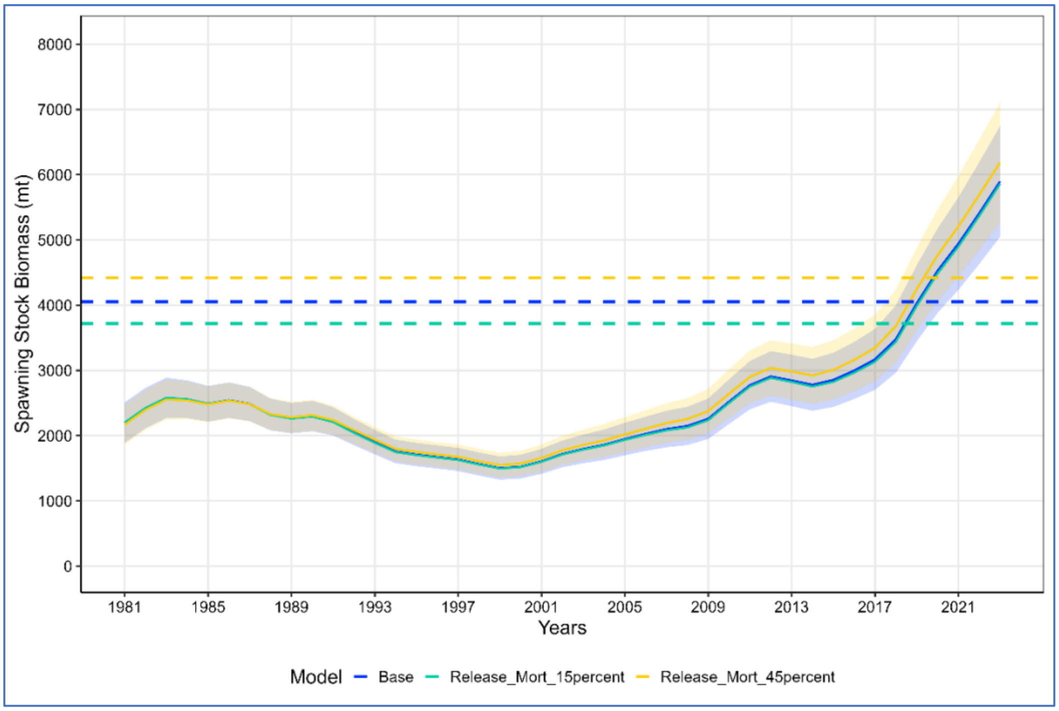


c)

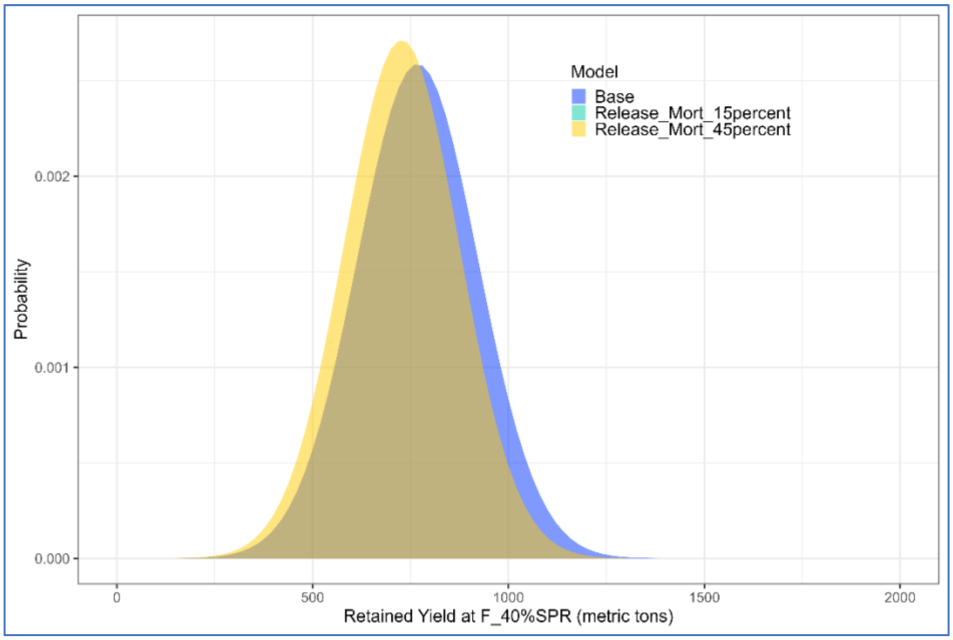
Figure 7. Comparison of fishing mortality rates (with $F_{40\%SPR}$), spawning stock biomass (with $75\%SSB_{F40\%SPR}$), and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with steepness fixed at 0.99 ('steepness-1').


Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model Base Release_Mort_15percent Release_Mort_45percent

a)

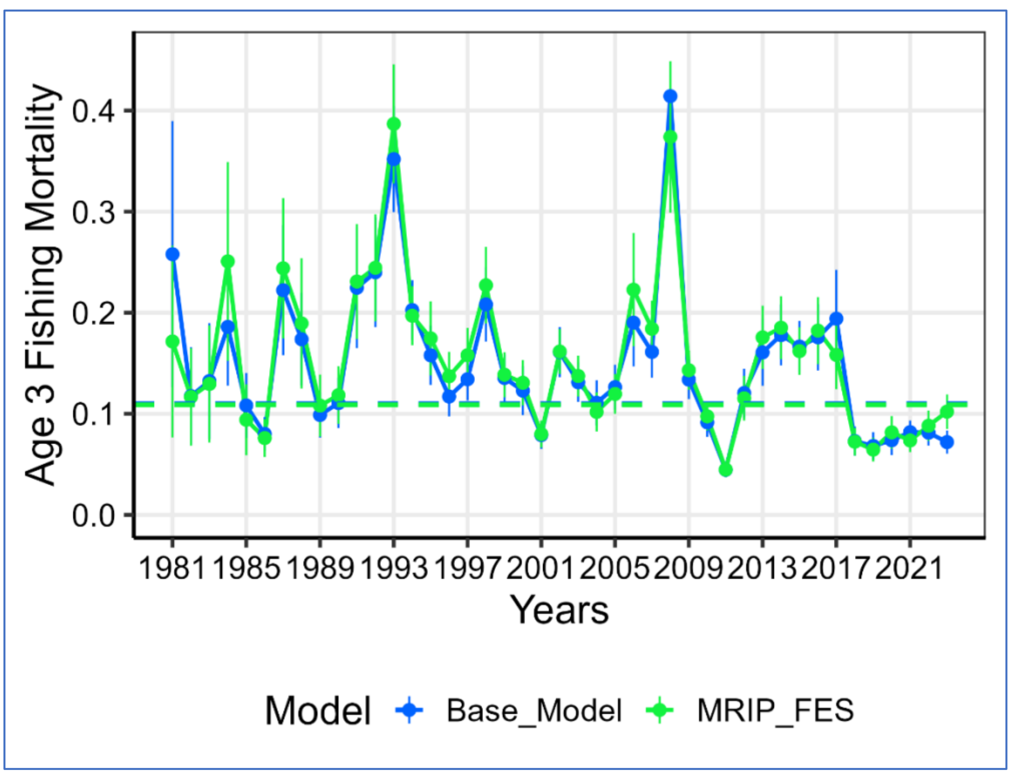

Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
8000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model Base Release_Mort_15percent Release_Mort_45percent

b)

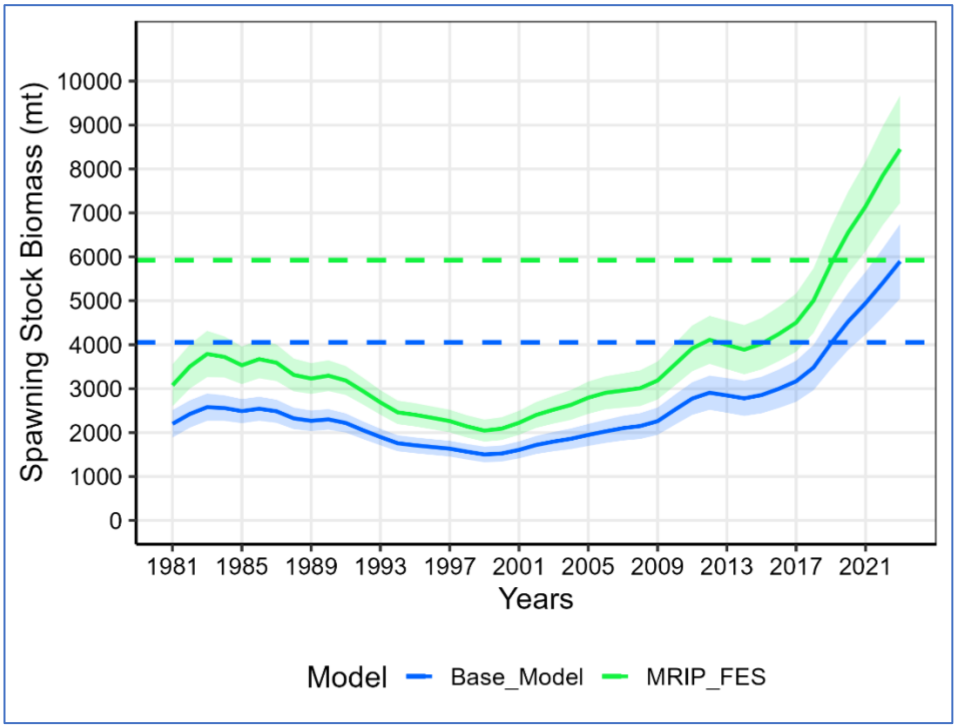


c)

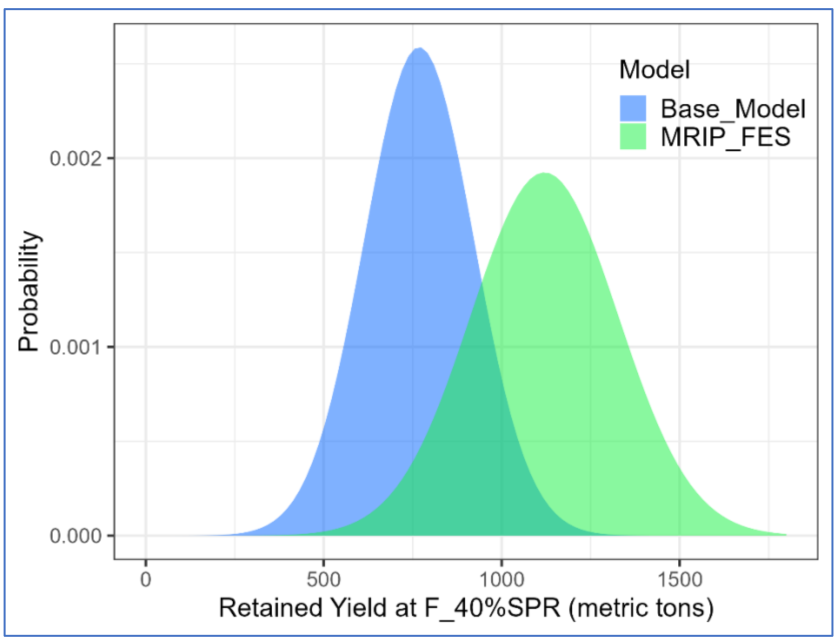
Figure 8. Comparison of fishing mortality rates (with $F_{40\%SPR}$), spawning stock biomass (with $75\%SSB_{F40\%SPR}$), and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with release mortality equal to 15% and 45%, respectively.



a)

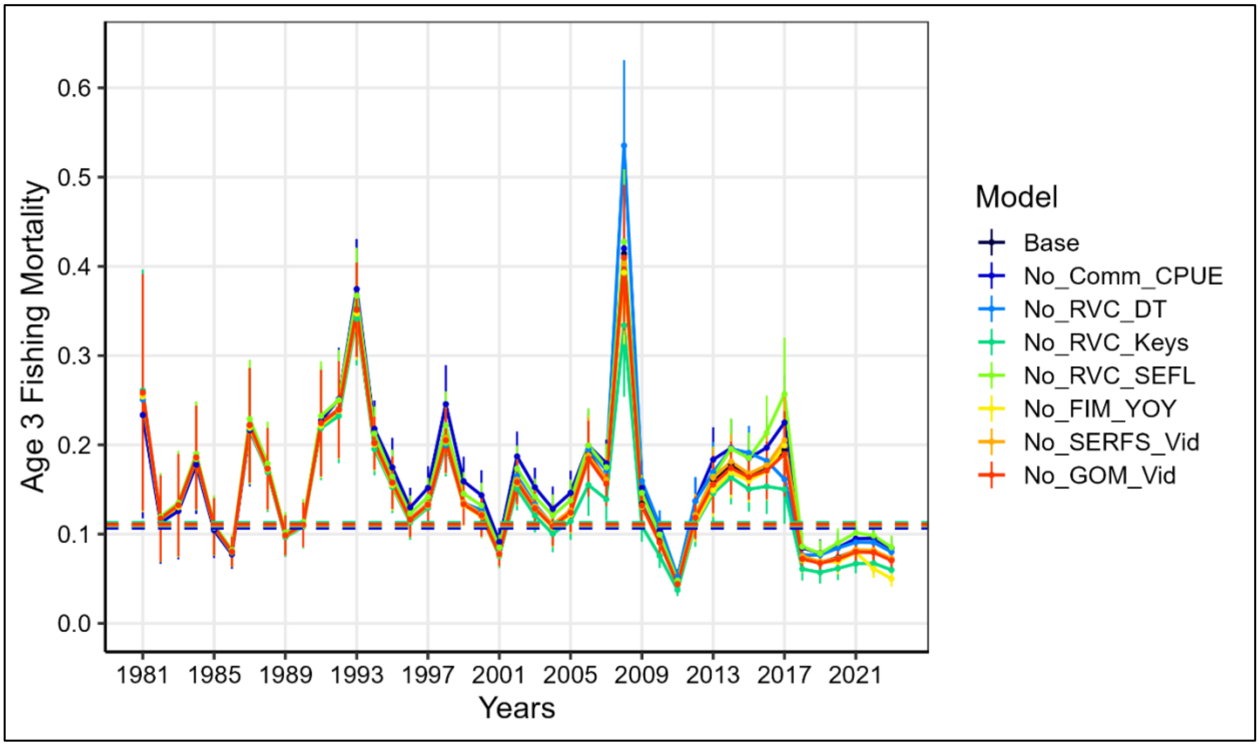


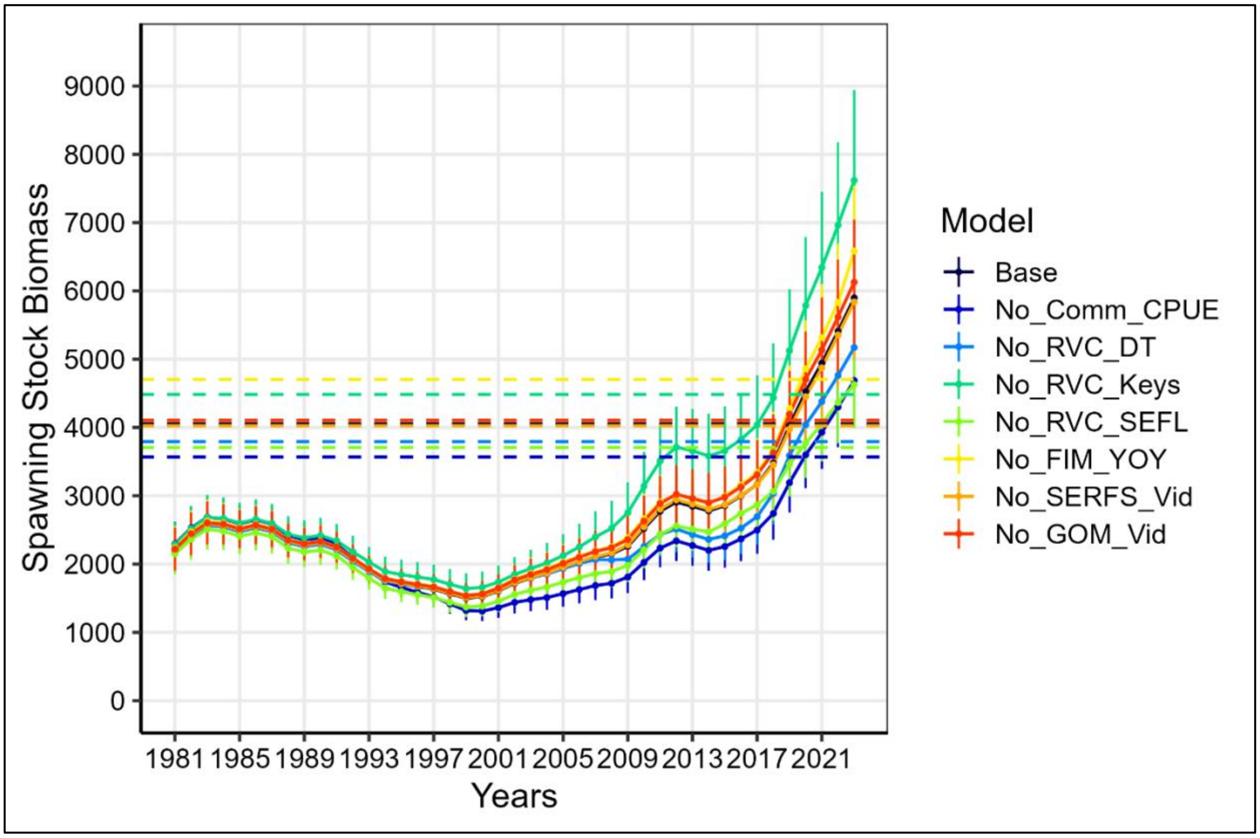
b)



c)

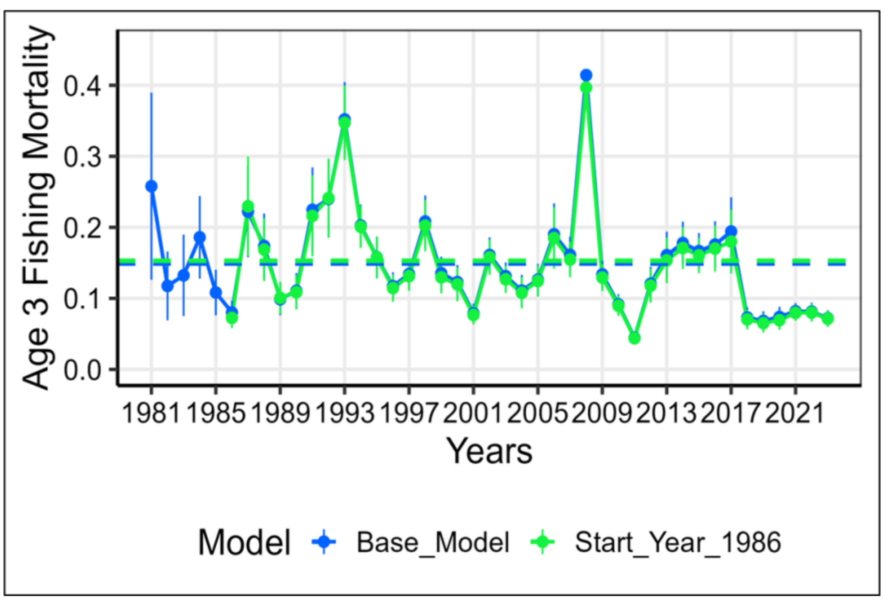
Figure 9. Comparison of fishing mortality rates (with $F_{40\%SPR}$), spawning stock biomass (with 75%$SSB_{F40\%SPR}$), and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with MRIP-FES Florida-only private mode landings and releases ('MRIP_FES' in green).


Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
No_Comm_CPUE
No_RVC_DT
No_RVC_Keys
No_RVC_SEFL
No_FIM_YOY
No_SERFS_Vid
No_GOM_Vid
a)

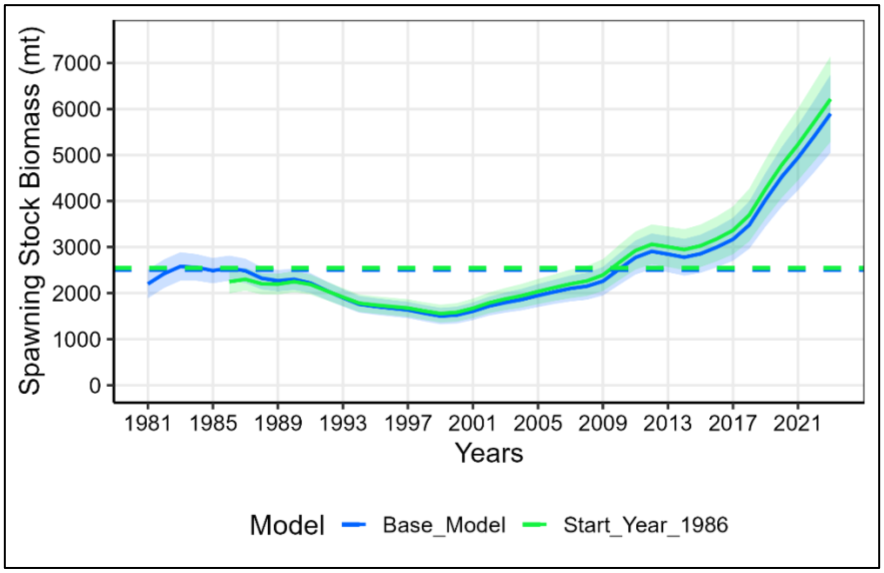


b)

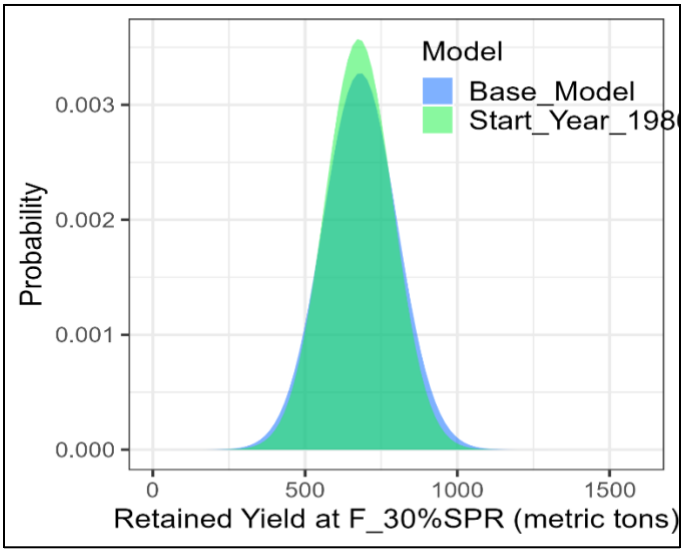
Figure 10. Comparison of fishing mortality rates with $F_{40\%SPR}$ and spawning stock biomass with $75\%SSB_{F40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when a single index of abundance is removed.



a)

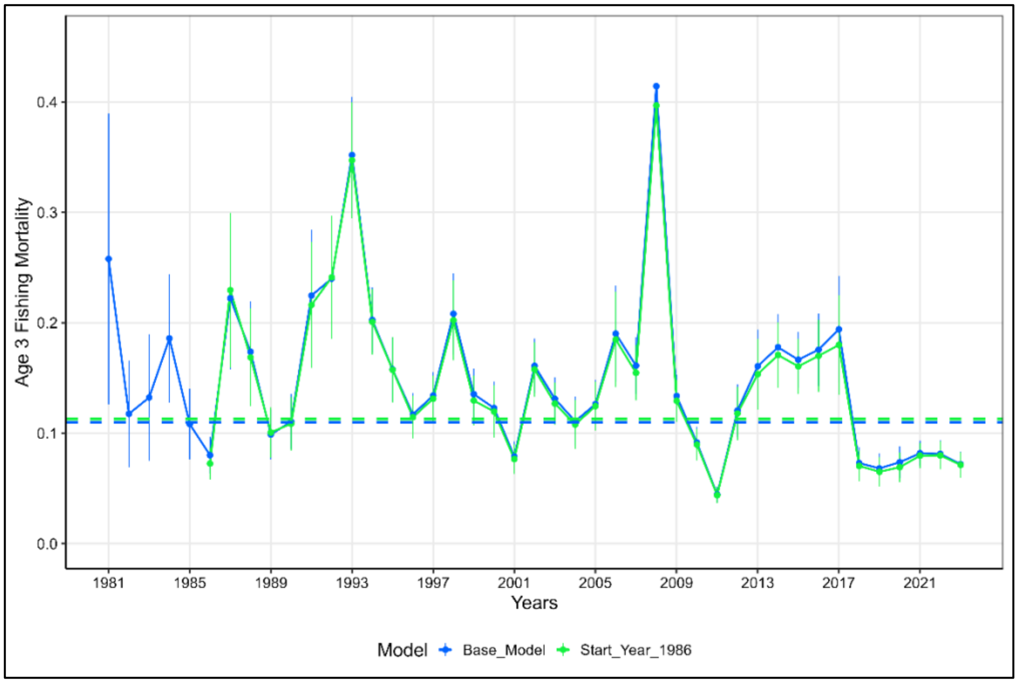


b)

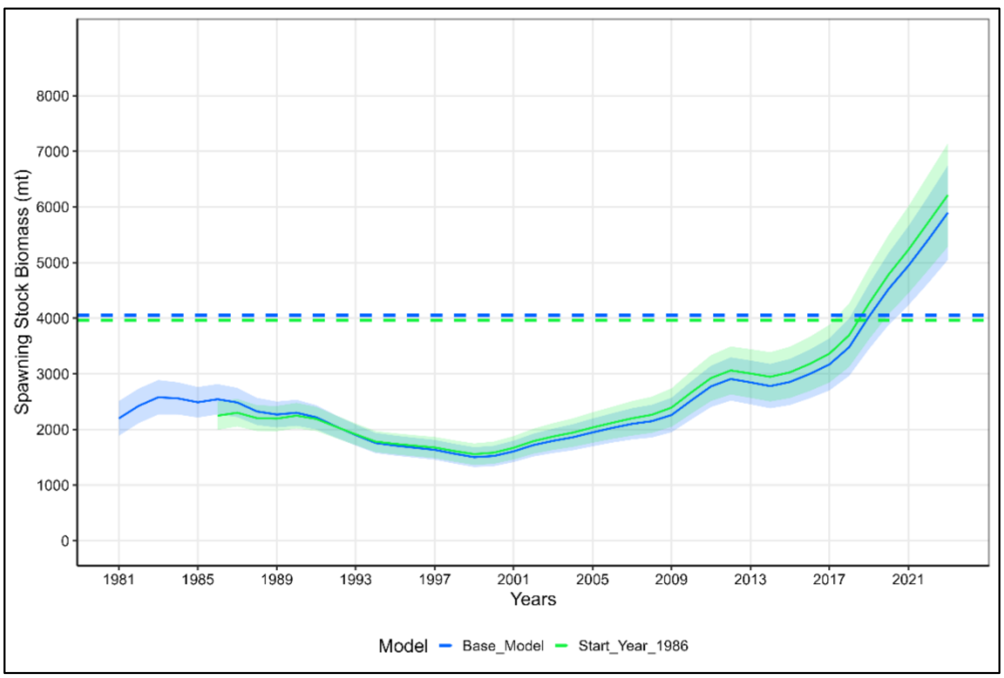


c)

Figure 11. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with 75%$SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with a start year of 1986.


Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base_Model
Start_Year_1986

a)


Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
8000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base_Model
Start_Year_1986

b)

c)

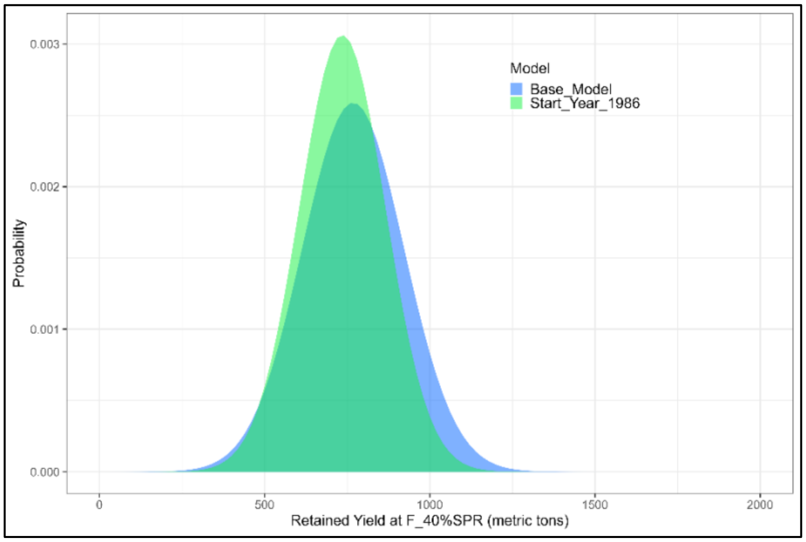
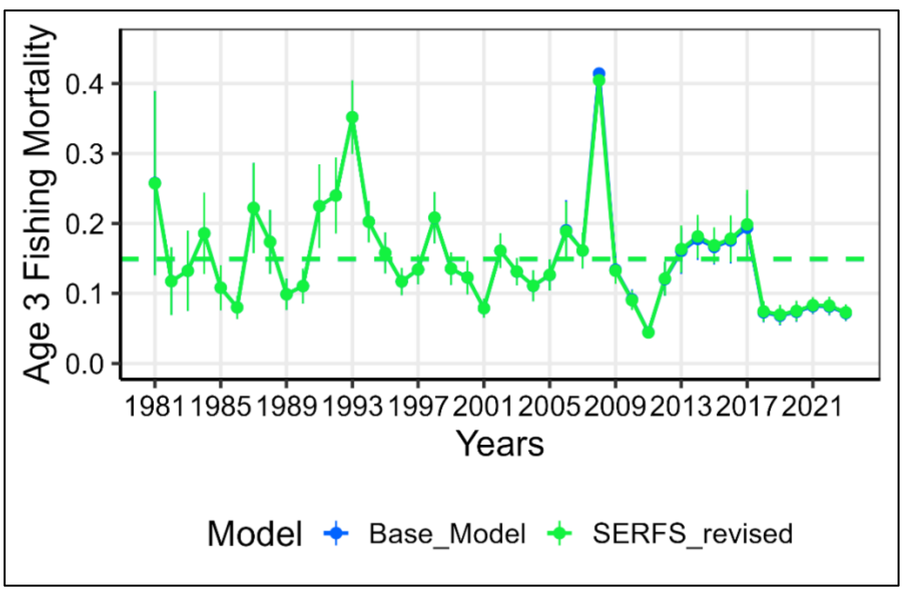
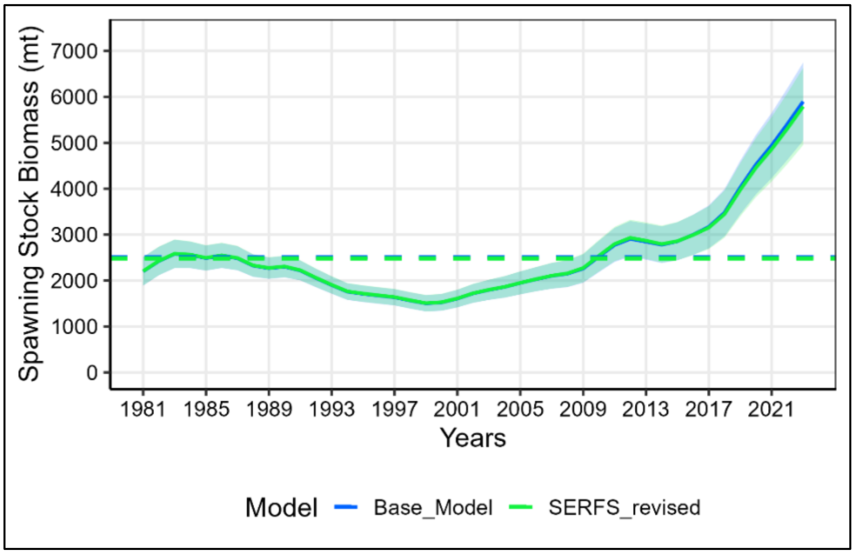


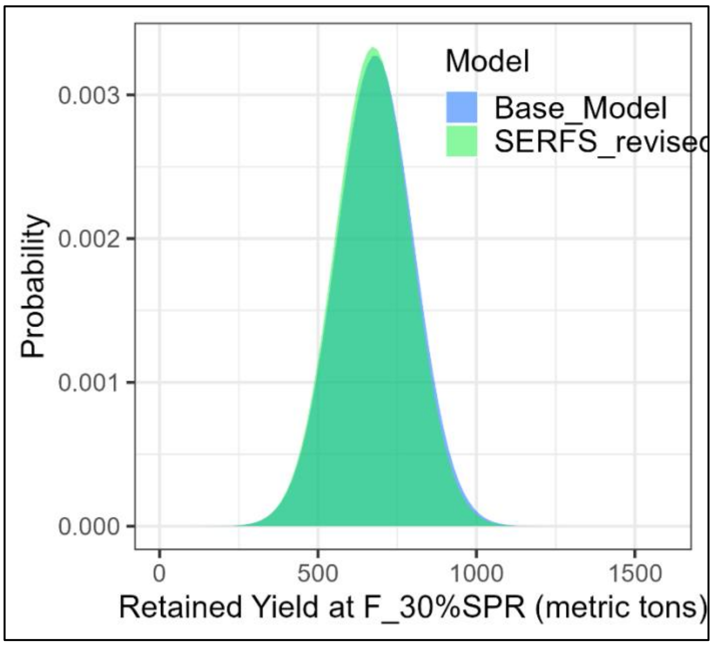
Figure 12. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with 75%$SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with a start year of 1986.

a)



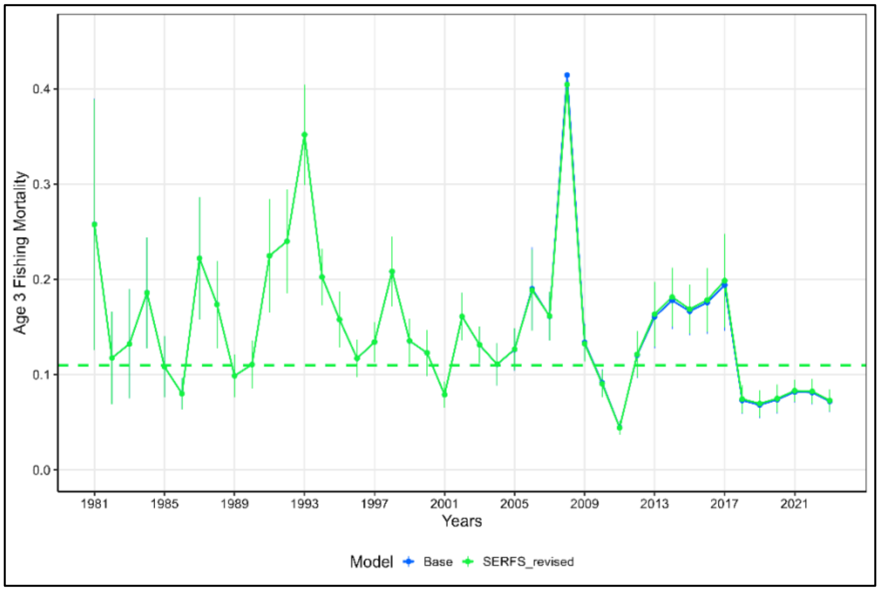


b)



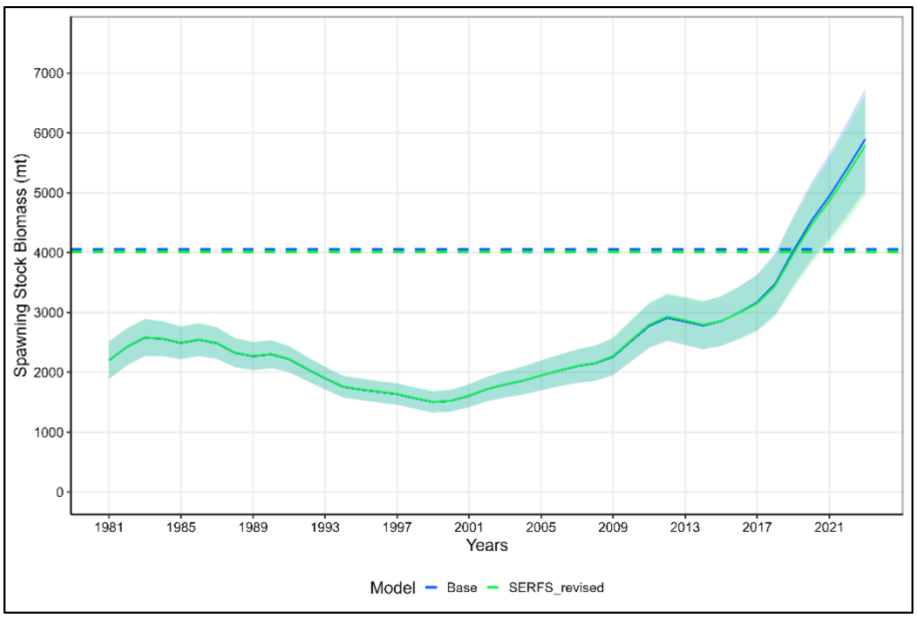
c)

Figure 13. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with $75\%SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with the first 3 years of the SERFS index removed (2011-2013).



Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
SERFS_revised

a)



Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
SERFS_revised

b)

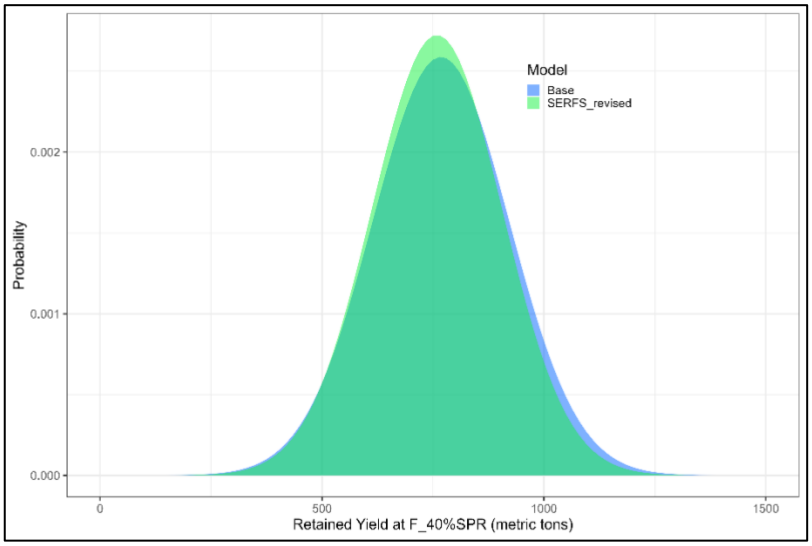
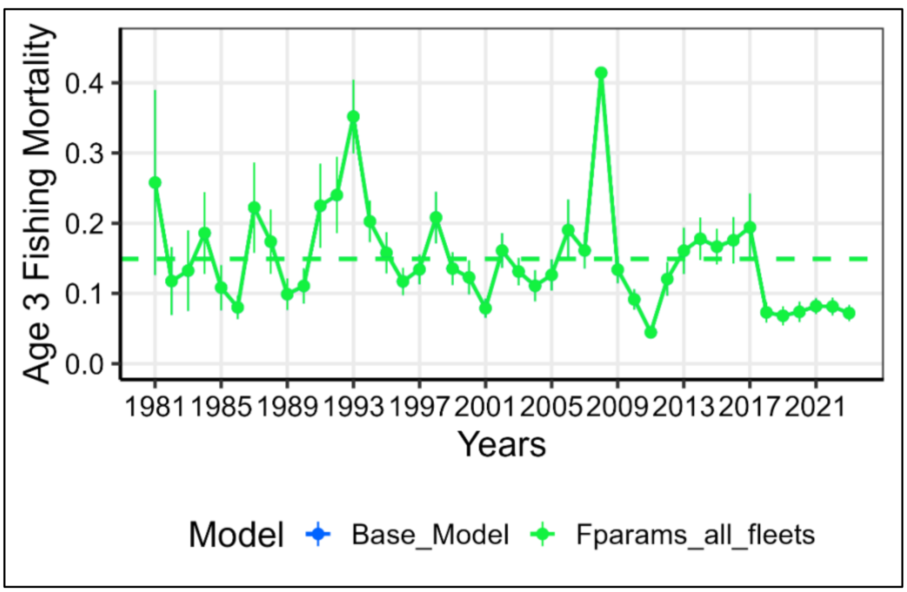
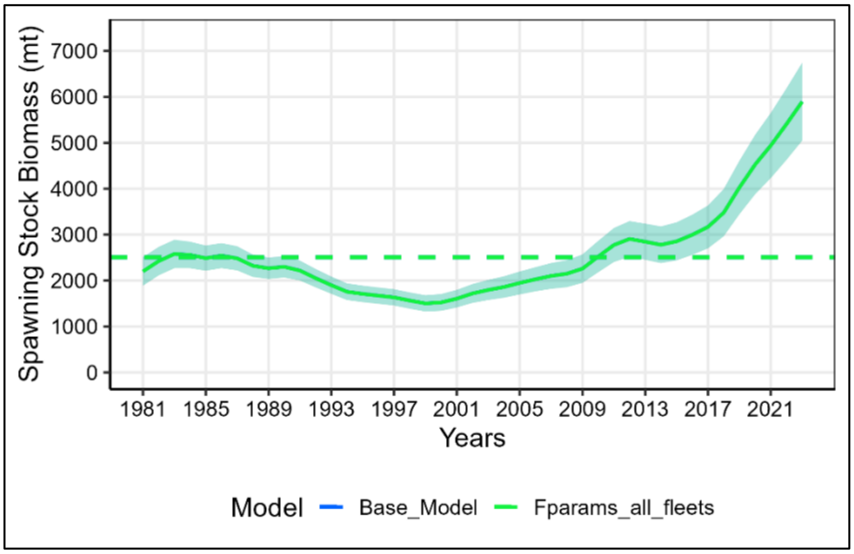
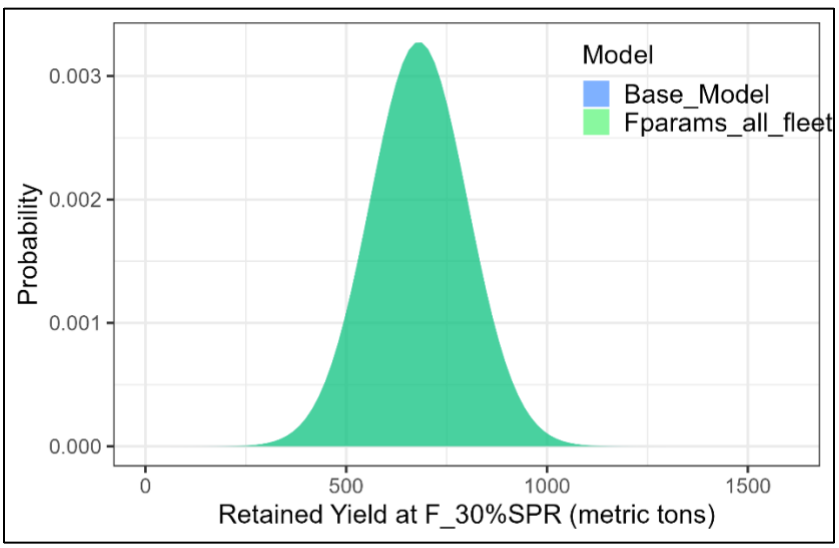
c) 

Figure 14. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with $75\%SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with the first 3 years of the SERFS index removed (2011-2013).

a) 

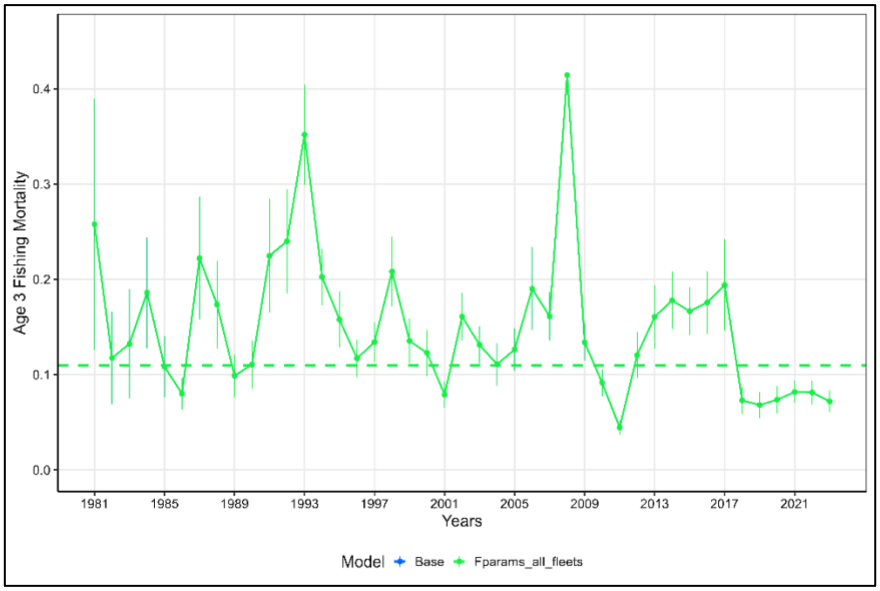


b)



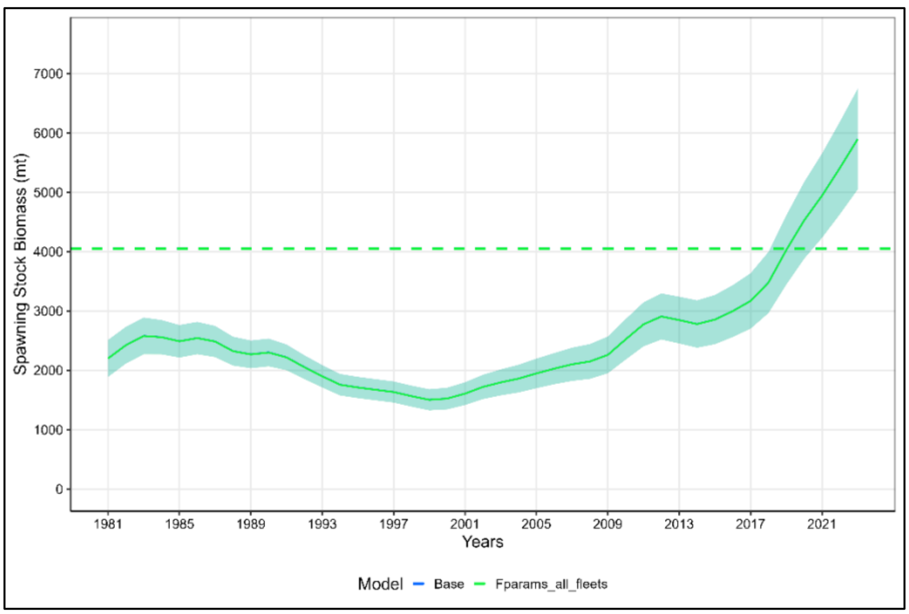
c)

Figure 15. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with 75%$SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when fishing mortality rate (F) parameters were estimated for all fleets.



Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
Fparams_all_fleets

a)



Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
Fparams_all_fleets

b)

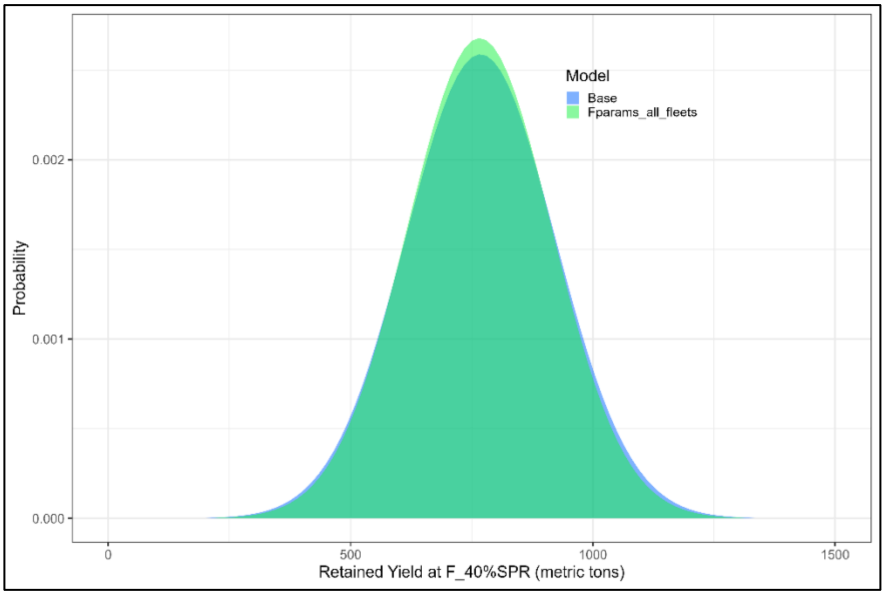
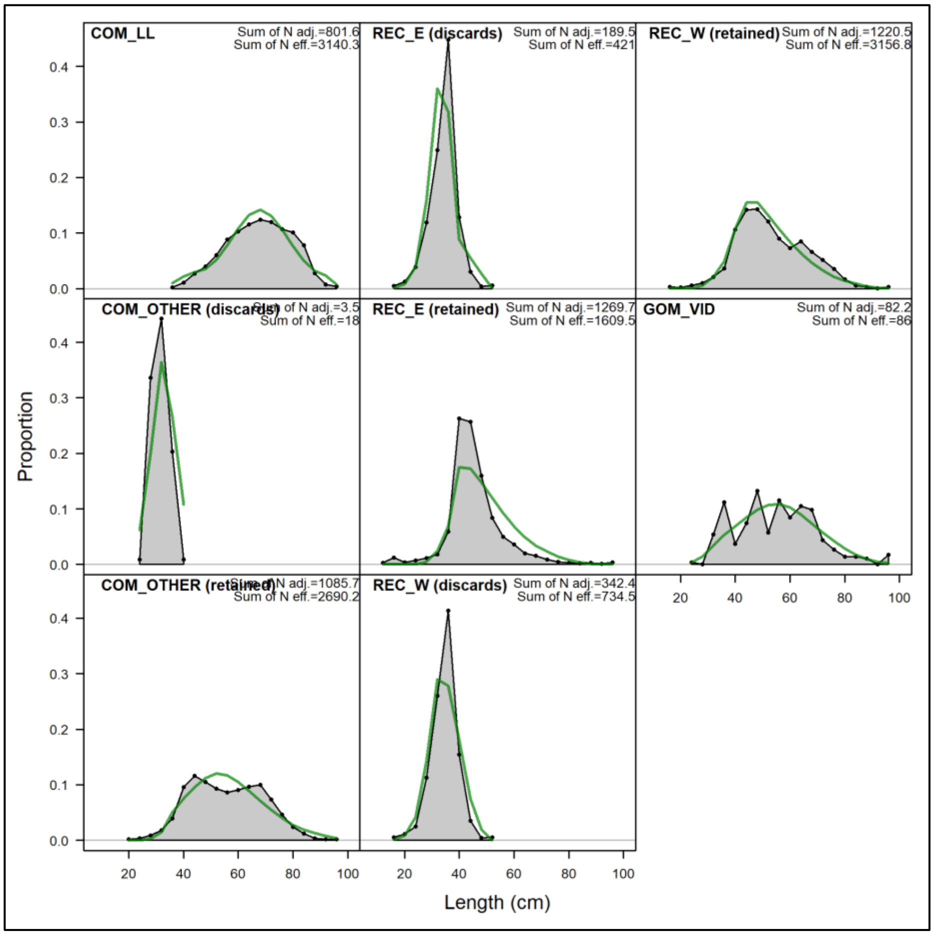
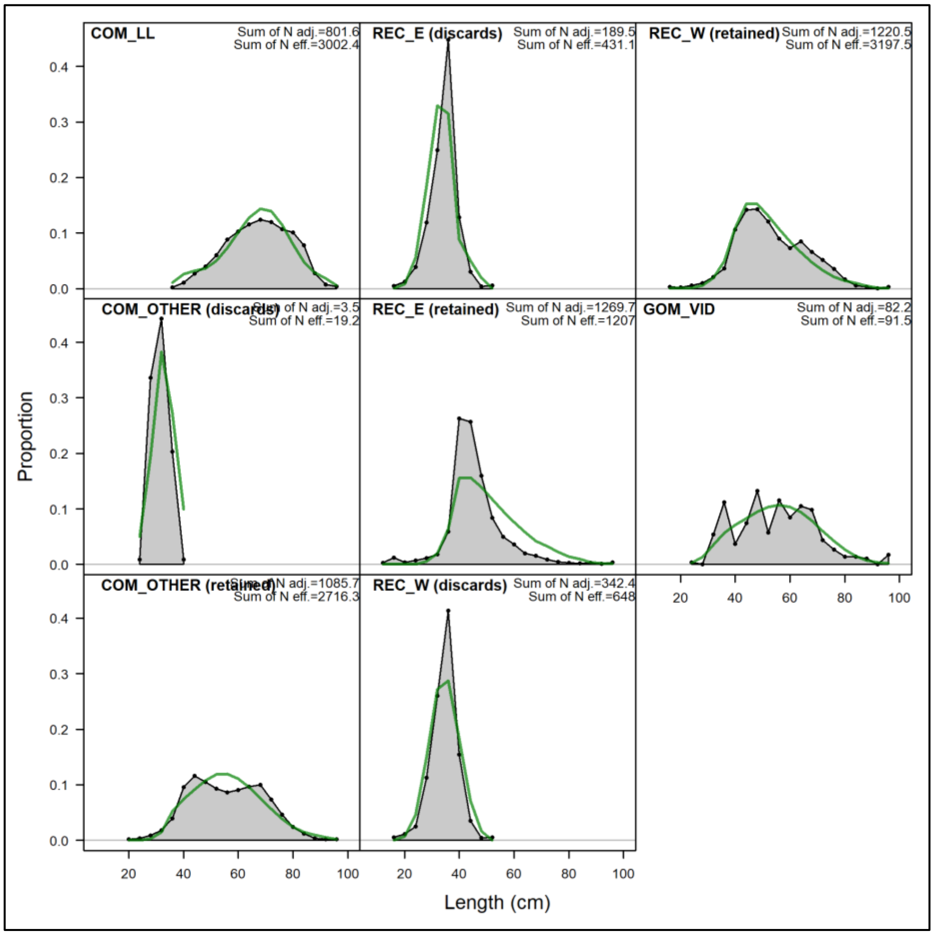
c)


Figure 16. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with 75%$SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when fishing mortality rate (F) parameters were estimated for all fleets.

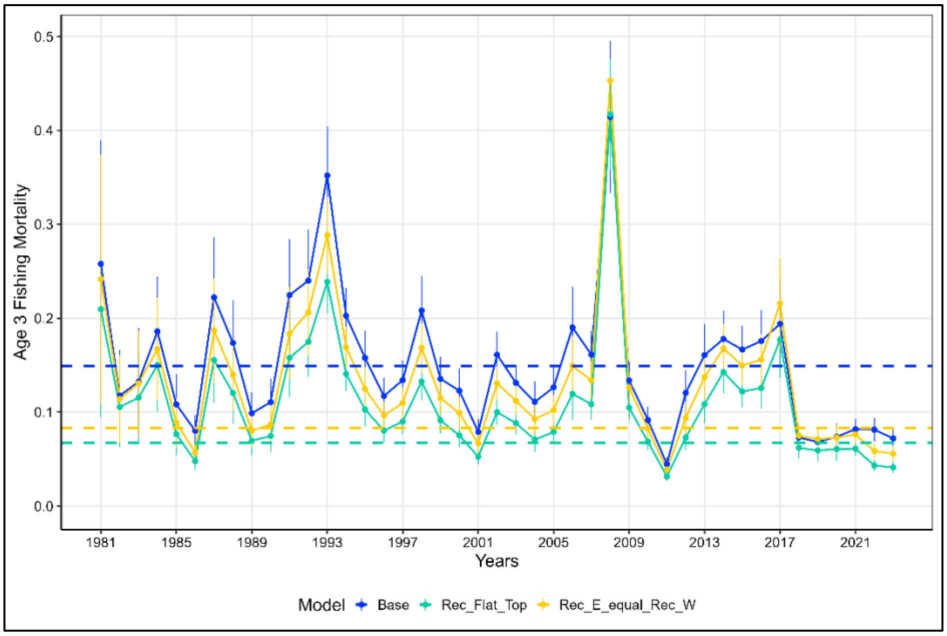

COM_LL
Sum of N adj.=801.6
Sum of N eff.=3140.3
REC_E (discards)
Sum of N adj.=189.5
Sum of N eff.=421
REC_W (retained)
Sum of N adj.=1220.5
Sum of N eff.=3156.8
COM_OTHER (discards)
Sum of N adj.=3.5
Sum of N eff.=18
REC_E (retained)
Sum of N adj.=1269.7
Sum of N eff.=1609.5
GOM_VID
Sum of N adj.=82.2
Sum of N eff.=86
COM_OTHER (retained)
Sum of N adj.=1085.7
Sum of N eff.=2690.2
REC_W (discards)
Sum of N adj.=342.4
Sum of N eff.=734.5
Proportion
Length (cm)

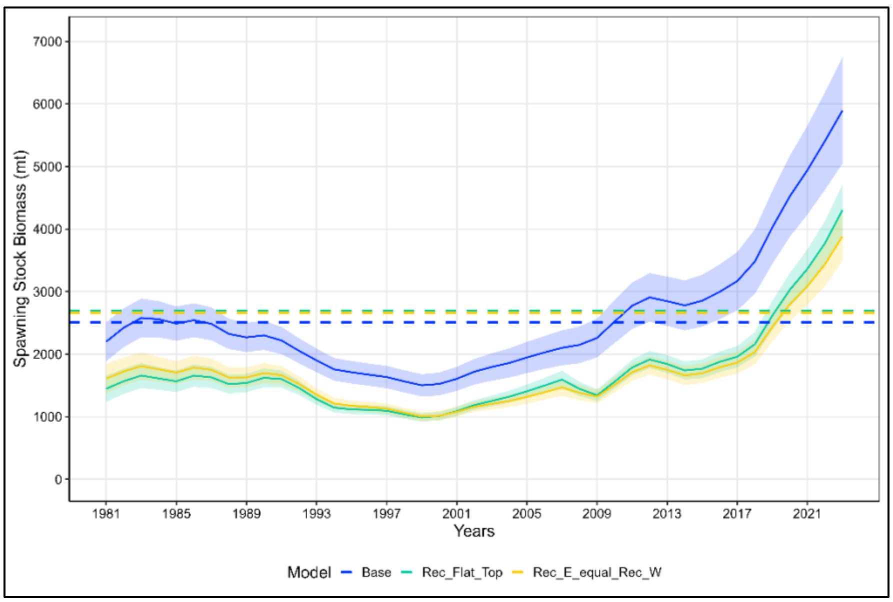
a)

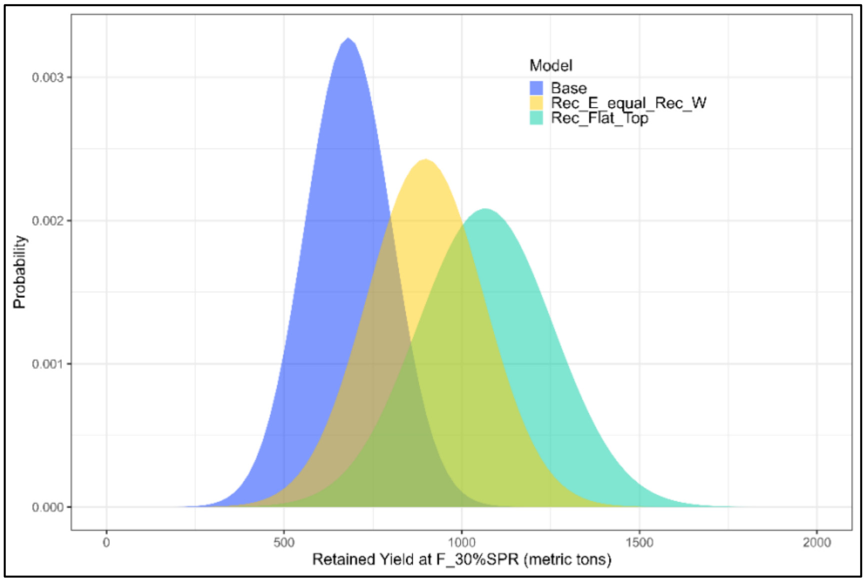


b)

Figure 17. Comparison of the overall fits to the observed length compositions as estimated when either flat-top selectivity is assumed for the Rec West and Rec East fleets (a; model = "Rec Flat Top") or the Rec East selectivity is fixed at the Base Model estimates for Rec West (b; model="Rec E equal Rec W_Base").

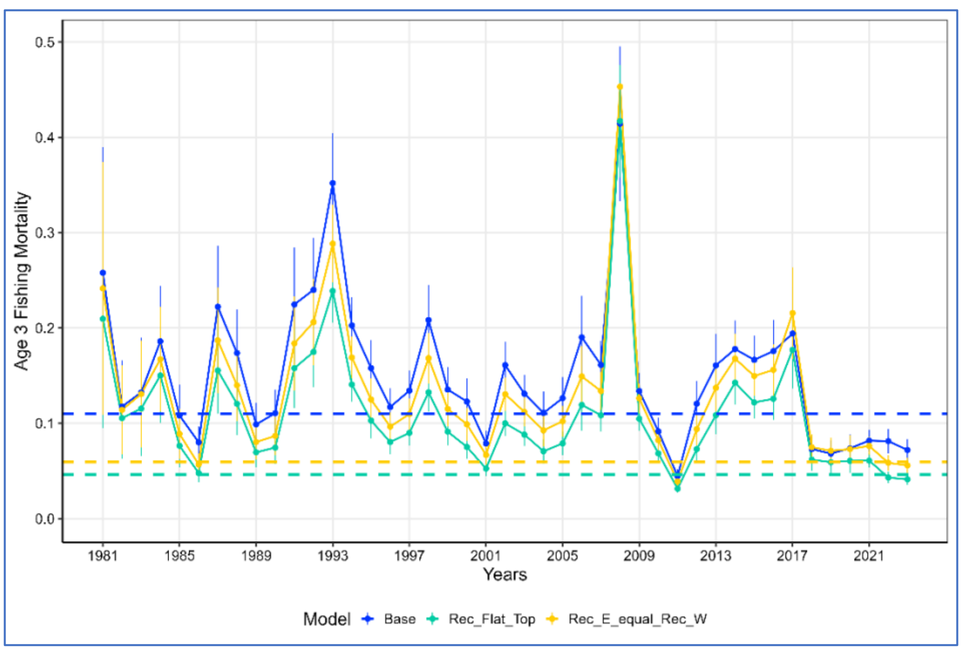
a) 
Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
0.5
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
Rec_Flat_Top
Rec_E_equal_Rec_W

b) 
Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
Years
Model
Base
Rec_Flat_Top
Rec_E_equal_Rec_W

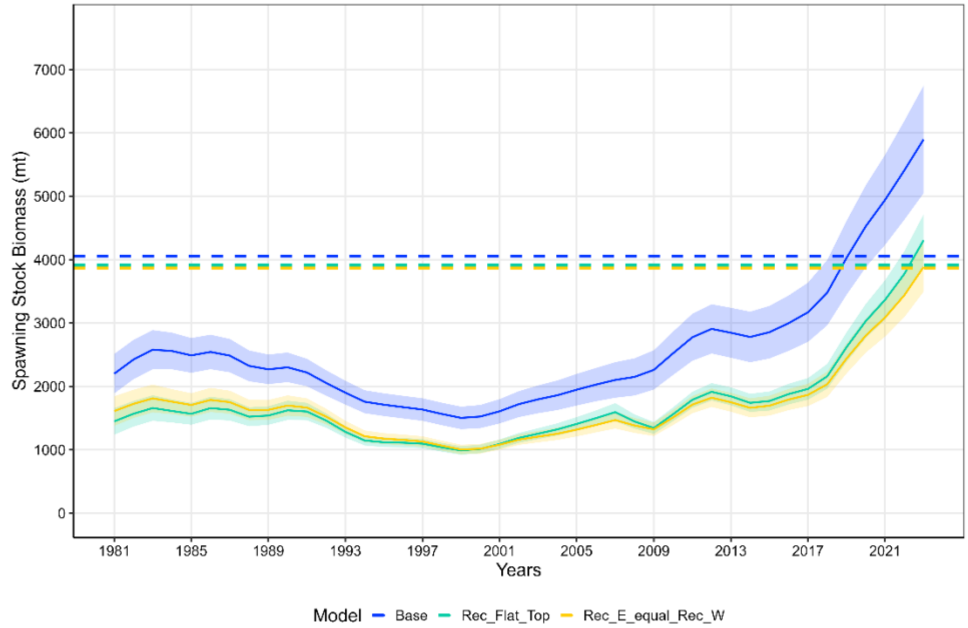


c)

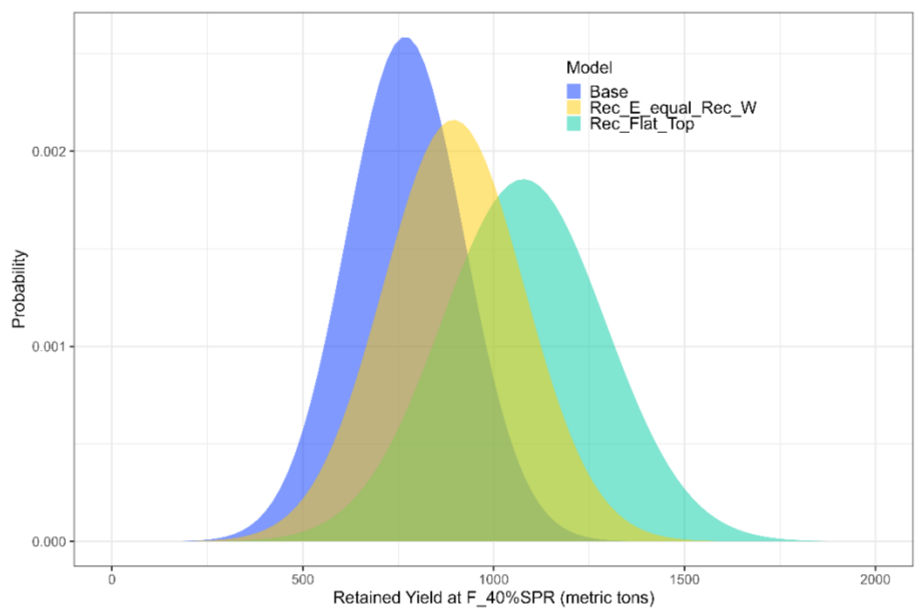
Figure 18. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with 75%$SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when either flat-top selectivity is assumed for the Rec West and Rec East fleets (model = "Rec Flat Top") or the Rec East selectivity is fixed at the Base Model estimates for Rec West (model="Rec E equal Rec W_Base").



a)



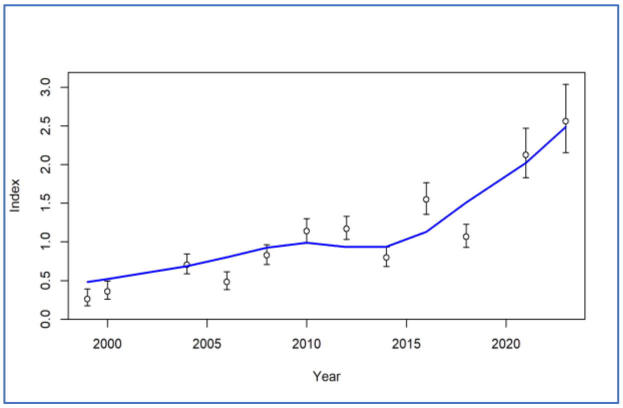
b)



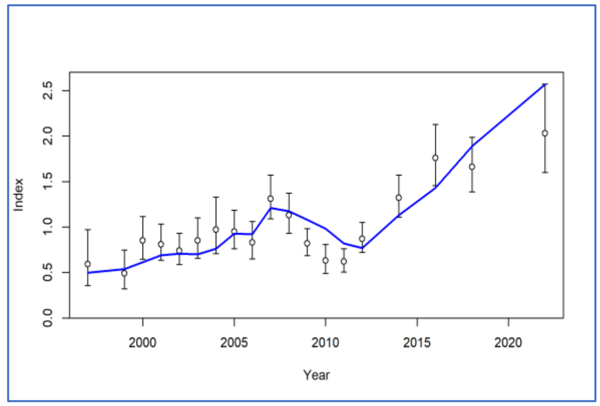
c)

Figure 19. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with $75\%SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model when either flat-top selectivity is assumed for the Rec West and Rec East fleets (model = "Rec Flat Top") or the Rec East selectivity is fixed at the Base Model estimates for Rec West (model="Rec E equal Rec W_Base").

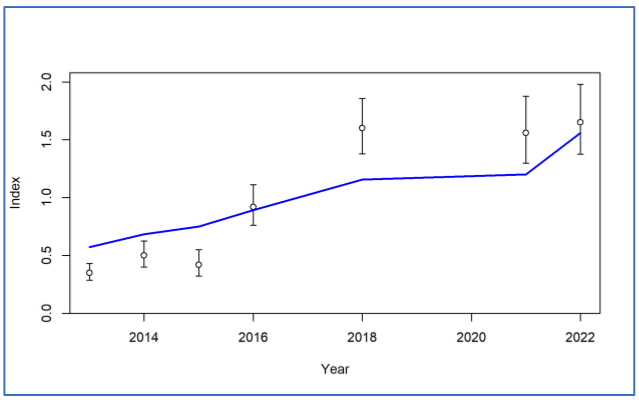
a) RVC Dry Tortugas Index



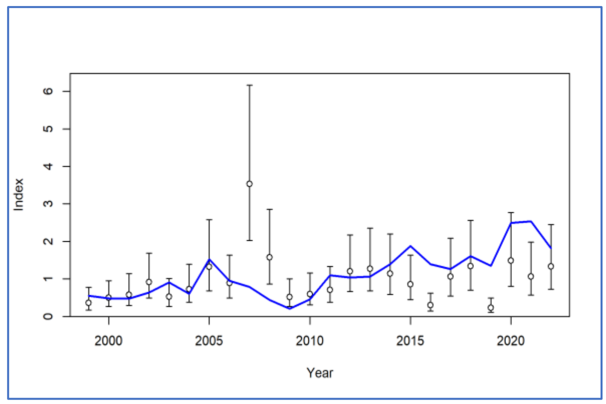
b) RVC FL Keys Index



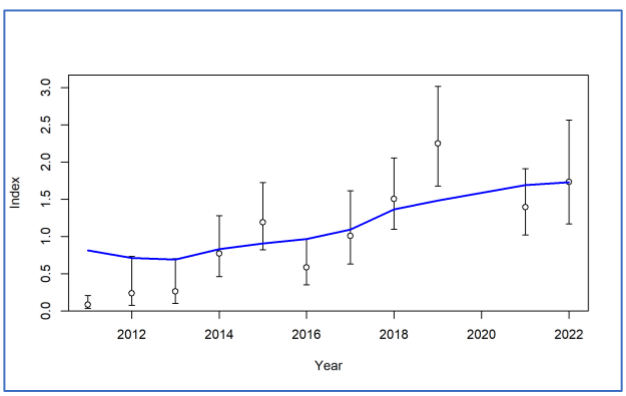
c) RVC SE FL Index



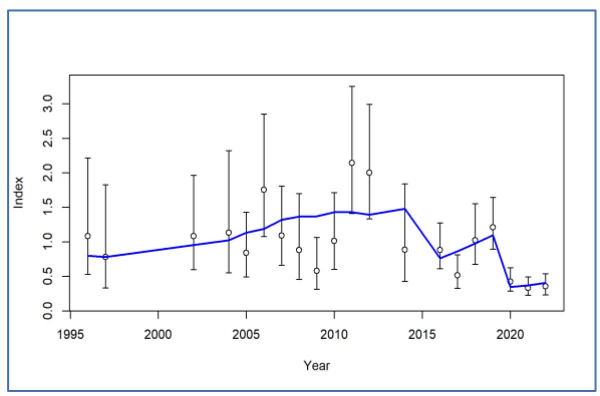
d) FIM YOY Index



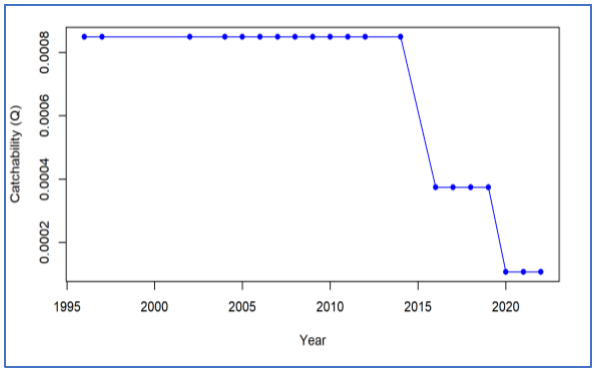
e) SERFS Video Index



f) Gulf Combined Video Index



g) Estimated Catchability for the Gulf Combined Video Index



h) Commercial Longline CPUE

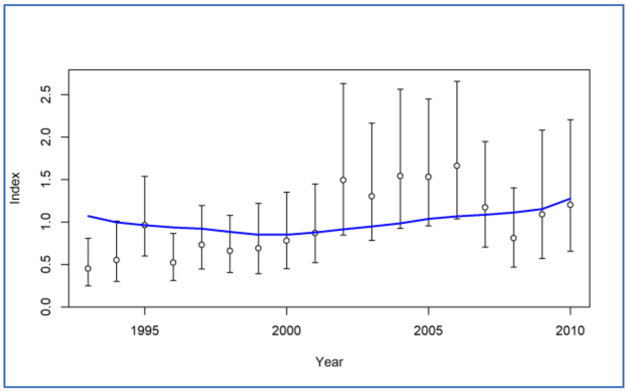
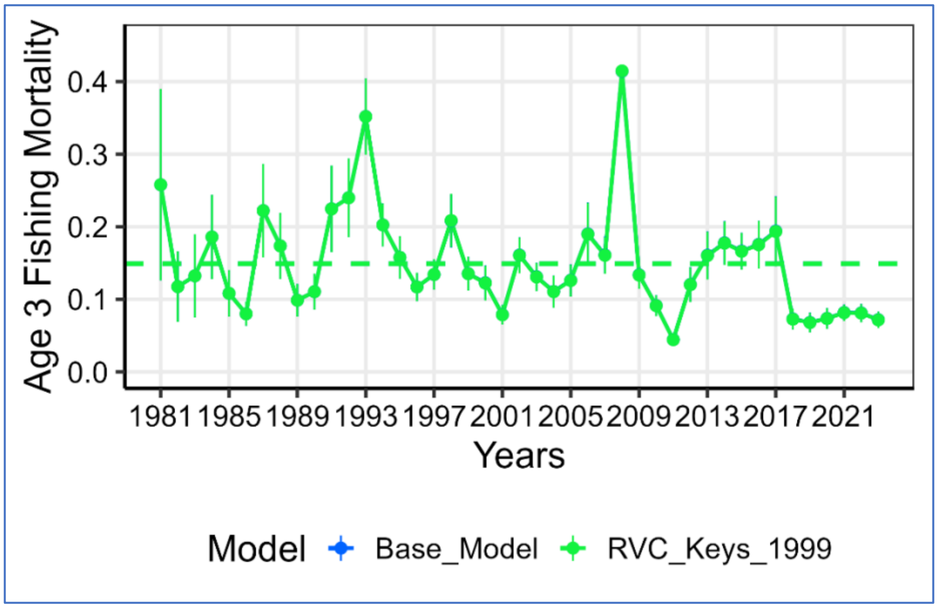
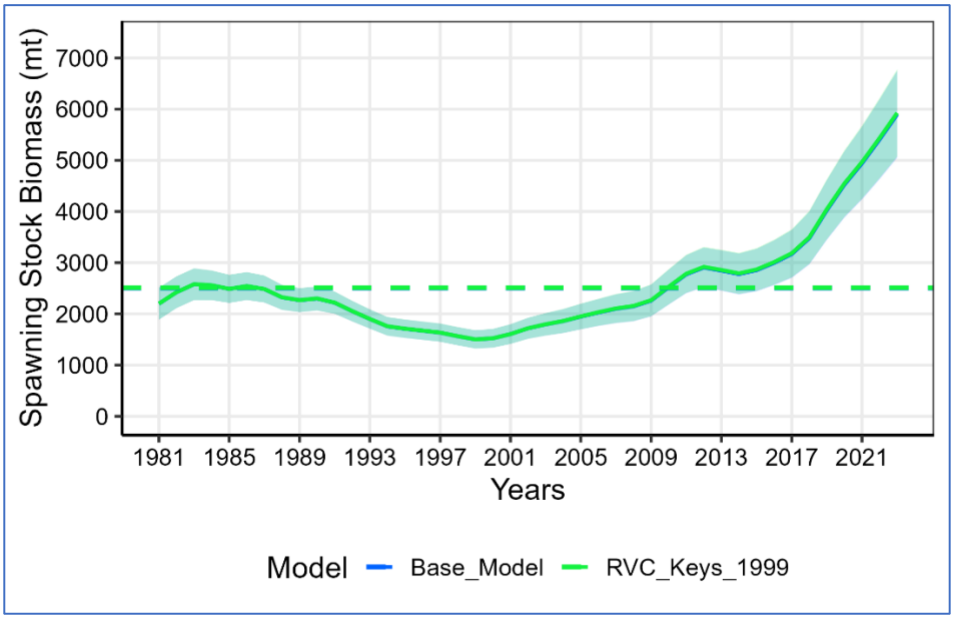


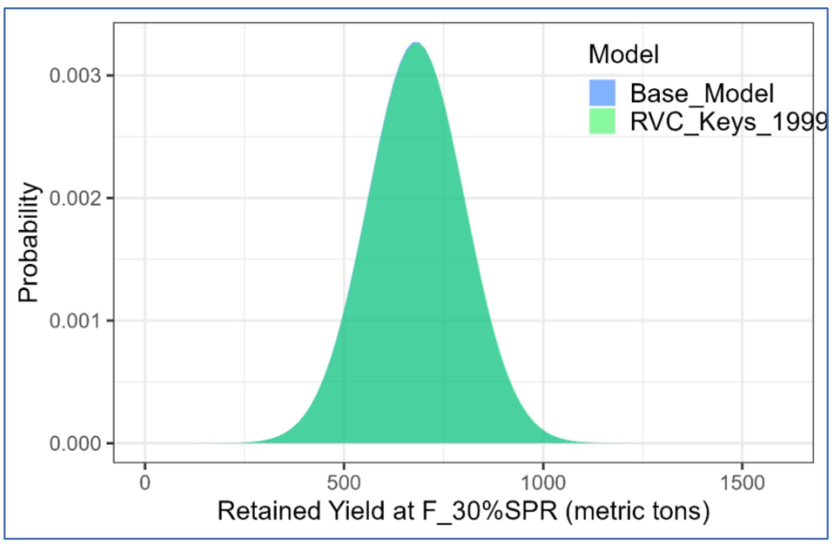
Figure 20. Fits to indices when the index value and related standard error in 1999 for the RVC FL Keys survey was included in the Base Model.



a)

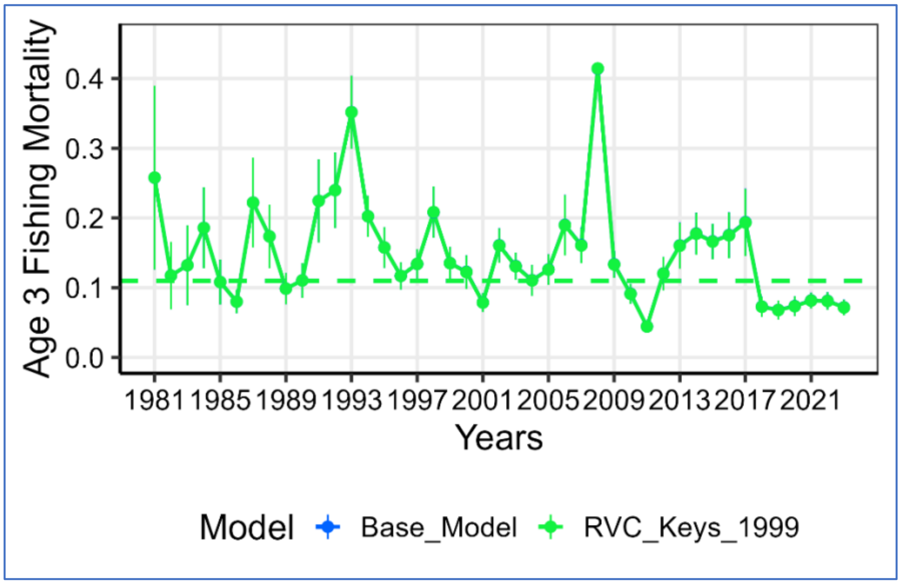


b)

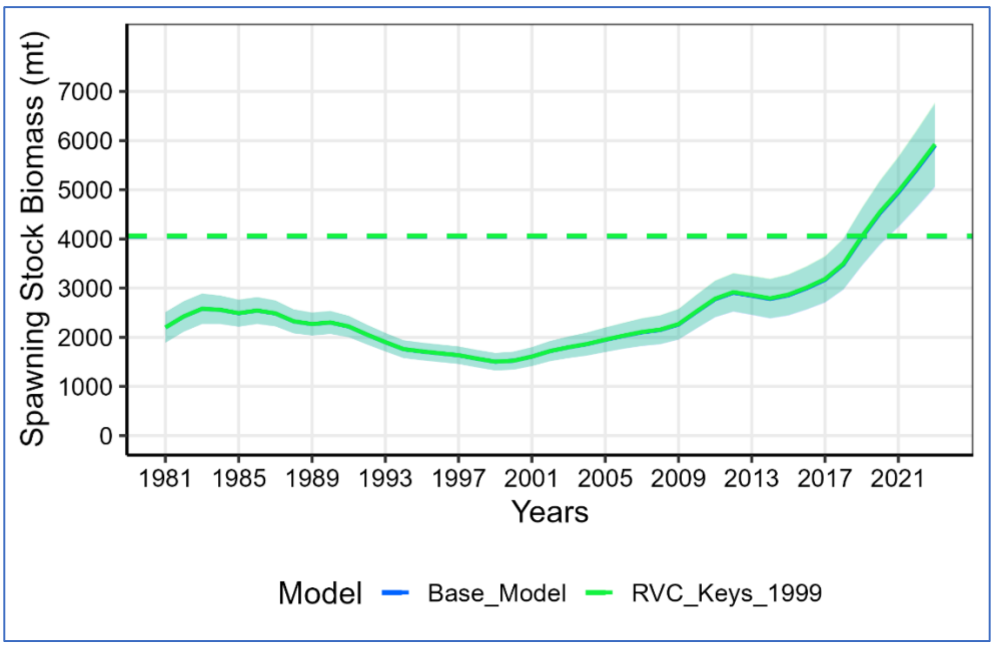


c)

Figure 21. Comparison of fishing mortality rates (with $F_{30\%SPR}$), spawning stock biomass (with $75\%SSB_{F30\%SPR}$), and retained yield at $F_{30\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with the inclusion of the RVC FL Keys index value and related standard error for 1999 ('RVC Keys 1999').


Age 3 Fishing Mortality
0.0
0.1
0.2
0.3
0.4
1981 1985 1989 1993 1997 2001 2005 2009 2013 2017 2021
Years
Model Base_Model RVC_Keys_1999

a)


Spawning Stock Biomass (mt)
0
1000
2000
3000
4000
5000
6000
7000
1981 1985 1989 1993 1997 2001 2005 2009 2013 2017 2021
Years
Model Base_Model RVC_Keys_1999

b)

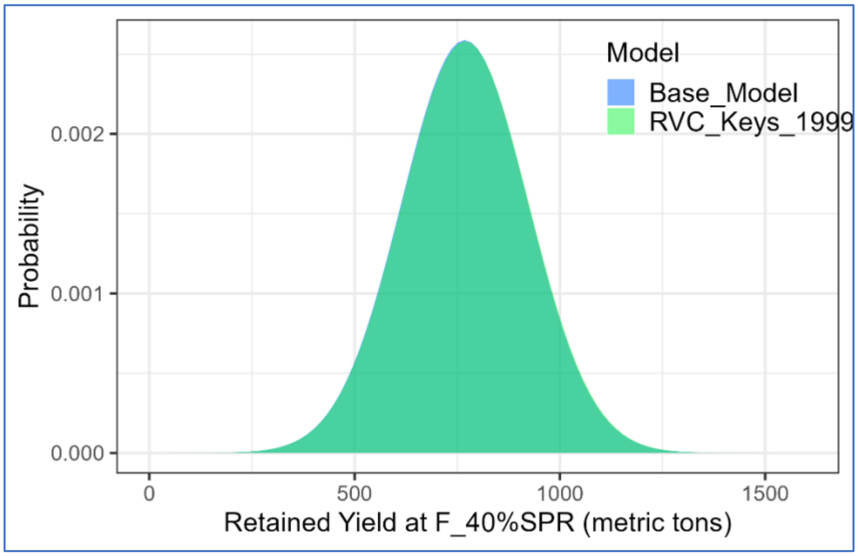
c) 

Figure 22. Comparison of fishing mortality rates with $F_{40\%SPR}$, spawning stock biomass with 75%$SSB_{F40\%SPR}$, and retained yield at $F_{40\%SPR}$ estimated by the SEDAR 79 Base Model ('Base') and the Base Model with the inclusion of the RVC FL Keys index value and related standard error for 1999 ('RVC Keys 1999').