# Red Snapper ABC subcommittee report

Monday, April 16, 2018

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# Executive Summary

A Red Snapper Acceptable Biological Catch subcommittee was convened over that last six months with the following stated task: To collate data, analyses, stock assessments, and any other background information on Red Snapper in order to determine an Acceptable Biological Catch (ABC). If necessary, work on additional analyses for providing an ABC or tracking an ABC.

The subcommittee met once per month for six months and vetted five main methods types that included the Center Interim Analysis, the SEDAR 41 stock assessment and projections, Data Limited Methods (DLM), index based methods used at other Science Centers, and Amendments 43 and 46. Each method was considered as either recommended or not recommended, and of the recommended options, a preferred approach was chosen. Methods that were not recommended for use included Data Limited Methods (DLM), index based methods used at other Science Centers, and Amendments 43 and 46. Both the Center Interim Analysis and the SEDAR 41 stock assessment and projections were recommended for use with the Center Interim Analysis being the preferred recommended option.

The Center Interim Analysis uses the stock assessment (SEDAR 41), which has been deemed best available science and data, as well as up to date catch, discards, fishery independent index ages, and index values to forecast recruitment cohorts. This analysis allows for up to date information to be used through the terminal year of 2016. While there is uncertainty in the data inputs (similar to the stock assessment) such as MRIP and discards; there is still utility in the analysis. Even with the uncertainties in the data, the Red Snapper ABC subcommittee recommends the Center Interim Analysis method as the preferred method for providing an ABC, as this method updates data to the fullest extent possible, which thereby provides the best available information on recruitment success in the most recent years.

# Introduction

This introduction is meant to provide an accurate representation of the current standings of the science and management for Red Snapper, the path that the SSC (South Atlantic Science and Statistical Committee) is providing to move forward via this workgroup and document, and a summary of the vetted and prioritized methods available for determining a Red Snapper ABC (acceptable biological catch).

## Recent happenings regarding Red Snapper science and management

During the week of the 15th of March 2016, the Red Snapper benchmark stock assessment was reviewed through the Southeast Data, Assessment, and Review (SEDAR) process. The independent reviewers determined that the stock assessment was best scientific information available and was useful for management purposes. The reviewers also stated that the stock was overfished and that overfishing is occurring. See final Red Snapper stock assessment report pages 472-515 for specifics discussed at the review workshop.

In May of 2016, the SSC reviewed the Red Snapper stock assessment and deemed that assessment best available science for management use. While the SSC discussed numerous uncertainties in the Red Snapper assessment (similar to all other assessments), the SSC also provided an ABC recommendation based on the stock assessment, which can be found in Table 2 of the May 2016 SSC Final report.

In October of 2016, the SSC reviewed Amendment 43 for Red Snapper and were directed to discuss specific action items, one of which was "Update or revise fishing level recommendations as appropriate". The SSC determined that "No new data have become available to justify a revision of the fishing level recommendations." Thus, the ABC provided during the May 2016 SSC meeting was confirmed.

In April of 2017, the SSC reviewed a corrected assessment for Red Snapper under the agenda item for Amendment 43 and was also provided some memos that were confusing and somewhat contradictory. The memo dated February 15, 2017 from the SEFSC stated that projections would be highly uncertain and that discard data was highly uncertain and therefore, there would be difficulty in monitoring the ABC. However, the stock assessment is still the best available science, and monitoring of the ABC is not a reason to delay providing an ABC. In addition, the memo stated that waiting for the new MRIP calibration would be preferable; however, the calibration is still not available and management should not be held up on account of including new data and methods yet to be released or developed. The memo dated April 21 concurred with the SEDAR Review panel and the SSC's approval of the SEDAR41 stock assessment and stated that monitoring the ABC to determine if management was working would be difficult. Thus, the memos from the SEFSC could have caused confusion regarding the ability to provide ABC advice. During the April 2017 meeting, the SSC deemed the assessment to be best available science for management use; however, the projection analysis that was needed wasn't provided to set an ABC. As a consequence, the notes from the meeting stated that an ABC couldn't be provided at the time.

After these events, the Council assumed the SSC was unable to provide an ABC at all and proceeded with Amendment 43, which was later broken into Amendments 43 and 46. Amendment 43 contained several proposed methods for determining an ACL (Annual Catch Limit). These methods included several alternatives ranging from no action to alternatives based on landings during 2012-2014. Amendment 46 contains proposals to have private recreational reporting and permitting and best practices for the Red Snapper fishery. Amendment 46 is still in development and may change with future Council actions.

At the October 2017 SSC meeting, there was much discussion focused on Red Snapper science and management. A large portion of time was spent discussing past events. It was suggested that the SSC needed a path forward, and it was proposed to create a working group to vet all methods available for ABC determination and provide a prioritized list of possibilities to the SSC at the May 2018 meeting. Working group members include: Rob Ahrens, Luiz Barbieri, Scott Crosson, Eric Johnson, Genny Nesslage, and Amy Schueller (Chair). Support via scheduling, background and scoping materials, and additional analyses has been provided to the workgroup through South Atlantic Fishery Management Council (SAFMC) staff and Southeast Fisheries Science Center (SEFSC) staff.

## Working group membership, task, and terms of reference:

Working group membership (alphabetical order): Rob Ahrens, Luiz Barbieri, Scott Crosson, Eric Johnson, Genny Nesslage, Amy Schueller (chair)

Working group task: To collate data, analyses, stock assessments, and any other background information on Red Snapper in order to determine an Acceptable Biological Catch (ABC). If necessary, work on additional analyses for providing an ABC or tracking an ABC.

Terms of Reference:

1. Collate and evaluate existing information on Red Snapper
2. Determine if an ABC can be determined from existing information
3. If an ABC cannot be determined from existing information, provide a plan of action for moving forward to determine an ABC
    a. Plan of action should include evaluation of index based methods for tracking ABC, as well as consideration of the index based method can be used to determine an ABC
4. Assess to the extent possible newly developed methods providing strengths and weaknesses of each method
5. Provide a final ABC recommendation and also include any viable alternatives in priority order based on the science and data available

## Summary of vetted options

- Center Interim Analysis (Preferred Recommendation)
    - Pros:
        - Uses best available science and data from the stock assessment
        - Uses up to date (terminal year 2016) catch, discards, fishery independent index ages, and index values to forecast recruitment cohorts
        - Least delay between catch and index terminal year (2016) and when management will be put into place
    - Cons:
        - Uncertainty in the inputs including discards and MRIP
- Stock assessment and projections - SEDAR 41 (Recommended)
    - Pros:
        - Uses best available science and data up to terminal year (2014) of the assessment
        - Projections use up to date (terminal year 2016) catch and discards
        - Reviewed by external CIEs
    - Cons:
        - Projections do not use updated, available data on the ages and index
        - Uncertainty in the inputs including discards and MRIP, as discussed during the review process, remain
        - Current age of assessment with a terminal year of 2014 (versus Center Interim Analysis)
- DLM (Not recommended)
    - Pros:
        - Easy to calculate
    - Cons:
        - Does not use all of the best data available for Red Snapper
        - Average catch method does not perform well if a stock is assumed overfished
        - Mean length methods have not been formally vetted and do not work with noisy length data
        - Methods were developed for active fisheries, rather than small or closed fisheries as is the case with Red Snapper
- Index methods used in other Science Centers (Not recommended)
    - Pros:
        - Fishery independent index was updated
    - Cons:
        - None of the indices have a time series that covers the current time period and spans a time during which the stock was either not exploited or only lightly exploited
        - We do not know the scale of the index
        - We do not have an estimate of catchability
- Amendments 43 and 46 (Not recommended)
    - Pros:

        - Fishery independent index was updated
    - Cons:
        - None of the indices have a time series that covers the current time period and spans a time during which the stock was either not exploited or only lightly exploited
        - We do not know the scale of the index
        - We do not have an estimate of catchability
        - Uses an index that didn't sample Red Snapper habitat sufficiently during the entire duration of sampling
        - Method hasn't been peer reviewed or reviewed by the SSC
        - Assumes that the 2012-2014 fishing level is sustainable

If the full SSC formally recommends the Preferred Recommended method, which is the Center Interim Analysis, then the table below (Table 3 from the Center Interim Analysis report) provides the ABC values for a 50% probability of rebuilding by 2044.

Table 3. Projection results based on IA1 under Scenario 2, with fishing mortality rate fixed at F = $F_{rebuild}$ starting in 2018. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), B = biomass (mt), S = spawning stock (1E8 eggs), L = landings expressed in numbers (1000s) or whole weight (1000 lb), and D = dead discards expressed in numbers (1000s) or whole weight (1000 lb), pr.rebuild = proportion of stochastic projection replicates with SSB greater than or equal to $SSB_{F30\%}$. The extension .base indicates expected values (deterministic) from the base run; the extension .med indicates median values from the stochastic projections.

| year | R.base(1000) | R.med(1000) | F.base | F.med | B.base(mt) | B.med(mt) | S.base(1E8) | S.med(1E8) | L.base(1000) | L.med(1000) | L.base(1000 lb) | L.med(1000 lb) | D.base(1000) | D.med(1000) | D.base(1000 lb) | D.med(1000 lb) | pr.rebuild |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | 439 | 316 | 0.17 | 0.19 | 2539 | 2323 | 118189 | 104120 | 27 | 27 | 241 | 248 | 59 | 56 | 307 | 303 | 0.024 |
| 2018 | 442 | 317 | 0.14 | 0.14 | 2801 | 2523 | 155517 | 133854 | 27 | 24 | 268 | 239 | 50 | 43 | 296 | 260 | 0.06 |
| 2019 | 444 | 316 | 0.14 | 0.14 | 3018 | 2717 | 191334 | 163695 | 29 | 26 | 316 | 280 | 49 | 43 | 314 | 275 | 0.101 |
| 2020 | 445 | 316 | 0.14 | 0.14 | 3171 | 2857 | 221801 | 189350 | 30 | 27 | 345 | 306 | 48 | 42 | 319 | 280 | 0.149 |
| 2021 | 445 | 322 | 0.14 | 0.14 | 3283 | 2959 | 246743 | 210182 | 30 | 27 | 362 | 322 | 47 | 42 | 319 | 281 | 0.2 |
| 2022 | 446 | 315 | 0.14 | 0.14 | 3369 | 3037 | 266706 | 226573 | 30 | 27 | 376 | 334 | 47 | 42 | 318 | 281 | 0.246 |
| 2023 | 446 | 320 | 0.14 | 0.14 | 3437 | 3109 | 282289 | 240079 | 30 | 27 | 386 | 344 | 47 | 42 | 318 | 282 | 0.288 |
| 2024 | 446 | 320 | 0.14 | 0.14 | 3490 | 3153 | 294543 | 250860 | 31 | 27 | 394 | 351 | 47 | 42 | 319 | 284 | 0.326 |
| 2025 | 446 | 318 | 0.14 | 0.14 | 3532 | 3201 | 303787 | 258943 | 31 | 28 | 401 | 358 | 47 | 42 | 321 | 287 | 0.361 |
| 2026 | 446 | 320 | 0.14 | 0.14 | 3565 | 3233 | 310844 | 265804 | 31 | 28 | 406 | 364 | 47 | 42 | 323 | 288 | 0.386 |
| 2027 | 446 | 318 | 0.14 | 0.14 | 3590 | 3258 | 316286 | 270669 | 31 | 28 | 410 | 367 | 47 | 42 | 325 | 290 | 0.405 |
| 2028 | 447 | 318 | 0.14 | 0.14 | 3610 | 3285 | 320395 | 274758 | 31 | 28 | 413 | 370 | 47 | 42 | 326 | 292 | 0.42 |
| 2029 | 447 | 321 | 0.14 | 0.14 | 3625 | 3304 | 323575 | 277859 | 31 | 28 | 416 | 373 | 47 | 42 | 327 | 293 | 0.433 |
| 2030 | 447 | 321 | 0.14 | 0.14 | 3637 | 3315 | 326053 | 280887 | 31 | 28 | 418 | 376 | 47 | 42 | 328 | 294 | 0.446 |
| 2031 | 447 | 322 | 0.14 | 0.14 | 3647 | 3326 | 327976 | 282835 | 31 | 28 | 419 | 378 | 47 | 42 | 328 | 294 | 0.456 |
| 2032 | 447 | 317 | 0.14 | 0.14 | 3655 | 3339 | 329478 | 284448 | 31 | 28 | 421 | 380 | 47 | 42 | 329 | 295 | 0.465 |
| 2033 | 447 | 321 | 0.14 | 0.14 | 3661 | 3355 | 330635 | 285754 | 31 | 28 | 422 | 380 | 47 | 42 | 329 | 295 | 0.469 |
| 2034 | 447 | 318 | 0.14 | 0.14 | 3665 | 3362 | 331507 | 286417 | 31 | 28 | 422 | 382 | 47 | 42 | 329 | 297 | 0.475 |
| 2035 | 447 | 318 | 0.14 | 0.14 | 3669 | 3371 | 332191 | 287620 | 32 | 29 | 423 | 383 | 47 | 43 | 330 | 297 | 0.479 |
| 2036 | 447 | 321 | 0.14 | 0.14 | 3672 | 3372 | 332725 | 288830 | 32 | 29 | 423 | 383 | 47 | 43 | 330 | 297 | 0.486 |
| 2037 | 447 | 324 | 0.14 | 0.14 | 3674 | 3372 | 333153 | 289327 | 32 | 29 | 424 | 384 | 47 | 42 | 330 | 297 | 0.491 |
| 2038 | 447 | 320 | 0.14 | 0.14 | 3676 | 3372 | 333494 | 290528 | 32 | 29 | 424 | 384 | 47 | 42 | 330 | 297 | 0.493 |
| 2039 | 447 | 321 | 0.14 | 0.14 | 3677 | 3370 | 333767 | 290656 | 32 | 29 | 424 | 383 | 47 | 42 | 330 | 297 | 0.496 |
| 2040 | 447 | 320 | 0.14 | 0.14 | 3679 | 3375 | 333985 | 290827 | 32 | 29 | 424 | 383 | 47 | 42 | 330 | 297 | 0.497 |
| 2041 | 447 | 325 | 0.14 | 0.14 | 3680 | 3381 | 334158 | 290834 | 32 | 29 | 425 | 385 | 47 | 43 | 330 | 298 | 0.5 |
| 2042 | 447 | 321 | 0.14 | 0.14 | 3680 | 3379 | 334296 | 291357 | 32 | 29 | 425 | 385 | 47 | 42 | 330 | 298 | 0.499 |
| 2043 | 447 | 323 | 0.14 | 0.14 | 3681 | 3390 | 334406 | 290894 | 32 | 29 | 425 | 386 | 47 | 43 | 330 | 299 | 0.499 |
| 2044 | 447 | 323 | 0.14 | 0.14 | 3681 | 3390 | 334494 | 291332 | 32 | 29 | 425 | 387 | 47 | 43 | 330 | 299 | 0.502 |

## Additional topics of interest to the SSC or Council:

- Landings and discards when setting an ABC

For Red Snapper, the ABC value is based on landings and discards. When a fishery is under a moratorium, then the ABC needs to be tracked in discards. With medium to high discard mortality rates and high effort levels, discard mortality rates can be high enough to exceed the ABC even under a moratorium. If this is the case, then managers need to consider alternative options to reduce effort and therefore discard mortality of the species of interest.

- ACL monitoring, as opposed to ABC determination

During the course of the discussions regarding Red Snapper, there are many points where ABC determination was used interchangeably with ACL monitoring. The two topics are different from one another, and while the ACL is dependent upon an ABC, the monitoring of the ACL is an entirely different issue than determining an ABC. The ABC is the Acceptable Biological Catch for the stock or the amount of fish that can be harvested while maintaining sustainability. The ACL is the Acceptable Catch Limit, which is the amount of fish that can be harvested taking into account management uncertainty. The ACL is monitored using the best data sets available for landings and discards. In some circumstances, data sets are best for monitoring, but still not ideal; however, the ACL must still be monitored using best available data.

- Discuss merits of the CVID index as both the stock assessment and Center Interim Analysis are dependent upon index (SEDAR41 report)

The CVID index was developed from data collected through the partner-led survey referred to as the Southeast Reef Fish Survey (SERFS). With the advent of the partner programs, sampling coverage in the region has expanded, primarily in Florida. SERFS now samples between Cape Hatteras, North Carolina and St. Lucie Inlet, Florida and targets a sampling universe of approximately 3,000 sites of hard-bottom habitats between approximately 15 and 100 meters deep. Sampling consists of Chevron traps with video cameras attached, which began in 2010. The spatial coverage of the survey after 2010 adequately covered the center of the distribution of Red Snapper and percent positives increased to levels high enough to develop an index. The DW provided a SERFS chevron trap and video index separately. However, because the data are collected from the same sampling platforms (i.e. cameras mounted on the chevron traps), the two indices are not independent measures of abundance. Therefore, the panel decided to combine the two using the Conn (2010) method for combining indices. The fishery independent CVID index selectivity was assumed logistic and informed by the SERFS chevron trap age compositions. As length and biological samples are not collected from the video information, the length and age compositions for the CVID index are those from chevron trap catches. A method to measure lengths from fish on the videos is being developed, and this development is considered a high research priority.

- Use of the chevron trap index from 1990 to the present (document why assessments haven't used this index during last two benchmark assessments)

While the chevron trap survey has been active since 1990, it was not used to provide an index of abundance for the Red Snapper assessment for the years of 1990 to 2009 (SEDAR 41 report). The index work group from the SEDAR 40 stock assessment truncated the time series to the years of 2010 - 2014 in order to provide the best information on Red Snapper trends in abundance. Specifically, prior to 2010, the spatial coverage of the chevron survey was not adequate to cover the center of the distribution of Red Snapper. Additionally, the percent positive catches were extremely low, likely related to the fact that the spatial coverage of the survey didn't adequately cover Red Snapper habitat. Given these two concerns, the index working group determined that the chevron trap index from 1990 to 2009 likely didn't index changes in the relative abundance of Red Snapper accurately for the entire SE region.

- Usefulness of the fishery independent data in general versus the usefulness for Red Snapper

While the chevron trap index over the entire time series (1990 - current) may be inadequate for use in the Red Snapper stock assessment, as stated above; the chevron trap index is useful for other species such as black sea bass, vermilion snapper, red porgy, red grouper, and gray triggerfish (SEDAR 55, 56, 1 [updates thereafter], 53, and 41). The chevron trap survey adequately samples the habitats of these other species and fluctuations in the index were deemed to indicate changes in relative abundance of the respective species. Thus, the chevron trap data from 1990 to 2009 has been useful in stock assessments for other important South Atlantic species. The introduction of the video recordings has significantly increased the value of the data for many other species. In addition, the chevron trap survey provides biological samples (including information about age, reproduction, diet, and genetics) that are critical for stock assessments and management of these species.

- Validity of indices at low population size and examples of interpreting data

Indices of abundance can be used in stock assessments as indicators of population trend, recruitment, and changes in age/size structure. Such indices are used in conjunction with life history, fishery catch, and age/size structure information to estimate biomass, fishing mortality, and sustainable fishing levels. Only fishery independent indices of abundance have the potential to provide trend information about portions of the stock not encountered by the fishery (e.g., recruits, unfished areas) and are thus vital components of stock assessments. However, there are several circumstances in which even fishery independent indices of abundance must be interpreted with caution, including the following situations, which might apply to Red Snapper in the South Atlantic:

1. Annual trends in relative abundance must be considered in light of the error in those abundance estimates. Apparent trends in relative abundance may be dampened greatly or even disappear completely when plotted with associated confidence intervals, indicating that annual trends can be insignificant relative to the error in those relative abundance

estimates. Relative abundance estimates should not be interpreted independent of their variance.

2. At low population size, surveys may rarely encounter existing individuals such that changes in relative abundance over time may be indicative of rare catches of the target species, not trends in the overall population. Rebuilding species such as Red Snapper are susceptible to this problem and may suffer from low detectability that could affect interpretation of trends in relative abundance.
3. Changes in management may not result in immediate changes in index trend depending on the spatial extent of the survey and the selectivity of the gear (i.e., ages typically caught by the survey gear). Detection of management impacts may not be immediate (i.e., following season or year), and the earliest possible detection should be a number of years into the future equal to the age at first recruitment to the survey gear. For example, significant management changes that positively impact recruitment might be not be observable in surveys until a number of years later when they are large enough to be captured by the survey gear or until they reach minimum legal size such that they are harvested by the fishery and are incorporated into fishery CPUE indices.
4. Interpretation of trends independent of other stock assessment information can lead to misinterpretation. For example, if spawning stock decreases due to increased catch coincidentally with increases in recruitment resulting from past management action (see #3 above), the overall relative abundance index might increase despite the fact that increased catch has negatively impacted the spawning stock. Using indices of abundance to assess management impacts can be extremely challenging and potentially misleading if associated age information is not collected or considered in interpretation of index trends. It is therefore important to investigate the overall trends in relative abundance with possible changes in length and age compositions.

- Observation versus process error in index

Interpreting changes in stock abundance from indices of abundance must consider the potential relative impact of both the expected variation in abundance (process error) and variation in sampling (observation error). Previous work has shown that understanding the ratio of process to observation error is a critical for appropriately filtering/smoothing time series data to extract changes in biomass (see Freeman and Kirkwood 1995, Walters and Hilborn 2005). Common approaches are to apply a Kalman filtering (Kalman 1960) and/or Rauch–Tung–Striebel smoothing (Rauch et al. 1965). While most index methods have associated standard error estimates, providing insight into observation error, understanding of process error is limited to the length of the index, as in many instances, process error is estimated as the difference between the apparent total variance in the index and the estimated observation error. In instances where short time series are used the estimation of the process error are poor.

- Fine scale shifts in spatial targeting and the inability to track them

Changes in the spatial distribution of fisheries and/or research surveys has the potential to obscure changes in stock abundance when catch and effort information are not geospatially referenced at spatial scales at which the assumption of representative sampling can be made. The resulting catch per effort that is commonly used to generate relative abundance trends will tend to not be proportional to stock abundance (hyperstable or hyperdeplete). In general the issue of non-proportionality is greater with fishery dependent data that is documented at broad spatial scales.

# Methods that were vetted

The following sections are summaries of the vetted methods that were considered by the Red Snapper ABC subcommittee. Please note that these are summaries, and that there may be supporting documentation listed under the heading ***List of additional supplementary information*** below. Also NOTE that each section has its own numbering of figures and tables, so please refer to table and figure numbers within the section of interest.

## Center Interim Analysis (taken directly from S3 Center Interim Analysis Report)

In the U.S. South Atlantic region, stock assessments are typically several years out of date by the time regulations based on them are implemented. This occurs for numerous reasons, including the length of time to complete an assessment from data provision to SSC review, the length of time for managers to develop new regulations, and the time between assessments themselves (at least 5 years for many species). Consequently, ABC advice is based on uncertain projections several years into the future. These status quo projections include, when available, the latest information on removals (landings, discards), but must make assumptions about annual recruitment. For example, they commonly assume that future recruitment occurs at the long-term, average value.

In this document, we propose an Interim Analysis approach to provide updated ABCs between stock assessments. The application of Interim Analysis is consistent with national guidance from a soon-to-be-released NOAA report, Implementing a Next Generation Stock Assessment Enterprise (eds. Lynch, Methot, and Link). The Interim Analysis approach described here is hybrid between the status quo projection methodology and an update assessment. In short, the approach advances the assessment model beyond the terminal year, fitting to the latest data on removals as well as other key data sources (e.g., index of abundance, age compositions) that might provide information on recent year-class strength. In this way, projections on which ABCs are based utilize more up-to-date information than does the status quo approach, without the need to re-do the full assessment. The approach holds potential for application to numerous stocks in the South Atlantic, increasing throughput of SEDAR in general. Here we focus on Red Snapper, which was last assessed through SEDAR-41 with a terminal year of 2014. The Interim Analysis updates recruitment estimates through 2016.

<u>Methods</u>

The Interim Analysis (IA) applies the latest assessment model and current projection model, but extends the assessment to include additional, more recent years. In this report, we describe how the assessment is extended, but rely on previous documentation for more complete descriptions of the assessment and projection models (SEDAR-41 2017).

In the SEDAR-41 Red Snapper assessment, the terminal year was T1=2014. The IA includes two more years of data, extending the terminal year to T2=2016. However, the IA differs from an Update assessment in two key ways:

- Unlike an Update assessment, not all data sources are updated through the new terminal year T2. Updated data sources include landings by fleet, discards by fleet, an index of abundance, and age compositions associated with that index.
- Unlike an Update assessment, the IA does not attempt to estimate all parameters of the assessment model. Instead, it fixes all parameters at their previously estimated values, with limited exception (described below). Thus, the Interim Analysis does not attempt to modify previous estimates of fishing mortality rate through year T1, selectivity ogives, the spawner-recruit relationship, or catchability applied to indices of abundance. Consequently, estimates of benchmarks remain unaltered from the previous assessment.

Most updated data sources include only the two additional years. The exception is the SERFS fishery independent index of abundance (CVID, combined chevron trap and video survey). Because the index is standardized, it was computed over its full time series (2010–T2) using identical methodology as in SEDAR-41 (2017), but with the two additional years. Specifically, the new data are the following:

- Landings in 2015 and 2016 for each fleet—commercial, headboat, general recreational (Table 1)
- Discards in 2015 and 2016 for each fleet—commercial, headboat, general recreational (Table 1)
- SERFS fishery independent index of abundance for 2010–2016. After standardization, the index was re-scaled such that values in the years 2010–T1 had the same mean as the SEDAR-41 index that spanned those same years. This way, the estimate of catchability from the assessment could be fixed, and the additional two years reflected population trends relative to the previous, SEDAR-41 index.
- Age compositions in 2015 and 2016 collected by SERFS chevron traps.

The intent of including an updated index of abundance and associated age compositions is to better inform recent year-class strength in the projections. Ideally, an index of recruitment would be available for this purpose. Such a focused index is not available for Red Snapper, however the SERFS did capture young Red Snapper (age 1+) and is therefore believed to contain information on recent, age-1 recruitment (in addition to older ages).

Only a limited number of parameters are estimated in the IA. These include parameters for each interim year describing fishing mortality associated with landings (3 fleets × 2 years = 6 parameters), fishing mortality associated with discards (3 fleets × 2 years = 6 parameters), and annual recruitment deviations (2 years = 2 parameters). Likelihood formulations for estimating these parameters were the same as for SEDAR-41. The additional years of data also have potential to inform year-class strength prior to the terminal year (T1=2014) of the assessment. We allow for this possibility by estimating an annual multiplier (my) on previously estimated recruitment deviations (ry) in years immediately prior to T1, such that lognormal recruitment deviations in the IA equal my × ry. The MARMAP age compositions included ages 1−13+, and thus we estimated the multipliers starting in year T0=T2−13+1=2004, which is the year age-13 fish in year 2016 would have been age-1. The multipliers were estimated for years T0 through

T1 (11 years = 11 parameters). A penalty term to constrain estimates of my was added to the total likelihood,

$$\Lambda^m = \sum_{y=T0}^{T1} (m_y - 1)^2$$

Thus, the likelihood was penalized for deviations away from 1, shrinking IA recruitment estimates toward the SEDAR-41 estimates unless informed by the new data.

Uncertainty

Uncertainty in the IA was quantified using MCB analysis. This was done by applying the IA to each MCB run from SEDAR-41. The primary reason for quantifying uncertainty in the IA was to carry that uncertainty forward into projections that may form the basis of ABC advice.

Effect of new data on interim recruitment estimates

To evaluate the effect of new data sources on estimating recruitment deviations and terminal-year (T2) age structure, we incrementally removed sources. For this evaluation, we label the analyses as follows:

- IA1: Interim analysis with all new data sets as described above
- IA2: Interim analysis without age composition data (index and removals only)
- IA3: Interim analysis without age composition or index data (removals only). In this analysis, the data cannot inform recent recruitment, and thus we turned off estimation of recruitment deviations through 2016, by fixing my=1 and by using expected, long-term values for 2015−2016 recruitment.

We consider model IA1, with all new data, to be the primary model and use it as the basis for subsequent projections. Model IA2 is a sensitivity analysis to investigate the importance of the new age composition data. Model IA3 is also a sensitivity analysis; it is analogous to the approach used in status quo projections.

Projections

To compute ABCs beyond the new terminal year T2, projections based on Model IA1 were run for 2017−2044. The projection methodology was identical to that from SEDAR-41. The primary difference is that the SEDAR-41 status quo projections started in 2015, and thus had to make assumptions about recruitment in 2015–2016. On the other hand, IA projections start in 2017 with an initial age structure that reflects recent recruitment as estimated from data.

In theory, IA could be performed without any lag between T2 and projections. However, in this application to Red Snapper, we have a one-year lag between T2=2016 and the earliest possible start of any new management implementation (2018). For the one year in between (2017), we assumed that landings were equal to the average level from 2012–2014, chosen because those years had Red Snapper season openings similar to 2017. Uncertainty in those landings was carried forward from the bootstrap of landings data performed as part of the SEDAR-41 MCB analysis.

We computed projections for two different levels of fishing mortality, F=F30% (Scenario 1) and F=Frebuild (Scenario 2), starting in 2018. F=Frebuild was defined to be the fishing mortality rate that provides a 50% chance of rebuilding SSB to SSBMSY by 2044.

## Results

The primary model (IA1) fit reasonably well to the new age composition data (Figure 1A,B). It under-fit age-1 fish in 2015, but then fit that same cohort nearly perfectly in 2016. The information content from age composition data must be interpreted in the context of selectivity (Figure 1C).

Model IA1 predicted that the spawning stock continued to increase in 2015 and 2016, and that overfishing continued (Figure 2). These results appear to be robust, based on the MCB uncertainty analysis (Figure 2). The overfishing result comes almost entirely from discard mortalities, especially from the general recreational fleet (Table 1). Although the model estimates that spawning biomass remains below its threshold, it also estimates that total abundance of age-2+ fish is near its highest level since 1970 (Figure 2). The age structure remains truncated relative to that expected at F30%, but this result of relatively high abundance is consistent with reports from anglers and with observations from the SERFS.

Models IA1 and IA2 both captured the recent increasing trend in the SERFS index of abundance, however IA3 did not (Figure 3). Although AI3 was not fit to the index, the model can still generate predictions for comparison to the observed index.

The increasing trend in the index was explained by higher than expected recruitment in recent years (Figure 4A). Compared to IA3, which depicts the SEDAR-41 recruitment estimates through 2014 and the status quo assumption in 2015−2016, the primary model IA1 predicted considerably higher recruitment in 2014−2016, and slightly higher values in years prior. Model IA2 predicted similarly higher values, except for year 2016. That exception underscores the importance of including age composition data for estimating recruitment. However, even with age composition data (as in IA1), the terminal year recruitment estimates are typically very uncertain, especially when selectivity of age-1 fish is low.

Estimated recent recruitment values determine the initial abundance at age in projections (Figure 4B). Estimated initial abundances (in 2017) of ages 2−4 were nearly twice as high for IA1 than for the status quo approach of IA3. These higher values affect projections, including catch levels and the rate of rebuilding, particularly in the short term.

In Scenario 1 projections based on IA1, with fishing rate at the limit reference point of F=F30%, the stock is not projected to recover with a 50% probability by 2044 (Figure 5, Table 2). However, the short-term catch levels are substantially higher than those calculated with status quo projections, a consequence of the initial abundance at age. For the same reason, Scenario 2 projections, with F=Frebuild, allows for higher short-term catch levels than status quo rebuilding projections (Figure 6, Table 3).

## Discussion

On the spectrum of complexity, Interim Analysis falls in between an Update Assessment and a stock projection. IA is less complex than an Update Assessment, because it does not update all of the data sources, nor does it re-estimate all model parameters. IA is more complex than a stock projection because it attempts to estimate year-class strength, in addition to fishing mortality, in years between the terminal year of the assessment and implementation of new management. For some stocks, this gap can span five years or more. If a goal of SEDAR is to provide up-to-date catch advice with more throughput than is currently possible, adopting more frequent IA in place of full assessments could be an efficient approach.

Since the terminal year (2014) of SEDAR-41, the abundance of Red Snapper has continued to increase, as evidenced by the CVID index of abundance. The IA accounts for this trend by estimating high recruitment in recent years, and these estimates form the basis of the initial age structure projected forward from year 2017. In this way, projections stemming from the IA are better informed by recent data than are those stemming from the SEDAR-41 Benchmark Assessment. We view this as an improvement, particularly for short-term forecasts. Nonetheless, the IA simply fills the gap of years since the last assessment. Forecasting future dynamics of fish stocks remains a highly uncertain endeavor, with all of the same caveats described in the SEDAR-41 AW report.

Table 1. Estimates of landings and discards for red snapper in the South Atlantic by fleet in 2015 and 2016.

| | Commercial | | Headboat | | General recreational | |
|---|---|---|---|---|---|---|
| | Landings (lb) | Discards (fish) | Landings (fish) | Discards (fish) | Landings (fish) | Discards (fish) |
| 2015 | 4,762 | 31,565 | 750 | 54,405 | 1,111 | 508,196 |
| 2016 | 4,151 | 34,568 | 331 | 66,511 | 72 | 788,460 |

Table 2. Projection results based on IA1 under Scenario 1, with fishing mortality rate fixed at $F = F_{30\%}$ starting in 2018. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), B = biomass (mt), S = spawning stock (1E8 eggs), L = landings expressed in numbers (1000s) or whole weight (1000 lb), and D = dead discards expressed in numbers (1000s) or whole weight (1000 lb), pr.rebuild = proportion of stochastic projection replicates with SSB greater than or equal to $SSB_{F30\%}$. The extension .base indicates expected values (deterministic) from the base run; the extension .med indicates median values from the stochastic projections.

| year | R.base(1000) | R.med(1000) | F.base | F.med | B.base(mt) | B.med(mt) | S.base(1E8) | S.med(1E8) | L.base(1000) | L.med(1000) | L.base(1000 lb) | L.med(1000 lb | D.base(1000) | D.med(1000) | D.base(1000 lb) | D.med(1000 lb | pr.rebuild |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | 439 | 316 | 0.17 | 0.19 | 2539 | 2323 | 118189 | 104120 | 27 | 27 | 241 | 248 | 59 | 56 | 307 | 303 | 0.024 |
| 2018 | 442 | 317 | 0.15 | 0.15 | 2801 | 2523 | 155229 | 133222 | 28 | 25 | 273 | 250 | 51 | 46 | 302 | 272 | 0.057 |
| 2019 | 444 | 316 | 0.15 | 0.15 | 3012 | 2705 | 190469 | 161787 | 30 | 27 | 322 | 291 | 50 | 45 | 320 | 287 | 0.092 |
| 2020 | 445 | 315 | 0.15 | 0.15 | 3158 | 2833 | 220247 | 186458 | 30 | 28 | 350 | 316 | 49 | 44 | 324 | 290 | 0.128 |
| 2021 | 445 | 322 | 0.15 | 0.15 | 3265 | 2923 | 244466 | 205829 | 30 | 28 | 367 | 331 | 48 | 43 | 324 | 290 | 0.169 |
| 2022 | 446 | 315 | 0.15 | 0.15 | 3346 | 2996 | 263728 | 221523 | 31 | 28 | 380 | 342 | 48 | 43 | 322 | 290 | 0.209 |
| 2023 | 446 | 320 | 0.15 | 0.15 | 3410 | 3056 | 278665 | 233821 | 31 | 28 | 390 | 350 | 48 | 43 | 322 | 290 | 0.242 |
| 2024 | 446 | 320 | 0.15 | 0.15 | 3460 | 3109 | 290340 | 243425 | 31 | 28 | 398 | 357 | 48 | 43 | 324 | 291 | 0.272 |
| 2025 | 446 | 318 | 0.15 | 0.15 | 3499 | 3146 | 299082 | 251261 | 31 | 28 | 404 | 364 | 48 | 43 | 325 | 293 | 0.299 |
| 2026 | 446 | 320 | 0.15 | 0.15 | 3529 | 3176 | 305711 | 256852 | 31 | 28 | 409 | 368 | 48 | 43 | 327 | 296 | 0.323 |
| 2027 | 446 | 318 | 0.15 | 0.15 | 3553 | 3198 | 310791 | 261425 | 31 | 28 | 413 | 372 | 48 | 43 | 329 | 296 | 0.342 |
| 2028 | 446 | 318 | 0.15 | 0.15 | 3571 | 3224 | 314599 | 266410 | 31 | 28 | 416 | 374 | 48 | 43 | 330 | 298 | 0.354 |
| 2029 | 447 | 321 | 0.15 | 0.15 | 3585 | 3243 | 317530 | 268617 | 32 | 29 | 418 | 377 | 48 | 43 | 331 | 299 | 0.368 |
| 2030 | 447 | 321 | 0.15 | 0.15 | 3596 | 3257 | 319803 | 271263 | 32 | 29 | 420 | 379 | 48 | 44 | 332 | 300 | 0.382 |
| 2031 | 447 | 322 | 0.15 | 0.15 | 3605 | 3265 | 321558 | 273056 | 32 | 29 | 422 | 382 | 48 | 43 | 332 | 301 | 0.393 |
| 2032 | 447 | 317 | 0.15 | 0.15 | 3612 | 3276 | 322922 | 274334 | 32 | 29 | 423 | 383 | 48 | 43 | 332 | 301 | 0.398 |
| 2033 | 447 | 321 | 0.15 | 0.15 | 3617 | 3291 | 323967 | 275526 | 32 | 29 | 424 | 384 | 48 | 44 | 333 | 302 | 0.404 |
| 2034 | 447 | 318 | 0.15 | 0.15 | 3621 | 3303 | 324751 | 276633 | 32 | 29 | 424 | 385 | 48 | 44 | 333 | 303 | 0.411 |
| 2035 | 447 | 318 | 0.15 | 0.15 | 3624 | 3308 | 325363 | 277547 | 32 | 29 | 425 | 386 | 48 | 44 | 333 | 304 | 0.417 |
| 2036 | 447 | 321 | 0.15 | 0.15 | 3627 | 3313 | 325840 | 279201 | 32 | 29 | 425 | 386 | 48 | 44 | 333 | 304 | 0.42 |
| 2037 | 447 | 323 | 0.15 | 0.15 | 3629 | 3311 | 326221 | 280149 | 32 | 29 | 426 | 387 | 48 | 44 | 334 | 303 | 0.426 |
| 2038 | 447 | 320 | 0.15 | 0.15 | 3631 | 3312 | 326524 | 280816 | 32 | 29 | 426 | 388 | 48 | 44 | 334 | 303 | 0.427 |
| 2039 | 447 | 321 | 0.15 | 0.15 | 3632 | 3312 | 326766 | 280788 | 32 | 29 | 426 | 388 | 48 | 44 | 334 | 303 | 0.431 |
| 2040 | 447 | 320 | 0.15 | 0.15 | 3633 | 3308 | 326959 | 280823 | 32 | 29 | 426 | 387 | 48 | 44 | 334 | 303 | 0.43 |
| 2041 | 447 | 325 | 0.15 | 0.15 | 3634 | 3313 | 327112 | 280465 | 32 | 29 | 426 | 388 | 48 | 44 | 334 | 304 | 0.432 |
| 2042 | 447 | 321 | 0.15 | 0.15 | 3635 | 3319 | 327234 | 281262 | 32 | 29 | 427 | 389 | 48 | 44 | 334 | 305 | 0.435 |
| 2043 | 447 | 323 | 0.15 | 0.15 | 3635 | 3323 | 327331 | 281149 | 32 | 29 | 427 | 390 | 48 | 44 | 334 | 305 | 0.436 |
| 2044 | 447 | 323 | 0.15 | 0.15 | 3636 | 3326 | 327408 | 281611 | 32 | 29 | 427 | 390 | 48 | 44 | 334 | 304 | 0.438 |

Table 3. Projection results based on IA1 under Scenario 2, with fishing mortality rate fixed at $F = F_{rebuild}$ starting in 2018. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), B = biomass (mt), S = spawning stock (1E8 eggs), L = landings expressed in numbers (1000s) or whole weight (1000 lb), and D = dead discards expressed in numbers (1000s) or whole weight (1000 lb), pr.rebuild = proportion of stochastic projection replicates with SSB greater than or equal to $SSB_{F30\%}$. The extension .base indicates expected values (deterministic) from the base run; the extension .med indicates median values from the stochastic projections.

| year | R.base(1000) | R.med(1000) | F.base | F.med | B.base(mt) | B.med(mt) | S.base(1E8) | S.med(1E8) | L.base(1000) | L.med(1000) | L.base(1000 lb) | L.med(1000 lb) | D.base(1000) | D.med(1000) | D.base(1000 lb) | D.med(1000 lb) | pr.rebuild |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | 439 | 316 | 0.17 | 0.19 | 2539 | 2323 | 118189 | 104120 | 27 | 27 | 241 | 248 | 59 | 56 | 307 | 303 | 0.024 |
| 2018 | 442 | 317 | 0.14 | 0.14 | 2801 | 2523 | 155517 | 133854 | 27 | 24 | 268 | 239 | 50 | 43 | 296 | 260 | 0.06 |
| 2019 | 444 | 316 | 0.14 | 0.14 | 3018 | 2717 | 191334 | 163695 | 29 | 26 | 316 | 280 | 49 | 43 | 314 | 275 | 0.101 |
| 2020 | 445 | 316 | 0.14 | 0.14 | 3171 | 2857 | 221801 | 189350 | 30 | 27 | 345 | 306 | 48 | 42 | 319 | 280 | 0.149 |
| 2021 | 445 | 322 | 0.14 | 0.14 | 3283 | 2959 | 246743 | 210182 | 30 | 27 | 362 | 322 | 47 | 42 | 319 | 281 | 0.2 |
| 2022 | 446 | 315 | 0.14 | 0.14 | 3369 | 3037 | 266706 | 226573 | 30 | 27 | 376 | 334 | 47 | 42 | 318 | 281 | 0.246 |
| 2023 | 446 | 320 | 0.14 | 0.14 | 3437 | 3109 | 282289 | 240079 | 30 | 27 | 386 | 344 | 47 | 42 | 318 | 282 | 0.288 |
| 2024 | 446 | 320 | 0.14 | 0.14 | 3490 | 3153 | 294543 | 250860 | 31 | 27 | 394 | 351 | 47 | 42 | 319 | 284 | 0.326 |
| 2025 | 446 | 318 | 0.14 | 0.14 | 3532 | 3201 | 303787 | 258943 | 31 | 28 | 401 | 358 | 47 | 42 | 321 | 287 | 0.361 |
| 2026 | 446 | 320 | 0.14 | 0.14 | 3565 | 3233 | 310844 | 265804 | 31 | 28 | 406 | 364 | 47 | 42 | 323 | 288 | 0.386 |
| 2027 | 446 | 318 | 0.14 | 0.14 | 3590 | 3258 | 316286 | 270669 | 31 | 28 | 410 | 367 | 47 | 42 | 325 | 290 | 0.405 |
| 2028 | 447 | 318 | 0.14 | 0.14 | 3610 | 3285 | 320395 | 274758 | 31 | 28 | 413 | 370 | 47 | 42 | 326 | 292 | 0.42 |
| 2029 | 447 | 321 | 0.14 | 0.14 | 3625 | 3304 | 323575 | 277859 | 31 | 28 | 416 | 373 | 47 | 42 | 327 | 293 | 0.433 |
| 2030 | 447 | 321 | 0.14 | 0.14 | 3637 | 3315 | 326053 | 280887 | 31 | 28 | 418 | 376 | 47 | 42 | 328 | 294 | 0.446 |
| 2031 | 447 | 322 | 0.14 | 0.14 | 3647 | 3326 | 327976 | 282835 | 31 | 28 | 419 | 378 | 47 | 42 | 328 | 294 | 0.456 |
| 2032 | 447 | 317 | 0.14 | 0.14 | 3655 | 3339 | 329478 | 284448 | 31 | 28 | 421 | 380 | 47 | 42 | 329 | 295 | 0.465 |
| 2033 | 447 | 321 | 0.14 | 0.14 | 3661 | 3355 | 330635 | 285754 | 31 | 28 | 422 | 380 | 47 | 42 | 329 | 295 | 0.469 |
| 2034 | 447 | 318 | 0.14 | 0.14 | 3665 | 3362 | 331507 | 286417 | 31 | 28 | 422 | 382 | 47 | 42 | 329 | 297 | 0.475 |
| 2035 | 447 | 318 | 0.14 | 0.14 | 3669 | 3371 | 332191 | 287620 | 32 | 29 | 423 | 383 | 47 | 43 | 330 | 297 | 0.479 |
| 2036 | 447 | 321 | 0.14 | 0.14 | 3672 | 3372 | 332725 | 288830 | 32 | 29 | 423 | 383 | 47 | 43 | 330 | 297 | 0.486 |
| 2037 | 447 | 324 | 0.14 | 0.14 | 3674 | 3372 | 333153 | 289327 | 32 | 29 | 424 | 384 | 47 | 42 | 330 | 297 | 0.491 |
| 2038 | 447 | 320 | 0.14 | 0.14 | 3676 | 3372 | 333494 | 290528 | 32 | 29 | 424 | 384 | 47 | 42 | 330 | 297 | 0.493 |
| 2039 | 447 | 321 | 0.14 | 0.14 | 3677 | 3370 | 333767 | 290656 | 32 | 29 | 424 | 383 | 47 | 42 | 330 | 297 | 0.496 |
| 2040 | 447 | 320 | 0.14 | 0.14 | 3679 | 3375 | 333985 | 290827 | 32 | 29 | 424 | 383 | 47 | 42 | 330 | 297 | 0.497 |
| 2041 | 447 | 325 | 0.14 | 0.14 | 3680 | 3381 | 334158 | 290834 | 32 | 29 | 425 | 385 | 47 | 43 | 330 | 298 | 0.5 |
| 2042 | 447 | 321 | 0.14 | 0.14 | 3680 | 3379 | 334296 | 291357 | 32 | 29 | 425 | 385 | 47 | 42 | 330 | 298 | 0.499 |
| 2043 | 447 | 323 | 0.14 | 0.14 | 3681 | 3390 | 334406 | 290894 | 32 | 29 | 425 | 386 | 47 | 43 | 330 | 299 | 0.499 |
| 2044 | 447 | 323 | 0.14 | 0.14 | 3681 | 3390 | 334494 | 291332 | 32 | 29 | 425 | 387 | 47 | 43 | 330 | 299 | 0.502 |

Figure 1. Fits of Model IA1 to the interim years of SERFS age compositions (top two panels). Selectivity of the SERFS gear, as estimated by the SEDAR-41 assessment model (bottom panel)

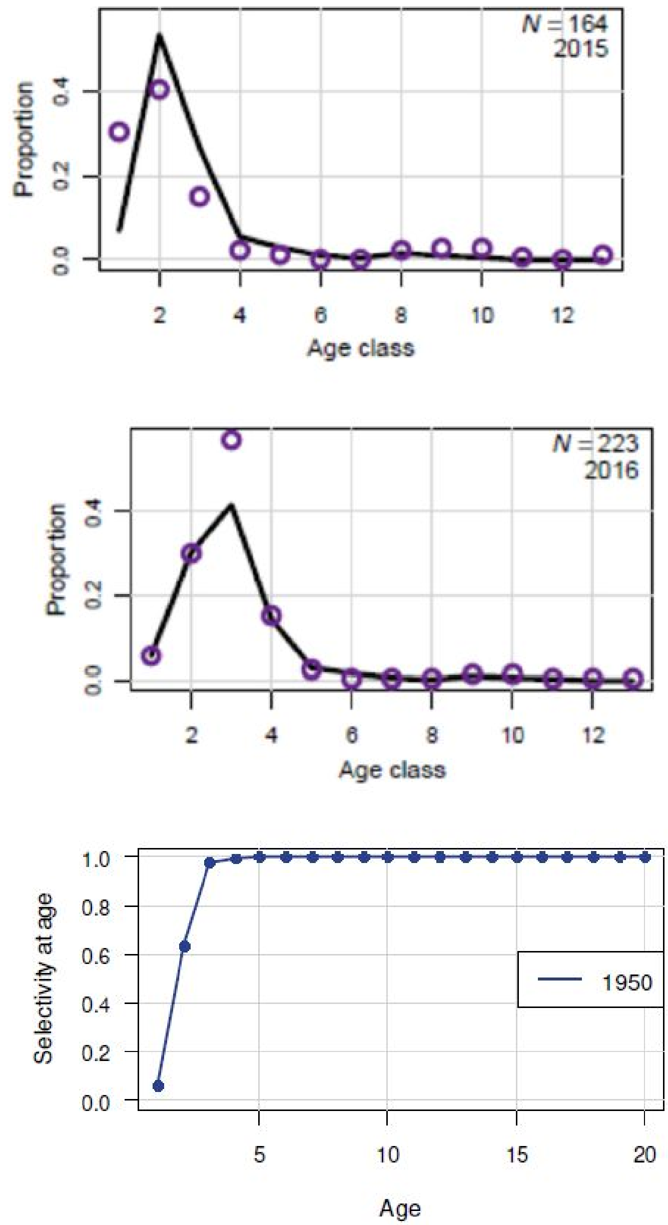


Figure 2. Results from model IA1: spawning biomass relative to that at $F_{30\%}$ (top panel), total abundance of age-2+ fish (middle panel), and F relative to $F_{30\%}$ (bottom panel). In each panel, the solid curve with filled circles represents base-run results, and the dashed line and gray bounds represent median and 95% intervals from the MCB analysis.

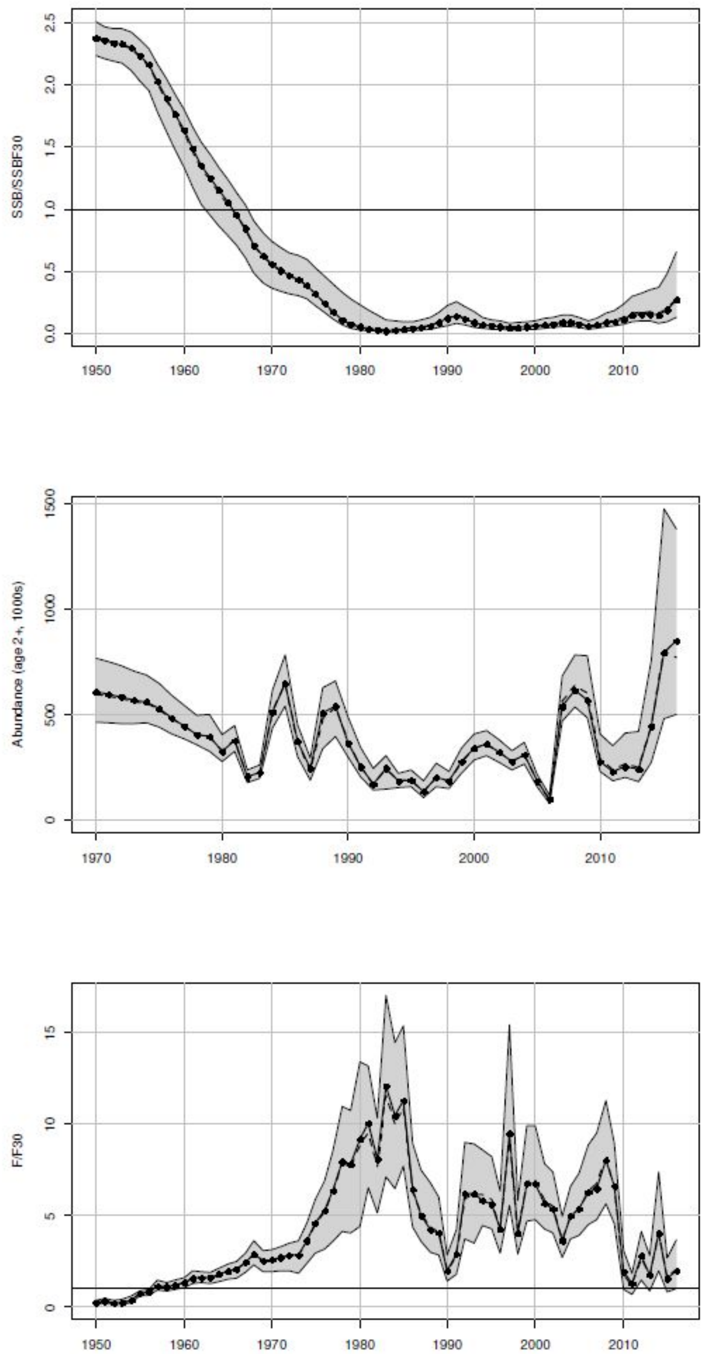


Figure 3. SERFS index of abundance fitted by Models IA1 (top) and IA2 (middle), and generated by Model IA3 (bottom). Model IA3 did not include the index in the objective function.

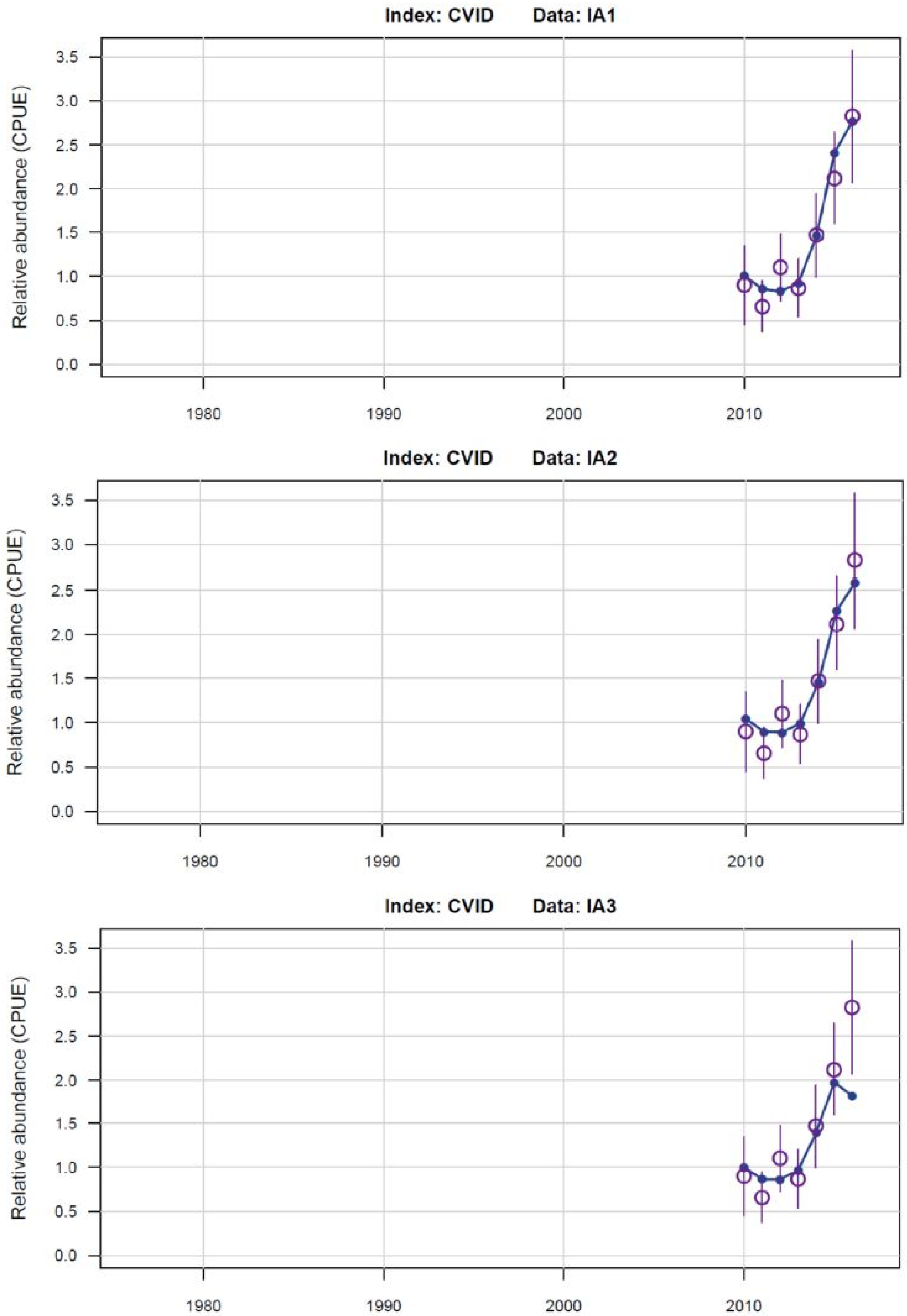


Figure 4. Predicted recruitment since the year 2000 from models IA1, IA2, and IA3 (top panel). Age structure (ages 2–10) in year 2017, as used to initialize population projections (bottom panel).

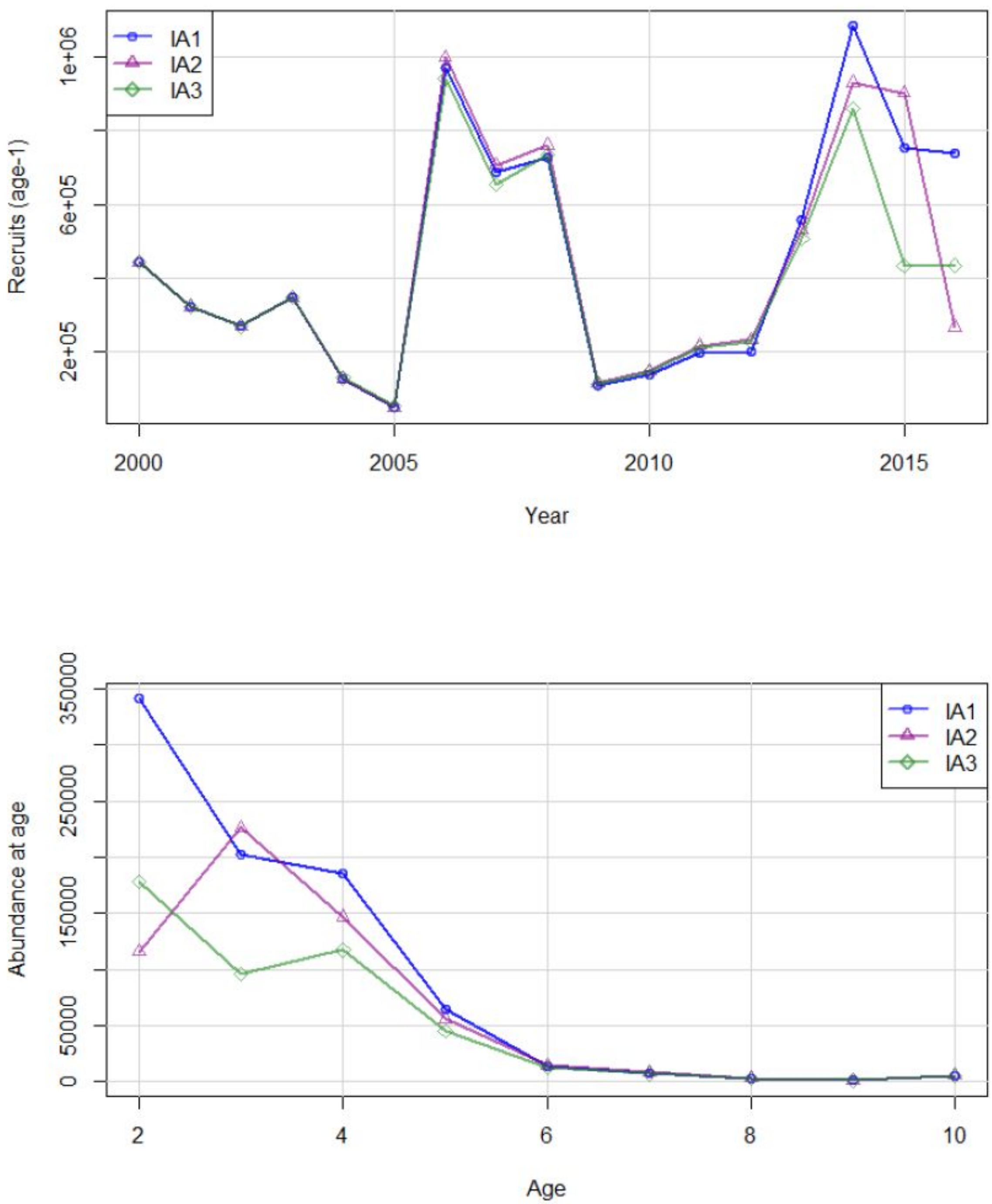
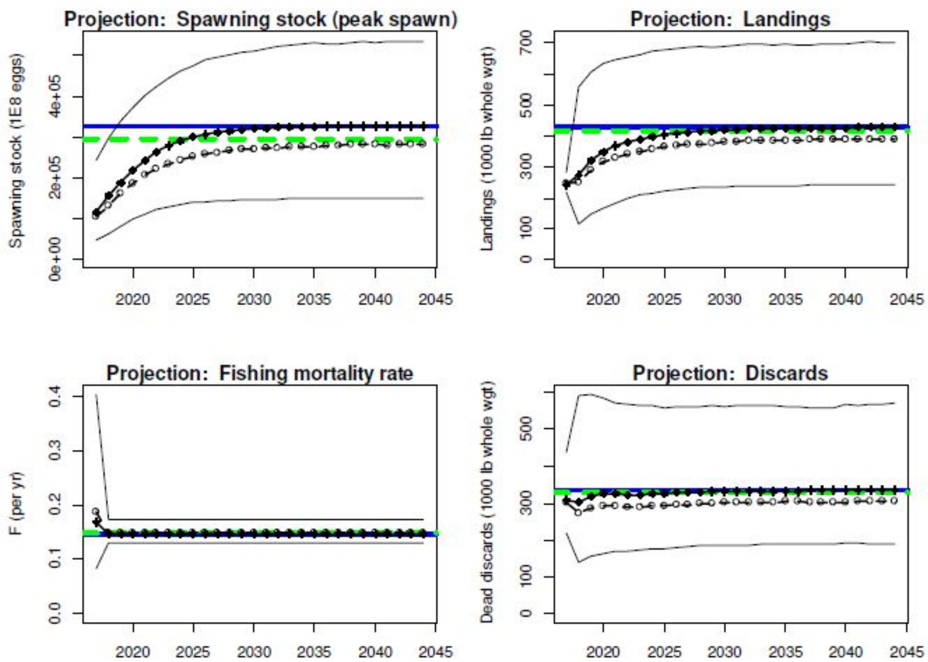


Figure 5. Projection results based on IA1 under Scenario 1, with fishing mortality rate at F = $F_{30\%}$ starting in 2018. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $SSB_{F30\%}$.



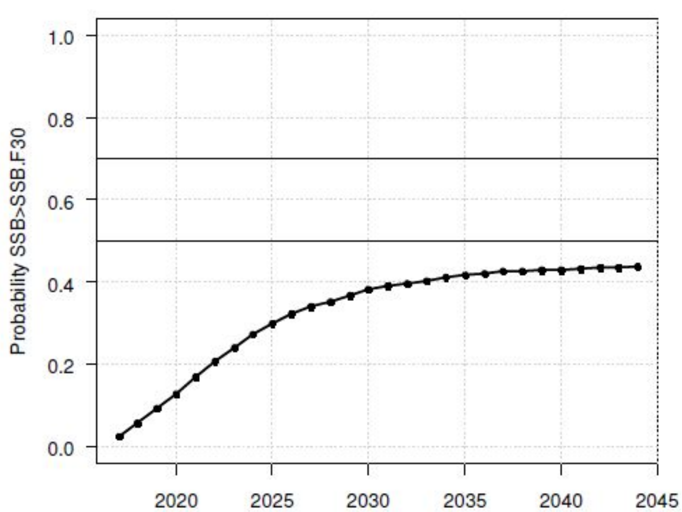
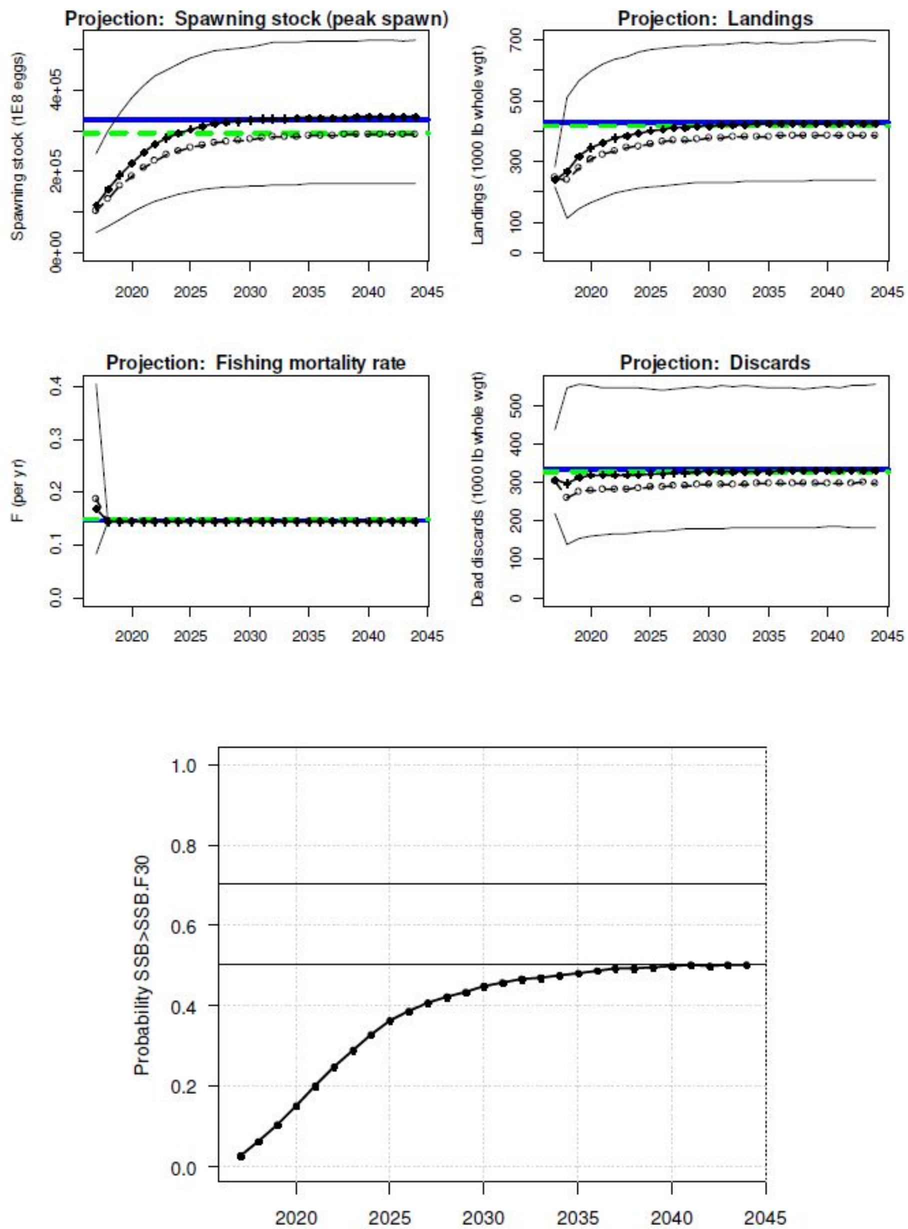



Figure 6. Projection results based on IA1 under Scenario 2, with fishing mortality rate at $F = F_{rebuild}$ starting in 2018. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $SSB_{F30\%}$.



Red Snapper ABC Subcommittee comments

The Center Interim Analysis uses the stock assessment (SEDAR 41), which has been deemed best available science and data, as well as up to date catch, discards, fishery independent index ages, and index values to forecast recruitment cohorts. This analysis allows for up to date information to be used through the terminal year of 2016. While there is uncertainty in the data inputs (similar to the stock assessment) such as MRIP and discards; there is still utility in the analysis. Even with the uncertainties in the data, the Red Snapper ABC subcommittee recommends the Center Interim Analysis method as the preferred method for providing an ABC, as this method updates data to the fullest extent possible, which thereby provides the best available information on recruitment success in the most recent years.

## Stock assessment and projections (SEDAR 41)

The SAFMC SSC requested additional projections of the Red Snapper stock, based on the SEDAR 41 assessment model, for consideration by the SSC Red Snapper ABC subcommittee.

Using the most recent estimates of actual landings and discard estimates for all fleets in 2015 and 2016, this document describes the following two scenarios:

Scenario 1 – Yield based on fishing the stock at the Fmsy proxy (30% SPR) with management taking effect in 2017.

Scenario 2 – Yield based on fishing the stock at $F_{rebuild}$ with management taking effect in 2017.

The most complete data available for 2015 and 2016 landings and discards are shown in Table 1. These data were provided by the SEFSC for each fleet (commercial, headboat, and general recreational from MRIP). The commercial data are electronically reported and have not yet gone through the quality control process in each state.

In the Assessment Workshop projections, average selectivities were used to characterize the fish taken for landings and discards from all fleets throughout the projection time period. Here, fleet-specific selectivities were used for landings and discards to calculate fishing mortality by fleet during the interim period (i.e. the period before new management takes effect). Projection results are shown in Figures 1–2, and tabulated in Tables 2–3.

Table 1. Estimates of landings and discards for Red Snapper in the South Atlantic by fleet in 2015 and 2016.

| | Commercial | | Headboat | | MRIP | |
|---|---|---|---|---|---|---|
| | Landings | Discards | Landings | Discards | Landings | Discards |
| 2015 | 4,762 lb | 31,565 fish | 750 fish | 54,405 fish | 1,111 fish | 508,196 fish |
| 2016 | 4,151 lb | 34,568 fish | 331 fish | 66,511 fish | 72 fish | 788,460 fish |

Table 2. Projection results with fishing mortality rate fixed at $F = F_{30\%}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), B = biomass (mt), S = spawning stock (1E8 eggs), L = landings expressed in numbers (1000s) or whole weight (1000 lb), and D = dead discards expressed in numbers (1000s) or whole weight (1000 lb), pr.rebuild = proportion of stochastic projection replicates with SSB greater than or equal to $SSB_{F30\%}$. The extension .base indicates expected values (deterministic) from the base run; the extension .med indicates median values from the stochastic projections. Highlighted values are those analogous to the fields the SSC has used to set OFL.

| year | R.base(1000) | R.med(1000) | F.base | F.med | B.base(mt) | B.med(mt) | S.base(1E8) | S.med(1E8) | L.base(1000) | L.med(1000) | L.base(1000 lb) | L.med(1000 lb) | D.base(1000) | D.med(1000) | D.base(1000 lb) | D.med(1000 lb) | pr.rebuild |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | 432 | 311 | 0.3 | 0.32 | 1691 | 1592 | 58160 | 53036 | 2 | 2 | 20 | 15 | 172 | 170 | 644 | 658 | 0 |
| 2016 | 435 | 313 | 0.46 | 0.53 | 1824 | 1670 | 69086 | 59429 | 1 | 1 | 7 | 7 | 257 | 253 | 1117 | 1119 | 0 |
| 2017 | 437 | 312 | 0.15 | 0.15 | 1657 | 1454 | 84145 | 70062 | 15 | 13 | 144 | 126 | 34 | 30 | 170 | 147 | 0 |
| 2018 | 439 | 306 | 0.15 | 0.15 | 1936 | 1696 | 105898 | 87154 | 17 | 15 | 177 | 153 | 38 | 33 | 198 | 171 | 0 |
| 2019 | 441 | 315 | 0.15 | 0.15 | 2200 | 1941 | 129158 | 105405 | 20 | 17 | 207 | 181 | 41 | 36 | 223 | 196 | 0.001 |
| 2020 | 443 | 314 | 0.15 | 0.15 | 2440 | 2161 | 153011 | 125626 | 22 | 20 | 241 | 211 | 43 | 38 | 247 | 219 | 0.002 |
| 2021 | 444 | 317 | 0.15 | 0.15 | 2651 | 2363 | 176587 | 145854 | 24 | 22 | 273 | 240 | 44 | 40 | 266 | 237 | 0.009 |
| 2022 | 444 | 314 | 0.15 | 0.15 | 2830 | 2537 | 199019 | 165155 | 26 | 23 | 300 | 266 | 45 | 41 | 280 | 251 | 0.027 |
| 2023 | 445 | 314 | 0.15 | 0.15 | 2980 | 2665 | 219379 | 182332 | 27 | 25 | 323 | 288 | 46 | 41 | 292 | 262 | 0.058 |
| 2024 | 445 | 313 | 0.15 | 0.15 | 3104 | 2776 | 237520 | 197494 | 28 | 25 | 343 | 306 | 47 | 42 | 301 | 270 | 0.099 |
| 2025 | 446 | 315 | 0.15 | 0.15 | 3206 | 2868 | 253248 | 211409 | 29 | 26 | 359 | 322 | 47 | 42 | 308 | 276 | 0.136 |
| 2026 | 446 | 319 | 0.15 | 0.15 | 3290 | 2955 | 266664 | 223484 | 30 | 27 | 372 | 333 | 47 | 42 | 313 | 282 | 0.183 |
| 2027 | 446 | 314 | 0.15 | 0.15 | 3358 | 3018 | 278050 | 233790 | 30 | 27 | 383 | 343 | 47 | 43 | 317 | 286 | 0.225 |
| 2028 | 446 | 317 | 0.15 | 0.15 | 3414 | 3082 | 287470 | 241562 | 30 | 27 | 391 | 351 | 48 | 43 | 320 | 289 | 0.262 |
| 2029 | 446 | 316 | 0.15 | 0.15 | 3458 | 3124 | 295221 | 249426 | 31 | 28 | 398 | 358 | 48 | 43 | 323 | 292 | 0.301 |
| 2030 | 446 | 318 | 0.15 | 0.15 | 3494 | 3152 | 301621 | 255471 | 31 | 28 | 404 | 364 | 48 | 43 | 325 | 293 | 0.33 |
| 2031 | 446 | 318 | 0.15 | 0.15 | 3523 | 3176 | 306819 | 259335 | 31 | 28 | 409 | 368 | 48 | 43 | 327 | 295 | 0.344 |
| 2032 | 446 | 320 | 0.15 | 0.15 | 3546 | 3205 | 311000 | 264020 | 31 | 28 | 412 | 372 | 48 | 43 | 329 | 297 | 0.368 |
| 2033 | 446 | 317 | 0.15 | 0.15 | 3565 | 3229 | 314375 | 267522 | 31 | 28 | 415 | 375 | 48 | 43 | 330 | 298 | 0.383 |
| 2034 | 447 | 319 | 0.15 | 0.15 | 3580 | 3258 | 317080 | 270558 | 32 | 29 | 418 | 378 | 48 | 44 | 331 | 300 | 0.396 |
| 2035 | 447 | 319 | 0.15 | 0.15 | 3591 | 3276 | 319247 | 273033 | 32 | 29 | 420 | 381 | 48 | 44 | 331 | 301 | 0.403 |
| 2036 | 447 | 317 | 0.15 | 0.15 | 3601 | 3288 | 320979 | 276065 | 32 | 29 | 421 | 383 | 48 | 44 | 332 | 303 | 0.416 |
| 2037 | 447 | 319 | 0.15 | 0.15 | 3608 | 3303 | 322356 | 278529 | 32 | 29 | 422 | 385 | 48 | 44 | 332 | 302 | 0.426 |
| 2038 | 447 | 320 | 0.15 | 0.15 | 3614 | 3314 | 323453 | 279138 | 32 | 29 | 423 | 387 | 48 | 44 | 333 | 302 | 0.428 |
| 2039 | 447 | 317 | 0.15 | 0.15 | 3619 | 3317 | 324325 | 279758 | 32 | 29 | 424 | 388 | 48 | 43 | 333 | 303 | 0.431 |
| 2040 | 447 | 314 | 0.15 | 0.15 | 3623 | 3316 | 325018 | 280540 | 32 | 29 | 425 | 389 | 48 | 43 | 333 | 303 | 0.435 |
| 2041 | 447 | 318 | 0.15 | 0.15 | 3626 | 3319 | 325569 | 281107 | 32 | 29 | 425 | 390 | 48 | 43 | 333 | 303 | 0.437 |
| 2042 | 447 | 318 | 0.15 | 0.15 | 3628 | 3331 | 326008 | 282300 | 32 | 29 | 426 | 389 | 48 | 44 | 333 | 303 | 0.441 |
| 2043 | 447 | 316 | 0.15 | 0.15 | 3630 | 3323 | 326356 | 282074 | 32 | 29 | 426 | 390 | 48 | 44 | 334 | 303 | 0.44 |
| 2044 | 447 | 316 | 0.15 | 0.15 | 3631 | 3325 | 326633 | 281476 | 32 | 29 | 426 | 389 | 48 | 44 | 334 | 303 | 0.438 |

Table 3. Projection results with fishing mortality rate fixed at F = $F_{rebuild}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), B = biomass (mt), S = spawning stock (1E8 eggs), L = landings expressed in numbers (1000s) or whole weight (1000 lb), and D = dead discards expressed in numbers (1000s) or whole weight (1000 lb), pr.rebuild = proportion of stochastic projection replicates with SSB greater than or equal to $SSB_{F30\%}$. The extension .base indicates expected values (deterministic) from the base run; the extension .med indicates median values from the stochastic projections.  Highlighted values are those analogous to the fields the SSC has used to set ABC.

| year | R.base(1000) | R.med(1000) | F.base | F.med | B.base(mt) | B.med(mt) | S.base(1E8) | S.med(1E8) | L.base(1000) | L.med(1000) | L.base(1000 lb) | L.med(1000 lb) | D.base(1000) | D.med(1000) | D.base(1000 lb) | D.med(1000 lb) | pr.rebuild |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | 432 | 311 | 0.3 | 0.32 | 1691 | 1592 | 58160 | 53036 | 2 | 2 | 20 | 15 | 172 | 170 | 644 | 658 | 0 |
| 2016 | 435 | 313 | 0.46 | 0.53 | 1824 | 1670 | 69086 | 59429 | 1 | 1 | 7 | 7 | 257 | 253 | 1117 | 1119 | 0 |
| 2017 | 437 | 312 | 0.14 | 0.14 | 1657 | 1454 | 84429 | 70448 | 14 | 12 | 139 | 119 | 33 | 28 | 164 | 138 | 0 |
| 2018 | 439 | 306 | 0.14 | 0.14 | 1943 | 1703 | 106769 | 88233 | 17 | 14 | 171 | 146 | 36 | 31 | 191 | 162 | 0 |
| 2019 | 441 | 315 | 0.14 | 0.14 | 2213 | 1959 | 130783 | 107879 | 19 | 16 | 201 | 172 | 39 | 34 | 216 | 186 | 0.001 |
| 2020 | 443 | 314 | 0.14 | 0.14 | 2462 | 2191 | 155516 | 128933 | 21 | 19 | 234 | 202 | 41 | 36 | 239 | 209 | 0.003 |
| 2021 | 444 | 317 | 0.14 | 0.14 | 2679 | 2410 | 180062 | 150545 | 24 | 21 | 266 | 231 | 43 | 38 | 258 | 227 | 0.011 |
| 2022 | 444 | 314 | 0.14 | 0.14 | 2866 | 2585 | 203515 | 171370 | 25 | 22 | 294 | 258 | 44 | 39 | 273 | 241 | 0.04 |
| 2023 | 445 | 314 | 0.14 | 0.14 | 3022 | 2724 | 224896 | 190096 | 27 | 24 | 317 | 280 | 45 | 40 | 284 | 252 | 0.078 |
| 2024 | 445 | 313 | 0.14 | 0.14 | 3153 | 2851 | 244027 | 206555 | 28 | 25 | 336 | 298 | 45 | 40 | 293 | 261 | 0.122 |
| 2025 | 446 | 315 | 0.14 | 0.14 | 3261 | 2936 | 260684 | 221223 | 28 | 25 | 353 | 313 | 45 | 40 | 300 | 266 | 0.172 |
| 2026 | 446 | 318 | 0.14 | 0.14 | 3350 | 3025 | 274953 | 234208 | 29 | 26 | 366 | 325 | 46 | 41 | 305 | 272 | 0.226 |
| 2027 | 446 | 314 | 0.14 | 0.14 | 3422 | 3097 | 287111 | 244764 | 29 | 26 | 377 | 335 | 46 | 41 | 310 | 277 | 0.28 |
| 2028 | 446 | 317 | 0.14 | 0.14 | 3481 | 3163 | 297212 | 253878 | 30 | 27 | 386 | 345 | 46 | 41 | 313 | 280 | 0.325 |
| 2029 | 446 | 316 | 0.14 | 0.14 | 3529 | 3206 | 305557 | 261926 | 30 | 27 | 393 | 351 | 46 | 41 | 316 | 282 | 0.355 |
| 2030 | 446 | 318 | 0.14 | 0.14 | 3568 | 3237 | 312476 | 268501 | 30 | 27 | 399 | 357 | 46 | 41 | 318 | 284 | 0.387 |
| 2031 | 447 | 318 | 0.14 | 0.14 | 3599 | 3270 | 318118 | 274049 | 31 | 27 | 404 | 362 | 46 | 41 | 320 | 285 | 0.408 |
| 2032 | 447 | 320 | 0.14 | 0.14 | 3624 | 3300 | 322676 | 278199 | 31 | 28 | 408 | 366 | 46 | 41 | 322 | 288 | 0.425 |
| 2033 | 447 | 317 | 0.14 | 0.14 | 3644 | 3321 | 326369 | 281477 | 31 | 28 | 411 | 369 | 47 | 42 | 323 | 289 | 0.438 |
| 2034 | 447 | 319 | 0.14 | 0.14 | 3660 | 3351 | 329342 | 284833 | 31 | 28 | 413 | 373 | 47 | 42 | 324 | 291 | 0.453 |
| 2035 | 447 | 319 | 0.14 | 0.14 | 3673 | 3366 | 331733 | 287730 | 31 | 28 | 415 | 375 | 47 | 42 | 324 | 292 | 0.468 |
| 2036 | 447 | 317 | 0.14 | 0.14 | 3684 | 3382 | 333651 | 290349 | 31 | 28 | 417 | 377 | 47 | 42 | 325 | 294 | 0.476 |
| 2037 | 447 | 320 | 0.14 | 0.14 | 3692 | 3395 | 335183 | 292558 | 31 | 28 | 418 | 379 | 47 | 42 | 325 | 294 | 0.488 |
| 2038 | 447 | 320 | 0.14 | 0.14 | 3698 | 3398 | 336407 | 294572 | 31 | 28 | 419 | 382 | 47 | 42 | 326 | 294 | 0.496 |
| 2039 | 447 | 317 | 0.14 | 0.14 | 3704 | 3400 | 337385 | 295413 | 31 | 28 | 420 | 382 | 47 | 42 | 326 | 295 | 0.502 |
| 2040 | 447 | 314 | 0.14 | 0.14 | 3708 | 3412 | 338166 | 295843 | 31 | 28 | 421 | 384 | 47 | 42 | 326 | 295 | 0.505 |
| 2041 | 447 | 319 | 0.14 | 0.14 | 3711 | 3417 | 338789 | 296341 | 31 | 28 | 421 | 385 | 47 | 42 | 327 | 294 | 0.507 |
| 2042 | 447 | 318 | 0.14 | 0.14 | 3714 | 3418 | 339286 | 296755 | 31 | 28 | 422 | 384 | 47 | 42 | 327 | 295 | 0.51 |
| 2043 | 447 | 316 | 0.14 | 0.14 | 3716 | 3419 | 339683 | 297088 | 31 | 28 | 422 | 385 | 47 | 42 | 327 | 294 | 0.511 |
| 2044 | 447 | 316 | 0.14 | 0.14 | 3718 | 3423 | 340000 | 297058 | 31 | 28 | 422 | 384 | 47 | 42 | 327 | 295 | 0.511 |

Figure 1. Projection results under scenario 1—fishing mortality rate at $F = F_{30\%}$ starting in 2017. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $SSB_{F30\%}$.

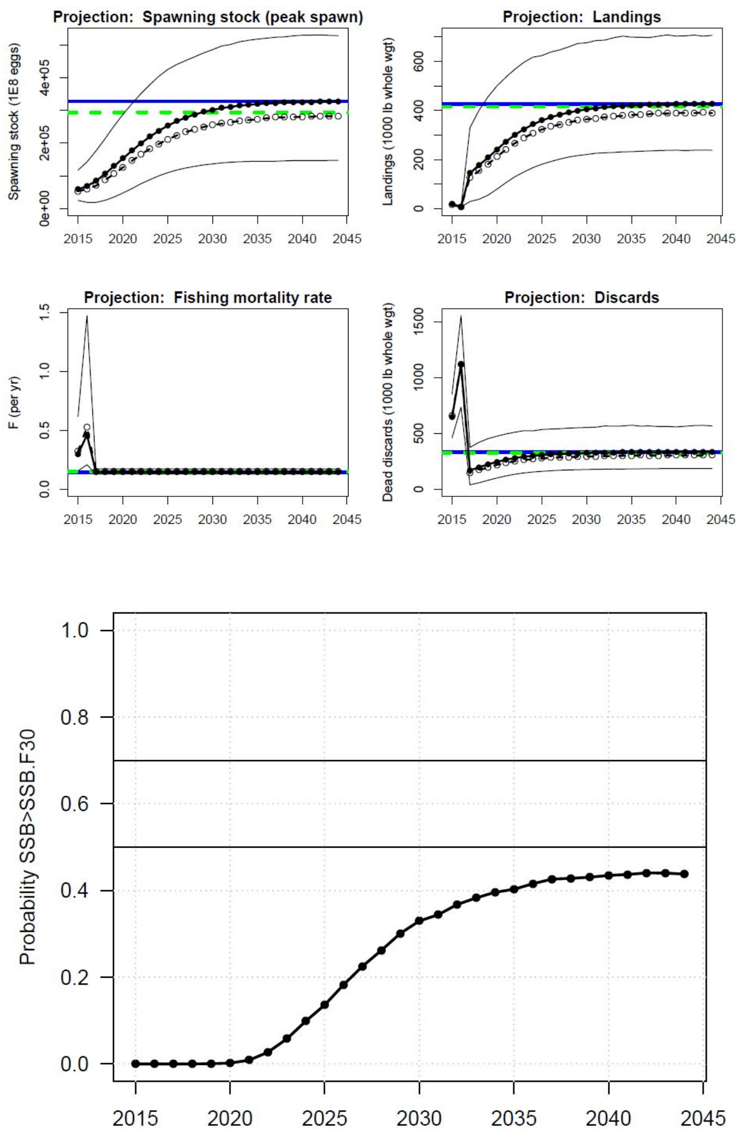
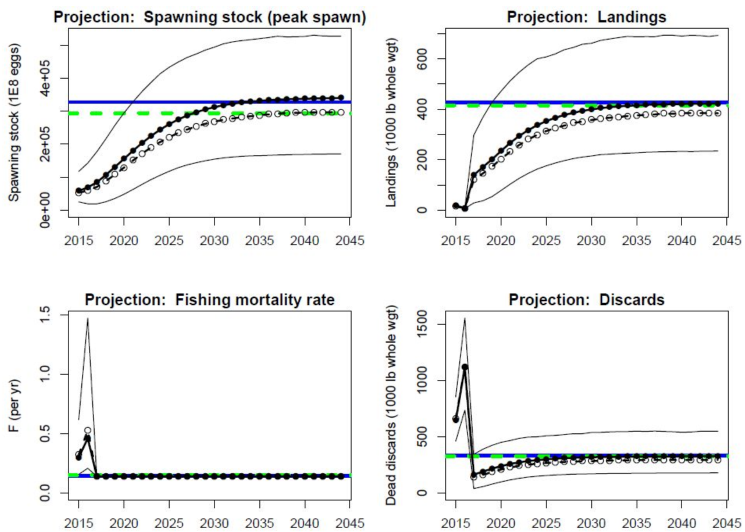
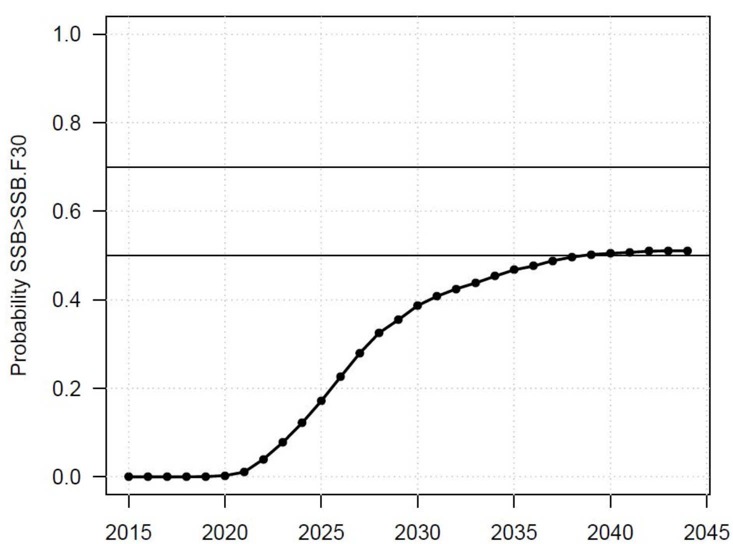


Figure 2. Projection results under scenario 2—fishing mortality rate at $F = F_{rebuild}$ starting in 2017, with rebuilding probability of 0.5 in 2044. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $SSB_{F30\%}$.



Red Snapper ABC Subcommittee comments

The stock assessment (SEDAR 41) and subsequent projections represent the use of the best available science and data to the terminal year of the assessment, which is 2014. The SSC and independent Center for Independent Expert Reviewers both deemed SEDAR 41 to be BSIA (best scientific information available). The projection analyses further update the best available science and data through the terminal year of 2016. While the projection analysis uses the updated catch and discards, the analysis does not use updated index age data and index data as seen in the Center Interim Analysis above. In addition, there is uncertainty in the data inputs (similar to the Center Interim Analysis) such as MRIP and discards. Even with the uncertainties in the stock assessment and projections, the Red Snapper ABC subcommittee recommends this method for providing an ABC; however, the preferred recommended method is the Center Interim Analysis.

## Data Limited Methods (DLM)

When assessing the utility of Data Limited Methods (DLM), it is important to consider the main assumption behind each method. In general most DLMs that do not rely on a relative abundance index assume that some semblance of equilibrium between fishing effort and stock size has been reached or that the stock in question is in decline. For South Atlantic Red Snapper the population is under rebuilding and therefore violates this assumption. In addition, most data limited methods do not take advantage of all available data for a stock.

The following section is intended to provide information on available data limited methods (DLMs) that can be applied to Red Snapper in the South Atlantic. Many of the methods have been implemented in some form in the R package DLM-toolkit. Much of the information in this document has been taken from the NRDC report by Newman et al. (2014) Improving the science and management of data limited fisheries: an evaluation of current methods and recommended approaches. Each section has the main references for the methods used, a summary of the methods, and when available a MSE performance evaluation of the methods. Given the data available for South Atlantic Red Snapper all methods presented below can be implemented.

Average catch methods

*AvC: Average catch over entire catch time series*
*CC1: Average catch over most recent 5 years of catch time series*
*CC4: 70% of average catch over most recent 5 years of catch time series*

*Method Description*

Utilized recent catches to set OFL.

*MSE evaluation*

MSE evaluation of average catch methods can be found in Carruthers et al. (2014). Carruthers et al. (2014) indicate that when **biomass ratios (ratio of $B_{current}$ to $B_0$) are moderate to low**, all average catch methods performed the worst (in terms of yield and potential for stock collapse) of all data poor a simple assessment method evaluated. This result suggest that average catch methods should be used with caution if the stock in question is assumed to be overfished. For stocks not overfished the average catch methods performed as well as other methods. These were developed assuming a period of stable catch such that the population is near an equilibrium.

The following is an excerpt from Restrepo et al. 1998 that provides a recommendation on how to provide catch advice using and average catch method based on the assumed status of the stock.

If there is no reliable information available to estimate fishing mortality or biomass reference points, it may be reasonable to use the historical average catch as a proxy for MSY, taking care to select a period when there is no evidence that abundance was declining.

*Recommended data-poor defaults*

In data-poor cases it is recommended that the default limit control rule be implemented by multiplying the average catch from a time period when there is no quantitative or qualitative evidence of declining abundance ("Recent Catch") by a factor depending on a qualitative estimate of relative stock size:

Above *BMSY*: Limit catch = 1.00*(Recent catch)
Above MSST but below *BMSY*: Limit catch = 0.67*(Recent catch)
Below MSST (i.e., overfished): Limit catch = 0.33*(Recent catch)

The multipliers 1.0, 0.67 and 0.33 were derived by dividing the default precautionary target multipliers below, in order to maintain the 0.75 ratio recommended as the default distance between the limit and target reference points for stocks above (1-*M*)**BMSY*. Since it probably will not be possible to determine stock status relative to *BMSY* analytically, an approach based on "informed judgement" (e.g., a Delphi approach) may be necessary.

In data-poor cases, the default policy may be interpreted qualitatively as follows:

Above *BMSY* : Target catch = 0.75*(Recent catch)
Above MSST but below *BMSY*: Target catch = 0.50*(Recent catch).
Below MSST (i.e., overfished): Target catch = 0.25*(Recent catch).

<u>SPMSY - Catch Trend Surplus Production MSY</u>

*Method Description*

SPMSY - Catch Trend Surplus Production MSY uses Martell and Froese (2012) method for estimating MSY to determine the OFL. Their approach estimates stock trajectories based on catches and a rule for a Schaefer production model intrinsic rate of increase and assumed depletion levels. Given their surplus production model predicts K, r, and depletion, it is straightforward to calculate the OFL for any replicate based on the Schaefer productivity curve as the estimated level of depletion in the final year of the catch time series times the associated carrying capacity and half the associated intrinsic rate of increase. This method requires max age, the von Bertalanffy K parameters and age at maturity to determine the range of r values to use. The default range for K depends on r and has a lower bound of the mean of the catch time series divided by r and an upper bound of 10 times the mean of the catch time series divided by r. Given assumed depletion levels at the start and the end of the time series, catch is removed for each r and K combination and r and K are selected if the stock falls within the specified depletion range at the end of the time series of catch. The default value for the stock depletion are based on catch.

*MSE evaluation*

Martell and Froese (2012) found reasonable agreement between MSY estimates produced from stock assessment and those from the SPMSY methods with most estimates falling between 0.5 and 1.5 of those from stock assessment. It is unclear how the default depletion levels in the DML tool kit relate to those used in Martell and Froese (2012).

<u>Mean length methods</u>

*Fdem_ML: Demographic FMSY and Mean Length*
*YPR_ML: Yield Per Recruit F0.1 and Mean Length*

*Method description*

Both Fdem_ML and YPR_ML utilize the Gedamke and Hoenig (2006) non-equilibrium method for determining instantaneous total mortality rate (Z). Within the DLM tool kit a single break point is identified within a time series of mean length creating period 1 and period 2. Total mortality is then estimated for each period (Z1, Z2) based on the minimization of a negative lognormal likelihood between the observed mean length and those predicted using the Gedamke and Hoenig (2006) equation. Instantaneous mortality (M) is then subtracted from Z to estimate instantaneous fishing mortality (F). Exploitation rate (hr) in the final year is calculated as hr=1-exp(-F) and biomass (B) in the final year is estimated from the catch (C) in the final year over the estimated exploitation rate B=C/hr. Both methods then use this biomass to determine the OFL as (1-exp(-Fmsy))*B.

The methods differ in how Fmsy is estimated. *Fdem_ML* uses demographic information and a range of steepness(h) within routines that solve the Euler-Lotka equation for the instantaneous rate of population increase (r) and then estimate Fmsy as r/2. Note that steepness is needed to back calculate recruits-per-spawner assuming a Beverton-Holt stock recruitment curve. Estimate YPR_ML uses F 0.1 as a proxy for Fmsy which requires the estimation of yield-per-recruit.

*MSE evaluation*

There has been no formal evaluation of the performance of data limited mean length methods. Some work at the Northwest center indicate poor performance of the methods when mean length data has no clear trend and is noisy. The main issue with noisy data is the difficulty in defining breakpoints and the estimation of negative F values when the trend in the mean length is determined to be positive.

<u>Depletion-Based Stock Reduction Analysis DBSRA</u>

*Method description*

DB-SRA (Dick and MacCall, 2011) samples the ratio of FMSY/M, M, BMSY/B0 and current stock depletion. Given the historical catches, each sample of these parameters can be used to numerically solve for unfished biomass B0 (age-at-maturity is also required to lag the delay-difference model). The OFL is calculated as (depletion*B0*FMSY*M). Variations on the method can assume depletion is at 40% or use changes in mean length (Gedamke and Hoenig 2006) to determine current stock depletion based on a non-equilibrium estimate of fishing mortality rate derived from mean length data. May also utilize a 40-10 rule.

*MSE evaluation*

Carruthers et al. (2014) found reasonable performance of DB-SRA, in particular when biomass was assumed at 40% of Bo, when stock depletion levels were near Bmsy, conservative performance when levels were <50% of Bmsy and poor performance when stock biomass was greater that 100% of Bmsy.

Depletion-Corrected Average Catch DCAC

*Method description*

The stochastic version of DCAC (MacCall, 2009) samples depletion over a given time period t, FMSY/M, M, BMSY/B0. Coupled with average catches over the time period t, DCAC seeks to calculate the average catches while accounting for the catch that went towards reducing the stock to productive levels (the "windfall harvest"). DCAC has been used to derive OFLs, but is not in fact an OFL method, as it does not account for low stock size. Previously, DCAC has been evaluated according to the similarity among DCAC estimates and MSY (the OFL at BMSY). Variations on the method can assume depletion is at 40% or use changes in mean length (Gedamke and Hoenig 2006) to determine current stock depletion based on a non-equilibrium estimate of fishing mortality rate derived from mean length data. May also utilize a 40-10 rule.

*MSE evaluation*

Carruthers et al. (2014) found reasonable performance of DCAC, in particular when biomass was assumed at 40% of Bo, when stock depletion levels were near Bmsy, conservative performance when levels were <50% of Bmsy and poor performance when stock biomass was greater that 100% of Bmsy.

Beddington and Kirkwood Life-History Analysis

*Method description*

In their simplest approach, Beddington and Kirkwood (2005) approximate FMSY using just the von Bertalanffy growth coefficient K, maximum length and length-at-first capture. Sets an OFL according to current abundance. This method can also be combined to use a naive catch curve analysis to estimate current abundance based on catches and recent F or use changes in mean length (Gedamke and Hoenig 2006) to determine current stock depletion based on a non-equilibrium estimate of fishing mortality rate derived from mean length data.

FMSY to M Ratio (FRATIO)

*Method description*

FMSY is estimated to be equal to a fraction of M (*e.g.*, 0.5), which is then multiplied by a current estimate of abundance (Gulland, 1971). Can be combined with a naive catch curve extension to estimate current abundance based on catches and recent F or use changes in mean length (Gedamke and Hoenig 2006) to determine current stock depletion based on a non-equilibrium estimate of fishing mortality rate derived from mean length data.

*MSE evaluation*

Carruthers et al. (2014) found poor performance when using Fratio methods.

Catch Curve Estimation

*Method description*

Age-composition of catches contains information about total mortality rate Z (Beverton and Holt, 1957). In a naive catch curve analysis, frequency of observations increases with age (older individuals are increasingly vulnerable to fishing) after which the decline in the frequency of observations with age can be interpreted as total mortality Z under equilibrium assumptions and will not perform well if vulnerability is dome shaped selectivity or if there have been marked temporal changes in recruitment. Several updates to the naïve catch-curve analysis have been proposed to reduce bias or incorporate the ascending limb of the vulnerability curve.

*MSE evaluation*

Simulation testing generally favors the simplest implementation due to the simulation of problematic catch composition samples.

Yield Per Recruit Analysis

*Method description*

Given a stock-recruitment relationship, a growth curve and a vulnerability schedule it is possible to derive the fishing mortality rate that maximizes the yield obtained per recruit. Since this estimate may be unstable under certain simulated conditions, the Toolkit estimates FMSY as F10% which is the fishing mortality rate corresponding to the ascending YPR curve at 10% of the gradient of the origin. This method can be extended to include estimates of current fishing mortality rates from catch curve analysis or use changes in mean length (Gedamke and Hoenig 2006).

Surplus Production Stock Reduction Analysis

*Method description*

A prior for r (intrinsic growth rate) is derived demographically using steepness, maturity and growth parameters. Similarly, to DB-SRA, this approach can be used to numerically solve for unfished biomass (carrying capacity K) given a depletion estimate. The method can be extended using the mean length extension (Gedamke and Hoenig, 2006) to determine current stock depletion based on a non-equilibrium estimate of fishing mortality rate derived from mean length data.

Demographic FMSY

*Method description*

A prior for r (intrinsic growth rate) is derived demographically using steepness, maturity and growth parameters (McAllister, Pikitch, and Babcock, 2001). The method can be extended using the mean length extension (Gedamke and Hoenig, 2006) to determine current stock depletion based on a non-equilibrium estimate of fishing mortality rate derived from mean length data.

Catch Composition – Stock Reduction Analysis

*Method description*

This approach uses the final three years (or less) of catch-at-age data. The SRA method removes annual catches according to a knife-edge vulnerability curve and seeks to numerically solve for the unfished biomass that fits the observed catch-at-age data. The method samples M, steepness, age at full selection, and the growth parameters to get a numerically derived B0 (and current stock size) for each sample. These same inputs can be used to numerically solve for FMSY providing a sample of the OFL. The family of stock reduction analysis (SRA) models is widely used to calculate sustainable harvest levels given a time series of harvest data. SRA works by solving the catch equation given an assumed value for spawning biomass relative to unfished levels in the final (or recent) year and resulting estimates of recent fishing mortality are biased when this assumed value is mis-specified. Compositional data in recent years is used to estimate a catch curve and hence estimating fishing mortality in those years.

*MSE evaluation*

Results confirm that the SRA yields biased estimates of current fishing mortality given mis-specified information about recent spawning biomass, and that the catch curve is biased due to changes in fishing mortality over time. CC-SRA, by contrast, is approximately unbiased for low or moderate recruitment variability, and less biased than other methods given high recruitment variability. We therefore recommend CC-SRA as a data-poor assessment method that incorporates compositional data collection in recent years, and suggest future management strategy evaluation given a data-poor control rule.

Length-based Integrated Mixed Effects (LIME)

*Method description*

This Length-based Integrated Mixed Effects (LIME) method at a minimum requires a single year of length data and basic biological information but can fit to multiple years of length data, catch, and an abundance index if available. The method does not require an equilibrium assumption and incorporates time-varying recruitment and fishing mortality.

*MSE evaluation*

Testing demonstrates that LIME can estimate how much fishing has reduced spawning output in the most recent year across a variety of scenarios for recruitment and fishing mortality. LIME improves data-limited fisheries stock assessments by its flexibility to incorporate additional years or types of data if available and obviates the need for equilibrium assumptions.

Red Snapper ABC Subcommittee comments

Overall, the DLM methods are easy to calculate; however, the DLM methods are not the best available science that will use the best available data for Red Snapper. DLM methods generally do not work well when a stock is recovering, the fishery is small or closed, the data are noisy, or the stock is overfished. Finally, the DLM method requires similar information to the stock assessment, but would go down a tier in the control rule, which is undesirable. Given these limitations, the Red Snapper ABC subcommittee does not recommend this method for providing an ABC.

## Index methods used at other Science Centers

Overview of index-based methods used by other NOAA Fisheries Centers

NOAA Fisheries Science Centers employ a variety of index-based methods to determine stock status and ABCs recommendations. Several stocks assessed by the NEFSC have ABCs that are set either by the NEFMC SSC or the MAFMC SSC using survey data and catch history as the primary sources of information. In all such cases, the survey used spans a time period during which the stock was either not exploited or only lightly exploited such that the stock was not negatively impacted by harvest. For these stocks, ABCs are set using MSY proxies generated during the assessment process from abundance index and catch data, and are not set independent of the overall stock assessment.

For example, management of the windowpane flounder stocks use the NEFSC bottom trawl survey data and information regarding relative F generated by the AIM (An Index Method) modeling package to help determine ABCs (https://www.nefsc.noaa.gov/publications/crd/crd1717/). This approach involves setting an ABC based on a proxy for MSY that is generated by either examining the trend in replacement ratio from the survey data and identifying a period where it is around 1, or by using the median catch during a reference period in which fishing did not result in index declines. Both an index of abundance and catch covering the same time period of low exploitation are required. This approach assumes survey catchability has not changed over the assessment period and can be sensitive to relative *F* smoothing decisions. The advantage of such an approach is that it leverages a long time series of reliable catch and an index of abundance to generate ABCs using very little data. Also, the AIM package has (limited) uncertainty and projection capabilities. However, it is questionable whether this type of survey information is available and suitable for use in managing Red Snapper. The SSC has not reviewed the use of AIM or other survey-based relative *F* approaches to help set ABCs in the South Atlantic.

Other stocks such as ocean pout and skates use survey and catch history to help set ABCs without the use of AIM due to a lack of a significant relationship between relative *F* and the replacement ratio (https://www.nefsc.noaa.gov/publications/crd/crd0204/crd0204.pdf, https://www.nefsc.noaa.gov/publications/crd/crd0902/skates/skateText.pdf). This approach involves selecting MSY by calculating the median landings during a reference period in which fishing did not result in index declines and setting ABCs based on that MSY proxy. The seven stocks in the Skate complex use survey data in slightly different ways to set the ABCs, but all require a long time series of relative abundance.

In addition to the survey-based methods described above, the recommended ABC for surf clam is set using a recent catch level that is believed to have been sustained by the stock historically and shown to have caused no harm based on examination of the estimates generated by a Stock Synthesis assessment model (https://www.nefsc.noaa.gov/publications/crd/crd1705/). This ABC is recommended for three years. Survey data, including CPUE indices and swept area estimates of biomass, catch records, and spatial distribution of the fishery are examined by the SSC as interim metrics of stock status. The SAFMC SSC has reviewed some methods for using average catch to set ABCs, but not this exact method or the use of interim metrics. This approach is easy to calculate, but, as with several of the methods described above, would require SSC examination of a suite of survey, model, and other data sources to determine an historical catch level that did not cause harm to the stock.

Alternatively, the NEFSC uses survey biomass expanded to population biomass through a catchability estimate along with an exploitation rate to derive an ABC (see https://www.nefsc.noaa.gov/saw/trac/ for the latest assessment) for Georges Bank yellowtail flounder, Gulf of Maine winter flounder, and Gulf of Maine witch flounder. The basic model of abundance is based on empirical measures of abundance and assumed parameters as follows $N = (A_d / ap_d)(I_t/e)$, where $N$ is the estimated total population, $I_t$ is the index of abundance expressed as numbers or weight per tow, $A_d$ is the total area within the sampling domain, $a$ is the average area swept per tow, $p_d$ is the fraction of the total area within the population domain, (i.e., $p_d=A_d/A$ where $A$ is the total area where the stock resides), and $e$ is the efficiency of the gear, expressed as probability of capture given encounter. While this method is straightforward, it does require data that are unavailable for Red Snapper. Specifically, an absolute biomass metric is not available to the SAFMC SSC for Red Snapper nor is a known estimate of survey catchability.

The NEFSC also has a survey smoothing approach that modifies recent catch according to changes in the survey. This approach has been used for both Georges Bank cod (https://www.nefsc.noaa.gov/publications/crd/crd1717/), Eastern Georges Bank cod (https://www.nefsc.noaa.gov/saw/trac/), and Monkfish (https://www.nefsc.noaa.gov/publications/crd/crd1609/crd1609.pdf), although in slightly different forms. The approach is currently under consideration by the NEFMC SSC for application to Southern New England Mid-Atlantic yellowtail flounder. This method is an expansion of the methods used for Georges Bank yellowtail flounder and requires an absolute biomass metric and an estimate of survey catchability, which is unavailable for South Atlantic Red Snapper. Note that this method has been used to address severe retrospective patterns.

Finally, the NEFSC is currently considering a method termed Rcrit for Atlantic halibut (document: Halibut-Assessment-Report-draft-12-01-17.pdf), which builds off of the Georges Bank cod index based method described above. The Rcrit method is used to determine if the differences seen over the duration of an index, specifically at the end of a time series, are significantly different. The method is outlined in the reference document on page 13 of the pdf. If the change in the index is significantly different, then an estimate of the catchability is needed to determine the scale or magnitude of the change. "While Rcrit provides a way of quantifying the rate of change in population size, it cannot distinguish the change in scale. For example a population that increase 3 fold during some period could increase from 2% to 6% of the virgin stock size for from 20 to 60%." (reference document). Thus, in order to use the Rcrit method an index that has a long time series and continues until the end of the time series is needed, as well as an estimate of catchability to determine the scale of the change and historic fishing mortality rates. This type of method has not been reviewed by the South Atlantic SSC, nor are data available for Red Snapper to adequately use this method.

In addition to the NEFSC, the NWFSC determines an ABC for Pacific Sardine using sea surface temperature (SST) to specify an $E_{MSY}$, which is then used to related to an OFL and ABC. The assessment can be found here: (http://www.pcouncil.org/wp-content/uploads/2017/05/Appendix-C-2017-sardine-assessment-NOAA-TM-NMFS-SWFSC-576.pdf), and a brief description of this approach is in the executive summary (pages 13-14). The SAFMC SSC has not reviewed methods for determining an ABC while using an environmental factor. While the approach is rather straight foward, no specific link between Red Snapper and an environmental factor has been identified. Thus, this methods cannot be used.

The other Science Centers were consulted on ways in which they determine ABCs, but their methods were similar to what has already been done in the South Atlantic.

Consideration of available Red Snapper indices

The Red Snapper ABC subcommittee assessed the appropriateness of the indices available for Red Snapper. Questions to discuss included: do any indices cross MSY or $B_{MSY}$, have catch at MSY, AND evidence that catch was not negatively impacting stock. The Red Snapper ABC subcommittee had the following comments:

- No reliable estimate of MSY available. Proxies for MSY and $B_{MSY}$ are landings at $F_{30\%}$ ($L_{F30\%}$) and $B_{F30\%}$, respectively, as in SEDAR 41. MSY proxy= 427 (1,000 lb), $B_{MSY}$ proxy=3,637 mt (SEDAR 41 pdf p. 722)
- Four indices used in final base run (Table 1, Figure 1). Several additional indices considered at data workshop are shown below in Table 1.
- Potential time frames for defining reference period of relatively low Red Snapper exploitation:
    - 1950-1953 when L largely $<L_{F30\%}$ (Figure 2)
    - 1950-1965 when $B>B_{F30\%}$ (Figure 3)
    - 1950-1965, if SSB relative to $SSB_{30\%}$ (327,706 eggs) is also considered as a metric of low impact (Figure 3)
    - 1950-1976 if h=0.84 and SSB relative to $SSB_{30\%}$ is also considered as a metric of low impact (Figure 4). This was also a period of expanded age structure as indicated by headboat landings weight vs. number and estimated biomass at age (Figure 5).
- Conclusion: No individual index covers both an obvious period of low exploitation and recent years. If the mid-70s can be considered a period of light exploitation with relatively low negative impact on stock, generation of a long-term composite index could be explored for use in setting an ABC. However, issues regarding differing selectivities among long-term and recent surveys (e.g. headboat vs. CVID) would need to be resolved.
- Recommendation: No index sufficiently addresses the questions posed above.

**Table 1**. Summary of available indices. RS=Red Snapper.

| Index | FI or FD | Start Year | Last year with reliable RS catch | Covers period of low exploitation/impact | Used in base run |
|---|---|---|---|---|---|
| Headboat[1] | FD | 1976 | 2009 | Maybe? | Yes |
| Headboat discards[1] | FD | 2005 | present | No | Yes |
| Handline[1] | FD | 1993 | 2009 | No | Yes |
| CVID[1] | FI | 2010 | present | No | Yes |
| SERFS CVT[2] | FI | 1990 (2010+ used in assmt. due to expansion of survey) | present | No | No |
| SERFS VID[2] | FI | 2010 | present | No | No |
| Headboat at sea observer[4] | FD | 2005/2010 | 2009/2013 | No | No |
| SC logbook[4] | FD | 1993 | 2013 | No | No |
| MRFSS/MRIP[4] | FD | 1982 | Present | No | No |
| Headboat logbook[4] | FD | 1995 | 2009 | No | No |

1. SEDAR41_SA_RS_SAR_REVISION1_Final_4.24.2017
2. SEDAR41_DW06_Ballenger_etal._RSChevronTrapIndicesWithAddendum_8.19.2014
3. SEDAR41_DW04_Purcell_etal._RSVideoIndex_7.31.2014
4. SEDAR 41. 2014. SEDAR 41 Indices of Abundance Report Cards. SEDAR41-DW39. SEDAR, North Charleston, SC. 75 pp.

**Figure 1**. From AW Report Addendum II Figure 1 (SEDAR 41 pdf p. 732)

*Figure 1. Indices of abundance used in fitting the assessment model. HB indicates the headboat logbook index; Handline indicated the the commercial handline logbook index; HB Disc indicated the headboat discard observer index, CVT indicates the SERFS chevron trap index; VID indicates the SERFS video index, and CVID indicates the combined chevron trap and video index. The CVT and VID indices were only used during sensitivity runs.*

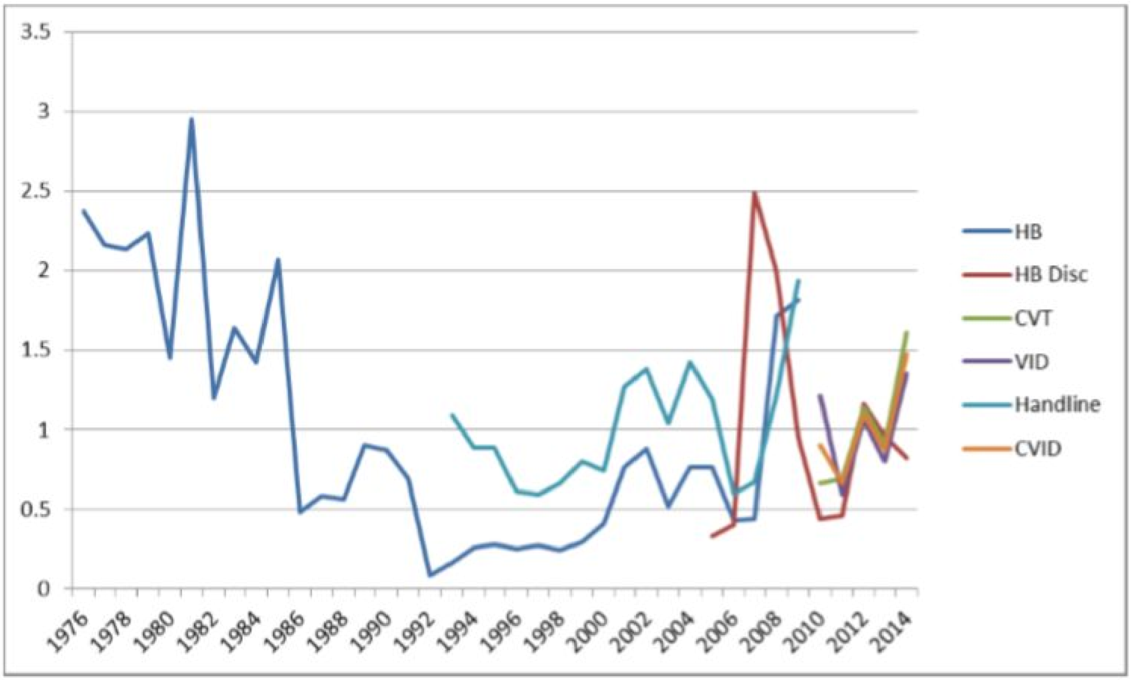


**Figure 2**. From AW Report Addendum II Figure 28 (SEDAR pdf p. 764)

*Figure 28. Estimated landings in numbers by fleet from the catch-age model. cH refers to commercial handlines, HB to headboat, and GR to general recreational. Horizontal dashed line in the top panel corresponds to the point estimate of $L_{F30\%}$ in numbers.*

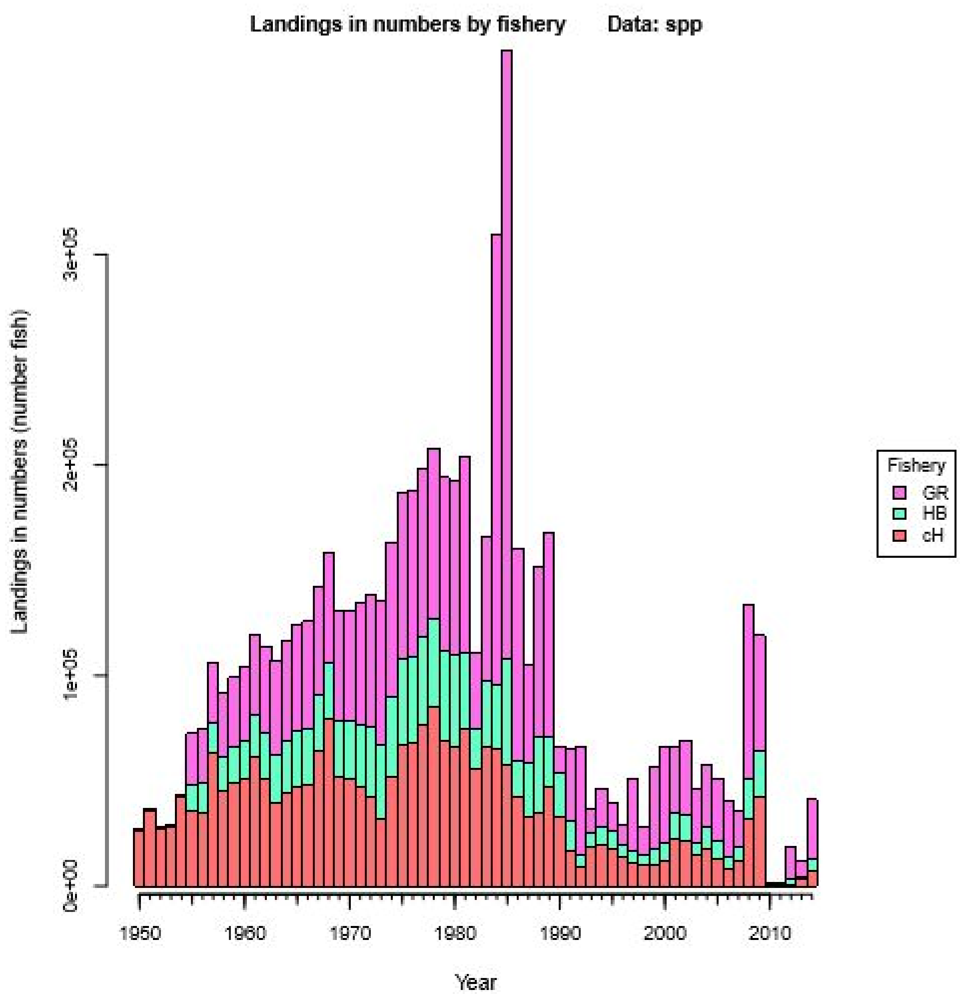
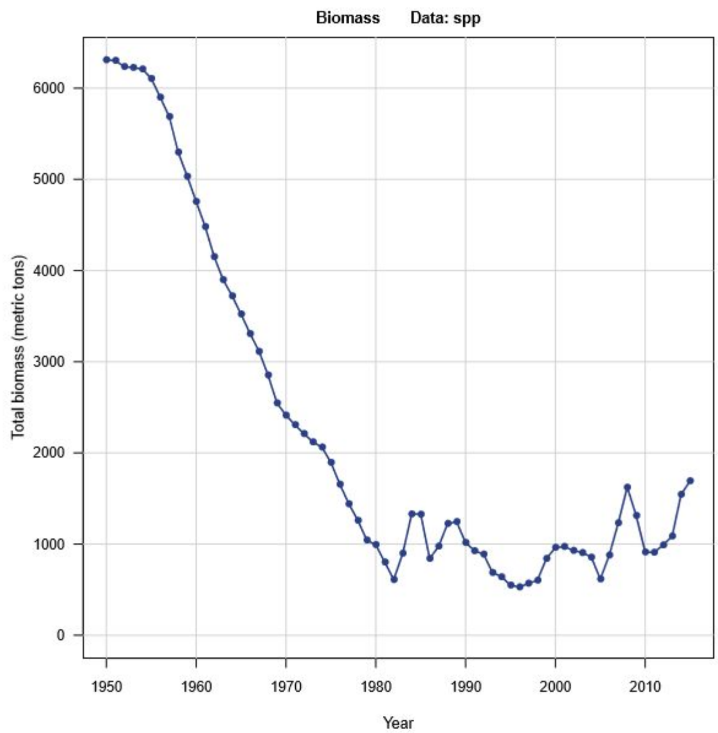


**Figure 3**. From AW Report Addendum II Figure 17 (SEDAR 41 pdf p. 753)

*Figure 17. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates $B_{F30\%}$. Bottom panel: Estimated spawning stock (population fecundity) at time of peak spawning.*



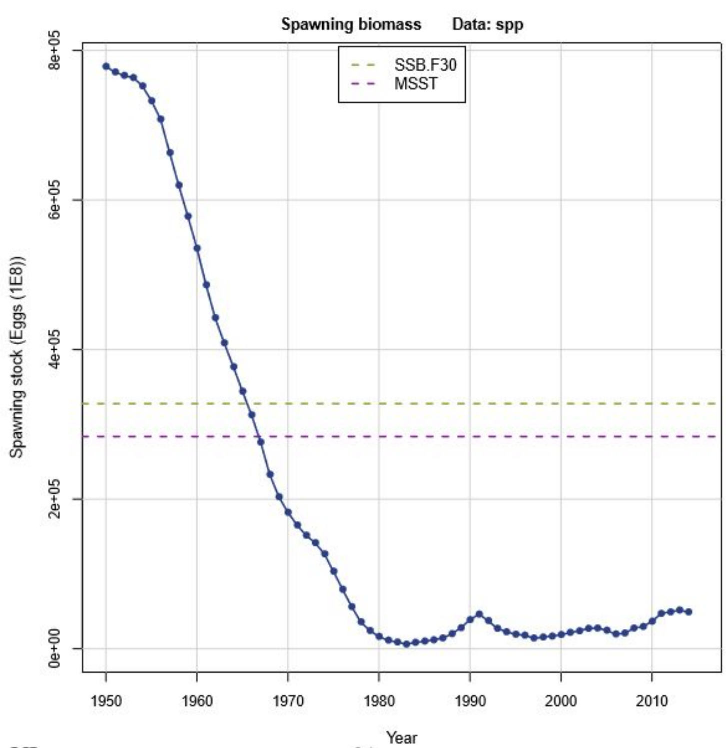



**Figure 4**. Bottom panel from AW Report Figure 42 (SEDAR pdf p. 778)

*Figure 42. Sensitivity to steepness (sensitivity run S11). Top panel: Ratio of $F$ to $F_{30\%}$. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

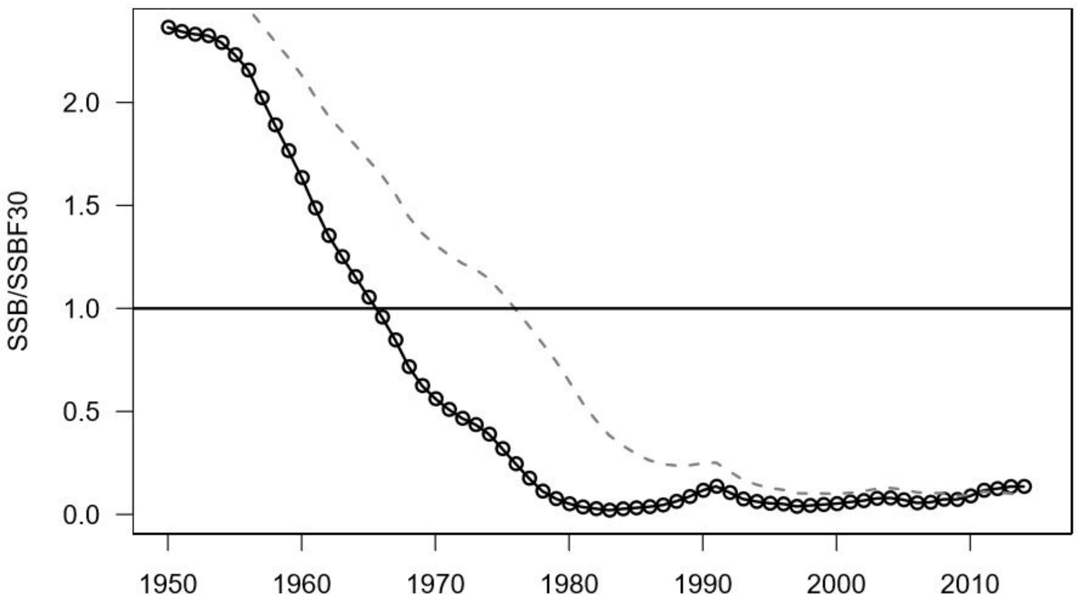


**Figure 5**. Top panel from DW Report Figure 4.11.3 (SEDAR 41 pdf p. 255); bottom panel from AW Report Addendum II Figure 16 (SEDAR 41 pdf p. 751).

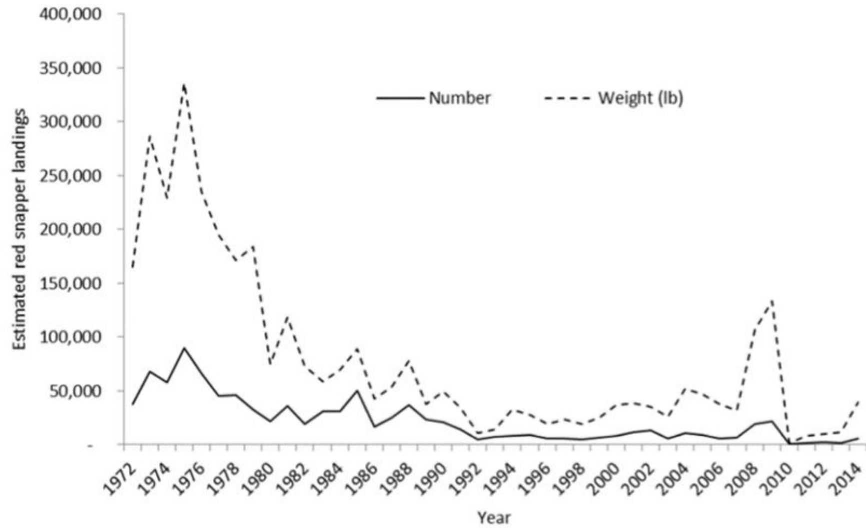
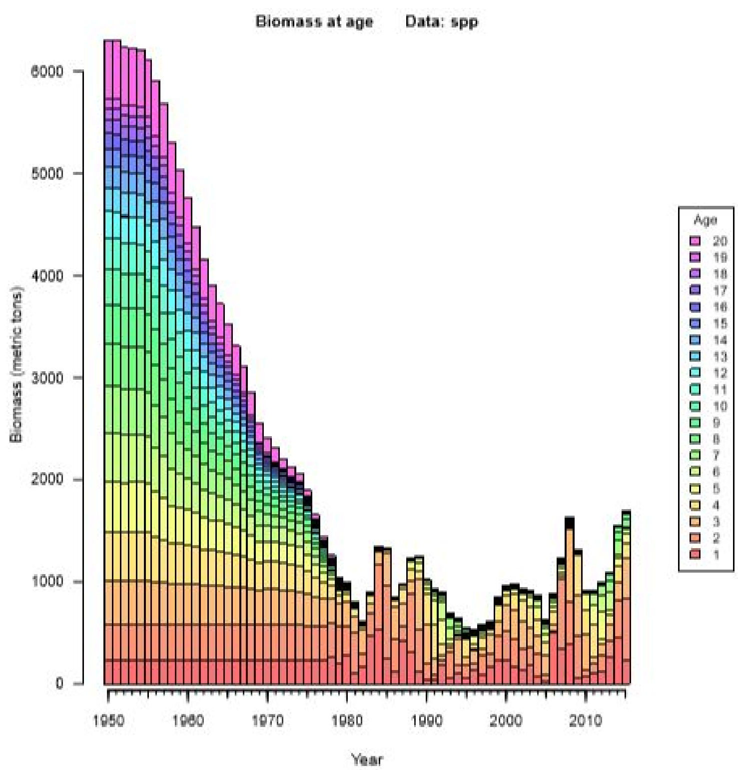



**Figure 4.11.3.** South Atlantic estimated red snapper landings (number and pounds) for the headboat fishery, 1972-2014.

*Figure 16. Estimated biomass at age at start of year.*



Red Snapper ABC Subcommittee comments

Indices could be used in one of two ways to set an ABC: 1) if the scale is known, then the index could be related to population size directly or 2) in an ad hoc way where catch is set and then you watch whether the index is increasing, stable, or decreasing and then adjust catch accordingly. Each of these options is currently unavailable for Red Snapper. For the first option, to know the scale of the index, you would need an absolute index of abundance (for Red Snapper, we have relative indices of abundance) or you would need to know the catchability of the index (which can not be estimated outside of the stock assessment with the available data). For the second option, management would need to be in place long enough to account for the time lag in management and recruitment of fish to the fishery versus index in order to determine if the management had impacted the population dynamics such that the population size was increasing, stable, or decreasing. The overall consensus of the discussion was that none of the indices for Red Snapper had a long time series for use and that none of the indices had the auxiliary information available to make then useful in an index based method. The committee did want to note that the indices are useful on a relative scale and have been used for the Red Snapper stock assessment (and have been used for many other stock assessments in the South Atlantic). Additionally, the increase in the indices for Red Snapper at the end of the time series may not be actual increases and could be the result of observation error. The committee did recognize that the Headboat index could be useful for comparative evidence in that the ABC should not be set larger than the catch observed during the 1970s. Given these limitations, the Red Snapper ABC subcommittee does not recommend this method for providing an ABC

## Amendments 43 and 46

Snapper-Grouper (SG) Amendment 43

The total removals of Red Snapper (landings plus dead discards) in the South Atlantic exceeded the ABC in 2014, 2015 and 2016. The accountability measure (AM), set forth in SG Amendment 28, sets the ACL to zero if total removals exceed the ABC in the previous year. As a result, no harvest for this species was allowed in three successive years (2015-2017). The purpose of SG Amendment 43 is to revise the methodology for determining the ACL for Red Snapper to allow for fishing access during a short mini-season (Appendix 1). This change is proposed to reduce the adverse socioeconomic effects of the year-round fishery closures and to provide managers access to valuable biological data (age- and size- structure, selectivity, etc.), while still preventing overfishing and continued stock rebuilding. The general rationale is that during the recent period when harvest was allowed (2012-2014), the chevron index (and presumably stock abundance) increased in the subsequent years, indicative of continued stock rebuilding despite this level of removals. Thus, it is inferred that current levels of stock abundance are sufficient to support a limited harvest while preventing overfishing and allowing the stock to continue rebuilding.

SG Amendment 43 proposes a suite of alternative methods for setting the ACL in the SA Red Snapper fishery either based directly on observed landings from the 2012-2014 mini-seasons or these landings as adjusted using available fishery independent indices (MARMAP and SEFIS; Appendix 1). Specifically, there are five alternatives: (1) no action, (2) ACL = average observed landings from 2012-2014, (3) ACL = average observed landings from 2012-2014 multiplied by 1.88, (4) ACL = highest observed landings from 2012-2014, (5) ACL = highest observed landings from 2012-2014 multiplied by 1.88. The adjustment factor (1.88) used in alternatives 3 and 5 is based on fishery independent surveys (MARMAP and SEFIS), which indicate a proportional increase in stock size of 1.88 when comparing the index values from 2012-2014 ( $\bar{x} = 0.875$) to those in 2015-2016 ($\bar{x} = 1.645$, Figure 1).

Snapper-Grouper (SG) Amendment 46

Amendment 46 was separated from Amendment 43 and does not address the setting of an ACL for Red Snapper management. Rather, Amendment 46 looks to better snapper-grouper data by considering recreational fishery permits and electronic reporting, among other options.

Red Snapper ABC Subcommittee comments

The subcommittee discussed the SG Amendment and identified a number of concerns with the proposed rationale and methodology. In each case, a general summary of the issue is followed by relevant comments captured during the webinar process.

- The committee noted that the methodology, while relatively straightforward, had not undergone any form of formal peer review and that currently available data are probably not sufficient to adequately validate the method.
    - *Not been through any peer review.*
    - *Overall, currently data are unavailable to determine if this method is sufficient to provide a sustainable ABC or ACL (see **Index methods used at other Science Centers** section for further details on needed information to provide an ACL or ABC when using an index).*
- There was concern that the index may not be suitable to estimate stock biomass. The chevron trap index, while valuable, only provides an estimate of numbers of fish. As such, this index may not capture changes in population biomass and demography that may be more reliable indicators of stock productivity. Further, the index could suffer from some of the same issues common to many indices (e.g., violations of proportionality).
    - *Age structure of indices and the age structure of the catch potentially do not match up. Might be a mismatch between increasing indices and what can be caught. Not considering time lags.*
    - *Simple, rough estimate that does not consider important demographic factors.*
    - *Assumes a linear relationship between index and catch, which is unlikely to exist.*
    - *Suffers from some of the same problems the other index based methods suffer from (see **Index methods used at other Science Centers** section for further details on needed information to provide an ACL or ABC when using an index).*
- The subcommittee also noted potential issues with the implementation of the proposed alternatives in SG Amendment 43. Firstly, the method infers that current levels of stock abundance are sufficient to support a limited harvest while preventing overfishing and allowing the stock to continue rebuilding. Stated alternatively, landings from 2012-2014 are assumed to be sustainable, which may not be the case. The committee also raised significant concerns regarding the index-derived scalar used to inflate catches in Alternatives 3 and 5. In particular, (1) the relationship between the index and harvest is uncertain, and (2) the degree to which observed increases in the index reflect measurement error versus actual abundance is not known. Lastly, while two of the

proposed Alternatives increase catch concomitant with the index, there is no mechanism to reduce harvest if the index declines over time.

  - *Assuming 2012-2014 was at a sustainable fishing level.*
  - *A change of 1.88 can simple be measurement error. We don't have a good understanding of the relationship between the index and harvest. Concerns about the level of noise contained within the index itself.*
  - *Concerns that if the index decreased that there is no accountability to decrease the catch in the current Amendment.*
- Given these limitations, the Red Snapper ABC subcommittee does not recommend this method for providing an ABC

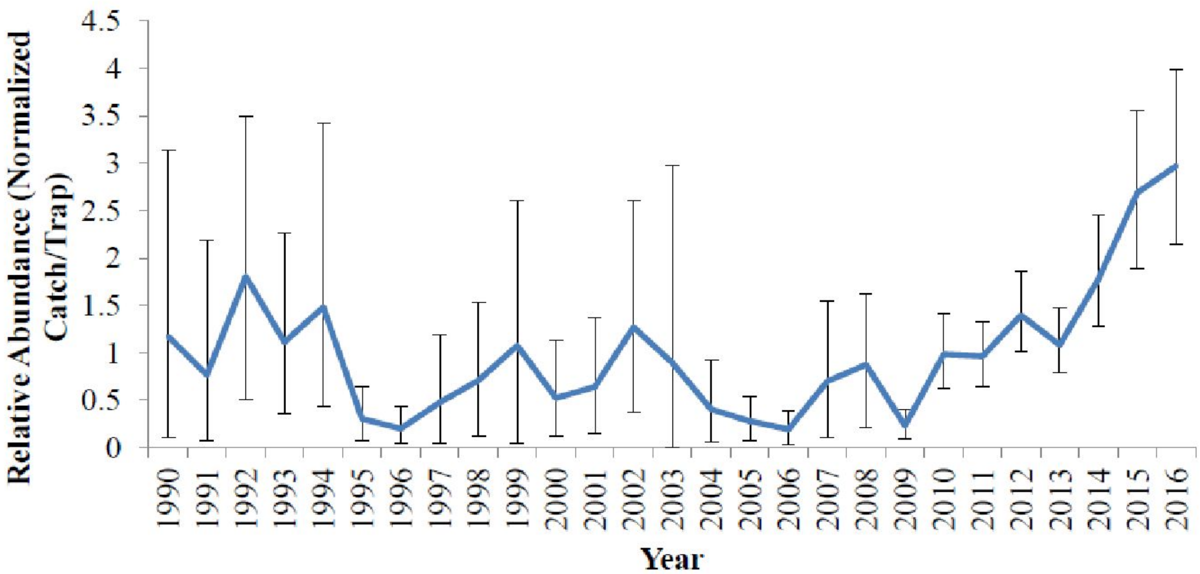



Figure 1. Relative abundance of Red Snapper collected in chevron traps in the South Atlantic Region calculated using methods developed in SEDAR 41 (2017). (Reprinted from SG Amendment 43)

Actions considered in SG Amendment 43

**Appendix 1.** Amendment 43 to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region (Amendment 43) proposes the following action for Red Snapper:

**1. Revise the Process to Determine the Annual Catch Limits (ACL) for Red Snapper.**

**Alternative 1 (No Action)**. The commercial and recreational ACLs for Red Snapper are zero. The process and formula established in Snapper Grouper Amendment 28 specifies current fishing year annual catch li Service determines that the previous year's estimated Red Snapper landings and dead discards are less than the acceptable biological catch.

**Alternative 2**. Remove the process and equation used to determine the Red Snapper ACL as specified in Snapper Grouper Amendment 28. Specify a total annual catch limit equal to 23,623 fish. Commercial annual catch limit equals 69,360 pounds (whole weight) and recreational annual catch limit equals 16,480 fish.

**Alternative 3**. Remove the process and equation used to determine the Red Snapper ACL as specified in Snapper Grouper Amendment 28. Specify a total annual catch limit equal to 44,411 fish. Commercial annual catch limit equals 130,396 pounds (whole weight) and recreational annual catch limit equals 30,982 fish.

**Alternative 4**. Remove the process and equation used to determine the Red Snapper ACL as specified in Snapper Grouper Amendment 28. Specify a total annual catch limit equal to 42,510 fish. Commercial annual catch limit equals 124,815 pounds (whole weight) and recreational annual catch limit equals 29,656 fish.

**Alternative 5**. Remove the process and equation used to determine the Red Snapper ACL as specified in Snapper Grouper Amendment 28. Specify a total annual catch limit equal to 79,919 fish. Commercial annual catch limit equals 234,652 pounds (whole weight) and recreational annual catch limit equals 55,753 fish.

**Note: In Alternatives 2 through 5, the sector annual catch limits were calculated using the established allocation in the Comp ACL Amendment (2011). The allocation is 28.07% commercial and 71.93% recreational based on weight.**

# Current monitoring of the Red Snapper ACL

The Red Snapper ACL is set before the beginning of each fishing year. When the Council passed Amendment 28 to the Snapper-Grouper FMP, they established a process for determining whether there would be a directed Red Snapper fishing season in any given year as well as the ACL for that season based on the catch and discards of the previous season. According to Amendment 28, NOAA should use the following formulas for calculating the ACL for Red Snapper each fishing year where ABC is the acceptable biological catch, yr is year of the proposed season and estCSR is the estimated closed season removals:

$$\textit{If total removals}_{yr-1} > ABC_{yr-1}\textit{, then } ACL_{yr} = 0$$

$$\textit{If total removals}_{yr-1} < ABC_{yr-1}\textit{, then}$$

$$ACL_{yr} = \left(\frac{ABC_{yr-2} - estCSR_{yr-2}}{ABC_{yr-2}} + \frac{ABC_{yr-1} - estCSR_{yr-1}}{ABC_{yr-1}}\right)/2 \times ABC_{yr}$$

Total removals are the sum of the following numbers and derived from the data sets noted:

1. Commercial landings and associated dead discards: commercial dealer reports, due weekly
2. Recreational headboat landings and associated discards: Southeast Regional Headboat Survey
3. Recreational private and charter landings and discards when Red Snapper *is not* open: MRIP converted to Marine Recreational Fisheries Statistics Survey (MRFSS) equivalent estimates because the current South Atlantic Red Snapper ABC is based in part on the MRFSS landings
4. Recreational private and charter landings and discards when Red Snapper *is* open: individual states do additional monitoring because the PSEs are too large for MRIP to be used for in-season monitoring. FL has additional phone calls to charters, boat counts at inlets to estimate offshore effort, and additional dockside and ramps efforts with direct sampling from caught fish. SC has additional sampling with drop off for carcasses (http://www.dnr.sc.gov/marine/carcassdropoff.html). GA and NC also do some additional sampling with recreational port agents. Landings from these efforts are added together and become the official landings history for the directed recreational fishery.

The Council changes its method for determining the ACL with the September 2016 passage of the Emergency Action for 2017 landings and Amendment 43 for 2018 landings in the absence of an ABC recommendation from the SSC. However, the landings estimates are still calculated as described above.

Future changes in quota monitoring

Commercial catch data is sufficiently timely in that there are no immediate plans to require changes in Red Snapper reporting. For the recreational Red Snapper fisheries, there are two potential changes, one further developed than the other.

The first change is for the charter fisheries. The Council passed a comprehensive amendment to require electronic reporting from charter captains in December 2016. This amendment is currently before the Secretary. Charter captains would have to turn in weekly reports for species caught and discarded from the snapper-grouper, dolphin wahoo, and coastal pelagic fisheries. A pilot study is already underway to test a tablet application. More information can be found at http://safmc.net/satl-federal-for-hire-electronic-reporting-outreach/

The second change is for anglers undertaking private trips. The material in Snapper Grouper Amendment 46 was originally split off from Amendment 43. The need for the Amendment 46 is "to improve data collection for snapper grouper species, reduce bycatch of Red Snapper and other snapper grouper species". Part of this amendment may require a permit with reporting requirements for private anglers. Council staff is in the process of developing a mobile phone app, MyFishCount, that will allow anglers to electronically report information on landed and discarded fish caught during recreational trips. This is a long term project that would eventually supplement ongoing recreational fishing sampling like MRIP. Pilot tests were done during the fall 2017 Red Snapper mini seasons to test the survey instruments, and the SSC's Socioeconomic Panel gave some feedback on survey structure and incentives to increase participation. The SSC will review these results in the May 2018 meeting. More information can be found at https://www.myfishcount.com/2017 and http://safmc.net/electronic-reporting-projects/red-snapper-reporting/.

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# List of additional supplementary information

*S1 RS ABC charge and scope of work*
    *Charge and scope of work for the subcommittee*
*S2 Agendas and notes*
    *Agendas and notes from the meetings of the RS ABC subcommittee*
*S3 Center Interim Analysis Report*
    *Draft report on the Center Interim Analysis provided by the SEFSC*
*S4 SEDAR 41 final stock assessment report*
    *Final stock assessment report from SEDAR 41*
*S5 Projections requested*
    *Draft report of projections requested by the subcommittee*
*S6 Summary of red snapper indices*
    *Summary of the available red snapper indices that were considered for use in index based methods*
*S7 Red snapper index working papers*
    *Zip file containing all of the working documents on the red snapper indices considered during SEDAR 41*
*S8 Center Index based methods*
    *Zip file containing all of the supporting documentation for the index based methods used at the various Science Centers*
*S9 Amendment 43*
    *Copy of the Snapper-Grouper Amendment 43*