Center for Independent Experts (CIE) Independent Peer Review Report

SEDAR 41 South Atlantic Red Snapper and South Atlantic Gray Triggerfish Assessment Review Workshop

By

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Executive Summary

The SEDAR41 panel review workshop (RW) on South-Atlantic red snapper and grey triggerfish assessments was competently chaired, and conducted in a spirit of cooperation and teamwork. The assessments were subject to a rigorous and very open peer review process that identified the most likely sources of uncertainty. I agree with the consensus of the panel that the Beaufort Assessment Model (BAM) used as the base model in these assessments is appropriate, and that the best available data were used. The BAM is an age -structured population model that is fit to data from fishery-dependent and fishery-independent surveys, such as landings, discards, indices of abundance, age compositions, and length compositions. The data used in the assessment were generally sound and robust, and the data were generally applied properly and uncertainty in data inputs was appropriately acknowledged. A range of sensitivity analyses were used to check if the stock status determinations hold for a wide range of data decisions, model assumptions and model configurations. The model was run for a plausible range of values for each factor. However, it should be noted that the sensitivity testing by alternating one factor at a time, although commonly done, may not fully reflect the uncertainty in model outputs from a complex model such as BAM with a large number of parameters where many are likely to be correlated. During the extensive extra analysis for both stocks in response to requests at the RW it was revealed that the ages of fish caught in the Chevron trap were based on the number of annuli alone and not correctly standardized to calendar-year age. This error had minor effects for red snapper, but caused large bias in the age-compositions for grey triggerfish.

South-Atlantic Red Snapper

The RW Panel was presented outputs and results of the SEDAR 41 South Atlantic red snapper stock assessment. Numerous sensitivity analyses and exploration of alternative scenarios were presented during the RW. Because of the errors discovered in age-compositions from the Chevron trap survey, it was agreed in the RW that the BAM base model runs should be rerun with corrected age composition data. The “new” base model and associated sensitivity runs could not be fully evaluated during the RW and a follow-up webinar on 8 April 2016 was necessary to continue discussion of projections and finalize the SEDAR 41 RW process. Unfortunately, I could not participate in this webinar, and thus I rely on the summary report. The new base model results and all sensitivity runs support the conclusion that the Atlantic Red Snapper stock is overfished and that overfishing is occurring. However, there were significant areas of uncertainty identified in assessment results. Of particular concern was the uninformative stock-recruitment relationship, poor estimates of discards by age class, likely changes in CPUE catchability due to changes in fishing behavior in response to a moratorium on fishing and other regulations, and the incomplete spatial coverage of the stock by the different fishery fleets. After the 2010 moratorium, recreational discards of red snapper are one of the most important yet most uncertain sources of information. Also, a strong retrospective pattern in apical F indicates the base BAM is very sensitive to terminal year of data and suggests high uncertainty in exploitation status. The small effects of varying one factor at a time in the sensitivity runs may be due to many model-parameters being correlated.

South Atlantic Grey Triggerfish

The RW Panel was presented outputs and results of the SEDAR 41 South Atlantic Gray triggerfish stock assessment from the Assessment Workshop. In general, the best available data were used in the assessment. However, the status of the grey triggerfish could not be properly evaluated during this RW because of the error discovered in the age composition data from the Chevron Trap survey that were used in the base configuration of the BAM used in the assessment. The corrected age compositions grey triggerfish differed significantly from the age composition data used in the BAM base run presented on day 2 of the RW. Hence, results and model diagnostics developed from the Assessment Workshop base model were based on severely biased CVID age composition data that in addition were up weighted relative to fishery-dependent data in the BAM. I agree with the Review Panel that the proposed base model parameterization was inappropriate to provide information on Gray triggerfish stock status or benchmarks. Further modeling is needed to fit the corrected age data, and a full range of sensitivity analyses should be conducted to assess stock status for grey triggerfish. As pointed out in the consensus panel review report, the very close fit of the BAM estimates to the CVID survey should be examined. The decision to use data from the Chevron trap index from 1990-2010, and a combined Chevron trap/Video index for 2011-2014, is reasonable. A concern with the Chevron trap index of abundance is the possible variable bias annually due to multispecies gear saturation effects. Also, in the update assessment it as advised to reconsider if 1990 should be dropped from the series due to possible effects from Hurricane Hugo.

1. Background

The South East Data, Assessment, and Review (SEDAR) process is part of the NMFS-Southeast Fisheries Science Center's program for quality control and assurance of stock assessments in the South East region. The SEDAR is a process conducted by the South Atlantic Fisheries Management Council (SAFMC) in close coordination with NMFS and the Interstate Commissions to ensure the scientific quality and credibility of stock assessments, and to assure that they continue to support effective fishery management. The SEDAR process comprises a Data Workshop, an Assessment Workshop, and a Stock Assessment Review Workshop conducted in sequence.

The SEDAR 41 Review Workshop for South-Atlantic red snapper and grey triggerfish was held from March 15-18, 2016 in North Charleston, SC. I agree with the findings and recommendations that are detailed in the SEDAR 41 workshop review panel consensus reports, which are included as separate chapters within the SEDAR 41 Stock Assessment Reports for South Atlantic red snapper and grey triggerfish. In this report, I evaluate the review process, and briefly summarize the findings and recommendations, with focus on my experience as a reviewer on the panel.

2. Description of the Individual Reviewer's Role in the Review Activities

Preparations in advance of the peer review meeting included a review of background material and reports provided by the SEDAR coordinator Julia Byrd (Listed in Appendix A) on February 19 via email and via an ftp site with files organized in subdirectories. The files in each subdirectory were listed to match the order of presentations on the meeting agenda, which made it much easier for the review panel to consult the background material during presentations. Unfortunately, I could neither attend the Pre-Review Workshop introductory call held Friday, March 11, nor the follow-up webinar on 8 April 2016, but transcripts of these webinar were provided.

The review meeting was kicked-off with the welcome by SEDAR Coordinator Julia Byrd, Science and Statistics Program, South Atlantic Fishery Management Council (SAFMC), and then participants in the peer review and everyone in the audience introduced themselves. The peer review was competently chaired by Luiz Barbieri (SAFMC SSC). In addition to the chair, the review panel consisted of three independent Center for Independent (CIE) reviewers and two reviewers from SAFMC (Appendix C). The chair delegated the writing assignments for the different TORs among review panel members.

A series of very informative power-point presentations were given during the review meeting. Kate Siegfried and Kevin Craig (Lead Analysts, SEFSC Beaufort Laboratory) presented the red snapper and grey triggerfish stock assessment modeling, respectively, with support from Kyle Shertzer and Erik Williams (Assessment Team, SEFSC Beaufort Laboratory).

My fellow peer reviewers and I asked questions during the presentations and participated in the panel discussions on validity, results, recommendations, and conclusions. The presentations covered each Term of Reference in depth, and the presenters answered questions when needed to clarify specific points. Julia Byrd acted as rapporteur and provided summaries of the discussions for each day. I was assigned to TORs 1, and 5, and also contributed to TORs 4,7, and 9. After compiling the write-ups for all TORs for the panel consensus report these were discussed in plenum. For the grey triggerfish, several of the ToRs could not be met due to the corrections in input data made during the RW. In this report I mainly defer to text from fellow panel members for TORs 2, 3, and 8 that wrote these sections for the Panel Summary Report that I agree with.

3. Summary of Findings for each ToR

1. **Evaluate the data used in the assessment, including discussion of the strengths and** weaknesses of data sources and decisions, and consider the following:
    a) Are data decisions made by the DW and AW sound and robust?
    b) Are data uncertainties acknowledged, reported, and within the normal or expected levels?
    c) Are data properly applied within the assessment model?
    d) Are data input series reliable and sufficient to support the assessment approach and findings?

Red snapper

General comments

Data decisions made by the DW and AW were sound and robust. The efforts of the DW and AW to compile the data and evaluate their strengths and weaknesses are commendable. The development of input data and parameters for the BAM and ASPIC models required complex compilations and thorough evaluation of all available data at the DW. Modifications made subsequently by the AW were fully explained.

Data uncertainties were acknowledged, reported, and were within the normal or expected levels, judged from information provided to the Review Panel. Data on fishery catches and length/age compositions, and fishery-dependent and independent relative abundance indices, varied widely in coverage and quality. Complex manipulations and standardization methods were often required to try and develop coherent time series from diverse data sources of differing designs, coverage and accuracy, and the combined data will have biases that in some cases are poorly understood especially in earlier years of the time series. All decisions made by the DW and AW in compiling data were explained and justified in detail. Data quality metrics were provided by the DW in terms of numbers of samples, CVs, or alternative plausible data series or biological parameter values. These were used by the AW to weight data series in the assessment model, estimate the uncertainty in the assessment results using the Monte Carlo / bootstrap method, or to explore the sensitivity of the assessment to data decisions and uncertainty. The sensitivity analyses were carried out altering one input at a time, and did not explore the impact of combinations of adjustments.

The data were properly applied within the assessment model. Any issues with application of the data such as time periods for fitting, use of length and age data from the same sampling schemes, or weighting of data according to data quality metrics, were explored at the SEDAR-41 RW if not previously evaluated by the DW and AW.

Data input series were applied if considered reliable and sufficient to support the assessment approach and findings. Reliability and sufficiency was evaluated based on a-priori criteria where possible, supported by data quality metrics such as numbers of samples or CVs and by model fits. The assessment is supported primarily by a wide range of fishery-dependent data covering landings and discards, and therefore is heavily dependent on assumptions related to their reliability and use. The base run used fishery-independent trap/video survey data set from 2010 only, although the Chevron trap survey goes back to 1990, due to very low incidence of red snapper catches prior to the recent increase in abundance due to strong recruiting year classes. This suggests that the red snapper stock depended on rare recruitment events, and therefore there is large uncertainty associated with stock recruitment relationships and forward projections.

A brief evaluation of the strengths and weaknesses of the data sources and decisions is given below for each type of data used.

Life history parameters

Reliability of data and assumptions on stock structure, reproductive biology and natural mortality affects the reliability of the red snapper assessment. Fixed mortality by age-class was based on a meta-analysis approach using growth parameters and maximum observed age. Reproductive biology was included in the model by computing total annual egg production at age based on maturity, length, number of batches and batch fecundity, allowing the effect of age structure on reproductive output to be reflected in setting SSB reference points and stock status. This represents a significant change from previous assessments. Interannual variation in fecundity, a possible source of uncertainty, was not able to be included as historical information was not available. The low estimate of age at first maturity in females (43% at age 1) was considered by the RW to be unusual for snappers, and it was speculated if it has declined as a compensatory response to heavy exploitation. Annual maturity data from the SERFS Chevron trap survey could not be used to test this because sample collections have been from different areas in different time periods.

Fishery removals

To allow a sufficient burn-in period for the BAM a historical series of commercial and recreational fishery removals – landings and dead discards – were reconstructed back to 1950 and assumed to be a period of stable age structure and low fishing mortality. The burn-in period was assumed to be one of stable age structure and low fishing mortality. Creation of a series of removals estimates since 1950 required a large number of decisions to infer historical values from more recent data or to calibrate data series where design has changed. This included calibration factors to adjust NMFS Marine Recreational Fisheries Statistics Survey (MRFSS) surveys catch estimates from 1981 to 2003 to be consistent with catches from the Marine Recreational Information Program (MRIP: 2004 to present), and to develop combined recreational landings back to 1955 using effort data from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey (FHWAR: SEDAR41-DW17) combined with average MRFSS and SRHS CPUE data for 1981-83.

The recording of landings of the commercial handline fleets have improved in accuracy over time, and the DW proposed CVs that could be used for Monte Carlo/bootstrap (MCB) uncertainty analysis in the assessment. Recreational landings of headboats are estimated from the Southeast Region Headboat Survey (SRHS) log book scheme which has improved in quality over time due to introduction of mandatory reporting in 1996 and improved logbook supply from 2008 onwards. Private boat and charter boat landings since the early 1980s were estimated from MRFSS/MRIP, which has a robust and peer-reviewed statistical design that has substantially reduced bias and improved precision over time, and for which CVs are estimated directly based on efficient estimators.

Discards estimates are inherently less reliable than landings for both the commercial and recreational fleets, and for commercial handlines involved extrapolating observations for 2002-2009 to other years back to 1992, with zero discards assumed prior to that due to low minimum landing size. Similarly, head boat discards estimates are available from log books and some at-sea observation since 2004 but had to be extrapolated back in time based on changes in length frequencies recorded by dockside sampling before and after changes in minimum landing sizes, with zero discards assumed pre 1984. All these data manipulations introduce additional error in the time series. Discards estimates from MRFSS/MRIP are self-reported by anglers intercepted at landing sites and are not verified.

Sample sizes and allocation in MRIP have not been sufficient to provide reliable estimates of red snapper landings or discards for the very brief mini-seasons since 2012, and alternative data sources from State surveys were also used for these periods, based on collaboration between MRIP staff and State laboratories which the Review Panel was advised is continuing in order to develop options for future sampling, which the Review Panel encourages.

Discarding of red snapper has increased over time due to changes in minimum landing size to 20 inches in 1992 and increases in abundance of young fish from above-average year classes in some recent years. The introduction of the moratorium in 2010 and 2011, and the small commercial catch limits and recreational bag limits in the mini seasons for 2012 onwards, have resulted in most of the catch now being discarded. Estimates of discards are of poorer quality than for landings, and are often self-reported with no verification although some data are available from at-sea observations. The Review Panel notes that under the current management regime, the quality of total fishery removals estimates may therefore have deteriorated significantly. The BAM has estimated a very strong 2013 year class, based mainly on recreational discards data and CVID Chevron trap survey data. Preliminary 2015 CVID data shown to the Review Panel confirmed this by showing increased numbers of 2-

year-olds. The accuracy of future BAM estimates for this year class, and projections of its contribution to future biomass and fishery catches, will depend on quality of discard estimates to quantify the fishery removals, and the Review Panel supports any initiatives to improve quality of discards estimates particularly as the BAM requires these and any landings estimates to be treated as precise.

Length and age compositions

The AW used age composition data in preference to length composition data in BAM where both data exist, and length composition data were fitted only for commercial handlines from 1984 – 1992, commercial discards in 2009 and 2013, and headboat discards from 2005 to 2014. Age compositions were fitted for commercial handiness landings from 1990 onwards, for head boat landings in two widely separated blocks in the 1980s and 2000s, for general recreational landings since 2001, and for the CVID survey from 2010. The CVID age data were found towards the end of the review meeting to have not been converted to calendar ages, and revised data were provided along with some preliminary assessment results which indicated some relatively small changes to the overall assessment results and stock status.

The Review Panel heard testimony from recreational and commercial fishermen, documented also in SEDAR 41-RW6, expressing concern that the BAM assessment underestimates the numbers of large, older red snappers. In their experience these fish occur more frequently in midwater than is the case for smaller snappers, and therefore are less likely to enter traps, and also have behavior and distribution that makes them less probable to be caught by commercial hand lines, suggesting that all fisheries have a domed selection. The scientific sampling of fishery catches shows that the incidence of large snappers is lowest in head boats operating inshore, highest in commercial lines operating in deeper water on average, and intermediate in recreational private and charter boats which typically operate in intermediate depths. The age composition of red snappers caught in the Chevron trap survey, which extends across a wide depth range, is closer to the composition of commercial hand lines. Broad spatial coverage of the commercial fishery and survey has been used by the DW and AW to justify asymptotic selectivity for these catches. The relative selectivity of the different fisheries is shown clearly by the size and age compositions in samples collected over time, but it is more difficult to prove that the commercial fishery and Chevron trap survey have asymptotic selectivity based purely on model diagnostics or spatial fishery distribution. The Review Panel did not see any empirical data from independent studies to confirm the selection pattern for commercial hand lines or Chevron traps. Studies are needed to provide independent data showing how red snapper behavior affects the probability of encounter with a fishing operation or trap, and the probability of being caught when encountering the gear, to help define selectivity patterns and resolve the different perspectives on abundance of large snappers during the rebuilding period.

Relative abundance indices

The input data series appear adequate to support the assessment results and findings. However, the CPUE series are likely to have large uncertainties as measures of abundance, and the trap/video index only covers the recent years. In particular, the fishery-dependent CPUE abundance indices after 2010 are based on discards, and may be biased downwards if the head boat (HB) and commercial fishery successfully avoids areas with high abundance of snappers.

The rationale for including abundance indices from the fisheries-independent combined CVID trap/video survey (2010-2014) and data from three fisheries-dependent CPUE series in the BAM stock assessment model was reasonable. The combination of trap/video survey indices of abundance for the years 2010-2014 is clearly supported since the video camera is mounted on the traps, and thus cannot be considered independent. The three fishery dependent indices of relative abundance consisted of head boat logbooks data (1976–2009), head boat discards data (2005–2014), and commercial hand line logbooks (1993–2009). The CPUE series were standardized to account for potential biases related to spatial and temporal coverage, and trip type, among other factors. The application of the method of Stephens and MacCall (2004), which takes into account other species than red snapper to subset trips in red snapper habitats, seems reasonable. The CPUE series from commercial hand line and head boat fisheries are likely to be biased indices of abundance for the stock since relatively more fishing effort will be spent in areas with high catch rates (before the 2010 moratorium), and since the spatial coverage cannot be controlled as in a fishery-independent survey. HB CPUE series cover shallower waters where younger and smaller red snapper occur disproportionately more than in the deeper water where the commercial hand line fishery spends more effort. A combination of the CPUE series developed external to the assessment model based on their spatial/depth coverage is an alternative that may be explored in future assessments.

The various sources of systematic errors (e.g., spatial coverage, selectivity) and random errors (e.g., sample sizes) in each individual relative abundance series are well documented. There is some indication of lower discards in the HB fishery immediately following the moratorium (Figure 1; SEDAR41-DW14), which could suggest changes in fishing patterns to avoid snapper catches. The Review Panel is of the opinion that changes in management actions such as the moratorium, mini-season and reductions in bag limits, all of which are expected to alter fishing behavior and hence catchability in fishery-dependent indices, should inform decisions on inclusion of data or periods of data in assessments. A member of the SAFMC stated on record that the behavior of anglers has changed substantially since the moratorium, to avoid catches and discarding of red snapper. The RP therefore considers the fishery CPUE series to be applicable only to 2009, the year before the moratorium. CPUE series are also likely to be affected by technology creep in catchability due to improvements in fishing gear, positioning (GPS) and communication systems, and also by rising fuel costs in recent years.

The application of the data in the model follows common practice and appears sound. However, since the CPUE indices of abundance partly cover different depths/areas it should be noted that they do not individually cover the entire stock. Of particular concern is that the age and length composition of data from the head boat fishery likely differ from the data from the commercial fishery that tends to operate in deeper waters. Also, the precision of the CPUE series differs depending on survey design and sample sizes. The results of the stock assessment modeling depend on the relative weights assigned to different data sets. However, there is no consensus amongst practitioners as to the best approach to data weighting. This stock assessment follows the common practice of weighting compositional catch data and abundance indices in two stages. The input data are first assigned relative weights before the model is run, and then iteratively weighted during a model run to improve model fit. Ideally, stage one weighting would use information about sample sizes (Primary sampling units, and lower level sample sizes) and the way in which the data were collected (i.e., multi-stage survey designs), through calculated precision and effective sample sizes (Francis 2011; Pennington and Vølstad 1994). In particular, abundance indices by cohorts are likely to have different precision due to differences in the number of primary sampling units (e.g., trips, or trap-sets) where the cohorts are caught (Aanes and Vølstad 2015). In general, the multi-stage sampling can introduce complex correlation structures among cohorts, and drastically reduce the effective sample sizes for estimating compositions, and indices of cohorts (Aanes and Vølstad 2015). This would allow different weighting to each data point. The current assessment appears to largely apply ad-hoc weighting of input data. In particular weighting of the fishery-independent abundance indices (across cohorts) in the base model is poorly justified. The inclusion of CPUE indices with fixed CVs (relative standard error) of 0.2 (i.e., equal weights) is based on Francis (2003) and the argument that the CVs of the fishery dependent indices do not reflect true variation in abundance. However, since sample sizes vary over the years, a fixed CV could cause bias. An estimate of the variance of CPUE indices based only on the between trip variability in CPUE may indeed underestimate the true variance of the CPUE abundance indices if catchability varies over time, which is likely. Pennington and Godø (1995) estimated the actual variance of survey abundance indices by cross-calibrating independent VPA estimates and survey catch per tow indices. For the current BAM assessment, the fishery-independent trap data could potentially be used for cross-calibration of CPUE indices, but since the fishery-independent index only is considered to be from 2010 this is problematic. A pragmatic alternative to the fixed CV of 0.2 for the CPUE series could be to apply this value for an average sample size (number of trips) for each series, and then adjust the CV for actual sample sizes every year.

Gray triggerfish

General comments

Data decisions made by the DW and AW were sound and robust. The efforts of the DW and AW to compile the data and evaluate their strengths and weaknesses are commendable. The development of input data and parameters for the BAM and ASPIC models required complex compilations and thorough evaluation of all available data at the DW. Modifications made subsequently by the AW were fully explained.

Data uncertainties were acknowledged, reported, and were within the normal or expected levels, where this could be ascertained from information provided to the RW. Data on fishery catches and length/age compositions, and fishery-dependent and independent relative abundance indices, varied widely in coverage and quality. Complex manipulations and standardization methods were often required to try and develop coherent time series from diverse data sources of differing designs, coverage and accuracy, and the combined data will have biases that in some cases are poorly understood especially in earlier years of the time series. All decisions made by the DW and AW in compiling data were explained and justified in detail. Data quality metrics were provided by the DW in terms of numbers of samples, CVs, or alternative plausible data series or biological parameters. These were used by the AW to weight data series in the assessment model, estimate the uncertainty in the assessment results using the MCB method, or to explore the sensitivity of the assessment to data decisions and uncertainty. The sensitivity analyses were carried out altering one input at a time, and did not explore the impact of combinations of adjustments.

The data were properly applied within the assessment model. Any issues with application of the data such as time periods for fitting, use of length and age data from the same sampling schemes, or weighting of data according to data quality metrics, were explored at the SEDAR-41 RW if not previously evaluated by the DW and AW.

Data input series were mostly considered reliable and sufficient to support the assessment approach and findings. Reliability and sufficiency were evaluated based on a-priori criteria where possible, supported by data quality metrics such as numbers of samples or CVs and by model fits. The assessment is supported by a well-designed fishery-independent trap survey since 1990 and a wide range of fishery-dependent data covering landings and discards. However, the corrections in input data on age compositions from the Chevron trap caused substantial changes compared to the age composition data used in the BAM base model runs in the Assessment Workshop. The changes in assessment results and the adjustments made to the base model lead to the Review Panel decision to put the assessment on hold pending a response from the AW as a whole to suggestions. This is explained under Term of Reference 2.

An evaluation of the strengths and weaknesses of the data sources and decisions is given below for each type of data used.

Life history parameters

Life history data and assumptions used in the gray triggerfish assessment include stock structure, reproductive biology and natural mortality. The assessment was sensitive to estimates of natural mortality (M) as is generally the case, although sensitivity to trends in M could not be evaluated as there is no information on this. An age-dependent, year-invariant estimate of M was determined by a meta-analysis approach using growth parameters and maximum observed age. Reproductive biology was included in the model by computing total annual egg production at age based on maturity, length, number of batches and batch fecundity, allowing the effect of age structure on reproductive output to be reflected in setting SSB reference points and stock status. Interannual variation in fecundity, a possible source of uncertainty, was not able to be included as historical information was not available.

Age in gray triggerfish is difficult to determine from hard structures e.g. otoliths, a previous impediment to developing a stock assessment. Strenuous efforts have been made to develop and validate accurate methods to determine age based on increments in dorsal spines (converted to calendar years), and those results are used in the BAM. gray triggerfish age readings show a broad distribution of length at age relative to the annual growth increment in length (Fig. 1 – from presentation to SEDAR-41 RW), which in combination with selectivity assumptions affect the ability for BAM to estimate annual age compositions though will fit to sample length compositions.

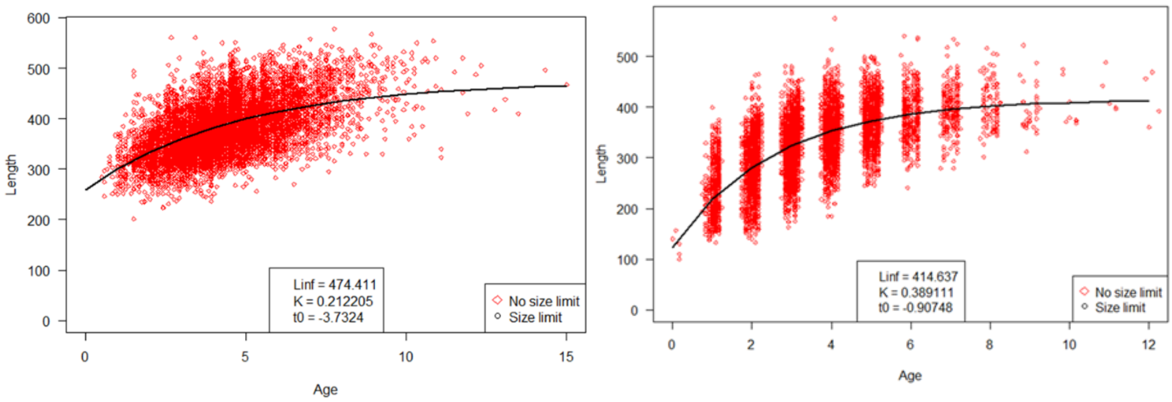

Fig. 1. Left: fishery dependent length-age data for gray triggerfish; right: fishery-independent (CVID trap) data. From gray triggerfish presentation to SEDAR-41 RW

Fishery removals

Reconstruction of a historical series of commercial and recreational fishery removals – landings and dead discards – was made back to 1988 for the assessment. This required a large number of decisions to impute missing values or to calibrate data series where design has changed, particularly for the change from the NMFS Marine Recreational Fisheries Statistics Survey (MRFSS) surveys (1981 to 2003) to the Marine Recreational Information Program (MRIP: 2004 to present), and for developing discards time series.

Landings of commercial hand line fleets have improved in accuracy over time, and the DW proposed CVs that could be used for MCB uncertainty analysis in the assessment. Recreational landings of head boats are estimated from the Southeast Region Head Boat Survey (SRHS) log book scheme which has improved in quality over time due to introduction of mandatory reporting in 1996 and improved logbook supply from 2008 onwards. Private boat and charter boat landings since early 1980s were estimated from MRFSS/MRIP, which has a robust and peer-reviewed statistical design with improved design and precision over time, and for which CVs are estimated directly based on efficient estimators.

Discards estimates are inherently less reliable than landings for both the commercial and recreational fleets, and for commercial hand lines involved extrapolating observations for 2001-2011 to other years back to 1988. Separate discards estimates for the open and closed seasons since 2012 were made for this fishery based on effort. Recreational head boat discards estimates are available from SRHS log books since 2004, but for previous years back to 1988 are inferred using MRIP charter boat data adjusted using ratios of SRHS to MRIP estimates for 2004-2013. gray triggerfish discards estimates from SRHS and MRIP are self-reported and are not verified. All these uncertainties and data manipulations introduce error in the time series.

Length and age compositions

For Red Snapper, the SEDAR-41 AW used age composition data in preference to length composition data in BAM where both data exist, but for gray triggerfish the AW fitted both length and age compositions for head boats and the CVID survey which will result in some over-weighting of composition data. Length compositions from 1988 onwards were fitted for landings of commercial lines, head boats and from 1990 for the CVID survey. Head boat discards length frequencies were fitted from 2005 onwards. Age compositions for commercial hand lines and head boat landings were fitted mainly from the 2000s onwards and for the CVID survey from 1990 onwards. The CVID age data for gray triggerfish were found towards the end of the review meeting to have not been converted to calendar ages. Revised data were provided, and the assessment was rerun. [see ToR 2 &3 for elaboration on this].

The Review Panel notes the broad length at age distributions relative to annual growth increment for many of the age classes making up a large portion of fishery-dependent and fishery-independent data (see Fig. 1 above), which will affect the ability of BAM to estimate annual age compositions through fit to length composition sample data. The Review Panel requested a sensitivity run of BAM with length data omitted where age data were available. This resulted in a deterioration in fit to some age composition data, suggesting that the sampling for age, given the age error matrix, was inadequate for those years or could also reflect the correlations between length and age data collected from the same samples and the use of length data to weight the age compositions in each length class. This needs to be examined by the AW.

Relative abundance indices

The Review Panel considers the rationale for including CPUE data from three fisheries-dependent surveys and the two fisheries-independent series from CDID trap and combined CVID trap/video survey in the BAM stock assessment model to be reasonable. The combination of trap/video survey indices from 2010 is clearly supported since the video camera is mounted on the trap, and hence cannot be considered independent. The standardized index for the fisheries-independent survey based on a zero-inflated model accounts for yearly shifts in sampling distributions relative to covariates that affect catch rates for Grey triggerfish, and is restricted to depths from 10-94 m where Grey triggerfish has been captured in any of the monitoring programs.

The various sources of systematic errors (e.g., spatial coverage, selectivity, trap saturation) and random errors (e.g., sample sizes) in each individual series are well documented. The established growth curves based on different data sources suggest that larger fish have lower probability to be captured in the CVID trap/video survey than by recreational fisheries [see data update assessment presentation report; Figure 2].

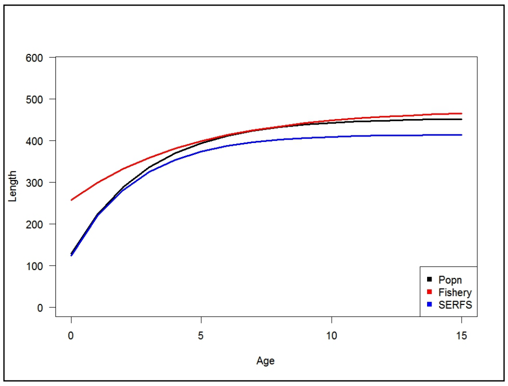

Figure 2. Growth curves fpr gray triggerfish

Since gray triggerfish is unlikely to be the target for most fishing trips, the CPUE series has potential to provide robust indices of abundance during periods of stable management measures that affect fishing behavior. However, the management measures applied to red snapper fishing since 2010 are likely to have caused a shift in targeting to other species which could also potentially cause a shift in catchability or selectivity for gray triggerfish.

The application of the relative abundance data in the assessment model follows standard practice and appears sound. However, since the CPUE indices of abundance partly cover different depths/areas it should be noted that they do not individually cover the entire stock. The inclusion of these indices with equal weight in the model could therefore cause bias. A combination of the CPUE series external to the model based on their spatial/depth coverage is an alternative that may be explored in future assessments.

The use of the CVID Chevron trap and video survey in the BAM for gray triggerfish was considered in detail at the RW meeting due to the AW decision to up-weight the series by a factor of 6 to ensure a good fit to the index. This fishery-independent index covers the center of the geographic range (NC – N. Florida), the full depth range, and extends over nearly entire time series (1990-2014). However, the first year (1990) of the CVID Chevron trap survey was conducted after Hurricane Hugo, and may have experienced drastic lower catching efficiency due to strong habitat disturbances. The Review Panel recommends that the inclusion of this first year be reconsidered.

The results of the stock assessment modeling depend on the relative weights assigned to the different data sets. However, there is no consensus amongst practitioners as to the best approach to data weighting. This stock assessment follows the common practice of weighting compositional catch data and abundance indices in two stages. The input data are first assigned relative weights before the model is run, and then iteratively weighted during a model run to improve model fit. Ideally, stage one weighting would use information about sample sizes (Primary sampling units, and lower level sample sizes) and the way in which the data were collected (i.e., multi-stage survey designs), through calculated precision and effective sample sizes (Francis 2011; Pennington and Vølstad 1994). In particular, abundance indices by cohorts are likely to have different precision due to differences in the number of primary sampling units (e.s., trips, or trap-sets) where the cohorts are caught (Aanes and Vølstad 2015). In general, the multi-stage sampling can introduce complex correlation structures among cohorts, and drastically reduce the effective sample sizes for estimating compositions, and indices of cohorts (Aanes and Vølstad 2015). This would allow different weighting to each data point. The annual CVs for the abundance indices from the fisheries-independent surveys are computed using bootstrapping (SEDAR41-DW52) but the weight assigned to the input data to the BAM are fixed and chosen ad-hoc. However, since sample sizes vary over the years and across cohorts CVs will vary annually, and fixed weights could therefore cause bias.

An estimate of the variance of the fishery-independent indices based only on the between trap variability will underestimate the true variance of the abundance indices if catchability varies over time. Pennington and Godø (1995) estimated the actual variance of survey abundance indices by cross-calibrating independent VPA estimates and survey catch per tow indices. For the current BAM assessment, the CPUE series could potentially be used to cross-calibrate the fishery-independent indices in a time series analysis.

The input data series appear adequate to support the assessment results and findings. However, of particular concern for abundance indices from trap surveys, which are assigned high weights in the stock assessment, is the possibility of gear saturation effects that may vary in space and time. Under the standard soak time of 90 mins for the Chevron trap surveys, Bacheler et al. (2013) have shown that catch rates of gray triggerfish taper off once a moderate number of total individuals were already caught in a trap. It is recommended that AW explores the time series of indices at age using diagnostics to evaluate year class tracking and year effects, such as showing bubble plots of annual distribution at age. Also, the effects of storms in the time series should be considered.

2. **Evaluate and discuss strengths and weaknesses of the methods used to assess the stock**, taking into account the available data, and consider the following:
    a) Are methods scientifically sound and robust?
    b) Are assessment models configured properly and used consistent with standard practices?
    c) Are the methods appropriate for the available data?

Red snapper

The assessment models used to assess the South Atlantic red snapper stock were reasonably configured and applied consistently with standard practices. The choice of the Beaufort Assessment Model (BAM) as the base model in the assessments of red snapper is well supported. The BAM is the approved method for many other stocks in the South Atlantic, and was recently used to assess the Gulf of Mexico red snapper stock. The model has many assumptions and many estimated parameters, but the base model configuration appears to have reasonable assumptions and parameter estimates. Additional stock assessments were done with the ASPIC (A Stock Production Model Incorporating Covariates) model and an Age Structured Production Model to provide alternative perspectives on stock status. These age-aggregate models do not consider length and age composition data. I agree with the RW panel reports and the Assessment Workshop that the BAM that incorporates length and age composition information is preferred, and provides the most credible assessment of stock status. Also, catch curves of age composition data were provided as exploratory information on trends in maturity, but the implicit assumptions of constant mortality rate at age do not appear to be valid. The BAM base configuration considers important information on demographic structure of the stock from fisheries-dependent and fisheries independent sources (Chevron trap/video data after 2010) and variable recruitment of new age classes, and is considered to be the most appropriate basis for status determination. Note that the results from the base configuration of BAM from the Assessment Workshop ('base') were revised with corrected age compositions of the Chevron Trap survey. Since the corrected age-compositions for the Chevron trap were quite similar to the annuli-based ones used in the Assessment Workshop base runs Results and diagnostics from the Assessment Workshop base model and the corrected base model ('newbase') were similar. The review of methods was based on the Assessment Workshop report and the corrected base model, but conclusions from the Review Workshop were confirmed with corrected results.

During the most recent years of the stock assessment series (i.e., the 2010-2014 moratorium), recreational discards are one of the most important sources of information for the assessment. Unfortunately, recreational discards are also one of the most uncertain sources of information. Despite the imprecision in estimates of recreational catch, the BAM base configuration is conditional on catch estimates (e.g., the input CV for catch was 0.05). Exploratory analyses that allow error in landings could not produce a solution, but the Review Panel requested an exploratory analysis that allowed error in the estimates of recreational discards, assuming the MRIP estimates of CV. Exploratory assessment models with more or less catch had similar estimates for the last 30 years (BAM runs S17–S20).

As indicated by sensitivity analyses reported by the Assessment Workshop and during the Review Workshop, the most important data and modeling decisions were the selection and relative emphasis of relative stock size indices in the assessment model and modeling the form and time variation in selectivity.

Fishery CPUE indices suggest a greater recent increase in stock biomass and lower mortality (BAM run S4). However, the Review Panel agrees that the fishery-independent index is informative and should be included in the assessment model. Considering the Chevron Trap Survey and Video Survey as separate indices (BAM run S22) also estimates a greater recent increase in stock biomass and lower mortality, but the Review Panel agrees that the two series are not independent and should not be considered as separate indicators of stock trends. An alternative model configuration that included the entire series of Chevron Trap Survey provided similar estimates as the base model.

Accurate interpretation of length and age composition data relies on accurate assumptions about the form of selectivity and estimates of selectivity at age in the fisheries and the survey. The commercial fishery is assumed to be asymptotic (i.e., 'flat topped'), and the model estimated that all red snapper older than age-4 have been fully vulnerable to commercial fishery since the minimum legal size regulation in 1992. The Review Panel agrees that the flat-topped selectivity assumption for the commercial fishery is justified, because the commercial fishery covers the entire resource area and targets large fish. Assuming 'dome-shaped' selectivity (i.e., oldest ages are not fully vulnerable) for the commercial fishery (BAM run S21) produced similar results as the base model.

Selectivity of the head boat fleet was assumed to be dome-shaped, and the model estimated full selectivity at ages 3-4 and low selectivity of ages 10+. Selectivity of the general recreational fleet was also assumed to be dome shaped until 2010, with full selectivity at ages 3-4 and low selectivity of ages 10+. Results were not sensitive to how selectivity was estimated for ages 10+ (BAM run S31).

Since 2010 (during the moratorium, mini-seasons and 1-fish bag limit), selectivity of the general recreational fleet was assumed to be flat-topped, with full selection at ages 6+. The Review Panel agrees that the flat-topped assumption is justified by the targeting of large fish during the mini-seasons, the larger size compositions and older age compositions since 2010, and the inability of the model to estimate lower selectivity at older ages. The Review Panel requested a sensitivity analysis in which selectivity of the recent general recreational fleet was assumed to be the same as the recent head boat fleet. Results suggest that the model does not fit age composition data well, underestimating catch at older ages, and estimates are not sensitive to the selectivity assumption of the recent general recreational fleet (Appendix X).

The perception of current selectivity used to derive reference points and projections is conditional on recent fishing behavior, and projections of alternative management scenarios should consider alternative selectivity assumptions that are consistent with each scenario. For example, alternatives that do not allow recreational landings (e.g., moratoria with no mini-seasons) should not assume the status quo composite selectivity that includes a flat-topped selectivity for general recreational landings.

The form of selectivity of the Chevron Trap Survey was assumed to be flat topped, and the model estimated that all red snapper older than age-3 are fully vulnerable to the trap survey. Public comment suggested that traps may not catch large red snapper as efficiently as small red snapper. However, some of the largest and oldest samples available are from the trap survey, and efforts to estimate lower selectivity of older ages produced estimates near full selectivity.

The flat-topped selectivity assumption for the Chevron Trap survey implies that relative abundance of old fish is represented by the survey. The assumed shift from dome-shaped selectivity to flat-topped selectivity of the general recreational fishery implies that the recent increase in catch of larger older fish reflects a shift in selectivity, rather than a proportional increase in the abundance of older fish in the population. Alternative interpretations would require evidence that larger, older red snapper are not fully vulnerable to the fishery or the survey.

Attempts to sample larger and older red snapper than sampled in the fisheries or trap survey have not been successful. Mitchell et al. (2014 Marine and Coastal Fisheries 6: 142-155 and SEDAR41-RD34) investigated length-specific depth distributions of red snapper in the South Atlantic region from two fishery-independent surveys targeting hard-bottom habitats, and reported "no evidence of a positive relationship between depth and age or length. Additionally, age and length distributions of Red Snapper ≥ 50 cm FL did not differ between fishery-independent surveys and the commercial hook-and-line fishery. These results provide no support for assertions of greater abundances of older and larger Red Snapper in deeper SEUSA waters."

The information available on size selectivity of red snapper by survey traps is equivocal on the form of selectivity. Wells et al. (2008, Fisheries Research 89: 294–299 and SEDAR31-RD36) compared catch rates of trawls, small fish traps, Chevron traps, and underwater video for sampling red snapper in the Gulf of Mexico. They concluded that "the Chevron trap is most effective for sampling adults, while trawls were the most effective gear for sampling age-0 yr fish." DeVries et al. (2012, SEDAR31-DW28) compared size samples of red snapper from traps and cameras and found that "the traps do select against most red snapper >650 mm TL, although fish that large appear to be uncommon in the survey area based on the few stereo measurements obtained" and "distributions of the trap fish and that from the stereo images, like in 2011, were very similar." Therefore, there is insufficient evidence to reject the selectivity assumptions in the assessment. However, the assumptions of asymptotic selectivity of the trap survey and recent recreational fishery should be investigated further in future assessments.

Grey triggerfish

This ToR could not be met since the base configuration of the Beaufort Assessment Model (BAM) from the Stock Assessment Workshop was rejected. The reason is the base model was revised during the RW, with corrected age compositions data from the Chevron Trap survey. The choice of the Beaufort Assessment Model (BAM) as the base model in the assessments of triggerfish is supported. The BAM is the approved method for many other stocks in the South Atlantic, and was recently used to assess the Gulf of Mexico red snapper stock. The corrected age compositions differed substantially from the age compositions used in the Assessment Workshop, and the results from new base model differed from the results from the original base model run to a degree that caused concerns. Based on requests from the Review Panel, two revised models were run to resolve apparent difficulties in fitting the BAM to the Chevron trap survey time series of abundance. Based on the magnitude of changes in the input data and results and model diagnostics from the Assessment Workshop base model I agree with the Review Panel that further modeling is needed to model the corrected data appropriately, even though the new model results did not suggest a change in stock status.

3. **Evaluate the assessment findings** and consider the following:
    a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
    b) Is the stock overfished? What information helps you to reach this conclusion?
    c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
    d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions? Mangel et al. 2013
    e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

Red snapper

I agree with the Review panel that the new base model with the corrected age compositions for the CVID survey index is the best available model to provide advice for the South Atlantic red snapper fishery. However, several concerns provided to the Review Panel Summary report are discussed below.

Of particular concern was the uninformative stock-recruitment relationship, poor estimates of discards by age class, likely changes in CPUE catchability due to changes in fishing behavior in response to the moratorium and other regulations, and the incomplete spatial coverage of the stock by the different fishery fleets. After the 2010 moratorium, recreational discards of red snapper are one of the most important yet most uncertain sources of information.

A number of sensitivity runs were conducted to investigate how sensitive the base case stock status determinations were to this combination of abundance indices. These runs indicated that the determination of stock status was fairly insensitive to changes such as using the longer time series for the CVID, removing the CVID (or up-weighting the fishery dependent indices) or dropping the head boat discard index. This behaviour suggests that the structure of age compositions and selectivity curves in the BAM are linking these two periods together, but could also be explained by correlation between parameters in the model.

Note that the CVs (relative standard errors) for the landings and discards were set to 0.05 so that the model would closely fit all of the landing and discard times series. Such CVs seem unreasonably low for estimates of discards from MRIP and higher CVs of 0.20 for the discard estimates were investigated in the MCB study. The higher CVs did not result in any change in stock status.

The estimated fishing mortalities (Figure 27 RS AW report) reflect the large decrease expected with the introduction of the moratorium. However, since 2010 fishing mortalities have increased from this low point mainly due to discard mortalities and catches from the general recreational fishery. Of more concern is the fact that the current estimates of these mortalities, which are highly uncertain, contribute to the continuing determination that overfishing is occurring. The base case estimates that abundance levels are close to levels in the 1950s albeit made up of younger fish. This younger age structure relative to equilibrium levels underlies the overfished determination made in the assessment.

A comparison of mean Fs at ages 1-4 and 5+ indicates that while fishing mortality was greatly reduced on both age groups in 2010, the fishing mortality greatly increased on the older group by 2014 while the Fs for the younger group fluctuated near the reference level. The moratorium appears to have been a benefit to the younger fish but not so for the older fish as interpreted by the selectivity curves used for the moratorium years.

The current estimate of fishing mortality of 0.417 and overfishing status $F_{CURRENT}/F_{30\%} = 2.84$ are both conditional on the current selectivity reflecting mini-seasons for a very limited directed fishery and discard mortality throughout the year. As such the 2014 fishing mortality is not comparable to fishing mortality in years prior to the moratorium or to fishing mortalities expected from possible changes in management in the immediate future due to differences in selectivity. Consequently, overfishing status will be a moving target because the $F_{CURRENT}$ will reflect current selectivity which will probably be very different from the selectivity assumed to calculate $F_{30\%}$.

The stock recruitment curve was not informative and inference was based on setting steepness to 0.99 and assumes average recruitment. Mean annual recruitment was assumed and lognormal deviations around that mean were estimated in the model.

Recruitment is typically not well estimated in the last year of stock assessments, because there is little information to inform the estimate. The estimate of strong recruitment in the last year of the assessment is supported by the high Chevron Trap Survey index as well as the length composition of the head boat fleet. Review Workshop participants reported continued signals of strong recruitment in the 2015 fishery and survey data. The Review Panel recognizes that projections are largely dependent on the estimate of recent recruitment, but the estimates of abundance at age from the base model is the most reliable basis for stock status determination and projection.

Alternative Metrics of Fishing Mortality

Evaluating trends in F over time requires a metric that is comparable among years and reflects exploitation across a range of ages. Apical F (maximum F at age, Figure 1) is based on a different range of ages among years, because of changing fleet contributions and changes in fleet selectivities. Apical F also does not reflect F for partially selected ages.

Gray triggerfish

Because of the corrections of age composition data from the Chevron trap and the need to develop a new configuration for the BAM there wasn't enough time during the RW meeting to establish a new base case for gray triggerfish and the assessment panel needed to review the findings to date and work with the assessment team to develop a new base case. Without an accepted base model, it was not appropriate to determine if the stock was overfished with respect the standard reference points. However, based on the information presented there was no evidence for a decline in abundance or biomass at this time, or for overfishing occurring with respect the standard reference points. The stock recruitment curve was not informative, with little evidence for low recruitment at low stock size. Inference was based on fixing steepness to 0.99 and mean annual recruitment was assumed. Without a reliable base case, quantitative estimates of status determination were not available.

4. **Evaluate the stock projections, including discussing the strengths and weaknesses**, and consider the following:
   a) Are the methods consistent with accepted practices and available data?
   b) Are the methods appropriate for the assessment model and outputs?
   c) Are the results informative and robust, and are they useful to support inferences of probably future conditions?
   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Red snapper

The projection method is consistent with those used widely in SEDAR assessments based on statistical models such as BAM and Stock Synthesis, and is consistent with the available data. The method used stochastic projections that extended the MCB fits of the assessment model with added stochasticity in recruitment, and hence the propagation of uncertainty from the assessment into the projection period is internally consistent. The stock projections provided for SEDAR 41 are appropriate for the BAM assessment model and outputs. The results of the projections are informative and robust, and are useful to support inferences of probable future conditions. Key uncertainties in the projections are acknowledged, discussed, and reflected in the projection results. The MCB runs included ranges of values of natural mortality, discard mortality and fecundity at age agreed by the AW, together with bootstrap selection of data using well-justified error distributions and additional random process error in recruitment conditional on the fitted stock recruit pattern with steepness fixed at 0.99. One concern about fixing steepness and life history parameters (natural mortality and growth) is that doing so essentially limits the way that the data can inform the reference points and stock status determination (Mangel et al. 2013).

Gray triggerfish

Since the base BAM for gray triggerfish was not accepted by the Review Panel, results were only reviewed in terms of the methodological approaches used. Projection results were not considered to be plausible for determining stock status. The projection method used is consistent with those used widely in SEDAR assessments based on statistical models such as BAM and Stock Synthesis, and is consistent with the available data.

5. **Consider how uncertainties in the assessment, and their potential consequences, are addressed.**
   a) Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.
   b) Ensure that the implications of uncertainty in technical conclusions are clearly stated.

Red snapper

Because of the large number of parameters in BAM a thorough evaluation of convergence and model sensitivity is necessary, but difficult. Uncertainties in the assessment were thoroughly explored through (1) a mixed Monte Carlo and bootstrap (MCB) analysis o quantify random errors in the assessment output; (2) sensitivity analysis around the base BAM run; and (3) the use of alternative assessment models. The Monte Carlo Bootstrap procedure also explored many combinations of alternative data and model assumptions. In the bootstrapping of observed data on landings, information from the head boat program was used to specify a decreasing CV by time blocks (i.e. CV = 0.15 for 1981-1995, CV = 0.1 for 1996-2007, and CV = 0.05 thereafter). These CVs reflect random errors. However, landings from the head boat fishery are monitored through mandatory logbooks, and thus should in principle have zero sampling errors for the vessels in the sampling frame. The CVs may reasonably reflect random errors in reporting. However, various sources of systematic errors (bias) is not reflected through these CVs. It is known that catch data may not always be 100% accurate (for example due to recall bias if log books are not filled in immediately after each trip), and that other variations in reporting likely occur. Because the distribution of such systematic errors is unknown, it is not possible to quantify the magnitude of the resulting uncertainty in the landings.

The input data on catch composition and abundance indices by cohort are obtained from multi-stage sampling programs where fishing trips typically are the primary sampling units (PSUs) for fisheries data, and locations/standardizes trap catches (90 min soak time) are the PSUs for the Chevron trap. Substantial correlations can be expected in age or length composition data sets that are constructed from samples/sub-samples from multiple catches (whether from fisheries-independent surveys or fisheries) (e.g., Aanes and Vølstad 2015). The BAM itself and the MCB are not likely to realistically account for complex error structure in data weighting without prior estimates of the actual variance-covariance matrices for the input data. The robust multinomial approach with number of PSUs as proxy effective sample sizes employed in the uncertainty evaluation of the BAM can only partly reflect the complex error structure. Ideally, it would be possible to run bootstrap resampling on the PSUs to create replicated BAM runs that reflect the complexity in input data, but given the complexity and configuration of BAM this is not possible. The Review Panel therefore considers the uncertainty in the assessment to be appropriately addressed given these restrictions.

The sensitivity analyses were used to explore a wide range of data decisions, model assumptions and model configurations to examine the robustness of stock status determination. The model was run for a plausible range of values for each factor. The Review Panel note that the sensitivity testing by alternating one factor at a time, although commonly done, may not fully reflect the uncertainty in model outputs from a complex model such as BAM with a large number of parameters where many are likely to be correlated (e.g., Saltelli and Annoni (2010). Global sensitivity analysis (Saltelli et al. 2008) may be used to untangle the contribution of single factors/parameters and interactions between parameters to the overall variability in model output. Anderson et al. (2011) provide an excellent overview of the literature, and many examples of applications of global sensitivity analysis to Integrated Assessment Models in climate research, and some of these are likely to be applicable to the BA model.

Model uncertainty was mainly explored by running an alternative Stock Production Model Incorporating Covariates (ASPIC software of Prager, Version 7.03, 2005) that relies on length-age aggregated catch and CPUE indices, with no compositional catch being included. The ASPIC runs resulted in biomass estimates above Bmsy and estimates of F below Fmsy, and hence do not place the stock in the „overfished-overfishing" category. The difference between the ASPIC and the BAM results can however be explained by the fact that ASPIC does not take into account the age-structure of the catches and the stock. Thus, a biomass made up largely by recruits can result in a stock status of not overfished-overfishing. In addition to ASPIC, a simple catch curve analysis was performed that tended to support the Z values estimated from the BAM. The BAM base configuration is therefore considered to provide the most appropriate basis for status determination, despite many sources of uncertainty.

Gray triggerfish

Assessment uncertainty results were only reviewed in terms of the methodological approaches used because the base BAM for gray triggerfish was rejected by the Review Panel. Because of the large number of parameters in BAM a thorough evaluation of convergence and model sensitivity is necessary, but difficult. Uncertainties in the assessment were explored through (1) a mixed Monte Carlo and bootstrap (MCB) analysis to quantify random errors in the assessment output; (2) sensitivity analysis around the base BAM run; and (3) the use of alternative assessment models. The MCB runs included ranges of values of natural mortality, discard mortality and fecundity at age agreed by the assessment working group, together with bootstrap selection of data using well justified error distributions. The sensitivity testing by alternating one factor at a time, although commonly done, may not fully reflect the uncertainty in model outputs from a complex model such as BAM with a large number of parameters where many are likely to be correlated (e.g., Saltelli and Annoni (2010). Model uncertainty was mainly explored by running an alternative Stock Production Model Incorporating Covariates (ASPIC software of Prager, Version 7.03, 2005) that relies on length-age aggregated catch and CPUE indices, with no compositional catch being included. However, the Assessment Panel concluded that none of the ASPIC runs produced during the Assessment Workshop produced plausible results and reasonable model diagnostics.

6. **Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.**
   a) Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
   b) Provide recommendations on possible ways to improve the SEDAR process.

Red snapper

- Increased fishery independent information, particularly maintaining reliable indices of abundance and composition data streams.
    - Recruit commercial fishers to conduct standardized fishing at representatively selected locations
- Improve the reliability of discard data as an abundance index by improving knowledge of private recreational fisherman behavior.
- Research to determine the spatial distribution (horizontal and vertical) of large adult Red Snapper using tracking and telemetry.

Gray triggerfish

- Increased fishery independent information, in particular reliable indices of abundance and age compositions.
    - Recruit commercial fishers to conduct standardized fishing at representatively selected locations

7. **Consider whether the stock assessment constitutes the best scientific information available** using the following criteria as appropriate: relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation, and peer review of fishery management information.

Red snapper

The Review Panel considers that the BAM assessment for red snapper constitutes the best scientific information available, and fulfils the following criteria:

Relevance: The SEDAR 41 assessment is highly relevant as the red snapper stock is depleted and undergoing rebuilding under a moratorium with limited landings permitted and most catches being discarded. The data and assessment provide the best means of establishing the rate of recovery of the stock, determining if measures are preventing overfishing, and providing information that can be used to adjust management actions where appropriate.

Inclusiveness: The SEDAR 41 assessment includes all data that have been quality assured and proved adequate for use in the assessment. This includes data from State as well as Federal sampling schemes where needed, for example to estimate discards during the mini-season where MRIP sampling is too limited for such a short season length.

Objectivity: The SEDAR 41 BAM is a highly objective procedure based on well-tested statistical modeling principles, and using data sets and assumptions that have been rigorously documented and reviewed through the SEDAR data, assessment and peer-review process. Where fully objective decisions are difficult to make, such as some decisions on scenarios for historic catches where evidence is lacking, the uncertainties around the decisions made have been explored and included in sensitivity analyses and the Monte Carlo Bootstrap evaluation of assessment uncertainty.

Transparency: All outputs of the data, assessment and review workshops in SEDAR 41 are fully documented and publicly available. The discussions at the review workshop are also recorded for record. All data sets are thoroughly explored and the quality of data on which the assessment is based is documented and transparent, as are all decisions related to the choice of assessment model, how it is implemented, and the results of the base run and sensitivity and uncertainty analyses.

Timeliness: The SEDAR process in general is arranged to provide timely fishery management advice where it is needed, and to ensure that assessments are benchmarked and reviewed at appropriate intervals.

Verification: The SEDAR 41 assessment process and deliverables comply with legal requirements under the Magnuson Stevens Act (2007) for developing and monitoring of fishery management plans and providing information on stock status.

Validation. The SEDAR 41 process is designed to meet the needs of fishery managers for peer-reviewed stock assessments and associated advice on stock status and future catches, and the process is open and fully transparent to the fishery managers and to stakeholders from commercial and recreational fisheries, conservation groups or others with a stake in the outcomes and who have opportunity to give their views on record.

Peer review: The SEDAR 41 process includes full peer-review by experts appointed by the CIE and by reviewers from the SAFMC SSC. The review panel report and the independent CIE reviews are publicly available

Gray triggerfish

I agree with the Review Panel conclusion that, as configured, the SEDAR 41 gray triggerfish stock assessment model could not be considered the best scientific information available.

8. Compare and contrast assessment uncertainties between the Gulf of Mexico and South Atlantic stocks.

Red snapper

Sources of Uncertainty	South Atlantic (SEDAR 41)	Gulf of Mexico (SEDAR 31)
Population	• Juvenile life history, including the location of juveniles before they recruit to the fishery • Spatial distribution (horizontal and vertical) of large adult Red Snapper • Variability in batch fecundity and spawning frequency with size and age • Effects of environmental variation on changes in recruitment • Density-dependent changes in growth, reproduction, and natural mortality	• Population structure and connectivity between eastern and western Gulf (for both adults and juveniles) • The use and effect of artificial reef structures on red snapper population abundance, age and length composition, and spatial distribution effects of environmental variation on changes in recruitment • Density-dependent changes in growth, reproduction, and natural mortality
	• Limited fishery independent indices of abundance • No fishery independent index of abundance for early juveniles	• Limited fishery independent index of abundance for early juveniles • Limited information on the magnitude, size, and age composition of discards

Data Sources	• Changes in selectivity, catch, and discard data due to changes in fisher behavior within and outside the mini-season • Poor information on the magnitude, size, and age composition of discards • Poorly-informed selectivity functions for most fleets	• Poorly-informed selectivity functions for most fleets
Assessment Methods	• Uninformative Stock-Recruitment relationship (had to use proxy reference points) • Uncertainty for certain parameters and data inputs was fixed to chosen values that could be considered arbitrary (e.g., CV for landings and discards set = 0.05) • Model uncertainty was mainly explored by running an alternative Stock Production Model	• Uninformative Stock-Recruitment relationship (had to use proxy reference points) • Uncertainty for certain parameters and data inputs was fixed to chosen values that could be considered arbitrary (e.g., CV for landings set = 0.05 and for discards = 0.5) • Model uncertainty was not explicitly explored by the use of different models

Gray triggerfish

It was not possible to complete this ToR since the SEDAR 41 stock assessment was rejected. Many of the assessment uncertainties could not be fully evaluated.

9. **Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.**

Red snapper

I strongly agree with the the RW Panel recommendation that more realistic timelines be considered for the next assessments, given the multiple sources of data and model complexities inherently associated with avstock assessment of South Atlantic Red Snapper.

Given that the input data on catch-at-age and abundance indices by cohort are likely to be cluster-correlated (Nelson 2014), and therefore have low effective sample sizes, it is problematic that the BAM has a very large number of parameters. It is therefore recommended to provide alternative runs using more parsimonious models to get a wider evaluation of the robustness of the assessment and stock status determination. One recommended candidate is a statistical assessment model (XSAM) (Sondre Aanes, Norwegian Computing Center) recently applied in the ICES Benchmark Assessment for Norwegian Spring Spawning Herring, and approved as the standard assessment model by ICES WKPELA 2016. This model framework is based on a state space model and structural time series models for fish stock assessment (inspired by Gudmundsson 1994), and includes the DTU Aqua SAM model (Nielsen and Berg 2014) that is widely used in ICES as a special case. The main advantage of this XSAM model template is that it can utilize the sampling distributions derived from analysis of sample survey data (estimated catch-at-age, and abundance indices at age) by giving appropriate weights to input-data points. It is coded in TMB (R library) which is efficient for nonlinear models with latent variables.

Grey triggerfish

Further modeling is needed to fit the corrected age data and to resolve the fit to the CVID survey (perhaps investigating a multispecies year effect in 1990) to consider possible effects from Hurricane Hugo and a justification for removing the 1990 survey observation.

The very low estimates of abundance in the first year of the assessment may be biased. The Chevron trap survey began in 1988, but a standardized protocol only came into effect in 1990. There have been no changes to the design of the survey since 1990, and thus this time series is considered to provide reliable measures of changes in abundance over time. However, bias in estimates could occur due to saturation effects for some years. Also, the 1990 estimates, although using standard protocol, may be severely affected by Hurricane Hugo, which hit the survey area 7-8 months prior to the 1990 data collections. An exploratory analysis during the RW that removed the 1990 survey observation produced estimates of abundance in the first year of the assessment that were similar to the rest of the time series. A study of Jamaican reef fish found changes in abundance, behavior, and distribution a year after Hurricane Allen (Kaufman 1983). I agree with the Review Panel recommendation that further modeling is needed to fit the corrected age data and to resolve the fit to the CVID survey.

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

I was assigned by the Review Panel chair to focus on write-ups for TORs 1, and 5 for the Panel Review Summary Report, and also contributed to TORs 4,7, and 9. The extra sensitivity runs for red snapper conducted after the RW, and the errors in the age composition data for grey triggerfish, caused some delays in the review process, and I regret that this report is submitted after the planned schedule due to calendar conflicts.

The Review Panel considers that the BAM assessment for Red Snapper constitutes the best scientific information available, and fulfils the following criteria:

Relevance: The SEDAR 41 assessment is highly relevant as the Red Snapper stock is depleted and undergoing rebuilding under a moratorium with limited landings permitted and most catches being discarded. The data and assessment provide the best means of establishing the rate of recovery of the stock, determining if measures are preventing overfishing, and providing information that can be used to adjust management actions where appropriate.

Inclusiveness: The SEDAR 41 assessment includes all data that have been quality assured and proved adequate for use in the assessment. This includes data from State as well as Federal sampling schemes where needed, for example to estimate discards during the mini-season where MRIP sampling is too limited for such a short season length.

Objectivity: The SEDAR 41 BAM is a highly objective procedure based on well-tested statistical modeling principles, and using data sets and assumptions that have been rigorously documented and reviewed through the SEDAR data, assessment and peer-review process. Where fully objective decisions are difficult to make, such as some decisions on scenarios for historic catches where evidence is lacking, the uncertainties around the decisions made have been explored and included in sensitivity analyses and the Monte Carlo Bootstrap evaluation of assessment uncertainty.

Transparency: All outputs of the data, assessment and review workshops in SEDAR 41 are fully documented and publicly available. The discussions at the review workshop are also recorded for record. All data sets are thoroughly explored and the quality of data on which the assessment is based is documented and transparent, as are all decisions related to the choice of assessment model, how it is implemented, and the results of the base run and sensitivity and uncertainty analyses.

Timeliness: The SEDAR process in general is arranged to provide timely fishery management advice where it is needed, and to ensure that assessments are benchmarked and reviewed at appropriate intervals.

Verification: The SEDAR 41 assessment process and deliverables comply with legal requirements under the Magnuson Stevens Act (2007) for developing and monitoring of fishery management plans and providing information on stock status.

Validation: The SEDAR 41 process is designed to meet the needs of fishery managers for peer-reviewed stock assessments and associated advice on stock status and future catches, and the process is open and fully transparent to the fishery managers and to stakeholders from commercial and recreational fisheries, conservation groups or others with a stake in the outcomes and who have opportunity to give their views on record.

Peer review: The SEDAR 41 process includes full peer-review by experts appointed by the Center for Independent Experts (CIE, University of Miami) and by reviewers from the SAFMC SSC. The review panel report and the independent CIE reviews are publicly available

References

Aanes, S., and Vølstad, J. H. 2015. Efficient statistical estimators and sampling strategies for estimating the age composition of fish. Canadian Journal of Fisheries and Aquatic Sciences, 72(6): 938-953.

Anderson, Barry, Emanuele Borgonovo, Marzio Galeotti and Roberto Roson. 2011. Uncertainty in Integrated Assessment Modelling: Can Global Sensitivity Analysis Be of Help? Working Paper Series. Working Paper 52. ISSN 1973-0381. IEFE - The Center for Research on Energy and Environmental Economics and Policy at Bocconi University. This paper can be downloaded at www.iefe.unibocconi.it

Francis, Chris RIC, Rosemary J. Hurst, and James A. Renwick. 2003. Quantifying annual variation in catchability for commercial and research fishing. Fishery Bulletin 101: 293-304.

Francis, RIC Chris. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68: 1124-1138.

Gudmundsson, G., 1994. Time series analysis of catch-at-age observations. Journal of the Royal Statistical Society: Series C (Applied Statistics) 43: 117–126.

Mangel, M., MacCall, A. D., Brodziak, J., Dick, E. J., Forrest, R. E., Pourzand, R., & Ralston, S. (2013). A perspective on steepness, reference points, and stock assessment. Canadian Journal of Fisheries and Aquatic Sciences, 70(6), 930-940.

Mitchell, W. A., Kellison, G. T., Bacheler, N. M., Potts, J. C., Schobernd, C. M., & Hale, L. F. 2014. Depth-related distribution of post-juvenile Red Snapper in southeastern US Atlantic Ocean waters: ontogenetic patterns and implications for management. Marine and Coastal Fisheries, 6(1): 142-155.

Nelson, G.A. 2014. Cluster Sampling: a pervasive, yet little recognized survey design in fisheries research. Trans. Am. Fish. Soc. 143: 926–938.

Nielsen, A., and Berg, C.W. 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fish. Res. 158: 96–101.

Pennington, Michael, and Olav Rune Godø. 1995. Measuring the effect of changes in catchability on the variance of marine survey abundance indices. Fisheries research 23: 301-310.

Pennington, M., and Vølstad, J. H. 1994. Assessing the effect of intra-haul correlation and variable density on estimates of population characteristics from marine surveys. Biometrics, 725-732.

Saltelli, A., S. Tarantola, F. Campolongo, and M. Ratto (2004), Sensitivity Analysis in Practice - A Guide to AssessingScientific Models (Chichester: John Wiley & Sons)

Saltelli, A., M. Ratto, T. Andres, F. Campolongo, J. Cariboni, D. Gatelli, M. Saisana, and S. Tarantola. 2008. Global Sensitivity Analysis - The Primer. John Wiley & Sons. Chichester.

Saltelli, A., and P. Annoni (2010), 'How to Avoid a Perfunctory Sensitivity Analysis', Environmental Modelling &Software 25, 1508-1517

Stephens, A., and MacCall, A. 2004. A multispecies approach to sub-setting logbook data for purposes of estimating CPUE. Fisheries Research, 70: 299-310.

Appendix A. List of provided documents

Document #	Title	Authors
Documents Prepared for the Review Workshop		
SEDAR41-RW01	Addendum to SEDAR41-DW16: Report on Life History of South Atlantic gray triggerfish, *Balistes capriscus*, from Fishery-Independent Sources: UPDATE on analyses of maturity, spawning fraction, and sex ratio	Kolmos et al. 2016
SEDAR41-RW02	Age structured production model (ASPM) for U.S. South Atlantic Red Snapper (*Lutjanus campechanus*)	SFB-NMFS 2016
SEDAR41-RW03	Age structured production model (ASPM) for U.S. South Atlantic gray triggerfish (*Balistes capriscus*)	SFB-NMFS 2016
SEDAR41-RW04	Red Snapper: Additional BAM diagnostics, analyses, and code	SFB-NMFS 2016
SEDAR41-RW05	Model Diagnostics and Source Code for SEDAR 41 gray triggerfish (*Balistes capriscus*) Benchmark Stock Assessment	SFB-NMFS 2016
Reference Documents		
SEDAR41-RD01	List of documents and working papers for SEDAR 32 (South Atlantic Blueline Tilefish and gray triggerfish) – all documents available on the SEDAR website.	SEDAR 32
SEDAR41-RD02	List of documents and working papers for SEDAR 9 (Gulf of Mexico gray triggerfish, Greater Amberjack, and Vermilion Snapper) – all documents available on the SEDAR website.	SEDAR 9
SEDAR41-RD03	2011 Gulf of Mexico gray triggerfish Update Assessment	SEDAR 2011
SEDAR41-RD04	List of documents and working papers for SEDAR 24 (South Atlantic Red Snapper) – all documents available on the SEDAR website.	SEDAR 24
SEDAR41-RD05	List of documents and working papers for SEDAR 31 (Gulf of Mexico Red Snapper) – all documents available on the SEDAR website.	SEDAR 31
SEDAR41-RD06	List of documents and working papers for SEDAR 15 (South Atlantic Red Snapper and	SEDAR 15

	greater amberjack) – all documents available on the SEDAR website.	
SEDAR41-RD07	2009 Gulf of Mexico Red Snapper update assessment	SEDAR 2009
SEDAR41-RD08	List of documents and working papers for SEDAR 7 (Gulf of Mexico Red Snapper) – all documents available on the SEDAR website.	SEDAR 7
SEDAR41-RD09	SEDAR 24 South Atlantic Red Snapper: management quantities and projections requested by the SSC and SERO	NMFS - Sustainable Fisheries Branch 2010
SEDAR41-RD10	Total removals of Red Snapper (*Lutjanus campechanus*) in 2012 from the US South Atlantic	NMFS - Sustainable Fisheries Branch 2013
SEDAR41-RD11	Amendment 17A to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region	SAFMC 2010
SEDAR41-RD12	Amendment 28 to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region	SAFMC 2013
SEDAR41-RD13	Total removals of Red Snapper (*Lutjanus campechanus*) in 2013 from the U.S. South Atlantic	NMFS - Sustainable Fisheries Branch 2014
SEDAR41-RD14	South Atlantic Red Snapper (*Lutjanus campechanus*) monitoring in Florida for the 2012 season	Sauls et al. 2013
SEDAR41-RD15	South Atlantic Red Snapper (*Lutjanus campechanus*) monitoring in Florida for the 2013 season	Sauls et al. 2014
SEDAR41-RD16	A directed study of the recreational Red Snapper fisheries in the Gulf of Mexico along the West Florida shelf	Sauls et al. 2014
SEDAR41-RD17	Using generalized linear models to estimate selectivity from short-term recoveries of tagged red drum *Sciaenops ocellatus*: Effects of gear, fate, and regulation period	Bacheler et al. 2009
SEDAR41-RD18	Direct estimates of gear selectivity from multiple tagging experiments	Myers and Hoenig 1997
SEDAR41-RD19	Examining the utility of alternative video monitoring metrics for indexing reef fish abundance	Schobernd et al. 2014

SEDAR41-RD20	An evaluation and power analysis of fishery independent reef fish sampling in the Gulf of Mexico and U.S. South Atlantic	Conn 2011
SEDAR41-RD21	Consultant's Report: Summary of the MRFSS/MRIP Calibration Workshop	Boreman 2012
SEDAR41-RD22	2013 South Atlantic Red Snapper Annual Catch Limit and Season Length Projections	SERO 2013
SEDAR41-RD23	Southeast Reef Fish Survey Video Index Development Workshop	Bacheler and Carmichael 2014
SEDAR41-RD24	Observer Coverage of the 2010-2011 Gulf of Mexico Reef Fish Fishery	Scott-Denton and Williams
SEDAR41-RD25	Circle Hook Requirements in the Gulf of Mexico: Application in Recreational Fisheries and Effectiveness for Conservation of Reef Fishes	Sauls and Ayala 2012
SEDAR41-RD26	GADNR Marine Sportfish Carcass Recovery Project	Harrell 2013
SEDAR41-RD27	Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States	Gulf and South Atlantic Fisheries Foundation 2008
SEDAR41-RD28	A Continuation of Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States	Gulf and South Atlantic Fisheries Foundation 2010
SEDAR41-RD29	Continuation of Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States	Gulf and South Atlantic Fisheries Foundation 2013
SEDAR41-RD30	Amendment 1 and Environmental Assessment and Regulatory Impact Review to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region	SAFMC 1988
SEDAR41-RD31	Final Rule for Amendment 1 to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region	Federal Register 1989
SEDAR41-RD32	Population Structure and Genetic Diversity of Red Snapper (Lutjanus campechanus) in the U.S. South Atlantic and Connectivity with Red Snapper in the Gulf of Mexico	Gold and Portnoy 2013
SEDAR41-RD33	Oogenesis and fecundity type of Gulf of Mexico gray triggerfish reflects warm water environmental and parental care	Lang and Fitzhugh 2014

SEDAR41-RD34	Depth-related Distribution of Postjuvenile Red Snapper in Southeastern U.S. Atlantic Ocean Waters: Ontogenetic Patterns and Implications for Management	Mitchell et al. 2014
SEDAR41-RD35	gray triggerfish Age Workshop	Potts 2013
SEDAR41-RD36	Age, Growth, and Reproduction of gray triggerfish *Balistes capriscus* Off the Southeastern U.S. Atlantic Coast	Kelly 2014
SEDAR41-RD37	Assessment of Genetic Stock Structure of gray triggerfish (*Balistes capriscus*) in U.S. Waters of the Gulf of Mexico and South Atlantic Regions	Saillant and Antoni 2014
SEDAR41-RD38	Genetic Variation of gray triggerfish in U.S. Waters of the Gulf of Mexico and Western Atlantic Ocean as Inferred from Mitochondrial DNA Sequences	Antoni et al. 2011
SEDAR41-RD39	Characterization of the U.S. Gulf of Mexico and South Atlantic Penaeid and Rock Shrimp Fisheries Based on Observer Data	Scott-Denton et al. 2012
SEDAR41-RD40	Does hook type influence the catch rate, size, and injury of grouper in a North Carolina commercial fishery	Bacheler and Buckel 2004
SEDAR41-RD41	Fishes associated with North Carolina shelf-edge hardbottoms and initial assessment of a proposed marine protected area	Quattrini and Ross 2006
SEDAR41-RD42	Growth of grey triggerfish, *Balistes capriscus*, based on growth checks of the dorsal spine	Ofori-Danson 1989
SEDAR41-RD43	Age Validation and Growth of gray triggerfish, *Balistes capriscus*, In the Northern Gulf of Mexico	Fioramonti 2012
SEDAR41-RD44	A review of the biology and fishery for gray triggerfish, *Balistes capriscus*, in the Gulf of Mexico	Harper and McClellan 1997
SEDAR41-RD45	Stock structure of gray triggerfish, *Balistes capriscus*, on multiple spatial scales in the Gulf of Mexico	Ingram 2001
SEDAR41-RD46	Evaluation of the Efficacy of the Current Minimum Size Regulation for Selected Reef Fish Based on Release Mortality and Fish Physiology	Burns and Brown-Peterson 2008
SEDAR41-RD47	Population Structure of Red Snapper from the Gulf of Mexico as Inferred from Analysis of Mitochondrial DNA	Gold et al. 1997

SEDAR41-RD48	Successful Discrimination Using Otolith Microchemistry Among Samples of Red Snapper *Lutjanus campechanus* from Artificial Reefs and Samples of *L.campechanus* Taken from Nearby Oil and Gas Platforms	Nowling et al. 2011
SEDAR41-RD49	Population Structure and Variation in Red Snapper (Lutjanus campechanus) from the Gulf of Mexico and Atlantic Coast of Florida as Determined from Mitochondrial DNA Control Region Sequence	Garber et al. 2003
SEDAR41-RD50	Population assessment of the Red Snapper from the southeastern United States	Manooch et al. 1998
SEDAR41-RD51	Otolith Microchemical Fingerprints of Age-0 Red Snapper, *Lutjanus campechanus*, from the Northern Gulf of Mexico	Patterson et al. 1998
SEDAR41-RD52	Implications of reef fish movement from unreported artificial reef sites in the northern Gulf of Mexico	Addis et al. 2013
SEDAR41-RD53	Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species	Then et al. 2014
SEDAR41-RD54	Length selectivity of commercial fish traps assessed from in situ comparisons with stereo-video: Is there evidence of sampling bias?	Langlois et al. 2015
SEDAR41-RD55	MRIP Calibration Workshop II – Final Report	Carmichael and Van Vorhees (eds.) 2015
SEDAR41-RD56	Total Removals of Red Snapper (*Lutjanus campechanus*) in 2014 from the U.S. South Atlantic	SEFSC 2015
SEDAR41-RD57	Assessing reproductive resilience: an example with South Atlantic Red Snapper *Lutjanus campechanus*	Lowerre-Barbiere et al. 2015
SEDAR41-RD58	Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey and its partners	Smart et al. 2014
SEDAR41-RD59	MRIP Transition Plan for the Fishing Effort Survey	Atlantic and Gulf Subgroup of the MRIP Transition Team 2015
SEDAR41-RD60	Technical documentation of the Beaufort Assessment Model (BAM)	Williams and Shertzer 2015

SEDAR41-RD61	Stock Assessment of Red Snapper in the Gulf of Mexico 1872-2013, with Provisional 2014 Landings: SEDAR Update Assessment	Cass-Calay et al. 2015
SEDAR41-RD62	Excerpt from the December 2013 SAFMC SEDAR Committee Minutes (pages 11-21 where SEDAR 41 ToR were discussed)	SAFMC SEDAR Committee
SEDAR41-RD63	Population structure of Red Snapper (*Lutjanus campechanus)* in U.S. waters of the western Atlantic Ocean and the northeastern Gulf of Mexico	Hollenbeck et al. 2015
SEDAR41-RD64	SEDAR31-AW04: The Effect of Hook Type on Red Snapper Catch	Saul and Walter 2013
SEDAR41-RD65	SEDAR31-AW12: Estimation of hook selectivity on Red Snapper (*Lutjanus campechanus*) during a fishery independent survey of natural reefs in the Gulf of Mexico	Pollack et al. 2013
SEDAR41-RD66	Effect of Circle Hook Size on Reef Fish Catch Rates, Species Composition, and Selectivity in the Northern Gulf of Mexico Recreational Fishery	Patterson et al. 2012
SEDAR41-RD67	Effect of trawling on juvenile Red Snapper (*Lutjanus campechanus*) habitat selection and life history parameters	Wells et al. 2008
SEDAR41-RD68	SEDAR24-AW05: Selectivity of Red Snapper in the southeast U.S. Atlantic: dome-shaped or flat topped?	SFB-SEFSC 2010
SEDAR41-RD69	Hierarchical analysis of multiple noisy abundance indices	Conn 2010
SEDAR41-RD70	Data weighting in statistical fisheries stock assessment models	Francis 2011
SEDAR41-RD71	Corrigendum to Francis 2011 paper	Francis
SEDAR41-RD72	Quantifying annual variation in catchability for commercial and research fishing	Francis et al. 2003
SEDAR41-RD73	Evolutionary assembly rules for fish life histories	Charnov et al. 2012
SEDAR41-RD74	User's Guide for ASPIC Suite, version 7: A Stock-Production Model Incorporating Covariates and auxiliary programs	Prager 2015
SEDAR41-RD75	Standing and Special Reef Fish SSC, September 2015 Meeting Summary (see pages 4-7 for SEDAR 43 review)	Gulf of Mexico Standing and Special Reef Fish SSC
SEDAR41-RD76	Standing and Special Reef Fish SSC, January 2016 Meeting Summary (see pages 2-7 for SEDAR 43 review)	Gulf of Mexico Standing and

		Special Reef Fish SSC
SEDAR41-RD77	SEDAR 43 Gulf of Mexico gray triggerfish Stock Assessment Report	SEDAR 43
SEDAR41-RD78	Review of 2014 SEDAR 31 Gulf of Mexico Red Snapper Update Assessment	Gulf of Mexico Standing and Special Reef Fish SSC
SEDAR41-RD79	Influence of soak time and fish accumulation on catches of reef fishes in a multispecies trap survey	Bacheler et al. 2013

Appendix B. Statement of Work

External Independent Peer Review by the Center for Independent Experts

SEDAR 41 South Atlantic Red Snapper and Gray Triggerfish Assessment Review Workshop

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: SEDAR 41 will be a compilation of data, an assessment of the stocks, and CIE assessment review conducted for South Atlantic red snapper and gray triggerfish.
The review workshop provides an independent peer review of SEDAR stock assessments. The term review is applied broadly, as the review panel may request additional analyses, error corrections and sensitivity runs of the assessment models provided by the assessment panel. The review panel is ultimately responsible for ensuring that the best possible assessment is provided through the SEDAR process. The stocks assessed through SEDAR 41 are within the jurisdiction of the South Atlantic Fisheries Management Council and the states of Florida, Georgia, South Carolina, and North Carolina. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the primary task of providing peer-review advice in compliance with the workshop Terms of Reference. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled in Charleston, SC **during March 15-18, 2016**.
Statement of Tasks: Each CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

<u>Prior to the Peer Review</u>: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also

responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/ http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

CIE reviewers shall conduct an impartial and independent peer review of the assessment in accordance with the SoW and ToRs herein.

A description of the SEDAR Review process can be found in the SEDAR Policies and Procedures document:
http://sedarweb.org/docs/page/SEDARPoliciesandProcedures_Oct14_FINAL.pdf

The CIE reviewers may contribute to a Summary Report of the Review Workshop produced by the Workshop Panel.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: Each CIE reviewer may assist the Chair of the panel review meeting with contributions to the Summary Report, based on the terms of reference of the review. Each CIE reviewer is not required to reach a consensus, and should provide a brief summary of the reviewer's views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the Schedule of Milestones and Deliverables.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate during the panel review meeting at the **Charleston, SC during March 15-18, 2016**.
3) Participate at the review meeting in **Charleston, SC during March 15-18, 2016** as specified herein, and conduct an independent peer review in accordance with the **ToRs (Annex 2).**
4) No later than April 11 2016, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Dr. Manoj Shivlani, CIE Lead Coordinator, via email to mshivlani@ntvifederal.net, and Dr. David Sampson, CIE Regional Coordinator, via email to david.sampson@oregonstate.edu. Each CIE report shall be written using the format and content requirements specified in **Annex 1**, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

February 9, 2016	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
March 1, 2016	NMFS Project Contact sends the CIE Reviewers the pre-review documents
March 15–18, 2016	Each reviewer participates and conducts an independent peer review during the panel review meeting
April 11, 2016	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
April 25, 2016	CIE submits CIE independent peer review reports to the COTR
May 2, 2016	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via email the contract deliverables (CIE independent peer review reports) to the COTR (Allen Shimada at allen.shimada@noaa.gov.

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:

(1) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

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Key Personnel:

NMFS Project Contact:

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.
2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.
    a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.
    b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.
    c. Reviewers should elaborate on any points raised in the Summary Report that they feel might require further clarification.
    d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.
    e. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.
3. The reviewer report shall include the following appendices:

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

Annex 2: Terms of Reference for the Peer Review

SEDAR 41 South Atlantic Red Snapper and Gray Triggerfish Assessment Review Workshop

1. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:
    a) Are data decisions made by the DW and AW sound and robust?
    b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
    c) Are data applied properly within the assessment model?
    d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and considering the following:
    a) Are methods scientifically sound and robust?
    b) Are assessment models configured properly and used consistent with standard practices?
    c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings and consider the following:
    a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
    b) Is the stock overfished? What information helps you reach this conclusion?
    c) Is the stock undergoing overfishing? What information helps you reach this conclusion?
    d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
    e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, including discussing strengths and weaknesses, and consider the following:
    a) Are the methods consistent with accepted practices and available data?
    b) Are the methods appropriate for the assessment model and outputs?
    c) Are the results informative and robust, and are they useful to support inferences of probable future conditions?
    d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
    a) Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.
    b) Ensure that the implications of uncertainty in technical conclusions are clearly stated.
6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.
    a) Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
    b) Provide recommendations on possible ways to improve the SEDAR process.
7. Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity,

transparency, timeliness, verification, validation, and peer review of fishery management information.

8. Compare and contrast assessment uncertainties between the Gulf of Mexico and South Atlantic stocks.
9. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.
10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Peer Review Summary Report in accordance with the project guidelines.

Annex 3: Tentative Agenda

SEDAR 41 South Atlantic Red Snapper and Gray Triggerfish Assessment Review Workshop

Charleston, SC

March 15-18, 2016

Tuesday

8:30 a.m.	**Convene**	
8:30a.m. – 9:00a.m.	**Introductions and Opening Remarks**	**Coordinator**
	- Agenda Review, TOR, Task Assignments	**Chair**
9:00a.m. – 12:00p.m.	Assessment Presentation and Discussion (RS*)	**TBD**
12:00p.m. – 1:30p.m.	**Lunch Break**	
1:30 p.m. - 3:30 p.m.	**Panel Discussion**	**Chair**
	- Assessment Data & Methods	
	- Identify additional analyses, sensitivities, corrections	
3:30p.m. – 3:45 p.m.	**Break**	
3:30 p.m. - 5:00 p.m.	**Panel Discussion**	**Chair**
	-Continue deliberations	
5:00p.m. – 6:00p.m.	**Panel Work Session**	**Chair**

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

Wednesday

Tuesday

8:30a.m. – 12:00 p.m.	**Assessment Presentation and Discussion (GTF**)**	**TBD**
12:00p.m. – 1:30p.m.	**Lunch Break**	
1:30 p.m. - 3:30 p.m.	**Panel Discussion**	**Chair**
	- Assessment Data & Methods	

	- Identify additional analyses, sensitivities, corrections	
3:30p.m. – 3:45 p.m.	**Break**	
3:30 p.m. - 5:00 p.m.	**Panel Discussion**	**Chair**
	-Continue deliberations	
5:00p.m. – 6:00p.m.	**Panel Work Session**	**Chair**

Wednesday Goals: Initial GTF** presentation completed, sensitivities and modifications identified.

Thursday

8:30a.m. – 12:00 p.m.	**Panel Discussion**	**Chair**
	- Review additional analyses, sensitivities	
12:00p.m. – 1:30p.m.	**Lunch Break**	
1:30 p.m. - 3:30 p.m.	**Panel Discussion**	**Chair**
	- Continue deliberations	
3:30p.m. – 3:45 p.m.	**Break**	
3:45 p.m. - 5:00 p.m.	**Panel Discussion**	**Chair**
	- Consensus recommendations and comments	
5:00p.m. – 6:00p.m.	**Panel Work Session**	**Chair**

Thursday Goals: Final sensitivities identified, preferred models selected, projection approaches approved, Summary report drafts begun.

Friday

8:30a.m. – 10:30 a.m.	**Panel Discussion**	**Chair**
	- Review additional analyses, final sensitivities	
	- Projections reviewed.	
10:30 a.m. – 10:45 a.m.	**Break**	

10:45 a.m. - 1:00 p.m.	**Panel Discussion or Work Session**	**Chair**
	- Continue deliberations	
3:30p.m. – 3:45 p.m.	**Break**	
3:30 p.m. - 5:00 p.m.	**Panel Discussion**	**Chair**
	- Review Consensus Reports	
1:00 p.m.	**ADJOURN**	

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

* RS = South Atlantic red snapper

**GTF = South Atlantic gray triggerfish

Appendix C. List of Participants

REVIEW WORKSHOP PANELISTS

Luiz Barbieri	Review Panel Chair	SAFMC SSC
Mike Armstrong	Reviewer	CIE
Jon Helge Vølstad	Reviewer	CIE
Stephen Smith	Reviewer	CIE
Steve Cadrin	Reviewer	SAFMC SSC
Churchill Grimes	Reviewer	SAFMC SSC

ANALYTICAL REPRESENTATIVES

Kevin Craig	Lead Analyst, GTF	SEFSC Beaufort
Kate Siegfried	Lead Analyst, RS	SEFSC Beaufort
Kyle Shertzer	Assessment Team	SEFSC Beaufort
Erik Williams	Assessment Team	SEFSC Beaufort
Rob Cheshire*	Assessment Team	SEFSC Beaufort
Eric Fitzpatrick*	Assessment Team	SEFSC Beaufort

APPOINTED OBSERVERS

Rusty Hudson	Recreational/Commercial	FL / SFA
Robert Johnson	For-Hire	FL

APPOINTED COUNCIL REPRESENTATIVES

Zack Bowen	Council Member	SAFMC
Mark Brown	Council Member	SAFMC
Chris Conklin	Council Member	SAFMC

COUNCIL AND AGENCY STAFF

Julia Byrd	Coordinator	SEDAR
Julie O'Dell	Admin	SEDAR / SAFMC
Chip Collier	Fishery Biologist	SAMFC
Mike Errigo	Fishery Biologist	SAFMC
Nick Farmer	Fishery Biologist	SERO

WORKSHOP ATTENDEES

Joey Ballenger, SCDNR
Peter Barile, SFA
Myra Brouwer, SAFMC
John Carmichael, SAFMC
Brian Cheuvront, SAFMC
Lora Clarke, PEW
Amy Dukes, SCDNR
Jimmy Hull, FL fisherman
Julie Neer, SAFMC

Adam Nelson, FL fisherman
David Nelson, FL fisherman
Michael Nelson, FL fisherman
Paul Nelson, FL fisherman
Marcel Reichert, SCDNR
Tracey Smart, SCDNR

*Appointees marked with a * were appointed to the workshop panel but did not attend the workshop.