Center for Independent Experts (CIE) Peer Review Report of the SEDAR 58 Review Assessment Review for Atlantic cobia (*Rachycentron canadum)*

Beaufort Hotel, 19-21 November 2019, Beaufort NC, USA

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Prepared for

Center for Independent Experts (CIE)

Independent System for Peer Review

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1 EXECUTIVE SUMMARY

The SEDAR 58 review workshop was held at the Beaufort Hotel, Beaufort, North Carolina from 9:00 a.m. on Tuesday 19 November 2019 through 5:00 p.m. on Thursday 21 November 2019. The meeting was efficiently organized, took place in comfortable surroundings and with full participation from all attendees.

The review panel comprised three reviewers appointed by the Centre for Independent Experts (CIE), a reviewer appointed by the Atlantic States Marine Fisheries Commission (ASMFC) and an ASMFC-appointed chair. The assessment team's lead assessor presented the outcomes from the data and assessment workshops, taking care to highlight any concerns or shortcomings raised during the assessment process with regard to the input data, model assumptions and output. All questions and additional requests from the review panel were dealt with professionally and in a timely manner.

The Beaufort Assessment Model (BAM) (Williams and Shertzer, 2015), together with input observations on catch at age from the commercial and recreational fisheries, a head-boat CPUE index and estimates for life history parameters, formed the basis of the assessment. The assessment panel had prepared an assessment report documenting their preferred base run which was the subject of the SEDAR 58 review. Following the review, a revised base model run was accepted by the panel which differed from the original only in that a single time block for selectivity was used for the head-boat index. That time block was assumed to be the same as the selectivity for the recreational fishery over the period 1986-2006.

Uncertainties were well described and tested by the assessment panel. Uncertainty is related primarily to three main areas:

1. *Uncertainty in catch data incorporating commercial and recreational removals estimates, age compositions for the recreational fishery prior to 2007 and length compositions for the commercial fishery.*
2. *Uncertainty associated with the estimates for natural mortality (M) at age.*
3. *Uncertainty associated with the assumptions on maturity at age.*

The results of the revised assessment represent the best estimates currently available with regard to the abundance, exploitation and biomass of Atlantic cobia. They are consistent with known or assumed population parameters, were derived using the best available science and are sufficiently reliable to be used as the basis for inferring stock status and for the provision of fisheries management advice.

Given the absence of accepted and approved fishery management reference points, the assessment team proposed the following:

1. *$F_{40\%}$ as a proxy for F_{MSY},*
2. *$SSBF_{40\%}$ as a proxy for SSB_{MSY}*
3. *$75\%F_{40\%}$ and $75\%SSBF_{40\%}$ as target reference points.*

In relation to the above proxies for MSY-based reference points, the estimates of SSB and F for Atlantic Cobia indicate that the population has been above $SSB_{F40\%}$ and below $F_{40\%}$ for the entire time-period of the assessment (1986-2017).

The assumptions regarding natural mortality were a key source of uncertainty within the assessment model. However, results of ensemble modeling using bootstraps of M based on 2x the standard error of the M around the regression line for the estimated mean size of Cobia at age, indicated that despite the large uncertainty in M estimates, the stock was highly unlikely to be below the $SSB_{F40\%}$ reference point.

Hence, in relation to the proposed proxy reference points for fishing mortality ($F_{40\%}$) and spawning stock biomass ($SSBF_{40\%}$), the stock of Atlantic cobia is not currently overfished and overfishing is not occurring.

Projections were carried out appropriately using accepted practices given the data available and were appropriate for the assessment model and required outputs. The results are informative and robust and can be used to support inferences on future stock status.

Projections were performed under 3 different scenarios for the years 2020-2024: i) $F=F_{current}$ ii) $F=F_{40\%}$ iii) $F = 75\%F_{40\%}$. Results of these projections indicated that for all scenarios, the mean deterministic and median stochastic estimates of SSB were greater than $SSBF_{40\%}$ for all years. Nevertheless, given the uncertainty around inputs, there was a small (12% at $F_{current}$) to moderate (50% at $F = F_{40\%}$) proportion of stochastic simulations that resulted in an overfished status ($SSB< SSBF_{40\%}$) between 2020 and 2024.

A number of priority research recommendations, drawn primarily from the extensive list provided in the SEDAR 58 data workshop and assessment workshop reports, are as follows:

1 ***Uncertainty on natural mortality estimates.*** Natural mortality is an important parameter that affects model estimates of recruitment and spawning stock biomass. The RP recommend that estimates of natural mortality be made using tagging data or other analytical approaches (e.g., meta-analysis, catch-curves, etc.) for use in the model or to ground-truth the life-history invariant method used currently.

2 ***Requirement for a reliable CPUE index of abundance.*** The fishery-dependent head-boat index ended in 2015. Hence, development of a new index, either fishery-dependent or preferably fishery-independent, should be given top priority. Without an index of abundance, it is unlikely that stock status would be able to be estimated with any reliability in the future. The RP recommends exploring other fisheries-dependent CPUE sources if available, developing fisheries-independent surveys such as egg/larvae surveys or close-kin methods, expanding analysis of the ten-year SERFS baited trap-video survey for cobia, or exploring the use of tag-data as potential indices of abundance.

3 ***Increase sampling for size and age.*** Given that age composition data are an important source of information for the assessment model, methods to increase sample size (such as expanding carcass collection locations and establishing similar programs in other states) should be implemented. In addition,

development of sampling programs to collect size and age information on fish released in the recreational fishery should be a priority.

4 ***Improve estimates for age-at-maturity and annual sex ratio.*** The uncertainty in the stock status would be improved if better information on age-at-maturity and annual sex ratios were to be collected.

2 BACKGROUND

Cobia *(Rachycentron canadum*) are distributed worldwide in tropical and warm-temperature waters. They occur along the Atlantic coast from Nova Scotia to Argentina, and are most abundant in U.S. waters from Chesapeake Bay south into the Gulf of Mexico. Two cobia stocks are recognized off the US Atlantic coast; the Atlantic Migratory Group (Atlantic cobia) and the Gulf of Mexico Migratory Group (Gulf cobia).

The SEDAR 58 process concerns a benchmark assessment for Atlantic cobia which falls under the jurisdiction of the Atlantic States Marine Fisheries Commission and the states of Florida, Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine.

The assessment review represents the final stage in the SEDAR 58 assessment process and the review panel is ultimately responsible for ensuring that the best possible assessment is provided through the SEDAR process and the assessment results and output are scientifically sound.

The previous SEDAR assessment for Atlantic cobia carried out in 2013 (SEDAR 28) concluded that the stock was not overfished and overfishing was not taking place.

3 REVIEW ACTIVITIES

The SEDAR 58 review workshop was held at the Beaufort Hotel, Beaufort, North Carolina from 9:00 a.m. on Tuesday 19 November 2019 through 5:00 p.m. on Thursday 21 November 2019.

The review panel comprised three reviewers appointed by the Centre for Independent Experts (CIE), a reviewer appointed by the Atlantic States Marine Fisheries Commission (ASMFC) and an ASMFC-appointed chair. In accordance with the SEDAR process, the review was an open meeting and in addition to the review panel, the meeting was attended by analysts from the cobia assessment team, appointed observers, council and agency staff and other interested parties. All participants are listed in Appendix 3.

The performance work statement for CIE reviewers is given in Appendix 2 together with the terms of reference for the review (Annex 2) and the provisional

Agenda (Annex 3). The peer review report requirements are given in Annex 1 of Appendix 2.

Some two weeks prior to the Review Workshop, I was provided with the draft stock assessment report and web access to all relevant supporting documentation and papers relating to and cited by the Data and Assessment Workshops (Appendix 1). The supporting documentation was comprehensive and informative and together with the Data and Assessment workshop reports, provided me with a good understanding of the data and methods used for the assessment and allowed me to develop a preliminary list of points to raise during the review.

The CIE reviewers were tasked to conduct an impartial and independent peer review in accordance with the Performance Work Statement (PWS) (Appendix 2), OMB guidelines and the Terms of Reference (Annex 2 of Appendix 2). Each reviewer was required to have a working knowledge in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the primary task of providing peer-review advice in compliance with the workshop Terms of Reference (Appendix 2, Annex 2).

During the review, all discussions were recorded for transparency. The results of the assessment were presented to the review Panel and other attendees. The input data, assessment approach, results and utility of the findings for management were evaluated through open discussion. The Terms of Reference (Appendix 2) were reviewed to ensure they had been fully addressed.

The review panel prepared a draft, summary panel report before the meeting ended on 21 November. The panel report was finalized by correspondence after the review meeting.

4 FINDINGS

4.1 Summary of findings

The accepted base model indicates that in relation to the proposed proxy reference point for spawning stock biomass ($SSBF_{40\%}$) and fishing mortality ($F_{40\%}$), the stock of Atlantic cobia is not currently overfished and overfishing is not taking place.

The data and assumptions used for the SEDAR 58 assessment and predictions are the best currently available. The decisions made in compiling such data were sound and robust and the uncertainties associated with such data were identified, described and adequately investigated.

The methods used are sound and robust, are appropriate for the available data and follow accepted scientific practices.

4.2 Findings in relation to specific items in the Terms of Reference

4.2.1. Evaluate the data used in the assessment addressing the following:

- *Are data decisions made by the DW and AW sound and robust?*

The time-series of recreational and commercial removals of cobia used as input for the assessment ranged from 1986 – 2017. Although removal estimates were available for years earlier than 1986, these were considered by the data workshop to be less reliable and were not used for the SEDAR 58 assessment. The rationale to exclude removals data prior to 1986 appeared reasonable and was appropriate.

Removals comprised:

i) commercial landings derived from ACCSP/State records.
ii) commercial dead discards derived from 3 data sources: a) Shark Gillnet observer program (NMFS), b) North Carolina Division of Marine Fisheries (NCDMF) Gill Net Observer Program, and c) NMFS Supplemental Discard Logbook Program. Release mortality was assumed to be constant at 55%.
iii) recreational (recalibrated MRIP) landings and dead releases derived from live release estimates, assuming a constant release mortality of 5%.

Only a single index of abundance derived from the head-boat time-series of catch and effort was used for the assessment. Furthermore, because of recreational fishery closures implemented in 2016 and 2017, the series was truncated to a terminal year of 2015.

Length and age data were collected mainly through state carcass collection programs in Virginia and South Carolina. Samples from each state were weighted by state landings, in an attempt to take into account any differences in samples between states.

Values for natural mortality (M) at age were derived using the Charnov et al. (2013) method which gave higher values than those derived in the previous (SEDAR 28, 2013) cobia assessment, where *M* was derived using the Lorenzen (1996) method. Values for *M*-at-age were assumed constant over time but decreasing with age.

For estimating spawning stock biomass (SSB), female maturity at age was modeled as a logistic function with 50% maturity at approximately age 1 and was assumed constant over time. Peak spawning was assumed to occur mid-June.

As for virtually all stock assessments, the input data and parameters can be uncertain. For the current assessment for cobia, I am confident that the decisions taken by the data and assessment workshops are credible and sound and that the input data are the best currently available.

- *Are data uncertainties acknowledged, reported, and within normal or expected levels?*

Major sources of uncertainty in data were acknowledged and reported by the data and assessment workshops and were discussed during the review meeting. Error bounds on input parameters were also provided in the data and assessment workshop reports as a basis for input to sensitivity and ensemble model runs.

The information provided both in the reports and during the meeting was sufficient to judge the relative extent of uncertainty in the different data sources.

Four potentially important sources of uncertainty can be identified:

1. *Uncertainty associate with commercial and recreational landings and discards estimates;*
2. *Uncertainty in the estimated age compositions for the recreational fishery for years before 2007 due to small sample sizes;*
3. *Uncertainty in the estimated length compositions for the commercial fishery due to very small sample sizes; and*
4. *Natural mortality (M) - Decreasing by age but assumed constant at age over time.*

While coefficients of variation (CVs) for commercial landings, recreational landings and discards, and head-boat index appeared realistic and adequate for assessment purposes, CVs for commercial discards appeared unrealistically high. I agree with the review panel that the values of the CVs for commercial discards should be investigated prior to future assessments to ensure that they have been correctly estimated.

In an attempt to mitigate any major influence of the high commercial discard CVs on ensemble modeling output, the review panel suggested that the CVs should be capped at 3.0 in the ensemble modeling. However, because commercial discards account for only an extremely small proportion of total removals, altering the magnitude of their CVs is unlikely to have a major influence on the ensemble model output.

The distribution and bounds on the values of the estimated rates of natural mortality (*M*) used in the ensemble modeling were based on the standard error estimates from Charnov et al. (2013) and appeared to be unrealistically narrow. To examine the influence of the assumed values for *M* in ensemble model runs for the agreed base model (co23, x-ref CEDAR-58-Addendum), the review panel agreed that the values from the Charnov et al. (2013) regression equation when the equation slope and intercept were adjusted using ± 2 standard errors should be used.

- *Are data applied appropriately within the assessment model?*

The review panel agreed that based on the assessment model diagnostics and output, the time series of removals (i.e., catch and discard mortality estimates), length and age composition data, and the head-boat CPUE index of abundance were appropriately applied in the Beaufort Assessment Model (BAM, see Item 2 below).

- *Are input data series reliable and sufficient to support the assessment approach and findings?*

While, the review panel agreed that the data used in the stock assessment were the best data available and that the data and assessment workshops satisfactorily characterized removals from all data sources, concerns were expressed regarding the estimated recreational removals for the years 1996 and 2015. Estimated

removals for both of these years appeared unusually high compared to adjacent years. In the absence of any apparent explanation for such high removal estimates, the review panel suggested that the underlying cause for the increased estimates should be investigated further.

To investigate the influence of the 1996 and 2015 recreational removal estimates on the assessment output, a sensitivity run in which the values were replaced with the mean values from the adjacent four years was carried out (SEDAR58-SAR 1-Addendum). The outcome indicated replacing the 1996 and 2015 recreational removals estimates with values more consistent with those for neighboring years, had little influence on the model results.

Despite the concerns expressed by the data workshop relating to the age compositions having been derived from non-random sampling (largely drawn from carcass collection programs in Virginia and South Carolina), the annual age composition data appeared sufficiently reliable because several cohorts could be tracked over several years.

The head-boat CPUE index was the sole index used for the assessment and because of recreational fishery closures in 2016 and 2017, the time series was truncated to 2015. As the BAM is a forward-projecting statistical model, the absence of indices in the most recent two years of the assessment, while not ideal, is not critical. However, should recreational closures continue into the future, the index will not be available. A minimum time-series of 3 additional consecutive annual index values will be required if the head-boat CPUE series is to be employed in a future assessment.

Currently, there are no other suitable indices of abundance available and it is highly desirable that additional indices of abundance be explored and developed and preferably, such indices would best be fishery-independent. The review panel suggested that spatial/temporal analyses of catch and effort data (i.e., using Gaussian random fields as, for example, implemented in VAST (Thorson 2019)) might provide a means to develop an index of abundance using the recreational catch and effort data. However, the baited trap-camera time-series (SERFS) that has been carried out in the region, may provide a useful index of abundance if these data were analyzed for Atlantic Cobia.

Despite the issues outlined above, the input data series are considered to be sufficiently reliable to support the assessment approach and findings.

4.2.2. Evaluate the methods used to assess the stock, taking into account the available data.

- *Are methods scientifically sound and robust? Do the methods follow accepted scientific practices?*

The primary assessment model (BAM) is an accepted, well-established statistical catch at age assessment tool and is implemented using AD-Model Builder software. The model simulates a population forward in time while accounting for fishing and biological processes. It estimates biomass and selectivity parameters using input

catches and stock productivity parameters by minimizing an objective function consisting of likelihoods applied to CPUE, age composition data, and length composition data, along with uniform priors on estimated parameters with the exception of those that had an assumed functional form.

Base run from the assessment report (SEDAR58-SAR1)

The assessment team provided a comprehensive description of their preferred base case (run co22) which was presented to the review panel together with the results of base model diagnostics, model sensitivities, analyses to investigate uncertainties, ensemble models, projections and supplementary analyses requested by the review panel.

A full description of the assessment model is given in SEDAR58-SAR1-Addendum.

Input data comprised age composition data from carcass samples of recreational landings, length composition data for commercial landings (aggregated over years because of low sample size) and a single time-series index of recreational catch and effort for head-boats (1991-2015). The head-boat catch represented roughly 5% of the total recreational catch from recreational fishers and the CPUE index indicated a slightly increasing trend in abundance over the time period.

Removals (landings and dead discards) were estimated for two fleets: the commercial fleet and the recreational fleet. Estimated removals from the model were almost identical to the observed removals.

Recreational catch was fitted using selectivity patterns representing different time blocks; 1986 - 2006 and 2007-2017. The justification for two time blocks was a change in fishing behavior post 2007 in response to regulatory changes.

Selectivity for the commercial catch was informed by fits to commercial length frequencies aggregated over years. While there were no representative age data for the commercial catch, the review panel agreed that because the commercial catch represented only a small proportion of overall removals (approx. 5%), the aggregated length composition data were adequate to determine selectivity for the commercial fleet in the assessment model.

The head-boat index was modeled as the vulnerable abundance using recreational selectivity from the 1986-2006 and 2007-2017 periods. However, following discussion on the appropriateness of two time blocks for head-boat selectivity, the review panel concluded that because the head-boat index represented only a small proportion of the recreational fishery that did not target Cobia, there was no obvious reason to assume that the head-boat fishing pattern would have changed in the same way as the recreational fishery as a whole. Consequently, the review further concluded that the head-boat index should be considered as the vulnerable abundance from the recreational selectivity from the period prior to 2007.

Considerable discussion took place regarding the choice of M. The Charnov et al. (2013) method used for the SEDAR 58 assessment gave values of *M*-at-age considerable higher than the Lorenzen (1996) estimates which were used for the SEDAR 28 assessment. Taking into consideration results of sensitivity tests on the

choice of M, it is clear as expected, that the model is sensitive to the choice of M. Nevertheless, the Charnov et al. (2013) approach was supported from both external sources as well and internal diagnostics when compared to the lower Lorenzen (1996) estimates which gave poorer model diagnostics. Based on such observations, the panel agreed that the Charnov et al. (2015) estimates of *M*-at-age were justifiable and appropriate and provided the best estimates currently available. However, the Review Panel suggested examination of *M* is warranted for future assessments and recommended starting with the 2015 SEDAR data best practices document.

Recruitment was estimated as the mean recruitment over time with relevant deviations. Such an approach is appropriate since, historically, recruitment has been highly variable with no clear stock-recruitment relationship apparent in the data.

Results of analyses conducted to test sensitivity of the model to alternative starting values indicated that the model was robust to the assumed starting values. There was no evidence of the model failing to converge.

While the methods employed for the assessment are scientifically sound and follow accepted practices, based on the outcome of the review of the assessment, the review panel requested that the base model be re-run assuming only a single time-block for the head-boat index (1991-2015) corresponding to the selectivity from the recreational fishery over the time period 1986-2006. The re-run (co23; SEDAR58-SAR1 Addendum) was accepted as the definitive base run for the assessment, the outcome of which is discussed in the next section below.

- *Are assessment models configured appropriately and applied consistent with accepted scientific practices?*

The decision to use 1986 as the starting year was appropriate, both from the perspective of a priori information indicating that data prior to 1986 are likely unreliable and from model diagnostics. In addition, sensitivity analyses undertaken by the assessment team indicated that there was no perceptible difference if the starting year for the assessment was set to 1950, as was done in the previous (SEDAR 28) cobia assessment (Figure 1).

The use of two fleets (recreational and commercial) with two time blocks of selectivity for the recreational fleet corresponding to the years 1986-2006 and 2007-2017 was appropriate given the change in management measures and observed increase in the VA catch estimates and increased proportions of smaller fish in the recreational catch since 2007. The changes in selectivity at age are shown in (Figure 2), which indicates that selectivity on age groups 3 and 4 approximately doubled in the period after 2007.

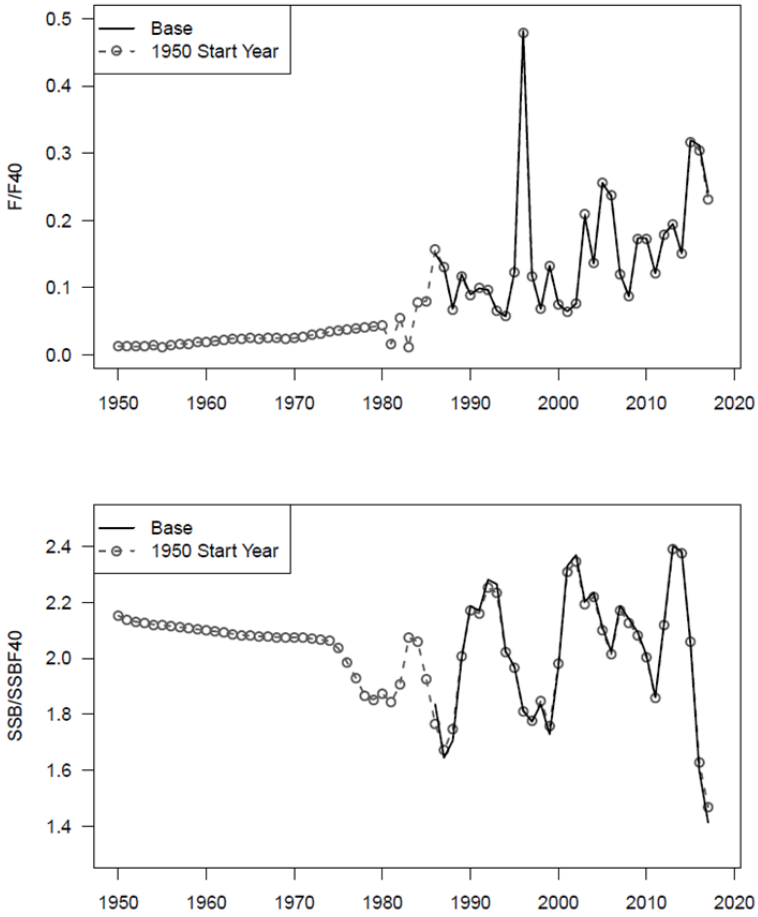

Figure 1: Start year value sensitivity. ratio of F to $F_{40\%}$ (top), ratio of SSB to $SSBF_{40\%}$ (bottom)

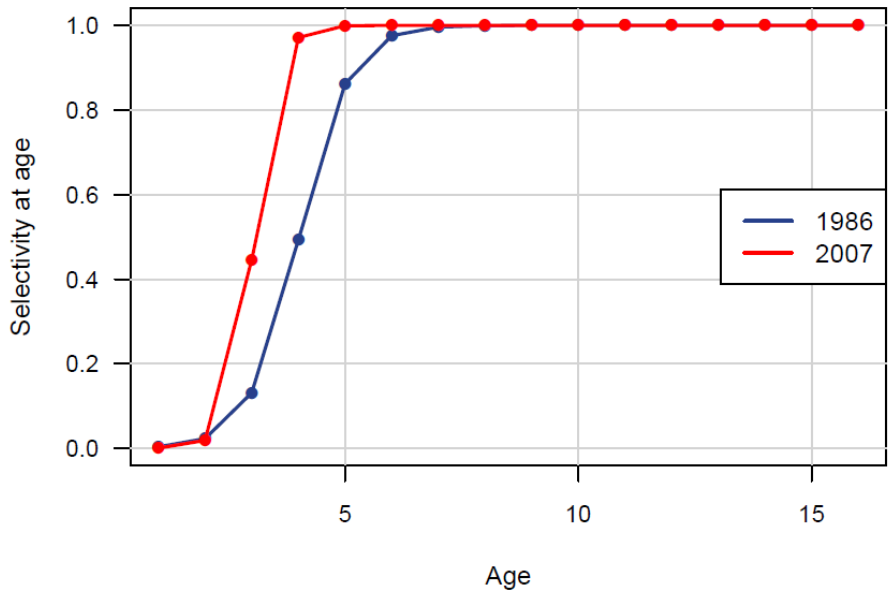

Figure 2. Estimated selectivities at age for the recreational fleet for each time block. 1986 = 1986-2006; 2007 = 2007-2017.

The amended base run (co23; SEDAR58-SAR1- Addendum) described in the preceding section and incorporating only a single block for selectivity (1986 to 2006 recreational selectivity) in the head boat fishery-dependent index of abundance, indicated only minor differences in the diagnostics of model fit but had a lower negative log likelihood for the fits to the age compositions in the most recent years.

The review panel concluded that following the amendments requested to the base run, the model was appropriately configured and was applied consistent with accepted scientific practices.

The amended base run (co23; SEDAR58-SAR1-Addendum) was accepted as the definitive assessment.

- *Are the methods appropriate for the available data?*

The stock assessment model used for Atlantic cobia is the Beaufort Assessment Model (BAM); a statistical catch at age model implemented with AD model-builder software. Nowadays, statistical catch at age models are commonly used for many age-based fish stock assessments in North America and elsewhere and the BAM has previously been used for several stock assessments under the SEDAR process.

Given the input data are primarily removals at age for both the commercial and recreational fisheries and the head-boat CPUE index for Atlantic cobia, the BAM is eminently suitable assessment modeling environment for cobia. The BAM is thoroughly documented (Williams & Shertzer, 2015) and the source code for the Atlantic cobia assessment is available in Appendix C of SEDAR58-SAR1-Addendum. The BAM is scientifically sound and is appropriate given the available data.

The review panel briefly discussed the potential for choosing alternative assessment modeling approaches but considered that other approaches to modeling catch at age date with a single, truncated time-series of abundance indices (index ending in 2015, catch at age to 2017), were likely to be less appropriate than the BAM.

4.2.3. Evaluate the assessment findings with respect to the following:

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

Comments on model output

Figure 3 indicates that the trends in stock biomass over time were relatively consistent with the head-boat index. Variance remained relatively constant and with no obvious trend in residual values.

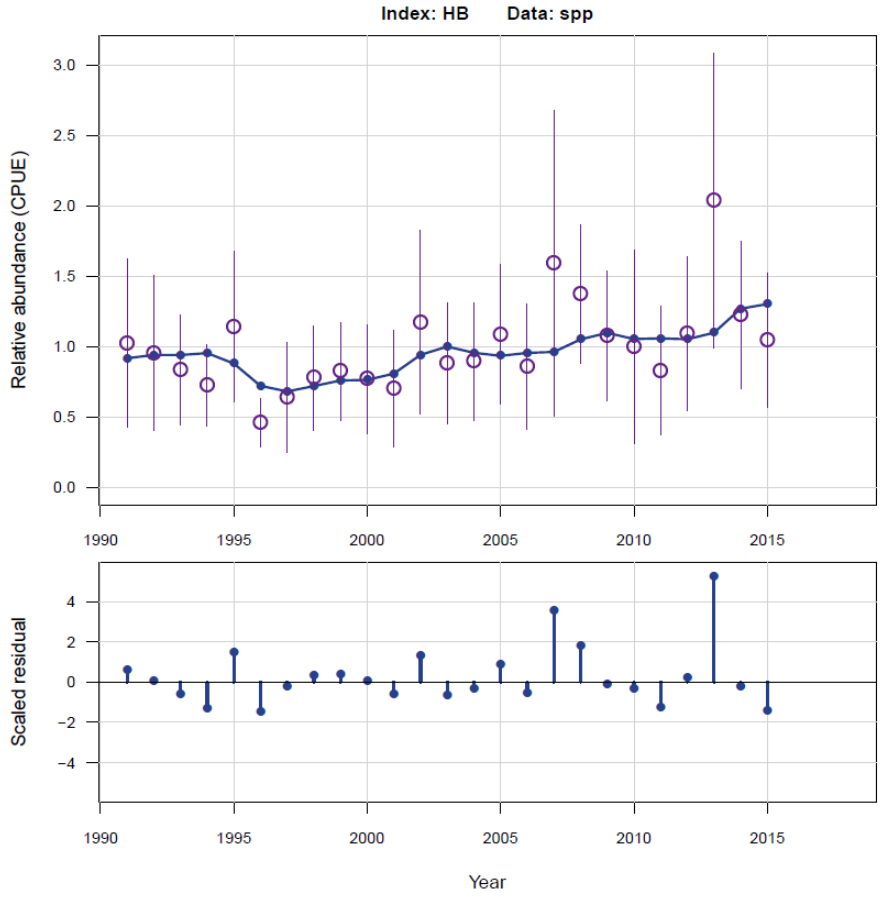

Figure 3. Revised base case model (co23) fits (top) and residuals (bottom) to the head-boat CPUE index of abundance for 1991-2015.

Similarly, the model fits to recreational catch at age compositions were acceptably good and Pearson residuals indicate no evidence of any systematic trend in the fit to annual age compositions (Figure 4).

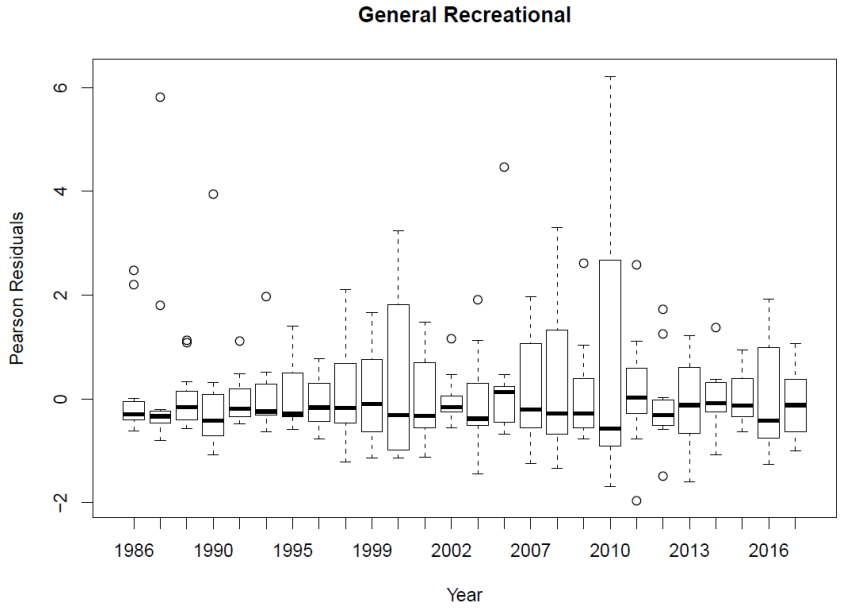

Figure 4. Pearson residuals for the age composition fits for years 1986-2017 for the revised base model (co23).

Fits across age groups (Figure 5) were generally acceptable, although there was some indication of a slightly poorer fit for age groups 4 and 5, which may be improved by adjusting the selectivity assumptions. It would be desirable to bear this in mind for future assessments when exploring relevant hypotheses and plausible assumptions on selectivity.

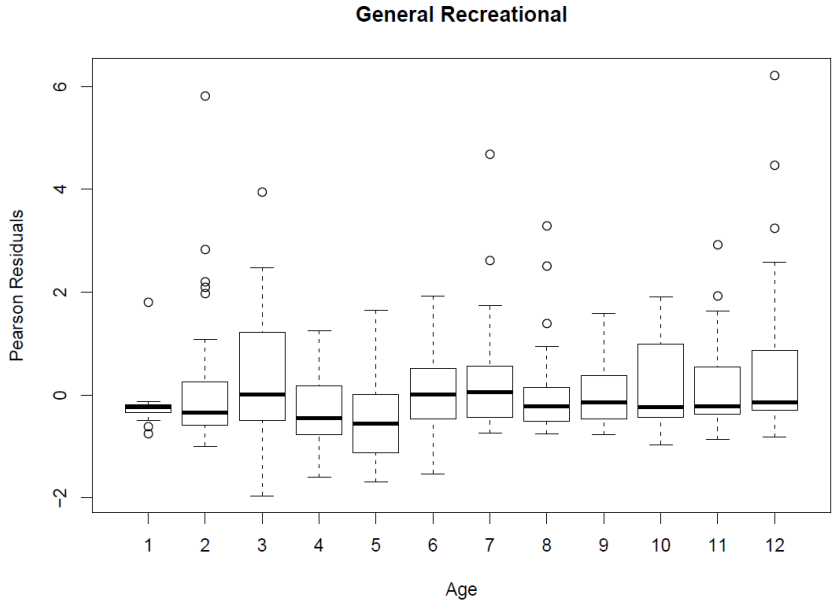

Figure 5. Pearson residuals for the age composition fits for ages 1-12 over the years 1986-2017 for the revised base case model (co23).

With reference to terms of reference 1 and 2, I conclude that the inputs to the assessment are the best currently available and are sufficiently reliable to support the use of the BAM as the assessment model. Furthermore, I am confident that the amended base run incorporating a single time block of selectivity for the head-boat index, is appropriately configured. Consequently, the population estimates for stock abundance, biomass and exploitation rates are the best estimates currently available and are consistent with known and assumed population parameters. Taken together with the comments above on model output, I also conclude that the assessment model output is based on the best available science and can be used to infer biomass and stock status.

Stock status

Given the absence of any meaningful stock-recruitment relationship, MSY-based reference points estimates (B_{MSY} and F_{MSY}) could not be computed. Alternative biological reference points based on the fishing mortality rate that would allow a stock to attain 40% of the maximum spawning potential which would have been obtained in the absence of fishing were proposed by the assessment workshop.

The review panel considered that the resulting reference points for fishing mortality ($F_{40\%}$) and spawning stock biomass ($SSB_{F40\%}$) are appropriate choices as proxies for F_{MSY} and B_{MSY}. Furthermore, the proposed reference point of 75%$SSB_{F40\%}$ is likely to be an appropriate proxy target reference point for management as this

provides an uncertainty buffer around the B_{MSY} proxy. Hence, stock status was assessed with respect to the above proxy reference points.

The results of the assessment indicate that the SSB for Atlantic cobia shows a gradually increasing trend between 1986 and 2011 followed by a sharp increase to 2014 and a subsequent decline to pre-2011 levels in 2017 (Figure 6). The marked increase in SSB 2012-2014 can be attributed the strong 2010 and above-average 2011 and 2012 year-classes. The rather steep decline between 2014 and 2017 may be largely attributable to the 2013, 2014 and 2015 year-classes which were below average. Figure 6 also indicates that SSB has remained above the $SSB_{F40\%}$ reference point for the entire assessment time series and is currently estimated to be at a level about 1.5 x $SSB_{F40\%}$. Fishing mortality has also remained below $F_{40\%}$ since at least 1986 apart from a low probability of being above $F_{40\%}$ in 1996 (Figure 6).

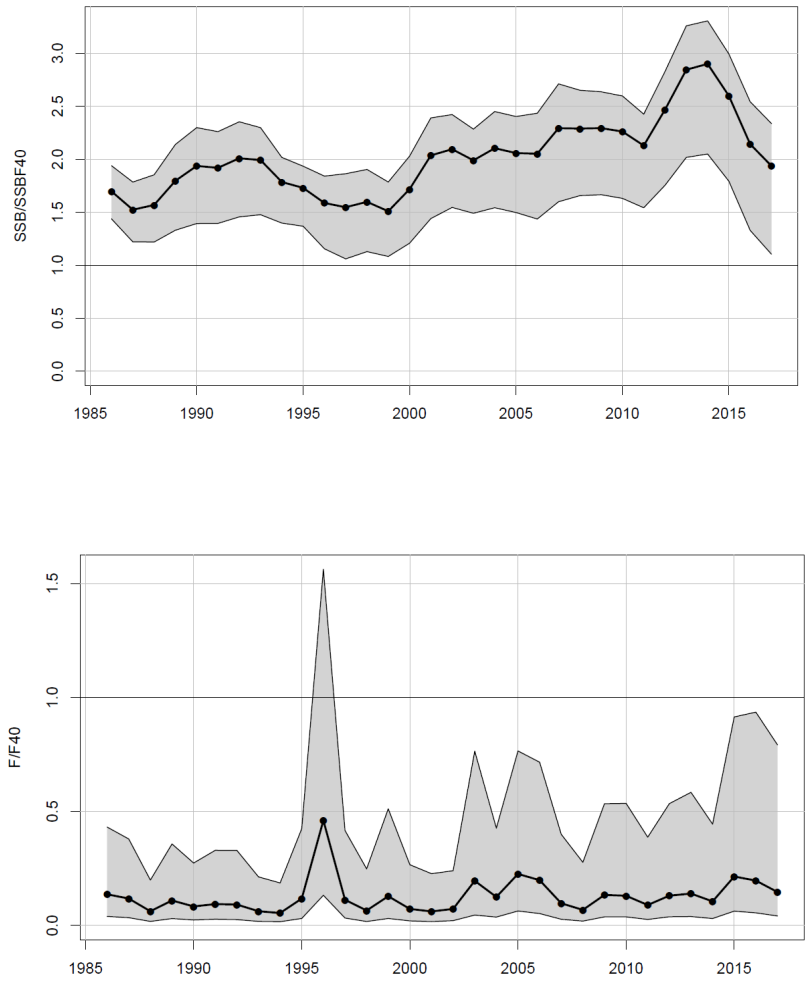

Figure 6: The 95% range for the estimates of $SSB/SSB_{F40\%}$ (top panel) and $F/F_{40\%}$ (bottom panel) from the ensemble models (grey shaded region) with the accepted base case (co23, solid line) for the assessment model for 1986-2017.

- *Is the stock overfished? What information helps you reach this conclusion?*

Ensemble modeling (Scott et al. 2016) is a recommended procedure for SEDAR assessments and was carried out by successively refitting the BAM base run (co23) in 4000 trials that differed from the original inputs by bootstrapping on data sources and by Monte Carlo sampling of several key input parameters. The results of the ensemble modelling provide an approximation of the uncertainty associated with each model output.

Figure 7 shows the output in terms of $F/F_{40\%}$ and $SSB/SSB_{40\%}$ from each ensemble model run for the accepted base model (co23).The ensemble model results clearly indicate that the stock was highly unlikely to be below the $SSBF_{40\%}$ reference point for the period 2015 to 2017. Only 3.0% of model runs delivered estimates for SSB that were below $SSBF_{40\%}$. Results of stock projections (see ToR 4 below) also showed that it was highly unlikely that the stock was below the $SSBF_{40\%}$ reference point in the most recent years (2017—2019).

In conclusion, in relation to the reference point for SSB recommended by the assessment panel ($SSBF_{40\%}$), the stock of Atlantic cobia is not currently overfished.

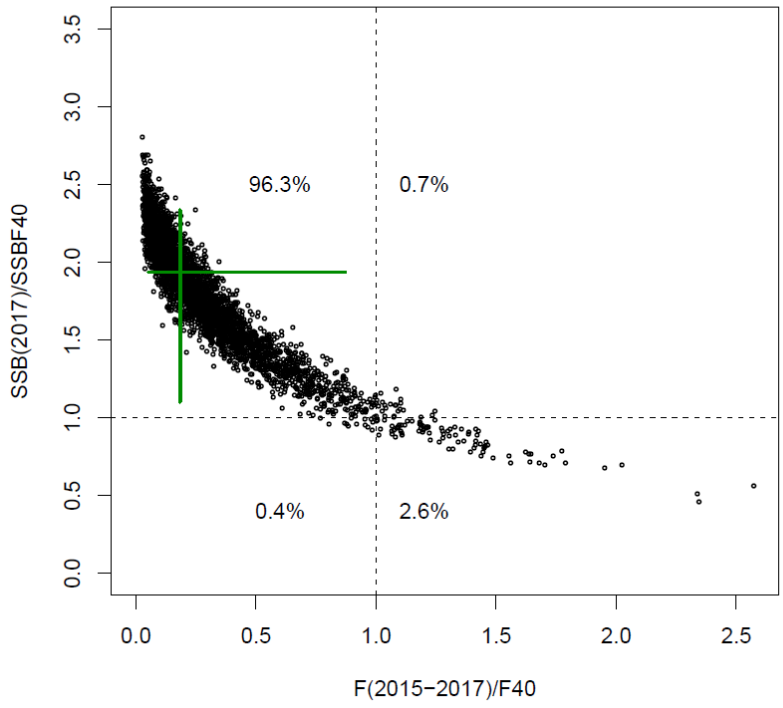

Figure 7: Ensemble model estimates of $SSB_{(2017)}/SSB_{F40\%}$ versus $F_{(2015\text{-}2017)}/F_{40\%}$ showing the proportion of ensemble model runs above and below the proposed proxy MSY-based reference points for F ($F_{40\%}$) and SSB ($SSBF_{40\%}$) for Atlantic Cobia from the revised base case model (co23).

- *Is the stock undergoing overfishing? What information helps you reach this conclusion?*

Results of the ensemble modeling (Figure 7) showed that it was highly unlikely that the stock was above the $F_{40\%}$ reference point for the period 2015 to 2017. Only 3.3% of model runs delivered estimates for $F_{(2015\text{-}2017)}$ that were below $F_{40\%}$. Results of stock projections (see ToR 4 below) also showed that it was highly unlikely that the *F* was above $F_{40\%}$ reference point in the most recent years (2017-2019).

In conclusion, in relation to the reference point for *F* recommended by the assessment panel ($F_{40\%}$), the stock is not currently undergoing overfishing.

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

There is no meaningful or informative stock-recruitment relationship for Atlantic cobia. As stock size has remained high over the modeled period, there was no available information to estimate a value for steepness (h) in the model. Hence, for computational ease, the revised base case assessment model (co23) and all sensitivities assume a steepness of *h*=1 thereby implying no relationship between spawning stock abundance and the mean number of recruits. Furthermore, given the current and historical stock status (not overfished with respect to $SSBF_{40\%}$) the review panel concluded that the choice of *h* was unlikely to alter the determination of current or projected stock status with respect to $SSBF_{40\%}$. However, the review panel noted that to a greater or lesser degree, the choice of steepness would affect the value of the targets for *F* and SSB and hence would affect the inferences on stock status relative to any alternative target reference points.

Consequently, it would be desirable that further research be conducted to consider evidence for the value for steepness *h* for Atlantic cobia ahead of the next assessment. Such research might involve meta-analyses or similar approaches to determine plausible values for *h* which could be used for sensitivity testing of the base model.

- *Are the quantitative estimates of the status determination criteria for this stock appropriate for management use? If not, are there other indicators that may be used to inform managers about stock trends and conditions?*

Currently, there are no management targets or thresholds defined and approved by the ASFMC, which has responsibility for management of Atlantic cobia. However, the reference points proposed by the assessment panel (i.e., $F_{40\%}$ and $SSBF_{40\%}$) are appropriate choices as proxies for F_{MSY} and B_{MSY}. *F*urthermore, 75% $SSB_{F40\%}$ and 75%$F_{40\%}$ are appropriate candidate proxies for management targets.

Examination of the results of catch curve analyses using regression estimators, Chapman-Robson estimators, and Poisson regression estimators, indicate a slight increase in total mortality *Z* (i.e., *F* + *M*) over time that is relatively consistent with the results of the assessment (Figure 8).

No additional indicators that might be appropriate to inform managers on stock status were identified.

In summary, while the quantitative estimates of the status determination criteria for this stock are appropriate for management, management targets and thresholds are yet to be defined and approved by the responsible management body (ASFMC).

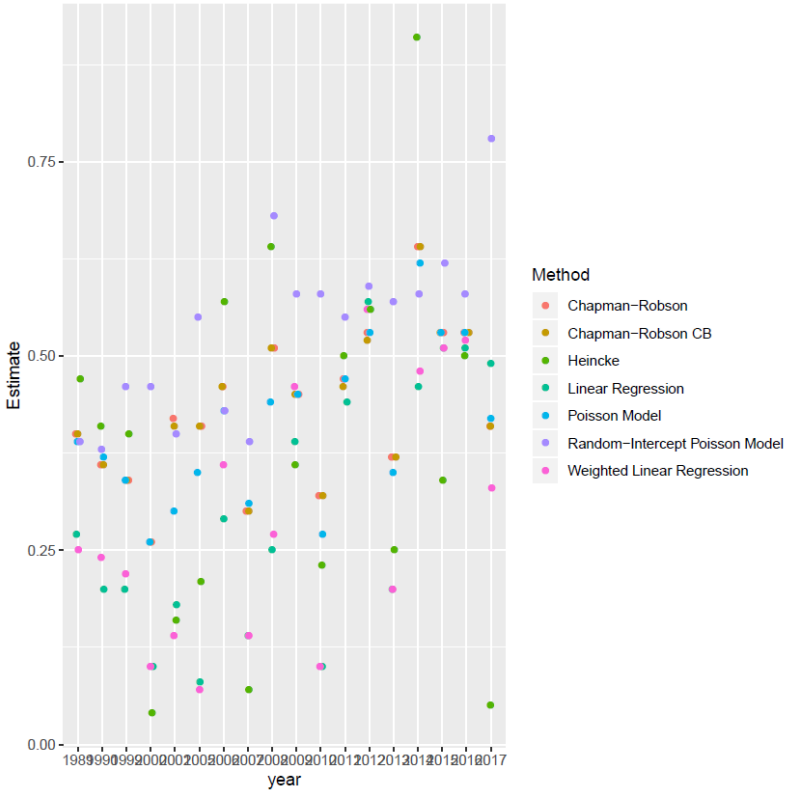

Figure 8. Catch curve estimates for 1989-2017 using alternative regression estimators for Atlantic Cobia. The figure indicates a slightly increasing trend in total mortality (Z) over time, consistent with the results of the assessment base run.

4.2.4. Evaluate the stock projections, addressing the following:

- *Are the methods consistent with accepted practices and available data?*
- *Are the methods appropriate for the assessment model and outputs?*

Because the assessment period ended in 2017, projections required an initialization period (2018 and 2019) for which it was assumed that total removals in each year were constant at the mean weight of removals over the years 2015-2017.

For the years 2020-2024, projections for landings in number (000's), *F*, SSB (000 mt) and recruits (000's at age 1) were carried out under 3 different scenarios as follows:

1. *Scenario 1: F = $F_{current}$, (where F current is computed as the geometric mean $F_{2015-2017}$)*
2. *Scenario 2: F = $F_{40\%}$, (proxy for F_{MSY})*

3. *Scenario 3: F = 75% $F_{40\%}$, (proxy for management target F)*

For each of the above scenarios, deterministic and stochastic projections were performed.

Population numbers at ages 2 and older in 2018 were derived from the assessment base run. For deterministic projections the number at age 1 was the arithmetic mean recruitment. For stochastic projections, age 1 recruits were drawn from the lognormal distribution of historical recruitment values.

In conclusion, projections were carried out using accepted practices using plausible assumptions which were appropriate given the assessment model, the available data and required outputs.

- *Are the results informative and robust, and useful to support inferences of probably future conditions?*
- *Are key uncertainties acknowledged, discussed, and reflected in projection results?*

Results of projections are given in Tables 1-3 and plotted in Figures 9-11.

Figures 9-11 indicate that deterministic results and median estimates from stochastic projections were broadly similar although the 95% confidence intervals on stochastic estimates indicate relatively large uncertainty associated with the projection results. Such uncertainty arises primarily because of an absence of a meaningful stock/recruit relationship and future recruit estimates being drawn from the historical variation in recruitment.

Although there is an increase in total removals from 2018-2019, such an increase arises because, in the Figures, landings are expressed as numbers of fish whereas the projections were constrained by input removals weight in 2018 and 2019.

Table 1. Results of projections for scenario 1. R = number of age 1 recruits ('000s), F = annual fishing mortality rate, S = spawning stock (mt), L= removals (landings + dead discards) in numbers (n=000s) or whole weight (w in '000lb). Extension b indicates expected deterministic values from the base run (co23). Extension med indicates the median values from stochastic projections.

Year	R.b	R.med	F.b	F.med	S.b(mt)	S.med(mt)	L.b(n)	L.med(n)	L.b(w)	L.med(w)
2018	1796	1399	0.16	0.22	6647	5333	82	87	2820	2908
2019	1796	1377	0.19	0.24	6060	5117	84	91	2820	2908
2020	1796	1389	0.10	0.15	6089	5112	46	58	1479	1817
2021	1796	1382	0.10	0.15	6306	5225	49	60	1553	1857
2022	1796	1385	0.10	0.15	6478	5327	51	62	1612	1905
2023	1796	1380	0.10	0.15	6606	5394	53	63	1653	1944
2024	1796	1383	0.10	0.15	6697	5443	54	64	1683	1967

Table 2. Results of projections for scenario 2. R = number of age 1 recruits ('000s), F = annual fishing mortality rate, S = spawning stock (mt), L= removals (landings + dead discards) in numbers (n=000s) or whole weight (w in '000lb). Extension b indicates expected deterministic values from the base run (co23). Extension med indicates the median values from stochastic projections.

Year	R.b	R.med	F.b	F.med	S.b(mt)	S.med(mt)	L.b(n)	L.med(n)	L.b(w)	L.med(w)
2018	1796	1399	0.16	0.22	6647	5333	82	87	2820	2908
2019	1796	1377	0.19	0.24	6060	5117	84	91	2820	2908
2020	1796	1389	0.69	0.65	5046	4361	254	212	8041	6507
2021	1796	1382	0.69	0.65	4109	3618	205	171	5945	4980
2022	1796	1385	0.69	0.65	3751	3338	188	156	5141	4315
2023	1796	1380	0.69	0.65	3616	3234	181	151	4836	4082
2024	1796	1383	0.69	0.65	3566	3201	179	149	4722	3981

Table 3. Results of projections for scenario 3. R = number of age 1 recruits ('000s), F = annual fishing mortality rate, S = spawning stock (mt), L= removals (landings + dead discards) in numbers (n=000s) or whole weight (w in '000lb). Extension b indicates expected deterministic values from the base run (co23). Extension med indicates the median values from stochastic projections.

Year	R.b	R.med	F.b	F.med	S.b(mt)	S.med(mt)	L.b(n)	L.med(n)	L.b(w)	L.med(w)
2018	1796	1399	0.16	0.22	6647	5333	82	87	2820	2908
2019	1796	1377	0.19	0.24	6060	5117	84	91	2820	2908
2020	1796	1389	0.52	0.49	5326	4591	202	168	6426	5188
2021	1796	1382	0.52	0.49	4602	4041	176	147	5222	4341
2022	1796	1385	0.52	0.49	4277	3804	165	137	4680	3921
2023	1796	1380	0.52	0.49	4132	3697	160	133	4437	3739
2024	1796	1383	0.52	0.49	4069	3656	158	131	4329	3659

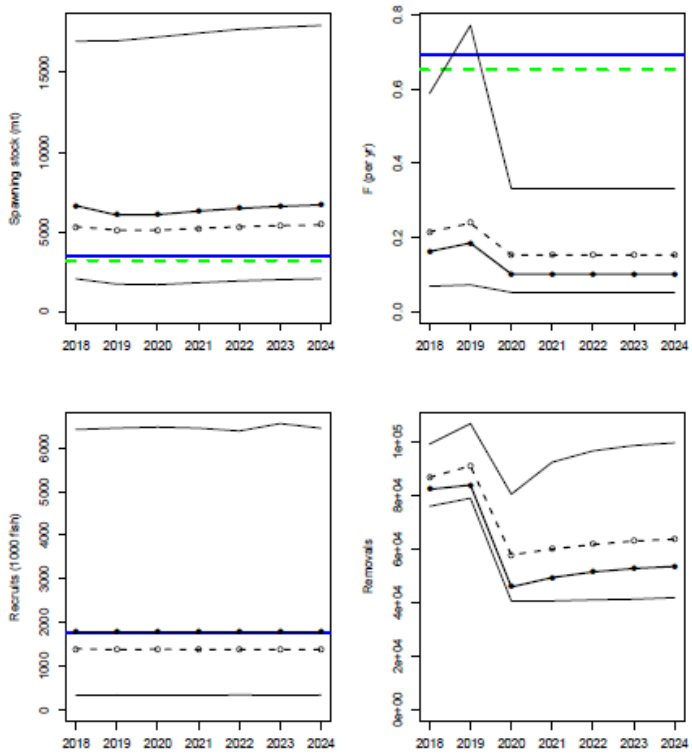

Figure 9. Results of projections for Scenario 1. Solid black line = deterministic projection; dashes black line = median of stochastic simulations; thin black lines = lower (5%) and upper (95%) confidence intervals; green and blue horizontal lines = stochastic and deterministic reference levels respectively.

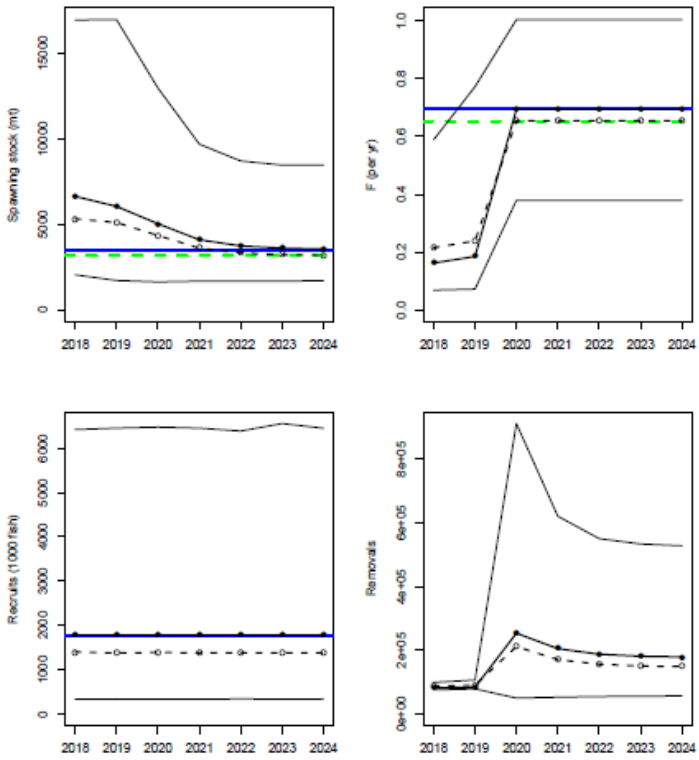

Figure 10. Results of projections for Scenario 2. Solid black line = deterministic projection; dashes black line = median of stochastic simulations; thin black lines = lower (5%) and upper (95%) confidence intervals; green and blue horizontal lines = stochastic and deterministic reference levels respectively.

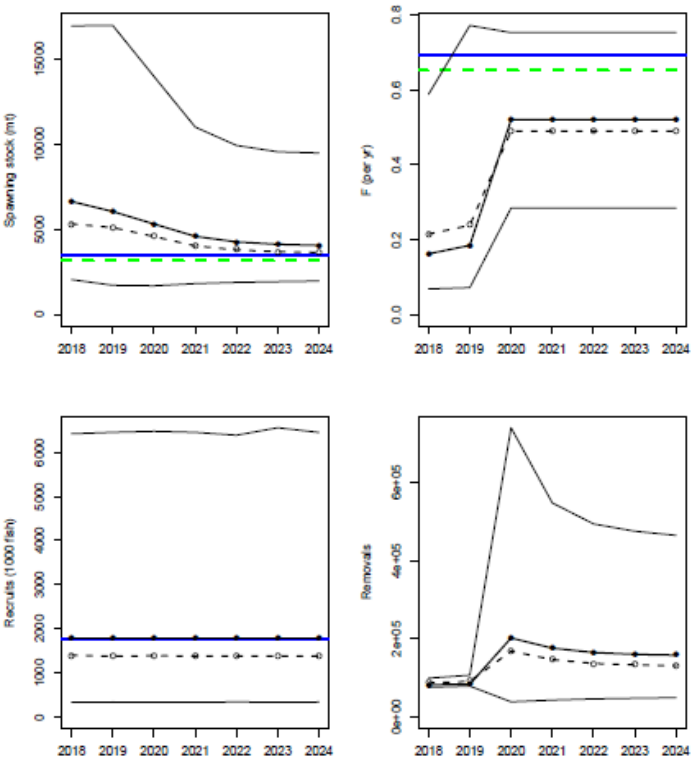

Figure 11. Results of projections for Scenario 3. Solid black line = deterministic projection; dashes black line = median of stochastic simulations; thin black lines = lower (5%) and upper (95%) confidence intervals; green and blue horizontal lines = stochastic and deterministic reference levels respectively.

Table 4 shows the proportion of stochastic projections runs where SSB falls below the $SSBF_{40\%}$ reference point for each of scenarios 1-3. The results indicate the following:

1. *If $F=F_{current}$, the probability of the SSB falling below the biomass corresponding to $SSBF_{40\%}$ between 2020 and 2024 was less than 0.12.*
2. *If $F=75\%F_{40\%,}$ the probability of the SSB falling below the biomass corresponding to $SSB_{F40\%}$ between 2020 and 2014 was less than 0.35.*
3. *If $F = F_{40\%}$, implying an increase in F above $F_{current}$ the probability of the SSB falling below the biomass corresponding to $SSBF_{40\%}$ tended to 0.46 by 2024.*

Table 4: Proportion of stochastic projections where SSB<SSBF40%.

	F40	75% F_{40}	$F_{current}$
2018	0.19	0.07	0.07
2019	0.23	0.11	0.11
2020	0.3	0.14	0.12
2021	0.4	0.23	0.11
2022	0.46	0.31	0.09
2023	0.49	0.34	0.08
2024	0.5	0.35	0.08

The above results imply that the chance that SSB will fall below the $SSBF_{40\%}$ reference point in the short-term ranges from 7% to 12% if fishing continues at the current (average 2015-2017) rate (scenario 1). Scenarios 2 and 3 imply an increase in *F* over the current rate, which implies a greater risk that SSB will fall below $SSBF_{40\%}$.

In conclusion, the projection results are informative and robust and are useful to support inferences of future stock status and biomass. The key uncertainties were well described and were reflected in projection results.

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

- *Comment on the degree to which methods used to evaluate uncertainty reflect and capture all sources of uncertainty in the population, data sources, and assessment methods.*
- *Are the implications of uncertainty in technical conclusions clearly stated?*

Considerable efforts were made by the assessment workshop to address uncertainty in assessment model output through sensitivities and using the ensemble modeling approach (Scott et al., 2016). The ensemble modeling used a total of 4000 simulation runs involving bootstrapping of observed input variables (landings, discard, head-boat index estimates, age and length composition data)

and fixed variables (natural mortality, discard mortality and recreational landings and discards) using Monte Carlo sampling with the relevant uncertainties.

Sensitivity runs were performed to investigate responses in model output to changes in inputs and to investigate model behavior. Ten alternative sensitivity runs were initially presented. Most of the model runs had a similar status as the base run presented in the assessment report (SEDAR58-SAR1). The sensitivity and ensemble analyses showed that the results were most sensitive to the choice of natural mortality (*M*).

The RP requested additional sensitivity runs to investigate uncertainty in the input natural mortality at age, maturity at age, and the assumption of two time blocks for selectivity for the head-boat index. The sensitivity analyses presented in the assessment report are appropriate, informative, and highlight the sensitivity of model output to *M*-at-age. This result was further confirmed by the additional sensitivity runs carried out during the review meeting.

Figure 7 summarizes the results of ensemble runs with respect to the proposed proxy reference points for *F* and SSB. 97% of ensemble runs indicate that the stock of Atlantic cobia is not overfished with respect to the proxy reference point for B_{MSY} ($SSBF_{40\%}$) and that 96.7% indicate that with respect to the F_{MSY} proxy ($F_{40\%}$) that overfishing is not taking place (Figure 7). The small proportion of runs that indicated the stock is currently overfished or that overfishing is currently taking place, occurred only in cases where input natural mortality was in the lowest region of its plausible range.

The main uncertainties within the assessment model are well-described in the assessment report (SEDAR58 SAR-1 Addendum). The main uncertainty associated with the assessment outcomes are the input estimates for natural mortality (*M*).

Estimates of *M*-at-age are based on the life-history invariant assumptions using the regressions in Charnov et al. (2013). Ensemble modeling was carried out to investigate sensitivity to *M*-at-age using bootstrapped estimates of *M* based on 2x the standard error of the *M* around the regression line for the estimated mean size at age of Cobia. Results indicated that although estimates for *M* are uncertain, the ensemble modeling results nevertheless indicate that the stock of Atlantic cobia is highly unlikely to be below the $SSBF_{40\%}$ reference point.

The choice of steepness (*h*) for the stock-recruit relationship also has a major influence on model outcomes, although in the absence of any meaningful relationship, the assumption that recruitment varies randomly with respect to SSB is reasonable and pragmatic. In making such an assumption, choosing a steepness of h=1 is appropriate to fit a Beverton and Holt stock-recruitment curve, as was done in the accepted base run.

Finally, the maturity ogive (proportion mature at age) used as input to the assessment was uncertain and potentially would have an impact on assessment output with respect to SSB. However, a sensitivity run carried out using a slightly right-shifted ogive indicated that model outcomes were rather insensitive to the choice of maturity ogive.

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

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

The review panel reviewed the large list of research recommendations given in the reports of the data and assessment workshops. I fully agree with the review panel that the following recommendations be given high priority by future data and assessment workshops because of their importance to the stock assessment model:

1. ***Uncertainty on natural mortality estimates.*** Natural mortality is an important parameter that affects model estimates of recruitment and spawning stock biomass. The RP recommend that estimates of natural mortality be made using tagging data or other analytical approaches (e.g., meta-analysis, catch-curves, etc.) for use in the model or to ground-truth the life-history invariant method used currently.
2. ***Requirement for a reliable CPUE index of abundance.*** Because the fishery-dependent index ended in 2015, development of a new index, either fishery-dependent or preferably fishery-independent, should be given top priority. Without an index of abundance, it is unlikely that stock status would be able to be estimated with any reliability in future. The RP recommends exploring other fisheries-dependent CPUE sources if available, developing fisheries-independent surveys such as egg/larvae surveys or close-kin methods, expanding analysis of the ten-year SERFS baited trap-video survey for cobia, or exploring the use of tag-data as potential indices of abundance.
3. ***Increase sampling for size and age.*** Given that age composition data are an important source of information for the assessment model, methods to increase sample size (such as expanding carcass collection locations and establishing similar programs in other states) should be implemented. In addition, development of sampling programs to collect size and age information on fish released in the recreational fishery should be a priority.
4. ***Improve estimates for age-at-maturity and annual sex ratio****.* The uncertainty in the stock status would be improved if better information on age-at-maturity and annual sex ratios was collected.

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

The following suggestions were made by the review panel (RP):

1. The SEDAR stock assessment review process would be improved if the Chair of the Data Workshop Group were to attend the review panel meeting, and be available to assist the assessment team (AT) describe decisions relating to the choice of data.

2. The data workshop report may be improved if the reasons for data choices were summarized and provided in the report.

3. In the future, a separate document that contained only information pertaining to final data streams used in the assessment, including the summary of the rationale for the data choices, would be helpful. In this case, where the RP required additional detail on what has been done, then the workshop documents could be consulted. The RP recommends that SEDAR request a stand-alone document or separate section in the data workshop (DW) report that summarizes main decisions and descriptions of why those decisions were made at the data workshop.

Based on my experiences with the SEDAR 58 review, I have no additional suggestions that might improve the SEDAR process.

4.2.7. Provide suggestions on improvements in data or modeling approaches which should be considered when scheduling the next assessment.

I consider the following issues should be treated as priorities for future investigations and discussions.

1. ***Indices of abundance.*** Work on an appropriate fishery-dependent or independent abundance index should be a priority. The current head-boat index as formulated through 2015 may not be useful after SEDAR-58. Ideally, a fishery-independent index is highly desirable. The continued absence of an appropriate index will compromise the ability to undertake a quantitative assessment and provide management advice.

2. ***Natural mortality at age.*** The results of the assessment including stock status are highly sensitive to assumptions of *M-at age* which currently are uncertain. Consequently, it is highly desirable that a suite of potential of *estimates for M* based on life history or other approaches, are investigated and fully documented before and during future assessments.

3. ***Management reference points.*** While the AT has proposed $SSBF_{40\%}$ and $F_{40\%}$ reference points for this stock that are based on a long history of use in other locations and for similar stocks, further work with fishery managers on goals and objectives is advised prior to conducting a new benchmark. Proposed reference points could then be fully evaluated while a new assessment is conducted. The reference points proposed are based on MSY proxies and management could consider alternative reference points that would be consistent with alternative levels of risk tolerance.

4. ***Landings' estimation.*** During the RW the RP noted some inconsistencies with regards to recreational landings; most notably the 1996 and 2015 catch. Further examination by the AT during the workshop provided no clear answers as to whether this was the result of the MRIP calibration or the result of other changes in the recreational catch stream. Prior to the next assessment, a full description of landings changes from SEDAR-28 through SEDAR-58 should be conducted. This

examination should be fully and completely documented in time for the next benchmark.

5. ***Uncertainty in maturity at age.*** The RP recommends that any uncertainty in the maturity ogive be included in future ensemble modeling.

4.2.8. Prepare a Peer Review Summary of the Panel's evaluation of the stock assessment, 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 project guidelines.

The Peer Review Panel Report was drafted during the SEDAR-58 review meeting and list of tasks to be completed was compiled by the chair in conjunction with agency staff and the panel. In accordance with that list and the project guidelines, the peer review panel report was finalized by correspondence and delivered to the SEDAR coordinator on 16 December 2019.

5 REFERENCES

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Appendix 1: Bibliography of materials provided for the review

Documents Prepared for the Review Workshop		
SEDAR58-RW01	An Age Structured Production Model for Atlantic Cobia	Siegfried, 2019
SEDAR58-RW02	Public Comment Forum	SEDAR 2019
Final Assessment Reports		
SEDAR58-SAR1	Assessment of Atlantic Cobia	To be prepared by SEDAR 58
Reference Documents		
SEDAR58-RD01	SEDAR 28 South Atlantic Cobia Stock Assessment Report	SEDAR 28
SEDAR58-RD02	SEDAR 28 Gulf of Mexico Cobia Stock Assessment Report	SEDAR 28
SEDAR58-RD03	List of documents and working papers for SEDAR 28 (South Atlantic Cobia and Spanish Mackeral) – all documents available on the SEDAR website.	SEDAR 28
SEDAR58-RD04	Managing A Marine Stock Portfolio: Stock Identification, Structure, and Management of 25 Fishery Species along the Atlantic Coast of the United States	McBride 2014
SEDAR58-RD05	Chapter 22: Interdisciplinary Evaluation of Spatial Population Structure for Definition of Fishery Management Units (excerpt from Stock Identification Methods – Second Edition)	Cadrin et al. 2014
SEDAR58-RD06	Mitochondrial DNA Analysis of Cobia *Rachycentron canadum* Population Structure Uisng Restriction Fragment Length Polymorphisms and Cytochrome B Sequence Variation	Hrincevich 1993
SEDAR58-RD07	Population Genetic Comparisons among Cobia from the Northern Gulf of Mexico, U.S. Western Atlantic, and Southeast Asia	Gold et al. 2013
SEDAR58-RD08	Population genetics of Cobia (*Rachycentron canadum*): implications for fishery management along the coast of the southeastern United States	Darden et al. 2014
SEDAR58-RD09	Growth, mortality, and movement of cobia (*Rachycentron canadum*)	Dippold et al. 2017
SEDAR58-RD10	Assessment of cobia, *Rachycentron canadum*, in the waters of the U.S. Gulf of Mexico	Williams, 2001
SEDAR58-RD11	Life history of Cobia, *Rachycentron canadum* (Osteichthyes: Rachycentridae), in North Carolina waters	Smith 1995

SEDAR58-RD12	A review of age, growth, and reproduction of cobia *Rachycentron canadum*, from US water of the Gulf of Mexico and Atlantic ocean	Franks and Brown-Peterson, 2002
SEDAR58-RD13	An assessment of cobia in Southeast US waters	Thompson 1995
SEDAR58-RD14	Reproductive biology of cobia, *Rachycentron canadum*, from coastal waters of the southern United States	Brown-Peterson et al. 2001
SEDAR58-RD15	Age and growth of cobia, *Rachycentron canadum*, from the northeastern Gulf of Mexico	Franks et al. 1999
SEDAR58-RD16	Synopsis of biological data on the cobia *Rachycentron canadum* (Pisces: Rachycentridae)	Shaffer and Nakamura 1989
SEDAR58-RD17	Age, growth, and reproductive biology of greater amberjack and cobia from Louisiana waters	Thompson et al. 1991
SEDAR58-RD18	Cobia (*Rachycentron canadum*) stock assessment study in the Gulf of Mexico and in the South Atlantic	Burns et al. 1998
SEDAR58-RD19	Gonadal maturation in the cobia, *Rachycentron canadum*, from the northcentral Gulf of Mexico	Lotz et al. 1996
SEDAR58-RD20	Length-weight relationships, location and depth distributions for select Gulf of Mexico reef fish species	Pulver & Whatley 2016
SEDAR58-RD21	Inshore spawning of cobia (*Rachycentron canadum)* in South Carolina	Lefebvre & Denson 2012
SEDAR58-RD22	Determining the stock boundary between South Atlantic and Gulf of Mexico managed stocks of Cobia, *Rachycentron canadum*, through the use of telemetry and population genetics	Perkinson et al. 2018
SEDAR58-RD23	SAFMC Mackerel Cobia Advisory Panel and Cobia Sub-Panel Cobia Fishery Performance Report April 2017	SAFMC Mackerel Cobia AP & Cobia Sub-Panel 2017
SEDAR58-RD24	Spawning of the Cobia, *Rachycentron canadum*, in the Chesapeake Bay Area, with Observations of Juvenile Specimens	Joseph et al. 1964
SEDAR58-RD25	SEDAR28-DW02: South Carolina experimental stocking of Cobia *Rachycentrom canadum*	Denson 2012
SEDAR58-RD26	Applying network methods to acoustic telemetry data: Modeling the movements of tropical marine fishes	Finn et al. 2014
SEDAR58-RD27	Developing a deeper understanding of animal movements and spatial dynamics through novel application of network analyses	Jacoby et al. 2012
SEDAR58-RD28	Status of the South Carolina Fisheries for Cobia	Hammond 2001
SEDAR58-RD29	Dynamic ocean management increases the efficiency and efficacy of fisheries management	Dunn et.al. 2016
SEDAR58-RD30	Using Pop-off Satellite Archival Tags To Monitor and Track Dolphinfish and Cobia	Hammond 2008

SEDAR58-RD31	Cusk (Brosme brosme) and climate change: assessing the threat to a candidate marine fish species under the US Endangered Species Act	Hare et al 2012
SEDAR58-RD32	Dynamic habitat suitability modelling reveals rapid poleward distribution shift in a mobile apex predator	Hill et. al. 2016
SEDAR58-RD33	Seasonal forecasting of tuna habitat for dynamic spatial management	Hobday et. al. 2011
SEDAR58-RD34	Near real-time spatial management based on habitat predictions for a longline bycatch species	Hobday et. al. 2006
SEDAR58-RD35	Seasonal forecasting for decision support in marine fisheries and aquaculture	Hobday et. al. 2016
SEDAR58-RD36	Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf	Nye et.al. 2009
SEDAR58-RD37	Projecting changes in the distribution and productivity of living marine resources: A critical review of the suite of modelling approaches used in the large European project VECTORS	Peck et. al. 2016
SEDAR58-RD38	Climate Change Affects Marine Fishes Through the Oxygen Limitation of Thermal Tolerance	Portner and Knust 2007
SEDAR58-RD39	Effects of water temperature and fish size on growth and bioenergetics of cobia (Rachycentron canadum)	Sun and Chen 2014
SEDAR58-RD40	Effect of temperature on growth and energy budget of juvenile cobia (Rachycentron canadum)	Sun et. al. 2006
SEDAR58-RD41	Managing living marine resources in a dynamic environment: The role of seasonal to decadal climate forecasts	Tomoassi et. al. 2017
SEDAR58-RD42	Model-estimated conversion factors for calibrating Coastal Household Telephone Survey (CHTS) charterboat catch and effort estimates with For-Hire Survey (FHS) estimates in the Atlantic and Gulf of Mexico with application to red grouper and greater amberjack	Dettloff & Matter 2019
SEDAR58-RD43	Understanding the Virginia Cobia Stock Through Analysis of Trophy Fish	Weng et. al. 2019

SEDAR58-RD44	Technical Documentation of the Beaufort Assessment Model	Williams and Shertzer, 2015
SEDAR58-RD45	Evolutionary assembly rules for fish life histories	Charnov et.al. 2013
SEDAR58-RD46	The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural systems and aquaculture	Lorenzen, 1996
SEDAR58-RD47	Bias in common catch-curve methods applied to age frequency data from fish surveys	Nelson, 2019

Appendix 2. Performance Work Statement

Performance Work Statement (PWS)
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Center for Independent Experts (CIE) Program
External Independent Peer Review

SEDAR 58 Atlantic Cobia Assessment Review

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

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf).
Further information on the CIE program may be obtained from www.ciereviews.org.

Scope
The **SouthEast Data, Assessment, and Review (SEDAR)** is the cooperative process by which stock assessment projects are conducted in NMFS' Southeast Region. SEDAR was initiated to improve planning and coordination of stock assessment activities and to improve the quality and reliability of assessments.

SEDAR 58 will be a CIE assessment review conducted for Atlantic Cobia. 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 58 are within the jurisdiction of the Atlantic States Marine Fisheries Commission and the states of Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware,

Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine. The specified format and contents of the individual peer review reports are found in **Annex 1**. The Terms of Reference (TORs) of the peer review are listed in **Annex 2**. Lastly, the tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements
NMFS requires three (3) reviewers to conduct an impartial and independent peer review in accordance with the Performance Work Statement (PWS), OMB guidelines, and the TORs below. The reviewers shall have a working knowledge in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the primary task of providing peer-review advice in compliance with the workshop Terms of Reference fisheries stock assessment.

Tasks for Reviewers
1) Two weeks before the peer review, the Project Contacts 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 Project Contacts will consult with the contractor on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the PWS scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

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

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

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

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

Foreign National Security Clearance
When reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the 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/ and http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration- system.html. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance
The place of performance shall be at the contractor's facilities, and in Atlantic Beach, NC.

Period of Performance
The period of performance shall be from the time of award through January 2020. Each CIE reviewer's duties shall not exceed 14 days to complete all required tasks.

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

Within two weeks of award	Contractor selects and confirms reviewers
2 weeks prior to the panel review	Contractor provides the pre-review documents to the reviewers
November 19-21, 2019	Panel review meeting
Approximately 3 weeks later	Contractor receives draft reports
Within 2 weeks of receiving draft reports	Contractor submits final reports to the Government

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

Travel
All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $12,000.

Restricted or Limited Use of Data
The contractors may be required to sign and adhere to a non-disclosure agreement.

Project Contacts:
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Kathleen Howington - SEDAR Coordinator

SEDAR Coordinator
Science and Statistics Program
South Atlantic Fishery Management Council
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Annex 1: Peer Review Report Requirements

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

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

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

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

   c. Reviewers should elaborate on any points raised in the summary report that they believe 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 report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The report shall represent the peer review of each TOR, and shall not simply repeat the contents of the summary report.

3. The report shall include the following appendices:

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

Annex 2: Terms of Reference for the Peer Review

SEDAR 58 Atlantic Cobia Assessment
Review Workshop Terms of Reference

1. Evaluate the data used in the assessment addressing the following:
    - Are data decisions made by the DW and AW sound and robust?
    - Are data uncertainties acknowledged, reported, and within normal or expected levels?
    - Are data applied appropriately within the assessment model?
    - Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
    - Are methods scientifically sound and robust? Do the methods follow accepted scientific practices?
    - Are assessment models configured appropriately and applied consistent with accepted scientific practices?
    - Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
    - Are population estimates (model output – e.g. abundance, exploitation, biomass) reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
    - Is the stock overfished? What information helps you reach this conclusion?
    - Is the stock undergoing overfishing? What information helps you reach this conclusion?
    - Is there an informative stock recruitment relationship? Is the stock recruitment curve realiable and useful for evaluation of productivity and future stock conditions?
    - Are the quantitative estimates of the status determination criteria for this stock appropriate for management use? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
    - Are the methods consistent with accepted practices and available data?
    - Are the methods appropriate for the assessment model and outputs?
    - Are the results informative and robust, and useful to support inferences of probably future conditions?
    - Are key uncertainties acknowledged, discussed, and reflected in projection results?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
    - Comment on the degree to which methods used to evaluate uncertainty reflect and capture all sources of uncertainty in the population, data sources, and assessment methods.
    - Are the implications of uncertainty in technical conclusions clearly stated?

6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.
    - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
    - Provide recommendations on possible ways to improve the SEDAR process.
7. Provide suggestions on improvements in data or modeling approaches which should be considered when scheduling the next assessment.
8. Prepare a Peer Review Summary of the Panel's evaluation of the stock assessment, 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 project guidelines.

Annex 3: Tentative Agenda - SEDAR 58 Atlantic Cobia Assessment Review Atlantic Beach, NC

November 19-21, 2019

Tuesday

8:00 – 8:30	**Introductions and Opening Remarks** **Coordinator** *- Agenda Review, TOR, Task Assignments*	
8:30 a.m. – 11:30 a.m.	**Assessment Presentations**	**TBD**
11:30 a.m. – 1:00 p.m.	**Lunch Break**	
1:00 p.m. – 5:00 p.m.	**Panel Discussion** *- Assessment Data & Methods* *- Identify additional analyses, sensitivities, corrections* *- Review additional analyses* *Take Breaks as needed*	**Chair**
5:00 p.m. - 6:00 p.m.	**Panel Work Session**	**Chair**

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

Wednesday

8:00 a.m. – 11:30 a.m.	**Panel Discussion** *- Review additional analyses, sensitivities* *- Consensus recommendations and comments*	**Chair**
11:30 a.m. – 1:00 p.m.	**Lunch Break**	
1:00 p.m. – 5:00 p.m.	**Panel Discussion**	**Chair**
5:00 p.m. - 6:00 p.m.	**Panel Work Session**	**Chair**

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

Thursday

8:00 a.m. – 11:30 a.m.	**Panel Discussion** *- Final sensitivities reviewed.* *- Projections reviewed.*	**Chair**
11:30 a.m. – 1:00 p.m.	**Lunch Break**	
1:00 p.m. – 6:00 p.m.	**Panel Discussion or Work Session** *- Review Consensus Reports*	**Chair**

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

Appendix 3: Participants in the SEDAR 58 Review workshop

Appointee	Function	Affiliation
REVIEW PANEL		
Jeff Buckel	Review Panel Chair	ASMFC Appointee
Gary Nelson	Reviewer	ASMFC Appointee
Alistair Dunn	CIE Reviewer	CIE
John Casey	CIE Reviewer	CIE
Matt Cieri	CIE Reviewer	CIE
APPOINTED OBSERVERS		
Collins Doughtie*	Fisherman – SC	SAFMC Mack/Cobia AP
Bill Gorham	Fisherman – NC	SAFMC Mack/Cobia AP
Wes Blow	Fisherman – VA	SAFMC Mack/Cobia AP
ANALYTICAL REPRESENTATIVES		
Katie Siegfried	Lead analyst	SEFSC Beaufort
Kyle Shertzer	Assessment Team	SEFSC Beaufort
Erik Williams	Assessment Team	SEFSC Beaufort
Rob Cheshire	Assessment Team	SEFSC Beaufort
COUNCIL AND AGENCY STAFF		
Kathleen Howington	Coordinator	SEDAR
Cierra Graham	Admin	SAFMC
Mike Schmidtke	ASMFC lead	ASMFC
Other		
Jie Cao	NC State	Morehead City, NC
Erik Fitzpatrick	NOAA	Beaufort, NC
Amy Scheuller	NOAA	Beaufort, NC
Matt Damiano	NC State	Morehead City, NC
Riley Gallagher	NC State	Morehead City, NC
Joseph W. Smith	NMFS Retired	Morehead City, NC
Amanda Tong	NCDMF	Morehead City, NC
Chris Batsavage	NCDMF	Morehead City, NC