Independent peer review report --- SEDAR 77 HMS Hammerhead Sharks Assessment Review

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Prepared for

Center for Independent Experts

January 2024

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Executive Summary

Activities

The 2023 SouthEast Data, Assessment, and Review (SEDAR) 77 HMS Hammerhead Sharks Assessment Review was reviewed by a CIE stock assessment review panel. The review panel aims to review three stock assessment models for Great Hammerheads for the Atlantic and Gulf of Mexico regions, Smooth Hammerheads for the Atlantic and Gulf of Mexico regions, and Scalloped and Carolina Hammerheads in the Atlantic and Gulf of Mexico regions, and to produce an independent peer review report that can be used by the Fishery Management Councils and other interested persons for developing management recommendations for the hammerhead sharks fishery in the Southeast Atlantic region. The review was supposed to take place in Panama City, FL, from August 28 to September 1, 2023, but it was influenced by Hurricane Idalia. The review was done in person on August 28 and then on November 13 through a webinar. The stock assessments were presented publicly to the review panel, and the validity of the data, assessment procedures, and results as to the recommended provisional base model and sensitivity model scenarios were discussed. The assessment team provided all the background information and stock assessment documents. Because of the disturbance of the hurricane and the change of the schedule, the review panel suggested alternative model configurations and sensitivity runs but did not request further data and model configuration explorations during the review. The summary report was not required anymore, according to the Chair, because of the schedule changes.

Main review processes and findings

Three different models conducted using different software packages were used for the three species and stocks because of the data availability and quality. The stock assessment for Great Hammerheads for the Atlantic and Gulf of Mexico regions (called Great Hammerhead stock in the following text) used a Bayesian state-space biomass dynamic model and was conducted using JABBA (Winker et al., 2018; version v.2.2.8.); the stock assessment for Smooth Hammerheads for the Atlantic and Gulf of Mexico regions (Called Smooth Hammerhead stock in the following text) used a Simple Stock Synthesis (SSS; Cope 2013) model; and the stock assessment for Scalloped and Carolina Hammerheads in the Atlantic and Gulf of Mexico regions (called Scalloped Hammerhead stock) used a sex-specific length-based age-structured statistical model implemented within Stock Synthesis (version 3.30.15.00; Methot et al. 2020).

There were some concerns about the assessments, mainly arising from the smoothed catch data, reconstructed historical commercial catch, relative abundance data availability and decisions on their usage, the fixed parameters in the models and sometimes, borrowed parameters from other species, and whether the models are ready for fisheries management purposes. The review panel suggested future explorations both on data processing and alternative model assumptions.

The Smooth Hammerhead stock assessment is in a proof-of-concept stage. Still, the estimated OFL from all the sensitivity runs is much higher than the current catch, suggesting a low probability of overfishing. The Great Hammerhead stock assessment results are robust to priors (informative from life history analysis), and the stock was found to be overfished, but overfishing was not happening in 2020. The Scalloped Hammerhead stock assessment suggested a low probability of overfishing in 2019, and the stock had not been overfished from 1981 to 2019. The assessment assumes a non-fished equilibrium status in 1981, the beginning year of the model. The data on length composition is limited in general. I suggest alternative model configurations and further sensitivity runs be performed to investigate the stock status. Despite the uncertainty on the model configuration and estimated stock status, the spawning output is increasing, indicating a low probability of overfishing under the fishing levels experienced since the early 2010s.

Given the data available and the stock assessment developed by the assessment team, for each species I suggest extra sensitivity runs or scenarios before a base model scenario and its corresponding projected biomass or abundance is selected for management consideration.

Main recommendations

- Data scenarios using the original estimated recreational non-smoothed catch time series, instead of smoothed AB1 and B2 recreational catch for the three "stocks", should be explored through sensitivity runs.

- Model-based approaches that deal with a high percentage of zeros and consider influences from strata, spatial-temporal patterns, etc., may be considered for discard and bycatch estimation (Bi et al. 2021; Zhou and Liao 2022).

- Because the recreational catch is a substantial part of the total catch for all three stocks, the catch uncertainty is high in general. Future consideration of decreasing the uncertainty in recreational catch should be of high priority. The best post-release mortality estimation was based on other species rather than the Hammerhead Sharks. Continued studies on Hammerhead sharks' post-release mortality are encouraged.

- The current SSS stock assessment for Smooth Hammerhead is in a proof-of-concept stage. The catch data are not informative to the only estimated parameter, Ln(R0). The assessment team should continue investigating the existing relative abundance surveys with Smooth Hammerhead sharks, either directly using them or using them to derive an informative depletion prior to use in the SSS. I also support future length frequency data collection from the catch data and surveys for this species.

- The Great Hammerhead JABBA model's prior parameters need to be clarified for repeatability. For example, the default prior of K needs to be clarified. The use of

informative priors based on life history parameters and the Leslie matrix model analysis results are reasonable; these priors contribute to the robustness of the results.

- Consider combining fleets and the corresponding length samples, especially the ones that share selectivity in the current reference run of the Scalloped Hammerhead model. The model may be further simplified by using a lower A+ group or considered a length-based stage-structured model. A further simpler model, such as the Bayesian state-space biomass dynamic model used for Great Hammerhead stock, may be explored as an alternative model for comparison with the Scalloped Hammerhead stock assessment model. I recommend exploring the influence of the fixed selectivity parameters and the assumption of unfished equilibrium status in 1981 and its influence on the Scalloped Hammerhead stock population size and trend estimation (Ichinokawa et al. 2014; S. Martell and Stewart 2014; Minte-Vera et al. 2017). I also suggest increasing the weight on the relative abundance of Scalloped Hammerhead stock, without changing the currently estimated efficient sample size, as a sensitivity run to see whether the assessment model can fit the relative abundance indices better and how it influences the abundance and stock status (Francis 2011). Simulation study may be used to validate the model.

- Changes in life history traits, such as growth and maturity, may be explored and linked to environmental and climate variations.

- Sampling the Carolina and Scalloped Hammerhead shark complex on the Atlantic side is recommended. It is important to diagnose whether the proportions of the species in the complex have a trend over time.

1. BACKGROUND

The 2023 SouthEast Data, Assessment, and Review (SEDAR) 77 HMS Hammerhead Sharks Assessment Review was reviewed by a CIE stock assessment review panel. The panel was expected to review the Hammerhead Sharks stock assessment and to produce a panel summary report that can be used by the regional Fishery Management Council and other interested persons to develop management recommendations for the hammerhead shark fishery in the Southeast Atlantic region. The review took place in Panama City, FL, in person on Aug 28, 2023, and then on Nov 13 through a webinar. The review panel chair was Dr. John Carlson, and the other panel members included Drs. Alistair Dunn, Peter Stephenson, and Yan Jiao (me).

The SEDAR 77 review process was coordinated by Kathleen Howington and Julie A Neer from SEDAR. The stock assessment documents for Hammerhead Sharks were prepared by the Analytic Team and were provided about two weeks before the review. A pre-review webinar was organized on Aug 21 to check the agenda, travel plans, and any questions the reviewers might have, including potential questions on the review process and assessment reports. The assessments were presented at the meeting mainly by the analytic team, Drs. Xinsheng Zhang and Dean Courtney, and the data (catch, bycatch, post-release mortality, relative abundance indices), assessment history, and life history of the hammerhead sharks were presented by Drs. John Carlson, Heather Moncrief-Cox, Karyl Brewster-Geisz, Andrea Kroetz and Dean Courtney.

According to the CIE scope description, “reviewers shall conduct the independent peer review in accordance with the requirements specified in this PWS, OMB guidelines, and TORs, … Each CIE reviewer will assist the Chair with contributions to a Summary Report …” As a review panel member, I was provided with draft stock assessment reports and web access to relevant files and documents, such as the previous data workshop report and meeting documents (see Appendix 1 for a complete list of documents) and participated in the Stock Assessment Review Meeting. During the review, the assessments of the Hammerhead Sharks were presented, and the validity of the data, assessment models, procedures, and results were discussed (see tentative Agenda in Appendix 2). No extra documents and model runs were requested by the review panel because of the schedule changes caused by Hurricane Idalia. Discussions on the quality of the data, including the data standardization or synthesis, the appropriateness of the model assumptions, parameterizations, estimation algorithms, and appropriate model projections for management purposes, were made throughout the review. The review panel summary report was not required, according to the Chair because of the schedule changes. The review panel was not able to discuss a summary report with the Chair.

During the review meeting, the assessment team was always available when required for further discussion, additional data and model exploration and clarification, and clarification of how each TOR was addressed.

As a CIE reviewer, my duty was to evaluate the stock assessments of Hammerhead Sharks with respect to their TORs (in Appendix 2) and work with the analytic team to facilitate discussions. This report provided the findings and recommendations of the independent review that is undertaken by me in accordance with the CIE Performance Work Statement (PWS).

2. ROLE of individual reVIEWER IN THE REVIEW ACTIVITIES

My role as a CIE independent reviewer was to conduct an impartial and independent peer review in accordance with the requirements specified in this PWS, OMB guidelines, and predefined TORs in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus.

About two weeks before the review meeting, Dr. Kathleen Howington shared the assessment documents and supporting materials with the review panel via emails and the SEDAR website. I read all the documents that I received prior to the review.

The SEDAR 77 review meeting was not able to follow the “tentative agenda (Appendix 2)” of the CIE review because of Hurricane Idalia. Part of the meeting was rescheduled to Nov 13 via webinar. The meeting was open to the public. On the morning of Aug 28, before the meeting, the review Chair, the assessment team, and the CIE review panel met to discuss the meeting agenda, review process, reporting requirements, and meeting logistics. During the meeting, all the documents were accessible through email. The review continued on the night of Aug 28 to minimize the influence of the schedule changes.

Presentations were given during the review to provide the review panel the background information on the Atlantic Highly Migratory Species Fishery Management Plan, the harvest control rule, the stock identification, population characteristics of the species, the data used in the stock assessment models, and the newly developed stock assessment models for the three stocks and stock complex. I was actively involved in the discussion during the presentations by 1) listening to the presentations carefully, making notes on the points that were not included or not clearly stated in the documents provided prior to the meeting, 2) asking questions for clarification on the data usage and model development, 3) making comments and providing possible alternative solutions to questions arising during the meeting, 4) discussing agreement on each model scenario and stock assessment TOR with the other review panel members. The time for the TOR discussion was limited, however, because of the schedule changes.

This report reflects my summarized findings and recommendations according to the predefined TORs. This review report is formatted according to my interpretation of the required format and content described in Appendix 2.

3. SUMMARY OF FINDINGs relative to TORs

Hammerhead sharks were assessed within the Large Coastal Shark species complex between 1990 and 2006. The SEDAR 11 review recommended data analysis and model development to permit species-specific assessment. Hayes et al. (2009) was reviewed by SEFSC to serve as the basis for U.S. management before this SEDAR 77 review. The three species and stock complex are Great Hammerheads for the Atlantic and Gulf of Mexico regions (called Great Hammerhead stock in the following text), Smooth Hammerheads for the Atlantic and Gulf of Mexico regions (called Smooth Hammerhead stock in the following text), and Scalloped and Carolina Hammerheads in the Atlantic and Gulf of Mexico (called Scalloped Hammerhead stock in the following text). Three different models were conducted for the three stocks based on the data availability and quality and data recommendations from the SEDAR 77 data workshop. The Smooth Hammerhead stock assessment used a Simple Stock Synthesis model (SSS; Cope 2013); the Great Hammerhead stock assessment used a Bayesian state-space surplus production model and was conducted using JABBA (Winker et al., 2018; version v.2.2.8.); and the Scalloped and Carolina Hammerheads stock assessment used a sex-specific length-based age-structured statistical model implemented within Stock Synthesis (version 3.30.15.00; Methot et al. 2020).

Below, I provide the summary of findings for the SEDAR 77 Hammerhead Sharks review for all three stock assessments, in which the weaknesses and strengths are described in accordance with the TORs.

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

a. *Are data decisions made by the DW and AW justified?*
b. *Are data uncertainties acknowledged, reported, and within normal or expected levels?*
c. *Is the appropriate model applied properly to the available data?*
d. *Are input data series sufficient to support the assessment approach?*

The TOR is well addressed, with some caveats. My interpretation of TOR 1c and 1d somewhat overlap with TOR 2b and 2c.

The data included were from the SEDAR 77 data workshop and are appropriate, justified, and well-documented. The assessment team, based on the recommendations from the data workshop, did an excellent job in filtering, documenting, and synthesizing datasets included in the assessment. It would be better if a general description of each type of data was included in the stock assessment report. I appreciate the citations on data workshop documents in the assessment reports and review presentations, which made it easy to find the right document.

The presentation on the selection of relative abundance indices was more on the results of the recommendation rather than the details of the evaluation processes

and criteria. This is reasonable, given the review schedule. It would be more informative to include in the assessment report the details of the selection criteria, the relative abundance indices considered, and reasons for each index being selected or not selected for use in the stock assessment.

The review panel suggested further looking into the relative abundance indices for Smooth Hammerhead sharks, for which none of the relative abundance indices were recommended to be used by the data workshop. The use of the relative abundance indices may help the Smooth Hammerhead stock assessment to have either a reasonable stock trend or provide a reasonable prior for depletion in the SSS model. For example, the current Smooth Hammerhead base model run used a 10% depletion from Jiao et al. (2011), but Jiao et al. used a Bayesian hierarchical state-space model with one relative abundance index.

The review panel demonstrated concerns about the use of smoothing recreational catch for years with peaks for all three stock assessments and suggested alternative sensitivity runs of using non-smoothed catch time series. The assumption of commercial catch between 1981 and 1990 is another source of uncertainty with limited data support.

The data workshop recommended that recreational post-release mortality be based on meta-studies on other shark species, not on hammerheads. Future studies to continue collecting samples directly on hammerhead species post-release are recommended, if possible. Sensitivity runs may be added using min- and max-catch scenarios. Not all the removals from the stocks, such as those from Caribbean nations, are considered. Discard estimates may consider using a model-based approach that deals with a high percentage of zeros to consider influences from strata, spatial-temporal patterns, etc. (Bi et al. 2021; Zhou and Liao 2022).

The data uncertainties are acknowledged, reported and within normal or expected levels. Because the recreational catch is a substantial part of the total catch for all three stock assessments, the catch uncertainty is high in general. Future consideration of decreasing the recreational catch uncertainty should be of high priority. The post-release mortality estimation was based on other species rather than the Hammerhead Sharks. Future studies specifically on Hammerhead Sharks should be important to improve the data quality of these species.

The use of life history data is appropriate. All three stock assessments used life history data heavily, either as informative priors or using fixed parameters. Some presentation and discussion on how the life history analysis was done and the data sources, whether it was based on the species itself or based on a meta-analysis, is recommended for any future assessment review.

The Scalloped Hammerhead stock is a mixture of both Scalloped and Carolina Hammerheads in the Atlantic and Gulf of Mexico. The percentage of Carolina

Hammerheads is as much as 27% of the total local catches on the Atlantic side, according to existing studies. Future monitoring of the species composition may be conducted every few years to see whether there are species composition changes, which may influence how the stock assessment of the species complex is conducted.

The models applied to the three stocks are appropriate, given their data availability and previous evaluations from the data workshop and assessment workshop. The Smooth Hammerhead shark stock assessment has no relative abundance indices recommended from the data workshop, and the length frequency samples had low sample sizes, so the use of SSS is appropriate. Because the Ln(R0), the only estimated parameter in SSS, is not informed by the data, it will also be useful to try another catch-only approach, such as catchMSY, to see whether the results are consistent. Increasing the number of Monte Carlo rejection sampling runs in the age-structured SSS, by using a high-performance machine, may be needed. I agree with the analytic team that future length frequency samples and relative abundance surveys are important for the Smooth Hammerhead stock assessment.

The Great Hammerhead sharks assessment has six relative abundance indices recommended to be used from the data workshop, but the length frequency samples are low from both the catch and survey, so a Bayesian state-space biomass dynamic model to consider both process and measurement errors is reasonable. The use of priors on r and initial depletion from life history analysis is reasonable.

The Scalloped Hammerheads stock assessment used a two-sex length-based age-structured statistical model implemented within Stock Synthesis (SS model in the following text). The SS model application is appropriate. The sample size of the length frequency samples is still low (4234 age 0 and 3656 age 1+ among years 1981-2020; limited years with sample size higher than 20) although much higher than the other two stock assessments. There are six fishery fleets, five age 1+ indices, and five age 0 indices; among them, the length frequencies of 4 fishery fleets, two age 1+ indices, and four age 0 indices were fitted. The low sample size of the length frequency data and the two-sex multi-fleet model configuration resulted in a poor fit of some parameters, such as selectivities of these fleets and Ln(R0). The analytic team fixed some parameters in the selectivities and catchabilities based on appropriate methods. The use of life history data is appropriate. The structured data does not seem sufficient to support the configured base model run based on both the model fitting results and the model diagnostics. The influence of these model configurations was not tested through sensitivity analysis because of time limitations (see suggestions on TORs 2 and 3).

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

a. *Are methods scientifically sound and robust?*
b. *Are the methods appropriate for the available data?*
c. *Are assessment models configured properly and used in a manner consistent with standard practices.*

This TOR was addressed adequately in general, although further exploration and documentation are suggested.

The methods and the types of models applied to the three stocks are appropriate, given their data availability, and scientifically sound and robust. Three very different methods were applied to the three stocks separately based on the data availability. The assessment model configurations are appropriate and consistent with many standard practices. Compared with previous studies on Hammerheads stock assessment, the new progress in data collection and the development of stock assessment are apparent.

A Simple Stock Synthesis (SSS) was developed for Smooth Hammerhead shark stock, because the data workshop recommended none of the relative abundance indices discussed, and the length frequency samples were low in sample size. Such an application of SSS, given the data availability, is appropriate. Because the Ln(R0), the only estimated parameter in SSS, is not informed from the data, it will be useful to also try other approaches, such as the catchMSY, for example, to see whether the results are consistent. I agree with the analytic team that future length frequency samples and relative abundance surveys are important for the Smooth Hammerhead stock assessment.

A Bayesian state-space surplus production model was developed for Great Hammerhead sharks, for which six relative abundance indices recommended to be used from the data workshop were used to calibrate the population changes. The sample size of length frequency samples was small from both catch and survey, so such a model to consider both process and measurement errors is reasonable. The application of JABBA for such a model is appropriate (Winker et al. 2018). The model results are relatively robust to alternative prior assumptions on r, m, and initial depletion. Model diagnostics are well done, including fitting, residual plots, retrospective analysis, predictive checking, and cross-validation (Carvalho et al. 2021).

Stock Synthesis was implemented for the Scalloped Hammerheads stock, for which a two-sex length-based age-structured statistical model was developed. The SS model application is appropriate and meets the data available, but I have some concerns with the fitting and output, which are likely because of the low length sample size and conflict between length composition data and relative abundance indices. **The sample size of length frequency samples is still low (Table 3.2 in the assessment report),** although much higher than the other two hammerhead stocks. The low sample size of the length frequency data and the sex-specific multi-fleets model configuration resulted in a high uncertainty for

some parameters, such as the selectivities of these fleets. Although the analytic team took strategies to fix some selectivities and catchability parameters to improve the fit, the influence of it is unclear. The selection of the time block is fit-driven rather than based on policy changes on size limit and bag limit. The SS also assumed an unfished equilibrium population structure at the start of the model (1981), which conflicted with the high catch in 1981 and 1982 (2 of the 3 highest years, Figure 3.8 in the assessment report). I recommend that a non-equilibrium assumption be explored in the future. The highly dome-shaped selectivity for multiple fleets is a concern also. The model diagnostics followed suggestions from Carvalho et al. (2021) and Punt (2023) and were done well. The diagnostics also suggest concerns about the stock assessment. The structured data does not seem sufficient to support the provisional base model run configuration. Further simulation study may help validate whether the model configuration is appropriate or not given the data availability.

In conclusion, **the assessment models were configured properly and used in a manner consistent with standard practices in general**, with limitations stated above and in TORs 3 and 4. Extra explorations and sensitivity runs are needed for the Scalloped Hammerhead shark stock assessment to test the influence of some model assumptions and configurations.

TOR 3: 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.*

This TOR was addressed adequately in general, although further exploration and documentation are suggested.

The assumption of commercial catch between 1981 and 1990 is another source of uncertainty with limited data support and was not evaluated. Catch data and post-release mortality were from the data workshop, and the recommendation on the best base mean, and min and max post-release mortality were reasonable, but there were no model sensitivity runs to explore the uncertainty of catch, such as using the min and max as alternative runs. The smoothing of the recreational catch also tends to underestimate uncertainty.

Beside the method to address catch data uncertainty stated above, **my comment on the degrees to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods are, as below, species specific**.

The Smooth Hammerhead shark stock uses life history data and catch time

series. Because the Smooth Hammerhead is more data-poor, the life history parameters from Cortes (2022) are not all based on the Smooth Hammerhead only but are also similar shark species. The uncertainty in catch is not considered in such a data-poor stock. The uncertainties in some of the life history-related parameters (here, M and steepness) and depletion prior to use in the SSS were addressed through sensitivity runs. The Smooth Hammerhead SSS stock assessment is still in a proof-of-concept stage. Future data collection of relative abundance is strongly suggested to better understand the population and fishery status.

The Bayesian state-space surplus production model used for the Great Hammerhead shark stock considered both process errors in the abundance dynamic equation and observation errors in the relative abundance indices. The uncertainties in the relative abundance indices were not considered in the assessment with the mean of the relative abundance indices used in the JABBA data input. This is not unusual compared with the general application of such kinds of models. Future runs to consider the weighting of the relative abundance indices may consider the uncertainty level of each index. Sensitivity runs were used to explore the uncertainty from using the priors on r and initial depletion and the Pella-Tomlinson shape parameter generated from life history information from both the Great Hammerhead and similar species (Cortes 2022). Because the model uses a Bayesian estimator, the uncertainties of the estimated parameters and N, F are included, and the probabilities of overfishing and being overfished are estimated. The application of the JABBA approach can be better clarified by including a full equation and table of priors shown as probability distributions. The current description of priors on $K = B_0$ is a bit confusing with the prior of B_0 not specified, and the prior for the shape parameter m can be clarified by listing the priors using probability distributions. The model diagnostics were well done, which included residual diagnostics, retrospective analysis, predictive p-value, and hindcast cross-validation.

The Scalloped Hammerhead stock is a mixture of both Scalloped and Carolina Hammerheads in the Atlantic and Gulf of Mexico. Sensitivity runs were conducted to explore the influence of combining the Atlantic stock and the Gulf stock and combining Carolina Hammerheads with the Scalloped Hammerhead by separating the Atlantic stock data and the Gulf of Mexico stock data and running separate models but with the same model configuration. Both sensitivity runs failed convergence tests, likely because of data limitation. Future monitoring of the species composition may be conducted every few years to see whether there are species composition changes and how likely they may influence the stock assessment and to simulate the influence of fishing on the species composition. The two-sex length-based age-structured SS model for Scalloped Hammerhead stock tried to fit the sex-specific length frequency data. The overall sample size of the length frequency data is low; the resulting parameters, such as for selectivity and likely fishing mortality, may be of high uncertainty, as the analytic team realized. Many parameters were fixed, such as natural mortality at

age and steepness, which substantially decreased the uncertainty estimated. The structured data does not seem sufficient to support the configured base model run. The model may be simplified by combining fleets and decreasing the number of age groups by using a lower age plus-group or considering a length-based stage-structured model. A further simpler model, such as the Bayesian state-space biomass dynamic model used for Great Hammerhead stock, may be explored as an alternative model for comparison. The ASPM was conducted for comparison, but their results are not consistent. A multivariate lognormal Monte-Carlo approach was used to estimate uncertainty about the stock status (Winker et al. 2019; Carvalho et al. 2021). The model estimated parameters or derived quantities from maximum likelihood estimation or via the delta method implemented in SS. The estimated uncertainty can be biased low by the fixed parameters or limited by the probability distributions of the observations assumed. A full Bayesian analysis may be considered in future model development.

Although some sources of uncertainty were not considered or evaluated, **the implications of uncertainty in technical conclusions are clearly stated**.

TOR 4: Evaluate the provisional 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.*** *Are the provisional stock status determination methods for each stock or stock complex appropriate? If not, are there other indicators that may be used to inform managers about stock trends and conditions?*

This TOR was addressed adequately in general, although further exploration and documentation are suggested.

The estimated abundance, exploitation, and biomass of the Smooth Hammerhead shark stock were not provided in the assessment report or in the presentation. Spawning output from the base run and alternative sensitivity runs were provided; its trend is generally robust to priors of M, steepness, and depletion. The prior and posterior of ln(R0) are similar, which indicates a lack of information from the catch time series when using SSS, or there is a need to increase the number of Monte Carlo runs in the rejection sampling using a high-performance machine. The analytic team also demonstrated the use of length frequency data in an SSS application as a proof-of-concept, which provided promising results. However, the years with a length frequency sample size larger than 20 are low, and the model results are sensitive to the length bin used. This suggested it would take a substantial year of collecting length frequency data before they could be useful in the SSS model. Because SSS needs to have depletion specified, it is not recommended to use the SSS results to interpret stock status. The estimated OFLs from all the sensitivity runs are much higher than the current catch, which can be an indicator

of a low probability of overfishing.

The estimated abundance, exploitation, and biomass of the Great Hammerhead shark stock using the Bayesian state-space surplus production model were provided, reliably consistent with the input data and population biological characteristics, and useful to support status inferences. The model results are robust to the informative priors of K, initial depletion in the year 1981, and the Pella-Tomlinson shape parameter m, and the model results are consistent with input data and population biological characteristics. The informative priors are from the hammerhead life history and Leslie matrix analysis (Cortes 2022), which is important for the stock assessment model performance. The stock status is relatively robust to the informative priors of K, r, and initial depletion. The stock was overfished, but overfishing was not happening in year 2020 according to the model runs.

The estimated abundance, exploitation, and biomass of the Scalloped Hammerhead stock using the SS model were provided, were consistent with the input data, and were useful to support status inferences. The results need to be interpreted with caution, and extra sensitivity runs and alternative model configurations may be considered. The estimated abundance had a high retrospective error, the analysts had to fix some selectivity parameters to have the model converge, and the model is likely more driven by the length frequency data than the abundance indices. The retrospective pattern indicated there might be a scaling issue in the abundance estimation. The overall sample size of the length frequency data is low. It is unclear how the fixed selectivity parameters and the assumption of an unfished equilibrium status in 1981 influence the population size and trend estimation (Ichinokawa et al. 2014; Martell and Stewart 2014; Minte-Vera et al. 2017). The SS reference case model configuration, defined as a provisional base model configuration, predicted that the stock was not overfished (SSF_{2019} > the minimum stock size threshold, MSST) and that the stock was not experiencing overfishing ($F_{2019} > F_{MSY}$). According to the assessment, there was no overfishing, and the stock had never been overfished in the past (1981-2019). This is quite different from the assessment results of Great Hammerhead Shark stock and previous studies based on a Bayesian state-space surplus production model (SEDAR 77 Great Hammerhead Shark assessment report). Additional model configuration and sensitivity runs (See TORs 2 and 3) are suggested to investigate the stock status further. Despite the uncertainty on the stock status given the SS model configuration, the spawning output is increasing, indicating a low probability of overfishing under the fishing level since the early 2010s.

Although the cases on the biomass and stock status reliability vary among the three stocks, **the provisional stock status determination methods for each stock or stock complex are appropriate**.

TOR 5: Evaluate the stock projection methods, 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 provisional results informative and robust, and useful to support inferences of probable future conditions?*
- ***d.*** *Are key uncertainties acknowledged, discussed, and reflected in the provisional projection results?*

This TOR was well addressed.

The analytic team used stock projection methods that were consistent with accepted practices and appropriate based on the available data recommended from the SEDAR Data Workshop, the estimated uncertainty, and the harvest control rule. **The methods used for stock projection are appropriate for the assessment model and outputs.** The software or packages selected to handle the stock projections are used for many other species with similar stock assessment models and results.

The **Smooth Hammerhead** stock assessment is data-poor, and only the catch time series and some limited length frequency data are available. However, life history analysis for such long-lived species is valuable and well-used as known "data" in the SSS model for this species. These applications are appropriate. The projection of the SSS is determined by the "known" life history "data." **The stock status and fishery status from the SSS are not suggested to be used**.

The **Great Hammerhead** shark stock assessment results are informative, robust, and useful to support inferences of probable future conditions. **Key uncertainties** in data, sources of priors, and estimated uncertainties in the estimated parameters, population size, and fishing intensity **are acknowledged, discussed, and reflected in the presented projection**. The uncertainty in catch is not reflected in the analysis. Alternative sensitivity runs using best, minimum, and maximum catch may be conducted to help understand the robustness to the catch uncertainty of the model projection in biomass, OFL, and ABC recommendation, etc. **The provisional results of the Great Hammerhead stock assessment are informative, robust, and useful to support inferences of probable future conditions.**

The **Scalloped Hammerhead** shark stock projection is well done. **The key uncertainties were acknowledged, discussed, and reflected in the provisional projection results.** The projection method followed the SS framework and was consistent with common practices. Although the model framework is appropriate, the Scalloped Hammerhead shark stock assessment has relatively low length frequency samples; the estimated abundance, fishing mortality, and stock status have some problems (see TORs 2-4). **Although the projection is well done, given the concerns on the estimated abundance**

and stock status, the OFL and ABC recommendation may further be specified with caution. Extra model analysis, as suggested in TORs 2-3, may be done before the OFL and ABC from the SS model are applied for management purposes.

TOR 6: Provide, or comment on, recommendations to improve the assessment.

- ***a.*** *Consider the research recommendations provided by the Data and Assessment workshops in the context of overall improvement to the assessments, and make any additional long-term research recommendations warranted.*
- ***b.*** *Provide suggestions on key improvements in data analysis or modeling approaches that should be considered when scheduling the subsequent operational assessment. These recommendations should be described in sufficient detail for application in the subsequent operational assessment, and consequently should be practical for short- term implementation (i.e., achievable within ~6 months).*
- ***c.*** *Comment on the degree of environmental and climate linkage(s) incorporated in the stock assessments and make recommendations for improvements in the future.*

I support the recommendations from the Data and Assessment workshops. Below are some extra suggestions for consideration.

a: Recommendations provided by the Data and Assessment workshops.

- Sampling the Carolina and Scalloped Hammerheads complex on the Atlantic side is recommended. It is important to see whether the proportion of the species in the complex has a trend in change or not.
- Changes in life history traits, such as growth and maturity, may be explored in the future, which may influence stock assessment results.
- Discard and bycatch estimated may be considered using a model-based approach that deals with a high percentage of zeros and considers influences from strata, spatial-temporal patterns, etc. (Bi et al 2021; Zhou and Liao 2022).
- Post-release mortality can be improved by increasing the cumulative sample size of the Hammerhead Shark species over time and comparing it with the meta-analysis based on other large shark species.
- Citizen science may be considered for the reconstruction of commercial catch in the 1980s.

b: Key improvements in data analysis or modeling approaches.

- Consider the use of the relative abundance indices by using a model-based approach that can handle a high percentage of zeros for the Smooth

Hammerhead stock.

- Consider clarifying the priors used in the Great Hammerhead stock assessment by using probability distributions, and clarify parameters fixed versus priors used.
- Data scenarios using the original estimated recreational catch instead of smoothed AB1 and B2 recreational catch for the three species should be explored as sensitivity runs.

Although there are multiple relative abundance indices and length samples from multiple fisheries and surveys for Scalloped Hammerheads, the length composition sample sizes are relatively small compared with many other fish species with successful sex-specific age-structured models. I have the following suggestion that may be explored before the subsequent operational assessment.

- Consider combining fleets and the corresponding length samples, especially the ones that share selectivity in the current reference run of the Scalloped Hammerhead model.
- The Scalloped Hammerhead model may be simplified by combining fleets and decreasing the number of age groups by using a lower age plus-group or considered a length-based stage-structured model. When combining fleets, the selectivity may be modelled as a random walk process to account for the potential effort variations among fleets and policy changes over time.
- A further simplified model, such as the Bayesian state-space surplus production model used for the Great Hammerhead stock, may be explored as an alternative model for comparison with the Scalloped Hammerhead stock assessment.
- It is unclear how the fixed selectivity parameters and the assumption of unfished equilibrium status in 1981 influenced the Scalloped Hammerhead stock population size and trend estimation (Ichinokawa et al. 2014; Martell and Stewart 2014; Minte-Vera et al. 2017). Sensitivity runs may be added to explore the influence of the fixed selectivity parameters and the assumed equilibrium status on abundance and stock status. The 1981 year age structure and population abundance may be solved in an intuitive way by replacing the equilibrium age structure and population abundance based on an F in 1981 estimated from the SS model. The procedure can be repeated a few times to reduce the influence of assuming the population in 1981 was in an unfished state.
- Consider increasing the weights on the relative abundance of Scalloped Hammerhead stock without changing the currently estimated efficient sample size as a sensitivity run to see whether the assessment model can fit the relative abundance indices better and how it influences the fishery and stock status (Francis 2011).

c: Environmental and climate linkage(s) incorporated in the stock assessments.

- The stock assessments of all three stocks, including the Scalloped and Carolina Hammerhead Sharks complex, don’t have environmental and

climate linkage(s) incorporated. These species are relatively data-limited.

- Changes in life history traits, such as growth and maturity, may be explored in the future through mixed effect models or Bayesian hierarchical models, and linked to environmental and climate variations.
- The relative abundance indices may be linked to climate indices or environmental factors to improve our understanding of the distribution of Hammerhead sharks.
- It should be useful to explore the relationship between the recruitment dynamics of the Scalloped Hammerhead sharks and the climate changes in the South Atlantic area.

TOR 7: Provide recommendations on possible ways to improve the Research Track Assessment process.

The Research Track Assessment process is critical to the successful stock assessment and fisheries management. Because the SEDAR data workshop, assessment workshop, and review workshop are separated, the review workshop would benefit from adding the summary presentations of the data workshop with some details on the data statistical description, criteria of evaluation, and rationale of selection or rejection. Overall, this is a well-organized process.

TOR 8: Prepare a Review Workshop Summary Report describing the Panel's evaluation of the Research Track stock assessment and addressing each Term of Reference.

This TOR was not completed. The review summary report is not required anymore because of the agenda changes caused by Hurricane Idalia.

4. Comments on the NMFS review process

I find the SEDAR review process effective, clear, and meaningful, even though this review was disturbed by Hurricane Idalia. This specific review done for Hammerhead Sharks did not get enough time to allow the review panel to discuss each TOR separately, and a summary panel report was not done. I find it important to keep a reasonable block of time to allow the review panel to discuss each TOR thoroughly. The analytic team has been very patient and cooperative in dealing with questions and requests. I have no further recommendations about the review process.

5. Acknowledgements

I would like to thank all the analytic team members and the other presenters contributing to the meeting for their informative presentations on the stock assessments of Hammerhead Sharks in the South Atlantic and Gulf of Mexico region and for their hard

work and willingness to provide helpful responses to the review panel's questions and requests. Many of our questions were about results or recommendations from the data workshop. I also would like to thank The SEDAR77 coordinating committee, who facilitated the review process and made it enjoyable and productive. Special thanks also go to other members of the review panel, Drs. John Carlson, Alistair Dunn, and Peter Stephenson for their respectful and productive discussions on the assessments.

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Appendix 1: Bibliography of materials provided for review

Research track stock assessment reports for review:

NOAA. 2023. SEDAR 77 HMS Hammerhead Sharks: Scalloped Hammerhead Shark Section III: Assessment Report.
NOAA. 2023. SEDAR 77 HMS Hammerhead Sharks: Great Hammerhead Shark Section III: Assessment Report.
NOAA. 2023. SEDAR 77 HMS Hammerhead Sharks: Smooth Hammerhead Shark Section III: Assessment Report.

Background material provided for* uku stock assessment review*:

Cortés, E. 2022. Estimates of vital rates and population dynamics parameters of interest for hammerhead sharks (Sphyrna lewini, S. mokarran, and S. zygaena) in the western North Atlantic Ocean. SEDAR77-AW04. SEDAR, North Charleston, SC. 14 pp.
Courtney, D. and Rice, J. 2023. Meta-Analysis of Historical Stock Assessment Uncertainty for U.S. Atlantic HMS Domestic Sharks: An Example Application within a Tiered Acceptable Biological Catch (ABC) Control Rule. SEDAR77-RD56.
NOAA. 2022. SEDAR 77 HMS Hammerhead Sharks Data Workshop Final Report.
NOAA. 2023. Final Amendment 14 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan NOAA Fisheries: Highly Migratory Species. SEDAR77-RD55.
NOAA. 2023. SEDAR 77 HMS Hammerhead Sharks Stock ID Process Final Report.

Appendix 2: Statement of Work

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 77 HMS Hammerhead Sharks 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[1].

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.

The SEDAR 77 review workshop will be a CIE assessment review conducted for Highly Migratory Species (HMS) Hammerhead Sharks. There are three models to be reviewed; one model for Great Hammerheads for the Atlantic and Gulf of Mexico regions, one model for Smooth Hammerheads for the Atlantic and Gulf of Mexico regions, and one model for Scalloped and Carolina Hammerheads in the Atlantic and Gulf of Mexico regions. 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 assessment is appropriate for use by fishery managers. The stocks assessed through SEDAR 77 are the Gulf of

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

Mexico and Atlantic stocks of Scalloped, Carolina, Smooth and Great Hammerhead Sharks in U.S. federal waters from Maine through Texas 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 this 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. It would be preferable for reviewers to have an expertise in shark population dynamics and/or shark assessments. The chair, who is in addition to the three reviewers, will be not be provided by the CIE. Although the chair will be participating in this review, the chair's participation (e.g., labor and travel) is not covered by this contract.

Tasks

Task 1. Two weeks before the peer review, the Project Contacts will make all necessary background information and reports available electronically to the reviewers 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.

Task 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.

Task 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.

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

Task 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 in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12

regulations available at the Foreign National Guest website. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance
The place of performance shall be at the contractor's facilities, and in Panama City, FL.

Period of Performance
The period of performance shall be from the time of award through November 2023. 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.

Schedule	Milestones and Deliverables
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
August 28-Sept 1, 2023	Panel review meeting
Approximately 3 weeks later	Reviewers submit draft peer-review reports to the contractor for quality assurance and review
Within 2 weeks of receiving draft reports	Contractor submits final reports to the Government

*The Chair's Summary Report will not be submitted to, reviewed, or approved by the Contractor.

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.

Confidentiality and Data Privacy
This contract may require that services contractors have access to Privacy Information. Services contractors are responsible for maintaining the confidentiality of all subjects and materials and may be required to sign and adhere to a Non-disclosure Agreement (NDA).

Travel
All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790), and all contractor travel must be approved by the COR prior to the actual travel. Any travel conducted prior to the receipt of proper written authorization from the COR will be done at the Contractor's own risk and expense. International travel is authorized for this contract. Travel is not to exceed $13,000.

Government Furnished Resources
The Government will provide all necessary information, data and documents to the Contractor for work required under this contract.

Project Contacts:
Larry Massey – NMFS Project Contact
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South Atlantic Fishery Management Council
4055 Faber Place Drive, Suite 201 North Charleston, SC 29405
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Annex 1: Peer Review Report Requirements

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

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each TOR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the 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 shall 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 shall 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 77 HMS Hammerhead Sharks Assessment
Review Workshop Terms of Reference

Review Workshop Terms of Reference

1. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions. Consider the following:
    a. Are data decisions made by the DW and AW justified?
    b. Are data uncertainties acknowledged, reported, and within normal or expected levels?
    c. Is the appropriate model applied properly to the available data?
    d. Are input data series sufficient to support the assessment approach?

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

3. 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.

4. Evaluate the provisional 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. Are the provisional stock status determination methods for each stock or stock complex appropriate? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

5. Evaluate the stock projection methods, 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 provisional results informative and robust, and useful to support inferences of probable future conditions?

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

6. Provide, or comment on, recommendations to improve the assessment

a. Consider the research recommendations provided by the Data and Assessment workshops in the context of overall improvement to the assessments, and make any additional long-term research recommendations warranted.

b. Provide suggestions on key improvements in data analysis or modeling approaches that should be considered when scheduling the subsequent operational assessment. These recommendations should be described in sufficient detail for application in the subsequent operational assessment, and consequently should be practical for short- term implementation (i.e., achievable within ~6 months).

c. Comment on the degree of environmental and climate linkage(s) incorporated in the stock assessments and make recommendations for improvements in the future.

7. Provide recommendations on possible ways to improve the Research Track Assessment process.

8. Prepare a Review Workshop Summary Report describing the Panel's evaluation of the Research Track stock assessment and addressing each Term of Reference.

Annex 3: Tentative Agenda - SEDAR 77 Atlantic Hammerhead Sharks Assessment Review

Panama City, FL

August 28 – Sept 1, 2023

Monday

9:00 a.m. – 9:30 a.m.	**Introductions and Opening Remarks** *- Agenda Review, TOR, Task Assignments*	**Coordinator**
9:30 a.m. – 5:00 p.m.	**Assessment Presentations**	**TBD**

Tuesday

9:00 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**	**Chair**

Thursday Goals: Complete assessment work and discussions.

Friday

9:00 a.m. – 1:00 pm	**Panel Discussion or Work Session** *- Review Consensus Reports*	**Chair**

***Friday goal*:** Final results available. Draft Summary Report reviewed

Appendix 3: Panel membership or other pertinent information from the peer review meeting

Review Panel:

John Carlson (Chair)	NMFS SEFSC
Alistair Dunn	CIE Reviewer
Yan Jiao	CIE Reviewer
Peter Stephenson	CIE Reviewer

Analytic Team:

Dean Courtney	NMFS SEFSC
Xinsheng Zhang	NMFS SEFSC

Staff:

Kathleen Howington	SEDAR
Michele Ritter	SAFMC Staff

Appointed Observers:

Fly Navarro

Workshop Observers in person:

Andrea Kroetz	NMFS Panama City
Alyssa Mathers	NMFS Panama City
Heather Moncrief-Cox	NMFS Panama City

Workshop Observers via Webinar:

Heather Baertlein	NOAA NMFS
Chip Collier	SAFMC Staff
Tessa Hunt-Woodland	FWC
Max Lee	Mote Marine Lab
Julie A Neer	SEDAR
Cami McChandless	NMFS NEFSC
Kaitlyn O'Brien	VIMS
Michelle Passerotti	NMFS NEFSC
Adam Pollack	NMFS SEFSC
Christina Vaeth	

Post-Review Workshop Webinar Observers:

Jason Cope	NMFS NWFSC
Meisha Key	SEDAR
Max Lee	Mote Marine Lab

Abbreviations:

CIE – Center for Independent Experts
SEDAR – SouthEast Data, Assessment, and Review
NMFS – National Marine Fisheries Service (NOAA)
NOAA - National Oceanic and Atmospheric Administration
NEFSC – Northeast Fisheries Science Center
NWFSC – Northwest Fisheries Science Center
VIMS - Virginia Institute of Marine Science
SAFMC – South Atlantic Fishery Management Council