Independent Peer Review Report for the Research Track Assessment of Hammerhead Sharks in the Gulf of Mexico and Atlantic Coast (SEDAR77).

Meeting at Boardwalk Hotel
Panama City, FL August 28, 2023
23 August 2023

Webinar video link
13 November 2023

Prepared for Center of Independent Experts
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1. EXECUTIVE SUMMARY

The independent Peer Reviewer 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.

The Research Track Assessment review for four Hammerhead Shark Species was conducted at a face-to-face meeting on August 23, 2023, followed by a Webinar conferencing meeting on November 13, 2023. The in-person meeting that began on August 23rd was cut short by Hurricane Idalia.

The presentations by the Assessment Team dealt with Great Hammerhead and Scalloped Hammerhead (including Carolina Hammerhead) on August 23, and with Smooth Hammerhead on November 13. Both meetings were well organized, open, and transparent with observers being encouraged to contribute. During both meetings, the Review Panel made suggestions on things needing further investigation, but it was expected these would be considered for the next assessment.

Due to different data availability for each species, different assessment software was used for each species. A production model using the software JABBA was used for Great Hammerhead, an age structured model using Stock Synthesis 3 was used for Scalloped Hammerhead, and a "data-limited" model Simple Stock Synthesis for Smooth Hammerhead sharks. The assessment presentations on the three species were detailed and informative with the data used in each model being that recommended by the Data Workshop team. I am convinced that the choice of assessment methods used was appropriate, given the data available, that assessment results are reliable, and the conclusions drawn are well founded.

After deliberation, considering the reports supplied and Review Meeting presentations I concluded that the assessment provided by the Assessment Review Group was scientifically sound and they had provided good evidence that:

The stock of Great Hammerhead sharks over the area from the Gulf of Mexico to the Atlantic was overfished but was not undergoing overfishing.

The stock of Scalloped (including Carolina) Hammerhead sharks over the area from the Gulf of Mexico to the Atlantic was not overfished and not undergoing overfishing.

For Smooth Hammerhead sharks over the area from the Gulf of Mexico to the Atlantic, due to data constraints it could not be determined if the stock was overfished. A realistic Overfishing Limit was estimated for the year 2021.

In addition, I endorse the use of the three software packages JABBA, Stock Synthesis 3, and Simple Stock Synthesis for the respective three species.

The Review Panel did not produce a Panel Report, it being left to the three CIE Reviewers to write their individual reports on each of the three species reviewed.

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.

2. BACKGROUND

The Research Track Assessment review for four Hammerhead Shark Species was due to be conducted as a five-day meeting at the Boardwalk Hotel conference room from 23 August to 27 August 2023. In the afternoon of 23 August, the participants were told they were required to go home the next day due to the presence of Hurricane Idalia. The Panel worked for 13 hours from 9:30 am to 10:30 pm to hear

presentations on Great Hammerhead, Scalloped Hammerhead, and Carolina Hammerhead sharks. The Review Panel agreed that a second meeting would occur to review Smooth Hammerhead sharks using Webinar conferencing at a future date. The Webinar meeting was conducted on November 13, 2023, from 12:05 p.m. to 5:15 pm (USA EST) which was 1:05 am to 6:15 am Perth time, where I was located.

The face-to-face meeting was well organized, open, and transparent. The Chair gave all participants opportunity to contribute and ask questions. He specifically asked observers from the public to make contributions at regular intervals. As is usually the case, questions came almost exclusively from the Review Panel. The presentations by the assessment team were detailed and well organized.

The Webinar meeting was efficiently organized, and the technical side worked very well. With the system used, it was good that there were no feedback problems when microphones were left on. There were difficulties asking questions during the presentations as the "hand up" feature appeared to be not noticed by the slide show presenter.

There were extensive data on landings, abundance indices surveys, and length-composition data which were well described in the Working Paper documents. The Data Workshop Report had excellent summaries of the working papers and was extremely useful. The three assessment documents, one each of Great, Scalloped (including Carolina), and Smooth Hammerhead sharks were highly detailed and excellent.

The Assessment Team confidently presented detailed descriptions of the model inputs, the methods used in the three assessment model platforms, and model outputs. The Assessment Team were able to respond to questions asked but there was no opportunity to request additional model runs.

During both meetings, the Review Panel asked questions and made suggestions on things needing further investigation. Sensitivity analyses were suggested by the Review Panel, but these could not be performed during the review, due to time constraints. The expectation was that these suggestions would be considered for the next assessment.

The three assessment models, JABBA, Stock Synthesis 3, and Simple Stock Synthesis were selected as the platforms considered most suited to generate an assessment of the three stocks. I am convinced the choice of assessment methods was suitable, given the data available, and the assessment results are reliable, and the conclusions drawn are well founded.

The Review Panel did not produce a Panel Report, it being left to the three CIE Reviewers to write their individual reports on each of the three stocks reviewed.

This report represents the independent review by Peter Stephenson in accordance with the guidelines shown in the Performance Work Statement shown in Appendix 2.

3. Review Process

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 panellists, 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.

Prior to the Review Workshop I read the Data Workshop reports, which were readily downloaded from the SEDAR77 website.

At my request, the Stock Synthesis files for Scalloped Hammerhead sharks were supplied by Dean Courtney. I examined the information in the data reports for Scalloped Hammerhead and was readily able to match it with the data in the Stock Synthesis input files, after making the necessary adjustment from dressed weight to whole weight and from pounds to metric tonnes.

On Friday 25 August 2023, I participated in a Webinar meeting where I was introduced to the SEDAR Review Meeting organizer Cathleen Howington, the chair, John Carlson, the Assessment Scientists, Dean Courtney and Xinsheng Zhang, and CIE reviewer Yan Jiao. We chatted briefly and asked questions about the upcoming meeting to be held on Monday August 28. This was an excellent idea and I commend it for future reviews.

The face-to-face meeting in Panama City was due to run from August 28 to September 1, 2023. In the early afternoon of the first day, we were informed the meeting would finish that day, due to the imminent arrival of Hurricane Idalia. The Review meeting on this one day went from 9:30 am until 10:30 pm. During this meeting, the assessment scientist Xinsheng Zheng gave a long presentation on the assessment of Great Hammerhead sharks. I actively participated in discussion on the data inputs and the results of the assessment model. The Reviewers made suggestions on exploring different input parameters through sensitivity runs, but due to time constraints, it was not expected that these would be performed for this assessment. In addition, it was not possible to produce a Review Summary Report. Despite these limitations, from the thorough Data Workshop and Assessment documentation, and the discussions during the meeting, I was satisfied that I could make a determination on the reliability of the assessment of Great Hammerhead sharks.

After dinner on August 28, the Review Panel was given a cut-down presentation on Scalloped Hammerhead sharks by Dean Courtney. The presentation outlined the reason for the choice of data sets and parameters, the Stock Synthesis model outputs, diagnostics, and sensitivity analyses. The Data Workshop summary report and the Assessment Report were very detailed and well presented during the Review Meeting presentation. I actively participated in discussion on the data and assessment despite the extremely limited time available. Possible sensitivity runs with alternate input parameters were suggested but these were not expected to be conducted for the current assessment. There was no opportunity to produce a Review Summary Report. Despite the limited discussion possible on the assessment, I was satisfied that I could make a determination on the reliability of the assessment of Scalloped Hammerhead sharks conducted using the software Stock Synthesis 3.

At 10:30 pm on August 28, it was decided that the Assessment review on Smooth Hammerhead sharks would take place over Webinar at a time convenient to the Assessment Team and the CIE reviewers. The Review Meeting for Smooth Hammerhead sharks was delayed until November 16, 2023.

The Webinar meeting occurred at 12:05 to 17:15 on November 16, 2023. Where I was located, this was 01:05 to 06:15 Perth time. The Webinar logon and joining the meeting was simple and worked very well. I actively participated in the discussion, despite minor technical problems in asking questions. I actively participated in the discussion on the data inputs for Smooth Hammerhead and the assessment outputs

from the model Simple Stock Synthesis. Sensitivity runs, with different input parameters, were suggested by the Review Panel, but it was not expected that these be completed for this assessment. There was no opportunity to produce a Review Panel Summary Report. Due to the excellent summary report from the Data Workshop group and also the Assessment Group, together with the thorough presentation by Xinsheng Zhang, I was satisfied that I could make a determination on the reliability of the assessment and conclusions drawn about the status of this stock.

The National Marine Fisheries Service review process was very thorough. The Data Workshop documents and Background Documents were easily located on the SEDAR website. The recommendations of the Data Workshop group, on data to be used in the assessment, was thoroughly explained in the Data Workshop Report. The Assessment Reports on the three stocks were very thorough and easily located.

The Webinar meeting a few days prior to the face-to-face meeting in Panama City was a great idea which should continue in the future.

During the Review Meeting, both the face-to-face and the Webinar meeting, there was ample opportunity for all the participants to make comments and ask questions. At regular intervals, the Chair formally asked the audience if they wished to contribute.

The join-up and login for the Webinar meeting was easy and problem-free. My only suggestion is to improve the method of asking questions during the presentation, with the "hand-up" gesture. On many occasions, the "hand-up" seemed to be not seen by the Chair or the Presenter. This meant the Presenter had to backtrack in the presentation to answer the question.

The review of three stocks with three different assessment models and different model inputs was very intensive. If the meeting had been five days face-to-face, the same comments would apply. There was a risk of confusion about stock-specific data sets and different assessment models. A review of three stocks may well reduce the opportunity for detailed discussion, formulating alternative model runs, and considering the results.

With three shark stocks, the number of Data Workshop reports and Reference Documents was rather overwhelming, but the Assessment Report for each stock gave excellent summaries that greatly helped the Review process.

The various management benchmarks like MSY, F_{MSY}, B_{MSY}, MSST, MFMT, OFL, ABC should be defined in each of the Assessment Documents and Assessment presentations, especially for benefit of the non-scientific audience.

In the Assessment Reports, Data Workshop reports, and presentations there is lack of consistency in the formatting, for example M and *M*, F_{MSY} and F_{MSY} in the same document, Serif and Sans Serif font in the body text, mixing fonts in table headings and figure captions. I also noticed that the NMFS publication guidelines say to denote metric tons as (t). I am sure it is just a matter of reminding authors of the NMFS reporting styles.

4. Review Workshop Terms of Reference

I have addressed each of the Terms of Reference (TOR 1 to TOR 9) below. The three shark stock assessments to be reviewed used different assessment models, with different data inputs, and different input parameters. Thus, I have addressed TOR 1 to TOR 6 for Great Hammerhead, then TOR 1 to TOR 6 for Scalloped Hammerhead, then TOR 1 to TOR 6 for Smooth (including Carolina) Hammerhead. TOR 7 to TOR 9 apply to all three stock assessments and are addressed thereafter.

4.1 Great Hammerhead sharks

4.1.1 Great Hammerhead sharks *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 SEDAR 77 Data Workshop (DW) group held webinar meetings from September 2021 to January 2022. They did an intensive examination of the data contained in the data workshop reports leading to the production of an excellent report "SEDAR 77 HMS Hammerhead Sharks Data Workshop Final Report, April 2022". This report summarized the information in the Data Workshop Reports (See Appendix 3) and made detailed recommendations to the Assessment Group on what data should be included in the assessment.

Stock Identification. The working groups conducted extensive reviews and determined this species comprised a single biological stock across the Gulf of Mexico and U.S. Atlantic, based on no regional differences in life history being observed, no significant genetic differentiation, and the observed movement of individuals between the regions. I am satisfied that this conclusion is well supported and justified.

The age and growth of the great hammerhead in the western North Atlantic Ocean is reported in document DW11. The sample sizes are satisfactory 204 females and 179 males. The annuli are easy to read, and the age estimates appear to be reliable. Maximum observed ages for females and males were 35 years and 38 years. The DW group decided to use sex-specific growth model parameters and a maximum age of 42 years from a bomb radiocarbon analysis by Passerotti et al. (2010).

I am satisfied with the recommendations on age and growth.

Reproduction. The reproductive information is reported in document DW18. The length sample sizes were good (751 animals mainly from the Gulf of Mexico) with 86 animals having associated ages. The DW recommendation was to use sex-specific age and size at maturity ogives for great hammerhead sharks. Brooding is biennial and 11-12 months, pup size 500 mm, brood size related to length.

Natural mortality. The recommendation of the DW was to use M=0.156/yr based on a distribution of random draws from the distributions of estimates from the five methods shown below.

Jensen's (1996) K-based and age at maturity estimators.
Modified growth-based Pauly (1980) estimator (Then et al. 2015).
Modified longevity-based Hoenig (1983) estimator (Then et al. 2015).
Chen and Yuan's (2006) estimator.
Mass-based estimator of Peterson and Wroblewski (1984).

A distribution of values of natural mortality were obtained from "the Leslie matrix stochastic analyses." I believe this means that random values were selected from the distribution of values for each estimator to obtain a distribution of values for natural mortality which had a mode of 0.156.

I believe there are some limitations to the approach used in this assessment. Firstly, it is complicated, and the Review Panel had to expend considerable time on determining the process used to determine the modal estimate of 0.156. Secondly, I would have liked to see the median estimate for each estimator, or each of the distributions to see if there was an outlier, which sometimes occurs. The median values for the

estimators might suggest there is a bi-modal distribution of values for natural mortality from these estimators.

It was not clear to the Review Panel if natural mortality was variable over ages. It is often the case that assessments use age varying natural mortality and I do not have a problem with this. I believe, for the sake of simplicity, it is preferable to use natural mortality constant with age. In the assessment, it is applied to mature adults; hence, it will probably not change the results.

Recommendation 4.1.2.1. The method of arriving at M=0.156 should have been made clearer to the Review Panel. I believe it is preferable to use a simple method for selecting a value of natural mortality as it makes the Review process easier. If the method currently used is preferred by the Data Workshop group and Assessment group, then I believe the distribution of values, or the median values of natural mortality obtained from the life history estimators should be presented in the report.

A comment needs to be made on whether natural mortality varies over ages.

Stochastic estimates of the annual survival at age, r_{max} = 0.144/yr, were determined as e^{-M} where M = 0.156/yr. Using an estimate of r_{max} is common procedure and is acceptable in this assessment.

Recommendation 4.1.1.2. I suggest sensitivity runs to investigate the impact of different values of M on the model outputs.

Catches. There are four sources of commercial catch from 1991 to 2019. Commercial bottom longline, commercial gillnet, commercial hook and line + hand line, and commercial longline dead discards. As the commercial landings by species only start in 1991, they were reconstructed back to 1981 with a linear increase of landings from 0 in 1981 to 90% of the mean of 1991-1993 in 1990 to account for the growing market for shark products. This increase is applied to the three fleets considered for each stock (longline, gillnets, and hook and line + unknown gear). Dead and live discards were also backdated from 1991 to 1981. The reconstruction of commercial catches is a reasonable and sensible decision, and I concur.

The recreational catch information, from 1981 to 2019 consist of the sum of estimates from

Marine Recreational Information Program (MRIP),
Southeast Region Headboat Survey (SRHS) operated by the SEFSC Beaufort Laboratory,
Texas Parks and Wildlife Department (TPWD) Survey.

The DW decided that when catches are reported as unclassified sphyrnid sharks:

a. For 1981-2000, use annual proportions based on catches (observed by interviewer)
b. For 2001-2020, use average proportion during 1981-2000 based on the catches (observed by interviewer) to account for management measures implemented.
c. Smooth the recreational catch series with a three-year geometric moving average.
d. Smooth individual years with noticeable peaks by setting them equal to the geometric mean of the three preceding and ensuing years (as available).

The DW decisions a. and b. above are sensible and I concur with them.

I have concerns about decision c. I agree that smoothing the catches in presentations to fishers or the public can be desirable because a pattern of erratic catches may attract unwonted attention. For scientific purposes, I believe it disguises the variability in the data, and should be avoided.

The current approach is to replace very high catches with the geometric mean. This will reduce the sum of the catches of the whole data series, albeit by a small amount.

It is possible that the catch time series was smoothed because the model is struggling to fit the variable catches. To me this seems unlikely and at the short Review Panel meeting there was not an opportunity to explore this. I believe, further investigation into the time series of catches should be undertaken to

determine if there are some spurious data causing the peaks. If no explanation can be found, then the unsmoothed data should be used in the assessment.

Data Workshop decision d., above, is of even greater concern. The way I read this, the sum of the catches over all the years would not be preserved. This adjustment should be removed so as to preserve the time series of data. I believe this adjustment would not change the outcome of the assessment, but it should be investigated in the future.

The Mexican catch of great hammerhead sharks (see DW04) is not included in the assessment. I am unsure why this is the case, and time available at the Review Panel meeting did not enable discussion on this.

Recommendation 4.1.1.3. In future assessments, the smoothing using a geometric mean should be removed. If the model fails to converge with the highly variable catches, then a different approach should be taken, for example, a LOESS smother.

Recommendation 4.1.1.4. An explanation for the exclusion of Mexican catches should be provided in the assessment documents.

In the assessment model, the catch in numbers is used.

Discard mortality. In surveys involving experienced recreational anglers, a minimum estimate of discard mortality of 11.8% was determined. The DW panel decided to use the results from a meta-analysis estimate for pelagic sharks of 26.8%. For commercial catch a discard mortality rate of 80.36% was applied to sharks released alive from commercial bottom longline gear and also for commercial gillnet gear. For hook and line, a discard mortality of 26.8% was applied.

For the current assessment, the DW recommendation is reasonable and acceptable.

Recommendation 4.1.1.5. In future assessments, the different survivability of sharks caught by bottom longline gear, commercial gill net should be investigated.

Recommendation 4.1.1.6. The commercial hook and line discard mortality rate should be investigated.

Recommendation 4.1.1.7. As the mortality is applied to live discards, the proportion of the discards that are live should be investigated.

Indices of abundance. 32 indices of abundance were examined by the Data Workshop Panel for the assessment of great hammerhead sharks, the recommendation was based on three things: were they used in previous assessments, were they stock wide surveys, did they cover a unique area.

The indices selected by the Data Workshop Group were:

1. "Shark Bottom Longline Observer Program" (DW12), split into two data series non-research (≤ year 2007) and the research (≥ year 2008).
2. "Florida State University Bottom Longline Survey" (DW14).
3. "Rosenstiel School of Marine and Atmospheric Science Drumline Survey" (DW15).
4. "NOAA Fisheries-Southeast Fisheries Science Center-Bottom Longline Survey" (DW24)
5. "SEAMAP Bottom Longline Survey (DW25).

In the Data Workshop Report, the reasons for selection of these indices were explained clearly, reiterated in a table with a brief description of why they were chosen, and drawn on a map to show the spatial coverage of the surveys used in the assessment. This is a great idea, and the team are commended for this excellent approach.

A standardized index of abundance was generated using a "generalized linear mixed model in a two-step delta-lognormal." Two of the data sets were revised so as to include data only from areas where Great

Hammerheads occur. At the Review Panel meeting, the Assessment team suggested the plots showed an increasing trend in the indices of abundance. I would note that this appears to be only in recent years.

The selection of indices appears sensible, and the standardization is a widely used standard approach and the method is commended.

Recommendation 4.1.1.8. It would be useful to plot the size frequencies with the catch rates to see if the size distribution has changed.

Recommendation 4.1.1.9. Indices of abundance in the time before 1990 would be very informative. There may have been some data collected and this could be worth investigation.

Length-composition. There are 2,714 samples over the years 1981 to 2019 with samples of about 110 to 160 fish lengths per year in the last 10 years. The recommendation of the DW group was to not use length-composition data in the assessment model, as there was insufficient data.

Recommendation 4.1.1.10. The sample sizes from 2010 to 2019 could be large enough to be considered in the assessment and this should be investigated.

Recommendation 4.1.1.11. Length-composition data could be collected for this species by commercial and recreational fishers at reasonable cost (a sample size of at least 300 per year would be good) and these length-composition data included in future assessments.

For the Great Hammerhead assessment, the Assessment Group did not deviate from the recommendations of the DW group in the assessment models even though on occasion the data did not contribute significantly to the likelihood function (for example, some of the indices of abundance). I commend the approach that the recommendations of DW group be accepted, without adjustment by the Assessment Team.

4.1.2. Great Hammerhead shark. *TOR2. 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.

The assessment model used for Great Hammerhead sharks is a Bayesian state-space production model conducted using the software platform JABBA (Winker et al., 2018) version v.2.2.8. This model has been used extensively for many assessments and has proved to be reliable and produces many useful diagnostics and graphics. The Pella-Tomlinson production function was recommended by the DW group and was adopted for the assessment.

It can be informative to run the data through an alternative assessment model to ensure your chosen model is configured in a manner appropriate to the data. It is not essential to do this, and the sole use of the JABBA software does not detract from the current assessment. The use of this modelling platform and the chosen production function are a suitable assessment method, given the data available for this species.

The years used in the assessment were 1981 to 2019, with indices of abundance from 1994 to 2019. The model is run in numbers of fish, so there is no growth and length-composition data were not used.

In the model, the priors (with standard deviations) for the model fitting were determined using all available information and they are sensible and justified.

Initial depletion, in 1981, was chosen as mean = 0.9, CV = 0.1. There was some confusion at the Review Meeting whether the justification for these values was based on the level of commercial catch in the 1980's. The recreational catch is dominant in the early years, and I would have thought that the recreational catches before 1981 would have been high, and an alternative initial depletion mean and CV could be investigated, in a sensitivity run. There was no opportunity to pursue this at the Review Meeting.

Recommendation 4.1.2.1. As *r* is very uncertain, it may be worth increasing the CV on *r* to see the impact on the model results.

Recommendation 4.1.2.2. Rewrite the rationale for the choice of beta mean=0.9 and CV = 0.1. I also recommend that a lower value of beta, say 0.6 with a high CV should be investigated.

Model Results. The posteriors for model parameters were, in general, close to the value of the prior. The values of the priors appear to define the behaviour of the posteriors.

Measures of model fit. The fit to catches was very good. The fit of the six indices of abundance was reasonable with the model picking up the recent increases in the index in recent years. There appears to be a problem with the graphs showing the fit to the indices. The graphs show values of log_index that are > 0. There may be a coding error or maybe the values controlling the plots needs to be refined. In addition, the plot shows the base case model fit with a blue line. This appears to be one realization of the posterior distribution, possibly the median. It would be much better to show the confidence interval of the posterior as a blue band.

Recommendation 4.1.2.3. The bug in the plotting routine needs to be addressed. The confidence intervals for the posterior distribution for the index plots should be shown.

Recommendation 4.1.2.4. A correlation plot between *k* and *R* would be useful.

Diagnostics To determine if the model was appropriate to the data and configured properly, extensive diagnostic tests were performed.

> **Predictive Fit.** The posterior predictive fit of the abundance indices was satisfactory with values of ρ = 0.756, 0.284, 0.366, 0.69, 0.422, 0.474, all falling within the range 0.2-0.8.
> **Runs Test.** The Runs Test shows the randomness of the time series of abundance index residuals. All six indices of abundance passed the runs test indicating there was no evidence of an unusual residual pattern.
> **Hindcasting cross-validation**. Of the five indices, only two had a MASE value greater than 1, indicating an unsatisfactory result.
> **Retrospective analysis.** The base run showed no consistent retrospective pattern for seven annual retrospective peels and the estimated Mohn's rho for all stock quantities fell within the acceptable range of -0.15 and 0.20.

The diagnostics indicate the model has satisfactory fits to the data and is quite stable for different input parameters.

Sensitivity Runs. A large number of sensitivity runs were conducted, varying the priors and their CVs for parameters *K* and *r.* The model was quite stable, but for some runs, the credibility intervals were large. Overall, the JABBA model performed reasonably well and is suitable as an assessment tool for this species.

4.1.3 Great Hammerhead. *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.

The input parameters for the model had associated CVs. The carrying capacity (K), intrinsic rate of population growth (r), initial depletion B_{1981}/K had associated CVs in the model setup. The variability in these parameters was reflected in realistic variability in the derived parameters, like biomass and fishing mortality.

There was no mention during the review of using alternative assessment software. The JABBA model has been used extensively for many assessments; thus, its sole use is not a drawback for this assessment.

The assessment results show confidence intervals for the estimated and derived parameters. The projected results also show the confidence intervals of the derived parameters.

In sensitivity runs, the parameters and the CVs of K and r were varied, the results giving a realistic picture of the variability in the results, with, in general, the sensitivity runs having much wider credibility intervals than those in the base case model run.

4.1.4 Great Hammerhead sharks *TOR 4. Evaluate the provisional assessment findings and consider the following:*

> *Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?*
> *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?*

Biomass and exploitation estimates were readily determined by the JABBA assessment model using standard procedures. The estimates had realistic confidence intervals.

The assessment model was run with different priors for K and r and different CVs. All the alternative model runs gave similar results for B_{MSY}, F_{MSY}, B_{2019}, and F_{2019} and these estimates had plausible confidence intervals.

The values of B_{2019}/B_{MSY}, and F_{2019}/F_{MSY} were used to determine the stock status for this species. The values of these parameters had similar values for all the alternative model runs mentioned above and the confidence intervals were realistic.

From these estimates, it was determined that the Great Hammerhead stock is overfished but not undergoing overfishing. I consider these results to be reliable and the conclusions valid.

4.1.5 Great Hammerhead shark. *TOR 5. Evaluate the stock projection methods, including discussing strengths and weaknesses, and consider the following:*

> *Are the methods consistent with accepted practices and available data?*
> *Are the methods appropriate for the assessment model and outputs?*
> *Are the provisional results informative and robust, and useful to support inferences of probable future conditions?*
> *Are key uncertainties acknowledged, discussed, and reflected in the provisional projection results?*

Projections. The stock is currently overfished, but overfishing is currently not occurring. Therefore, projections were carried out for a rebuilding strategy and there was no need to determine the Acceptable Biological Catch (ABC).

The overfishing limit (OFL) is the best estimate of the maximum amount of a stock that can be caught in a year without resulting in overfishing. In this assessment, OFL_{2020} is the amount of catch in 2020 that corresponds to the estimate of F_{MSY} applied to the stock biomass in 2020 using the projection of the terminal year plus 1. For this species OFL_{2020} = 5900 sharks yr^{-1} with confidence intervals 2096 sharks yr^{-1} to 13118 sharks yr^{-1}.

As this stock is overfished, a strategy to rebuild the stock is required. From the assessment model, with F=0 the stock will rebuild with a probability of 70% in the year 2041. Because this is > 10 years, the target rebuilding year is 2041 + 15 = 2056 (where 15 is the generation time, in years, for this species). The fixed level of removals, in numbers of sharks, which result in the stock rebuilding to this level in 2056 with a probability of 50% and 70% are 7264 sharks yr^{-1} and 4994 sharks yr^{-1} respectively.

These results produced in the JABBA assessment model can be considered reliable. The catch level in the year 2019 was 1659 sharks, considerably less than results from the rebuilding strategy.

4.1.6 Great Hammerhead sharks *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.

The Assessment Workshop made recommendations on further sensitivity runs as well as improving the recreational catch data.

The following sensitivity runs could be considered in future assessments.

- Different values of natural mortality.
- Natural mortality invariant over ages.
- Steepness of the stock-recruitment relationship with a lower value, say h=0.5.

The way the catch data are altered before incorporation in the assessment needs careful consideration. The present method of removing peaks in the data series needs attention for the next assessment.

Length-frequency data should be collected for this species and included in the assessment. Just one year of data with a good sample size (say 300) would not be too expensive to collect and would improve the reliability of the assessment of this stock.

The development of relative abundance index for this stock will be an expensive exercise. We should be mindful of the experience for Scalloped Hammerhead sharks where localised surveys did not appear to be informative in the assessment. I recommend, that if an abundance index is developed, that it will need to be spatially extensive, so that it will be money well spent. I believe that a fishery dependent index of abundance will be out of the question, given the nature of the fishery.

There was no mention, at the Review meeting, of changes in spatial abundance of this species due to changes in water temperature. Environmental considerations could be considered in future assessments.

4.2 SCALLOPED HAMMERHEAD SHARKS

4.2.1 Scalloped hammerhead *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?

Stock ID. The working groups concluded that the reported catch of this stock in the Atlantic probably consists of about 27% Carolina Hammerhead, which are difficult to distinguish from Scalloped Hammerhead sharks. It is thought that the Carolina Hammerhead does not occur in the Gulf of Mexico, so the reported catch in this area is only Scalloped Hammerhead. No genetic differences were found for Scalloped Hammerhead between the Gulf of Mexico and United States Atlantic and tagging studies showed there was exchange of individuals of this species between the two regions. The final recommendation was that when sufficient information exists for Carolina Hammerhead, a separate assessment for this species should be conducted in United States Atlantic but currently a single stock assessment for Scalloped and Carolina Hammerhead combined should be conducted across both regions. This is a sensible and pragmatic decision given the amount of data available.

Catch. The DW group made adjustment to the catch. In 1982 spurious data were removed. For 1993 the catch was smoothed with a geometric mean. The 1984 and 1985 catches were also adjusted using the geometric mean. These catch adjustments are sensible and justified.

The smoothing of the whole data series use of the geometric mean, I believe is unsatisfactory. See comments under **Great Hammerhead 4.1.1** and **Recommendation 4.1.1.3.** There were Mexican catches of Scalloped Hammerhead, but these were not included in the assessment.

I examined the catch data inputs used for the Stock Synthesis model. After adjustment from dressed weight to whole weight (multiply by 1.39) and adjustment from pounds to metric tonnes (multiply by 0.000453592), I was satisfied that the assessment model was using the data recommended by the Data Workshop Group.

Discard Mortality. The Data Workshop recommendation for commercial gear was 69.15% for scalloped hammerheads released alive from bottom longline gear and further, and to use the same estimate for commercial gillnet gear. For recreational catches, the recommendation was to use the rate for pelagic sharks of 26.8% as the best estimate. The recommendation appears reasonable and justified.

Length-composition. Recreational length-composition data are available for Scalloped Hammerhead sharks, but the sample sizes are small.

Life History parameters. The parameters used in the assessment came from data collected in the fishery. Sample sizes were good, and estimates derived are reliable.

Age and Growth. The assessment is based on data from the Atlantic and Gulf of Mexico combined. These data may contain Carolina Hammerheads, which occur in the Atlantic but not the Gulf of Mexico (GoM).

1,026 vertebrae were aged, 403 were female and 623 were males. Sample sizes were low in the GoM but satisfactory for the Atlantic. The size range was good, and the annuli were readily visible. The sample sizes were satisfactory, and the ages were determined using best practice methods and I consider them to be reliable. There is no mention of the use of reference collections for age determination. Maximum estimated ages were 29.5 for females, and 39.5 for males.

The DW group decided to use a sex-specific growth model with parameters estimated in the Stock Synthesis model and a maximum age of 39.5 years. The von Bertalanffy growth curve does not fit very well, possibly due to sampling size selectivity or possibly this growth curve is not the most appropriate.

Maturity. Maturity data were available for 1571 scalloped hammerhead sharks. Age information was available for 459 from the Atlantic and 174 from the Gulf of Mexico.

Reproduction. The assessment used age-at-maturity and size-at-maturity ogives, annual pupping, gestation time of 11 months, 18 pups per brood, mean size at birth 35.2 cm and no relation between length and brood size.

Indices of abundance. The data collection and the methodology for determining the indices was well explained in the DW reports. The DW group recommended the use of six indices in the assessment. A summary of each index and the reasons for its selection were explained in the Data Workshop Final Report. The report also includes maps showing the spatial coverage of the surveys. This is an excellent idea.

The six selected indices are:

Shark Bottom Longline Observer Program and Shark Research Fishery;
Texas Parks and Wildlife Gillnet Survey;
Northeast Gulf of Mexico (GULFSPAN) Gillnet Survey - recruitment index;
Cooperative Atlantic States Shark Pupping and Nursery longline survey - recruitment index;
South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping; and Nursery long-gillnet survey - recruitment index.

The standardized indices used in the assessment were obtained by a two-step delta-lognormal approach. I would have thought it would be conventional to scale them to 1 in the standardization process, but this is not a problem for the assessment process.

I compared the indices of abundance shown in the Stock Synthesis data file with those that were in the DW report. All the indices recommended in the data workshops matched those in the assessment data file.

The plots of the indices show generally low values in 2012-2013 and increasing trend in the last 5-6 years.

4.2.2. Scalloped Hammerhead *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.

The data available for this stock is more extensive than for the other two stocks. For Scalloped Hammerhead there are catch, age-composition, length-composition, indices of abundance, and biological data for this species in the assessment area.

The assessment tool selected for this assessment is Stock Synthesis 3, which is well suited to use all the available data. This tool has been used to conduct assessments in many fisheries in many countries. The assessment team used a standard well accepted model setup using natural mortality varying with age, a Beverton-Holt stock-recruitment relationship, estimated length selectivity (where possible), and effective sample size for the length-composition data, with the usual bias adjustment. The assessment method is sound and robust.

The suitability of the data used in the model and the model configuration can be assessed by looking at the diagnostics. The Assessment Team ran extensive diagnostics for Scalloped Hammerhead using the standard suite of tools.

Convergence. The model, in most cases, did not have convergence issues. The parameter estimates were not at the bounds, the final gradient was small (<0.0001), the hessian was positive definite, the parameters are not highly correlated, and the parameters do not have high variance.

Jitter analysis. The jitter analysis with 100 iterations resulted in the model converging to the apparent global solution 98 times.

Likelihood profiles. The run plots for the change in log-likelihood for different data inputs are interesting. The *recruitment* likelihood and the *index of abundance* likelihood are flat for log(R_0) between 3.9 and 5.0. This means that these indices are not really helping the model make its way down to the minimum at 4.29. Looking more closely at the "Changes in Index likelihoods by fleet", the indices where the log-likelihood is really flat are those used as recruitment indices.

Looking at the length-composition plots separately, the data sets where the change in log-likelihood is really small are again data used for recruitment of 0+ sharks.

Retrospective Patterns. With a 5-year peel, there were problematic retrospective patterns in recent years (Mohn's rho=2.5 which is greater than the reference level of 0.2). The model is overestimating the spawning biomass in 2014, 2015, and 2016, but not 2017, and 2018. Although this is undesirable, I feel it does not seriously compromise the results of the assessment.

Hind-cast cross-validation. Of the eight abundance indices, four passed the test and four failed. All the length-composition indices passed this test.

The Assessment Team made a comment on the "hindcast cross validation" check for the abundance indices, suggesting that the indices were either not proportional to abundance or there is some process not accounted for in the assessment model. The diagnostics indicated the Stock Synthesis model is quite stable and appropriately configured. The retrospective patterns are undesirable, but I feel it does not seriously compromise the results of the assessment.

It appears that length-composition data are informative in determining stock size with the indices being less informative. I was pleased to see the assessment team used effective sample size.

I commend the assessment team on the extent of the diagnostic tools used in the assessment of Scalloped Hammerhead sharks. Although the model performance was not ideal in some areas (e.g., retrospective analysis), I believe the model structure is sound and outputs are able to give a reliable determination of the stock status.

Recommendation 4.2.2.1. The likelihood profiles relating to recruitment were problematic for the indices of abundance and the length-composition data. I recommend investigation of alternate values for natural mortality and steepness to see if this makes a difference to the model fitting.

4.2.3 Scalloped Hammerhead sharks. *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.

Two sources of uncertainty in the assessment are whether it is appropriate to treat Scalloped Hammerhead as one stock across the Gulf of Mexico and the Atlantic, and also the catch data contained Scalloped

Hammerhead sharks as well as Carolina Hammerhead sharks. These problems were acknowledged by the Assessment team. The assessment approach is satisfactory for the present, but it would be better, some time in the future if Carolina Hammerhead in the Atlantic could have a separate assessment.

The stock assessment was conducted on the combined catch of the two species using biological data for Scalloped Hammerhead. The uncertainty in the assessment due to these complications is acknowledged by the Data Workshop and Assessment team. A sensitivity analysis doing separate model runs for the Atlantic and the Gulf of Mexico, failed to converge. I believe the use of a single area assessment based on Scalloped Hammerhead data is a practical and pragmatic decision for the current assessment.

The uncertainty in the biological inputs is incorporated in the assessment. The inputs into the model had priors and associated standard deviations (apart from maximum age) which means the variability in the input data flows into the variability of the derived parameters like biomass and fishing mortality.

The credibility intervals for the derived parameters were reported in the tables of outputs and the associated graphs. The extensive sensitivity runs show the variability in the assessment results for different parameter inputs.

The assessment was conducted in Stock Synthesis and an alternative assessment platform using the same data was not presented. There is an advantage in testing an alternative assessment platform to check that the most appropriate model configuration for the available data is being used. Given the considerable time spent exploring sensitivity options and diagnostic testing, and the proved reliability of Stock Synthesis, I believe this is not a drawback to the assessment. Overall, I believe the uncertainties in the results are accounted for in the assessment.

4.2.4 Scalloped Hammerhead sharks. *TOR 4. Evaluate the provisional assessment findings and consider the following:*
Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
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?

The abundance, exploitation, and biomass estimates were determined from Stock Synthesis. The reliability of the outputs of these derived parameters has been thoroughly investigated in many assessments in many fisheries. For the Scalloped Hammerhead assessment, the reliability of the outputs is dependent on the configuration being consistent with the available data. The abundance estimates were plotted against the abundance indices and found to be reasonably consistent. The diagnostic tests gave satisfactory results.

The estimation of the parameters for length-composition selectivity was problematic, as is often the case. The approach taken was to get the best possible initial values for the either asymptotic or dome-shaped selectivity use the SELEX24 helper spreadsheet. And then attempt to estimate the selectivity parameters. If the parameters could not be estimated, then they were fixed at the initial values. This is a good approach which is acceptable, but of course the variability in the estimated derived parameters will consequently be lower.

The thorough approach of the Assessment Team leads me to the conclusion that the model outputs are reliable.

To determine the stock status of this species, Stock Syntheses uses standard, well tested, and reliable methods to determine SSF_{2019} (spawning stock fecundity), F_{2019} , SSF_{MSY} , and F_{MSY}, and MSST (Minimum Stock Size Threshold) where MSST = (1− mean(M_a)) x SSF_{MSY}, with M_a the age-specific values of M. From Stock Synthesis outputs, SSF_{2019} > MSST and F_{2019} > F_{MSY}, that is, the stock is not overfished and the stock is

not experiencing overfishing, in the terminal year of the assessment. The spawning stock fecundity is used as a proxy to female spawning biomass. These results are consistent with standard practice and are considered reliable.

The conclusions from the model results are consistent with the data. The assessment indicates that the stock was overfished in the periods 1981 – 1985, 1990 – 1995, and 2003 – 2005. This is consistent with the catch data we see in these periods. The low catches after this are consistent with the overfishing not occurring in recent times.

Given the current stock status, the projections can be utilized to determine the *F* and corresponding catch to ensure that overfishing will not occur, and the stock is not being overfished with a probability of 70%. An example of results from the projections are mean ($OCL_{2023\text{-}2025}$) = 339.54 mt and the ABC = 0.804 x OFL = 273.13 mt.

4.2.5 Scalloped Hammerhead sharks. *TOR 5. Evaluate the stock projection methods, including discussing strengths and weaknesses, and consider the following:*

Are the methods consistent with accepted practices and available data?
Are the methods appropriate for the assessment model and outputs?
Are the provisional results informative and robust, and useful to support inferences of probable future conditions?
Are key uncertainties acknowledged, discussed, and reflected in the provisional projection results?

The stock projections generated by Stock Synthesis have been proved reliable in many assessments and are appropriate for this stock which is not overfished nor experiencing overfishing. They can be used with confidence to generate estimates of likely future levels of fishing mortality and biomass.

The estimates of the derived parameters in the projections included the credibility intervals in the tables and graphs. The uncertainty in the estimates appeared realistic, although variability may be under-estimated due to the fixed selectivity parameters.

4.2.6 Scalloped Hammerhead sharks *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.

The Assessment Workshop made recommendations on further sensitivity runs, the effect of management actions on abundance index standardization, the length-composition of recreational catch, the fitting of selectivity parameters related to model fit and uncertainty, improving the quality of the catch data, and the implication of reproductive output timing on model fit.

The biological parameters for scalloped Hammerhead are determined from the fishery. If timing of reproduction is thought to be important, the structure of the Stock Synthesis model would allow for a different timing to be incorporated in the assessment.

The following sensitivity runs could be incorporated in future assessments of this species.

- Different values of natural mortality
- Natural mortality invariant over ages
- Steepness of the stock-recruitment relationship with a lower value, say *h*=0.5.
- Different timing of recruitment

There was a recommendation from the Assessment group about estimation of selectivity parameters. The estimation of selectivity parameters for Scalloped Hammerhead sharks will, I believe, always be a problem, especially for dome-shaped selectivity. Fixing the parameter values is a common procedure and the approach used by the Assessment Teams to try and estimate them is satisfactory. The consequence of this will be narrower confidence intervals of the outputs.

The way the catch data are altered before incorporation in the assessment needs careful consideration. The present method of removing peaks in the data series needs attention for the next assessment.

There was no mention, at the Review meeting, of changes in spatial abundance of this species due to changes in water temperature. Environmental impacts on stock distribution could be considered in future assessments.

4.3 Smooth Hammerhead sharks

4.3.1. Smooth Hammerhead *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 DW did an intensive examination of the data leading to the production of the excellent document Data Workshop Final Report which contained excellent summaries of the DW Reports and detailed recommendations to the Assessment Group on what data should be included in the assessment.

The Smooth Hammerhead Assessment Report gave summaries of the DW recommendations, and the methods used to arrive at the choice of Simple Stock Synthesis as the chosen Assessment Model.

Stock Identification. There were limited data on this species, with no genetic studies, but it is a wide-ranging species, and it is reasonable that it could move between the Gulf of Mexico and the U.S. Atlantic. The working group recommended that a single stock assessment across both regions should be conducted. The decision to treat this species as a single stock across both regions for the assessment is a sensible and pragmatic decision.

Age and growth. No information is available for this species, so the Data Workshop group decided to use sex-specific growth model parameters and maximum ages from Rosa et al. (2017), as this study used samples from the north and south Atlantic Ocean.

Recommendation. 4.3.1.1. Some investigation should be made into possible latitudinal differences in parameter estimates.

Catch. Recreational catch statistics are available since 1981 and commercial landings only start in 1991. Thus, the commercial landings were reconstructed back to 1981 with a linear increase of landings from 0 in

1981 to 90% of the mean of 1991-1993 in 1990. This increase is applied to the three fleets, commercial longline, commercial gillnet, and commercial hook and line/unknown gear. A spurious 1991 estimate was removed and replaced by the geometric mean of adjacent years. The adjustment of the catches outlined in the documents is sensible and I approve of the method used.

Catches are smoothed with a 3-year moving geometric mean. I believe this is an unsatisfactory approach and should be removed. If the model does not converge with these more variable catches, then a different approach is required, starting with further investigation into the reasons for the catch variability. I have commented on this in **Recommendation 4.1.1.3** above.

At the Review meeting, there was discussion on the reason the period of low catches starting in the year 2000. In the commercial fishery, the number of permit holders was reduced from about 2000 to 800 with only about 100 being active. After the year 2000 there was a period of permit holder uncertainty and then in 2007 this species was CITES listed.

In the recreational fishery, at about the same time, a catch limit of 1 hammerhead per trip and a minimum size limit of 4.5 feet, based on sandbar sharks, was introduced. These measures contributed to the hammerhead catch reduction in the recreational fishery.

Discard mortality. For Smooth Hammerhead sharks, the information on post release mortality for commercial catches is not known but was thought to be closer to that of Great Hammerhead than Scalloped Hammerhead, thus the post release mortality of smooth hammerhead, 81%, was used for commercial catches of this species, this being applied to live discards for both bottom longline gear and commercial gillnet gear. For recreational catches, it was recommended by the Data Workshop group to use a meta-analysis estimate for pelagic sharks of 26.8% for smooth hammerhead sharks.

Recommendation 4.3.1.4. I believe the proportion of live/dead discards is unknown. If possible, this should be investigated.

Recommendation 4.3.1.5. I would expect that the gillnet and long line would have different survivability, probably gillnet having lower survivability. This should be investigated.

Indices of abundance. The DW group examined 32 surveys and found that only two contained data on Smooth Hammerhead sharks. For example, the "Southeast Fisheries Science Centre-Bottom Longline Survey" did not catch smooth hammerhead sharks because this species is pelagic and not available to the gear. The two sources with data on Smooth Hammerhead sharks are the following.

The pelagic longline observer program. Unfortunately, there were low numbers of positive counts, and this survey was considered not useful as an index of abundance for this species.

The personal logbooks of Mark Sampson, data held at the Maryland Department of Natural Resources contains useful information of Smooth Hammerhead sharks but needs development if it is to be useful as an index of abundance.

Recommendation 4.3.1.6. The Maryland data set should be developed as a matter of priority.

Length-composition. The recorded lengths for this species extend over 55 years but there are only 524 observations and only 7 years had more than 20 observations. The data were considered unreliable and not used in the base case assessment.

Length-selectivity is required in the assessment model, so all the length data were pooled and the lengths at 50% and 95% selectivity were approximated by eye as 120 and 200 cm fork length, assuming a logistic selectivity curve.

4.3.2. Smooth Hammerhead. *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 is a data-limited fishery. There are no age-composition data, the length-composition data are sparse, and there are no reliable indices of abundance. In addition, the biological parameters are determined from results from other fisheries.

The assessment team used Fishpath to investigate which data-limited stock assessment approaches are available for this fishery.

The assessment model chosen was Simple Stock Synthesis (SSS). This tool has been used in many stock assessments and has advantages over, for example, a production model, in that:

it is fully age structured,
it incorporates biological data,
sensitivity analyses are easy performed,
an allowable catch can be calculated,
data can be easily added as they become available.

I believe the choice on Simple Stock Synthesis is a sensible approach given the data available. When length-composition data become available, it will be easy to incorporate them in the SSS assessment model.

The configuration of the model relies on suitable choices for the input parameters. This assessment is data poor (really only catch data) and assumption rich with many parameters taken from other fisheries.

Biological parameters. The fecundity-length relationship was unknown and values from a literature search were used. The parameters for fecundity, growth, weight-at-length all have standard deviations equal to zero in the assessment. The values of CV at length (young then old) were taken as 0.1 and 0.1. There is no information to support the selected values of 0.1 but it may be important in the length-age relationship.

Recommendation 4.3.2.1. The variability of these parameters and the choice of values for CV at length should be explored in future assessments.

Natural mortality. This value was obtained from the life history estimators in the same manner as for Great Hammerhead and Scalloped Hammerhead sharks. The comments made in Great Hammerhead TOR2 (Section 4.1.2) apply here. Simply put, I believe it is un-necessarily complicated and not easily explained to the Review Panel nor the audience.

The value of natural mortality used was 0.129/yr and standard deviation 0.024. It was not clear to the Review Panel if natural mortality is variable over ages. It is often the case that assessments use age varying natural mortality and I do not have a problem with this. I believe, for the sake of simplicity, it is preferable to use natural mortality constant with age. In the assessment of Smooth Hammerhead sharks, it is applied to mature adults; hence, it will almost certainly not change the results.

Steepness parameter. The assessment uses a Beverton-Holt stock-recruitment relationship. I was surprised to hear that the assessment model was not very sensitive to a change in steepness from 0.78 to 0.58. During the Review Meeting there was considerable discussion on what was happening here.

The prior on steepness was 0.78 with a standard deviation of 0.15 and the prior type is symmetric beta. The two distributions with modes 0.78 and 0.58 would have considerable overlap, but this could not be confirmed as only the base case was shown to the Review Panel. It is possible that the recruitment may not change much with this steepness change due the biological characteristics of Smooth Hammerhead, like low mortality of pups. Most importantly, I believe, the change in steepness from 0.78 to 0.58 should have

been applied to the base case assessment of depletion of 0.1 in the year 2000. In the assessment the change in steepness was applied to sensitivity runs with depletion fixed at 0.1, 0.2, … 0.7 in 2010.

Recommendation 4.3.2.2. In future assessments, the distribution of steepness priors should be included in the assessment documents and presentations.

Recommendation 4.3.2.3. The testing of the model outputs for different values of steepness should be conducted on the base case where depletion = 0.1 in the year 2000.

Initial recruitment. The initial recruitment ($\ln R_0$) is the only estimated parameter in the assessment. Initial values of 12 and 2 were explored. The model run time was shorter with $\ln R_0$=2, and consequently the Data Workshop group recommended the use of $\ln R_0$=2.

Depletion. As there are no length-composition or age-composition data available, it is necessary to assume the stock status (a depletion value) in a particular year. In the base case assessment, the DW group recommended a depletion of 0.1, with a beta standard deviation = 0.2, in the year 2000. The year 2000 was selected because it is the start of the period of very reduced catches and as such it is considered to be the time when the stock was most depleted. In support of this, the preliminary assessment of Great Hammerhead suggests a depletion of 0.1 in 2000. Other sensitivity depletions of 0.2, 0.3, 0.5, and 0.7 were explored. In addition, depletion values of 0.1, 0.2, … 0.7 in 2005, 2010 were explored.

The assessment in SSS is valuable as a starting point for a more comprehensive assessment in the future when more data become available. I commend the use of SSS as an assessment tool for this data limited fishery.

4.3.3. Smooth Hammerhead. *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.

There is little information to determine if there is a single stock or two separate stocks in the Gulf of Mexico and the Atlantic. This is a pelagic species, not caught by bottom dropline, and it is considered possible that it moves between the Gulf of Mexico and the Atlantic. The choice of a single stock area for the assessment is sensible and pragmatic, considering the limited data available.

There are 23 input parameters in the assessment model and of these only two, natural mortality and steepness, have non-zero standard deviations. Even though the parameter values are taken from other fisheries, they should have published standard deviations.

Recommendation 4.3.3.1. In future assessment, the standard deviations for the parameters should be included.

Recommendation 4.3.3.2. A sensitivity analysis, varying the CV in length-at-age (young then old) should be conducted in future assessments.

There are limited choices when deciding a suitable assessment method for this species. Simple Stock Synthesis has the advantage over other choices in that it easily accommodates new data.

In a “proof of concept” assessment run, the length-composition data from 2016 to 2019 were pooled and incorporated as a length-composition sample in 2016 and also 2019. This meant that the allocation of a value of depletion in the year 2000 could be dispensed with. The model converged and the assessment

results were not greatly different to the base case assessment. This exercise demonstrated the collection of length-composition data would be a valuable and worthwhile activity. The estimate of biomass in 2019 was lower than that for the base case assessment, suggesting that the depletion value 0.1 in the year 2000 could possibly be lower.

Recommendation 4.3.3.3. The collection of length-composition data and incorporation into the assessment model should be a high priority.

Recommendation 4.3.3.3. If a length-composition sample is not available, a depletion value of less than 0.1 in the year 2000 should be investigated.

4.3.4. Smooth Hammerhead. *TOR 4. Evaluate the provisional assessment findings and consider the following:*

Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
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?

Biomass and exploitation estimates were readily determined by the SSS assessment model using standard procedures that have been well tested in other assessments. The estimates had confidence intervals which were probably too narrow due to the stand deviation of most of the priors being zero.

Many sensitivity analyses were conducted, most with different values of depletion applied in different years. The model gave results in the same ballpark with large confidence intervals. With the limited data available, the results are acceptable.

For this data-limited assessment a value of depletion in a particular year needs to be set as a fixed value in the assessment. This fixed input value represents the prior belief on the status of the stock in a given year, measured as stock depletion. Thus, it cannot be determined if the stock is overfished in the terminal year with the data currently available.

As the stock is data limited, the way forward, in regard to stock status, is to determine an Overfishing Limit (OFL) in the year 2021.

4.3.5. Smooth Hammerhead. *TOR 5. Evaluate the stock projection methods, including discussing strengths and weaknesses, and consider the following:*

Are the methods consistent with accepted practices and available data?
Are the methods appropriate for the assessment model and outputs?
Are the provisional results informative and robust, and useful to support inferences of probable future conditions?
Are key uncertainties acknowledged, discussed, and reflected in the provisional projection results?

This fishery is data-limited and using SSS it is possible to perform a projection to the terminal year plus one. Longer term projections are not possible. The methods used to determine stock status are appropriate given the limited data available and are consistent with accepted practices.

The overfishing limit (OFL) is the best estimate of the maximum amount of a stock that can be caught in a year without resulting in overfishing. Using this assessment model, an OFL can be calculated for the terminal year plus one, that is 2021.

As this assessment requires an input value of depletion in a particular year, which is a proxy stock status, it cannot be determined if the stock is overfished.

The median of OFL_{2021} for the base case assessment run was 71.208 (CV=2.45). The assessment team commented that the total catch in the terminal year 2021, 4.4 mt, was much less than this and thus over-fishing is most likely not occurring. There is no reporting of the confidence intervals for OFL_{2021}, which would have been valuable to support the suggestion regarding overfishing.

For the sensitivity runs, using depletion values of 0.2, 0.3, 0.5, and 0.7 in the year 2000, the estimates of OFL_{2021} were much larger than 71.208.

The assessment falls under tier 3 of the ABC (Acceptable Biological Catch) control rule and as such, two approaches were used to calculate ABC from OFL.

1. ABC = 30th percentile of OFL = 50.178
2. ABC = OFL x 0.647 = 46.072 where 0.647 is an adjustment for tier 3 stocks with the acceptable risk of overfishing being 0.3. (see Courtney and Rice, 2023)

The ABC results with both methods were very similar. The results overall are informative and support the view of the assessment group that the current catch is acceptable.

The uncertainties in the assessment were probably under-estimated for several reasons. The biological parameters of growth, maturity at length, fecundity at length, and weight-at-length all had priors with standard deviations equal to zero. The parameters were borrowed from results in other fisheries, but I am sure there are values for the standard deviations that could have been used. This was mentioned at the Review meeting, but, unfortunately, extra model runs were not possible.

There is considerable uncertainty in the values of OFL due to the choice for the fixed value of depletion and the year it was applied. This was extensively investigated by varying the depletion value from the base case of 0.1 in the year 2000 to values of 0.2, 0.3, 0.5, and 0.7 in years 1990, 2010, 2020. Given that the model takes 10 hours to run, I believe many of these scenarios were not realistic options and a smaller number of combinations would have satisfied the reviewers.

The uncertainty of the results to different values of natural mortality was discussed but a sensitivity run with a different value of *M* was not possible, but this could be considered in the future.

The Assessment team did a sensitivity run with a lowered value of steepness, but I believe it should have been run for the base case assessment of depletion of 0.1 in the year 2000. Unfortunately, this could not be done during the Review Meeting but could be considered in the future.

An extremely useful exercise was the two model runs using pooled length-composition data, applied in 2016 and 2020. Using these data, it is not necessary to have a fixed depletion value in the assessment. The results of these model runs were used as a demonstration that with one year of length-composition data, the model converged and gave results in the same ballpark as the base case assessment. This is a valuable result, demonstrating the value of collecting length data for this species for future assessments.

The choice of SSS for the assessment is appropriate given the available data and I believe the assessment results are reliable and gave valuable results on the status of the stock and the sustainability of the current level of catch in the future.

Recommendation 4.3.5.1. In future assessments the confidence intervals for the OFL should be reported.
Recommendation 4.3.5.1. If an assumed depletion level is required, a value <0.1 in the year 2000 should be investigated.
Recommendation 4.3.5.1. Confidence intervals for ABC should be reported.

4.3.6 Smooth Hammerhead. *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.

The Assessment Workshop made recommendations on the use of super years for use of length-composition data. The use of super years is a great idea for the Smooth Hammerhead assessment as it demonstrates how a single length-composition data set can be used in the assessment. I do not think it is worthwhile extending this concept by developing another super year by pooling data from an earlier set of years. A much better idea is to collect length-composition with a good sample size and incorporate this into the assessment and then a fixed depletion in 2000 is no longer required. This would not be too expensive and should reap immediate benefits.

The following sensitivity runs would be valuable in future assessments.

- Different values of natural mortality for all three species.
- Natural mortality invariant over ages.
- Steepness of the stock-recruitment relationship with a lower value, say h=0.5.

The way the catch data are altered before incorporation in the assessment needs careful consideration. The present method of removing peaks in the data series needs attention for the next assessment.

The development of a relative abundance index for this species would be extremely valuable. The most affordable option is the development of the logbook data at Maryland University, which I believe is the best option.

The development of biological information on Smooth Hammerheads in this fishery will, I expect, be difficult, but the feasibility should be investigated. Part of this could be investigation of reproductive timing.

There was no mention, at the Review meeting, of changes in spatial abundance of this species due to changes in water temperature. Environmental considerations should be left to future assessments.

4.4 Terms of reference for Great Hammerhead, Scalloped Hammerhead, and Smooth Hammerhead sharks.

4.4.1. All three stocks. *TOR 7. Provide recommendations on possible ways to improve the Research Track Assessment process.*

The assessment process for Great Hammerhead, Scalloped (and Carolina) Hammerhead and Smooth Hammerhead sharks was very thorough and well organized. In the assessment of all three stocks, I liked the approach of thoroughly examining the data inputs at the Data Workshop meetings and making recommendations to the Assessment Team on what data to include in the assessment. In all three stocks, the assessment models used all of the recommended data, an approach which I believe has great merit.

4.4.2. Three species. *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.*

Due to the meeting in Panama City being cancelled after one day, no Review Workshop Summary Report was prepared.

APPENDIX 1: MATERIALS PROVIDED OR REFERENCED DURING THE STOCK ASSESSMENT PEER REVIEW MEETING.

Documents Prepared for SEDAR 77 Stock ID process.

SEDAR77-SID01. Regional movements of great, *Sphyrna mokarran*, and scalloped, *Sphyrna lewini*, hammerhead sharks in the US Atlantic, Gulf of Mexico and the Bahamas: preliminary results. Vital Heim, Dean Grubbs, Bryan Frazier, Matthew J. Smukall, Tristan L. Guttridge. Received 6/28/2021.

SEDAR77-SID02. Catches of Hammerhead Sharks from the Congressional Supplemental Sampling Program (CSSP) in the Northern Gulf of Mexico. Adam G. Pollack and David S. Hanisko. Received 6/29/2021.

SEDAR77-SID03. Supplementary Material: Regional movements of great, *Sphyrna mokarran*, 1 and scalloped, *Sphyrna lewini*, hammerhead sharks in the US Atlantic, Gulf 2 of Mexico and the Bahamas: preliminary results Vital Heim, Dean Grubbs, Bryan Frazier, Matthew J. Smukall, Tristan L. Guttridge. Received 6/29/2021.

SEDAR77-SID04. Tag and recapture data for Great Hammerhead, *Sphyrna mokarran*, and Scalloped Hammerhead, *Sphyrna lewini*, sharks caught in the western Gulf of Mexico from 2014- 2021. Kesley G. Banks, and Gregory W. Stunz. Received 7/2/2021.

SEDAR77-SID05. Residency and movements of juvenile great hammerheads, *Sphyrna mokarran*, in the Tampa Bay area: preliminary results Jayne M. Gardiner, Tonya R. Wiley, Susan K. Lowerre-Barbieri, Kim Bassos-Hull, and Krystan Wilkinson 7/2/2021 Revised: 11/30/2021.

SEDAR77-SID06. Directed Sustainable Fisheries, Inc. A Saltwater Fisheries Consulting Company: Some Large Hammerhead shark information based on shark fin business knowledge from the mid-1980's through to September 1997 from Rusty Hudson. Rusty Hudson. Received 7/5/2021.

SEDAR77-SID07. Report on spatial movements of great and scalloped hammerhead sharks in the US Atlantic and Gulf of Mexico using Satellite tags Neil Hammerschlag. Received 7/14/2021. Revised: 9/8/21.

Documents Prepared for SEDAR 77 Data process.

SEDAR77-DW01. Hammerhead Shark Catches from Bottom Longline and Pelagic Longline Surveys conducted by Mississippi Laboratories Adam G. Pollack and David S. Hanisko. Received 9/7/2021.

SEDAR77-DW02. Report on spatial movements of great and scalloped hammerhead sharks in the US Atlantic and Gulf of Mexico using Satellite tags Neil Hammerschlag. Received 9/8/2021.

SEDAR77-DW03. Morphometric conversions for great hammerhead *Sphyrna mokarran* and scalloped hammerhead *Sphyrna lewini* from the western North Atlantic Ocean and Gulf of Mexico Lisa J. Natanson, Camilla T. McCandless William B. Driggers III, Eric R. Hoffmayer, Bryan S. Frazier, Carolyn N. Belcher, James Gelsleichter, Michelle S. Passerotti. Received 11/8/2021.

SEDAR77-DW04. Preliminary catches of hammerhead sharks in the U.S. Atlantic, Gulf of Mexico, and Caribbean Enric Cortes. Received 11/28/2021.

SEDAR77-DW05. Hammerhead Shark (Sphyrna spp.) Electronic Monitoring Data Review from the Gulf of Mexico Bottom Longline Reef Fish Fishery Max Lee, B.S., Genevieve Patrick, M.S., Carole Neidig, M.S., and Ryan Schloesser, Ph.D. Received 11/17/2021.

SEDAR77-DW06. Size distribution and trends in relative abundance of scalloped hammerheads (*Sphyrna lewini*) in the northern Gulf of Mexico, 2006- 2021 M. B. Jargowsky, S. P. Powers, and J. M. Drymon 11/29/2021. Revised: 12/16/21.

SEDAR77-DW07. Post-release mortality and behavior of sharks in shore-based recreational fisheries using citizen scientists and low-cost tags. John A. Mohan , R.J. David Wells, Marcus Drymon, Gregory Stunz, and Matthew Streich. Received 12/16/21.

SEDAR77-DW08. Standardized abundance indices for scalloped hammerhead shark from the Pelagic Longline Observer Program, 1992-2019 John K. Carlson, Sasha Cushner, and Lawrence Beerkircher. Received 11/28/2021.

SEDAR77-DW09. Stress physiology of scalloped and great hammerhead sharks from a bottom longline fishery Bianca K. Prohaska, Heather Marshall, R. Dean Grubbs, Bryan S. Frazier, John J. Morris, Alyssa Andres, Karissa Lear, Robert E Hueter, Bryan A Keller, Nicholas M Whitney. Received 11/29/2021.

SEDAR77-DW10. Stress physiology of scalloped and great hammerhead sharks from a bottom longline fishery: Supplemental Tables Bianca K. Prohaska, Heather Marshall, R. Dean Grubbs, Bryan S. Frazier, John J. Morris, Alyssa Andres, Karissa Lear, Robert E Hueter, Bryan A Keller, Nicholas M Whitney. Received 11/29/2021.

SEDAR77-DW11. Age and growth of the great hammerhead, *Sphyrna mokarran*, in the western North Atlantic Ocean. William B. Driggers III, Christian M. Jones, Kristin M. Hannan, Andrew Piercy, and Bryan S. Frazier. Received 11/29/2021.

SEDAR77-DW12. Standardized abundance indices from scalloped and great hammerhead from the Shark Bottom Longline Observer Program, 1994-2019 John K. Carlson and Alyssa N. Mathers. Received 11/30/2021.

SEDAR77-DW13. Standardized Abundance Indices for Scalloped Hammerhead from the Southeast Coastal Gillnet Fishery John Carlson and Alyssa Mathers. Received 11/30/2021.

SEDAR77-DW14. Standardized Abundance Indices for Great Hammerhead from the Florida State University Longline Survey – with addendum John Carlson and R. Dean Grubbs. Received 11/30/2021. Addendum added: 3/21/2022.

SEDAR77-DW15. Standardized Abundance Index for Great Hammerhead from the Rosenstiel School of Marine and Atmospheric Science Drumline Survey John Carlson, Neil Hammerschlag, and Robert J. Latour. Received 11/30/2021. Revised: 2/9/2022.

SEDAR77-DW16. Relative abundance index for young-of-the-year scalloped hammerhead shark based on a fishery-independent gillnet survey off Texas, 1982-2019. John K. Carlson and Mark Fisher. Received 12/1/2021.

SEDAR77-DW17. Relative abundance index for young-of-the-year scalloped hammerhead shark from the northeastern Gulf of Mexico John K. Carlson, Jill Hendon, Jeremy Higgs, Dana M. Bethea, Bethany Deacy, Heather Moncrief-Cox, and Andrea Kroetz. Received 12/1/2021.

SEDAR77-DW18. Reproductive parameters of great hammerhead sharks (*Sphyrna mokarran*) and scalloped hammerhead sharks (*Sphyrna lewini*) from the western North Atlantic Ocean Heather E. Moncrief-Cox, Kristin M. Hannan, Michelle S. Passerotti, William B. Driggers III and Bryan S. Frazier. Received 12/1/2021

SEDAR77-DW19. Age and growth of scalloped (*Sphyrna lewini*) and Carolina (Sphyrna gilberti) hammerheads in the western North Atlantic Ocean Bryan S. Frazier, Ashley S. Galloway, Lisa J. Natanson, Andrew N. Piercy, and William B. Driggers III. Received 12/2/2021.

SEDAR77-DW20. Bycatch estimates of scalloped and great hammerhead shark in the shark bottom longline fishery John Carlson, Alyssa Mathers, Heather Moncrief-Cox, Kevin McCarthy. Received 12/8/2021.

SEDAR77-DW21. Bycatch Estimates of Scalloped and Great Hammerhead Shark in the Southeast Coastal Gillnet Fishery John Carlson, Alyssa Mathers, and Kevin McCarthy. Received 12/8/2021.

SEDAR77-DW22. Report on the post-release mortality rates of great hammerhead sharks *Sphyrna mokarran* in the recreational, catch and release, shore-based fishery in Florida, USA. Hannah B. Medd and Jill L. Brooks. Received 12/6/2021.

SEDAR77-DW23. Relative abundance of scalloped hammerhead, *Sphyrna lewini*, and Carolina hammerhead, Sphyrna gilberti, along the southern U.S east coast. David S, Portnoy, Amanda M. Barker, and Bryan S. Frazier. Received 12/8/2021.

SEDAR77-DW24. Scalloped and Great Hammerheads Abundance Indices from NMFS Bottom Longline Surveys in the Northern Gulf of Mexico and Western North Atlantic Adam G. Pollack and David S. Hanisko. Received 12/9/2021.

SEDAR77-DW25. Standardized Catch Rates of Great Hammerheads (*Sphyrna mokarran*) Collected During Bottom Longline Surveys In Coastal Waters Of The Northern Gulf Of Mexico, 2006- 2019 Eric Hoffmayer, Adam Pollack, Jill Hendon, Marcus Drymon, and Sean Powers 12/10/21 Revised: 3/17/2022.

SEDAR77-DW26. An Updated Literature Review of Post-Release Live-Discard Mortality Rate Estimates in Sharks for use in SEDAR 77 Dean Courtney, Alyssa Mathers, and Andrea Kroetz. Received 12/13/21.

SEDAR77-DW27. Estimation of scalloped and smooth hammerhead discards in the northeast gillnet fishery using data collected by the NOAA Northeast Fisheries Observer Program Camilla T. McCandless and Joseph J. Mello. Received 1/24/22 Revised: 1/29/2022.

SEDAR77-DW28. Standardized index of abundance for scalloped hammerhead sharks from the NOAA Northeast Fisheries Science Center coastal shark bottom longline survey Camilla T. McCandless and Lisa J. Natanson. Received 1/7/22.

SEDAR77-DW29. Standardized indices of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources red drum and Southeast Area Monitoring and Assessment Program longline surveys Camilla T. McCandless and Bryan S. Frazier 1/7/22

SEDAR77-DW30. Standardized index of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery long-gillnet survey Camilla T. McCandless, Bryan S. Frazier, James Gelsleichter, and Carolyn N. Belcher. Received 1/7/22.

SEDAR77-DW31. Standardized index of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery long-gillnet survey. Camilla T. McCandless and Bryan S. Frazier. Received 1/7/22.

SEDAR77-DW32. Standardized index of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery short-gillnet survey Camilla T. McCandless and Bryan S. Frazier. Received 1/7/22.

SEDAR77-DW33. Standardized index of abundance forscalloped hammerhead sharks from the University of North Carolina shark longline survey south of Shakleford Banks Camilla T. McCandless and Joel Fodrie. Received 1/7/22.

SEDAR77-DW34. Movement and post-release mortality data for great hammerheads, *Sphyrna mokarran*, tagged during research bottom longline surveys in the northern Gulf of Mexico from 2012-2014 Eric R. Hoffmayer, Jill M. Hendon, Jennifer A. McKinney, Brett Falterman, William B. Driggers III. Received 12/16/21.

SEDAR77-DW35. Hammerhead post-release mortality data summary for SEDAR N.M. Whitney, K.O. Lear, H.M. Marshall, J. Morris, A.M. Andres, C.F. White, T. Driggers, B. Prohaska, J. Gelsleichter, B. Frazier, R.D. Grubbs. Received 12/17/2021.

SEDAR77-DW36. Report on post-release mortality of scalloped hammerhead, *Sphyrna lewini*, and great hammerhead, *Sphyrna mokarran.* Jayne M. Gardiner, Tonya R. Wiley, Jorge Brenner. Received 1/24/2022.

SEDAR77-DW37. Revised bycatch estimates of scalloped and great hammerhead shark in the shark bottom longline fishery Xinsheng Zhang, John Carlson, Enric Cortés, Elizabeth Babcock, Robert Latour. Received 1/31/22.

SEDAR77-DW38. Revised Bycatch Estimates of Scalloped and Great Hammerhead Shark in the Southeast Coastal Gillnet Fishery Xinsheng Zhang, John Carlson, Enric Cortés, Elizabeth Babcock, Robert Latour. Received 1/31/22.

Documents Prepared for SEDAR 77 Assessment process.

SEDAR77-AW01. Exploratory analysis of U.S Atlantic and Gulf of Mexico scalloped hammerhead recruitment indices Henning Winker. Received 5/27/2022.

SEDAR77-AW02. Hierarchical analyses of U.S. Atlantic and Gulf of Mexico scalloped hammerhead recruitment indices Camilla T. McCandless and John K. Carlson. Received 5/31/2022.

SEDAR77-AW03. Cami Not Recieved

SEDAR77-AW04. 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. Enric Cortés. Received 6/17/2022.

SEDAR77-AW05. Reconciling age-0 indices of relative abundance of the U.S. Atlantic and Gulf of Mexico scalloped hammerhead (*Sphyrna lewini*). Dean Courtney, Robert J. Latour, and Cassidy D. Peterson. Received 6/20/2022.

SEDAR77-AW06. Fishpath Questions. Enric Cortes. Received 9/21/2022.

SEDAR77-AW07. Selected FishPath Results for Smooth hammerhead shark, U.S. Atlantic, and Gulf of Mexico Enric Cortes. Received 9/21/2022.

SEDAR77-AW08. Selected FishPath Results for Smooth hammerhead shark, U.S. Atlantic, and Gulf of Mexico: Enric Cortes. Received 9/21/2022.

Documents Prepared for SEDAR 77 Review process.

SEDAR77-RW01. SEDAR 77 Hammerhead Sharks Data Workshop Final Report. April 2022

SEDAR 77-SAR1. Hammerhead Sharks: Great Hammerhead Shark Assessment Report. June 2023

SEDAR 77 –SAR2. Hammerhead Sharks: Scalloped Hammerhead Shark Assessment Report. June 2023

SEDAR 77- SAR3. HMS Hammerhead Sharks: Smooth Hammerhead Shark Assessment Report. June 2023

Reference Documents

SEDAR77-RD01. Movement, Behaviour, and Habitat Use of a Marine Apex Predator, the Scalloped Hammerhead R. J. David Wells, Thomas C. TinHan, Michael A. Dance, J. Marcus Drymon, Brett, Falterman, Matthew J. Ajemian, Gregory W. Stunz, John A. Mohan, Eric R. Hoffmayer, William B. Driggers III and Jennifer A. McKinney. Received 5/27/2021.

SEDAR77-RD02. First Verified Record of the Smooth Hammerhead (Sphyrna zygaena) in Coastal Waters of the Northern Gulf of Mexico with a Review of their Occurrence in the Western North Atlantic Ocean Bethany M. Deacy, Heather E. Moncrief-Cox, and John K. Carlson. Received 5/27/2021.

SEDAR77-RD03. Use of marine protected areas and exclusive economic zones in the subtropical western North Atlantic Ocean by large highly mobile sharks Fiona Graham, Patrick Rynne, Maria Estevanez, Jiangang Luo, Jerald S. Ault and Neil Hammerschlag. Received 5/27/2021.

SEDAR77-RD04. Overlap between highly suitable habitats and longline gear management areas reveals vulnerable and protected regions for highly migratory sharks Hannah Calich, Maria Estevanez, Neil Hammerschlag. Received 5/27/2021.

SEDAR77-RD05. Regional-scale variability in the movement ecology of marine fishes revealed by an integrative acoustic tracking network. Claudia Friess, Susan K. Lowerre-Barbieri, Gregg R. Poulakis, Neil Hammerschlag, Jayne M. Gardiner, Andrea M. Kroetz, Kim Bassos-Hull, Joel Bickford, Erin C. Bohaboy, Robert D. Ellis, Hayden Menendez, William F. Patterson III, Melissa E. Price, Jennifer S. Rehage, Colin P. Shea, Matthew J. Smukall, Sarah Walters Burnsed, Krystan A. Wilkinson, Joy Young, Angela B. Collins, Breanna C. DeGroot, Cheston T. Peterson, Caleb Purtlebaugh, Michael Randall, Rachel M. Scharer, Ryan W. Schloesser, Tonya R. Wiley, Gina A. Alvarez, Andy J. Danylchuk, Adam G. Fox, R. Dean Grubbs, Ashley Hill, James V. Locascio, Patrick M. O'Donnell, Gregory B. Skomal, Fred G. Whoriskey, Lucas P. Griffin. Received 5/27/2021.

SEDAR77-RD06. Restricted connectivity and population genetic fragility in a globally endangered Hammerhead Shark Danillo Pinhal, Rodrigo R. Domingues, Christine C. Bruels, Bruno L. S. Ferrette, Otto B. F. Gadig, Mahmood S. Shivji, Cesar Martins. Received 5/27/2021.

SEDAR77-RD07. Tracking the Fin Trade: Genetic Stock Identification in western Atlantic scalloped hammerhead sharks *Sphyrna lewini*. Demian D. Chapman, Danillo Pinhal, Mahmood S. Shivji. Received 5/27/2021.

SEDAR77-RD08. Seasonal Movements and Habitat Use of Juvenile Smooth Hammerhead Sharks in the Western North Atlantic Ocean and Significance for Management Ryan K. Logan, Jeremy J. Vaudo, Lara L. Sousa, Mark Sampson, Bradley M. Wetherbee and Mahmood S. Shivji. Received 5/27/2021.

SEDAR77-RD09. The complete mitochondrial genome of the endangered great hammerhead shark, *Sphyrna mokarran* Cassandra L. Ruck, Nicholas Marra, Mahmood S. Shivji & Michael J. Stanhope. Received 6/18/2021.

SEDAR77-RD10. New insights into the migration patterns of the scalloped hammerhead shark *Sphyrna lewini* based on vertebral microchemistry. Claire Coiraton, Felipe Amezcua, James T. Ketchum. Received 6/18/2021.

SEDAR77-RD11. Global Phylogeography with Mixed-Marker Analysis Reveals Male-Mediated Dispersal in the Endangered Scalloped Hammerhead Shark (*Sphyrna lewini*) Toby S. Daly-Engel, Kanesa D. Seraphin, Kim N. Holland, John P. Coffey, Holly A. Nance, Robert J. Toonen, Brian W. Bowen. Received 6/18/2021.

SEDAR77-RD12. Species composition of the largest shark fin retail-market in mainland China Diego Cardeños, Andrew T. Fields, Elizabeth A. Babcock, Stanley K. H. Shea, Kevin A. Feldheim & Demian D. Chapman. Received 6/18/2021.

SEDAR77-RD13. Identification of young-of-the-year great hammerhead shark *Sphyrna mokarran* in northern Florida and South Carolina A. M. Barker, B. S. Frazier, D. M. Bethea, J. R. Gold and D. S. Portnoy. Received 6/18/2021.

SEDAR77-RD14. Sphyrna gilberti sp. nov., a new hammerhead shark (Carcharhiniformes, Sphyrnidae) from the western Atlantic Ocean Joseph M. Quattro, William B. Driggers Iii, James M. Grady, Glenn F. Ulrich & Mark A. Roberts 6/18/2021.

SEDAR77-RD15. Genetic evidence of cryptic speciation within hammerhead sharks (Genus Sphyrna) J. M. Quattro, D. S. Stoner, W. B. Driggers C. A. Anderson, K. A. Priede, E. C. Hoppmann N. H. Campbell, K. M. Duncan, J. M. Grady. Received 6/18/2021.

SEDAR77-RD16. Philopatry and Regional Connectivity of the Great Hammerhead Shark, *Sphyrna mokarran* in the U.S. and Bahamas Tristan L. Guttridge, Maurits P. M. Van Zinnicq Bergmann, Chris Bolte, Lucy A. Howey, Jean S. Finger, Steven T. Kessel, Jill L. Brooks, William Winram, Mark E. Bond, Lance K. B. Jordan, Rachael C. Cashman, Emily R. Tolentino, R. Dean Grubbs, and Samuel H. Gruber. Received 6/18/2021.

SEDARE77-RD17. Potential distribution of critically endangered hammerhead sharks and overlap with the small-scale fishing fleet in the southern Gulf of Mexico Mercedes Yamily Chi Chan, Oscar SosaNishizaki,Juan Carlos Pérez-Jiménez. Received 6/23/2021. Revised: 6/29/2021.

SEDAR77-RD18. Complete mitogenome sequences of smooth hammerhead sharks, Sphyrna zygaena, from the eastern and western Atlantic. Derek S. Guy, Cassandra L. Ruck, Jose V. Lopez & Mahmood S. Shivji. Received 6/18/2021.

SEDAR77-RD19. Cryptic hammerhead shark lineage occurrence in the western South Atlantic revealed by DNA analysis D. Pinhal, M. S. Shivji, M. Vallinoto, D. D. Chapman, O. B. F. Gadig, C. Martins. Received 6/18/2021.

SEDAR77-RD20. Double tagging clarifies post-release fate of great hammerheads (*Sphyrna mokarran*) J. Marcus Drymon and R. J. David Wells. Received 6/22/2021.

SEDAR77-RD21. Defining Sex-Specific Habitat Suitability for a Northern Gulf of Mexico Shark Assemblage J. M. Drymon, S. Dedman, J. T. Froeschke, E. A. Seubert, A. E. Jefferson, A. M. Kroetz, J. F. Mareska and S. P. Powers. Received 6/22/2021.

SEDAR77-RD22. Distribution and relative abundance of scalloped (*Sphyrna lewini*) and Carolina (S. gilberti) hammerheads in the western North Atlantic Ocean Amanda M. Barker Bryan S. Frazier, Douglas H. Adams, Christine N. Bedore, Carolyn N. Belcher, William B. Driggers III, Ashley S. Galloway, James Gelsleichter, R. Dean Grubbs, Eric A. Reyier, David S. Portnoy. Received 6/23/2021.

SEDAR77-RD23. Distributions and Movements of Atlantic Shark Species: A 52-Year Retrospective Atlas of Mark and Recapture Data Nancy E. Kohler And Patricia A. Turner. Received 7/6/2021.

SEDAR77-RD24. First identification of probable nursery habitat for critically endangered great hammerhead *Sphyrna mokarran* on the Atlantic Coast of the United States Catherine Macdonald, Jacob Jerome, Christian Pankow, Nicholas Perni, Kristina Black, David Shiffman, Julia Wester. Received 7/12/2021.

SEDAR77-RD25. Characterization of a scalloped hammerhead (*Sphyrna lewini*) nursery habitat in portions of the Atlantic Intracoastal Waterway Bryanna N. Wargat. Received 7/15/2021.

SEDAR77-RD26. Age and growth of the great hammerhead shark, *Sphyrna mokarran*, in the north-western Atlantic Ocean and Gulf of Mexico Andrew N. Piercy, John K. Carlson and Michelle S. Passerotti 9/8/2021

SEDAR77-RD27. Status Review Report: Great Hammerhead Shark (*Sphyrna mokarran*) Margaret Miller, John Carlson, LeAnn Hogan, and Donald Kobayashi. Received 9/8/2021.

SEDAR77-RD28. Hammerhead Sharks of the Northwest Atlantic and Gulf of Mexico (2014 – 2020) Lisa Clarke, Librarian, NOAA Central Library. Received 9/8/2021.

SEDAR77-RD29. Age validation of great hammerhead shark (*Sphyrna mokarran*), determined by bomb radiocarbon analysis Michelle S. Passerotti John K. Carlson Andrew N. Piercy Steven E. Campana. Received 9/8/2021.

SEDAR77-RD30. Age and growth of the smooth hammerhead, Sphyrna zygaena, in the Atlantic Ocean: comparison with other hammerhead species Daniela Rosa, Rui Coelho, Joana Fernandez-Carvalho & Miguel N. Santos. Received 9/8/2021.

SEDAR77-RD31. Status Review Report: Scalloped Hammerhead Shark (*Sphyrna lewini*) Margaret H. Miller, Dr. John Carlson, Peter Cooper, Dr. Donald Kobayashi, Marta Nammack, and Jackie Wilson. Received 9/8/2021.

SEDAR77-RD32. Age and growth of the scalloped hammerhead shark, *Sphyrna lewini*, in the north-west Atlantic Ocean and Gulf of Mexico Andrew N. Piercy, John K. Carlson, James A. Sulikowski and George H. Burgess. Received 9/8/2021

SEDAR77-RD33. Scalloped hammerhead shark (*Sphyrna lewini*) 2014-2019 Trevor Riley, Head of Public Services, NOAA Central Library. Received 9/8/2021

SEDAR77-RD34. The biology and conservation status of the large hammerhead shark complex: the great, scalloped, and smooth hammerheads Austin J. Gallagher and A. Peter Klimley. Received 9/8/2021

SEDAR77-RD35. Hooking mortality of scalloped hammerhead *Sphyrna lewini* and great hammerhead *Sphyrna mokarran* sharks caught on bottom longlines SJB Gulak, AJ de Ron Santiago & JK Carlson. Received 9/8/2021.

SEDAR77-RD36. ENDANGERED SPECIES ACT STATUS REVIEW REPORT Smooth Hammerhead Shark (Sphyrna zygaena) M.H. Miller. Received 9/8/2021.

SEDAR77-RD37. Scalloped Hammerhead Shark (*Sphyrna lewini*) 5-Year Review: Summary and Evaluation National Marine Fisheries Service Office of Protected Resources Silver Spring, MD. Received 9/8/2021.

SEDAR77-RD38. Periodicity of the growth-band formation in vertebrae of juvenile scalloped hammerhead shark *Sphyrna lewini* from the Mexican Pacific Ocean C. Coiraton,| J. Tovar Ávila, K. C. Garcés García, J. A. Rodríguez Madrigal, R. Gallegos Camacho, D. A. Chávez Arrenquín, F. Amezcua. Received 9/8/2021.

SEDAR77-RD39. Range extension of the Endangered great hammerhead shark *Sphyrna mokarran* in the Northwest Atlantic: preliminary data and significance for conservation Neil Hammerschlag, Austin J. Gallagher, Dominique M. Lazarre, and Curt Slonim. Received 9/8/2021.

SEDAR77-RD40. Identification of a nursery area for the critically endangered hammerhead shark (*Sphyrna lewini*) amid intense fisheries in the southern Gulf of Mexico Gabriela Alejandra Cuevas-Gómez, Juan Carlos Pérez-Jiménez, Iván Méndez-Loeza, Maribel Carrera Fernández, and José Leonardo Castillo-Géniz. Received 9/8/2021.

SEDAR77-RD41. SEDAR65-RD20 - An Updated Literature Review of Post-release Live-discard Mortality Rate Estimates in Sharks for use in SEDAR 65 Dean Courtney and Alyssa Mathers. Received 9/23/2021.

SEDAR77-RD42. Physiological stress response, reflex impairment, and survival of five sympatric shark species following experimental capture and release A. J. Gallagher, J. E. Serafy, S. J. Cooke, N. Hammerschlag. Received 9/23/2021.

SEDAR77-RD43. Integrating reflexes with physiological measures to evaluate coastal shark stress response to capture J. M. Jerome, A. J. Gallagher, S.J. Cooke, and N. Hammerschlag. Received 9/23/2021

SEDAR77-RD44. SEDAR29-WP17- A preliminary review of post-release live-discard mortality estimates for sharks. Dean Courtney. Received 12/14/21.

SEDAR77-RD45. SEDAR34-WP08- A preliminary review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 34 Dean Courtney. Received 12/14/21.

SEDAR77-RD46. SEDAR39-DW21 - A preliminary review of post-release live-discard mortality rate estimates in sharks for use in SEDAR 39. Dean Courtney. Received 12/14/21.

SEDAR77-RD47. Updated Post-release Live-discard Mortality Rate and Range of Uncertainty Developed for Blacktip Sharks Captured in Hook and Line Recreational Fisheries for use in the SEDAR 29-Update Dean Courtney. Received 12/14/2021.

SEDAR77-RD48. Meta-analysis of post-release fishing mortality in apex predatory pelagic sharks and white marlin Michael K. Musyl and Eric L. Gilman. Received 1/31/2022.

SEDAR77-RD49. Stock Assessment of Scalloped Hammerheads in the Western North Atlantic Ocean and Gulf of Mexico Christopher G. Hayes, Yan Jiao, and Enric Corte. Received s 11/30/2020.

SEDAR77-RD50. Poor-data and data-poor species stock assessment using a Bayesian hierarchical approach Yan Jiao, Enric Corte´s, Kate Andrews, And Feng Guo. Received 11/30/2020.

SEDAR77-RD51. Hierarchical Bayesian approach for population dynamics modelling of fish complexes without species specific data Yan Jiao, Christopher Hayes, and Enric Cortes. Received 11/30/2020.

SEDAR77-RD52. Highly migratory species predictive spatial modeling (PRiSM): an analytical framework for assessing the performance of spatial fisheries management Daniel P. Crear, Tobey H. Curtis, Stephen J. Durkee, John K. Carlson. Received 5/26/2022.

SEDAR77-RD53. Dynamic factor analysis to reconcile conflicting survey indices of abundance Cassidy D. Peterson, Michael J. Wilberg, Enric Corte´s, and Robert J. Latour. Received 5/26/2022.

SEDAR77-RD54. SEDAR 65 - AW03: Reconciling indices of relative abundance of the Atlantic blacktip shark (Carcharhinus limbatus) RobertJ. Latour and Cassidy D. Peterson. Received 5/31/2022.

SEDAR 77-RD55. Final Amendment 14 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan NOAA fisheries: Highly Migratory Species. Received 4/18/2023.

SEDAR77-RD56. 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 Dean Courtney and Joel Rice. Received 7/25/23.

APPENDIX 2

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

Under Contract #1305M219DNFFK0025

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

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

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 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
150 Du Rhu Drive, Mobile, AL 36608
(386) 561-7080
larry.massey@noaa.gov

Kathleen Howington - SEDAR Coordinator
Science and Statistics Program
South Atlantic Fishery Management Council
4055 Faber Place Drive, Suite 201 North Charleston, SC 29405
Kathleen.howington@safmc.net

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:
    d. Are data decisions made by the DW and AW justified?
    e. Are data uncertainties acknowledged, reported, and within normal or expected levels?
    f. Is the appropriate model applied properly to the available data?
    g. 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 **Coordinator**

- Agenda Review, TOR, Task Assignments

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**	**Chair**
	- Assessment Data & Methods	
	- Identify additional analyses, sensitivities, corrections	
	- Review additional analyses	
	Take Breaks as needed	
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**	**Chair**
	- Review additional analyses, sensitivities	
	- Consensus recommendations and comments	
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**	**Chair**
	- Final sensitivities reviewed.	
	- Projections reviewed.	
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 **Chair**

- Review Consensus Reports

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

Revised Agenda SEDAR 77 Atlantic Hammerhead Sharks Assessment Review

Panama City, FL August 28 2023

Monday August 28

***9:00 a.m.-9:30 a.m*. Introductions and Opening Remarks**

Coordinator

- *Agenda Review, TOR, Task Assignments*

***9:30 a.m. - 11:30 a.m*.**	**Assessment Presentation Great Hammerhead**	**Xinsheng Zhang**
11:30 a.m. - 1:00 p.m.	**Lunch Break**	
1:00 p.m. – 6 p.m.	**Assessment Presentation Great Hammerhead**	**Xinsheng Zhang**

***6:45 p.m. - 10:30 p.m*.** **Assessment Presentations Great/ Scalloped Hammerhead** **Dean Courtney**

SEDAR 77 Atlantic Hammerhead Sharks Assessment Review
Webcam November 13, 2023

Monday November 12. Times are USA EST

***12:05 p.m. - 12:20 p.m*.**	**Introductions and Opening Remarks**	**Julie Neer**
***12:20 p.m. - 5:05 a.m*.**	**Assessment Presentation Scalloped Hammerhead**	**Xinsheng Zhang**
***5:05 p.m. - 5:15 p.m*.**	**Concluding Remarks**	**Julie Neer**

APPENDIX 3 LIST OF PARTICIPANTS

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

Appointed Observers

Fly Navarro

Staff

Kathleen Howington	SEDAR
Michele Ritter	SAFMC Staff

Workshop Observers

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. November 13, 2023

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

Julie A Neer	SEDAR

Observers

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