Independent Peer Review of SEDAR 77: HMS Atlantic Hammerhead Sharks Review Workshop

Panama City, Florida
28th August 2023

Report on SEDAR 77: HMS Atlantic Hammerhead Sharks Review Workshop prepared for the Center of Independent Experts

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1. EXECUTIVE SUMMARY

A review of assessments for Atlantic and Gulf of Mexico Great, Smooth, and Scalloped Hammerhead sharks was held during an in-person workshop and subsequent virtual meeting in August and November 2023 as part of the SEDAR 77 process. Three CIE reviewers participated in the review panel and were present at both the in-person workshop and the virtual meeting. Due to the arrival of Hurricane Idalia onto the coast of Florida on 30 August 2023, the in-person Review Workshop proceedings were shortened and limited to one day (28th August 2023) rather than the scheduled five days.

For all assessments (for each species and stock) the panel briefly reviewed the decisions of the stock identification, the data, and the assessment process workshops. The decisions of the panel are generally supported, and the assessment teams provided a comprehensive summary of the analyses and assessments for each of the three species.

Available data for each species and region differed, but included landings of recreational and commercial catch, estimates of discards, fishery dependent and independent indices of abundance for Great and Scalloped Hammerhead sharks. No indices of abundance were available for Smooth Hammerheads. Species identification issues between Scalloped and Carolina Hammerhead sharks confounded the analyses. For all species, the data were low information, but were likely adequate for the investigation by means of low information quantitative stock assessments.

For Great Hammerheads, the conclusions of the assessment were supported with appropriate models and with exploration of the robustness of the conclusions to a range of sensitivities. For Scalloped Hammerheads, time restrictions in the period leading up to the review had not allowed full investigation of the model and more work and sensitivities are required to ensure that the conclusions are robust. For Smooth Hammerhead sharks, biological parameters were assumed from neighbouring regions and there were no indices of abundance. Hence model outputs are only informed by assuming the level of depletion in a year immediately following a large reduction in catch. While highly uncertain, sensitivity analyses suggested that the conclusions of the assessment using this approach was indicative of a stock that had been depleted and was potentially recovering given more recent additional reductions in catch.

Future research is recommended on developing region specific biological parameters for Smooth Hammerhead sharks, resolving the species identification issue between Scalloped and Carolina Hammerhead sharks, and either developing (Smooth Hammerheads) or improving the indices of abundance (Great and Scalloped Hammerheads) used to model the species. The use of SSS (Simple-Stock Synthesis) models to undertake the assessments is recommended where indices of abundance are lacking, noting that JABBA (Bayesian production model) can provide an alternative model structure that can be used to compare with age structured approaches. Future work to refine existing indices of abundance and develop indices for those species without an index is recommended. Where used, the fishery dependent indices may need to be further refined and could be investigated for evidence of "target and avoid behaviour" by fishers, especially as the catch limit for these species has declined significantly in recent years and may have resulted in changes in practise to avoid hammerhead shark capture. The selectivity parameters are not well informed by the available data due to the lack of adequate length composition data and are crucial in interpreting the indices of abundance, but there was little information informing to inform the choice of selectivity functions.

The amount of information available for each assessment was low, and clearly low-information approaches were the most appropriate means to evaluating the status of these species. In all three species assessments, uncertainty in the catch history, indices of abundance, and the biological parameters was high. The models and analyses presented were reasonably robust (within moderate bounds) to alternative plausible choices for the biological parameters, indices of abundance, and biological parameters.

The level of analyses was appropriate for each species within the Atlantic and Gulf of Mexico regions, and the analytical teams had undertaken a large amount of work to both capture the ranges of uncertainty and provide appropriate analyses that took the uncertainties into account. While these were low

information analyses, the assessments were generally of high quality given the information available, and while further work for Scalloped Hammerhead sharks is required, they each represented the best available science.

2. BACKGROUND

The stock assessments for HMS Hammerhead Sharks (Great Hammerhead shark, Smooth Hammerhead shark, and Scalloped Hammerhead shark) were reviewed in SEDAR 77. The Hammerhead Stock identification was considered through a series of stock identification webinars with the final review report in October 2021. The data process was a series of webinars and in-person workshops with the final report in April 2022. The assessment process was a series of webinars with the final review report in June 2023.

The SEDAR 77 Review was held partially in-person at a workshop in Panama City, Florida in August 2023 and at a webinar on 14 November 2023. The proposed agenda for the workshop is given in Appendix 3. However, due to the arrival of Hurricane Idalia on to the coast of Florida on 30 August 2023, the in-person Review Workshop proceedings were limited to one day (28th August 2023) and the opportunity for the review team to request additional analyses and sensitivity models runs was significantly limited. Following the presentations on 28th August, a follow-up webinar was held on 14 November for the remaining presentations and for the review team to ask questions of the presenters.

Great, Smooth, and Scalloped Hammerhead sharks from the Gulf of Mexico and Western North Atlantic Ocean have been previously assessed together within the Large Coastal Shark species complex, which consisted of multiple shark stocks with the number of stocks in the complex changing over time (SEDAR 11 CIE Review). The most recent Assessment Workshop (AW) found that information from various species components within the catch and abundance index data did not support those assessment results for use in management and recommended prioritising research, data analysis, and model development to permit species-specific assessments for the main components of the complex.

The stock assessment of Scalloped Hammerheads in the Western North Atlantic Ocean and Gulf of Mexico was updated and summarised in Hayes et al. (2009). A SEFSC review noted that the assessment of Scalloped Hammerhead sharks could serve as the basis for management and noted the updated assessment included revisions resulting from the recommendations from the SEDAR 11 CIE review, including the use of observer data rather than logbook data and removal of the fishery dependent CPUE time series. That assessment found that the Scalloped Hammerhead shark stocks were likely depleted and consequently, management changes were implemented. The analyses by Jiao et al. (2009) and Jiao et al. (2011) were not reviewed by the SEFSC for use in management.

The stock identification process synthesised available information and determined the most plausible hypotheses of population structure. The recommendations of the stock identification report were based on the review and analysis of life history characteristics, genetics, and archival satellite, SPOT (smart position and temperature) transmitting tags, and conventional tagging data. The review found that the following:

(i) Great Hammerhead sharks: it was not possible to conclude whether regional differences in life history existed. There was no significant genetic differentiation between the Gulf of Mexico and U.S. Atlantic, and the report concluded Great Hammerhead likely comprise a single biological stock.

(ii) Smooth Hammerhead sharks: There was limited data for the stock identification, with no local life history data available and no population genetic studies that could have differentiated between fish caught at different locations. Spatial movements indicated that Smooth Hammerheads could move large distances and hence were assumed to comprise a single biological stock in the U.S. Atlantic Ocean and Gulf of Mexico

(iii) Scalloped Hammerhead sharks: Carolina Hammerhead could not easily be differentiated from Scalloped Hammerhead and the catch represented both species in unknown proportions. There were very limited data on life history and movements but a genetic study of a sample of Carolina and Scalloped Hammerheads suggested that Carolina Hammerhead made up 27% of the fish sampled in the U.S. Atlantic. The analysis found no samples of Carolina Hammerhead in the Gulf of Mexico. Hence it was assumed that Carolina Hammerhead was only found in the U.S. Atlantic and not the Gulf of Mexico. It was not known if there are regional differences in life

history for Scalloped Hammerheads and there was no significant genetic differentiation between the fish caught in the two areas. Hence it was assumed that Scalloped Hammerheads comprise a single biological stock based on observations of movement of individuals between regions. However, two assessment sensitivity runs were attempted, one for the U.S. Atlantic (Scalloped and Carolina Hammerheads combined) and for the Scalloped Hammerhead in the Gulf of Mexico only.

2.1 Great Hammerhead sharks

Data available for the Great Hammerhead sharks included catch (predominantly recreational), six standardised indices of abundance from the Atlantic and Gulf of Mexico (the shark Bottom Longline Observer Program, Shark Research Fishery, FSU Longline, RSMAS Drumline, SEFSC MS Bottom Longline, and the SEAMAP BLL survey), and life history parameters. The CPUE indices were standardised using general linear models for use in the assessment.

The stock assessment was implemented using the Bayesian state-space surplus production model framework JABBA (Winker et al. 2018) with the Pella-Tomlinson production function following explorations with Fox, Schaefer, and Pella-Tomlinson models. Estimated parameters were informed by weakly informative priors, and parameters included r, K, and the abundance in 1981 relative to K (B_{1981}/K or initial depletion at the beginning of the model). In addition, process and observation error variances, the time series of proportions of carrying capacity, and the catchability coefficients for the indices were also estimated.

2.2 Smooth Hammerhead sharks

Data available for Smooth Hammerheads included catch, and life history estimates based on species specific life history parameters from other regions, and a limited number (n=524) of length measurements that were combined into unscaled length compositions. The length compositions were likely unrepresentative of the true length composition of the catch. There are no available indices of abundance. A decision support tool (FishPath, see https://www.fishpath.org, Dowling et al. 2016) was used to identify the most appropriate low information method for the assessment. The FishPath tool was used to aid the process of identifying a short list of viable assessment options. It identified that potential length-based methods could include:

- Length-based Spawning Potential Ratio (LB-SPR)
- Length-based Bayesian Biomass Estimation (LBB)
- Length-Only Integrated Model
- Mean length mortality estimators (Z and F)
- Analysis of sustainability indicators based on length-based reference points (LBRP)

And catch-only methods could include:

- (Refined) Only Reliable Catch Stocks (ORCS)
- Depletion-Corrected Average Catch (DCAC)

And life-history-based methods including:

- Yield-Per-Recruit

The insufficient data of the length compositions precluded the use of most length-based methods including the length based spawning potential ratio method. The Stock Assessment Panel had recommended the use of Simple Stock Synthesis (SSS), which is an application of the Stock Synthesis Data-limited Tool (Cope 2013). This implements a number of data-limited assessment methods in one framework, allowing extension to include additional data sources as they become available. However, SSS requires the strong assumption that the value of depletion in a given year is known without error and must be provided as an input (i.e., as a proxy of overfished stock status), so SSS could not be used to determine if the stock was overfished.

2.3 Scalloped Hammerhead sharks

Data available for the Scalloped Hammerhead shark assessment included commercial catches, recreational catches (including estimates of discard mortality), indices of abundance, life history parameters, and sparse length composition data. However, species identification issues with Carolina Hammerhead sharks made separation of these species in the Atlantic region difficult. Due to the lack of Caroline Hammerheads in samples from the Gulf of Mexico, they were assumed to be absent from that area. Hence assessments were for both species combined when assessing the North Atlantic and were assumed to be for Scalloped Hammerheads only in the Gulf of Mexico assessments.

SS3 (Methot & Wetzel 2013) was used as the analytical approach implemented as a length-based age-structured statistical model. Sensitivity analyses aimed to included uncertainty in catches, but the high and low catch scenarios were not implemented due to time constraints. Other sensitivities included the choice of indices of abundance, selectivity assumptions, and life history parameters.

2.4 Carolina Hammerhead sharks

There was limited life history data for Carolina Hammerhead Sharks, and there was little data from juvenile and adult samples. Therefore, the Life History Working Group had no confidence that model results were representative of Carolina Hammerhead population life history. Carolina Hammerhead sharks were not included within the Review Workshop, except where the data was included within the Scalloped Hammerhead shark assessment, including in sensitivity analysis.

3. REVIEW ACTIVITIES

Prior to the meeting the Review Workshop reports for the assessments were received and reviewed. A list of additional documents was also received and reviewed, including documents made available during the review period (Appendix 1). Immediately before the Review Workshop, a preliminary meeting was held to identify the documents, venue and confirm the travel arrangements. At the Review Workshop meeting, the reviewer participated in the discussions and made requests for additional information. However, the arrival of Hurricane Idalia shortened the workshop to a single day in which most of the presentations were given, and precluded requests for additional sensitivity runs or further model exploration during the workshop. Following the in-person meeting, a webinar was conducted to present the remaining key presentations and for any follow up questions. With the significantly shortened period available for the Review Workshop, it was determined by the Workshop Review Chair (John Carlson) that a summary report combining the key points from each reviewer would not be prepared and that the review would consist only of the individual reviewers' reports. Hence, following the final webinar, this review report was prepared, and was undertaken independently from the other reviewers' reports or a summary review. The statement of work is given in Appendix 2.

4. NMFS REVIEW PROCESS

The review process was carried out according to the standard approach used for SEDAR reviews. However, the shortened period for the in-person workshop did result in a reduced ability to request additional runs or to explore sensitivities for the assessment models that would normally be conducted as a part of the review process. The arrival of Hurricane Idalia was not foreseeable, and it was unfortunate that the predicted path of landfall included the location where the review was being held and at the same time as the review was scheduled.

5. FINDINGS UNDER THE REVIEW WORKSHOP TERMS OF REFERENCE

In this report, the Terms of Reference were evaluated for each of the three hammerhead shark species. In each term of reference, general considerations are listed, and species recommendations are also noted where these apply for each of the Great Hammerhead, Smooth Hammerhead, and Scalloped Hammerhead (including Carolina Hammerhead) shark analyses.

5.1 Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions

The data available for each shark species were limited, and data limited approaches were required for each stock, albeit different model methods were applied for the assessment in each case. The use of integrated methods, where possible was a useful approach taken by the assessment teams, and the methods applied to derive catch histories and life history parameters were appropriate and, where applicable, consistent.

In general, data consisted of landings from the commercial fleet, estimates of recreational catch, length compositions covering some years for Great and Smooth Hammerheads, and fishery independent and fishery dependent indices of abundance. Biological parameter values were obtained external to the stock assessments and, for Smooth and Scalloped Hammerheads, based on the values for these species from other areas. Natural mortality estimates were derived from methods of Then et al. (2018) and Lorenzen (2022) and based on life history characteristics and meta-analyses. Catch and discard mortality were provided by the data process review for each species. Recommendations from the Data Workshop were briefly reviewed at the Review Workshop and supported.

Given the low level of available data, the decisions of the data process review workshop were appropriate, and consideration was given to how the available information may be best used and interpreted. In providing the data to the assessment, the data uncertainties were acknowledged and discussed. Sensitivities were proposed that included sensitivity of the assessment model results to the key elements of the uncertainties of the data and model parameters and assumptions, however, the AW Report noted that a shortage of time precluded the running of high and low catch scenarios for the Scalloped Hammerhead shark assessment. The data process review noted that there were significant differences among von Bertalanffy growth function parameter estimates between the sexes, based on aging derived from vertebrae.

The use of the sources of the information for each species was appropriate given the lack of data, and the input data series, while having low information, supported the approach taken in each case. However, given the similarities (and differences) between the data availability for each species, it would have been useful to have seen how similar methods compared when applied to each stock compared. Comparative tables of the available data, the decisions of where the biological parameters were taken, and the resulting data and parameter choices for each species assessment would also be useful to see presented as summary tables.

For the catch data and the survey indices, uncertainty (CVs) was estimated and assumed for the models. However, given the assumptions for the biological parameters, this may not capture all sources of uncertainty, such as changes in the spatial distribution of fish, the influence of time varying environmental factors or changing locations where the fish have been sampled in any given year. To some extent, such uncertainty was captured in the models and the application of sensitivity analyses within each specie. However, it is likely that the resulting uncertainty of the assessment could be much larger than reported for each assessment.

In general, the recommendations for each stock focus on improving the low amount of information available for each stock. Consideration and future research should ideally include the development of (i) species specific biological parameters for these species within the Atlantic and Gulf of Mexico regions to better inform the assessments, (ii) update and revise the estimates of discard mortality, and (iii) develop methods to generate indices of abundance (with appropriate length data to determine their relative selectivity) to inform estimates of recovery and future status.

The DW report noted that it was not possible to conclude whether regional differences in life history existed for Great Hammerheads, but no significant genetic differentiation between the Gulf of Mexico and U.S. Atlantic populations was found. While there was evidence for large scale movements, alternative stock structure hypotheses could have considerable influence on management and on the estimated stock status, specifically if the Great Hammerhead stocks were regionally specific.

The approach of considering objective criteria for the use of indices of abundance for Great Hammerheads was appropriate and recommended as a general approach to the consideration of such indices. While implicit in the criteria used to evaluate the indices by the analytical team, a measure of spatial-temporal and fleet consistency in the CPUE abundance indices could formally be included to assist the evaluation of their utility as indices of abundance. In addition, as noted by the analysts, the indices of abundance (CPUE) may be representative of different areas and CPUE standardization may not result in independent year-effects due to overfitting and other issues,

The assessment of Smooth Hammerhead sharks was very limited by the low amount of data. The lack of a reliable index of abundance is a key uncertainty for the assessment, and the use of the SSS model would allow inclusion of these data if/when they become available. The development of an index of abundance for Smooth Hammerheads is recommended as a high priority research objective. The DW Report recommended research to evaluate the effect of federal and state management actions, such as size restrictions and bag limits, on CPUE standardization and length composition of recreational catch available for use in stock assessment. Such research is also recommended here as future work. Similarly, collection of additional length data is recommended in order to estimate selectivity ogives.

As there were no biological data for the Smooth Hammerheads from the Atlantic or Gulf of Mexico, biological parameters were inferred from other areas, specifically north of the south west Atlantic region. No information was available to support the idea that the assumed parameter values were unaffected by latitude or some other environmental gradient. It might be useful to investigate whether the assumed biological parameters should be modified to account for latitudinal or other environmental effects

There was strong evidence for sex specific growth differences in Scalloped Hammerheads, and the data DW Report recommended that region and sex-specific growth model parameter estimates and a maximum age of 39.5 years for both regions be used. The growth and maturity estimates for Scalloped Hammerhead were different between the Atlantic and the Gulf of Mexico, although it was not clear if this was related to the misidentification of Scalloped Hammerheads as Carolina Hammerheads (or vice versa) or to regional differences in the growth of Scalloped Hammerheads (Carolina Hammerheads only occurred in the Atlantic region). It was noted that the Carolina Hammerhead data were likely taken from a single location and hence were not considered representative. Given the differences identified, the conclusion of the assessment team to develop separate stock assessments for these regions is supported. However, sensitivity analysis may be useful where the known Carolina data was not excluded from the data to evaluate the effect of this choice.

Difficulty in the species identification for Scalloped and Carolina Hammerheads in the Atlantic showed that work on species identification methods should be continued, and where possible, biological parameters and input data should be split, as much as is possible, for these species in the assessments. Specifically, development of estimates of the catch composition would need to be undertaken, including determining if the relationship varied in a sex- or length-specific manner.

5.2 Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data

The amount of information available for each assessment was low, and clearly low-information approaches were the most appropriate means for evaluating the status of these species. In all three species assessments, uncertainty in the catch history, indices of abundance, and the biological parameters was high. This made the assessments challenging and a large amount of work by the

analytical team was summarised and presented to ensure the conclusions from the assessments were as robust as possible.

The use of the decision support tool (Fishpath, Dowling et al. 2016) to identify the most appropriate low information method was appropriate given the amount of information available. The models and analyses presented were reasonably robust (within moderate bounds) to alternative plausible choices for the biological parameters, indices of abundance, and biological parameters. The recommendations from the assessment workshop were briefly reviewed and supported.

The SS3 (Scalloped Hammerheads), SSS (Smooth Hammerheads), JABBA (Great Hammerheads) models were appropriate for each of these species. However, the application of the JABBA model (using the Pella-Tomlinson production function) and the SSS models could also be applied to Scalloped Hammerheads. The use of 'lower' information stock assessment methods, when there are additional data, could help provide a basis for comparing the results using the 'lowest' information method with those for species with more information. More generally, the SSS approach for all species could be considered as future work, with the extension to SS as the data allow. This would allow comparison of the alternative methods within a single framework.

An area of considerable uncertainty was the estimates of discard mortality. The assumption of the same post release mortality for demersal longlines and gillnets appeared unlikely (although there was little data to suggest otherwise). Similarly, estimates of discard mortality rates using data from experienced fishers may not be adequate across the wider fishery (albeit this was considered a minimum estimate and sensitivity analysed assumed different rates). Future work on improving the estimates of discards (including post-release mortality) from each species and from different capture methods is therefore recommended. Where possible, sensitivity analysis should be conducted to evaluate how these may affect the outcome of the assessment.

In all three stock assessments, the methods were based on best available methods as adapted to the specific circumstances for each region and species. As far as could be ascertained during the review, the assessments appeared to be configured correctly, with the model outputs providing consistent results given the choice of data and parameters used.

The application of the SSS model allowed the available data to be included into the models, and as the data are developed in future, provides a good way to update the assessments when the data become available. The use of SSS models to undertake the assessments is recommended, noting that JABBA (Bayesian production model) can provide an alternative model structure to compare when the data are extremely low information (i.e., for Smooth Hammerhead shark).

The choice of stock recruitment function and parameter (steepness) is critical in determining reference points. For these stocks, there were few independent data to estimate this function. Determining appropriate values for steepness is difficult, especially where there are few data to directly estimate annual recruitment values. While steepness is unlikely to [affect] estimates of current status, it is likely to impact projections.

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

The amount of information available for each species assessment was low, and clearly low-information approaches were the most appropriate means to evaluating the status of these species.

In all three stock assessments, uncertainty in the catch history, indices of abundance, and the biological parameters was high. A substantial number of sensitivity analyses were conducted for the Great and Smooth Hammerhead shark assessments that captured a broad range of uncertainty in the input data and assumptions. Given that there are multiple plausible alternative assumptions, exploring the full range of uncertainty was difficult. However, the models and analyses presented were reasonably robust (within

moderate bounds) to alternative plausible choices for the biological parameters and indices of abundance. The resulting estimates of stock status (albeit within wide bounds) appeared relatively robust to alternative choices of parameters and assumptions.

For Smooth Hammerhead sharks, the assessment was severely data limited. Catch and life history data (derived from analyses from other regions) were available to be used in this stock assessment, but there were no time series data to develop indices of abundance or to inform the population dynamics. This leads to significant uncertainty, and the conclusions of the model relied heavily on the assumed level of stock depletion in a given year. Sensitivity analyses were carried out assuming the relative stock status in different years using different levels of stock depletion, as well as with a lower steepness (*h*). The conclusion that the current catch was lower than the Over Fishing Limit (OFL) in 2021 appeared robust to the assumptions. The level of analyses was appropriate for each species within the Atlantic and Gulf of Mexico regions, and the analytical team had undertaken a large amount of work to both capture the ranges of uncertainty and provide appropriate analyses that took the uncertainties into account. While these were low information analyses, the assessments were of high quality and represented the best available science,

For Scalloped Hammerhead sharks, the SS model included two sexes to account for the different sex-based growth parameters. However, the Assessment Workshop review had recommended several additional sensitivity analyses during the stock identification and assessment processes, including low and high productivity, low and high catch and others such as the use of super years in Stock Synthesis for length composition data sets with low sample size. However, for this stock only two model sensitivity analyses were evaluated while the sensitivity to reproductive output timing was not investigated. The assessment workshop noted the following: "However, regarding sensitivity analyses, while multiple sensitivity analyses were identified, most were not implemented due to time constraints". Model fits to the abundance indices, while following the broad trend, did not appear to reflect the interannual variations in the observations. In addition, some of the indices (COASTPSPAN-BLLS) declined in recent years while others (TXPWD-GN) appear to have increased. Model sensitivities that consider suitable choices of subsets of the indices are recommended to evaluate the uncertainty from the different choices of abundance index. While the combined Atlantic and Gulf of Mexico Scalloped Hammerhead model converged, the separate Atlantic and Gulf of Mexico models that were run as another sensitivity evaluation did not pass convergence criteria tests, and hence diagnostics were not available. Additional work is recommended to investigate these sensitivity models to determine the reason for the failure to converge, and to update the sensitivities with these models if this can be achieved.

5.4 Evaluate the provisional assessment findings

The assessment model estimates appeared to be consistent with the available data and model assumptions for each of the three stocks, albeit that they were estimated with a high level of uncertainty. For both the Smooth and Scalloped Hammerhead sharks, the lack of reliable indices of abundance hinders the interpretation of the assessment results. However, the available data were consistent with the conclusion of each assessment, and the assessments explored a range of parameter estimates to evaluate the uncertainty. While there is future work to improve the assessments identified in the review, the underlying conclusions of the Great and Smooth Hammerhead assessments appeared likely and supported by the analyses and evidence. However, as these were low information assessments and strong assumptions in the choices of catch history and life history parameters, caution is necessary due to the uncertainty in the level of depletion and the likelihood of rebuilding .

For Great Hammerheads, the assessment suggested that there had been considerable depletion in the stock, but that overfishing was no longer occurring (Figure 1). The six indices of abundance were fitted to varying degrees, although while well within confidence intervals, there was some evidence of a weak systematic pattern in the residuals. Retrospective analyses indicated no evidence of trend. While difficult, it would be useful to undertake additional analyses to determine the reasons for the different trends in a few of the indices, specifically if there are any fleet or operational behaviours, or spatial-

temporal influences that may have resulted in different recent trends. Overall, there was insufficient information in the data to provide a robust estimate of the overall scale of biomass.

For assessing Smooth Hammerhead sharks using SSS, the choice of the depletion level is a critical assumption that strongly influences the outcome. As SSS requires an assumption of the depletion in a given year as an input, the assessment analyst noted that this method should not be used to determine if the stock is overfished. This conclusion is supported. However, the assessment results with the assumed choices of depletion found that the current estimated catch in the terminal year was less than the estimated overfishing limit in 2021, the conclusion that overfishing is unlikely to be occurring is supported. In addition, given that the median of the terminal year depletion for the reference and sensitivity runs was larger than the assumed depletion in the year 2000, the conclusion of the assessment that the stock status is improving is also supported (Figure 2).

For Scalloped Hammerhead sharks, the Assessment Workshop review had recommended several sensitivity analyses during the stock identification and assessment processes but not all of these were able to be run in the time available prior to this review. While the model results indicated that the stock was above or about target, and overfishing was unlikely to be occurring (Figure 3), the lack of a more complete set of sensitivity analyses suggests that more work would need to be undertaken in order to ensure that this is a robust conclusion. Model fits to the indices of abundance suggested some conflict in the most recent years (Figure 4) and there appeared to be some weak systematic patterns in the CPUE that were unable to be fitted to the model. Additional work to resolve these patterns is recommended.

The strength of the integrated assessment approaches (SS and SSS) comes from the inclusion of a wide range of data into a single modelling framework, allowing the data sources to be compared and allowing the models to use as much of the information in the data as possible. However, caution is required to avoid providing conflicting information that cannot be reconciled within the model. Sensitivity analyses that include or exclude subsets of data where conflict is evident would help provide more robust conclusions. SS and SSS both have a comprehensive set of diagnostic tools to aid understanding of the model performance and to assist quantifying the uncertainty. In the Scalloped (SS) and Smooth Hammerhead (SSS) assessments, the analysists appear to have been thorough in using and applying these tools.

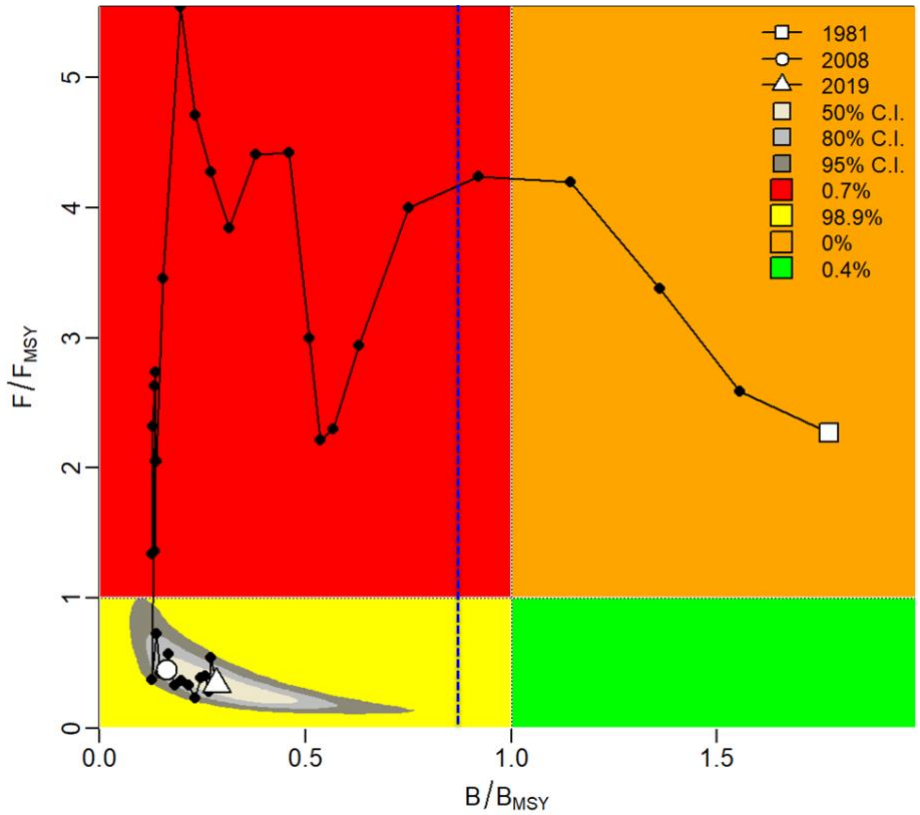

Figure 1: Kobe phase plot showing estimated trajectories (1981-2019) of B/BMSY and F/FMSY for the base run. Different grey shaded areas denote the 50%, 80%, and 95% credibility interval for the terminal assessment year. The probability of terminal year points falling within each quadrant is indicated in the figure legend. The blue dash line is the Minimum Stock Size Threshold ((1-M)BMSY) reference line. [reproduced from Figure 3.1.1 in SEDAR 77 HMS Hammerhead Sharks: Great Hammerhead Shark. Section III: Assessment Report]

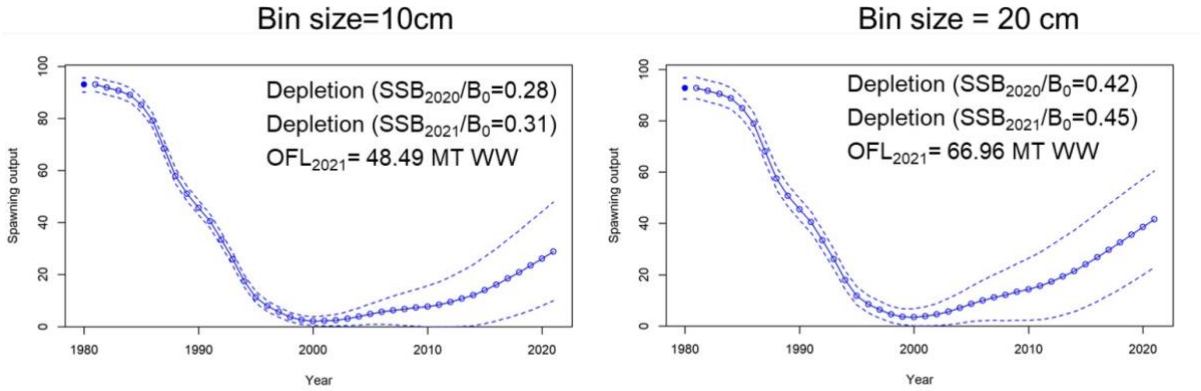

Figure 2: Depletion and OFL2021 estimated from SSS including super year 2016 based on aggregated 2016-2019 data. Length is in cm fork length.[Reproduced from Figure 3.25 in SEDAR 77 HMS Hammerhead Sharks: Smooth Hammerhead Shark Section III: Assessment Report]

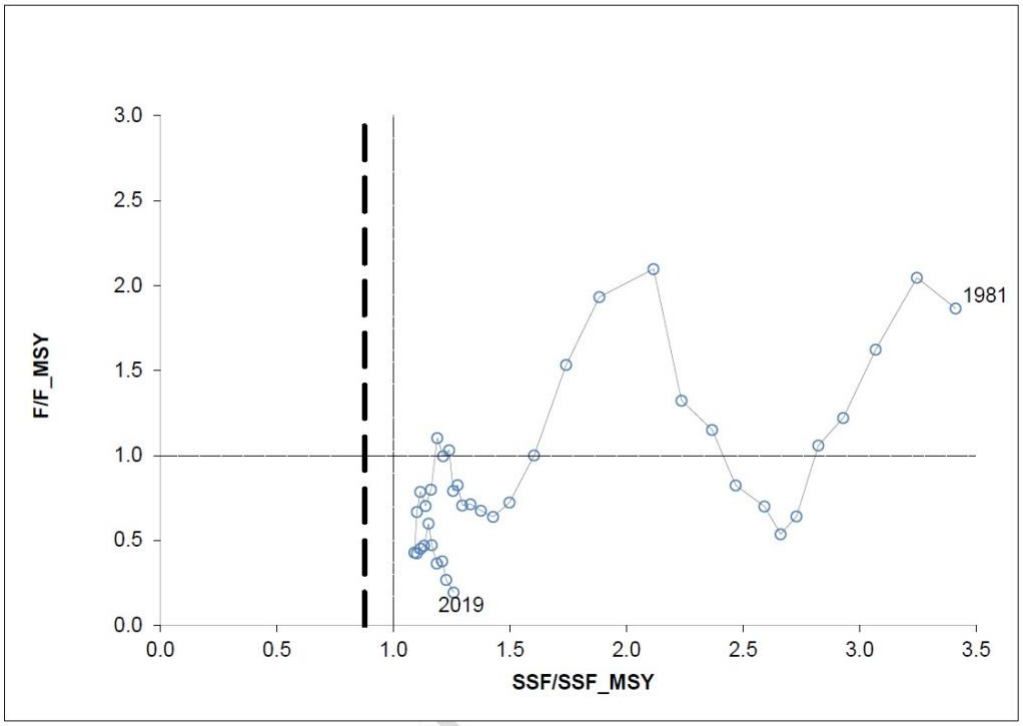

Figure 3: Phase plot of the relative spawning stock fecundity (SSF) and relative fishing mortality (F) trajectories by year from 1981 to 2019 obtained for the Stock Synthesis reference case (GOM + ATL) model configuration; The dotted horizontal and vertical lines indicate FMSY and SSFMSY. The dashed vertical line indicates MSST =()1aM−*SSFMSY, with aM calculated as the arithmetic mean of the female age-specific values of M used in the provisional base model configuration. [Reproduced from Figure 3.10.in SEDAR 77 HMS Hammerhead Sharks: Scalloped Hammerhead Shark. Section III: Assessment Report]

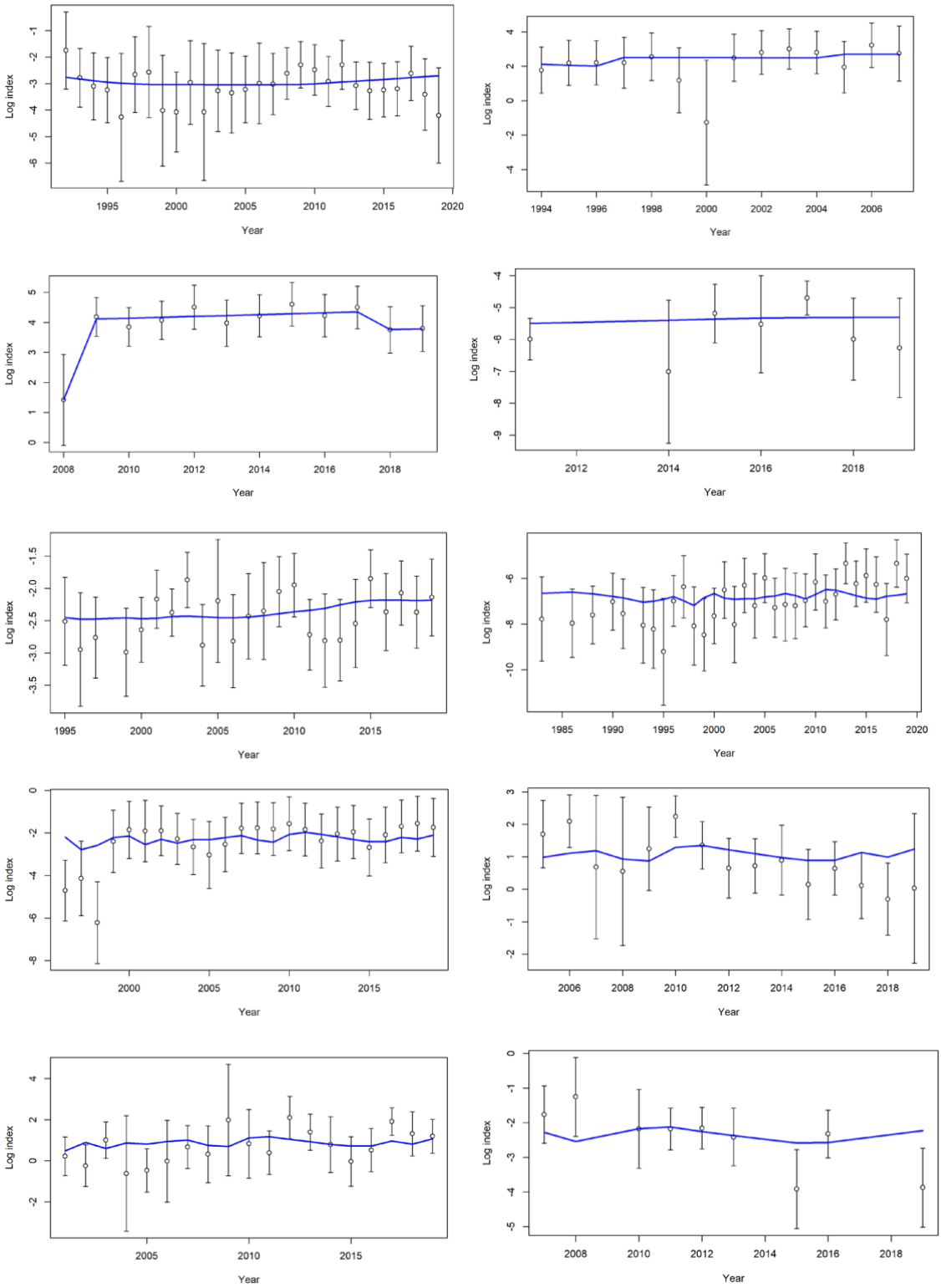

Figure 4: Fits to abundance indices obtained for the Stock Synthesis reference case (GOM + ATL) model configuration for (left to right, top to bottom): S1 (PLL-Obs), S2 (Shark-BLL-Obs), S3 (Shark-BLL-Res), S4 (FSU-BLLS), S5 (SEFSC-BLLS), R1 (TXPWD-GNS), R2 (GULFSPAN-GNS), R3 (COASTSPAN-BLLS), R4 (COASTSPAN-LGNS), R5 (COASTSPAN-SGNS). [Reproduced from Figure 3.2 in SEDAR 77 HMS Hammerhead Sharks: Scalloped Hammerhead Shark. Section III: Assessment Report]

5.5 Evaluate the stock projection methods, including discussing strengths and weaknesses

For each stock, different modelling approaches were used, reflecting the different amounts of data available to each. While SS provides the best approach by integrating all of the available data, it does require reliable indices of abundance and catch-composition data. For each species, the approach taken was consistent with the data available. However, it may be informative to compare using the alternate models (SSS and JABBA) to assist in the evaluation of these methods where this is possible.

In each case, the model results were used to provide projections and calculations of ABC, where required. However, the discussion of the projections for each stock did not fully summarise the uncertainties in input biological assumptions, the data and hence the assessment results. In particular, additional sensitivity runs were identified for Scalloped Hammerheads in the assessment process but were not able to be fully explored in the time available.

For Great Hammerheads, the JABBA model used a standard Pella-Thompson production model appeared a well-constructed software tool that included the ability to undertake projections using the estimation model configuration. It was notable that the process error deviates had a negative process error during the last 10 years or so. While noted in the AW Report that this was not uncommon for shark species, it would be useful to undertake additional diagnostics or a simulation study to understand why this occurs.

Due to the available data, catch-based and F-based projections were carried out to estimate the OFL2020 for Great Hammerhead sharks. Projections were carried out in accordance with the Assessment Process ToRs (item 9a) for rebuilding using the built-in JABBA procedure and were consistent with accepted practises and the available data.

For the Smooth Hammerheads assessment, while catch and some life history data were available, there were no available abundance indices or suitable composition data to inform catch-at-age or catch-at-length population dynamics. The need to input an assumed depletion level into the SSS model was an important source of uncertainty The discussion in the assessment report described the conclusions and did consider the evidence for the conclusion that the current catch was likely below the overfishing level. The conclusion that the current catch was likely below the overfishing level is supported. The overfishing level in 2021 was estimated with the SSS inbuilt terminal year plus one projection. The AW Report noted that longer term catch-based and F-based projections were not carried out due to the limitations of the catch-only method. Here, the lack of an index of abundance hampers the ability to place a strong reliance on any of the individual model run projections. However, the conclusion that current catches are likely to be below the overfishing level is supported.

For the Scalloped Hammerheads assessment, the use of SS allowed a fuller set of diagnostics to be evaluated. However, as noted in the AW Report, while multiple sensitivity analyses were identified, most were not implemented due to time constraints. There were a number of sensitivities presented to the Review Workshop, but given the reduced time available in the workshop due to Hurricane Idalia, the ability of the review team to fully consider these with the analytical team was limited. The AW Report noted that a poor fit to some annual length composition data sets was accepted as these data may not be representative of annual changes in the length composition. Sensitivity runs to evaluate alternate choices of data weighting in these cases would allow a fuller exploration of these data and the effect on model conclusions including trade-offs in model fit with combining selectivities or fixing those that may not be well estimated.

5.6 Provide, or comment on, recommendations to improve the assessment

For all stocks, the available biological information could be enhanced, and consideration should be given to the development of data collection plans to enable the data to be collected.

The collection of data to inform age-related parameters for Great, Smooth, and Scalloped Hammerhead is supported. However, age determination for elasmobranchs can be difficult, and any ageing using vertebrae should be evaluated to ensure the method is correctly measuring data for Smooth Hammerheads and for female Scalloped Hammerheads should be the priority. Stock identification and in particular, stock structure of hammerheads between the Gulf of Mexico and the Atlantic should be ongoing and remains a priority. Species identification for Scalloped and Carolina Hammerheads remains a critical uncertainty in the Scalloped Hammerheads assessment. Priority should be given to development of methods to assist identification of these species where possible.

The recommendation of the DW Report that discard mortality estimates using GLMs are supported, but consideration should be given to exploring if the data support spatial-temporal covariates, using for example, spatial-temporal and random effects with GAMS. Similarly spatial-temporal approaches should be investigated with the CPUE indices and evaluated to determine if this provides additional information not currently captured by the models. As abundance indices for all stocks are a priority, development of alternative methods, such as investigating the utility of close kin genetics are recommended, especially for Smooth Hammerheads.

With data poor species, the ability to investigate and model climate and environmental factors that effect productivity is limited. While important, the development of biological parameters and indices of abundance should take priority. Even so, range changes due to climate change is an aspect that should be monitored, especially if there is evidence that these species may change their distribution in response to environmental changes. The use of surveys to identify potential range changes, either though habitat change or prey species distribution change is a potential area of future research. Tag recapture studies may help, but care would need to be taken in evaluating the numbers and locations of animals tagged and the spatial distributions of the probability of recapture for this to be interpreted correctly. A desk study to evaluate the information that could be obtained from this approach would be recommended before embarking on field studies.

For Great and Smooth Hammerheads, better estimates of the recreational catch and the associated uncertainty would improve the assessment, especially if combined with improved length- or age-composition data. Work to collect and estimate length composition data is a high priority. For Smooth Hammerhead sharks (i) data collection systems to allow the estimation of abundance indices that can be incorporated into the assessment models should be developed, and (ii) information to inform the biological parameters should be developed.

The range of sensitivities for Scalloped Hammerheads meant that a number of these were not able to be undertaken in the time available before the Review Workshop. As noted in the AW Report, prioritisation of these sensitivity would help alleviate this situation. In particular, sensitivities that identify the range of potential outcomes should be prioritised first, so that the overall range of model conclusions can at least be evaluated.

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

The Review Workshop of SEDAR 77 was effective in reviewing the scientific information for the assessments of Great, Smooth, and Scalloped Hammerhead sharks in the south west Atlantic and Gulf of Mexico. The workshop was well organized with material available in advance of the meeting.

Due to the arrival of Hurricane Idalia on to the coast of Florida on 30 August 2023, the in-person review workshop proceedings were limited to one day (28th August 2023) and the opportunity for the review team to request additional analyses and sensitivity models runs was therefore significantly limited. A webinar was held on the 14 November 2023 for the remaining presentations and for the review team to ask questions of the presenters and provided some opportunity for follow-up but was not as ideal as a focused week of in-person meetings.

Both the in-person and virtual meeting facilities were well organised, and the meetings went well and allowed for a good level of engagement with the presenters. Such reviews, where multiple species are considered, may be improved by the analysts providing a summary document that outlines the approaches for each species and makes it explicit where the same methods are applied (including methods for the development of the catch time series, indices of abundance, and the biological parameters), and where divergence between occurs. This may assist the review team to draw conclusions on where individual stocks/species may be improved and where comparing approaches between stocks/species may allow a more insightful review.

The presenters and assessors at the workshop conducted their work in a positive and thorough manner with the analytical team providing a high level of engagement and cooperation. The review panel comprised experts with a wide range of relevant expertise that covered the main disciplines involved in the analysis. There were no important disagreements during the meeting nor from each reviewer in their approach to the review.

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

This report describes the review in partial fulfilment of this Term of Reference. However, the arrival of Hurricane Idalia shortened the workshop to a single day for the in-person meeting in which most of the presentations were given, and precluded requests for additional sensitivity runs or further model exploration during the workshop. Following the in-person meeting, a webinar was conducted to present the remaining key presentations and for any follow up questions. With the significantly shortened period available for the review workshop, it was determined by the Workshop Review Chair (John Carlson) that a summary report would not be prepared and that the review would consist only of the individual reviewers' reports. Following the webinar, this review report was prepared. The statement of work is given in Appendix 2.

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Appendix 1: Bibliography of materials provided for review

Document #	Title	Authors	Received
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 2 Bahamas: preliminary results	Vital Heim, Dean Grubbs, Bryan Frazier, Matthew J. Smukall, Tristan L. Guttridge	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	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	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	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	7/5/2021
SEDAR77-SID07	Great and scalloped hammerhead sharks in the US Atlantic and Gulf of Mexico using Satellite tags	Neil Hammerschlag	7/14/2021 Revised: 9/8/21
SEDAR77-DW01	Hammerhead Shark Catches from Bottom Longline and Pelagic Longline Surveys conducted by Mississippi Laboratories	Adam G. Pollack and David S. Hanisko	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	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	11/8/2021
SEDAR77-DW04	Preliminary catches of hammerhead sharks in the U.S. Atlantic, Gulf of Mexico, and Caribbean	Enric Cortes	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.	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	11/29/2021 Revised: 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	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	11/29/2021

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

Document #	Title	Authors	Received
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	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	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.	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.	1/7/22
SEDAR77-DW31	Standardized index of abundance for calloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery long-gillnet surveys	Camilla T. McCandless and Bryan S. Frazier	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	1/7/22
SEDAR77-DW33	Standardized index of abundance for scalloped hammerhead sharks from the University of North Carolina shark longline survey south of Shakleford Banks	Camilla T. McCandless and Joel Fodrie	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	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	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	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	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	1/31/22
SEDAR77-AW01	Exploratory analysis of U.S Atlantic and Gulf of Mexico scalloped hammerhead recruitment indices	Henning Winker	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	5/31/2022
SEDAR77-AW03		Cami	Not Received

Document #	Title	Authors	Received
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	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	6/20/2022
SEDAR77-AW06	Fishpath Questions	Enric Cortes	9/21/2022
SEDAR77-AW07	Selected FishPath Results for Smooth hammerhead shark, U.S. Atlantic and Gulf of Mexico	Enric Cortes	9/21/2022
SEDAR77-AW08	Selected FishPath Results for smooth hammerhead shark, U.S. Atlantic and Gulf of Mexico:	Enric Cortes	9/21/2022
SEDAR77-RW01			
Final Assessment Report			
SEDAR77-SAR1	SEDAR 77: Stock Assessment Report of HMS Hammerheads	To be prepared by SEDAR 77	
Reference Documents			
SEDAR77-RD01	Movement, Behavior, 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	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	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	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	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	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.	5/27/2021

Document #	Title	Authors	Received
		Gadig, Mahmood S. Shivji, Cesar Martins	
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	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	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	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	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	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	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	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	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	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 Sosa- Nishizaki, Juan Carlos Pérez-Jiménez	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	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	6/18/2021
SEDAR77-RD20	Double tagging clarifies post-release fate of great hammerheads (Sphyrna mokarran)	J. Marcus Drymon and R. J. David Wells	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	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,	6/23/2021

Document #	Title	Authors	Received
		James Gelsleichter, R. Dean Grubbs, Eric A. Reyier, David S. Portnoy	
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	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	7/12/2021
SEDAR77-RD25	Characterization of a scalloped hammerhead (Sphyrna lewini) nursery habitat in portions of the Atlantic Intracoastal Waterway	Bryanna N. Wargat	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	9/8/2021
SEDAR77-RD28	Hammerhead Sharks of the Northwest Atlantic and Gulf of Mexico (2014 – 2020)	Lisa Clarke, Librarian, NOAA Central Library	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	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	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	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	9/8/2021
SEDAR77-RD33	Scalloped hammerhead shark (Sphyrna lewini) 2014-2019	Trevor Riley, Head of Public Services, NOAA Central Library	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	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	9/8/2021
SEDAR77-RD36	ENDANGERED SPECIES ACT STATUS REVIEW REPORT Smooth Hammerhead Shark (Sphyrna zygaena)	M.H. Miller	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	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	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	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	9/8/2021

Document #	Title	Authors	Received
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	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,	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	9/23/2021
SEDAR77-RD44	SEDAR29-WP17- A preliminary review of post-release live-discard mortality estimates for sharks.	Dean Courtney	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	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	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	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	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 Cortes	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	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 Corte´s	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	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	5/26/2022
SEDAR77-RD54	SEDAR 65 - AW03: Reconciling indices of relative abundance of the Atlantic blacktip shark (Carcharhinus limbatus)	Robert J. Latour and Cassidy D. Peterson	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	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	7/25/23
SEDAR77-RD57	1996 REPORT OF THE SHARK EVALUATION WORKSHOP	NOAA, National Marine Fisheries Service	8/25/2023
SEDAR77-RD58	1998 REPORT OF THE SHARK EVALUATION WORKSHOP	NOAA, National Marine Fisheries Service	8/25/2023
SEDAR77-RD59	A study of Shark exploitation in the U.S. Atlantic Coastal waters During 1986 - 1989	Michael L. Parrack	8/25/2023
SEDAR77-RD60	REPORT OF THE SHARK EVALUATION WORKSHOP March 14-18, 1994	NOAA, National Marine Fisheries Service	8/25/2023
SEDAR77-RD61	Stock Assessment of Large Coastal Sharks in the U.S. Atlantic and Gulf of Mexico	Enric Cortés, Liz Brooks, Gerald Scott	8/25/2023

Document #	Title	Authors	Received
SEDAR77-RD62	Memo: SEFSC Scientific Review of Scalloped Hammerhead Stock Assessment by Hayes, et. al. (2009)	Bonnie Ponwith	8/25/2023

Appendix 2: Performance Work Statement

Performance Work Statement (PWS)

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

SEDAR 77 HMS Hammerhead Sharks Assessment Review

Background

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

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards[1].

Scope

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

The SEDAR 77 review workshop will be a CIE assessment review conducted for Highly Migratory Species (HMS) Hammerhead Sharks. There are three models to be reviewed: one model for Great Hammerheads for the Atlantic and Gulf of Mexico regions, one model for Smooth Hammerheads for the Atlantic and Gulf of Mexico regions, and one model for Scalloped and Carolina Hammerheads in the Atlantic and Gulf of Mexico regions. The review workshop provides an independent peer review of SEDAR stock assessments. The term review is applied broadly, as the review panel may request additional analyses, error corrections and sensitivity runs of the assessment models provided by the assessment panel. The review panel is ultimately responsible for ensuring that the assessment is appropriate for use by fishery managers. The stocks assessed through SEDAR 77 are the Gulf of 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**.

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

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:
    a. Are data decisions made by the DW and AW justified?
    b. Are data uncertainties acknowledged, reported, and within normal or expected levels?
    c. Is the appropriate model applied properly to the available data?
    d. Are input data series sufficient to support the assessment approach?
2. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data. Consider the following:
    a. Are methods scientifically sound and robust?
    b. Are the methods appropriate for the available data?
    c. Are assessment models configured properly and used in a manner consistent with standard practices.
3. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
    a. Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.
    b. Ensure that the implications of uncertainty in technical conclusions are clearly stated.
4. Evaluate the provisional assessment findings and consider the following:
    a. Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
    b. Are the provisional stock status determination methods for each stock or stock complex appropriate? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
5. Evaluate the stock projection methods, including discussing strengths and weaknesses, and consider the following:
    a. Are the methods consistent with accepted practices and available data?
    b. Are the methods appropriate for the assessment model and outputs?
    c. Are the provisional results informative and robust, and useful to support inferences of probable future conditions?
    d. Are key uncertainties acknowledged, discussed, and reflected in the provisional projection results?
6. Provide, or comment on, recommendations to improve the assessment
    a. Consider the research recommendations provided by the Data and Assessment workshops in the context of overall improvement to the assessments, and make any additional long-term research recommendations warranted.
    b. Provide suggestions on key improvements in data analysis or modeling approaches that should be considered when scheduling the subsequent operational assessment. These recommendations should be described in sufficient detail for application in the subsequent operational assessment, and consequently should be practical for short-term implementation (i.e., achievable within ~6 months).
    c. Comment on the degree of environmental and climate linkage(s) incorporated in the stock assessments and make recommendations for improvements in the future.
7. Provide recommendations on possible ways to improve the Research Track Assessment process.
8. Prepare a Review Workshop Summary Report describing the Panel's evaluation of the Research Track stock assessment and addressing each Term of Reference.

Annex 3: Tentative Agenda –

SEDAR 77 Atlantic Hammerhead Sharks Assessment Review

Panama City, FL. August 28 – Sept 1, 2023

Monday

9:00 a.m. – 9:30 a.m. Introductions and Opening Remarks **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 p.m. **Assessment Presentation Scalloped Hammerhead**
Xinsheng Zhang

5:05 p.m. - 5:15 p.m. **Concluding Remarks**
Julie Neer

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

Review Panel

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

Analytic Team

Dean Courtney	NMFS SEFSC
Xinsheng Zhang	NMFS SEFSC

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 Observers

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