Desk review of stock assessments for sandbar, dusky, and blacknose shark prior to their consideration by the SEDAR 21 panel Review Workshop.

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1. Executive Summary

1. The CIE Reviewer undertook a desk review of the pre-review stock assessment reports for the sandbar, dusky, and two blacknose shark stocks between 17 January and 14 February, 2011.
2. **It is recommended that research on age, growth and reproduction is undertaken.** These are key life history processes that determine the form of the stock-recruitment relationship, and reliable data on these processes are important if the assessment model is to adequately describe the dynamics of the stock.
3. **It is recommended that research is undertaken to produce more reliable estimates of age-dependent natural mortality.** Natural mortality is typically a key source of model uncertainty, and sound estimates of this parameter are essential if reliable estimates of stock status are to be determined from the stock assessment models.
4. The lack of reliable data on the survivorship of sharks that were caught by different fishing gears by different fishing sectors, and then discarded, was recognised by both the Data and Assessment Workshops as a major impediment to assessing the removals from the stock that arose as a result of discarding sharks that had been caught. **It is recommended that research is undertaken to assess the survivorship of sharks caught by different types of fishing gear and subsequently discarded by fishers.**
5. The descriptions of the assessment models were reviewed. A number of editorial changes were proposed and the need for greater detail in some sections of the descriptions was identified**. It is recommended that the descriptions of the models in the assessment reports are refined to correct the errors, address the inadequacies, and, where appropriate, take into account the various suggestions listed in the findings for ToR 2, and that, where necessary, ADMB source code for each model is updated to match the revised description.**
6. Although their descriptions need to be slightly refined, the structures of the stock assessment models appear appropriate, given the life histories of the species and the types and quality of the data that are available for each stock.
7. There is considerable imprecision in the time series of effort used for the dusky shark assessment. Thus, as suggested by the Data Workshop, **it is recommended that the influence of the assumptions used when calculating fishing effort for the dusky sharks is explored in greater detail**. As with the time series of catches for the sandbar and blacknose shark stocks, **it is also recommended that the sensitivity of model results to uncertainty in the time series of effort for dusky sharks is investigated.**
8. No details of the data used to construct the age-length keys or the application of those keys are currently presented in the assessment reports. **It is recommended that a detailed description of the data used and the method of construction of the age-length keys and their subsequent application is included in each assessment report, accompanied by a table for each age-length key showing the proportions of sharks of each age within each length class.**

9. Age composition data for the survey indices and removals data were insufficient to allow reliable calculation of selectivity curves for these time series. **It is recommended that monitoring programs are expanded to collect appropriate age and length samples from the catches and discards of the commercial fishers employing different gear types, from catches of recreational fishers, and from the catches taken in research surveys, and thereby to provide a reliable estimate of the age composition that characterizes each survey index and the removals by each gear type and fishing sector.**
10. Many of the curves describing the selectivity at age for the removals and indices of abundance were fitted by eye rather than statistically. As the curves were fitted outside the model, their uncertainty was not carried into the model and considered when assessing stock status. **It is recommended that, in future stock assessments, the calculation of parameters of the selectivity curves is undertaken within the assessment model, such that uncertainty associated with sample size, age-length keys, etc., can be carried through into the estimates of the uncertainty of the indicators of stock status.**
11. To assist in assessing the extent to which values predicted by the assessment model fitted the observed data, taking into account the imprecision of the estimated values, **it is recommended that 95% confidence limits of the predicted values are displayed on the plots of observed versus predicted catches and abundance indices**.
12. Indices of abundance that are currently employed in the base models exhibit apparently inconsistent trends and the fitted models represent a compromise between the alternative signals. **It is recommended that inconsistencies among abundance indices are explored by examining the statistical adequacy of the survey design of each index, evaluating the extent to which the data collected to derive the values of the index are representative of the population, and assessing whether any processes might exist that would cause the time series of values for the index to exhibit a trend that differs from that exhibited by population abundance.**
13. Numerous assumptions were required to resolve deficiencies in removals data and to produce the time series of data required by the models. The uncertainty that results from a number of these assumptions has yet to be explored. **It is recommended that the sensitivity of the assessment to uncertainties associated with the development of the removals data, particularly those associated with the reconstruction of the earlier data in the historical period, is assessed.**
14. Artefacts, which were associated with the inclusion of different sets of abundance indices in the different periods examined, were evident in the plots of F/F_{MSY} produced from the results of the retrospective analysis. **It is recommended that periods considered in the retrospective analyses extend backward only through years for which the same suite of abundance indices, as were present in the most recent year, are available.**

15. The use of an age-dependent rather than constant natural mortality requires that the reference point for the minimum stock size threshold is respecified, i.e., for small M, it is not appropriate to specify that MSST is the product of (1-M) and BMSY as M is assumed to vary with age. For the dusky shark, because a catch-free assessment model was employed, the benchmark reference point will need to be expressed in terms of a proxy, e.g., the ratio of biomass to virgin biomass.
16. For each of the blacknose, sandbar and dusky shark stocks, the assessments of stock status, which were produced by the base model and by the range of alternative models, i.e., uncertainties, considered in the various selectivity trials for that stock, were relatively consistent. Note, however, that the sensitivities of estimates of stock status to other sources of uncertainty have yet to be explored.
17. While the quality of the assessments would be improved by proposed research and the acquisition of additional data, the results of the assessments appear sufficiently reliable to be used as indicators of the current status of the stocks provided that the underlying assumptions of the data and model structure and the uncertainties exhibited in the base model and various sensitivity trials are taken into consideration.
18. Projections for the blacknose and sandbar stocks are still to be undertaken by the Assessment Workshop.
19. While noting the issues that have been identified in this report, and recognising that a number of recommendations have been made to improve the quality of the assessments, the data and science that have been presented in the assessment reports appear to the best that are currently available for the Atlantic and Gulf of Mexico stocks of blacknose shark and the stocks of sandbar and dusky shark in the waters of the Gulf of Mexico and off the Atlantic coast.

2. Background

2.1. Overview

The Center for Independent Experts (CIE) contracted for an independent peer review of SEDAR stock assessments for HMS sandbar, dusky, and blacknose shark, prior to a panel Review Workshop that will consider these assessments. This review was to be undertaken as a desk review, between 17 January and 14 February, 2011.

On January 17, 2011, the address of the SEDAR FTP site, from which the pre-review Assessment Reports for the sandbar and dusky sharks, and supporting documents and files, could be downloaded, was provided. Copies of these Assessment Reports were also emailed to the reviewer on that date. Subsequently, on 1 February, the pre-review Assessment Reports for the two blacknose shark stocks were also made available on the FTP site, and copies of the reports were emailed. A list of these documents is presented in Appendix 1.

The Statement of Work provided to Dr Norm Hall by the CIE is attached as Appendix 2. This report documents the findings of the independent review that was undertaken by Dr Hall in accordance with this CIE Statement of Work.

2.2. Terms of Reference

The terms of reference for this independent peer review of the pre-review SEDAR stock assessments for HMS sandbar, dusky, and blacknose shark are presented in Annex 2 of Appendix 2.

2.3. Date and place

The independent review of the pre-review SEDAR stock assessments for HMS sandbar, dusky, and blacknose shark was conducted by the reviewer as a desk study, in Perth, Western Australia, between 17 January and 14 February 2011.

3. Description of Reviewer's role in review activities

As required under the CIE's statement of work, the reviewer familiarised himself with the documents that had been provided and then undertook the review that had been requested, addressing each of the terms of reference specified in the statement of work.

4. Summary of findings

ToR 1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.

Overview of findings for ToR 1.

The Data Workshop appears to have made appropriate use of the data that were available for the blacknose, sandbar and dusky sharks. While catch data were found to be adequate for the blacknose and sandbar stocks, reliability of the catch data for the dusky shark was considered by the Data Workshop to be inadequate for those data to be used in stock assessment. The sensitivity of the assessments to imprecision associated with a number of the assumptions made in developing the time series of removals data for blacknose and sandbar sharks and effort data for dusky sharks remains to be assessed. Discard mortality, reproduction and natural mortality were identified by the Data Workshop as sources of uncertainty. Characterization of the age compositions of removals from the stocks relied on the conversion of length compositions to age compositions using age-length keys. The latter were poorly described, and the quality of the resulting age compositions remains to be assessed. Numerous candidate indices of abundance were available for each stock, from which a selection was made for each species of the indices likely to be most reliable and informative. The statistical analyses used to construct these indices were appropriate. While the criteria used for selection appeared appropriate, many of the indices of abundance displayed considerable inter-annual variability and inconsistencies in trends appeared to exist.

Details of findings for ToR 1.

Values of commercial catches of blacknose sharks from the Gulf of Mexico (GOM) and Atlantic (ATL) coasts of the U.S. and of sandbar and dusky sharks were derived for the Data Workshop from the various databases that had been used to store the landings data collected during the historical period, i.e., the data reported to the various State and Federal agencies responsible for collecting and collating the data and maintaining the databases in which those data were stored. The quality of these data thus reflects the reporting requirements, the types of data reported (whole or dressed weight), the extent to which landed catches provided complete coverage, the extent to which landed catches were reported to and included in two (or more) databases thereby duplicating some records, and whether the landed weights were reported for unclassified or separate species. Over the historical period, there have been changes in the approaches used to collect data, changes in management, and changes in the markets for sharks and shark fins. The Data Workshop's task of collating the commercial catch data and distilling the resultant data set to produce tables of historical catch data thus required an approach that would take into account the changing nature of the various sets of source data. Such an approach was described in SEDAR21-DW-09 and used to produce estimates of the catches of dusky, sandbar and blacknose shark, with catch data for the latter two species being accepted by the Data Workshop as adequate for use in subsequent stock assessments. The Data Workshop noted that the quality of the dusky shark data was affected by under-reporting and mis-identification, and that, since 1993, dusky sharks had been listed as "Protected".

The data sets and methods used to produce the tables of commercial catch data have been described broadly in SEDAR21-DW-07 and SEDAR21-DW-09. Precise details of the data that were used as input and produced as output at intermediate stages of the calculations were not provided in these or the assessment reports, however. It is thus not possible to ascertain the full extent to which it was necessary to expand the reported data to account for missing data, or to disaggregate unclassified data into catches of individual species. Thus, for example, it is unclear whether account has been taken of those removals from the different stocks that were associated with the landing of shark fins prior to 1993 (NMFS, 1996, p.9). **It is recommended that, for future assessments, tables of input data and the results of intermediate calculations are reported explicitly in the background papers, thereby communicating more effectively the uncertainties associated with the catch and removal estimates.** Without such detailed data, it is difficult to assess the magnitude of the uncertainty in the estimates of removals.

It is recommended that, for dusky shark, a brief description is provided of the basis for the conclusion that catch data were affected by under-reporting and mis-identification, the extent of the problem, and the years in which this affected data quality. This would have allowed assessment of the appropriateness of the decisions by the Data Workshop that the data were of insufficient quality for use in the assessment and by the Assessment Workshop that, provided the parameter estimates produced by the catch-free assessment model were not affected, the removals data for 1993-1998 could be used in model projections to scale levels of relative abundance to absolute levels. It would be useful to include a comment in the assessment report explaining why under-reporting and mis-identification did not also affect the quality of the estimates of the removals from the sandbar and blacknose stocks to the extent that estimates for these stocks also became unreliable. An important question for future assessments is whether the factors affecting the reliability of data for dusky shark have been addressed.

In response to the recommendation by Dr Robin Cook, CIE, in his review of the Data Workshop, that an analysis should be undertaken to quantify the uncertainty in the catch estimates, the Assessment Workshop developed low and high catch scenarios for the sandbar and two blacknose shark stocks, which were used to assess the sensitivity of model results for the assessments for these stocks. These catch scenarios were developed by applying the lower and upper 95% confidence limits, respectively, for the mean weight of sharks in the commercial catch, for the recreational landing and dead discards, bycatch estimates and for ratios used in extrapolating when calculating the various catch estimates for each stock. While the use of these low and high catch series does address, to some extent, the recommendation by Dr Cook, other sources of uncertainty remain, e.g. allocation of unclassified shark catches among individual species, catch estimates based on extrapolation or assumptions rather than recorded catches, etc.

Reconstruction of commercial blacknose shark catches for earlier years was based upon assumptions of linear increases in catch over selected periods for different gear types. For catches of sandbar sharks, an exponential decline back to 1975 then a linear decline back to 1960 were assumed. Commercial effort for dusky shark for earlier years was assumed to increase linearly. It would be informative to assess whether assessment results are sensitive to these assumptions. It would thus be useful to explore the sensitivity of model results to alternative assumptions for reconstructing earlier commercial catches of blacknose and sandbar sharks and earlier commercial effort for dusky sharks.

To overcome problems that arose when fitting the data for the blacknose shark stocks, the Assessment Workshop combined the pre-TED and post-TED data for bycatches from the shrimp fishery into a single time series, using the post-TED selectivity for this fleet. While the method used to produce estimates of bycatch for blacknose sharks, which was described in SEDAR-21-DW15, takes into account the effect of the TEDs on catches, the use within the assessment model of a single selectivity curve for the combined series implies that the age compositions of removals were not affected by the introduction of TEDs, which is unlikely. This is particularly important for the GOM stock of blacknose shark, for which bycatch from the shrimp fishery has dominated the removals. **It is recommended that separate selectivity curves are applied to the pre-TED and post-TED removals that arose from the bycatch of blacknose sharks by the shrimp fishery.**

The decision to apply a catch-free approach when assessing the status of the dusky shark stock replaced the need to provide catch data for the assessment model with the need to supply time series of effort data for the various fleets. Accordingly, the Data Workshop developed time series of effort estimates for the dusky shark stock. These effort estimates were based primarily on the time series of effort data for the pelagic longline fishery and on the average ratios for 2002-2007 of recreational and bottom longline catches to pelagic long line catches. There is likely to be considerable imprecision in the resulting time series of effort, and thus, as suggested by the Data

Workshop, **it is recommended that the influence of the assumptions used when calculating fishing effort for the dusky sharks is explored in greater detail**. As with the time series of catches for the other two species, **it is also recommended that the sensitivity of model results to uncertainty in the effort time series for dusky sharks is investigated.**

Length compositions of removals are derived from observer programs. While each of the assessment reports advises that age-length keys were (or will be) used to convert length compositions to age compositions, no details of the data used to construct the age-length keys or the application of those keys are currently presented in the assessment reports. **It is recommended that a detailed description of the data used and the method of construction of the age-length keys and their subsequent application is included in each assessment report, accompanied by a table for each age-length key showing the proportions of sharks of each age within each length class.**

The litter size of blacknose sharks and the reproductive cycle of sandbar sharks are uncertain and warrant further research. There appears considerable uncertainty regarding the values of discard mortality, which also warrants further research. Currently, the uncertainty in the values of discard mortality does not appear to be carried through into the stock assessment.

The assumption that natural mortality is age-dependent appears more appropriate for blacknose, sandbar and dusky shark than that it is constant. A more detailed description of the derivation of the survival schedules for the different species would have been useful, as this would provide details of the data that were input to the different mortality models allowing an assessment of the adequacy of those inputs. As model predictions are typically very sensitive to the value of natural mortality that is assumed, in addition to the trial that was undertaken by the Assessment Workshop to explore the sensitivity of an alternative trend of natural mortality with age, it would be informative also to assess the sensitivity of model results to a proportional overall increase or decrease in the age-dependent estimates of natural mortality.

As noted by Dr Cook, in his review of the Data Workshop, the statistical methods that were employed, i.e. the use of generalized linear models and a delta-lognormal distribution, were appropriate for the analysis of the mixture of zero and non-zero catches that arise in the observer and survey data collected and used to develop indices of abundance for these shark species.

The variation within and inconsistencies among the abundance indices, which were noted by Dr Cook in his review of the Data Workshop, were evident. When fitting the assessment model, such variation within an index is likely to mask any trend in abundance. Furthermore, inconsistencies among the different indices (after taking differences in selectivity into account) will lead to tensions among the different indices when fitting the model and different predictions when different combinations of indices are employed. The assessment model is likely to propose a trend in abundance that represents a compromise solution that accommodates the different trends displayed by the indices, but the model will not be able to distinguish which of those alternate trends in abundance is more likely to represent reality. Given such input data, it is important to examine the data collection regimes very critically and assess whether the indices are representative of the full stock, or only representative of a portion of the stock, and whether factors exist that might explain a trend in the index which differs from the trend in abundance of the stock.

ToR 2. **Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.**

Overview of findings for ToR 2.

The models that were developed to assess the state of the two blacknose shark stocks and the sandbar stock appear appropriate and to have been soundly applied. The descriptions of the models for these stocks lack key elements, however, such as details of the equations that update the system state at the end of each 12-month period by moving sharks from one age to the next and by adding the annual recruitment. Although this latter equation is present in the description of the model for dusky shark, it lacks a term that adds annual recruitment. Note that these particular deficiencies in the model descriptions do not appear to exist in the ADMB code that I have examined, recognizing however that a thorough, in-depth examination of the program code was not possible in the time available for this review. The intended structure of the catch-free model for the dusky shark stock appears appropriate, but the description of the model needs to be refined. Likelihood functions need to be defined for all models.

The models make use of the available life history data. They also use the available abundance indices, and, in the case of the blacknose and sandbar shark stock, the available catch data.

The base models for the blacknose and sandbar shark provide a good fit to catch data, and that for the dusky shark provides a good fit to several indices. The former models provide a generally poor fit to the indices of abundance and the latter model fails to fit the other indices. The Assessment Workshop has suggested that this lack of fit may be due to the inter-annual variability of these indices and inconsistencies among the indices.

There is little information available to "pin down" the trend in abundance through much of the historical period as the indices of abundance are relatively short and do not extend sufficiently far backward into this period. Much of the abundance trajectory for this earlier period is therefore determined by the catch or effort data that were input for this period and by the assumptions that were used to extend the available data backward in time into the historical period.

While uncertain, results of the base model and sensitivity trials are relatively consistent in the conclusion that the blacknose, dusky, and, to a slightly lesser extent, sandbar sharks, are considerably depleted from their virgin levels of abundance. This consistency suggests that, despite the uncertainty, the results are likely to be adequate for indicating the status of the stocks.

Details of findings for ToR 2.

Length composition data from the various scientific observer programs, recreational fishing surveys and fishery-independent surveys were converted to age compositions by employing age-length keys. The source of the data for these age-length keys, their construction, and the quantity and representativeness of each age-length key of the data to which that key was applied are not described. Curves describing the selectivity at age for the removals and indices of abundance were then fitted to the resulting age-composition data. Two forms of curve were considered, i.e. logistic and double-logistic curves. As an aside, the denominator of the term on the right-hand side of the equations presented for the double-logistic should be written as the maximum of the product in the numerator; in the current form, the equation appears circular as it defines selectivity as a function of selectivity. The choice between these two forms of curves appears to have been subjective, with many of the curves fitted by eye rather than statistically. The resulting parameters were input to the assessment models and the externally-derived selectivity curves are thus imposed on the model without carrying into the model the uncertainties associated with the derivation of the age-composition data, the subjective selection of the form of the selectivity curve, and the often subjective approaches employed when fitting the selectivity curves to the age-composition data. As a consequence, the uncertainty estimated by each assessment model will be underestimated. **It is recommended that, in future stock assessments, the calculation of parameters of the selectivity curves is undertaken within the assessment model, such that uncertainty associated with sample size, age-length keys, etc., can be carried through into the estimates of the uncertainty of the indicators of stock status.**

Model description

Although the descriptions of the assessment models for the blacknose and sandbar stocks provide equations for the calculation of the recruitment of age-1 pups that is expected to be produced by the mature females in the stock, together with equations describing the calculation of the number of sharks at each age in the unexploited stock, no formulae are presented to describe the calculation of spawning females and subsequent annual recruitment (one year later) to the exploited stock and the transition between ages at the conclusion of the twelfth monthly time step.

In describing Equation 2 in the blacknose and sandbar assessment models, "spawners" are defined as having units equal to the number of mature adult females times pup production at age. As the model describes the dynamics of the sharks (of both sexes), and does not discriminate between the sexes, it would be useful to remind the reader that fecundity was adjusted to account for the sex ratio. That is, it might be preferable to present the equation showing the calculation of "spawners" as the number of sharks at age multiplied by the proportion of females, the proportion of those females that are mature, and the average pup production per year (taking into account the reproductive cycle for the females). "Spawning production" might be a more appropriate term than "spawners". A typographical error in equation 3 of the sandbar report was brought to the attention of the SEDAR Coordinator (the versions of this equation presented in the blacknose reports are correct), but examination of the ADMB source code for the base model for sandbar sharks, which was subsequently supplied, demonstrated that the calculations undertaken in the assessment were correct.

The notation that has been used to denote the number at age in Eq. 3.1 of the dusky shark assessment model is inconsistent; the term in the left-hand side of the equation contains two elements in its subscript while those on the right contain only one element in the subscript for number at age. Presumably the additional subscript relates to "year". The equation to calculate the unexploited spawners per recruit for dusky shark, i.e. Eq. 3.4, should include a term that recognises that age A is a plus group. Equation 3.3 of the assessment model for dusky shark, is said to calculate the relative spawning stock biomass, but actually calculates the relative number of pups produced by mature females. If this is intended to calculate the number of spawners in year y relative to the unexploited number of spawners, the numbers at age in the numerator on the right-hand side of the equation should be the numbers at age in year y, while those in the denominator should be the numbers at age in year 1, i.e. when the stock was unexploited. The statistical distribution of the random variable in Eq. 3.8 of the dusky shark model is not defined. The equation, Eq. 3.9, which describes the propagation of numbers of dusky shark at age through successive ages and years, should include a term for the annual recruitment to age a_r.

The period covered by the model for the blacknose and sandbar stocks is divided into two portions, i.e., a historical and modern period. Selection of the year that marks the boundary between the two periods appears subjective and is a possible source of uncertainty. The assessment reports advise that effort in the historical period is assumed to be either constant or to have a linear trend. It is unclear which assumption was actually applied when the model was fitted and how the value of the constant or intercept of this equation was determined. The trend in historical effort is a source of uncertainty that should be considered in the assessment.

It is unclear how the age-dependent selectivity for each fleet (removal series or abundance index) has been included in the blacknose and sandbar models, i.e., while it is assumed that the fleet-dependent vulnerability at age is calculated using the selectivity curves, which were input to the model, this is not stated in the text.

Equation 7 of the blacknose and sandbar models indicates that catches of the different fleets are removed sequentially. How was the order of removal determined, and what was this order? Does a change in the order of removal affect the results of the assessment model?

The objective function for each assessment model and for each of the likelihood functions in those models should be defined explicitly. The assessment reports advise that prior density functions were assumed for a number of the parameters, suggesting that the objective function may have maximized the posterior density given these prior distributions. Clarification is required in the model descriptions.

It is recommended that the descriptions of the models in the assessment reports are refined to correct errors, address inadequacies, and take into account the various suggestions listed above, and that, where necessary, ADMB source code for each model is updated to match the revised description.

Source code for the catch-free model used for the dusky shark stock is available from the SEDAR FTP site. Copies of the ADMB source code and data files for the base models for other stocks should also be made available.

Model fit

While the base case assessment model for the Atlantic stock of blacknose sharks provided a reasonable fit for the highly variable catch data, the fit to the abundance indices was poor. The time series for the indices of abundance are relatively short, however, and it is interesting to note that the UNC index, which was among the longest of these time series, suggested that depletion may have been greater than was predicted by the model. As pointed out in the assessment report, the lack of fit to the indices of abundance was possibly due to the highly variable nature of the indices and inconsistent trends among the different indices. A similar result was found for GOM blacknose shark, i.e. the model produced a good fit to the catches but a relatively poor fit to the abundance indices. Much of the predicted decline in abundance was in the period that preceded the time series for the abundance indices, i.e., the indices do not extend into the historical period during which catches by the shrimp fishery were increasing and when much of the depletion of the stock is predicted to have occurred. Again, for sandbar sharks, the catch predictions for the base model provided a good fit to the input data but the indices of abundance were poorly fit. The base model for the dusky shark provided a reasonable fit to the data for the LPS, BLLOP, and PLLOP indices of abundance, but a poorer fit to the VIMS and NELL indices**. It is recommended that 95% confidence limits of the predicted values are displayed on the plots of observed versus predicted catches and abundance indices.**

Estimates of stock status indicators

The base model and the various sensitivity trials for the Atlantic blacknose stock suggest that the stock is considerably depleted from the virgin level. Although several of the sensitivity trials for the GOM blacknose stock suggest that this stock is less depleted, the base model and majority of trials indicate that this stock is likewise considerably depleted. Although not depleted to the same extent as the blacknose shark stocks, the base model and sensitivity trials for the sandbar shark stock suggest that the biomass of this stock is now less than 40% of the virgin level. The base model and sensitivity trials for the dusky shark suggest that this stock has been considerably depleted from the virgin level. As many of the analyses were undertaken outside the models, e.g. calculation of selectivity curves, results of the assessment models probably underestimate the true uncertainty. Nevertheless, it is interesting to note that, for each of the four stocks, estimated values of SSF have shown a progressive decline, i.e. the base models suggest that this variable has not yet begun to recover from earlier depletion.

Retrospective analyses

While the majority of the retrospective plots for the blacknose shark stocks reveal no issues, that for F/F_{MSY} for the Gulf of Mexico blacknose shark stock shows a marked decrease when extending the data in the assessment from 2006 to later years. Such a jump is typical of the effect of a discontinuity in an index of abundance, such that, in this instance, it influences the parameter estimates for the data to 2006 and data post-

2006 in different ways. Thus, the DISL index in the assessment to 2006 is represented by a single point and provides no information of the trend in abundance. With the addition of the 2007 value for the DISL index, information on the trend of this index now affects the estimates of fishing mortality. Thus, the inconsistency between the plot of F/F_{MSY} for the analysis of the GOM blacknose shark stock to 2006 and the results obtained for analyses of data extending to 2007 and later years is likely to be due to the inclusion of the DISL index.

The retrospective plots for the sandbar shark are interesting, as they suggest that, as additional data become available to the current stock assessment model, estimates of the extent to which the stock is depleted are revised to lower levels of depletion. Similarly, estimates of F/F_{MSY} are revised to lower levels. Examination of the latter plot suggests that an explanation for the differences between the trends for the analyses that included only data to 2007 and those that included subsequent years of data may be due to the historical red drum index, for which the time series only extended to 2006. It is possible that the ranges of years over which other indices of abundance extend may have introduced other artefacts into the trends seen in the plots of the results of the retrospective analysis. The results of the retrospective analysis reinforce the need to consider the influence of the inclusion/exclusion of the different indices of abundance when fitting the assessment model to the data for the different stocks. . **It is recommended that periods considered in the retrospective analyses extend backward only through years for which the same suite of abundance indices, as were present in the most recent year, are available.**

ToR 3. Evaluate the methods used to estimate population benchmarks and management parameters (e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies); comment on the reliability of the estimated benchmarks.

Overview of findings for ToR 3.

The use of an age-dependent rather than constant natural mortality requires that the reference point for the minimum stock size threshold is respecified, i.e., for small M, it is not appropriate to specify that MSST is the product of (1-M) and B_{MSY} as M is assumed to vary with age. In addition, for the catch-free model used for dusky shark, as absolute estimates of biomass and MSY cannot be calculated by the model, proxies for the values of reference points, such as MSY, B_{MSY}, MSST, etc., will need to be expressed as ratios with respect to the values of variables for the virgin stock. Although requiring some refinement of the descriptions for the dusky shark assessment, the methods that have been proposed in the assessment reports provide reference points or proxies for reference points that allow assessment of the extent of depletion, whether the stock is overfished relative to an MSY-based criterion, and whether, relative to an F_{MSY}-based criterion, overfishing is occurring.

Estimates of the state of the virgin stock and of MSY rely on the early catch and effort histories, on the assumptions used to develop those historical data, and on extrapolation backwards in time well beyond the extent of most of the available indices in abundance. The uncertainty, which is associated with estimates of indicator variables and reference points derived from the virgin state or the state at MSY, and which is reported by the assessment models, is likely to be underestimated, e.g. through the imposition of selectivity curves calculated outside the model and input without taking fully into account the imprecision of those curves. Nevertheless, recognising that uncertainty, the base models and sensitivity trials provide a fairly consistent indication that stocks of blacknose, dusky, and, to a lesser extent, sandbar sharks are considerably depleted and that fishing mortality is in excess of F_{MSY}.

Details of findings for ToR 3.

ATL and GOM blacknose shark and sandbar sharks.

The assessment models for the blacknose and sandbar sharks produced estimates of the values in 2009 of the following indicator variables, F_{2009}, SSF_{2009}, B_{2009}, N_{2009}, and $N_{mature2009}$, where SSF is the spawning stock fecundity, i.e., the sum of the number at age times pup production at age. As $N_{mature2009}$ is not defined in the text, it is unclear whether this variable represents the number of mature females or the number of mature sharks. The assessment models also produced estimates of the following reference points, MSY (in numbers), F_{MSY}, SSF_{MSY}, N_{MSY}, and SPR_{MSY}. From these and estimates of values of the indicator variables for the initial, unexploited stocks, estimates of the current status, i.e., F_{2009}/F_{MSY}, SSF_{2009}/SSF_{MSY}, and N_{2009}/N_{MSY}, and estimates of depletion from the virgin level, i.e. SSF_{2009}/SSF_0 and B_{2009}/B_0, were derived.

Estimates of B_{MSY} and the minimum stock size (biomass) threshold, MSST, were not calculated. The value of M that is used when calculating the latter reference point would need to take into account the age-dependent nature of M, particularly in the case when age-dependent survival is of the “bathtub” form. The value to be used as the maximum fishing mortality threshold, MFMT, was not discussed explicitly in the assessment reports.

Dusky shark

As catch data were not considered of sufficient reliability for use in the assessment model for dusky shark, and a catch-free model was employed for stock assessment, it was not possible to calculate MSY. It was possible, however, to calculate the ratio of MSY to the estimate of recruitment for the unexploited stock. Note that the equation used for this calculation, Eq. 4.24, should be modified to account for the fact that age A represents a plus group. Note also that the equation numbers in Section 3 of the assessment report for dusky shark leap suddenly from Eq. 3.10 to Eq. 4.23, and that the explanation for Eq. 4.26 refers to Eq. 4.17, which does not exist. Again, Eq. 4.26 should be modified to account for the plus group, age A.

Equations have been presented in the assessment report that explain how the number of dusky sharks in 2009 relative to the number in the virgin stock, i.e. N_{2009}, was calculated, how the apical fishing mortality in 2009, i.e. F_{2009}, was calculated, how F_{MSY} was calculated, and how SPR_{MSY} was calculated. It is possible to infer how the biomass of dusky sharks in 2009 relative to the biomass in the virgin stock, i.e. B_{2009}, was estimated. From these values, it is possible to calculate F_{2009}/F_{MSY}.

A comment is made in the caption to Table 3.6 that “Relative spawning stock biomass is defined as in Equation 3.3”, and the column containing the values relating to “relative spawning stock biomass” is headed “SSB”. If relative SSB is calculated using Eq. 3.3, then SSB is the number of pups produced by mature females relative to that produced by the virgin stock and not the biomass of mature female sharks. Accepting SSB as this variable, values of SSB_{2009} and SSB_{MSY} can be calculated using the equations of the assessment report, and from these, SSB_{2009}/SSB_{MSY} may be estimated. The assessment report presents values of SSB_{MSY}/SSB_0, but, from Eq. 3.3, SSB_0 is equal to 1 and SSB_{MSY}/SSB_0 is equal to SSB_{MSY}.

Although the assessment report for dusky shark advises that SSB_{MSST}/SSB_0 and SSB_{2009}/SSB_{MSST} were calculated, the variable SSB_{MSST} is not defined, and, if calculated from natural mortality, which of the age-dependent values of M is employed in the calculation?

Other benchmark variables calculated for the dusky shark stock were pup-survival, α (the maximum number of recruits produced by each female over its lifetime), $F_{20\%}$, $F_{30\%}$, $F_{40\%}$, $F_{50\%}$, $F_{60\%}$, and SPR_0.

ToR 4. **Evaluate the adequacy, appropriateness, and application of the methods used to project future population status. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Comment on the degree to which uncertainties are identified and evaluated, and implications of uncertainties stated. Identify any Terms of Reference which are inadequately addressed by the Data or Assessment Workshops.**

Projections

It is proposed in the assessment reports for the blacknose and sandbar sharks that Pro-2Box (Porch, 2003) will be used to assess future population status and rebuilding time with zero exploitation and with fixed F and fixed TAC strategies. The reports advise that the actual projections, which have not yet been run, will be undertaken prior to the Review Workshop. When constrained to a single stock and single management zone, the model structure that is used in Pro-2Box is consistent with the model structure that has been employed in the assessment models for the blacknose and sandbar shark stocks. Although the details of the file structure used by Pro-2Box when it reads the sets of data output by the assessment model for each bootstrap run are not explicitly described by Porch (2003), the user guide describes the use of the bootstrapping option. This indicates that the uncertainty of parameter estimates and predicted values will be carried from the ADMB code through the bootstrapped data into the Pro-2Box package. The proposed use of Pro-2Box thus appears appropriate and adequate, and the projections should reflect the implications and uncertainties of the results from the stock assessment models for the blacknose and sandbar sharks.

The assessment model for the dusky sharks was extended to allow exploration of the results of projecting the trajectories of stock status expected under a range of different fishing mortality regimes. The assessment report advises that values of B_{2009}, F_{2009}, and pup survival in 2009 used in the Monte Carlo bootstrapped runs were selected from a multinomial distribution derived from the expectations, standard deviations and covariance matrix produced by the base model. Although the text is not explicit, presumably B2009 is the relative rather than absolute biomass in 2009. A scaling factor to relate predicted relative landings to the actual landings between 1993 and

1998 was estimated by extending the likelihood function used when fitting the model. The results of the projection analysis appear appropriate and adequate, but for this and the other shark stocks, it should be recognised that the uncertainty present in the projection results relates only to the uncertainty associated with the base model and its underlying assumptions. The presence of additional uncertainty, such as that associated with the various sensitivity trials, should also be recognised.

Uncertainty

AD Model Builder provides post-convergence facilities to calculate estimates of the asymptotic standard errors and conditional profile likelihoods of parameters and specified derived variables. It also provides a post-convergence Markov Chain Monte Carlo (MCMC) utility that can be used to produce estimates of the true marginal distributions of the posterior probability distributions of those parameters and of derived variables. The assessment models for all four shark stocks reported the asymptotic standard deviations that were output by ADMB following model convergence. The dusky and sandbar shark models made use of ADMB's facility to produce conditional profile likelihoods for selected parameters and stock status indicators. An attempt was made in the dusky shark assessment to employ ADMB's MCMC facility but, because of autocorrelation, convergence was not achieved despite a very large number of iterations. Thus, results from the MCMC analysis for the dusky shark were unreliable and the Assessment Workshop reverted to the use of profile likelihoods to explore the imprecision of estimates of various parameters and indicators of stock status. Note that it is useful to also plot the contributions made by the different components when plotting the profile likelihoods as this may assist in identifying inconsistencies among data sets. Note also that it is useful to confirm that a model has fully converged and that the resulting parameter estimates are stable through use of a jitter test, where, for a number of trials, initial values of the parameters are selected randomly from their feasible ranges, the model is fitted for each set of initial parameters, and the resulting likelihoods and parameter estimates are compared.

A second element of uncertainty is that which is associated with the choice of model structure. Thus, for the blacknose, dusky, and sandbar sharks, a decision was made to model the combined sexes rather than to treat males and females separately, to ignore any size- or age-dependent spatial distribution of the sharks, i.e., to treat the area as a single region, and to treat removals from the stock within this area by different fishing sectors and gears as arising from fishing a common stock with different selectivity functions. For some key elements of model structure, such as whether natural mortality is constant or age-dependent, and, if the latter, the form of the relationship of natural mortality with age, explicit alternative model structures have been developed. Thus, while the base model for each stock assumed that the value of natural mortality at age was the maximum of the values calculated using the approaches described by Hoenig (1983), Chen and Watanabe (1989), Peterson and Wroblewski (1984), and Lorenzen (1996), results obtained using an alternative U-shaped relationship of natural mortality with age were explored in a sensitivity trial for each stock. The implications of a two or three rather than 2.5 year reproductive cycle were also explored in the sensitivity trials for the sandbar shark, while, for the dusky sharks, the possibilities that (1) the catchability of bottom long lines decreased in 2000, and (2) the selectivity function for pelagic long lines was dome shaped rather than logistic were explored in sensitivity trials. The results obtained by fitting the different models should be assessed, e.g. by comparison of the Akaike Information Criteria, and the extent to which the data support the different models evaluated, e.g. through evaluation of Akaike Weights. Thus, comparing the values of the AIC, after correcting for low sample size, the models with a U-shaped relationship of natural mortality with age produce a poorer fit than the base model for the two blacknose shark stocks, but not for the sandbar shark. In addition, the model that assumes a two-year reproductive cycle for the sandbar sharks provides a slightly better fit than the base model, which assumes 2.5 years, and the base model provides a slightly better fit than the sensitivity trial that assumed a three-year reproductive cycle. No data were presented for the dusky shark that would allow an assessment of the quality of the fit provided by the alternative model trials.

A further element that contributes to the uncertainty of parameter estimates and model predictions is the set of weights that are assigned to the different likelihood components, particularly when the data sets associated with those likelihoods are inconsistent, i.e. support quite different parameter estimates, reference points, and values of indicator variables. The set of weights is often used to remove or down weight the influence of specific components to explore the inconsistencies among the data sets that might exist, and to identify where further research may be needed to determine which of the contradictory data sets are likely to be more accurate and/or which processes are poorly described. As the change in weights results in a change in the value of the overall likelihood for a given set of parameters, it is inappropriate to compare the values of the AIC for these trials or, using such comparison, to attempt to assess which of the models provides the best fit.

For the Atlantic blacknose shark stock, a number of sensitivity trials that explored different weights for the various abundance indices or included different sets of indices, i.e., sensitivity trials 1, 3, and 7, were compared with the results obtained when fitting the base model. The model failed to converge for sensitivity trials 1 and 3 and the results for these trials are unreliable. Scenarios 1 and 3 for the GM blacknose shark stock explored different weights and/or data sets from those used for the base model, and in both cases the runs converged. For the sandbar shark, sensitivity trials S1, S2, S8, and S9, all of which converged, explored the implications of different weights and/or the inclusion of different indices of abundance. A number of sensitivity trials for the dusky shark explored the results of applying different weights to the abundance indices, or including different indices when fitting, i.e. S6, S7, S8, S10, and S11. From the discussion of the results of these sensitivity trials, each appears to have converged.

These sensitivity trials, which explore the influence of applying different weights to the various abundance indices or including different subsets of the suite of abundance indices that are available, provide a range of results that, for the set of trials that have been explored, reflects the uncertainty associated with the indices of abundance. Thus, estimates of stock status potentially range over the full range of the values of stock status estimated by the base model and the various sensitivity runs, and must also take into account the imprecision of each estimate. If the information contained in the different indices of abundance is consistent, similar values will be produced by each sensitivity run. However, if inconsistent, the range of values may be large, and consideration may need to be given to undertaking research to determine which of the indices is most accurate and identifying factors that lead to bias in survey estimates.

The need to identify uncertainties in data and to develop alternative data sets that reflect these uncertainties and then to explore the influence of these alternative data sets through sensitivity runs of the assessment model has been raised earlier.

There is value in bringing calculations that are undertaken externally into the model such that all calculations are internal. This ensures that (1) uncertainty associated with the calculations is carried through to model output, and (2) a common set of assumptions is employed in all calculations.

Terms of Reference for Data Workshop

1. *Characterize stock structure and develop a unit stock definition. Provide maps of species and stock distribution.*

   Partially achieved. Two stocks of blacknose sharks were identified by the Data Workshop, one occupying the Gulf of Mexico and the other located in the Atlantic, but no map of the species and stock distribution was provided.

2. *Review, discuss and tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling.*

   Achieved. The Data Workshop noted the lack of direct empirical data to provide estimates of natural mortality for blacknose, sandbar, and dusky sharks. For all stocks and fishing gears, there was a lack of data on post-release discard mortality. Due to low sample sizes, data from the Gulf of Mexico and Atlantic stocks were pooled when fitting a growth model for blacknose sharks. The paucity of data on reproduction of blacknose sharks led to determination of litter size by consensus among scientists rather than analysis. Further research is necessary to determine the reproductive cycle for sandbar sharks.

3. *Provide measures of population abundance that are appropriate for stock assessment. Consider and discuss all available and relevant fishery dependent and independent indices. Document all programs evaluated, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey coverage. Develop CPUE and index values by appropriate strata (e.g., age, size, area, and fishery); characterize uncertainty. Evaluate the degree to which available indices adequately represent fishery and population conditions. Consider implications of changes in gear, management, fishing effort, etc. in relationship to the different indices. Recommend which indices are considered statistically adequate and biologically plausible for use in assessment modeling.*

Achieved. Much of the documentation required to achieve this term of reference lies within the background documents prepared for the Data Workshop.

4. *Characterize commercial and recreational catch by gear. Include both landings and discards, in pounds and number by gear type as feasible. Provide estimates of dead discard proportions by fishery and other strata as appropriate or feasible. Evaluate and discuss the adequacy of available data for accurately characterizing fishery removals by species, area, gear type, and fishery sector. Consider implications of changes in gear, management, fishing effort, etc. in reconstructing historic catches. Provide length and age distributions if feasible. To provide context and spatial scale of species distribution, fishery effort, and data coverage, provide maps of fishery effort and harvest, as available.*

   Achieved. Issues identified by the data workshop were the inadequacy of the data relating to post-release discard mortality, low sample sizes of data to characterize length composition of blacknose shark catches in observer programs and research surveys, low sample sizes for recreational catches, and, for all stocks, the need to develop a more appropriate approach to convert length composition to age composition. Maps showing the distribution of fishing effort were not produced, and presumably were not available.

5. *Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.*

   Partially achieved. Recommendations for future work were presented in Section 4 of the full assessment report. While it was recommended that coverage in observer programs should be increased to 5%, specific guidance on sampling intensity was not provided.

6. *Develop a spreadsheet of assessment model input data that reflects the decisions and recommendations of the Data Workshop. Review and approve the contents of the input spreadsheet.*

   Achieved.

7. *Prepare the Data Workshop report providing complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report). Provide a list of tasks that were not completed during the meeting week, who is responsible for completing each task, and when each task will be completed.*

   Achieved. It was noted in the Data Workshop reports that revisions recommended in the Data Workshop had been made, that indices had been constructed for survey data that was late in arriving at the Workshop, and that the indices had been ranked at a subsequent webinar. Thus, presumably there were no other outstanding tasks.

Terms of Reference for Assessment Workshop

1. *Review data, including any changes since the Data Workshop, and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.*

   Achieved.

2. *Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations.*

   Partially achieved. Some aspects of documentation, such as details of the objective function and the component likelihood functions, are missing. The documentation for the dusky shark needs to be refined.

3. *Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates.*

   Achieved. For the dusky shark, as a catch-free model was employed, recruitment, abundance, and biomass estimates are relative rather than absolute measures. Selectivity was estimated outside the model. When attempting to fit the assessment model for each of the blacknose shark stocks, the estimated value of pup survival at age 0 hit the upper limit of the range and the model failed to converge. Accordingly the value of the parameter was fixed for these two stocks, i.e., this parameter was not estimated.

4. *Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and 'goodness of fit'.*

   Partially achieved. A range of sensitivity analyses were undertaken and the influence on the estimated values and on the extent of depletion of selected changes to input data and model structure, and the use of alternative abundance indices or alternative weighting given to these indices, was explored. The assessment report for the two blacknose shark stocks, and for the sandbar stock, advises that a comparison of model fits will be undertaken before the Review Workshop.

5. *Provide spawning stock fecundity and stock-recruitment evaluations, including figures and tables of complete parameters.*

   Achieved. A table and plot of the time series of estimated values of spawning stock fecundity derived from the base model were presented for the Atlantic stock of blacknose sharks, together with a plot of the stock-recruitment relationship, on which the estimated values are presented. Parameters of the stock-recruitment relationship were presented in the tables. Similar data were presented for the

GOM stock of blacknose sharks and for sandbar sharks. Although incorrectly referred to as relative spawning stock biomass, a table of estimated values of relative spawning stock fecundity and relative recruitment for dusky shark was presented in the stock assessment report.

6. *Provide estimates for benchmark and biological reference points, consistent with the Consolidated HMS FMP, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards. This may include: evaluating existing reference points, estimating benchmarks or alternative benchmarks, as appropriate, and recommending proxy values.*

   Achieved. For each of the stocks, an assessment was made of the current (2009) status of fishing mortality and stock size. It would have been useful if the relationship between the reference points that were used and those of the Consolidated HMS FMP, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards had been discussed in the assessment document to demonstrate that the reference points or proxies used were indeed consistent with the accepted standards.

7. *Provide declarations of stock status based on the status determination criteria.*

   Achieved.

8. *Provide stochastic projections of stock status at various harvest or exploitation levels for various timeframes.*

   Partially achieved. While projections of stock status have been explored for dusky shark, the assessment reports advise that projections for the two stocks of blacknose sharks and for sandbar shark will be completed before the Review Workshop.

9. *Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules, if warranted. Provide the estimated generation time for each unit stock. Stock projections shall be developed in accordance with the following:*
   A) If stock is overfished:
   F=0, F=current, F=Fmsy, Ftarget (OY),
   F=Frebuild (max that rebuild in allowed time)
   B) If stock is undergoing overfishing:
   F=0, F=Fcurrent, F=Fmsy, F= Ftarget (OY),
   F=Freduce (different reductions in F that could prevent overfishing, as appropriate)
   C) If stock is neither overfished nor undergoing overfishing:
   F=Fcurrent, F=Fmsy, F=Ftarget (OY)

   Partially completed. Generation time has been estimated for all four stocks. While projections of stock condition and rebuilding have been explored for dusky shark, the assessment reports advise that projections for the two stocks of blacknose sharks and for sandbar shark will be completed before the Review Workshop.

9. *Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity and emphasize items which will improve future assessment capabilities and reliability.*

   Achieved.

10. *Prepare an accessible, documented, labelled, and formatted spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and any projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.*

    Not achieved.

11. *Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report). Provide a list of tasks that were not completed, who is responsible for completing each task, and when each task will be completed.*

    Partially achieved. Tasks to be undertaken were identified in the relevant sections, and the due date, i.e. before the Review Workshop, specified. The individuals/research team responsible for the tasks were not explicitly identified.

ToR 5. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments.

A number of the research recommendations of the Data and Assessment Workshops for the Atlantic and Gulf of Mexico blacknose shark stocks, and the sandbar and dusky shark stocks were common to all stocks. Thus, grouping these and restating the recommendations slightly (shown in blue italics), the Workshops recommended the following:

Life history

- *Increase research on post-release survivorship of all shark species by gear type*

  Current estimates of post-release survival are highly uncertain. The assessments would be improved by more accurate and precise estimates.

- *Update age and growth and reproductive studies for all four stocks*
  - *blacknose sharks*
    - *emphasis on smaller individuals in the Atlantic and larger individuals in the Gulf of Mexico.*
    - *more information on litter size and reproductive periodicity is needed.*
  - *sandbar sharks*
    - *Continue to investigate reproductive periodicity*
    - *Continue to collect vertebral samples from the shark research fishery to develop an ageing material archive and to keep track of*

the age distribution of the catch, and continue monitoring juvenile shark ages through the collection of fishery-independent samples

Age, growth and reproductive studies should be pursued to reduce the uncertainty relating to various aspects of the life histories of these four stocks. The suggestion that there should be an emphasis on smaller individuals in the Atlantic and larger individuals in the Gulf of Mexico requires that, in a two-phase stratified sampling design to produce estimates of age composition, larger proportions of the sharks in smaller and larger length classes are aged. Thus, when estimating life history parameters, the analysis would need to take into account the fact that the length distribution of fish at age for younger and older sharks would be biased towards smaller and larger individuals, respectively. The development of an ageing material archive would establish a valuable resource that would aid future ageing studies. The recommendation to continue monitoring juvenile shark ages focuses on a single group of sharks. Monitoring studies should be considered in the context of the information required for stock assessment of the entire stock, and the question that needs to be considered is how monitoring the juvenile sharks would contribute to the overall monitoring need. While monitoring juveniles would make a valuable contribution, the monitoring program may need to be broadened to provide the data that are needed for stock assessment.

- *Develop empirically based estimates of natural mortality for all four stocks*

Reliable estimates of natural mortality at different ages through the life of the various shark species would improve the accuracy and precision of the stock assessment greatly.

- *Continue tagging efforts*

It is not possible to comment on this recommendation as insufficient information was provided in the assessment reports as to what the tagging data would be likely to contribute to improving the accuracy and precision of the assessments.

- *For blacknose sharks, undertake population level genetic studies for stock discrimination(s).*

Reliable information on stock structure is essential.

Commercial statistics

- *Observer coverage*
    - *Blacknose*
        - *expansion of the shrimp trawl observer coverage towards a goal of 2 to 5 % of the total effort.*
        - *strive for even spatial coverage (particularly adding more south Atlantic coverage), randomness in vessel selection, and full identification to species of elasmobranchs.*
    - *Sandbar*
        - *Expand observer coverage to obtain 5% coverage of total trips or 20 to 30% PSE (percent standard error).*
        - *Conduct more studies to better estimate post-release mortality*

- *Review bycatch estimation models*
- *Discard rates of sandbar sharks in the current directed and non-directed bottom longline fishery should be calculated and extrapolated using BLLOP data.*
- *Continue to develop better methods to quantify discards and effort from logbook programs and observer programs*

Observer programs are typically developed with a sound statistical sampling design and clear objectives. Over time, however, fisheries and objectives evolve and the original sampling design may lose some of its original statistical integrity. The recommendation to strive for even spatial coverage and randomness in vessel selection in the observer program for the blacknose shark stocks suggests that a review of sampling design is warranted. If the sampling design is modified, however, the comparability of old with new data needs to be considered. Thus, the time series of data may be modified to the extent that the series is "broken". A period of overlap of the old with the new sampling design may allow the new "measures" to be calibrated with the old. The percentage coverage should be determined by the nature of the data and the precision that is to be achieved, not by comparison with the typical level of coverage in other fisheries. The need to achieve full identification of elasmobranch species is emphasized by the difficulties encountered by the Data Workshop in dealing with shark catches and discards that were not broken down to the species level. There is a clear need to improve the reliability of the estimates of the removals from the different stocks due to discards and discard mortality. Improved methods of quantifying discards would improve the reliability of future stock assessments.

Recreational statistics

- *No specific research recommendations were provided.*

Indices of abundance

- *Specific research recommendations, if provided, were given for each index.*

Assessment

- *Investigate alternative approaches to age-length keys for estimating age from length*
- *Blacknose*
  - *Improve observer coverage, particularly during regulatory or gear changes in the fishery.*
  - *Longer time series for surveys will always aid the assessment process. However, it is equally important to maintain the sampling methods and document them well for the most appropriate statistical analyses to be applied to the data.*
  - *More time was necessary to complete the data vetting process for this many species, and in the future we strongly recommend that no more than probably two stocks be assessed simultaneously with the same number of participants.*
- *Dusky*
  - *Improve the reliability of removal data*
  - *Develop a stock-wide fishery independent monitoring program.*

- *Develop a consistent life history sampling program that gathers annual samples of length and age-frequencies.*

The fact that, in many cases, data on the age compositions of the removals and abundance indices were inadequate to fit selectivity curves provides strong evidence that current monitoring programs are not providing the types of data that are essential for reliable stock assessment. It was recommended by the Assessment Workshop that there should be an investigation of alternative approaches to the use of age-length keys to determine reliable estimates of age from length. The key to determining reliable estimates of age composition is the establishment of a well-designed sampling program to collect representative length and age data for an appropriate number of sharks. If existing data are insufficient to develop reliable age-length keys and produce sound estimates of age compositions, it may prove better to predict the length composition of the removals data and abundance indices in the model and fit these predictions to the observed length data thereby estimating the parameters of the selectivity curves internally within the model rather than externally to unreliable age composition data.

Reviewer's Research Recommendations

Having considered the research recommendations that were proposed by the Data and Assessment Workshops, I now set down my view of research that might improve the quality of the assessments. There are two key areas of concern, i.e. the quality of the data that are input to the assessment model and the assessment of the uncertainties associated with the estimates of stock status.

Turning firstly to the quality of the data that are input to the assessment, I should first acknowledge the quality of the work done by the Data Workshop and scientists responsible for preparing the background documents. They had the difficult task of synthesizing historical and modern data to produce the tables of data and parameter estimates that made the assessment possible. Even for more recent years, there was still a need to resolve data issues such as the duplication of data in different databases, allocation of unclassified catch and discard data to individual species, estimation of catches of the different shark species that were taken in Mexico or as bycatch of the Gulf Menhaden fishery, etc. It would be useful to review the approaches that were used to produce estimates of the total 2009 removals from each stock by each fishing sector/gear type, and, where it was necessary to make assumptions to estimate a component of the total, to develop or refine the methods of data collection to resolve the need for those assumptions. **It is recommended that, where it has been necessary to introduce assumptions to estimate the current removals of blacknose, sandbar and dusky sharks for some sections of the fisheries or some gear types, methods of data collection are refined to improve the quality of the data that are collected, such that, where possible, the need for such assumptions is obviated**. This recommendation has been made as it is not clear from the assessment reports that, where it is possible, action is being taken to improve future data collection such that the deficiencies that have been noted by the Data Workshop are being addressed.

The Assessment Workshop is to be commended for constructing low and high time series of catch estimates for the blacknose and sandbar shark stocks and thereby attempting to incorporate uncertainty in the magnitude of the catches as recommended by the DW CIE reviewer. For this, estimates were derived by using the lower and upper 95% confidence intervals for the average weight used to convert the weight of sharks landed by commercial fishers to numbers landed, the estimates of recreational catch calculated from the MRFSS data, and, in the case of blacknose sharks, the estimates of bycatch from the shrimp fishery. For blacknose sharks, the means of the ratios of the lower and upper limits to the estimated value for each year from 1972 to 2009 were used in extrapolating catches for 1950-1971. While this approach addresses some of the statistical uncertainty, other sources of uncertainty need to be considered, e.g., the imprecision of the proportions used when extrapolating or allocating catch among species, regions or gear types. Particular attention should be given to uncertainty that is introduced through the assumptions that are made by considering the range of outcomes that might arise from alternative, equally viable assumptions, e.g. the assumptions used when reconstructing historical catch to the year in which the stock was assumed to be in a virgin state. For other fisheries, catch reconstruction has involved trawling through reports and records, and obtaining anecdotal data from fishers and dealers, to determine a subjective range of likely values of historical catches, then using the lower and upper bounds of the resulting time series as alternative scenarios to assess the sensitivity of the results of the stock assessment model to these scenarios. **It is recommended that the sensitivity of the assessment to uncertainties associated with the development of the removals data, particularly those associated with the reconstruction of the earlier data in the historical period, is assessed.**

As the Data and Assessment Workshops have already identified, the data that are available to characterize the age compositions of removals and indices of abundance are inadequate. **It is recommended that monitoring programs are expanded to collect appropriate age and length samples from the catches and discards of the commercial fishers employing different gear types, from catches of recreational fishers, and from the catches taken in research surveys, and thereby to provide a reliable estimate of the age composition that characterizes each survey index and the removals by each gear type and fishing sector.**

The recommendation of the Data and Assessment workshops, that research is needed to improve the estimates of the numbers of sharks that are discarded and the survivorship of those sharks that are caught and discarded, is strongly endorsed. From the assessment reports, this was clearly a source of considerable uncertainty.

The recommendations of the Data and Assessment workshops, that research is needed to improve knowledge of growth, maturity, and the reproductive cycle, are also endorsed. These are important as the structure of the stock assessment models is based on the life history of the sharks and information on maturity and the reproductive cycle is essential in the model of the stock-recruitment relationship.

Uncertainty in the estimate of the instantaneous rate of natural mortality is a major source of uncertainty for most stock assessment models. In the case of shark stocks, where natural mortality is considered to be age-dependent, the uncertainty increases as not only is the magnitude of the mortality important, but so also is the trend with age. Research to obtain estimates of natural mortality at age is therefore strongly endorsed.

In considering the contribution that different data sets provide to an assessment of the status of the shark stocks, it becomes clear that, for the period prior to the beginning of the time series of abundance estimates, the historical removals data or, in the case of dusky sharks, historical fishing effort data, can provide information only on the extent to which the stock is depleted. Information on the changes in abundance that result from different levels of removals, relationships between indices of abundance and actual abundance, and on the stock-recruitment relationship must be derived from the period when both abundance indices and removals, or, in the case of dusky sharks, fishing effort, are available. Thus, the abundance indices are crucial to understanding how the stocks have responded to the removals. If abundance indices are imprecise, inconsistent or, taking the selectivity of the fishing gear and survey into account, unrepresentative of the abundance of the stock, estimates of stock status are likely to be imprecise and unreliable.

Indices of abundance that are currently employed in the base models exhibit apparently inconsistent trends and the fitted models represent a compromise between the alternative signals. The resulting uncertainty of the trajectory of population abundance leads to increased imprecision in the parameters estimated by the model. The fact that indices appear to exhibit different trends suggests that some indices are providing a poor representation of the trend in the overall abundance of the stock. Identification of these indices, such that their influence on model outcomes can be removed, will require a more thorough investigation of the inconsistencies that are present among the different indices of abundance, taking into account the different selectivity patterns of the fishing gear used to collect the data from which values of these indices are derived. **It is recommended that inconsistencies among abundance indices are explored by examining the statistical adequacy of the survey design of each index, evaluating the extent to which the data collected to derive the values of the index are representative of the population, and assessing whether any processes might exist that would cause the time series of values for the index to exhibit a trend that differs from that exhibited by population abundance.**

ToR 6. Prepare a Peer Review Report documenting findings pertaining to these Terms of Reference.

This report documents the findings with respect to the above terms of reference.

5. Conclusions and recommendations

This report reiterates many of the conclusions of the Data and Assessment Workshops, which reported on the deficiencies and uncertainties of various data and the implications of those uncertainties to the results of the stock assessment. Despite the deficiencies that exist, the data are in fact relatively comprehensive compared with those that are available for many other shark fisheries. Thus, for example, examination of the scientific literature for many shark species reveals that the sample sizes used to assess maturity and reproductive cycles are typically small, that there is a high level of uncertainty (and often subjectivity) in the assessment of reproductive cycles, and that ageing is often very difficult. The fisheries that exploit sharks often target other species or a complex of species, and lack of classification of catches to species level is frequently an impediment to stock assessment. The Data and Assessment Workshops are therefore to be commended for their collation of the data for the blacknose, sandbar, and dusky shark stocks and for their development of assessment models that appear appropriate given the life histories of those stocks and the types of data that are available.

A number of recommendations have been made in this report, many of which duplicate the recommendations of the Data and Assessment Workshops. Although it is planned to move from the current assessment model to Stock Synthesis III, the suggestions that have been made should be relevant to that environment. One of the features of Stock Synthesis is that it encourages internalization of estimation. Thus, the advantage of fitting selection curves within the assessment model rather than externally to the model ensures that the uncertainty associated with fitting the selection curves is considered when assessing the estimates of stock status.

If requested to identify the area of greatest concern in the stock assessment, i.e., the area on which research should focus, I would select the need to refine the indices of abundance and to determine the extent to which each provides an accurate indication of the trends in abundance such that an appropriate weighting can be applied or an appropriate selection curve used if the index is representative of only a portion of the stock. The next area of concern is to improve the reliability of the estimates of uncertainty of the parameters, benchmark reference points, and indicator variables that are produced by the model. This would entail incorporation of the uncertainty associated with the assumptions that were employed when producing estimates of removals. A key uncertainty here is likely to be the trend that was assumed when reconstructing historical catches. A third area of concern is the characterization of the age composition of removals by different gear types and of abundance indices. The ability to improve this characterization is constrained by the data that are available and the key to improving this aspect of the assessment is likely to be the collection of appropriate age and length data from the various fishing sectors and research surveys. Thus the review and possible refinement or implementation of monitoring regimes capable of producing reliable and precise estimates of abundance, together with reliable estimates of age composition, should be of high priority. Other research needs include the development of more reliable estimates of age-dependent natural mortality and improved knowledge of life history.

The assessments of the blacknose, sandbar and dusky shark stocks have yielded estimates of stock status that, allowing for the range of uncertainties considered in the scenarios evaluated in the various sensitivity trials, were relatively consistent. While the reliability of the assessments would be improved by the proposed research and the acquisition of additional data, the results of the assessments appear sufficiently reliable to be used as indicators of the current status of the stocks provided that the underlying assumptions of the data and model structure and the uncertainties exhibited in the base model and various sensitivity trials are taken into consideration.

6. References

Chen, S.B. and Watanabe, S. 1989. Age dependence of natural mortality coefficient in fish population dynamics. Nippon Suisan Gak. 55:205-208.

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 81:898–903.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. J. Fish Biol. 49:627-647.

NMFS (National Marine Fisheries Service). 1996. 1996 Report of the Shark Evaluation Workshop. NOAA, NMFS, SEFSC, Miami, FL. 80 p.

Peterson, I. and Wroblewski, J.S. 1984. Mortality rates of fishes in the pelagic ecosystem. Can. J. Fish. Aquat. Sci. 41:1117-1120.

Porch, C.E. 2003. Pro-2Box v.2.01 User's guide.

Appendix 1: Bibliography of all material provided

Data Workshop Reports (from SEDAR FTP Site)

Title	***Authors***
SEDAR 21 Blacknose Shark Data Workshop Report	SEDAR 21 Panels
SEDAR 21 Dusky Shark Data Workshop Report	SEDAR 21 Panels
SEDAR 21 Sandbar Shark Data Workshop Report	SEDAR 21 Panels

Documents prepared for the Data Workshop (from SEDAR FTP Site)

Document #	***Title***	***Authors***
SEDAR21-DW-01	Standardized catch rates of sandbar and blacknose shark from a fishery independent survey in northwest Florida, 1996-2009.	J. Carlson and D. Bethea
SEDAR21-DW-02	Standardized catch rates of sandbar, dusky and blacknose sharks from the Shark Fishery Bottom Longline Observer Program, 1994-2009	J. Carlson, L. Hale, A. Morgan and G. Burgess
SEDAR21-DW-03	Standardized Catch Rates of Blacknose Shark from the Southeast Shark Drift Gillnet Fishery: 1993-2009	J. Carlson and M. Passerotti
SEDAR21-DW-04	Standardized Catch Rates of Blacknose Shark from the Southeast Sink Gillnet Fishery: 2005-2009	J. Carlson and M. Passerotti
SEDAR21-DW-05	Effects of turtle excluder devices (TEDs) on the bycatch of small coastal sharks in the Gulf of Mexico Penaeid shrimp fishery	S.W. Raborn, K.I. Andrews, B.J. Gallaway, J.G. Cole, and W.J. Gazey
SEDAR21-DW-06	Reproduction of the sandbar shark *Carcharhinus plumbeus* in the U.S. Atlantic Ocean and Gulf of Mexico	Baremore, I. and L. Hale
SEDAR21-DW-07	Description of data sources used to quantify shark catches in commercial and recreational fisheries in the U.S. Atlantic Ocean and Gulf of Mexico	Baremore, I.E., Balchowsky, H., Matter, V, Cortés, E.
SEDAR21-DW-08	Standardized catch rates for dusky and sandbar sharks from the US pelagic longline logbook and observer programs using generalized linear mixed models.	E. Cortés
SEDAR21-DW-09	Updated catches of sandbar, dusky and blacknose sharks	E. Cortés
SEDAR21-DW-10	Large and Small Coastal Sharks Collected Under the Exempted Fishing Program Managed by the Highly Migratory Species Management Division	J. Wilson
SEDAR21-DW-11	Indices of Abundance from the Marine Recreational Fisheries Statistics Survey	Babcock, E.A.
SEDAR21-DW-12	Catches of Sandbar Shark from the Southeast US Gillnet Fishery: 1999-2009	M.S. Passerotti and J.K. Carlson

SEDAR21-DW-13	Errata Sheet for 'Catch and Bycatch in the Shark Gillnet Fishery: 2005- 2006', NOAA Technical Memorandum NMFS-SEFSC-552	M.S. Passerotti and J.K. Carlson
SEDAR21-DW-14	Data Update to Illegal Shark Fishing off the coast of Texas by Mexican Lanchas	K. Brewster-Geisz, S. Durkee, and P. Barelli
SEDAR21-DW-15	An update of blacknose shark bycatch estimates taken by the Gulf of Mexico penaeid shrimp fishery from 1972 to 2009	W.J. Gazey, J.G. Cole, and K. Andrews
SEDAR21-DW-16	A Negative Binomial Loglinear Model with Application for the Estimation of Bycatch of Blacknose Shark in the Gulf of Mexico Penaeid Shrimp Fishery	W.J. Gazey, K. Andrews, and B.J. Gallaway
SEDAR21-DW-17	Life history parameters of the sandbar shark, *Carcharhinus plumbeus*, in the Northwest Atlantic	Romine, J.G. and Musick, J.A.
SEDAR21-DW-18	Standardized catch rates of sandbar sharks and dusky sharks in the VIMS Longline Survey: 1975- 2009	Romine, J.G., Parsons, K.T., Grubbs, R.D., Musick, J.A., and Sutton, T.T.
SEDAR21-DW-19	Updating the blacknose bycatch estimates in the Gulf of Mexico using the Nichols method	K. Andrews
SEDAR21-DW-20	Tag and recapture data for blacknose, *Carcharhinus acronotus*, sandbar, *C. plumbeus*, and dusky shark, *C. obscurus*, as kept in the NOAA Fisheries Southeast Fisheries Science Center Elasmobranch Tagging Management System, 1999-2009	D.M. Bethea and Carlson, J.K.
SEDAR21-DW-21	Age and growth of the sandbar shark, *Carcharhinus plumbeus*, from the Gulf of Mexico and the United States southern Atlantic Ocean.	L.F. Hale and I.E. Baremore
SEDAR21-DW-22	Shark Bottom Longline Observer Program: Catch and bycatch 2005 to 2009	Hale, L.F., S.J.B. Gulak, and J.K. Carlson
SEDAR21-DW-23	Identification and evaluation of shark bycatch in Georgia’s commercial shrimp trawl fishery with implications for management	C. N. Belcher and C.A. Jennings
SEDAR21-DW-24	Increases in maximum observed age of blacknose sharks, *Carcharhinus acronotus*, based on three long term recaptures from the western north Atlantic	B.S. Frazier, W.B. Driggers III, and C.M. Jones
SEDAR21-DW-25	Catch rates and size distribution of blacknose shark *Carcharhinus acronotus* in the northern Gulf of Mexico, 2006-2009	J. M. Drymon, S.P. Powers, J. Dindo and G.W. Ingram
SEDAR21-DW-26	Reproductive cycle of sandbar sharks in the northwestern Atlantic Ocean and Gulf of Mexico	A. Piercy

SEDAR21-DW-27	Standardized catch rates for juvenile sandbar sharks caught during NMFS COASTSPAN longline survey in Delaware Bay	C.T. McCandless
SEDAR21-DW-28	Standardized catch rates for sandbar and dusky sharks from the NMFS Northeast Longline Survey	C.T. McCandless and L.J. Natanson
SEDAR21-DW-29	Standardized catch rates [for] sandbar and blacknose sharks from the GADNR COASTSPAN and red drum longline surveys	C.T. McCandless and C.N. Belcher
SEDAR21-DW-30	Standardized catch rates of sandbar and blacknose sharks from the SCDNR COASTSPAN and red drum surveys	C.T. McCandless and B. Frazier
SEDAR21-DW-31	Standardized catch rates for sandbar and dusky sharks from exploratory longline surveys conducted by the Sandy Hook, NJ and Narragansett, RI labs: 1961-1996	C.T. McCandless and J.J. Hoey
SEDAR21-DW-32	Not available on SEDAR FTP site	
SEDAR21-DW-33	Standardized catch rates for blacknose, dusky and sandbar sharks caught during a UNC longline survey conducted between 1972 and 2009 in Onslow Bay, NC	F.J. Schwartz, C.T. McCandless, and J.J. Hoey
SEDAR21-DW-34	Sandbar and blacknose shark occurrence in standardized longline, drumline, and gill net surveys in southwest Florida coastal waters of the Gulf of Mexico	R. Hueter, J. Morris, and J. Tyminski
SEDAR21-DW-35	Atlantic Commercial Landings of blacknose, dusky, sandbar, unclassified, small coastal, and requiem sharks provided by the Atlantic Coastal Cooperative Statistics Program (ACCSP)	C. Hayes
SEDAR21-DW-36	Life history and population structure of blacknose sharks, *Carcharhinus acronotus*, in the western North Atlantic Ocean	W.B. Driggers III, J.K. Carlson, B. Frazier, G.W. Ingram Jr., J.M. Quattro, J.A. Sulikowski, and G.F. Ulrich
SEDAR21-DW-37	Movements and environmental preferences of dusky sharks, *Carcharhinus obscurus*, in the northern Gulf of Mexico	E. Hoffmayer, J. Franks, W. Driggers, and M. Grace
SEDAR21-DW-38	Preliminary Mark/Recapture Data for the Sandbar Shark (*Carcharhinus plumbeus*), Dusky Shark (*C. obscurus*), and Blacknose Shark (*C. acronotus*) in the Western North Atlantic	N.E. Kohler and P.A. Turner
SEDAR21-DW-39	Catch rates, distribution and size composition of blacknose, sandbar and dusky sharks collected during NOAA Fisheries Bottom Longline Surveys from the U.S. Gulf of Mexico and U.S. Atlantic	W. Ingram

	Ocean	
SEDAR21-DW-40	Standardized catch rates of the blacknose shark (*Carcharhinus acronotus*) from the United States south Atlantic gillnet fishery, 1998-2009	K. Erickson and K. McCarthy
SEDAR21-DW-41	Index of Abundance of Sandbar Shark (*Carcharinus plumbeus*) in the Southeast Region, 1992-2007, from United States Commercial Fisheries Longline Vessels	H. Balchowsky and K. McCarthy
SEDAR21-DW-42	Examination of commercial bottom longline data for the construction of indices of abundance of dusky shark in the Gulf of Mexico and US South Atlantic	K. McCarthy
SEDAR21-DW-43	Indices of abundance for blacknose shark from the SEAMAP trawl surveys	A. Pollack, W. Ingram, and K. Andrews
SEDAR21-DW-44	Standardized catch rates of sandbar sharks (*Carcharhinus plumbeus*) and dusky sharks (*Carcharhinus obscurus*) from the large pelagics rod and reel survey 1986-2009	J, Walter and C,A. Brown
SEDAR21-DW-45	A note on number of pups for two blacknose sharks (*Carcharhinus acronotus*) from the Gulf of Mexico	D.A. Stiller
SEDAR21-DW-46	Not available on SEDAR FTP site	

Workshop data from Data Workshop (from SEDAR FTP Site)

Title	***Authors***
Blacknose Shark Data Workshop Spreadsheet	SEDAR 21 Data Workshop
Dusky Shark Data Workshop Spreadsheet	SEDAR 21 Data Workshop
Sandbar Data Workshop Spreadsheet	SEDAR 21 Data Workshop

Supplementary documents for Data Workshop (from SEDAR FTP Site)

Document #	***Title***	***Authors***
SEDAR21-RD01	SEDAR 11 Stock Assessment Report – Large Coastal Shark Complex, Blacktip and Sandbar Shark	SEDAR 11 Panels
SEDAR21-RD02	SEDAR 13 Stock Assessment Report - Small Coastal Shark Complex, Atlantic Sharpnose, Blacknose, Bonnethead, and Finetooth Shark	SEDAR 13 Panels
SEDAR21-RD03	Stock assessment of dusky shark in the U.S. Atlantic and Gulf of Mexico	E. Cortés, E. Brooks, P. Apostolaki, and C.A. Brown
SEDAR21-RD04	Report to Directed Shark Fisheries, Inc. on the 2006 SEDAR 11 Assessment for Sandbar Shark	F.J. Hester and M, Maunder

SEDAR21-RD05	Use of a Fishery-Independent Trawl Survey to Evaluate Distribution Patterns of Subadult Sharks in Georgia	C.N. Belcher and C,A. Jennings
SEDAR21-RD06	Demographic analyses of the dusky shark, *Carcharhinus obscurus*, in the Northwest Atlantic incorporating hooking mortality estimates and revised reproductive parameters	J,G. Romine, J.A. Musick, and G,H. Burgess
SEDAR21-RD07	Observations on the reproductive cycles of some viviparous North American sharks	J.I. Castro
SEDAR21-RD08	Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery	I.C. Stobutzki, M.J. Miller, D.S. Heales, and D.T. Brewer
SEDAR21-RD09	Age and growth estimates for the dusky shark, *Carcharhinus obscurus*, in the western North Atlantic Ocean	L.J. Natanson, J.G. Casey and N,E. Kohler
SEDAR21-RD10	Reproductive cycle of the blacknose shark *Carcharhinus acronotus* in the Gulf of Mexico	J.A. Sulikowski, W.B. Driggers III, T.S. Ford, R.K. Boonstra, and J.K. Carlson
SEDAR21-RD11	A preliminary estimate of age and growth of the dusky shark *Carcharhinus obscurus* from the south-west Indian Ocean, with comparison to the western north Atlantic population	L.J. Natanson and N.E. Kohler
SEDAR21-RD12	Bycatch and discard mortality in commercially caught blue sharks *Prionace glauca* assessed using archival satellite pop-up tags	S.E. Campana, W. Joyce, M.J. Manning
SEDAR21-RD13	Short-term survival and movements of Atlantic sharpnose sharks captured by hook-and-line in the north-east Gulf of Mexico	C.W.D. Gurshin and S.T. Szedlmayer
SEDAR21-RD14	Plasma catecholamine levels as indicators of the post-release survivorship of juvenile pelagic sharks caught on experimental drift longlines in the Southern California Bight	B.V. Hight, D. Holts, Jeffrey B. Graham, B.P. Kennedy, V. Taylor, C.A. Sepulveda, D. Bernal, D. Ramon, R. Rasmussen and N. Chin Lai
SEDAR21-RD15	The physiological response to capture and handling stress in the Atlantic sharpnose shark, *Rhizoprionodon terraenovae*	E.R. Hoffmayer and G.R. Parsons
SEDAR21-RD16	The estimated short-term discard mortality of a trawled elasmobranch, the spiny dogfish (*Squalus acanthias*)	J.W. Mandelman and M.A. Farrington
SEDAR21-RD17	At-vessel fishing mortality for six species of sharks caught in the northwest Atlantic and Gulf of Mexico	A. Morgan and G.H. Burgess

SEDAR21-RD18	Evaluating the physiological and physical consequences of capture on post-release survivorship in large pelagic fishes	G.B. Skomal
SEDAR21-RD19	The Physiological Response of Port Jackson Sharks and Australian Swellsharks to Sedation, Gill-Net Capture, and Repeated Sampling in Captivity	L. H. Frick, R. D. Reina, and T. I. Walker
SEDAR21-RD20	Serological Changes Associated with Gill-Net Capture and Restraint in Three Species of Sharks	C. Manire, R. Hueter, E. Hull and R. Spieler
SEDAR21-RD21	Differential sensitivity to capture stress assessed by blood acid–base status in five carcharhinid sharks	J.W. Mandelman and G.B. Skomal
SEDAR21-RD22	Review of information on cryptic mortality and the survival of sharks and rays released by recreational fishers	K. McLoughlin and G. Eliason
SEDAR21-RD23	Pathological and physiological effects of stress during capture and transport in the juvenile dusky shark, *Carcharhinus obscurus*	G. Cliff and G.D. Thurman
SEDAR21-RD24	JIMAR, PFRP Annual Progress Report FY 2001 - Pop-off satellite archival tags to chronicle the survival and movements of blue sharks following release from longline gear	M. Musyl and R. Brill
SEDAR21-RD25	Evaluation of bycatch in the North Carolina Spanish and king mackerel sinknet fishery with emphasis on sharks during October and November 1998 and 2000 including historical data from 1996-1997	C.F. Jensen and G.A. Hopkins

Assessment Workshop - Pre-review Assessment Reports (on SEDAR FTP site and emailed by SEDAR Coordinator)

Title	*Authors*
SEDAR 21 Dusky Shark Pre-Review Assessment Process Report	SEDAR 21 Panels
SEDAR 21 HMS Atlantic Blacknose Shark Pre-Review Assessment Process Report	SEDAR 21 Panels
SEDAR 21 HMS Gulf of Mexico Blacknose Shark Pre-Review Assessment Process Report	SEDAR 21 Panels
SEDAR 21 Sandbar Shark Pre-Review Assessment Process Report	SEDAR 21 Panels

Assessment Workshop – Working Papers (on SEDAR FTP Site)

Document #	*Title*	*Authors*
SEDAR21-AP-01	Hierarchical analysis of blacknose, sandbar, and dusky shark CPUE indices	P.B. Conn
SEDAR21-AP-02	Computer code for the SEDAR 21 age-structured catch-free model for dusky sharks	Sustainable Fisheries Branch, NMFS, SEFSC

Supplementary documents received from SEDAR during this Review

Title	***Authors***
1996 Report of the Shark Evaluation Workshop	NOAA, NMFS, SEFSC
ADMB code for Sandbar base model (source code, data files and executable program)	NOAA, NMFS, SEFSC

Appendix 2: Copy of CIE Statement of Work

Statement of Work for Dr. Norman Hall

Attachment A: Statement of Work for Dr. Norm Hall

External Independent Peer Review by the Center for Independent Experts

SEDAR 21 Highly Migratory Species (HMS) Sandbar, Dusky, and Blacknose sharks Pre-Review Workshop Desk Review

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

SEDAR 21 will be a compilation of data, a benchmark assessment, and an assessment review conducted for HMS sandbar, dusky, and blacknose shark. The desk review will provide an independent peer review of SEDAR stock assessments prior to the panel Review Workshop. The term review is applied broadly, as the reviewer may suggest additional analyses, error corrections and sensitivity runs of the assessment models provided by the assessment workshop panel. In providing peer review advice during this pre-review workshop comment period, the independent expert can improved the overall assessment process by advising the analysts regarding issues that might become points of contention in the formal peer review workshop—at which time it would be too late to revise the actual assessment (assessment data decisions, assumptions, models, modifications, etc. are confined to the assessment process before the peer review workshop). The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewer: One CIE reviewer shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. The CIE reviewer shall have working knowledge and recent experience in the application of stock assessment, statistics, fisheries science, and marine biology sufficient to complete the Terms of Reference of the peer review described herein. The CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: The CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Statement of Tasks: The CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewer. The NMFS Project Contact is responsible for providing the CIE reviewer with the background documents, reports, and other pertinent information. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

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

Desk Review: The CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

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

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

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than REPORT SUBMISSION DATE, the CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to David Sampson

david.sampson@oregonstate.edu. The CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

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

3 December 2010	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
17 January 2011	NMFS Project Contact sends the CIE Reviewer the background documents and report for sandbar and dusky shark assessments
31 January 2011	NMFS Project Contact sends the CIE Reviewer the background documents and report for the blacknose shark assessments
17 January 2011 through 14 February 2011	The reviewer conducts an independent peer review as a desk review
15 February 2011	The CIE reviewer submits draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
01 March 2011	CIE submits the CIE independent peer review reports to the COTR
08 March 2011	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewer to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

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

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) the CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) the CIE report shall address each ToR as specified in **Annex 2**,
(3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

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

Support Personnel:

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

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

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

SEDAR 21 Highly Migratory Species (HMS) Sandbar, Dusky, and Blacknose sharks Pre-Review Workshop Desk Review

1.Evaluate the adequacy, appropriateness, and application of data used in the assessment.

2.Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

3.Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); comment on the reliability of the estimated benchmarks..

4.Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Comment on the degree to which uncertainties are identified and evaluated, and implications of uncertainties stated. Identify any Terms of Reference which are inadequately addressed by the Data or Assessment Workshops.

5.Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments.

6.Prepare a Peer Review Report documenting findings pertaining to these Terms of Reference.