Review of 2002 Stock Assessment for

Large Coastal Sharks

DOC/NOAA/NOS/NMFS/OAR

Order No.: DG133F-02-SE-0666

Prepared by:

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Independent Reviewer #3

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I. EXECUTIVE SUMMARY

The author found some difficulty in relating the work of the SEW to the subsequent major stock assessment document undertaken by the NMFS and it was not always clear whether NMFS had followed the suggestions of the SEW in regard to procedures and recommended mixing rates between the U.S. and Mexico stocks and other potential out migrations. Nevertheless, in my opinion, the works of the 2002 SEW and the NMFS are highly professional in character, management recommendations contained in the 2002 SEW and NMFS (Sept.) documents are based on appropriate fisheries stock assessment techniques and that the scientist based their conclusions on relevant available science. The major effort of the 2002 SEW and NMFS efforts were dedicated to responding to comments made by independent scientists regarding the information base, the need to standardize data sets, underlying assumptions used and the legitimacy and nature of the models employed. In this regard the SEW/NMFS scientists have undertaken an exhaustive effort to organize and reassemble the catch data to

include information on catches in Mexico and bycatch mortality, standardize data sets and extended the modeling to include age dependent data and open populations. In addition, a range of statistical methods has been employed to evaluate the model's sensitivity to different inputs and to examine model performance. These efforts demonstrate a very real commitment to respond to earlier identified problems noted by industry and outside reviewers. In my view, the SEW/NMFS scientists provide a range of projections upon which managers can precede with appropriate measures to maintain the sustainability of the LCS resources. Since the comments on the status of stocks and the need for potential management actions is only found in the NMFS document it is not clear how the SEW members have or would have responded to the NMFS generic management comments. This reviewer is in general agreement with the findings and recommendations of the SEW/NMFS 2002 reports.

In the future, work of the SEW should be completed at the time of the meeting of the selected SEW scientists and not dependent on work subsequently done outside the SEW by any party. It is suggested that over the next several years the scientists concentrate on improving life history, taxonomic and behavioral aspects of important LCSs. Some attempt to examine open and closed populations should consider the probability of recovery. In the LCS group, reductions in the TAC of species other than sandbar and blacktip sharks should be considered, as proposed by the NMFS. For sandbar and other sharks further reductions in fishing related mortalities should be achieved through the decrease of bycatch mortality and/or increasing the survival of sharks caught as bycatch in non-target fisheries. The possibility of increasing the catch of blacktip sharks should be carefully examined. Considering the uncertainty in some of the CPUE indices, perhaps the TAC should remain unchanged and the trend in the population reviewed over the next several years.

II. INTRODUCTION (Background)

The following report constitutes reviewer #3's response to a series of topics and questions that the NMFS has asked each reviewer to address under the SCOPE OF WORK. The following steps were taken in the conduct of the review.

A. GENERAL METHOD OF REVIEW

1. Organization of the 55 reports received including SB background documents, NMFS (September Report) and the independent scientists' reviews, into the following topical areas: (SEW contemporary and historical reports and the NMFS 2002 document, modeling efforts, catch and CPUE information, life history, bycatch, and shark migration and management.

2. Undertook in-depth reading of the June SEW 2002 and September NMFS (2002) stock assessment documents.

3. Reviewed earlier SEW reports to develop historical perspective.

4. Read the reports of independent scientists.

5. Read all remaining documents.

6. Further reviewed documents that appeared to be directly related to terms of reference.

7. Compiled set of notes on relevant documents.

8. Drafted my conclusions.

B. BASIC PROBLEM CONFRONTING REVIEWER

A major problem in following the prescribed scope-of-work is that the 2002 SEW document does not contain, or come to, any significant scientific findings or management recommendations. It reviews and comments on documents received and makes recommendations to NMFS regarding assessment methods and technical approaches. The SEW apparently did not have time to complete the necessary assessment including incorporation of the recent catch and CPUE data (1998-2001). The SB background papers deal with a range of issues, but the models submitted do not examine data from the most recent years (1998-2001) and hence, are new evaluations of the 1998 SEW assessment efforts. Thus, the 2002 SEW report, unlike the 1998 SEW, cannot be judged in terms of scientific findings and management recommendations. The SEW apparently didn't manage to complete their work in the time available. As noted by the SEW attached comments of R. H. Huddson (Directed Shark Fisheries Inc.), "the meeting of the 2002 SEW this past June was more an examination of the database, various assessment models and some modeling--for the first time open to all participants." (Note: I have slightly altered the quote to make it more readable.)

The important aspects of assessment, scientific findings, modeling runs, treatment of fisheries catch and effort data and performance evaluations are found in the NMFS September 2002 report that is an assessment of the LCS in the Atlantic and Gulf of Mexico. It is not at all clear whether or not this document has been reviewed by the SEW group and what their opinion might be on the NMFS efforts. It is important to note that the NMFS September 2002 document was not a part of the SEW efforts.

Nevertheless, I have proceeded with the review and assumed that the major questions outlined in the statement of work regarding scientific finding, recommendations and the use of best available science were meant to incorporate the NMFS September 2002 document. The review notes that there is information in the SB background documents that provides information on the statistical methods used, standardization of datasets, updated catch data used in the analyzes, however, they often deal only with information leading to the 1998 SEW findings and do not include catch and CPUE data for 1998-2001 in their modeling efforts.

The reviewer's job is further complicated by the fact that the SEW and NMFS documents are not crossed referenced and thus, the explicit responses of the NMFS effort to SEW recommendations were at times difficult to sort out. Finally,

some of the topics for discussion in the scope-of-work, at times, appear to lack an understanding of what issues were evaluated by the SEW and the NMFS.

In order to make the reviewer's findings clear and easily associated with the identified scope of work, each question is first noted and the associated reviewer's response follows. A general conclusion and recommendation section addressing all of the questions is provided at the end of the document.

III. FINDINGS IN RESPECT TO THE SEW AND NMFS REPORTS

Requirement: Each reviewer shall evaluate whether the scientific conclusion and scientific management recommendations contained in the 2002 SEW Report are based on scientifically reasonable uses of the appropriate fisheries stock assessment techniques and the best available (at the time of the 2002 SEW Report) biological and fishery information relating to large coastal sharks.

Response: It is this reviewer's opinion that the scientific conclusions and management recommendations contained in the NMFS 2002 document are based upon appropriate fisheries stock assessment techniques (methods). Further, I have no reason to conclude that in the conduct of their work that the best available biological and fishery information relating to LCS was not used. However, confirmation that the best available science was used requires that the reviewer have a comprehensive understanding of all relevant LCS fisheries datasets and peer reviewed relevant science. I do not, and can only base my findings on the submitted background papers and the SEW and NMFS reports. Considering the noted limitations, it is my view that the scientists involved used the best science available (at the time the SEW and NMFS reports were prepared) in coming to their conclusions and recommendations.

The models and datasets utilized to estimate LSC population trends were subject to a wide range of statistical tests that make the model outcomes more acceptable and demonstrate a more rigorous scientific process than used in prior SEWs. Nevertheless, the ability of the models to correctly assess actual population trajectories is subject to the quality of the model inputs (catch and effort information and estimates of population parameters), which are often uncertain. The assessment scientists make the matter clear and the 2002 NMFS (September) effort shows substantial progress in the handling of datasets and in evaluating the performance of the modeling efforts.

IV. RESPONSE TO SPECIFIC SCOPE OF WORK REQUIREMENTS

Requirement: Each reviewer shall assess the points listed below in reference to the 2002 Report consistent with his/her expertise. Each reviewer shall identify any points for which he/she lacks the required expertise.

Response: In this regard, it should be noted that reviewer #3 did not attempted to repeat the calculations of the mathematical model formulas and the

sample/re-sampling technique. I assumed the scientists employed the models properly and conducted the calculations correctly as required. However, I am familiar with the application of the models to the problem, the modeling concepts and data requirements used in the SEW and NMFS assessment reports and I am qualified to comment on the appropriateness of the models employed and the quality of the model outputs.

1. Question 1: How the appropriateness of specific modeling approach(es) was (were) determined for assessing LCS's a long-lived species (or species complex), including considerations of alternative modeling approaches employed in prior evaluation workshops.

Summary of Findings: The modeling efforts have been driven by the quality and availability of information regarding the LCS. Over time, the datasets have been standardized, catch data improved, new information on the life history generated and shark migrations evaluated. Models responding to the reviewers' suggestions and incorporating the latest datasets have been appropriately evolved and subjected to a broad range of data inputs. This has extended the range of possible population trajectories. It is interesting to note the NMFS 2002 analysis has led to conclusions that the LCS, blacktip and sandbar populations have all increased, suggesting that some of the rather pessimistic 1998 modeling efforts were in error. The 2002 results are not in conflict with the known CPUE data. However, I am concerned over the use of the aggregation (pooled) data used in the evaluation of the mixed set of species for LCS and question whether the projected trends based on the "remains" after subtracting data from blacktip and sandbar sharks are reliable.

Expanded Explanation/Analysis: The NMFS 2002 report involves a number of modeling efforts, including: (a) a Bayesian Surplus Production model coupled with sampling importance re-sampling (SIR) algorithm software, (b) a Bayesain Surplus Production modeling State-Space methodology and MCMC for numerical integration, (c) A Bayesian Lagged Recruitment, Survival and Growth model using advanced integration methods, (d) a Maximum Likelihood Estimation (MLE) model and () a Bayesian Age-structured model. The age sex area model developed, which is perhaps the most advanced modeling effort, was apparently not used in the NMFS assessment, perhaps because of time limitations.

The type and quality of the data available have, to a large degree, driven the selection of the models used. That is, the quality of the catch and CPUE data and sketchy knowledge of the life history features of LCS have forced scientists to employ models that require limited data inputs.

The Maximum Likelihood Estimation (MLE) model employed in the early SEW (1992-1996) was chosen because of the simple data requirements and knowledge that the recreational fishery catch data was potentially inaccurate. Haist and other independent reviewers who reviewed the MLE modeling efforts point out underlying problems with the model including the assumptions regarding model error structure and the relatively few observations per estimated parameter. Although the SEW scientists used this modeling technique (with modifications) again in 2002, it is apparent that they place greater reliance on Bayesian modeling efforts applied to production models. The production models are also

dependent on the historical catch and CPUE data but add estimates of the intrinsic rate of increase and the unfished population size. These models have been extended and improved to accommodate migrations between two areas, lagged recruitment, age structured data, etc. The more sophisticated modeling attempts have evolved on the basis of suggestions of reviewers, improved data quality and differentiation of the catch and effort database.

Haist (independent review) and the industry position statement of January 2001 track the evolution of modeling efforts nicely. Many of the concerns noted in the industry statement and in reviewers' comments are addressed in the 2002 assessment effort. The scope of the modeling attempts have improved as catch and effort limitation, age data and possible migrations have, in part, been addressed.

Production models were used in 1996, 1998 and 2002. The production model, like the MLE, is also appropriate for limited datasets. Use of the Bayesian methods is assumed to improve the estimates of r and K in the model. Further, the estimate of pup survival adds additional information into the modeling efforts. The Bayesian approach is a reasonable and appropriate step in the modeling effort considering the improved datasets. The production model has several assumptions that are not always easy to test, the most important being that the CPUE index is directly related to population size. In this regard, several scientists have noted that passive fishing techniques do not always yield CPUE's having a linear relationship with population size. It is an area that needs further study in regards to the historical shark CPUE indices.

Production models have the advantage of producing an estimate of the Maximum Sustainable Catch (MSC) or Maximum Sustainable Yield (MSY). They also allow for a quick check on overfishing if the MSC is assumed to occur at one-half of the virgin stock level. This assumption, proposed by Russian scientists, is frequently used in fishery population assessments, although for some species the relationship may not hold. Application of Bayesain techniques to improve the estimates of certain population parameters has become fashionable in fisheries modeling. Is a frequently used and appropriate methodology to narrow estimates of population parameters when the life history features of the fish (sharks) involved are uncertain. Production model are, however, very sensitive to estimates of the unfished biomass and the natural rate of increase in the population. Poor estimates of these parameters can have a large influence on the model predictions. I failed to find any discussion of the reliability (uncertainty) of the MSC or MSY levels resulting form the various production models employed.

The Bayesian delay difference model and Bayesian age structured model (with state space implementation) constitute more advanced modeling efforts that deal with juveniles and adults, growth, recruitment and survival. Both use a Beverton and Holt spawner-recruit relationship and growth, recruitment and survival parameters. The later two models add a greater dimension of reality into the assessments

2. <u>Question 2:</u> How the availability and quality of alternative datasets

was considered, including recent catch, catch rates, trends in stock status and other biological parameters (i.e. how the data series were determined, how they were weighted for analysis, and how they were applied as age-specific indices of abundance) and (2A) whether the best available scientific data (at the time of the 2002 report) were used (including consideration of CIE and NRC reports that reviewed and gave recommendations regarding data used in the 1998 SEW report).

Summary of Findings: It is not clear what the intent of the NMFS or the Court is in relationship to this topic. It appears that it is asking the reviewer to parrot back information given in the background documents. In general, I have been impressed with the changes introduced in the 2002 SEW/NMFS stock assessment work. A major effort has been made to deal with historical problems concerned with catch and effort data, model limitations and data weighting methodology. The models have been evaluated in terms of their sensitivity to different CPUE series, as well as estimates of population parameters. Additionally, convergence diagnostics of the modeling efforts and the various stock assessment runs, as well as, "goodness of fit" of the models to the data were undertaken. It is clear that the SEW/NMFS (2002) efforts have given serious attention to available catch and effort information in addition to scientific studies concerned with migration and life history. The statistical and scientific data have been subjected to a range of modeling efforts using various catch databases and CPUE series. The SEW/NMFS 2002 work makes every effort to take into account the vast majority of recommendations made by the independent reviewers.

Expanded Explanation/Analysis: It is this reviewer's opinion that the SEW and NMFS assessment work encompassed an extensive spectrum of scientific and statistical information in a highly professional manner and, based on my knowledge of the data and literature, they used the best available science in the conduct of their work.

The SEW and the NMFS appear to have gone out of their way to consider the full range of catch and CPUE datasets and respond in a positive way to the comments of CIE and NRC reviewers. They have differentiated the catch and effort data by (a) fishery dependent and fishery independent datasets, (b) fishing methods, (c) locations, (d) time series and (e) age/size. Further, these datasets have been standardized using generalized linear model techniques (log transformation is at times employed to develop CPUE indices). In addition, they have evaluated the quality of various datasets and weighted them employing inverse variance and equal average variance (equal weights) for most CPUE time series but also MLE and other weighting schemes. The purpose of the weighting has been to give greater reliance to datasets that have lower variability and improve the precision of the estimates. However, such weighting schemes cannot be evaluated in terms of accuracy in that the true population sizes and relationship of the CPUE indices to population size are never known for certain.

The catch data series has been improved by estimating earlier catches, bycatch losses and adding information on Mexican catches. This has led to three catch scenarios including the "updated scenario, baseline scenario and the alternative catch scenario." These scenarios reflect efforts to improve the general catch data and provide for alternative inputs into model runs. The modeling efforts have

been extended to accommodate aged-based data, closed and open populations and sample the "importance re-sampling" algorithm to improve estimated population parameters. The alternative data set has been expanded to include historical catch rates.

> Question 3: How the selected modeling approach(es) was (were) applied (in 2002) to the data chosen for analyses, including:
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> (a) how information was handled or applied relating to whether, each of the LCS species under consideration represented open closed populations, and
>
> (b) how discard mortality was accounted for in the stock assessment and whether options were identified to account for dead discard mortality in setting a landings quota based on the assessment.

Response to (a), Summary of Findings: The open or closed population issue has, in part, been addressed by including updated catch estimates from Mexico. Although the general migration of LCS to areas outside those included in the 1998 modeling was not considered significant by some scientists, the new tagging information was adequate to encourage modeling which took into account the possibility of open populations. At least two modeling papers submitted to the 2002 SEW incorporate models that include the possibility of open LCS populations. One of the models allows for age and sex specific migrations between the eastern and western Gulf of Mexico, taking into account specific management measures. A second model (MLE model) which allows or immigration and emigration was presented to the SEW and apparently used in the NMFS assessments. It is, however, not clear to the reviewer what levels of mixing rates were accounted for in the NMFS modeling efforts

The results of the tag and recovery studies are not clear in that the opportunity for tag recovery based on the distribution of fishing activity does not appear to have been taken into account, thus, the results may be misleading. That is, if there are no fisheries or the magnitude of fishing in areas outside the study area is low, there may be few, if any, recoveries even though there may be important migrations between the study area and adjacent regions.

Expanded Explanation/Analysis to (a): In the comments of the fishing industry, as well as the reports of the independent scientific reviewers, it is obvious that there has been a historical concern that the assessments did not take into account the possibility that the populations of LCS of concern were open and subject to emigration and immigration. The production model employed in earlier SEWs assumed a closed population, yet there was some evidence to support open populations. Tagging studies reported in the 2002 SEW gave added support to the open population hypotheses at least for dusky sharks.

Tag recovery information is provided in at least five background documents that deal with sandbar, blacktip and dusky sharks. Rather significant movements of sandbar sharks (SB-02-19) from Northeastern U.S. waters to the Gulf of Mexican are noted. If only movements between the U.S. and Mexico waters are considered, the mixing rates are much lower. NMFS tag and recovery data used to

calculate mixing rates for sandbar sharks between U.S. and Mexican waters, from earlier studies, implied a 5.6% mix rate. However, the 2002 SEW felt that this mixing rate might be to low. A 16% mixing rate was noted for dusky sharks. As a result of the more recent tag recovery information, the SEW recommended theoretical mixing levels of 10%, 20% and 30% be used in "what if" scenarios. It is unclear whether the NMFS model runs involving open populations used these "what if scenarios."

Additional information on blacktip sharks is provided in SB-02-22. The north/south migration and lack of mixing between tagging areas was confirmed. Preliminary genetic evidence indicated that the eastern and western Gulf of Mexico may support separate stocks of blacktip sharks.

Response to (b), Summary Findings: The bycatch mortality has been accounted for in the baseline catch history. The alternative catch scenario included longline bycatch and menhaden seine data, but did not include Mexican catches. Thus, catch data that includes mortality estimates in the menhaden fishery has been used in various modeling efforts. The proposed options for reducing bycatch mortality noted below should be given high priority.

Expanded Explanation to (b): Bycatch was taken into account very early in the federal management of LCS in the Atlantic and Gulf of Mexico waters. In 1993, an annual bycatch quota of 2,436 metric tons (dressed weight) was established for LCS with an additional 580 mt for pelagic sharks. These quotas were subsequently reduced by 50%. Under revised management, LCS were classified into two subgroups, including ridgeback and non-ridgebacks. The establishment of quotas considered an "allowance of reasonable takes," however, the real concern involved accounting for shark bycatch mortalities occurring in fisheries not targeting sharks.

Two options were identified in background paper SB-02-39 to reduce mortality or minimize bycatch in non-target fisheries such as the menhaden seine fishery. The approaches included (a) reducing shark bycatch through the development of mechanisms to increase survival of sharks captured or modifying fishing practices to reduce the number of sharks captured during menhaden seining, and (b) a method to minimize the take of sharks when more than four per seine set were encountered. It was felt that the desired results could be achieved through avoidance techniques and fishers taking extreme care in the handling and discard of sharks.

> Question 4: How the reliability of projections was evaluated based on the above three considerations.

Summary Findings: The statistical methods employed seem robust and powerful, but it is difficult to judge how much more reliable the modeled projects might be compared to a simple evaluation of the standardized CPUE series coupled with estimates of virgin biomass (Bo), using 1/2 (Bo) as the population level not to fall below and 1/2 m (natural mortality rate) x Bo as the MSC. Regardless, the NMFS scientists have taken every effort to undertake a thorough analysis, used a plethora of possible data series and a range of modeling techniques.

Expanded Explanation: The reliability of the projections and overall assessment was facilitated as the result of a comprehensive set of model runs using alternative catch scenarios, differentiated and standardized CPUE series and value weighting using several methods. The models themselves have been examined in various terms including; their sensitivity to different CPUE data and population parameters, goodness of fit of the data, alternative hypotheses, SIR techniques and convergence diagnostics, adding to the reliability of the projection. The extension and embracement of modeling efforts that take into account open populations and age structured inputs enhance the likelihood that the range of projections encompass valid estimates of population trends.

Question 5: How the effects of a range of catch scenarios, including the effects of current regulations on stock trajectories were evaluated.

Summary Findings: Three catch scenarios were evaluated in various modeling efforts and the projected stock trajectories compared within and between model runs. In regard to "the effects of current regulations on stock trajectories," the reviewer could not find any in-depth discussion of this issue in the SEW or NMFS (2002) reports. This may have occurred because at the time of the SEW, the updated (1998-2001) catch and CPUE and stock assessments had not been completed. The NMFS (September 2002) also fails to discuss regulations and stock trends in any detail. Although, under the management section the report does note a general improvement in LCS, sandbar and blacktip sharks, it also points out the need to assist in the rebuilding of the LCS and to reduce fishing mortality on sandbar sharks. There is also a general comparison of stock projections and tends derived from the modeling efforts. There is some inconsistency for trends in the different runs, in particular, for sandbar sharks.

Expanded Explanation/Analysis: Some information on the performance of regulations is provided in background document SB-02-2 concerning the effectiveness of bag limits in the recreational fishery. It is noted that in 1993 a large coastal shark limit of four sharks per boat trip was imposed. In 1997, this limit was changed restricting the recreational fishery to a bag limit of two LCS, pelagic or small sharks per boat trip. In 1999, the bag limit was reduced to one shark, excluding Atlantic sharpnose shark per boat trip. The one shark limit, along with a minimum size limit (4.5 feet) was anticipated to reduce the harvest of blacktip and sandbar sharks by about 80%.

The authors of SB-02-2 conclude that the 1999 bag and size limits have caused an increase in catch and release fishing in the recreational fishery. Nevertheless, the majority of sharks sampled by the MRFSS were still below the size limit and a large fraction of the trips are still harvesting more than one shark per trip. It is noted that reductions in mortality could be achieved if recreational fishermen complied with the size and bag limits. Other difficulties reported were that federal regulations might not be enforced in state waters, fishers may not be aware of the regulations and fishers may not be able to identify shark species. If the regulations were followed, it is suggested that the mortality of sharks in the recreational fishery could be reduced as much as 81%-82%. Note this single background paper dealing with management, did not discuss the relationship of a

reduction in mortality of LCS to stock trends. Further, it is not apparent in the NMFS or the SEW reports that any recommendation is made in response to these observations.

Finally, the NMFS (September) document does have an excellent set of figures, along with supporting commentary, in the report text that track mortality rate trajectories and relative abundance projections (2001-2031). The future projections for all but the LME model are based on various catch scenarios compared to the 2000 catch levels. These trajectories and projections should provide managers important mental images of possible future regulatory options. It would appear that these data have formed the basis of management actions suggested in the NMFS document.

> Question 6: Whether candidates for prohibited species status were considered, including whether the species on the existing prohibited species list are appropriate.

Response: This is an interesting question in light of the fact that this topic is not included in the SEW report and only two paragraphs are presented in the NMFS report dedicated to this matter. Further, although I may have missed something, the issue of prohibited species is not contained in any of the 2002 background papers. However it is, a topic included in the earlier SEW reports. No mention of this topic is given in the 2002 SEW agenda. The 2002 NMFS report has two short paragraphs dealing with prohibited species. They note that, based partly on the 1998 assessment, NMFS extended the prohibited species to include 19 species of sharks, four of which were species previously described as coastal sharks. Since 1998, there is no mention of additional candidates for the list or whether the species on the list are appropriate. However, since 1998, studies have shown that several species of LCS sharks have low population growth rates as might be expected. The relevance of theses studies to the prohibited species list is not discussed.

IV. GENERAL CONCLUSION AND RECOMMENDATIONS

In general the 2002 SEW and NMFS reports provide a comprehensive response to industry and reviewers' suggestions and criticisms. The SEW and NMFS have made a major effort to provide a set of models responsive to earlier concerns and have attempted to improve the quality of the CPUE and catch datasets. They end with a set of extensive projections for stock trends (relative abundance) in the future and the NMFS report suggests possible actions for managing the sandbar, blacktip and LCS group. The reviewer feels that they have used the best available science and methodologies in the conduct of their work. The process and basis for the assessment efforts was consistent and valid throughout the SEW and NMFS reports. The following comments and recommendations should be considered in the organization of future workshops and research.

1. The failure of the SEW to deal with assessments involving the data

from 1998 through 2001 and the subsequent stock assessment produced by the NMFS made the reviewer's work assignments difficult and leaves the question as to whether the SEW members have reviewed and are in accord with the NMFS conclusions. In the future, the work of the SEW should be completed by the time of the meeting of the selected SEW scientists and not dependent on work subsequently done outside the SEW by any party.

2. Although the reviewer was pleased with the extensive modeling efforts undertaken by the NMFS, it is suggested that over the next several years the scientists concentrate on improving data collection of life history, taxonomic and behavioral aspects of important LCS which will improve the results of the modeling efforts.

3. Some attempt to examine open and closed populations should consider the probability of recovery.

4. In the LCS group, reductions in the TAC of species other than sandbar and blacktip sharks should be considered as proposed by the NMFS.

5. For sandbar and other sharks, further reductions in fishing related mortalities should be achieved through the decrease of bycatch mortality and/or increasing the survival of the bycatch of sharks taken in non-target fisheries.

6. The possibility of increasing the catch of blacktip sharks should be examined carefully. Considering the uncertainty in some of the CPUE indices, perhaps the TAC should remain unchanged and the trend in the population reviewed over the next several years.

7. Some effort to examine the uncertainty of the MSC/MSY values should be considered in future workshops.

Appendix C. Required literature

Review

2002 Report of the Shark Evaluation Workshop.

NOAA Fisheries. Final Meeting Report for the 2002 Shark Evaluation Workshop. August 20, 2002.

Previous Reviews

1998 Report of the Shark Evaluation Workshop.

NRC, Inc. Independent review of the scientific management recommendations in the June 1998 large coastal shark evaluation workshop report. October 10, 2001.

Haist, V. Center of Independent Experts. Review of Atlantic large coastal sharks assessment. September 27, 2001.

Hale, P. Center of Independent Experts. Status of Atlantic large coastal sharks: Evaluation of the US Atlantic Large Coastal Shark Stock Assessment. September 2001.

Punt, A.E. Center of Independent Experts. Review of the Assessments of and Management Advice for Atlantic Large Coastal Sharks. September 16, 2001.

Background Documents

SB-02-1. Apostolaki, A., E.A. Babcock, M.K. McAllister, and R. Bonfil. Assessment of large coastal sharks using a two-area, fleet-disaggregated, age-structured model.

SB-02-2. Babcock, E.A. The effectiveness of bag limits in the U.S. Atlantic recreational fishery.

SB-02-3. Bonfil, R. and E.A. Babcock. Estimation of catches of sandbar (Carcharhinus plumbeus) and blacktip (C. limbatus) sharks in the Mexican fisheries of the Gulf of Mexico.

SB-02-4. Brooks, E. Maximum likelihood estimation of shark abundance.

SB-02-5. Brooks, E., C. Porch, and E. Cortes. An age-structured production model (ASPM) for application to large coastal sharks.

SB-02-6. Brown, C.A. Updated standardized catch rates of four species of sharks in the Virginia-Massachusetts (U.S.) rod and reel fishery.

SB-02-7. Brown, C. and J. Cramer. Large pelagic logbook catch rates for sharks.

SB-02-8. Carlson, J.K. A fishery-independent assessment of shark stock abundance for large coastal species in the Northeast Gulf of Mexico.

SB-02-9. Carlson, J.K. The directed shark gillnet fishery: characterization of the large coastal shark catch and a standardization of catch rates from observer data.

SB-02-10. Carlson, J.K. and I. Baremore. Biological parameters for the blacktip shark, Carcharhinus limbatus, from the US South Atlantic Ocean and Gulf of Mexico.

SB-02-11. Cortes, E. A simplified Bayesian delay-difference model: application to large coastal sharks.

SB-02-12. Cortes, E. Catch rates of large coastal sharks.

SB-02-13. Cortes, E. Incorporating uncertainty into demographic modeling: applications to shark populations and their conservation.

SB-02-14. Cortes, E. Sensitivity analysis of the 1998 Large Coastal Shark Evaluation Workshop results to new data and model formulations following recommendations from peer reviews.

SB-02-15. Cortes, E. and J.A. Neer. Updated catches of sharks.

SB-02-16. Grace, M., T. Henwood, and W. Ingram. Fishery independent catch rate statistics for large coastal sharks in the western North Atlantic Ocean as derived from bottom longline surveys.

SB-02-17. Heupel, M., and R.E. Hueter. Use of an automated acoustic telemetry system to passively track juvenile blacktip movements.

SB-02-18. Heupel, M., and C. Simpfendorfer. Estimation of mortality of juvenile blacktip sharks, Carcharhinus limbatus, within a nursery area using telemetry data.

SB-02-19. Hudson, R.H. Tag recapture data by area for sandbar, dusky, and blacktip sharks from Kohler, et al. (facsimile from N.E. Kohler).

SB-02-20. Hudson, R.H. 1998 letter from Steve Branstetter (NMFS) to Richard Condrey (LSU) on methodology for calculating bycatch in the Gulf menhaden fishery.

SB-02-21. Heuter, R.E. Early life history and relative abundance of blacktip and other coastal sharks in eastern Gulf of Mexico nursery areas, including bycatch mortality of sharks and associated fishes.

SB-02-22. Heuter, R.E. and J. Tyminski. U.S. shark nursery research overview.

SB-02-23. Heuter, R.E. and J. Tyminski, and C. Simpfendorfer. Relative abundance of juvenile blacktip sharks in two Florida Gulf nursery areas (1995-2001).

SB-02-24. Kohler, N.E. and P.A. Turner. Tag and recapture data for the blacktip shark, Carcharhinus limbatus, in the Western North Atlantic.

SB-02-25. McAllister, M.K. E.A. Babcock, R. Bonfil, and E.K. Pikitch. Importance sampling issues in the 1998 large coastal shark assessment.

SB-02-26. McAllister, M.K. and E.A. Babcock. Bayesian surplus production model with the Sampling Importance Resampling algorithm (BSP): a user's guide.

SB-02-27. McCandless, C.T., H.L. Pratt, and N.E. Kohler. Monitoring the juvenile sandbar shark, Carcharhinus plumbeus, population in the Delaware Bay nursery grounds. **[Authors did not submit to the SEW]**.

SB-02-28. Musick, J.A., and C.L. Conrath. A delineation of shark nursery grounds in Chesapeake Bay and an assessment of abundance of shark stocks (2001-2002).

SB-02-29. NMFS. 1996 Report of Shark Evaluation Workshop.

Sb-02-30. NMFS. 1998 Report of Shark Evaluation Workshop. **[Duplicate of document listed under Previous Reviews.]**

SB-02-31. Porch, C.E. A preliminary assessment of Atlantic white marlin (Tetrapturus albidus) using a state-space implementation of an age-structures production model.

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