Final Meeting Report of the 2002
Shark Evaluation Workshop

(NOAA/NMFS/Panama City Laboratory, June 24-28, 2002)

1. Opening, arrangements for the meeting, and adoption of agenda

The meeting was opened by the meeting chairman, Dr. Gerald Scott. The agenda, which was distributed in advance of the meeting, was discussed and is attached as **Appendix 1**. Participants ("the Group", **Appendix 2**) were introduced and documents tabled (**Appendix 3**).

It was noted that a broad array of potential participants, including all independent peer reviewers of the 1998 Shark Evaluation Workshop (SEW) report, were invited to attend and/or provide data or documents to the meeting. In total, 33 documents were initially submitted for consideration at the meeting (a summary of document SB-02-27 was sent prior to the meeting but a full document was not submitted) and 7 more documents were added as a result of discussions during the meeting (SB-02-35 to SB-02-41). Numerous data sets were also made available to the working group for analysis. It was noted that due to the large number of papers to be reviewed and because of the need to conduct a wide range of assessment analyses with the available data, as recommended by the various reviewers of the 1998 stock assessment, that a complete set of stock evaluation analyses would not be possible within the time available at the meeting. For these reasons, this workshop focused on the available inputs for updating the stock assessment.

Comments were solicited on the agenda, which was adopted without changes. Agenda items were then subdivided into several main categories and individual documents assigned to each category. The following NMFS representatives agreed to serve as rapporteurs of the various sections of the report.

Agenda item	Rapporteurs	Document numbers
2	J. Castro	2
3	J. Carlson	10,13, 17, 18, 21, 22, 27, 28, 32, 37
4.1	E. Cortes	3, 15, 20, 32, 34, 35, 38, 40
4.2	T. Henwood	6, 7, 8, 9, 12, 16, 21, 23, 28, 32,33,34
4.3	J. Neer	32
4.4	N. Kohler	19, 24, 32
5.1	L. Brooks/E. Cortes	4, 5, 11, 14, 25, 26, 31
6	G. Scott	
7	G. Scott	

Participants who submitted documents were asked to provide a one-paragraph summary of their contributions to the relevant rapporteur. Additionally, three working groups were established to examine the available data in greater detail: catches, catch rates, and assessment methods.

Note that some of the information that was discussed during the workshop is not included herein because of time constraints, but will necessarily be part of the assessment runs and sensitivity analyses that will be conducted in the following weeks. This includes, for example, the sets of CPUE series to be used in the various scenarios, age-frequency distributions and selectivity patterns from the commercial and recreational sectors, and catches by area for the blacktip shark.

2. Review of recent fishery developments for Large Coastal Sharks

Document SB-02-2 used Marine Recreational Fisheries Statistical Survey (MRFSS) intercept survey data to examine recreational harvest per boat trip of large coastal, small coastal and pelagic sharks in the U.S. Atlantic and Gulf of Mexico. In 1993, the Fisheries Management Plan for sharks applied a bag limit of four large coastal or pelagic sharks per boat-trip. In 1997, a bag limit of two large coastal, pelagic or small coastal sharks per boat trip, excluding Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) was imposed. In 1999, the bag limit was reduced again, to one shark excluding Atlantic sharpnose. The MRFSS data indicate that the one shark bag limit and 137 cm fork length size limit have caused an increase in catch and release fishing in the recreational fishery. However, the majority of the sharks sampled by the MRFSS survey (84% of sandbar and 95% of blacktip) are still below the size limit. Also, a significant fraction of trips (8% of trips and about 30% of harvest) are still harvesting more than one bag-limited shark per trip. The bag and size limits would reduce the mortality of sharks caused by the recreational fishery by much more than the required 81-82% if the problems in implementation of the regulations could be resolved.

There was a comment regarding the fact that if compliance is contingent on states, state-by-state data and time of interaction will be needed. It was reminded, however, that the purpose of the meeting was not to identify states that are or are not in compliance, but rather to determine the effects on the stocks. An additional comment emphasized the importance of identifying the reasons for the lack of effectiveness of the bag limit, which—it was pointed out —was determined at a previous shark workshop.

3. Review of large coastal shark biological information with relevance to the stock evaluation

Document SB-02-10 was an update of biological parameter estimates for the blacktip shark, *Carcharhinus limbatus*, in which age, growth, and size-at-maturity for populations in the eastern Gulf of Mexico and U.S. south Atlantic Ocean were determined. Growth parameters derived for blacktip shark from the Gulf of Mexico show that they attain a smaller theoretical maximum size (L_∞) and that they reach L_∞ at a faster rate (K) than conspecifics in the U.S. Atlantic Ocean. Von Bertalanffy growth parameters for sharks in the Gulf of Mexico were L_∞=141.6 cm fork length (FL), K=0.24 yr^{-1}, t_o=-2.18 yr and L_∞=126 cm FL, K=0.27 yr^{-1} t_o=-2.21 yr for females and males, respectively. In the U.S. south Atlantic Ocean, parameter estimates were L_∞=158.5 cm FL, K=0.16 yr^{-1}, t_o=-3.43 yr and L_∞=147.4 cm FL, K=0.21 yr^{-1}, t_o=-2.58 yr for female and male blacktip sharks, respectively. The maximum observed age was 15.5+ (female) and 13.5+ yr (male) in the U.S. south Atlantic Ocean and 12.5+ yr (female) and 11.5+ yr (male) in the Gulf of Mexico, based on vertebral band counts. Based on a logistic model, median age of maturity was 5.7 yr and 4.5 yr for females and males, respectively, in the Gulf of Mexico, and 6.7 yr and 5.0 yr for females and males captured in the U.S. Atlantic Ocean.

An initial question was raised on the ageing methodology used in this study, which was explained to have used thin sections. Samples used in this study came from a variety of sources, and it was suggested that differences in life-history traits reported might have been due to sampling bias associated with small sample sizes and the effect of fishery-dependent and fishery-independent selectivity patterns. It was also pointed out that blacktip sharks are larger in the western Gulf of Mexico than in the eastern Gulf of Mexico. As this study lacked samples from the western Gulf of Mexico (samples were obtained as far as Louisiana in the west), future research should increase sampling efforts in the western Gulf of Mexico with the cooperation of the directed shark fishery and possibly the recreational fishery. Additional analysis of comparing predicted mean-size-at age between the two areas was also recommended.

Document SB-02-13 explored the effect of uncertainty in demographic traits on demographic analyses of sharks. Age-structured life tables and Leslie matrices were used to model the demography of 41 populations from 38 species of sharks representing 4 orders and 9 families. Monte Carlo simulation was used to reflect uncertainty in the estimates of demographic traits and calculate population statistics and elasticities (proportional sensitivities) for these populations. Correlation analysis was also used to identify the demographic traits that explained most of the variation in population growth rates (λ). The populations examined fell along a continuum of life-history characteristics that can be linked to elasticity patterns. Sharks with early age at maturity, short lifespan, and large litter size had high λ values and short generation times, whereas sharks that mature late, have long lifespan, and have small litter size have low λ values and long generation times. Sharks at the "fast" end of the spectrum tended to have comparable adult and juvenile survival elasticities, whereas sharks at the "slow" end of the continuum had high juvenile survival elasticity and low age-zero survival (or fertility) elasticity. Elasticity analysis suggested that changes in juvenile survival would have the greatest effect on λ, and correlation analysis indicated that variation in juvenile survival, age at maturity, and reproduction accounted for most of the variation in λ. In general, combined results from elasticity and correlation analyses suggested that research, conservation, and management efforts should focus on these demographic traits.

A point was made on the usefulness of this document because it provides a summarization of all current life history data and population statistics for important species and populations. A question was asked on how the elasticity patterns were derived, which was subsequently explained, and on whether the publication by Smith et al. (1998) considered elasticities. It was pointed out that although elasticities were not considered in the Smith et al. paper, their results using a density-dependent approach mirrored the results of this study in terms of the placement of the species of interest along a continuum of values of r (intrinsic rate of increase). An issue was raised concerning the substantially separate placement of the two populations of *Sphyrna lewini* from the Gulf of Mexico and the Pacific along the elasticity landscape. It was suggested that the discrepancy was probably due to methodological differences between the two age and growth studies. This led into a more general discussion regarding whether population differences in age and growth are real or the result methodological differences or differences in sample sizes. It was pointed out that the incorporation of uncertainty into this paper took into account many of the variation in these life history studies. A question was also raised on the age of maturity used for the sandbar shark, and the response was that only accepted, published material was used. Discussion was then raised on a study by Springer (1960; ***document SB-02-36***) describing a sandbar shark raised in an aquarium that reached sexual maturity in 3 years. The validity of the Springer study was vigorously debated and it was explained that aquarium-raised sharks grow faster than sharks in the wild. The general agreement was that this paper was highly speculative and based on very little evidence as recognized by the author, but it was recognized that a sensitivity analysis contemplating a younger age at maturity (10 vs. 13 years) for sandbar shark could be undertaken with the stock assessment age-structured methodology.

Document SB-02-17 described the use of automated acoustic telemetry to passively track juvenile blacktip shark movements in Terra Ceia Bay, a known nursery area for *C. limbatus.* The use of this technology provided long-term data on the movements of sharks within the study site. Sharks were continuously tracked for periods from 3 – 159 days. The data collected from the hydrophone stations were sorted and condensed for analysis using a FORTRAN program that allows the user to define the time block or other variable to search the database. These analyses were used to define the number of stations visited per day by the sharks present. During the first three months of the study (May – July) sharks visited less than five stations and were confined to the northernmost portion of the study site. In the fourth month (August) sharks began to move throughout the entire study site and were detected at every hydrophone station. Analysis of the time spent at each station after the third month of the study revealed a spatial shift from the northern end to the middle of the bay. Reasons for this shift are unclear, but may be due to an environmental change. Active tracking efforts validated the data compiled by the automated system and provided fine-scale details about the movements of sharks. The volume of data collected by the automated system and the distance between hydrophone stations decreased the spatial resolution of data, making active tracking results better for producing fine-scale location data. However, the automated system provided several advantages over active tracking including decreased labor, removal of possible chasing bias involved in following an animal, the ability to track several animals simultaneously, and to track in all weather conditions. Each system has advantages and disadvantages, but when used in conjunction these technologies can be used to conduct a more complete study of shark movements.

A question was raised concerning the lifetime of the acoustic tags. The answer was 18 months. An interesting note was also brought up concerning a mass exodus of blacktip sharks from the study area prior to tropical storm Gabrielle and the progressive return of the same individuals after the tropical storm had passed. It was thought that this was a result of the sharks' ability to detect changes in barometric pressure.

Document SB-02-18 estimated mortality of juvenile blacktip sharks in a nursery area using telemetry data. A population of young blacktip sharks was monitored over three years to determine their mortality rates using a series of acoustic listening stations. Based on these data it was possible to use several mortality estimators, including indirect life-history based methods and direct methods such as the Kaplan-Meier and SURVIV methods, to estimate natural, fishing and total mortality. Kaplan-Meier (61-91%) and SURVIV (62-92%) methods provided nearly identical total mortality rates during the first six months of life. This agreement suggests that these estimates are accurate for this population. All natural and fishing mortality occurred within the first 15 weeks of the study. This suggests that young sharks are most vulnerable to all types of mortality during this period. Sharks that survived beyond the first 15 weeks successfully left the nursery and were presumed to have migrated southward during fall months. These results provide critical information concerning the early life history of young sharks and the importance of nursery areas to the survival of young animals.

A point was made on the variability in estimates between 1999 and 2000 and it was proposed that the difference was due to a smaller sample size in 1999. Questions were also raised regarding the partitioning between natural and fishing mortality. Natural mortality was estimated from those animals that stopped moving and fishing mortality took account of tag recaptures by fishermen. Regarding the applicability of the mortality rates estimated to other areas outside the study site, it was felt that the mortalities would have been expected to be higher. There was continued discussion on this issue and also on environmental effects on mortality.

Document SB-02-21 dealt with the 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. Eastern Gulf of Mexico coastal areas south of Cedar Key, Florida, were assessed as nursery grounds for species of large and small coastal sharks. Species-specific abundance, bycatch mortality in gillnet fishing gear, and various biological parameters (distribution, food habits, growth and migration) were studied intensively in three nursery areas (Yankeetown, lower Tampa Bay and Pine Island Sound/Charlotte Harbor) in 1995-97. Over this period 3,227 sharks of 13 species, including 1,416 juvenile blacktip sharks, were documented in the surveys. To quantify relative abundance of juvenile blacktips, monthly random stratified sets of 400 yd x 10 ft (366 x 3 m) weighted monofilament gillnets with a 4-5/8" (11.8 cm) mesh size were made in five of ten 1 x 1 km blocks of a 10 km^2 grid within each nursery area. Results show no significant increasing or decreasing trends in juvenile blacktip shark abundance during the project (see further results in SB-02-23). Fall and winter tag recaptures of juvenile blacktips indicate the young sharks inhabiting the eastern Gulf nurseries in the spring and summer leave their nurseries in the fall and generally migrate south, with some recaptures in winter occurring as far south as the Florida Keys. Returns of one and two year-old juvenile blacktips back to the natal nursery in the spring/summer of subsequent years also are indicated.

A question was asked concerning the “behavioral scale” at release and how this was used to assess post-release mortality. A point was made that other similar behavioral scales are used in mortality studies in teleosts. A higher tag return rate was noted in sharks that were released in better condition.

Document SB-02-22 was an overview of U.S. shark nursery research. Since 1991, Mote Marine Laboratory’s Center for Shark Research (CSR) has conducted comprehensive studies of shark nurseries for large and small coastal sharks in U.S. waters. These studies have focused on nurseries in the eastern Gulf of Mexico and have also included studies in the western Gulf of Mexico off Texas as well as limited studies in the U.S. south Atlantic off the Florida east coast. Sampling by gillnet, longline, rod and reel, and beach seine has been used to characterize the distribution of shark nurseries in coastal areas. In this document, characteristics of six Florida shark nurseries and three Texas nurseries are described. Data on over 15,000 sharks of 16 species and four families are summarized to produce species profiles for the sharks utilizing these areas as nurseries. Each of these 16 species has its own temporal and spatial patterns of habitat use, but several overall trends are noted. First, the majority of pupping typically occurs in late spring and early summer, and neonate and young-of-the-year (YOY) sharks inhabit the primary nurseries throughout the summer and into the fall. As water temperatures begin to drop in the fall, YOY sharks leave the primary nurseries and undergo typically southerly, and in some cases offshore, migrations to winter nursery areas. One year-old juveniles return to the summer nurseries the following year, and in some cases for several years after that, beginning in early spring. These juveniles leave the summer nursery in the fall to return to their winter nursery areas. In summary, annual cycles of philopatric behavior in which juveniles migrate back to specific nursery areas are seen in large and small coastal shark species.

A question was raised as to the location of nurseries for blacktip sharks. It was concluded that blacktip nursery areas, as well as nurseries for other species of large and small coastal sharks, are located in productive estuarine systems throughout the Gulf of Mexico.

Document SB-02-32 was an analysis of the status and ecology of the dusky shark, *Carcharhinus obscurus*, in the western North Atlantic based on information derived from the directed shark bottom longline observer program and the VIMS shark longline survey. Observer data from the commercial fishery show that summer long-line catches of dusky sharks off the southeastern U.S. were lower and consisted of larger animals than winter catches. The average fork length of the summer season catches was 189 cm compared to 117 cm FL for the winter season. This is indicative of larger sharks moving into the system to pup and the smaller sharks moving north into the mid-Atlantic Bight due to warming water temperatures in late spring and early summer as shown in the fishery-independent VIMS data set. Throughout 1994-1999 catch rates for small sharks (<179 cm) increased in both data sets (although the VIMS data set had no observations for 1994), while catch rates of older mature animals declined in both data sets. In the authors' view, the lack of an increase in adult dusky sharks in the VIMS data sets, and a marked decline in adult dusky sharks in the Observer data set are a cause for concern.

Some comments were made that the maximum distance traveled recorded for a dusky shark may have corresponded to a Galapagos shark. There was some debate on the 3-year reproductive cycle, but further discussion was deferred until other parties were present.

4.1. Catch (including discards)

Document SB-02-3 presented detailed estimates of Mexican catches of blacktip and sandbar sharks for the period 1962-2000. Species composition in weight for the different shark fisheries taking place along Mexican waters was estimated from the data given in several Mexican studies. These were then used to estimate the total weight and numbers caught of each species in each state. The estimated total level of blacktip catches ranged from 118,000 to 280,000 sharks per year from 1990-2000. In comparison, the corresponding catch of sandbar sharks was estimated at around 7,000-11,000 sharks per year. Because of constraints in the degree of detail contained in the information used to estimate the species composition in weight, these estimates should be taken as a first approximation, especially for blacktip sharks. It is likely that the numbers of small blacktip sharks taken in Mexican fisheries were overestimated. Recalculating the estimates with the more-detailed data on length frequencies for each of the species that should exist from recent studies (Rodriguez et al. 1996) could improve the estimates.

It was further explained that catches had to be split between small ("cazon") and large ("tiburon") sharks according to the classification used in the official Mexican fishery statistics and several other studies that were reviewed to prepare the document. The studies used typically included the total number of individuals by species, but no weight was included. When available, length-frequency information was transformed into weight-frequency by using length-weight relationships to calculate the total contribution of each species to the catches by weight. It was noted that blacktip sharks were estimated to make up a larger portion by weight of the total small shark component (60%) than they likely contribute in reality. It was noted that this occurs because length-frequency distributions were not available, only an average size of 110 cm, which was transformed into weight. This average size is based not only on small blacktip sharks, but also on larger individuals, and it is thus likely to be overestimated. Tables 9-14 summarize the estimated catches of sandbar and blacktip shark by state in weight and numbers.

Questions were asked about whether any shark fishery regulations were in place in Mexico. In response, the authors indicated that a Fishery Management Plan (FMP) was drafted over three years ago, but that it had not been implemented yet. The management measures included in the Mexican FMP are fairly "rough" in that they do not include quantitative measures such as TACs. It was also asked why there were such dramatic changes in the catch series for blacktip in Table 14. The response was that it was a direct result of the official published statistics that were used to generate the estimates. The statistics used came from the Mexican government and from FAO, which gets the data from the Mexican government. Prior to 1975, the data came from FAO. Apparently, the level of credibility of the statistics decreases the further back in the time series one goes. One participant noted that for stock assessment purposes, estimates now include catches by more than the two states that were considered in the 1998 shark SEW.

Document SB-02-15 presented updated commercial and recreational catch estimates for Atlantic sharks up to 2001, with special emphasis on sharks of the large coastal complex. Species-specific information on the geographical distribution of both commercial and recreational catches was presented along with the different gear types used in the commercial fisheries. Length-frequency information and average weights of the catches in three separate recreational surveys and in the directed shark bottom-longline observer program were also included.

Commercial landings are compiled based on Northeast Regional and Southeast Regional general canvass landings data, and the SEFSC quota monitoring data based on southeastern region permitted shark dealer reports. Landings prior to 1996 were taken as reported in the 1998

SEW report. Landings in southeastern states reported in the general canvass and quota monitoring data files were combined to define the species composition and volume of landings. The quota monitoring data provide a more diverse species listing than the general canvass data, whereas the general canvass data apportion a higher volume of shark landings as unclassified. The larger reported landing of a given species in the two data sets was taken as the actual landed volume for that species. The positive difference between the quota monitoring data and the general canvass data was then subtracted from the unclassified sharks category of the general canvass data to maintain the total landings volume equal to that reported in the general canvass data files. For the state of North Carolina (NC), it was assumed that some "dogfish" might have also been assigned to the unclassified sharks category. To adjust for this possibility for the state of NC, the NC unclassified sharks were first apportioned between the large coastal, small coastal, pelagic and dogfish categories based on the reported distribution of landings by species and gear for that state. For states other than NC, the remainder of unclassified shark landings was assigned to the large coastal group unless the harvesting gear was pelagic longline, in which case the landings were assigned to the pelagic group.

Longlines were the primary gear type used in all regions to catch large coastal sharks from 1987 to 2001. Gillnets were the second-most common gear utilized, followed by lines. Blacktip and sandbar sharks were predominantly caught in the Gulf of Mexico region and predominantly caught using longline gear. There was a question as to what the "other" gear category represented, since it accounted for over 40% of the landings for blacktip in the Gulf of Mexico region. It was indicated that this category included any gear type not included in the other main gear categories listed. It was later clarified that a high proportion of the "other" gear category corresponded to a subcategory identified as "combined gears", which can thus include a variety of unknown gear types. Table 1 of this document summarized all known sources of landings and dead discards for the large coastal shark complex. It was noted that the coastal discards by the directed bottom longline shark fishery had changed somewhat with respect to those values reported in earlier documents because a revised analysis including sharks used for bait resulted in slightly different discard rates.

In terms of recreational catches, concerns were expressed that Table 13 of the document listed estimated catches of dusky sharks of 2,397 and 5,703 individuals in 2000 and 2001, respectively. It was noted that for the MRFSS survey these are estimates obtained after combining dock intercept information on catch and effort with effort information from telephone surveys. This could result in high estimates even when there are only a few observed individuals after applying the effort expansion factor. Several participants raised concerns about the validity of species identification for this particular species.

Document SB-02-20 was a March 1998 letter that critiqued the methodology used in a manuscript that estimated bycatch of large coastal sharks in the Gulf of Mexico menhaden fishery based on species identification problems and the low number of individuals observed. The manuscript was subsequently published in 2001 (document SB-02-38) and was used as the basis for estimating bycatch by the menhaden fleet in Table 1 of document SB-02-15. It was recommended that the working group dealing with catches address the issue of the appropriateness of the estimates generated in this document.

***Document SB-02-38*,** as indicated above, estimated bycatch of sharks in purse seines of the U.S. Gulf of Mexico menhaden fleet in 1994 and 1995. It was estimated that 30,000 individuals were caught as bycatch annually during that period, with a high proportion of the 726 sharks observed being blacktip sharks.

Document SB-02-40 described the use of hose cages as a bycatch reduction device being used in the U.S. Gulf of Mexico menhaden fishery to reduce retention of large bycatch species such as sharks. It was recommended that the working group on catches attempt to generate the best set of estimates of bycatch in the Gulf of Mexico menhaden fishery taking into account the information presented in documents SB-02-20, 38, and 40.

Document SB-02-32 was an analysis of the status and ecology of the dusky shark based on information derived from the directed shark fishery bottom longline observer program and the Virginia Institute of Marine Science (VIMS) shark longline survey. Issues relevant to catches were discussed. Some relevant points noted were that the catches in North Carolina were dominated by small individuals, that young are susceptible to fishing mortality, that higher mortality in longlines occurred with increasing soak time, and that even if this species is protected (it is now a prohibited species) bycatch mortality is still very important.

Document SB-02-34 summarized Gulf of Mexico and southeastern U.S. Atlantic shark catch and fishing effort obtained from coastal fishery logbook reports. It was noted that the reporting requirement for sharks started in January of 1994. The logbooks covered in this document had been previously referred to as "snapper-grouper" logbooks. It was pointed out that set-by-set logbook reports submitted by shark fishermen were not included in this report. Various measures of effort were presented in Tables 1 and 2, with the caveat that data for 1993 and perhaps 1994 were incomplete. The numbers of vessels reported for each year were shark-permitted vessels, but it is unknown whether the individual vessels operated during the whole time series or whether the numbers reflect different vessels entering or leaving the fishery. For 2000 and 2001, the logbook reports represent about 90% of the total landings reported in the Canvass data set. Questions were raised about the validity of some species reported in the logbooks, such as leopard sharks, which do not occur in the area of coverage or about the identity of what was reported as a "bonito" shark. Landings prior to 1996 included a large proportion of unidentified sharks. From 1996 on, the relative proportions of sandbar and blacktip shark increased, whereas the unidentified category was greatly reduced. It was thus assumed that the unclassified sharks prior to 1996 were mostly sandbar and blacktip sharks. However, the issue was raised of why in this data set the contribution of blacktip sharks to total landings was substantially less important than that reported in the combined Canvass/quota monitoring system estimates reported in document SB-02-15, where it is reported to be comparable to that of sandbar sharks. There was also a suggestion that the data for blacktip shark be disaggregated into three areas: northeast Gulf, western Gulf, and Atlantic. The rationale was that conflicting CPUE series for blacktip shark in the western Gulf and Atlantic were identified in the 1998 SEW, as well as a possible separation of blacktip shark stocks from the western and eastern Gulf based on tagging and genetic data.

Document SB-02-35 represents a sampling of data summaries addressing catch composition, disposition, size structure of the catch, depth of capture/fishing, sex ratios, CPUEs, fishing mortality, and discard rates the commercial shark fishery bottom longline observer program (CFSOP) for 1994-2001. Part of the data set was provided to NMFS Panama City personnel for use in the workshop. The data were incorporated in several of the analyses and documents presented in the workshop.

Upon revision of the figures and tables, relevant points were noted. The high proportion of dead blacktip and dusky sharks in the longlines was noted. The species composition of the catch and landings and disposition of the catch was described. Mean fork lengths by year and region for individuals species were presented as well as length-frequency distributions by depth. A length-frequency distribution for dusky sharks indicated that mostly immature individuals were caught, especially off North Carolina. Catch rates and effort information by depth were also presented. There was a question about whether the discard rate presented in the last table also included live releases, and after consultation, it was verified that it did not, i.e., it is a dead discard rate. It was also pointed out by some participants that the decrease in average weights for sandbar sharks in 1998 was due to a high proportion of landings from North Carolina, which caught smaller individuals. Regarding the dusky shark, it was noted that future dusky shark stock assessments will have to recognize that different components of the stock are affected by a variety of fisheries, and that spatial and temporal issues will have to be taken into account.

Catch Working Group Activities

The following discussion points for the catch working group were identified in plenary:

1) Identify baseline and alternative catches for the large coastal complex, sandbar, and blacktip shark (aggregated and disaggregated by fleet if possible)
2) Consider spatial distribution of catches
3) Attempt to quantify Mexican catches
4) Consider all known sources of bycatch (bottom longline, pelagic longline, menhaden fishery)
5) Consider the stability of fishery components (changes of selectivity over time) and attempt to reconstruct the catch history before period currently available

The Working Group decided to specify an updated catch scenario and at least a baseline catch scenario for the large coastal complex, sandbar, and blacktip shark. The purpose of the updated scenario was to keep the same catches that were identified and used in the 1998 assessment (with changes that might have occurred up to 1997) and to add information for the period 1998-2001. Tables 1-3 represent the updated catch scenarios for the large coastal complex, sandbar, and blacktip shark, respectively. For the large coastal complex, modifications in the baseline scenario with respect to the updated scenario were the inclusion of discards estimated from the menhaden fishery, the sum of the Mexican catches corresponding to sandbar and blacktip sharks from document SB-02-03, and extending the bottom longline discards back to 1981. Bottom longline discards were extended back to 1981 by multiplying the commercial landings by the average 1994-2001 discard rate of 5.66% (Table 4).

For sandbar (Table 5) and blacktip shark (Table 6), the baseline scenario consisted of extending commercial landings and recreational catches back to 1981, and adding discards in the menhaden fishery and Mexican catches for 1981-2001. Commercial landings for 1981-1986 were estimated by calculating the proportion of the total large coastal shark commercial landings that sandbar or blacktip sharks represented each year from 1986 to 2001, and multiplying that proportion by the total LCS commercial landings (in Table 1). Recreational catches were taken from MRFSS. Menhaden fishery bycatch estimates were taken as reported in document SB-02-15 and extended back to 1981. Mexican catches were taken from document SB-02-03, and corresponded to 50% of the sum of small fish caught in the states of Tamaulipas and Veracruz for blacktip shark. This percentage was used to take account of the potential mixing of U.S. and Mexican stocks in the Mexican fishing grounds. For sandbar sharks, the total sum of catches was used because there is no scientific evidence of nursery areas in Mexican waters.

An alternative scenario for the large coastal complex included a number of significant modifications with respect to the updated scenario in an attempt to reconstruct historical catches (Table 7). As in the 1998 assessment, commercial landings for 1981-1985 were multiplied by factor of 1.5, landings for 1986-1992 by a factor of 2, and landings in 1993 by a factor of 1.5 to account for underreporting. In addition, commercial catches for 1960-1980 were estimated based on a document by Anderson (1990. Estimates of large shark catches in the Western Atlantic and Gulf of Mexico, 1960-1986. NOAA Tech. Rep. NMFS 90, pp. 443-454) in which U.S. catches of large sharks in the Atlantic and Gulf of Mexico were reported. The Group recognized significant limitations of this source of information, in which it was stated that the catches reported could have included sharks of any species excluding dogfish, that there was no market for large coastal sharks during the period, and the overall uncertainty of the estimates. Despite these caveats, the Group decided to continue with this exercise. The method used to back-calculate the 1960-1980 catches was as follows: the reported catches in mt for 1981-1986 in Anderson (1990) were transformed into numbers assuming a whole weight average of 90 lb ww and compared to the commercial landings for the corresponding year from the updated catch scenario. The ratio of these two catch estimates was calculated for each year from 1981 to 1986, and then the 1981-1986 average used as a multiplier for the landings reported in Anderson (1990) to produce an annual estimated catch for the period 1960-1980.

Pelagic longline discards were extended to include the period 1978-1986 using the same estimate of 10,000 fish used for the alternative catch scenario in the 1998 assessment. The series was further extended back to 1970 using the minimum reported estimate of dead discards (4,300 fish) for the period 1987-2001. For recreational catches, a document was presented (Casey and Hoey 1990. Shark catches from selected fisheries off the U.S. East Coast. NOAA Tech. Rep. NMFS 31, pp. 15-19) that reported a catch of about 70,000 large coastal sharks for the U.S. Gulf of Mexico and South Atlantic in 1978. To estimate catches for 1979-1980 and prior to 1978, tagging data from the NMFS/Narragansett Laboratory were used to produce a multiplier. That index was calculated as the ratio of the number of LCS tagged in any given year to the number of LCS tagged in 1978. The index was then multiplied by 70,000 to generate annual estimates extending back to 1963 (the year in which tagging data first became available).

Table 1 UPDATED SCENARIO
CATCHES OF LARGE COASTAL SHARKS (thousands of fish)

Year	Commercial Landings	Pelagic longline discards	Recreational catches	Unreported catches	Bottom longline discards	Total
1981	16.2	0.9	265			282.1
1982	16.2	0.9	413.9			431
1983	17.5	0.9	746.6			765
1984	23.9	1.3	254.6			279.8
1985	22.2	1.2	365.6			389
1986	54	2.9	426.1	24.9		507.9
1987	104.7	9.7	314.4	70.3		499.1
1988	274.6	11.4	300.6	113.3		699.9
1989	351	10.5	221.1	96.3		678.9
1990	267.5	8	213.2	52.1		540.8
1991	200.2	7.5	293.4	11.3		512.4
1992	215.2	20.9	304.9			541.1
1993	169.4	7.3	249.0		11.3	437
1994	228	8.8	160.9		16.3	414
1995	222.4	5.2	176.3		13.9	417.8
1996	160.6	5.7	188.5		7.6	362.4
1997	130.6	5.6	165.1		8.3	309.6
1998	174.9	4.3	169.8		9.9	358.9
1999	111.5	9.0	91.0		3.8	215.3
2000	111.2	9.4	140.4		4.8	265.8
2001	99.2	9.4	142.0		6.3	256.9

Table 2 UPDATED SCENARIO
CATCHES OF SANDBAR SHARK

Year	Commercial Landings	Recreational catches	Unreported catches	Total
1986	22187	123660	6225	152072
1987	63667	32551	17575	113793
1988	76266	64792	56650	197708
1989	117428	27417	48150	192995
1990	112158	58814	26050	197022
1991	91716	36794	5650	134160
1992	96670	36294		132964
1993	69171	26607		95778
1994	126455	14974		141429
1995	84372	24906		109278
1996	65515	35711		101226
1997	41415	41618		83033
1998	62776	35766		98542
1999	53248	20553		73801
2000	37331	10743		48074
2001	50668	35880		86548

Table 3 UPDATED SCENARIO
CATCHES OF BLACKTIP SHARK

Year	Commercial Landings	Recreational catches	Unreported catches	Mexican catches	Total
1986	59173	162402	18675	15642	255892
1987	71392	129551	52725	22346	276014
1988	160991	139806	56650	29050	386497
1989	186947	111368	48150	35754	382219
1990	100112	94136	26050	42458	262756
1991	133868	150794	5650	49161	339473
1992	176108	157663		55865	389636
1993	150584	109057		62569	322210
1994	198413	66106		62569	327088
1995	142234	59892		62569	264695
1996	97326	79753		62569	239648
1997	91974	70963		62569	225506
1998	103012	82310		62569	247891
1999	56133	34962		62569	153664
2000	51354	74055		62569	187978
2001	43157	48848		62569	154574

Table 4 BASELINE SCENARIO
CATCHES OF LARGE COASTAL SHARKS (thousand of fish)

Year	Commercial landings	Pelagic longline discards	Recreational catches	Unreported catches	Bottom Longline discards	Mexican catches	Menhaden fishery discards	Total
1981	16.2	0.9	265		0.9	119.971	25.1	428.1
1982	16.2	0.9	413.9		0.9	81.913	25.1	538.9
1983	17.5	0.9	746.6		1.0	85.437	25.1	876.5
1984	23.9	1.3	254.6		1.4	120.684	25.1	426.9
1985	22.2	1.2	365.6		1.3	87.748	25.1	503.1
1986	54	2.9	426.1	24.9	3.1	81.835	25.1	617.9
1987	104.7	9.7	314.4	70.3	5.9	80.160	25.1	610.3
1988	274.6	11.4	300.6	113.3	15.5	89.290	25.1	829.8
1989	351	10.5	221.1	96.3	19.9	105.562	25.1	829.4
1990	267.5	8	213.2	52.1	15.1	122.220	25.1	703.3
1991	200.2	7.5	293.4	11.3	11.3	95.695	25.1	644.5
1992	215.2	20.9	304.9		12.2	103.366	25.1	681.6
1993	169.4	7.3	249.0		11.3	119.820	25.1	581.9
1994	228	8.8	160.9		16.3	110.734	26.2	550.9
1995	222.4	5.2	176.3		13.9	95.996	24.0	537.8
1996	160.6	5.7	188.5		7.6	106.057	25.1	493.6
1997	130.6	5.6	165.1		8.3	83.051	25.1	417.8
1998	174.9	4.3	169.8		9.9	74.136	25.1	458.1
1999	111.5	9.0	91.0		3.8	57.061	25.1	297.5
2000	111.2	9.4	140.4		4.8	52.057	25.1	343.0
2001	99.2	9.4	142.0		6.3	52.057	25.1	334.1

Table 5 BASELINE SCENARIO
CATCHES OF SANDBAR SHARK

Year	Commercial Landings	Recreational catches	Unreported catches	Menhaden fish. Bycatch	Mexican catches	Total
1981	6640	128841		465	10065	146012
1982	6640	32955		465	11822	51882
1983	7173	415722		465	11126	434486
1984	9797	56426		465	11708	78396
1985	9100	67396		465	7910	84871
1986	22187	123660	6225	465	9368	161905
1987	63667	32551	17575	465	6962	121220
1988	76266	64792	56650	465	9142	207315
1989	117428	27417	48150	465	8346	201806
1990	112158	58814	26050	465	10738	208225
1991	91716	36794	5650	465	9063	143688
1992	96670	36294		465	9675	143104
1993	69171	26607		465	9080	105323
1994	126455	14974		486	8762	150677
1995	84372	24906		445	9892	119615
1996	65515	35711		465	10732	112423
1997	41415	41618		465	8364	91862
1998	62776	35766		465	7208	106215
1999	53248	20553		465	7976	82242
2000	37331	10743		465	7051	55590
2001	50668	35880		465	7051	94064

Table 6 BASELINE SCENARIO
CATCHES OF BLACKTIP SHARK

Year	Commercial Landings	Recreational catches	Unreported catches	Mexican catches	Menhaden fish. Bycatch	Total
1981	7812	54875		109906	11700	184293
1982	7812	70665		70091	11700	160268
1983	8439	33633		74311	11700	128083
1984	11525	37839		108976	11700	170040
1985	10705	97425		79838	11700	199668
1986	59173	162402	18675	72467	11700	324417
1987	71392	129551	52725	73198	11700	338566
1988	160991	139806	56650	80148	11700	449295
1989	186947	111368	48150	97216	11700	455381
1990	100112	94136	26050	111482	11700	343480
1991	133868	150794	5650	86632	11700	388644
1992	176108	157663		93691	11700	439162
1993	150584	109057		110740	11700	382081
1994	198413	66106		101972	12200	378691
1995	142234	59892		86104	11200	299430
1996	97326	79753		95325	11700	284104
1997	91974	70963		74687	11700	249324
1998	103012	82310		66928	11700	263950
1999	56133	34962		49085	11700	151880
2000	51354	74055		45006	11700	182115
2001	43157	48848		45006	11700	148711

Table 7 *ALTERNATIVE SCENARIO*
CATCHES OF LARGE COASTAL SHARKS (thousands of fish)

Year	Commercial Landings	Pelagic longline discards	Recreational catches	Unreported catches	Bottom longline discards	Menhaden fishery discards	Total
1960	2						2
1961	9						9
1962	1.9						1.9
1963	2.1		3.5				5.6
1964	2.1		1.8				3.9
1965	5.9		6.1				12
1966	3.5		9.2				12.7
1967	15.3		9.2				24.5
1968	1.5		6.1				7.6
1969	1.6		7.6				9.2
1970	1.5	4.3	8.8				14.6
1971	1	4.3	10.1				15.4
1972	1.4	4.3	24.6				30.3
1973	5	4.3	34.7				44
1974	2	4.3	32.5				38.8
1975	3.7	4.3	32				40
1976	3.8	4.3	46.5				54.6
1977	5.1	4.3	62.7				72.1
1978	7.1	10	70				87.1
1979	4.3	10	65.8				80.1
1980	12	10	67.7				89.7
1981	24.3	10	265		1.4	25.1	325.8
1982	24.3	10	413.9		1.4	25.1	474.7
1983	26.2	10	324.6		1.5	25.1	387.4
1984	35.8	10	254.6		2.0	25.1	327.5
1985	33.3	10	365.6		1.9	25.1	435.9
1986	108	10	426.1	24.9	6.1	25.1	600.2
1987	209.4	9.7	314.4	70.3	11.9	25.1	640.8
1988	549.2	11.4	300.6	113.3	31.1	25.1	1030.7
1989	702	10.5	221.1	96.3	39.7	25.1	1094.7
1990	535	8	213.2	52.1	30.3	25.1	863.7
1991	400.4	7.5	293.4	11.3	22.7	25.1	760.4
1992	430.4	20.9	304.9		24.4	25.1	805.7
1993	254.1	7.3	249.0		14.4	25.1	549.9
1994	228	8.8	160.9		16.3	26.2	440.2
1995	222.4	5.2	176.3		13.9	24	441.8

1996	160.6	5.7	188.5	7.6	25.1	387.5
1997	130.6	5.6	165.1	8.3	25.1	334.7
1998	174.9	4.3	169.8	9.9	25.1	384
1999	111.5	9	91.0	3.8	25.1	240.4
2000	111.2	9.4	140.4	4.8	25.1	290.9
2001	99.2	9.4	142.0	6.3	25.1	282

4.2. CPUE

Document SB-02-6 reported on updated standardized catch rates of four shark species in the Virginia-Massachusetts (U.S.) rod and reel fishery. Abundance indices for several shark species off the coast of the U.S. from Virginia through Massachusetts were developed using data obtained during interviews of anglers in 1986-2001. Subsets of the data were analyzed to assess effects of month, area fished, boat type (private or charter), and interview type (dockside or phone) on catch per unit effort. Standardized catch rates were developed using general linear models for unclassified mako, sandbar, dusky, and blue sharks. Models developed in previous analyses were applied to current data to update the indices through 2001. The nominal catch rate trend is presented for unclassified hammerhead sharks.

Several questions regarding methodologies were raised, and all answers were found in the text, with the exception of what sampling fraction the total observed trips represent (Table 2). The main issue was the potential for misidentification of sandbar vs. dusky sharks, and mako vs. sandbar sharks. It was pointed out that these are interview data and misidentifications are always a possibility.

Document SB-02-7 reported on large pelagic logbook catch rates for large coastal sharks. Indices of abundance from 1986 through 2001 for large coastal sharks in the combined areas (Atlantic, Caribbean and Gulf of Mexico) were developed using mandatory reports from longline vessels. Gear type was limited to longline or bottom longline by selecting records reporting at least 100 hooks per set. Gear type was used as one of the factors in the GLM analysis.

The first issue addressed was the high proportion of the catch that was reported as "unclassified". In 1992 and 1994 the logbook was expanded to include more species of sharks. Misidentification remains a possibility. The question was raised about hook changes that have occurred over time. There was also an issue about whether blacktip identifications were in fact spinners or some other species. There was also a question of how the closure of Florida waters might have biased results. It was explained that the specific closure effect was not taken into account for 2001, that the sampling area now extends beyond the closed areas off the Florida east coast. Regarding the decreasing trend in catch rates of hammerhead species depicted in Figure 1, a comment was made that a paper by Myers and Crowder to appear in Science showed that hammerheads could be classified as critically endangered according to IUCN criteria.

Document SB-02-8 described a fishery-independent assessment of shark stock abundance for large coastal species in the northeastern Gulf of Mexico. Fishery-independent catch rates were standardized using a two-part generalized linear model analysis. The first part modeled the proportion of sets that caught any sharks (at least one shark was caught) assuming a binomial distribution with a logit link function while the second part modeled the catch rates of sets with positive catches assuming a Poisson distribution with a log link function. Standardized indices were developed for the large coastal species aggregate and blacktip shark from a longline survey and a gillnet survey. Two additional age-specific catch rate series were also developed for the blacktip shark: young-of-the year (age 0+) and juvenile (age 1-5). Depending on species, the final models varied with the factors area, year, and season. Time of day (i.e., the time of start of the set: dawn, dusk, day, night) explained very little deviance in any of the final models. Although factors such as area and month were significant in most models, results from this study indicate any bias associated with these aspects did not significantly change the trends between nominal and standardized data. Overall, trends were not statistically significant. It is possible that additional factors such as sea temperature, dissolved oxygen, and salinity may contribute more to an explanation of the variability in the models. Further analyses using generalized additive models could improve the explanatory ability of the model.

Discussions revolved around specifics of the paper. There was a question about negative values of the lower confidence limit in Figure 7. Also, there was some question about 1993 values, which seemed out of line with other years. The biggest issue was mortality associated with sampling. Concern was expressed that this sampling gear does not reflect gear used by fishermen, and any mortalities associated with this sampling method should not be extrapolated to what is happening in the fishery.

Document SB-02-9 was a characterization of the large coastal shark catch and standardization of catch rates from observer data in the directed shark drift gillnet fishery. It was developed based on observer programs operated from 1993-1995 and 1998-2001. Depending on season and area, large coastal species (primarily blacktip) are targeted, making up between 10.8%-55.9% of the total shark catch by number. By number, the blacktip shark comprised 94.1% of the large coastal shark catch. Average size of blacktip sharks was 105 cm FL in 2000 and 124 cm FL in 2001. Gillnet selectivity parameters for the blacktip were derived from a fishery-independent survey, but can be applied to this fishery because of the overlap in mesh sizes. Peak selectivities increased from 550 mm FL for the 8.9 cm and 10.2 cm mesh panels to 850 mm FL for the 14.0 cm mesh panel in 100 mm increments per mesh panel. Selectivity was highest at 1150 mm FL for the mesh panel of 20.3 cm. Catch rates were standardized for the large coastal aggregate, the blacktip shark, and a hammerhead aggregate using a two-part generalized linear model analysis. Depending on species, the final models varied with factors area, year, vessel, mesh, and moon. Results from this study indicate that the use of the two-step modeling approach was appropriate for standardizing catch rates for large coastal sharks. The importance of fishery factors (e.g. vessel) as explanatory variables in the final models for blacktip reflects differences in the effectiveness of the vessels in the fleet. Additional differences in nominal catch rates with respect to those estimated from the standardized indices are more likely a result of changes in observer coverage rather than abundance.

It was suggested that a negative binomial distribution might provide a better fit to the positive catches data than the Poisson distribution used in the analysis. It was also noted that the 1998 value for the hammerhead shark aggregate was high, but this could be explained by low sample size.

Document SB-02-12 was an analysis of catch rate series for large coastal sharks. Catch rate series for large coastal sharks from three fishery-independent surveys and two fishery-dependent surveys were examined. The fishery-independent data included the NMFS longline survey in the northeast region, the South Carolina Department of Natural Resources longline survey, and the NEFSC bottom trawl survey. The fishery dependent data included the directed shark longline observer program and the MRFSS recreational survey. A total of 41 series for large coastal sharks were examined: 8 series for the large coastal shark complex, 8 for sandbar shark, 7 for blacktip shark, 6 for dusky shark, 4 for hammerhead sharks, 4 for bull sharks, 2 for tiger sharks, 1 for scalloped hammerhead, and 1 for silky sharks.

Most questions addressed the various databases used. One observer questioned the results in 2001 from the directed shark fishery bottom-longline observer program (Figure 3) where blacktip shark CPUE was low and sandbar shark CPUE was unusually high. These changes in nominal catch rates were attributed to low sample sizes. The point was raised that regressions should probably be weighted by the CVs.

Document SB-02-16 summarized methods and results relating to catch rates of large coastal sharks in the western North Atlantic Ocean derived from fishery-independent bottom longline surveys. In efforts to maintain viable shark populations, the National Marine Fisheries Service (NMFS) Mississippi Laboratories (MSL) instituted field surveys (1995-2001) to assess distribution and relative abundance of coastal sharks in the western North Atlantic Ocean and Gulf of Mexico. Although the entire western North Atlantic Ocean study area could not be completely surveyed during each year, continental shelf areas surveyed since the inception of this longline study including the U.S. western North Atlantic Ocean seaboard from Maine to the Florida Keys, the U.S. and Mexican Gulf of Mexico, and the circumference of Cuba and Navassa Island. Studies with Mexico and Cuba were conducted to facilitate shark research throughout as much of the known range as possible for several important shark species typically distributed in U.S. coastal waters. Monofilament bottom longline gear was used during this study. Longline gear included one nautical-mile-long main line with 100 hooks, either #3/0 J-hooks or #15/0 circle hooks (C-hooks) baited with Atlantic mackerel or Atlantic bonito on gangions 8 or 12 feet in length. This gear was fished for 1 hour, and catch-per-unit-effort (CPUE) was defined as catch per 100 hook hours. All longline sites during all surveys were selected at random. Sampling density for a given area or statistical zone was a function of available sea days and the amount of study area designated for a particular survey. Tables were presented summarizing catch rate data (1995-2001) in many ways: by year, by area, by hook type and by combinations of these categories. These tables included statistics such as mean CPUE, standard error and percent standard error (i.e. coefficient of variation of the mean). The data were summarized for shark catches between 10 and 30 fathoms in depth due to consistent coverage of this depth stratum throughout all U.S. surveys. Catch rate statistics for three species (blacktip, sandbar and tiger sharks) and the large coastal species complex were included.

It was pointed out and advised that the data presented in this study could be subjected to a general linear model analysis to take account of time-year and area-gear effects, among other factors. A question was raised by an observer about the validity of a zero catch rate for sandbar in the Atlantic in 1999. The authors indicated that the cruise in question was conducted during late winter, whereas all other cruises in this region were conducted in summer months. Also, it was requested that information on length frequency of the catches of large coastal sharks be provided.

Document SB-02-21 described the 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. Eastern Gulf of Mexico coastal areas south of Cedar Key, Florida, were assessed as nursery grounds for species of large and small coastal sharks. Species-specific abundance, bycatch mortality in gillnet fishing gear, and various biological parameters (distribution, food habits, growth and migration) were studied intensively in three nursery areas (Yankeetown, lower Tampa Bay and Pine Island Sound/Charlotte Harbor) in 1995-97. Over this period 3,227 sharks of 13 species, including 1,416 juvenile blacktip sharks, were documented in the surveys. To quantify relative abundance of juvenile blacktips, monthly random stratified sets of 400 yd x 10 ft (366 x 3 m) weighted monofilament gillnets with a 4-5/8" (11.8 cm) mesh size were made in five of ten 1 x 1 km blocks of a 10 km^2 grid within each nursery area. Results show no significant increasing or decreasing trends in juvenile blacktip shark abundance during the project (see further results in SB-02-23). Fall and winter tag recaptures of juvenile blacktips indicate the young sharks inhabiting the eastern Gulf nurseries in the spring and summer leave their nurseries in the fall and generally migrate south, with some recaptures in winter occurring as far south as the Florida Keys. Returns of one and two year-old juvenile blacktips back to the natal nursery in the spring/summer of subsequent years also are indicated.

Document SB-02-23 described the relative abundance of juvenile blacktip sharks in two Florida Gulf nursery areas from 1995 to 2001. The relative abundance of neonate and young-of-the-year blacktip sharks in two Florida Gulf shark nurseries (Yankeetown and Pine Island Sound) was estimated for the period 1995-2001. Monthly random stratified gillnet sampling was conducted from March through October in all years except 1998, using gear and methodology developed in 1995 (see SB-02-21). Surveys collected a total of 2,220 juvenile blacktips. CPUE data of number of sharks caught per hour fished (first net mesh in to last mesh out) were log-transformed and standardized catch rates were calculated using a General Linear Model (GLM) with year, month, and area as factors. Results indicated significant differences in catch rates between all factors tested but the slope of the catch time series was not significantly different from zero. Thus, no significant increasing or decreasing trends in recruitment to blacktip shark nursery areas on the Florida Gulf can be discerned in the years between 1995 and 2001. Decreasing catch rates from June to October were used to estimate the relative number of pups lost in the nursery due to mortality (both natural and fishing) as well as dispersal of those individuals that left the nursery prior to the main fall migration. This decline in catch rate from June to October was 87%, which compares favorably with other estimates of blacktip shark mortality in the first six months of life in eastern Gulf nurseries.

Regarding both documents SB-02-21 and SB-02-23, the authors reported a lack of discernable trends since 1995. A question was raised about the extent of the total nursery area in the Gulf of Mexico. The issue of mortality rates in gillnets in fishery-independent surveys was raised. It was pointed out that it might be worthwhile to integrate all similar nursery area/fishery-independent abundance surveys. The question was also posed of why the upper confidence limit for blacktip sharks in 1996 was so high, the response being that in that year only the Yankeetown sampling site, where higher abundances are generally observed, was surveyed.

Document SB-02-28 presented a delineation of shark nursery grounds in Chesapeake Bay and an assessment of abundance of shark stocks. Catch rates of large coastal sharks in 2001 were similar to those of the past six years and greater than observed in 1990-93. However, catch rates declined by about 75% between 1974 and 1992. Recent data reflect a modest recovery from these depressed levels. Analysis of standardized data (mean CPUE; sharks/100 hooks/hours fished for all coastal stations >3h soak time, June-September) indicated that catch rates have remained at a level significantly below that from 1974-81. Mean catch in biomass (kg/100 hooks/hours fished) clearly shows that catch rates remain stabilized and that increases in CPUE in the latter 1990s are due to increased catch of smaller, juvenile sharks. Since the late 1970's, species-specific CPUEs have decreased considerably for four individual species: the sandbar shark, the dusky shark, the tiger shark, and the sandtiger shark. Sandbar and dusky sharks are, or were, important components of the shark fauna in the Chesapeake Bight region. The sandbar shark typically dominates the large coastal shark catch and the dusky shark, at one time, comprised 10-20% of the total catch. In 1992, however, dusky sharks represented less than 1% of the catch.

The question was asked that if few sandbar sharks reach adulthood (Fig. 4), why the biomass is increasing in Figure 2. The question was also asked that if offshore longlining occurs from May through September, if any adjustments were made to account for fleet activities. It was noted that the Observer program data track the VIMS' data, also showing a decline in shark size. It was questioned why recovery of adolescents has not translated into an increase in subadults. The answer was that the fishery is removing these young fish before they can reach maturity. It was counter-stated that the commercial fishery is only removing a small proportion of the existing large juvenile biomass.

Document SB-02-32 was an analysis of the status and ecology of the dusky shark in the western North Atlantic based on information derived from the directed shark fishery bottom longline observer program and the VIMS shark longline survey. Summer long-line catches of dusky sharks off the southeastern U.S. were lower and consisted of larger animals. The average fork length of the summer season catches was 189 cm compared to 117 cm FL for the winter season. This is indicative of larger sharks moving into the system to pup and the smaller sharks moving north into the mid-Atlantic Bight due to warming water temperatures in late spring and early summer as shown in the VIMS data set. Throughout 1994-1999 catch rates for small sharks (<179 cm) increased in both data sets while catch rates of older mature animals declined in both data sets. The lack of an increase in adult dusky sharks in the VIMS data sets, and a marked decline in adult dusky sharks in the Observer data set are a cause for concern.

The discussion centered on describing catch rates of dusky shark. It was suggested that the increase in CPUE in the 1990s was a result of an increase in young-of-the-year (YOY) dusky sharks (possibly a large recruitment event), a decrease in large animals, or a combination of both. There was also a comment that the temporal and spatial coverage by the CSFOP program was biased due to low or no sampling in some strata as a result of funding difficulties.

Document SB-02-33 and SB-02-33r (which replaced 33) described bottom longline logbook catch rates for large coastal sharks. Indices of abundance from 1996 through 2001 for large coastal sharks in the Atlantic and Gulf of Mexico were developed using mandatory reports from bottom longline vessels.

The group had no comments on this document, which was an attempt to standardize logbook data in document 34. Document 33r compared the top 20% producing vessels in terms of average yearly CPUE ("shark-targeting" vessels) to all vessels in the fleet. It was noted that it would be useful to know the number of observations in each zone.

Document SB-02-34 summarized Gulf of Mexico and southeastern U.S. Atlantic shark catch and fishing effort from coastal fishery logbook reports. Data were compiled from the logbooks data collection systems operated by the Southeast Fisheries Science Center, National Marine Fisheries Service. Although the logbook program for coastal fisheries in the region began in 1990 (logbook data collections for swordfish permitted fishermen began in 1986), reporting for shark fishing was not required until July 1993. The reporting regulations require that all vessels with a federal vessel permit for shark must complete a logbook that provides information on the catches, fishing location, amount of fishing effort and type of gear used. Various summaries of log-reported catch and effort for the Gulf of Mexico and the southeastern U.S. Atlantic are provided.

The issue of misidentifications was raised again. The identification of blacktip sharks from deeper waters was questioned, and a comment was made that they were likely to be spinner or silky sharks. The high level of "unidentified" sharks prior to 1996 was questioned – the logbooks were changed in 1996. It was also noted

CPUE Working Group Activities

The following discussion points for the CPUE working group were identified in plenary:

1) Compile various indices on a common scale
2) Identify age-specific series for sandbar and blacktip shark
3) Identify positive and negative aspects for each series (add comments in summary spreadsheet)
4) Identify spatial (Western Gulf, Eastern Gulf, Atlantic) and temporal coverage (time of year) for each series

The CPUE Working Group calculated CPUE indices for the NMFS (Mississippi Laboratories) surveys for the period 1995-2001 using a general linear mixed model. CPUE indices were calculated for the large coastal complex (LCS), blacktip, and sandbar sharks. For LCS, the hook type variable was not significant in both the binomial model for proportion of positive sets and the Poisson model for positive catches. The LCS series was standardized using year, area, and depth as explanatory variables, which were significant in both models. Figure A illustrates the CPUE indices for LCS.

Standardization of CPUE series for blacktip and sandbar sharks was more problematic. After initial runs of both the blacktip and sandbar models, a limited data set was used. The data were limited to only J-hooks and sharks captured in water depths of 30 fathoms or less. The data were limited due to a lack of convergence of the models, which was probably a result of the high number of zeros in the catch data. Final models were run using only year and area effects. Figures B and C illustrate CPUE indices for blacktip and sandbar sharks, respectively. Table 8 summarizes all the series that were available at the workshop.

Figure A. CPUE Indices for large coastal sharks. Error bars shown represent 95% confidence intervals.

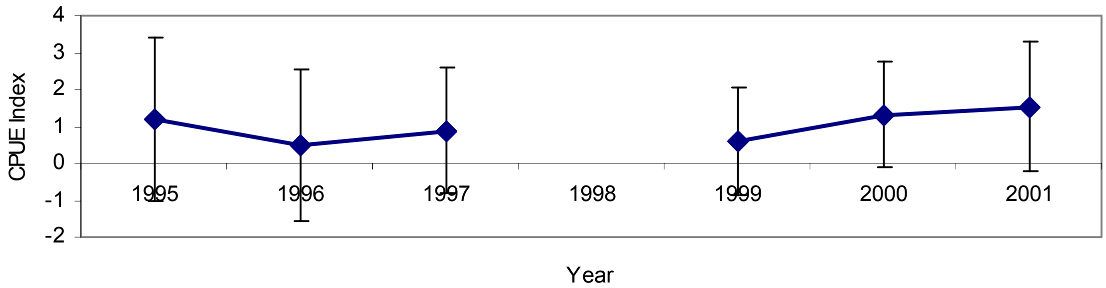

Figure B. CPUE Indices for blacktip sharks. Error bars represent 95% confidence intervals.

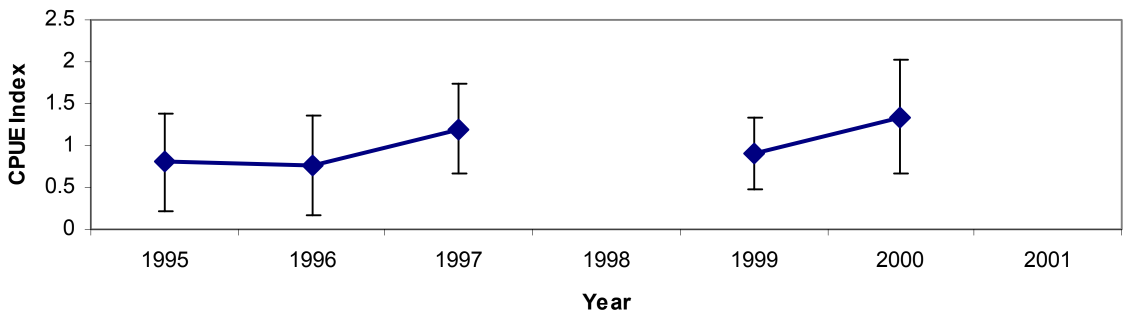

Figure C. CPUE Indices for sandbar sharks. Error bars represent 95% confidence intervals.

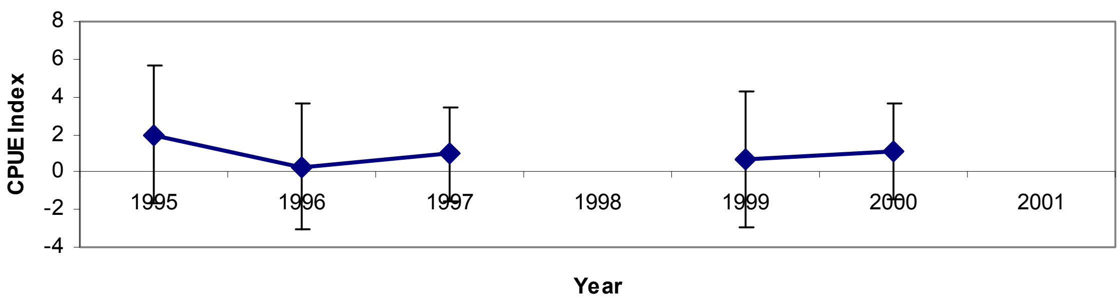

Table 8. A summary of catch series available for the shark evaluation workshop 2002.

Species	Series	Name	Reference	#Boats	Area	Years	Season	Biomass/ Number	Fishery type	Standardized	Selectivity info.	Age range	Positive aspects	Negative Aspects
LCS	1	Brannon	SB-III-13	1-9	AL, NC	86-91	All	B, N	Comm.	Nominal	Ave. wt		Historic info.	Area effect, No CV,
LCS	2	Hudson	SB-II-16, SB-II-Report	~30-50	W. FL	85-91	Sum.	N	Rec.	Nominal	Spec. Ave. wt.		Historic info.	Localized, No CV
LCS	3	Crooke LL	SB-II-16, SB-II-Report	1	NW. FL	75-89	All	N	Comm.	Nominal	Spec. Weight ave.		Historic info	Localized, No zero observ. No CV
LCS	4	Shark Observer	Update SB-02-12	>50	Atl., W. Gulf	94-01	Sum/ Win.	N	Comm.	Nominal	Size freq.		Stockwide, Observ. data	Lack stand., possible area, gear effect
LCS	5	Jax.	SB-II-16, SB-II Report	50-100 angler/yr	S. Atl.	74, 89, 90	Sum.	N	Rec.	Nominal	Spec. Wt		Historic info.	Localized. tourn. No CV
LCS	6	NC#	SB-II-Report	6	NC	88-89	All	B, N	Comm.	GLM	Ave. Wt		Historic info	Limited series, no species ID
LCS	7	SC LL Recent	Updated SB-02-12	1	SC	95-01	Sum.	N	FI	GLM	Size Freq.		Fishery independ.	Localized
LCS	7.1	SC LL Early	SB-IV-Report	1	SC	83, 94	Sum.	N	FI	Nominal	Size Freq.		Fishery independ. Historic info	Localized, Limited series
LCS	8	Pt. Salerno	SB-II-16, SB-II Report	50-100 angler/yr	E. FL	76-90	Sum.	B, N	Rec.	Nominal	Size		Historic info.	Possible localized, No CV Possible mis-ID

Species	Series	Name	Reference	#Boats	Area	Years	Season	Biomass/ Number	Fishery type	Standardized	Selectivity info.	Age range	Positive aspects	Negative Aspects
LCS	9	Tampa Bay	SB-II-16, SB-II Report	200 angler/yr	W. FL	85-90	Sum.	B, N	Rec.	Nominal	Size		Historic Info.	Possible localized, No CV Possible mis-ID
LCS	10	VA LL	Updated SB-02-12	1	Mid. Atl.	74-01	Sum.	B, N	FI	Nominal fixed station	Size Spec.		Long FI time series	Not useful for blacktip
LCS	11	LPS	SB-02-06	150-1,000 trips/yr	Mid-NW Atl.	86-01	Spr-Fall	N	Rec.	GLM	Size Freq.		Long stand. time series	Possible mis-ID
LCS	12	Charterboat	SB-III-19	9-43	N. Gulf	89-95	All	N	Rec.	GLM	N/A		Stand. Time series	Possible mis-ID
LCS	13	Pelagic log	Updated SB-02-07	150-250	Atl. Gulf	86-01	All	N	Comm.	GLM	Wgt. from slip		Stockwide, Long stand. time series	Possible mis-ID on blacktips
LCS	14	Early Rec.	Updated SB-02-12	~700 boat trip/yr	Atl. Gulf	81-93	Spr-Fall	N	Rec.	Nominal	Length/ Freq.		Stockwide, Historic info	Possible mis-ID No CV Extrapolated data
LCS	15	Late Rec.	Updated SB-02-12	~700 boat trip/yr	Atl. Gulf	94-00	Spr-Fall	N	Rec.	Nominal	Length/ Freq.		Stockwide,	Mostly small sharks No CV
LCS	16	NMFS LL NE Recent	Updated SB-02-12	1	Atl.	96, 98, 01	Spr-Sum.	N	FI	Nominal fixed station	Size Spec.		FI time series, Wide dist.	Missing years
LCS	16.1	NMFS LL NE Early	Updated SB-02-12	1	Atl.	89, 91	Spr-Sum.	N	FI	Nominal fixed station	Size Spec.		FI time series, Wide dist.	Yankee gear Missing years

Species	Series	Name	Reference	#Boats	Area	Years	Season	Biomass/ Number	Fishery type	Standardized	Selectivity info.	Age range	Positive aspects	Negative Aspects
LCS	17	NMFS LL SE	Updated SB-02-16	1	Atl. Gulf	95-97 99-01	Sum.	N	FI	GLM	Size Spec.		Stockwide FI stand. survey	Missing year
LCS	18	Gillnet observer	SB-02-09	6	Atl.	93-95 98-01	All	N	Comm.	GLM	Size Spec.		Stand. time series	Low samples in some years
LCS	19	NE Trawl	SB-02-12	1	Mid-NW Atl.	72-01	Fall	N	FI	GLM	Size Spec.			Recommend remove due to low catches
LCS	20	SE Trawl	SB-02-xx	1	Gulf	7x-01	Fall	N	FI	Nominal	Size Spec.			Recommend remove due to low catches
LCS	21	PC LL	SB-02-08	1	NE Gulf	93-00	Spr-Fall	N	FI	GLM	Size Spec.		Stand. FI time series	Localized
LCS	22	PC Gillnet	SB-02-08	1	NE Gulf	96-01	Spr-Fall	N	FI	GLM	Size Spec.		Stand. FI time series	Localized
LCS	18.2	Bottom LL Logs	SB-02-33R	157 (31 trgt shark)	S. Atl. Gulf	96-01	Sum./ Win.	B	Comm.	GLM	Size Freq.		Stand. time series	Same info. in observer prog.
SB	1	VA LL	Updated SB-02-12	1	Mid. Atl.	74-01	Sum.	B, N	FI	Nominal fixed station	Size Spec.	0-1 1-7 8-12 13+	Long FI time series	Missing years Not useful for blacktip
SB	2	Pelagic log	Updated SB-02-07	150-250	Atl. Gulf	86-01	All	N	Comm.	GLM	Wgt. from slip	8+	Stockwide, Long stand. time series	Possible mis-ID on blacktips
SB	3	Early Rec.	Updated SB-02-12	~700 boat trip/yr	Atl. Gulf	81-93	Spr-Fall	N	Rec.	Nominal	Length/ Freq.	0-3	Stockwide, Historic info	Possible mis-ID No CV Extrapolated data

Species	Series	Name	Reference	#Boats	Area	Years	Season	Biomass/ Number	Fishery type	Standardized	Selectivity info.	Age range	Positive aspects	Negative Aspects
SB	4	Late Rec.	Updated SB-02-12	~700 boat trip/yr	Atl. Gulf	94-00	Spr-Fall	N	Rec.	Nominal	Length/ Freq.	0-3 (size limit in 1999)	Stockwide,	Mostly small sharks No CV Extrapolated data
SB	5	NMFS LL NE Recent	Updated SB-02-12	1	Atl.	96, 98, 01	Spr-Sum.	N	FI	Nominal fixed station	Size Spec.	2+	FI time series, Wide dist.	Missing years
SB	5.1	NMFS LL NE Early	Updated SB-02-12	1	Atl.	89, 91	Spr-Sum.	N	FI	Nominal fixed station	Size Spec.	2+	FI time series, Wide dist.	Yankee gear Missing years
SB	6	NMFS LL SE	Updated SB-02-16	1	Atl. Gulf	95-97 99-01	Sum.	N	FI	GLM	Size Spec.	2+	Stockwide FI stand. survey	Missing year
SB	7	SC LL Recent	Updated SB-02-12	1	SC	95-01	Sum.	N	FI	GLM	Size Freq.	1-12	Fishery independ.	Localized
SB	7.1	SC LL Early	SB-IV	1	SC	83, 94	Sum.	N	FI	Nominal	Size Freq.	1-12	Fishery independ. Historic info	Localized, Limited series
SB	8	Shark Observer	Update SB-02-12	>50	Atl., W. Gulf	94-01	Sum/ Win.	N	Comm.	Nominal	Size freq.	2-3 (S. Atl.) 3-24	Stockwide, Observ. data	Lack stand., possible Area, gear effect
SB	9	Bottom LL Logs	SB-02-33R	157 (31 trgt shark)	S. Atl. Gulf	96-01	Sum./ Win.	B	Comm.	GLM	Size Freq.	2-3 (S. Atl.) 3-24	Stand. Time series	Same info. in observer prog.
SB	10	LPS	SB-02-06	150-1,000 trips/yr	Mid-NW Atl.	86-01	Spr-Fall	N	Rec.	GLM	Size Freq.	12+	Long stand. time series	Possible mis-ID
SB	11	NE Trawl	SB-02-12	1	Mid-NW Atl.	72-01	Fall	N	FI	GLM	Size Spec.			Recommend remove due to low catches

Species	Series	Name	Reference	#Boats	Area	Years	Season	Biomass/ Number	Fishery type	Standardized	Selectivity info.	Age range	Positive aspects	Negative Aspects
BT	1	Pelagic log	Updated SB-02-07	150-250	Atl. Gulf	86-01	All	N	Comm.	GLM	Wgt. from slip		Stockwide, Long stand. time series	Possible mis-ID on blacktips
BT	2	Early Rec.	Updated SB-02-12	~700 boat trip/yr	Atl. Gulf	81-93	Spr-Fall	N	Rec.	Nominal	Length/ Freq.	0-5	Stockwide, Historic info	Possible mis-ID No CV Extrapolated data
BT	3	Late Rec.	Updated SB-02-12	~700 boat trip/yr	Atl. Gulf	94-00	Spr-Fall	N	Rec.	Nominal	Length/ Freq.	0-5	Stockwide,	Mostly small sharks No CV Extrapolated data
BT	4	Shark Observer	Update SB-02-12	>50	Atl., W. Gulf	94-01	Sum./ Win.	N	Comm.	Nominal	Size freq.	3+	Stockwide, Observ. data	Lack stand., possible Area, gear effect
BT	5	NMFS LL NE Recent	Updated SB-02-12	1	Atl.	96, 98, 01	Spr-Sum.	N	FI	Nominal fixed station	Size Spec.	4+	FI time series, Wide dist.	Missing years
BT	5.1	NMFS LL NE Early	Updated SB-02-12	1	Atl.	89, 91	Spr-Sum.	N	FI	Nominal fixed station	Size Spec.	4+	FI time series, Wide dist.	Yankee gear Missing years
BT	6	NMFS LL SE	Updated SB-02-16	1	Atl. Gulf	95-97 99-01	Sum.	N	FI	GLM	Size Spec.	4+	Stockwide FI stand.	Missing year
BT	7	Bottom LL Logs	SB-02-33R	157 (31 trgt shark)	S. Atl. Gulf	96-01	Sum./ Win.	B	Comm.	GLM	Size Freq.	3+	Stand. Time series	Same info. in observer prog.
BT	8	Gillnet observer	SB-02-09	6	Atl.	93-95 98-01	All	N	Comm.	GLM	Size Spec.	3+	Stand. Time series	Low samples in some years
BT	9	PC LL	SB-02-08	1	NE Gulf	93-00	Spr-Fall	N	FI	GLM	Size Spec.	0-5	Stand. FI time series	Localized

Species	Series	Name	Reference	#Boats	Area	Years	Season	Biomass/ Number	Fishery type	Standardized	Selectivity info.	Age range	Positive aspects	Negative Aspects
BT	10	PC Gillnet	SB-02-08	1	NE Gulf	96-01	Spr-Fall	N	FI	GLM	Size Spec.	0-1 1-5	Stand. FI time series	Localized Not useful for surplus-prod. model
BT	11	SC LL Recent	Updated SB-02-12	1	SC	95-01	Sum.	N	FI	GLM	Size Freq.	All but most 0-5	Fishery independ.	Localized
BT	12	Mote gillnet	SB-02-28	1	E. Gulf	95-01	Sum.	N	FI	Nominal random station	Size Spec.	0-1	FI time series	Localized Not useful for surplus-prod. model

4.4. Tagging and other information

Document SB-02-01 **(appendix)** presented a preliminary analysis of the information on sandbar shark movements in the NW Atlantic contained in the data from the Cooperative Shark Tagging Program of the NMFS Narragansett Lab. The analysis includes data on tagging and recapture from 1962 until 2000. During this period, a total of 22,955 sandbar sharks (11,874 females and 7,484 males; the rest unsexed) were tagged by the program and a total of 1163 recaptures (605 females and 423 males) were reported. The recapture rate of sandbar sharks is about 5%, with a very slight difference in the recapture rate by sex. The total number of reported recaptures from Mexican waters is 46, 13 females, 17 males and 16 unsexed fish. This represents a recapture rate of only 0.2% from Mexican waters. A gross estimate of the ‘net loss’ of sandbar sharks from U.S. to Mexican waters can be obtained by dividing the recapture rate in Mexican waters by the total recapture rate. This estimate indicates that about 3.96% of the sandbar shark population might be living in Mexican waters. The data also seem to indicate that the ‘net loss’ rate is higher for males than for females, but the difference needs to be statistically tested. Considering swimming speeds calculated from the data, it would take a sandbar shark a minimum of 2 years and a maximum of 28 years to complete this one-way trip. In contrast, actual data show that at least one shark (male) completed the trip from the coast of New Jersey to Veracruz in only 0.87 years while the mean and median time at liberty for Mexican-recaptured sandbar sharks were 6.1 years and 5.9 years respectively; the mean and median values of these quantities for males were 5.9 years in both cases, and for females 4.2 and 5.2 years, respectively. Most of the sandbar sharks recaptured in Mexican waters are mature or near-mature fish.

The discussion on Mexican mixing rates continued. It was contended that removing fish less than one year at liberty and fish of age less than 4+ is unjustified based on the analysis above. The data show that two small fish, less than 140 cm fork length, crossed from the U.S. to Mexico. Thus, to get total mixing, the whole stock should be used. Two issues were brought up: 1) what age range was capable of the movement; and 2) how much time at liberty is necessary to make the exchange. Discussion returned to mixing rate and 41% was said to be too high as it includes all the Atlantic to Gulf of Mexico recaptures and not just to Mexico. If just Mexican transfers are used, mixing rate becomes 7.5%, which was considered by some to be a minor exchange. The issue of transfer back from Mexico and that it is not a net loss was also brought up; perhaps inclusion of Mexican catches (Document 02-03) will take the exchange into account. It was also pointed out that one cannot see the fish that go to Mexico and back without being recaptured and that telemetry information is needed for that. It was added that improved identification would improve the data for assessment and that looking at time at liberty would give relative fishing mortality rate. This has been applied in other HMS assessments of fishing mortality indicators. A discussion took place on the possibility of a nursery area in Mexican waters and a mating area in the Gulf of Mexico and North Carolina. Finally, it was suggested that in the future, greater spatial, age, and sex information will help support the assessment process.

Document SB-02-19 presented data on blacktip, dusky, and sandbar shark recapture rates, which have been and should be used to estimate potential mixing rates for open populations of these sharks shared with Mexico and Cuba. The topic was started with a presentation of document SB-02-19, which summarized tag-and-recapture data from the National Marine Fisheries Service

Cooperative Shark Tagging Program. The data in the document were then updated. Using these data, a hypothesis was put forth that 41% of sandbar sharks travel from the northeastern U.S. to the Gulf of Mexico. It was contended that sharks in the northern Gulf of Mexico are easily able to go to Mexican waters and that the 5.6% mixing rate calculated in the 1998 SEW is too low. Data on sharks at liberty for over one year were used to formulate this hypothesis. A 16% estimate of mixing rate for dusky sharks was also proposed, as well as theoretical levels of 10, 20, and 30% mixing to be used in "what-if" scenarios in stock assessment models. Discussion ensued and it was suggested that only sharks 4+ years old at tagging be used to determine mixing as they are more likely to move long distances, since those sharks from Chesapeake Bay do not move past Virginia until after age 4 and males leave after age 8 and do not return. It was determined that age/size information could be obtained from the tag/recapture database to utilize the actual age of the animal when migrating. It was also suggested that spatial structure be added to the analysis of mixing rates. Additionally, the subject of one-way flow (from the US to Mexico) was introduced and that the implication of only outflow is not realistic, yet there is no tagging information originating from Mexico.

Document SB-02-22 included information on tagged blacktip sharks showing that they return to their natal nursery area and move further distances as they get larger. Discussion focused on the similarities to the VIMS study on sandbar sharks and whether electronic tagging has been considered on this species. It was stated that 9 archival tags have been placed on blacktip sharks and that 10-20 archival satellite tags will be placed on sandbar sharks this summer.

Document SB-02-24 presented tag-and-recapture information from the National Marine Fisheries Service's Cooperative Shark Tagging Program for blacktip shark for the period 1964-2001. A total of 4,663 blacktip sharks were tagged along the U.S. east coast, in the Bahamas, Gulf of Mexico, and the Caribbean Sea to Northern Brazil. The study area was divided into seven geographical areas to examine regional trends in size categories. Of the 4,073 fish of known sex, 1,642 (40%) were males and 2,431 (60%) were females resulting in a 1:1.5 male to female sex ratio. Overall mean fork length was 86.0 cm for the 4,658 blacktip sharks with size information, with a range of 31-190 cm FL. A total of 161 blacktip sharks were recaptured from 1966 through 2001 with a recapture rate of 3.4%. Longest time at liberty was 5.9 years and longest distance traveled was 618 nautical miles. Blacktip sharks demonstrated seasonal North-South movements, and limited exchange (n=9) occurred between the tagging areas. Considerable movement (n=31) did occur, however, between the western Gulf region (Texas) and Mexican waters. The extent of this movement is unclear due to the possibility of under-reporting of recaptures.

The North-South migration and the lack of mixing between tagging areas was confirmed. Tag/recapture data and DNA analysis are being used in conjunction, and archival satellite tags will also be used to study migratory patterns of blacktip sharks. The question was asked of whether a link between the Eastern Gulf of Mexico and Mexico has been established. The connection is weak between the Eastern Gulf of Mexico and Atlantic, and preliminary genetic evidence indicates that blacktip sharks in the eastern and western Gulf of Mexico may belong to separate stocks. The identification problem with blacktip sharks, particularly from the pelagic Gulf of Mexico, was re-addressed (these data were not used in the analysis described in document SB-02-24). A similar question was asked about the proportion of spinner sharks from pelagic longline data, in the sense that it should be higher than that of blacktip sharks, and fishermen may be miss-identifying these fish. It was also suggested that for the blacktip shark assessment, catch rate information from Texas headboats be used.

Document SB-02-28 presents information on delineation of shark nursery grounds in Chesapeake Bay and an assessment of abundance of shark stocks. The objectives are to continue the juvenile sandbar shark tagging program, to estimate juvenile abundance, and to examine long-term movements and the degree of site fidelity while in the Chesapeake Bay nursery as well as during migrations to and from wintering areas.

This document was summarized in relation to the tag/recapture of small sandbar sharks in Chesapeake Bay and evidence of strong philopatry. Discussion focused on movements of this species to the Bay in summer and to over-wintering areas in North and South Carolina. The data support the contention that small sandbar sharks do not have the capacity to travel to the Gulf of Mexico because they do not move past the Carolinas until age 4. It was also stated that male sandbar sharks do not return to Virginia after age-8. The maximum time at liberty for a sandbar shark from the area has been 3-4 years.

5.1. Methods and data for stock evaluation

Document SB-02-01 presented an age- and sex-structured, fleet disaggregated population dynamics model that simulates the dynamics of the shark population and fisheries taking into account specific characteristics of shark biology. The simulated population was assumed to occupy two areas, which for the purpose of the assessment, were taken to be the area in the U.S. EEZ and the Mexican part of the Gulf of Mexico. The model allowed for age- and sex-specific movement between these two areas. Bayesian statistical methods were applied to fit the model to the data and deal with the uncertainty in the model parameters and assumptions. The model was applied to sandbar shark and the results showed that the population has decreased to less than 30% of its virgin size. Runs using different values for movement rates showed that the qualitative predictions of the model were not sensitive to the values of movement rate from the U.S. to the Mexican waters. However, the choice of the selectivity curve for the commercial and recreational fishery affected considerably the predictions of the model. The predictions of the model regarding the status of the stock were similar to the predictions of the surplus production model used at the 1998 assessment of sandbar sharks (NMFS 1998). The authors concluded that the age-based model is preferable to less sophisticated models in that it can account for fisheries with different size selectivity, fish migration, and age-specific management measures, but it requires more detailed information, such as selectivity data.

Discussion on several issues ensued. It was pointed out that this model run only included data through 1997 (from the 1998 SEW) and so it did not include the recent observations up to 2001. A question was raised about the existence of a nursery ground in Mexico. It was pointed out that the model was shown not to be sensitive to transfer rates, but that it is sensitive to the shape of the selectivity vector. Another issue was that although the model is estimating historic fishing, it does assume virgin biomass back in the 1960s (equilibrium conditions): the stock not being at equilibrium could be another sensitivity scenario to include. It was also clarified that this is a new model that emerged from the recommendation by the independent reviewers to incorporate age structure and an open population. The model can now be used including the four most recent years of data that have been presented here at the workshop. It was further pointed out that this is a standard approach in many stock assessment arenas, in which an application is developed, and then fit to the data used before. It is then up to the assessment group to define sensitivity trials. It was pointed out that other model applications had not been presented yet. Other models must be presented first before too much more discussion can take place. A comment was made that the weakness does not reside in the models, but in the data. It was suggested that a table of estimated qs would be helpful as well as a graphical presentation of results.

Document SB-02-04 presented the maximum likelihood estimation model of Parrack (1990), which was implemented using the software AD Model Builder (Otter Research Ltd. 2000). This model assumes a Poisson process for the following events: recruitment, immigration, emigration, and all mortality except that due to fishing. As such, it does not consider carrying capacity nor density-dependent changes in population dynamics. This density-independent model theoretically allows for exponential growth or decline of the population. When this model was developed, its simplicity was intended to capitalize on the fact that available data was "uniquely meager." The model requires only the following: 1) a time series of fishing effort; 2) an annual estimate of catch and its variance and/or an annual estimate of individual average weight and its variance; and 3) total annual yield. The present implementation of this MLE model was tested on the data given in Parrack (1990) and the resulting parameter estimates were compared. The results appear to be comparable, although an exact replication has not been achieved. An attempt was made to apply the model to current information, as available in the 1998 SEW. Weight information from the commercial fishery and catch information for the recreational fishery for the years 1994-1997 were used. This time series was short, but reflected availability of input and also a time-span when that data could be assumed to be reasonably consistent. Convergence was not attained from runs of this model (Hessian=0), and so no parameter estimates were possible. The most likely explanation for this convergence failure was the flat trend in the data. It is hoped that the inclusion of more years of data, particularly data that would provide contrast to the present time series, will help the model to converge.

It was clarified that the measure of effort used for both commercial and recreational fisheries was vessel trips, and that there was not enough contrast in the data, especially in the effort time series, for the model to converge. It was recommended that catch and effort information used across time series be consistent with that used in other models, and also that the average weight information consider area differences (e.g., smaller blacktips are caught off North Carolina). There was a question raised about the validity of this model and whether it is a widely accepted model. In response, it was stated that this fishery-independent model is hard to use for projections, that it is limited, but that no fatal flaws were found when it was reviewed. It is one of the various tools that can be used and should be applied to consistent sets of information. The question was also raised of whether this software allowed time trajectories and projections to be made. Projections are not currently coded in the software, but this capability could be incorporated by fixing the estimated parameters and assuming that they do not change when projected forward in time. A comment was also made that it is good to be conservative, keeping old models and comparing the results to those obtained from applying new ones. It was pointed out, that that was done for the 1996 shark stock evaluation.

Document SB-02-05 described an age-structured production model (ASPM) for application to large coastal sharks. This model is explained in detail in ***document SB-02-31***, which was submitted as a reference paper. An age-structured production model was developed using the software AD Model Builder (Otter Research Ltd. 2000). The state-space implementation of this ASPM provides great flexibility in that it allows specification of Bayesian priors as well as the possibility of inter-annual changes in model parameters. Because data for both biological and fishery related parameters for these sharks are scant, it is believed that the use of informative Bayesian priors will improve model estimation capabilities. An application of the ASPM was presented for both Blacktip and Sandbar shark using data available from the 1998 SEW. The input needs and data structure (including specification of priors) was discussed. For the blacktip shark models, it was found that 2 types of assumptions greatly affected the model results: the choice of selectivity function, and the assumption regarding the presence/absence of historical fishing. The models that assumed historical fishing estimated that the stock is currently at 24-36% of the virgin stock. If no historical fishing is assumed (i.e. the stock is in a virgin condition at the start of the time series) then the stock is estimated to be at 45% of virgin level. For the Sandbar models, there was a problem with the estimation of the steepness parameter, which led to the estimate of steepness always being the upper bound (which was set to 0.9). Information on selectivity with respect to the different fisheries (and hence, to the different CPUE series) is desirable. Also, an index of juvenile abundance is very desirable since the current data provide no information about recruitment.

Document SB-02-11 described a simplified delay-difference (lagged recruitment, survival, and growth; LRSG) state-space model that was used to model the dynamics of the large coastal shark complex and sandbar and blacktip shark stocks. This model takes into account the lag between birth and subsequent recruitment to the adult stock, as well as growth and natural mortality, and the stock recruitment relationship. Bayesian statistical techniques were used to fit the model using a Markov Chain Monte Carlo (MCMC) method for numerical integration. In this approach, a state-space model accounts for both process error and observation error in a unified analytical framework that uses Gibbs sampling to sample from the joint posterior distribution. Results from an implementation with the catch and catch rate series used for the 1998 shark assessment agree with those from a recent sensitivity analysis that used several stock assessment methodologies, and indicate that the 1998 biomass of the large coastal shark complex and sandbar shark was below that producing MSY, whereas the 1998 biomass for blacktip shark was above that producing MSY.

There was a comment that the assumption that sharks become vulnerable to the fishing gear and reproductively mature at the same age is not realistic for large coastal sharks. The question was also asked of whether the software allowed for projections to be made, the answer being that not with the present software (Winbugs). There was also a question of why Bmsy was so low with respect to K. It was explained that the answer lies in the Beverton-Holt stock-recruitment function in that a low steepness sends the inflection point to S_0, but a steepness of 0.5 or 0.6 pushes it more to the left of the stock-recruit curve. This can be interpreted as the stock being very resilient, one interpretation in that case being that input to the population is coming from elsewhere (a violation of the closed population assumption).

Document SB-02-14 is a document referenced in the previous document (SB-02-11) describing the sensitivity analysis of the 1998 Large Coastal Shark Evaluation Workshop results to new data and model formulations following recommendations from peer reviews.

Document SB-02-25 described importance sampling issues in the 1998 large coastal shark assessment. For most Bayesian models, the joint posterior distribution of the parameters cannot be integrated analytically, and the integration must be approximated using a numerical integration method such as the Sampling Importance Resampling (SIR) algorithm or Markov Chain Monte Carlo (MCMC). To be sure that the numerical algorithm has provided an adequate approximation of the posterior distribution, it is necessary to use diagnostics of convergence. This is particularly important when the data show inconsistent trends (i.e., they are contradictory). In such instances, the form of the importance function chosen for importance sampling can bias the estimated marginal posterior distributions of the parameters if the number of importance draws is insufficient. From the sensitivity analyses carried out in this paper, it appears that the diagnostic of the CV of the weights divided by the CV of the likelihood times priors takes large (greater than 10) values if the importance function is narrower than the posterior distribution. Values less than 1.0 indicate that the importance function is not influencing the posterior distribution. Some of the runs for which the diagnostic was in the range of 1 to 3 seem to be estimating the posterior distributions adequately also. For future surplus production model assessments, we recommend using wider importance functions, either by expanding the variance of the multivariate t distribution or by drawing from the priors. Because drawing from the priors works well, it should be tried first. If the CV diagnostic is greater than one, then more than one importance function should be tried. Also, when possible, results should be checked by using different methods of integration such as both SIR and grid methods, and having different people develop independent sets of computer code to fit the same stock assessment model to the data. If it is possible to implement them, grid based methods are preferable to Monte Carlo integration methods because it is very easy to see from the results obtained from grid-based methods whether the implementation is working. However, grid-based methods work only when there are relatively few estimated parameters e.g., < 5 and the posterior correlations between parameters are small ($-0.6 < \text{corr}(x,y) < 0.6$) and in most stock assessment situations, these conditions do not jointly hold. In such circumstances, the next best thing is to compare SIR results with MCMC results for consistency. Finally, the contradictory CPUE series for blacktip should not be combined in a single assessment. Instead, at the very least, the series showing consistent trends should be grouped and stock assessments done separately for the different groups of these data and a decision analysis approach should be used to present the different results obtained.

It was pointed out that it takes time to look thoroughly at the models and the various convergence criteria. Published diagnostics for MCMC were used in Table 2 of the document: they looked at this and it suggested convergence, but further analysis of other criteria showed that the MCMC algorithm actually had not converged for blacktip shark. There was a question regarding whether the technical error in the 1998 SEW model for blacktip resulted from conflicting CPUE series. The answer was that CPUE trends are going in different directions and the model became "confused" with what the trends were indicating. In the current approach, something similar to the MLE estimate is examined. Previously, it was assumed that what was seen at the mode of the posterior was representative of the whole surface, the method did not acknowledge the long right tail, but now that is being taken into consideration. There was another question regarding the breakdown of shark groups into Atlantic and Gulf. It was clarified that what is being broken down here are sets of data that show different trends. If the data go in different directions, the "best estimate" is not the average. The model should be allowed to account for those different trends, if, e.g., they can be explained by a function of different age components in the population being affected by different indices. The question arose then of whether guidelines were going to be developed at this meeting for evaluating conflicts in the indices. The answer was deferred to the next document to be discussed.

Documents SB-02-26 and SB-02-41 concerned the Bayesian surplus production (BSP) model that was used in the 1998 assessment. SB-02-41 is a peer-reviewed journal publication of the BSP model using the data available before the 1998 SEW. It describes how demographic information such as pup survival, number of pups and age at maturity were included in the surplus production model through the use of an informative prior for *r*. This greatly improved the biological realism of the model fit. The code for the BSP model was made available at the meeting, and document SB-02-26 is the program user's guide. The user's guide explains the input files, model structure options, diagnostics and available outputs. The BSP program fits either a Schaefer model or a Fletcher / Schaefer model to CPUE data using the Sampling /Importance Resampling algorithm. Required inputs are catch for all years (missing catch data in the first years of the fishery are allowed), at least one catch rate (CPUE) index of abundance, with CVs if available (missing data are allowed). The parameters that can be fit are carrying capacity (K), the intrinsic rate of population growth (r), the biomass in the first modeled year defined as a ratio of K (alpha.b0), the shape parameter for the surplus production function for the Fletcher/Schaefer fit (n), the average annual catch for years before catch data were recorded (cat0), and variance parameters for each CPUE series, depending on the method used to weight the CPUE series. The available weighting methods include the inverse variance/maximum likelihood estimate method used in the previous assessment, an equal weighting method, and a method that inputs the sampling CV of each data point and then allows the model to fit a single additional variance parameter that is added to the variance for each point. Priors can be used for all of the fitted parameters for a Bayesian fit. The program can be used to project the biomass trajectory under any constant catch or constant F harvest policy, with confidence bounds. Program outputs include decision tables showing the probability of stock rebuilding and other indicators of policy performance at various time horizons.

The question to define "expert judgment" for method 9 of the paper was asked. The answer was that if one has reason to believe that one series is more reliable than another (e.g., fishery-dependent vs. fishery-independent), this method can account for it by tuning the input variances. It was then asked what mathematical criteria are used to support these choices. In response, an ICCAT document that summarizes the various criteria that should be considered was identified. It describes statistical criteria to determine the appropriate weighting method. It was also pointed out that some series result from good sampling design, other series may or may not have been corrected though GLM procedures, and that series based on commercial fleets may include thousands of sets whereas fishery-independent series may have small sample sizes. This could affect the precision of the indices. Considering only the precision (e.g.: commercial CV=0.15 vs. survey CV=0.5) is not always desirable because very high sample sizes can yield high precision but the estimates may be biased, and thus this can result in subjective weighting. It was further clarified that the issue of weighting CPUE series has received a lot of attention in many stock assessments. Unless there are compelling reasons to do so, one should not give the different series different weights. In the absence of information, one should give equal weight to the series or use the CVs as weights. Expert judgment weights must not be used necessarily, but the option to incorporate them exists in the software. It was further explained that simulation testing can also be used and that using precision as the sole criterion can be dangerous because one might end up being "precisely wrong" if total variability is not actually being measured. A GLM procedure does not necessarily remove the variability from the indices. When this was done in 1998, the idea was to use the measure of precision of the individual data points within the series. In 1996, an attempt was made to separate the points that had been standardized and to combine all data points to get an overall, single index. That is still a reasonable way to go, but there was a progression to using each time series internally to the population dynamics fit to the catch. This is arguably an improvement to the approach. It was concluded that these issues best be discussed in a small group setting. Sensitivity of the results to various different weighting schemes may have to be examined. But it was agreed that the procedure used in the 1998 assessment, an inverse variance weighting approach, should be repeated for the sake of comparison. The current plans are to update the method applied the last time, using the same assumptions but with updated data, because we must see the impact of the additional years of data on the results.

Methods Working Group Activities

The following discussion points for the Methods working group were identified in plenary:

1) Validation of age-structured models
2) Decision about weighting methods for CPUE series
3) Summary of Model Inputs, Model Attributes, Model Outputs
4) Discussion about parameterization of Beverton-Holt S-R
5) Summary of outputs to be generated for age-lumped and age-structured models
6) Discussion of diagnostics to assess model convergence
7) Discussion about 2 methods of treating historical catch

1) Validation of age-structured models

The age-structured models of P. Apostolaki and C. Porch are new contestants in the "Shark Bowl" arena. Previous models used at shark workshops did not incorporate age structure. Early on in the 2002 shark workshop, it was decided that a comparison of models should take place. Each model input was discussed and a value/vector was agreed upon for using as a standard input data set that would be used by both models. Due to the availability of more biological information, it was agreed that the model validation would be based on blacktip sharks. Several attempts were made to run the two models with the same input. However, for the model of

Porch, there was a persistent estimation problem associated with the steepness parameter that prevented convergence. This validation will be continued in the weeks following the workshop.

2) Decision about weighting methods for CPUE series

When different time series of relative abundance (e.g., cpue) that reflect the same components of the population suggest different trends in abundance, the method to weight alternative time series can influence the estimated trends in abundance. In theory, data series with contradictory trends should not be assessed together unless the statistical modelling methodology has been developed to explicitly reconcile contradictory trends in data (e.g., Schnute and Hilborn (1993)). The issue of selecting a statistical method to weight different cpue time series in stock assessment is therefore an important issue and careful attention needs to be given to the choice of a weighting method.

In the 1998 stock assessment, the baseline method of assessment used the principle of inverse variance weighting (McAllister et al. 2002c, document 41) in which the mean variance in the deviates between cpue and model-predicted cpue (residuals) was estimated within the stock assessment for each of the separate cpue series included. Therefore, the larger the variance in residuals for a cpue series the lower the weight it had in fitting the model to the data. Furthermore, where estimates of sampling error such as coefficients of variation (CVs) were available from e.g., GLM analysis, for individual cpue data points in a cpue data series, these were used to readjust the residual variance for each data point so that the resulting residual variance for the data point was directly proportional to the sampling error CV^2. Following this adjustment, the mean value for the adjusted residual variances for each cpue series still retained the estimated mean residual variance for the cpue series. The general formula for this likelihood function is documented as "weighting method 3" in McAllister et al. (2002b, document 26). It is also documented in the Canadian Fisheries and Aquatic Sciences Publication, McAllister et al. (2002c, document 41).

Weighting method 3 is a convenient method for assigning weights to different cpue series because it applies an automated, judgment-free approach to weighting different time series based on a minimum variance criterion. As a result, the method should provide the most precise estimate of the stock assessment quantities of interest. This is statistically a desirable property. The method also down-weights individual data points that have high input "sampling error" CVs, e.g., as a result of having relatively few observations in a given year, relative to those that are more precisely estimated. Because of these desirable features and because the method was used as the baseline method in the 1998 SEW, it is recommended that this method also be considered in the 2002 SEW.

There are a few additional considerations in the choice of a weighting method that suggest the possible use of a few alternative weighting methods for sensitivity tests and the adoption of a new improved baseline weighting method in future assessments. This relates to the issue of trend bias. In stock assessment, it is common to analyze commercial catch rate data using GLM methods to attempt to produce bias-corrected time series of relative abundance, even though the new data points are typically based on very high numbers of vessels per year and the resulting estimates can be highly precise. However, it is well known that fishing vessels do not allocate their fishing effort to obtain randomly placed samples of the fish population in space and time as would be required to obtain unbiased estimates of trends in abundance. The GLM modelling efforts are applied to remove the potential biases introduced in the nominal time series of catch rates that could be due to non-random placements of fishing effort in time and space and changes in fishing methodology. It is commonly acknowledged that even after GLM analyses have been applied, the resulting time series of cpue can still provide biased estimates of trends in abundance. The cpue series resulting can yet show very smooth trends due to the very large sample sizes involved. When stock assessment models are fitted to such data, very low residual variance estimates can result. If the cpue time series is trend-biased, the end result can be a very precise set of estimates of population parameters and trends in abundance. But due to trend bias in the cpue data, the results can be very biased and results can be "precisely wrong".

In contrast, cpue observations in fishery independent time series are often less precisely estimated due to limited sample sizes in each year. But due to the application of principles of sampling design, the indicated trends in abundance from fishery independent abundance indices can often be expected to be unbiased. Such time series can be thus imprecise but unbiased. Inverse variance weighting methods such as method 3, however, assume incorrectly that all time series used are unbiased in their indication of trends in population abundance and weight each cpue series only according to its estimated residual variance. Inverse variance weighting methods such as method 3 would tend to down-weight the fishery independent cpue series, even though they might be less biased in trend estimates than the fishery dependent ones and this is undesirable.

Additionally, weighting methods that are based on the estimated residual variance of each relative abundance series can lead to instability in assessments of stock status when cpue series are updated from one stock assessment to the next. When cpue time series are updated with new analyses of updated time series of catch and effort, the estimated trends can often change and the estimated sampling error CVs from e.g., GLM analysis for historic data points can also change. Such changes in the alignment of cpue series can lead to large shifts in the assessment of the biological status of the assessed population when weighting of the cpue series is based entirely on their estimated residual variances. This unstable property is undesirable and suggests that other weighting methods with greater stability should be considered instead.

Many different weighting methods have been developed and applied in stock assessment, some of these to address the issues of bias and instability, and a number of these are described in document 26. One of these that is more commonly applied is method 5 in document 26 (known as the input variance multiplied by scalar method). This method allows each different time series of cpue to be assigned a relative value for the residual variance. Expert judgment is applied to assign smaller residual variances (or residual CVs) to cpue series that are deemed to be more reliable indicators of trends in abundance and vice versa. The relative weighting of the different series is preserved in the stock assessment estimation because a single multiplicative scale factor is estimated to jointly increase or decrease the residual variances of each cpue time series, depending on the goodness of fit of the model to the entire set of cpue data. In method 5 (document 26), the inputted residual variance for each observation in each cpue series is directly multiplied by the estimated scalar so that the overall goodness of fit of the model to the data can be adjusted appropriately. For example if the inputted residual variances for the different cpue series is overall too low, the estimated scalar parameter will be larger than one and vice versa. In addition, if sampling error variances are estimated beforehand for each time series, these can be used to adjust the individual inputted variances for each data point in each series so that the relative value for the inputted residual variance for each data point is directly proportional to the already-estimated sampling error variance (e.g., from GLM analysis). In other words the CVs of each series are normalized by dividing by their mean, multiplied by the assigned CV to the series and then multiplied by the estimated scalar. This latter feature is similar to that in method 3.

Two additional weighting methods are proposed for tests of the sensitivity of stock assessment results to the choice of the method of weighting and possible replacements for the estimated variance weighting method used in the 1998 SEW. These include the following:

Alternative 1: Apply method 5 (Document 26) and assign equal average variances to all cpue time series. On average, this will give each datapoint in each time series equal weighting in the stock assessment. Time series covering the same number of years will be given approximately the same weight. Time series covering larger numbers of data points will be given more weight and vice versa. Wherever sampling error variances are provided with each cpue time series, set each variance for each data point in each series to be directly proportional to the GLM estimated sampling error variance. This method would be most appropriate if all time series of cpue could be considered to be equally plausible in indicating trends in population abundance.

Alternative 2: Apply method 5 (Document 26) and assign a relative average CV^2 to each time series based on expert judgment. The CV should be on a relative scale of 1 to 2 (continuous in this interval) with 1 indicating the most precise value possible and 2 indicating the least precise value possible. This scale of one to two for the inputted residual CV limits the relative amount of weight any one time series can be given in the fitting of the model to the data. It also still allows series given the lowest possible weight to still have some influence in the fitting of the model to the data. For example for any two time series of the same length, a series with a CV of 1 will have four times the weight of a series with a CV of 2 since the CVs are squared in the likelihood function where the weighting takes place. The criteria to be applied should be only the positive and negative attributes of each cpue time series in so far as the series is expected to serve as an unbiased estimate in abundance trends for the shark species or grouping assessed. The assigning of this relative CV should take place without knowledge of the trend indicated by the CPUE time series as indicated in the ICCAT document (McAllister and Babcock 2001). This method would be most appropriate if it could be agreed that some time series of cpue were more plausible than others in indicating trends in population abundance.

Alternative 3. The method here is the same as Alternative 1, except that all data points in a given series are also assigned equal weight. This is appropriate for this stock assessment because some concerns have been raised about the estimates of sampling error CVs in some of the series since several CVs appear to be extraordinarily high (up to 400%) and this cannot be explained easily by the associated sample sizes.

3) Summary of model inputs, model attributes, model outputs

(see attached Table 9)

4) Discussion about parameterization of Beverton-Holt S-R

A common parameterization of the Beverton – Holt (B-H) stock recruit function requires the inputs of virgin biomass (B_o) and steepness (z) (the proportion of virgin recruitment when population biomass is at 20% of virgin levels). This is commonly applied for teleosts and meta analysis has been applied to stock-recruit datasets for different stocks to develop priors for steepness (Myers et al. 2000). However, for sharks, few if any datasets from different populations of sharks are available for meta-analysis. In documents 5 and 11 fairly flat priors for steepness bounded between 0.2 and 0.9 were applied. Because there is very little information in catch rate data about steepness, this prior is perhaps too uninformative for stock assessment. Moreover, the wide prior for steepness can give rise to unrealistically low values for the inflection point relative to carrying capacity for B_{msy}, B_{MSY} / B_o. Modeling studies of animals with life history characteristics similar to large coastal sharks have indicated that the inflection point values should be about 0.5 or larger. Results from document 5, for example, suggest unexpectedly low posterior mean estimates for B_{MSY} / B_o of 25-35%. Values in this range are commonly estimated for commercially harvested teleosts. Differences in life history between sharks and teleosts lead us to expect sharks to have larger values.

Using priors that support values of steepness more suitable for sharks could help to achieve more realistic biological realism within the stock assessment models. However, there exists no biological information to help us formulate an informative prior on steepness for sharks and without such information only non-informative priors for steepness should be used leaving with the same problems of lack of biological realism in the form of the population dynamic models used. Punt and Hilborn (1997) suggest that in such circumstances, stock-recruit functions should be reparameterized so that existing scientific data and expertise could be applied to justify the development of informative priors for the new stock-recruit function parameters. This could be achieved easily for sharks by a simple reparameterization of the B-H model so that it better utilizes available biological information on large coastal sharks.

The following proposed reparameterization of the B-H stock recruit function could lead to B-H model parameter inputs for which biological information exists for sharks. Parameter *a* in the B-H stock-recruit function reflects $1/S_o$, where S_o is the density independent survival rate of pups. Recent studies on young of year in large coastal sharks (e.g., Document 18) can be used to develop informative prior distributions for S_o. Other studies have been applied to develop estimates of survival rates of sharks of older ages (see Document 13 for references). The B-H model is therefore reparameterized so that its parameter inputs include S_o and not steepness. The parameter alpha is commonly computed as a function of B_o, R_o, and z:

(5.1): $$a = \frac{B_0}{R_0}\left(1 - \frac{z - 0.2}{0.8z}\right)$$

Steepness in this model is solved for algebraically as follows:

$$\frac{aR_0}{B_0} = 1 - \frac{z - 0.2}{0.8z}$$

$$\frac{z - 0.2}{0.8z} = 1 - \frac{aR_0}{B_0}$$

$$z - 0.2 = 0.8z - 0.8za\frac{R_0}{B_0}$$

$$z - 0.8z + 0.8za\frac{R_0}{B_0} = 0.2$$

$$z\left(1 - 0.8 + 0.8a\frac{R_0}{B_0}\right) = 0.2$$

(5.2) $$z = \frac{0.2}{0.2 + 0.8a\frac{R_0}{B_0}}$$

Given that $a = 1/S_0$

$$z = \frac{0.2}{0.2 + 0.8\frac{R_0}{S_0 B_0}}.$$

In most age-structured models (e.g., Doc. 5 and 11), B_0 is directly proportional to R_0 and some combination of the other model parameters, $B_0 = R_0 f(\theta")$ (where $\theta"$ is the parameter set excluding R_0) and the equation becomes.

(5.3) $$z = \frac{0.2}{0.2 + 0.8\frac{1}{S_0 f(\theta")}}$$

In delay difference models (e.g., Document 11), B_0 is given by:

$$B_0 = \frac{R_0}{(1 - S_a)}$$

where S_a is the survival rate of fish of age one year and larger. The equation for steepness then becomes:

(5.4) $$z = \frac{0.2}{0.2 + 0.8\frac{1}{S_0}(1 - S_a)}$$

Because steepness, z, ranges between 0.2 and 1, and it is reasonable to assume that S_a is on average greater than S_o, a joint prior is required for S_a and S_0.

Using equation 5.4, and general biological considerations, we can specify conditions on the joint prior to limit the extent of plausible parameter space:

1. $(1 - S_a) \le S_0$ therefore $1 \le S_a + S_0$
2. $\frac{(1 - S_a)}{S_0} \ge 0$ therefore $S_a \le 1$
3. $S_a \ge S_0$

In practice, input prior distributions should be specified for S_a and S_0 with the range of potential values lying between 0 and 1 or some shorter interval within this range, depending on expert judgment. In Monte Carlo integration, extra coding would be required to implement these restrictive conditions.

In fully age-structured models that use the steepness formulation of the B-H model (e.g., Document 5), the reparameterization in equation 5.3 would apply and similar conditions for the joint prior for S_0 and f(θ") would need to be identified.

5) Summary of outputs to be generated for age-lumped and age-structured models

(See attached Table 10)

The subgroup decided that a table should be created that would list the sort of output to be generated by each model (as appropriate given model structure). The categorization of output is two-fold:

1. "Estimation": Output of this nature refers to the model fit to observed data, parameter estimates, and predicted values generated in the assessment of the stock.
2. "Projection": Output of this nature refers to projections beyond the observed data. This would encompass the sorts of decision analysis scenarios that are deemed appropriate to consider by the participants at this workshop during the plenary.

With respect to the estimated model output, it was decided that we would generate the same sorts of Tables and Figures that were produced in the 1998 Report for the sake of comparison for the non-age structured model. Specifically, this means replicating tables 7, 8, and 9; the summary of priors in Appendix 2, and figures showing the predicted versus observed CPUEs (Figs 4.2-4.7). This is summarized in Table 10 under the column "1998 S-P OUTPUT" (i.e., 1998 output generated by the Surplus Production models). In addition, there is a column labeled "2002 A-S OUTPUT," which is an initial list of the sorts of additional output that can be generated by the age-structured models presented at this workshop. This list can be updated based on the plenary discussion.

6) Discussion of diagnostics to assess model convergence

For most Bayesian models, the joint posterior distribution of the parameters cannot be integrated analytically, and the integration must be approximated using numerical integration methods such as the Sampling Importance Resampling (SIR) algorithm or Markov Chain Monte Carlo (MCMC). Four of the stock assessment methods that have been proposed for assessing large coastal sharks apply Bayesian estimation methods. Two of these (Documents 1 and 25) use importance sampling and the other two (Documents 11 and 31) use MCMC.

To ensure that the numerical algorithm has provided an adequate approximation of the posterior distribution, it is necessary to use diagnostics of convergence (see Document SB-02-25 for an evaluation of convergence diagnostics for importance sampling). This is particularly important when the data show inconsistent trends (are contradictory). In such instances, the characteristics of the integration algorithm such as the form of the importance function can bias the estimated marginal posterior distributions of the parameters if the number of importance draws is insufficient. This is the case for both importance sampling and MCMC methods.

The following steps are therefore recommended to help ensure that the results obtained in the stock assessment have converged, are reasonably precise and unbiased and the statistical model specification provides an acceptable goodness of fit to the data.

(1) Applications of each Bayesian estimation method should use convergence diagnostics to formally evaluate whether and when convergence has been achieved.

(2) Each Bayesian application should employ at least two different diagnostics for convergence. For importance sampling, those suggested in Document 25 are appropriate; for MCMC methods those included in BOA (included with WinBUGs software and available free on the web) should be used.

(3) Each set of results obtained from a Bayesian application reported in the stock assessment should include in the output the diagnostics results obtained and an interpretation of them.

(4) Wherever possible, different methods of Bayesian integration (e.g., importance sampling, MCMC or Grid-based methods) should be applied for the same assessment, and the results obtained compared for consistency.

(5) If time permits for this stock assessment, each new statistical assessment method should be tested for bias and accuracy against simulated data. The structure and parameter values for an underlying population dynamics model (preferably age structured) to simulate data should be set beforehand. This is a requirement for stock assessment methods used at ICCAT.

(6) CPUE series with contradictory time trends should not be combined in a single assessment. Instead, at the very least, the series showing consistent trends should be grouped and stock assessments done separately for the different groups of these data and a decision analysis approach should be used to present the different results obtained.

(7) Model deviance should be calculated to test the goodness of fit of the model to the data (Gelman et al. 1995). A formulation of a chi-square goodness of fit criterion for fitting surplus production models to cpue data and interpretation of the resulting p-values is given in McAllister and Babcock 2000 (ICCAT paper on a protocol to choose a method to weight different cpue series).

(8) The Hessian should be computed at the posterior mode to evaluate the posterior correlation matrix at the mode. The magnitude of the estimated posterior correlations between parameters should be found to be acceptably low (e.g., $-0.9 < \text{corr}(x, y) < 0.9$). Correlation values outside of this range indicate a mis-specification of the statistical model with regards to the information available in the data and input priors. Large correlation values indicate that the model could be overparameterized with respect to the information in the data and priors. Either the model should be simplified slightly to reduce parameterization, additional data should be applied to increase the information in the data, or more informative priors should be applied for at least one of the parameters where correlations are high. The effect of high parameter correlation can also make convergence more difficult to obtain if weighting is based solely on estimated residual variance. This is because different series can acquire higher weighting at different combinations of parameter values.

7) Discussion about 2 methods of treating historical catch

Population models need to account for removals made prior to normally available catch series. Several possible mechanisms exist to do this:

- Extrapolate catch series back to earlier periods. The year to which catches should be extrapolated needs to be decided. Historic catches of sharks in the Gulf of Mexico and the South Atlantic states have been variable. Substantial fisheries for sharks have been documented in the literature during much of the 20th century. Additionally, during the same period sharks are known to have been taken as bycatch in a variety of fisheries.
- Let the model estimate a parameter that accounts for catches prior to the available catch series. This parameter can take the form of a historic fishing mortality (F_H) (e.g. SB-02-5) or mean catch (C_0) (SB-02-1). This second method uses catch rate data that extends back prior to catch series. In the case where catch rate series do not extend back further than catch series this mean catch estimation cannot be implemented. In models where these parameters will be estimated priors will need to be specified.

In the situation where catch histories are extrapolated validation may be possible if mean catch can also be estimated.

Table 9. Summary of models presented at the Shark Bowl V (24-28 June 2002).

Stock assessment model	Population Dynamics	Inputs * indicates inputs having the most influence on outputs	Estimation Method	Outputs	Decision Analysis
Bayesian surplus production (McAllister et al. 2002a)	- Schaefer surplus production - closed population - no age structure - single area - can accommodate single or aggregated species grouping (e.g. LCS grouping) - starts 1975 (other start dates possible)	*- fitted to one or more relative abundance (e.g., cpue) data series - catch time series not necessarily complete from the start of the years modelled *- informative priors for r (intrinsic rate of increase), C_o (catch in years where there are no catch observations), K (carrying capacity, N_1/K (abundance relative to K in first year) - uses non-informative or informative priors for * CV in likehood function (CV) and constant of proportionality (q)	<u>Estimation Approach</u> Bayesian - uses importance sampling (Rubin 1988; Gelman et al. 1994)) <u>Convergence Diagnostics</u> - assesses convergence by two different convergence statistics (McAllister et al. 2002b) and use of different importance functions - MCMC (Hastings-Metropolis) (Gelman et al. 1995) also can be applied - uses Gelman-Rubin convergence statistic (Best et al. 1995; Spiegelhalter et al. 2000) <u>CPUE weighting method</u> - method 3 Document 26	- Results are in form of Bayesian posterior probability distributions <u>Parameters estimated</u> - r, C_o, K, B_1/K, q, CV <u>Calculated values</u> MSY, N_{MSY}, N_{last}/K, N_{last}/N_{MSY}, N_{year} - Diagnostics for model convergence	- probabilistic decision analysis - evaluates potential consequences of alternative TAC options (fixed or variable) or Fishing mortality rate options (assuming perfect implementation) - can be projected any number of years into the future
Bayesian age-sex-area structured model (Apostolaki et al. 2002)	- age-sex-area structured model - migration of single population between two areas - six month time step - migration pattern is sex-, age-and area-dependent - hockey stick or Beverton-Holt recruitment model can be used - can accommodate only single species grouping and a grouping of species with similar life histories - models capture by different fishing fleets (e.g.,	*- fitted to one or more relative abundance data series - abundance series can be fitted by age/fleet/area grouping - catch time series by fleet type - informative priors for * A, (dens indep. surv rate), B_o (average unfished mature biomass), C_o - priors for q, CV *- selectivity for each fishing fleet - migration rate ogives	<u>Estimation Approach</u> Bayesian - uses importance sampling (Rubin 1988; Gelman et al. 1994) <u>Convergence Diagnostics</u> - assesses convergence by two different convergence statistics (McAllister et al. 2002b), use of different importance functions <u>CPUE weighting method</u> - method 3 Document 26 or method 6 Document	- Results are in form of Bayesian posterior probability distributions <u>Parameters estimated</u> - A, C_o, virgin mature fish biomass, q, CV <u>Calculated values</u> MSY, N_{MSY}, N_{last}/K, N_{last}/N_{MSY}, N_{year}, number of fish at age, mature fish biomass in each year - Diagnostics for model convergence	- can do probabilistic decision analysis - can evaluate potential consequences of alternative - TAC options - minimum size restrictions - time-area closures - can be projected any number of years into the future - effort restrictions

	recreational, commercial LL, Gillnet) - can apply different assumptions about unobserved historical catches - starts 1965 but other years possible	- age at 50% maturity - fecundity at age *- survival at age > 1 - length and weight at age	26		

Bayesian age-structured model (Porch 2002)	-age-based model -"combined sex" parameters -closed population/single area -only appropriate for single species -state-space allows consideration of error in observation and process -process error can be incorporated in M (random walk), Recruitment (random walk), growth (random walk), catchability -Beverton-Holt Stock-recruitment parameterized for steepness (the percent of virgin recruitment at 20% SSB) and R0 (virgin recruitment) -can estimate historical fishing or can fix population at virgin level pre-observation - flexible time step (from monthly to annual)	*-fitted to one or more cpue data series -requires catch time series (total or by fleet type) -priors can be placed on: historical fishing level, natural mortality, steepness and R0, q (catchability), effort, selectivity, overall variance *selectivity can be estimated or fixed, and can be fishery-specific *historical fishing mortality rates (before first year in model) can be estimated (big difference between virgin stock vs historical fishing assumption) but with all fleets aggregated - maturity ogive - fecundity at age - survival, length, and weight at age	<u>Estimation Approach</u> Bayesian -MCMC to estimate posteriors <u>Convergence Diagnostics</u> -no convergence diagnostics at present <u>CPUE weighting method</u> - method 5 Document 26	<u>Parameters estimated</u> R0, steepness, q, variance, historical fishing mortality rate (before first year in model) <u>Calculated values</u> -produces a report file that includes management benchmarks (virgin and MSY values) for F, SSB, and current values for F and SSB; produces number and biomass at age/year for time series of observations, fishing rate by age/year, trajectory of population biomass, predicted catch and cpue	-projections are handled by a separate software package, not performed directly in this model -probabilistic output
MLE Model (Parrack 1990)	-density-independent -no age structure -no stock-recruit relationship -OPEN population -can accommodate single or aggregate species grouping -poisson event for recruitment, natural mortality, immigration, emigration -fishing is mid-year pulse	**Catch Information** -*estimate of annual catch -estimate of var(annual catch) -*time series of effort **Weight Information** -*estimate of annual mean weight -estimate of var(mean weight) -enumeration of Yield -*time series of effort	<u>Estimation Approach</u> Frequentist Maximum Likelihood estimates; Objective function minimizes difference between observed catch and predicted catch (Catch Information) and/or difference between observed mean weight and predicted mean weight (Weight Information) <u>Convergence Diagnostics</u> - Hessian works if converges <u>CPUE weighting method</u>	**Parameters Estimated** -N_{final}, q (fishery specific), m ("lumped parameter") -standard deviation calculated for these parameters -m can be fixed over years, or can be estimated annually **Calculated Values** -annual catch (numbers and biomass), fishery specific mortality, annual population size, predicted annual mean weight	-projection capability not currently coded; this model could be updated to do projections by fixing the estimated parameters and projecting forward in time assuming that they do not change (this sort of projection would not be recommended for more than 5 years)

			Not applicable		

Table 10. Summary of output to be generated for the surplus production (S-P) and age structured (A-S) models with respect to estimation and fitting to observed data.

OUTPUT CATEGORY	1998 S-P OUTPUT	2002 A-S OUTPUT (proposed)
Priors	-r (intrinsic rate of increase) -K (carrying capacity) -C_0 (average catch from 1974 – year of first observed catch) -z (ratio of abundance in 1974 to K)	-Parameters of S-R function -Historical Fishing -Natural Mortality (at age) -q (catchability or proportionality constant) -variance for each abundance series
Posterior values, CVs	r, K, $C_{1975\text{-}1980}$, MSC, N_{98}, N_{98}/K, N_{98}/N_{75}, C_{97}/MSC	(those listed above) AND: $F_{current}$, $B_{current}$, MSY, $N_{current}$, $PSB_{current}$ (Pupping Stock Biomass)
Trajectories	N_t, N_t/K, N_t/N_{MSC}, F_t, F_t/F_{MSC}	$N_{current}/N_0$, $PSB_{current}/PSB_0$
Figures	Predicted vs Observed CPUE for each species or aggregate group corresponding to 2 catch scenarios: baseline catch or alternative catch	-Predicted vs Observed CPUE for Blacktip and Sandbar; -Predicted vs Observed Catch -B_t/B_{MSY} and F_t/F_{msy} -Age structure at end of current year
Other		-depletion in number or biomass (=1-$B_{current}/B_0$ OR 1-$N_{current}/N_0$)

5.2. Stock status evaluations to be conducted

In addition to the updated analyses utilizing the catch and cpue series updated to 2001, the following analyses were identified in plenary:

a) Aggregated models
   i) Using “baseline” catch and CPUE

"added variance"
- ii) Sensitivity evaluations
  (alternative catches)
- iii) SLM (Parrack's model)

b) Age-structured models (using "baseline" catch and CPUE)
- i) Sensitivity evaluations
  1. Alternative selectivities
  2. Alternative B_{init}

c) Retrospective patterning
d) Prior on So (first-year survivorship) – sensitivity
e) Sensitivity to age at maturity of sandbar shark (try 10 years)

5.5. Projections to be conducted

The following potential projections were identified in plenary:

-Catch = 0
-Catch = 1.0 * recent
-Catch = 0.8 * recent
= 0.5 * recent
= 1.2 * recent
= 1.5 * recent

-P(Number or Biomass) > B_{2001} @5,10,15,20 years
-P(N or B) ≥ B_{MSY}
-P(N or B) ≥ (1-M) B_{MSY}

Discussion on agenda items 5.3 and 5.4 ensued. The first question that was raised related to the inclusion of density-dependent regulatory compensation in reproduction in the models. This issue will be handled through the stock-recruitment relationship and the reparameterization of the model, wherein z (steepness) will be expressed in terms of first-year survivorship (S_0), which is more easily known than z (see point 4 of Methods working group activities). There were comments made that in sharks density dependence is more likely to operate through changes in juvenile survival rather than reproduction because there is little room for compensation in the reproductive capacity of sharks. This is supported by biological observations and elasticity analysis of matrix population models, which shows that juvenile survival is the vital rate that most affects population growth rates. In terms of S_0, information in documents SB-02-13 and SB-02-18 was used to define priors for this parameter for sandbar and blacktip sharks. A normal distribution with mean=0.56, SD=0.2 and range=0.2-08 was proposed for blacktip and a very similar distribution for sandbar: mean=0.60, SD=0.20, range=0.2-0.8. It was also recommended that age-based estimates of survival be provided for sandbar and blacktip (a range of 0.75-0.90 and 0.72-0.88 for sandbar and blacktip, respectively, was identified from information in document SB-02-13) and that new priors of r be redefined if necessary. A proposal was made that if there was sufficient time a sensitivity scenario considering an age at maturity of 6 or 7 years for sandbar is run.

Selectivity was also discussed. It was proposed that a logistic curve be used to represent selectivity patterns for the commercial sector. Years will probably have to be combined and an age-frequency distribution generated from length-frequency information from the bottom-longline observer program. The mode in the catches will identify the start of the asymptote in the logistic curve, whereas the rate of ascendance and the age at 50% selectivity (inflection point) can be obtained by fitting a logistic function to the age data. It was pointed out that standardizing catch for depth should be considered if possible to gain a better understanding of the size structure for each year and over the whole fleet. For the recreational sector, a dome-shaped curve such as a gamma distribution was proposed to describe selectivity patterns. The modal age will indicate the peak of the dome and several levels of vulnerability can be examined to truncate the right side of the curve (e.g., flatten out the right side of the curve at 20 years for sandbar shark). Years will probably have to be combined and an age-frequency distribution generated from length-frequency information from the three recreational surveys (weighting by the proportion of the total catch that each survey accounts for).

The last point of discussion revolved around the issue of the 2-box model for sandbar and blacktip sharks. For this formulation, the following is required:

-Catch by box
-CPUE by box
-Movements Rates:
    Sandbar:
        -In: 5% to Mexico
        -Out: various levels can be considered for sharks other than pregnant females (10%, 50%, 80% return to U.S.); all pregnant females return to U.S.
        -Age at first migration of 6 years, could be represented by a logistic curve
    Blacktip:
        -In: Tags from Western Gulf to Southern Gulf (Mexico)
        -Out: 50% of Mexican catch comes from U.S.
        -Age at movement: all age classes

It was further suggested that for blacktip shark the 2-box model consider the western Gulf and the eastern Gulf and Atlantic. CPUE series for the western Gulf can be obtained from the Texas Parks and Wildlife recreational survey and from the NMFS Mississippi Laboratories longline survey. Catch can also be broken down into these two areas: the recreational catches much more easily than the commercial catches.

6. Recommendations for research and statistics

Several research recommendations were made. They are summarized below.

Stock Structure and Distribution Research

- Long-term life history and migratory information for sandbar, blacktip and dusky sharks
- Satellite and archival tagging of sharks in U.S. and Mexican waters
- Age-structured studies of stock distribution and migratory patterns
- Genetic studies of stock structure of blacktip shark in Gulf and U.S. south Atlantic

Relative Abundance/Catch Rate Studies

- Consistent, long-term fishery-independent studies of LCS relative abundance targeting sandbar, blacktip and dusky sharks at various ages/areas
- Enhanced directed shark fishery observer program to improve coverage

Catch Records

- Enhanced directed shark fishery observer program
- Research into species-specific commercial catch records to determine extent of misreporting of species due to market forces, misidentification, etc.
- Improvements in data collection system for recreational shark fisheries

Future Stock Assessments

The group recommended focusing attention on stock status evaluations for additional species. The highest priority species for consideration include:

a) Dusky sharks
b) Hammerhead sharks (scalloped, great, and smooth)
c) Sand Tiger sharks
d) Silky sharks
e) Spinner sharks
f) Bull sharks.

Of these, the first three are of somewhat higher priority than the last three due to perceived depletion based on some catch rate time series.

7. Other matters

No other matters are reported on in the report of the meeting.

8. Adjourn

The meeting chair thanked the participants for cooperation during the meeting. It was noted that there was a healthy discussion of sometimes different views during the meeting, which are summarized in the report. The meeting was adjourned after the group thanked Dr. Cortes and his staff at the Panama City for their hard work in preparation for and during the meeting.

Appendix 1. Meeting agenda

2002 Shark Evaluation Workshop

24-28 June 2002

(Shark Bowl V)

Meeting Location:
Southeast Fisheries Science Center
National Marine Fisheries Service
3500 Delwood Beach Road
Panama City, FL 32408
Tel. (850) 234-6541

Agenda

A report of the meeting will be prepared by NMFS staff. Review comments by each individual participant in the workshop will be solicited. A finalized meeting report will be distributed to participants after the Workshop. This report will not necessarily reflect the whole range of stock evaluations proposed during the Workshop, because there may not be sufficient time to conduct all the proposed sensitivity scenarios during the Workshop. A separate resource evaluation document will be produced by NMFS staff approximately within one month after the end of the Workshop. Discussions will be held in Plenary on the agenda items. To the degree necessary, working groups will be established to address issues of concern under the agenda items. Progress made within working groups will be reported to the Plenary at the end (or beginning) of each daily session. Work will commence daily at 8:30am.

Meeting Agenda

1. Opening of the meeting and arrangements
2. Review of recent fishery developments for Large Coastal Sharks
3. Review of Large Coastal Shark biological information with relevance to the stock evaluation
   - 3.1 Growth, mortality, reproduction, other life history characteristics, and demography
   - 3.2 Stock ID
   - 3.3 Habitat preferences
   - 3.4 Other information
4. Review and updates to Large Coastal Shark database
   - 4.1 Catch (including discards)
   - 4.2 CPUE
   - 4.3 Size/age data
   - 4.4 Other information (tagging, etc.)
5. Stock evaluations of Large Coastal Sharks
   - 5.1 Methods and data available to be used
   - 5.2 Stock status evaluations to be conducted

   5.3 Sensitivity trials to be examined
   5.4 Projections to be conducted
6. Recommendations for research and statistics
7. Other matters
8. Adjourn

Appendix 2.

List of participants

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Appendix 3. List of 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. Cortés. 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. Cortés, E. A simplified Bayesian delay-difference model: application to large coastal sharks.

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

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

SB-02-14. Cortés, 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. Cortés, 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. Hueter, 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. Hueter, R.E. and J. Tyminski. U.S. shark nursery research overview.

SB-02-23. Hueter, R.E., 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.

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 the shark evaluation workshop.

SB-02-30. NMFS. 1998 Report of the shark evaluation workshop.

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

SB-02-32. Romine, J.G., J.A. Musick, and G.H. Burgess. An analysis of the status and ecology of the dusky shark, *Carcharhinus obscurus*, in the western North Atlantic.

SB-02-33. Brown, C.A. Bottom longline logbook catch rates for large coastal sharks.

SB-02-33R. Brown, C.A. Bottom longline logbook catch rates for large coastal sharks (Revised).

SB-02-34. Heinemann, D. and J. Poffenberger. Summaries of Gulf of Mexico and Southeastern US Atlantic shark catch and fishing effort from coastal fishery logbook reports.

SB-02-35. Burgess, G. Directed shark longline fishery observer program: miscellaneous information.

SB-02-36. Springer, S. Natural history of the sandbar shark, *Eulambia milberti*.

SB-02-37. Simpfendorfer, C.A. Validated age and growth of the dusky shark, Carcharhinus obscurus, from Western Australian waters (2002).

SB-02-38. De Silva, J.A., R.E. Condrey, and Thompson, B.A. Profile of shark bycatch in the US Gulf of Mexico menhaden fishery.

SB-02-39. Compagno, L.J.V. FAO Species catalogue, Vol.4 Part 2. *Carcharhinus limbatus, Carcharhinus plumbeus, Carcharhinus obscurus.*

SB-02-40. Rester, J.K. and R.E. Condrey. Characterization and evaluation of bycatch reduction devices in the Gulf menhaden fishery.

SB-02-41. McAllister, M.K., E.K.Pikitch, and E.A. Babcock. Using demographic methods to construct Bayesian priors for the intrinsic rate of increase in the Schaefer model and implications for stock rebuilding.