Report to Directed Shark Fisheries, Inc. on the 2006 SEDAR 11 Assessment for Sandbar Shark

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Abstract

The Review Panel for SEDAR 11 (Large Coastal Sharks) was held 5–9 June 2006 at Panama City, FL. The panel was conducted by the Center for Independent Experts (CIE) and concluded that:

"The population model and resulting population estimates were the best possible given the data available.

"Stock status was determined from the results of a range of model fits reflecting the Panel's uncertainty about life history parameters. All results indicate that the stock is overfished and that overfishing is occurring. The target year to rebuild the stock is estimated to be 2070."

At the request of Directed Shark Fisheries, Inc., we reviewed the data and modeling of SEDAR 11 upon which the CIE based their conclusions. After review, we concluded that:

- ***The assessment proceeded without using the largest data set available, the BLOP data, which inter alia shows that average age of the catch has not declined over time, as it should if the stock were being overfished.***
- ***The BLOP data also show that the selectivity curve used for the commercial catch is wrong and needs to be re-examined.***
- ***Catch-rates for recent years remain level indicating a population in equilibrium; overfishing is not occurring, whereas the model trajectory indicates a continuing decline in abundance.***
- ***The assessment used several catch-rate series (LPS and NMFS – NE) that were either inappropriate, or did not include the available (but withheld) size and sex data (VA LL).***
- ***The age-at-maturity ogive was derived from a study that is technically flawed.***
- ***The biological parameters used in the model were selected subjectively and there may be some evidence that different values are more appropriate.***

If NMFS relies on this technically flawed assessment to make the formal finding that the stock is overfished and overfishing is occurring a legal process will begin that will require a severe reduction in TAC equivalent to closing the fishery. There is time yet to revisit the assessment before that reduction is in place if NMFS is willing to devote the effort to address the concerns that the CIE raises in their Report and we have raised in ours. Redoing the maturity ogive study may not fit into this period, but the other corrective work could be done a matter of months.

Background.

The Review Panel for SEDAR 11 (**S**outh **E**ast **D**ata and **A**ssessment **R**eview) of Large Coastal Sharks was held 5–9 June 2006 at Panama City, FL. The panel was conducted by the Center for Independent Experts (CIE) and concluded that:

- *The population model and resulting population estimates were the best possible given the data available.*
- *The change in stock status in the 2006 assessment from the more optimistic status in 2002 appears to be mainly attributable to revisions to the life history parameters in the current assessment. The population is assessed to be less productive than was assumed in 2002.*
- *In 2006, the 3-part SEDAR process of data workshop, assessment workshop, and review workshop was adopted for large coastal sharks. This process resulted in a more thorough review at all stages of the process, which was not possible with the previous stock assessments. For this reason and those concerning the life history parameters given above, the Panel is confident that the 2006 assessment gives a more reliable estimate of stock status than obtained from the 2002 and earlier assessments.*
- *Stock status was determined from the results of a range of model fits reflecting the Panel's uncertainty about life history parameters. All results indicate that the stock is overfished and that overfishing is occurring. The target year to rebuild the stock is estimated to be 2070.*

Directed Shark Fisheries, Inc. (DSF) represents several entities involved with the commercial fishery for Atlantic large coastal sharks. The group disagrees with these conclusions, which are at variance with their observations of the fishery. There is no indication of a continuous decline in either catch rate or fish size (average carcass weight) predicted by the modeling. Of particular concern to the fishermen is the determination that the fishery for sandbar shark needs to be closed for a 65-year rebuilding period. Directed Shark Fisheries, Inc. has asked us to review the data and modeling of SEDAR 11 upon which the CIE based their conclusions to attempt to reconcile the two different perceptions of the status of the sandbar stock, report our findings and make such recommendations as may be appropriate.

The Problem

The CIE in reaching their conclusions stopped short of taking the vital but simple step of comparing the model results with actual information from the fishery. A cursory examination would show that the commercial landings and catch rates have remained stable for over a decade, and catch-rate (abundance) indices are mostly flat or trend upward over this period. These observations are inconsistent with the model output, which indicates a steady decline in biomass over the same period. The problem this created is that the CIE and SEDAR are pronounced by NMFS to have provided a peer review approval of this assessment, "…the best possible given the data available." The fishery now likely faces a major reduction in TAC under current law.

The CIE accepted both the data and analyses provided by SEDAR 11 and the conclusion that the stock is overfished and that overfishing is occurring with some caveats, and raised a number of issues for future examination. The issues raised by the CIE are important; so important in fact; that we wonder why the CIE did not express greater concern about the confidence that can be put on the SEDAR 11 assessment and recommend that some issues be addressed before the assessment was accepted.

These concerns might have been more strongly phrased had the CIE been advised that some of the data they highlighted for future work were actually available but not presented at SEDAR 11. We will now make use of additional data to explain some of the inconsistencies between the perception created by the model results and the perception held by the commercial sector.

The Data

The Review Panel qualified their conclusions by stating:

Research recommendations are included in the reports from the Data and Assessment Workshops (and in 2.3 below), so what follows is not intended to replace them but rather to emphasize specific needs for sandbar shark.

Two recommendations in particular are extremely important. These are:

Issue: A number of catch-rate indices were used, and it was not obvious which components of the sandbar population they were monitoring.

- *Using information on the size composition of catches from these indices, if available, would be helpful*
- *Maps of where (and when) the catch-rate series are located, along with the location of the fisheries, would aid in interpreting these series*

Issue: The assessment used an age-structured model, but no age information was used.

- *The predicted age compositions for the population and the catch in the model may provide useful diagnostics for the performance of the model. Research should be directed into developing these diagnostics, including verification with any available data on age composition. One example of a diagnostic indicator is the mean size/age in the catch and population, and from any catch-rate index that may collect size composition data…*

Size, sex, location and other information are contained in two data sets used at SEDAR 11 and this additional information was available to SEDAR 11 and the CIE, but was not presented. One set is the Bottom Longline Observer Program (BLOP)[1], the other the VIMS longline survey (VA LL). The BLOP comprises observed sets during the period from 1994 through 2004 from N. Carolina south and into the eastern Gulf of Mexico and covers all seasons and most of the range of the commercial fishery using a gear (bottom longline) that accounts for nearly 90% of the commercial landings. The latter, the VA LL, comprises sets from an intermittent summer longline survey from 1974 through 2004 confined to a small area off Virginia.

The BLOP data for 1248 observed sets were used to develop a catch-rate index at SEDAR 11, but the size and sex composition of the catch was not made available at SEDAR 11. The VA LL data were presented to SEDAR 11 in summarized form with no detailed information. NMFS standardized the series after the Data Workshop ended using the limited data provided that did not include age, size or sex. Through the cooperation of NMFS and University of Florida, we were provided with extracted BLOP data that includes length and sex and reproductive state information, general location (we were not given precise locations for the sets because of confidentiality concerns) and some environmental information. For the VA LL series, we do not have the data set available to SEDAR 11. The Principal Investigator for the VA LL survey declined to provide age, size or sex information until he has analyzed and published his 30-years of data.

The BLOP data set is useful for several reasons:

1. It is arguably representative of about 90% of the commercial catch of sandbar (but see bullet 3).
2. It provides length and sex information on all sandbar taken including discards (which were few) and should be a reasonably unbiased sample of the commercial catch.
3. It covers the South Atlantic Region and the eastern Gulf of Mexico Region (where most of the sandbar catch occurs). This is most of the range of the fishery. It does not include the North Atlantic Region.
4. It covers all months when fishing is allowed.

The VA LL data set includes information from 637 bottom longline sets beginning in 1973 and running through 2004. No sets were made in some years. The number of sets in any year varied from 3 to 47. There were 371 sets made between 1995 (none in 1994) and 2004, the same period covered by the BLOP data; however, the two areas do not overlap.
The standardized index used in the assessment was done after the Data Workshop and the procedure omitted the years prior to 1981. The index is not size or age specific, but assumes that the selectivity curve used for the commercial fishery should apply.

In addition to the above data sets, we received a copy of the State-Space Age-Structured Production Model (SPASM) from Dr. Liz Brooks, NMFS, and we will refer to several SEDAR 11 documents.

Analyses and Results

1. **BLOP Data**

[1] A.k.a. PLLOP and Commercial Shark Fishery Observer Program (CSFOP).

Length frequency samples.

The BLOP data set contains length measurements on 21,031 individual sandbar sharks. The distribution of the sample lengths by sex is shown below (Fig.1).

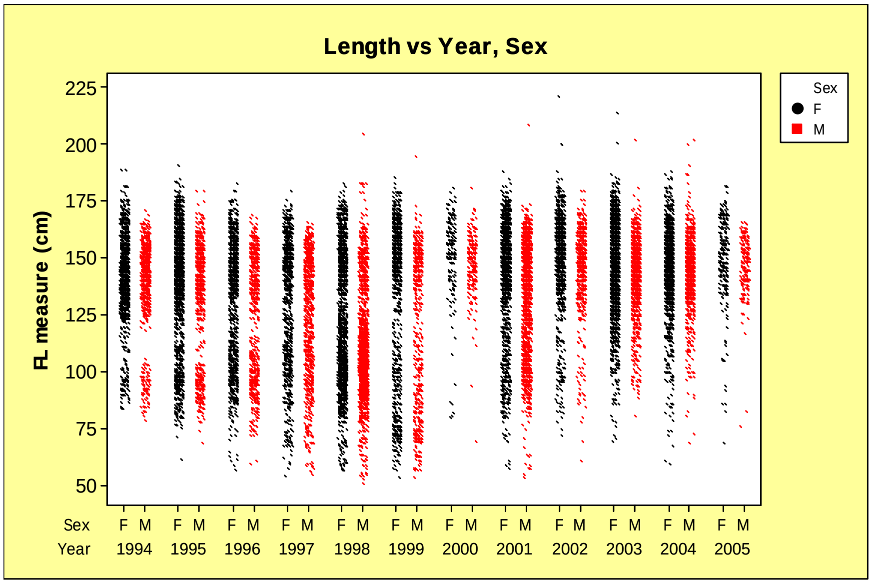


Figure 1. Lengths of individual sandbar sharks taken during Bottom Longline Observer Program trips

These 21,031 length frequency samples are important for two reasons. The allowed us to look for changes in the size (age) composition of the population over 12-years of exploitation, and they provide an indication of the pattern of selectivity of the bottom longline gear.

Change in age composition.

The average age (size) in a population of fish under exploitation is expected to decrease. This is particularly true for populations of long lived fish like sandbar.

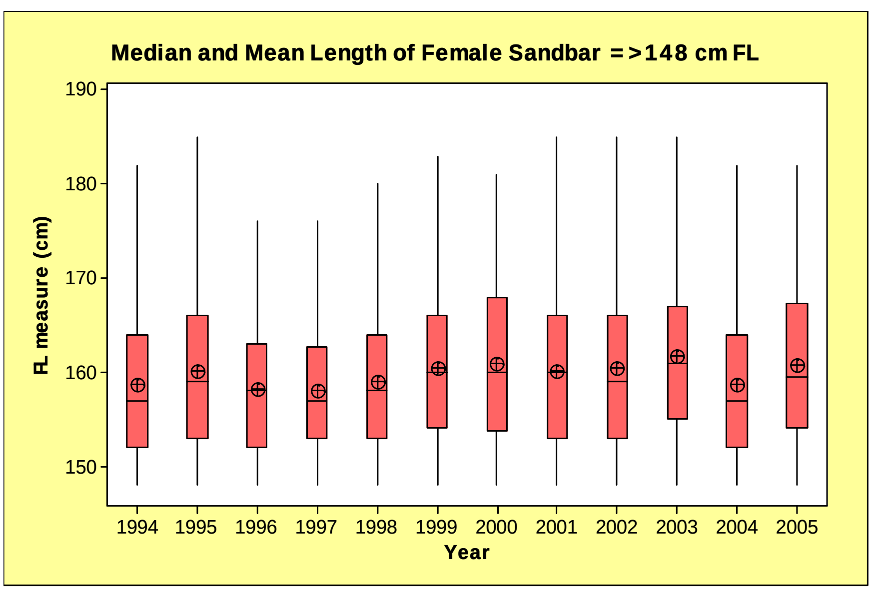


Figure 2. Median length mature females; means are indicated by circled cross symbol

The SPASM Model predicts a 45-percent decline in spawning biomass over these years, which should be reflected by a decrease in the average age of spawners (taken as >148 cm Fork Length). The BLOP data on the other hand indicate a stable size or slight increase in average size (Fig. 2) over the period. How this should be interpreted is arguable, but if size at age is constant as the model assumes the observed data are at variance with the model prediction.

<u>Selectivity.</u>

Converting lengths to ages using a von Bertalanffy equation (Sminkey and Musick, 1995) gives the distribution for the BLOP catches shown in Figure 3.

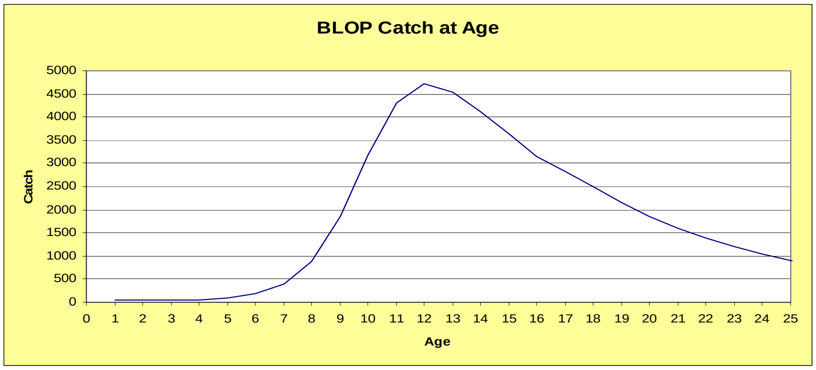
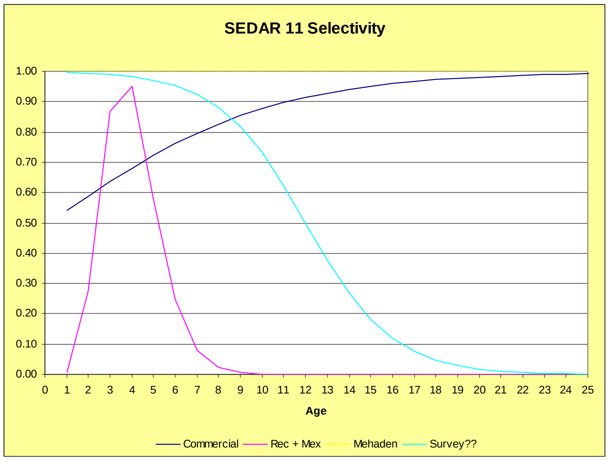


Figure 3. Sandbar catch at age from the observed "commercial" catch.

SEDAR 11 developed a series of curves believed representative of the selectivities in various sectors (fleets) of the fishery. These are reproduced in Figure 4a below. A revised selectivity curve is shown in Figure 4b.



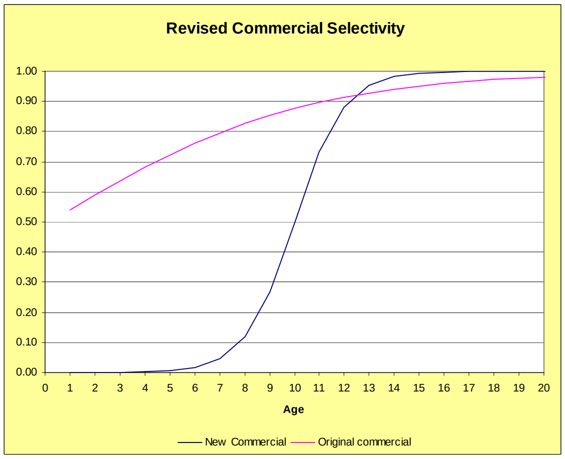


Figure 4a. The four selectivity curves used for the 2006 assessment.

Figure 4b. The SEDAR 11 commercial selectivity curve and the BLOP based commercial curve

The plot indicates that juvenile sandbar sharks are less vulnerable to the commercial gear than was assumed by the SEDAR 11workshop.

<u>Time and area differences.</u>

The catch-at-age and selectivity patterns estimated in Figures 3 and 4b were derived using all BLOP observations combined. For the BLOP program, fishing takes place in three Regions (not the same as the three Regions used by the HMS management plan). The BLOP Mid-Atlantic Bight Region does not extend north into Virginia and there were few sets made north of 37° N. The HMS North Atlantic Region begins off

Virginia, so that the HMS South Atlantic Region comprises both the BLOP Mid-Atlantic Bight Region and the BLOP South Atlantic Region.

The BLOP data set include information by region and date. There are significant differences in average size among regions and seasons. These are shown in Figure 5, suggesting that a single selectivity may not be appropriate for all regions and seasons. In particular, season one in the mid Atlantic bight catches smaller individuals. This region is closest to the area used for the VA LL survey and indicates that the selectivity for the VA LL survey may also be different from the commercial selectivity used in the model.

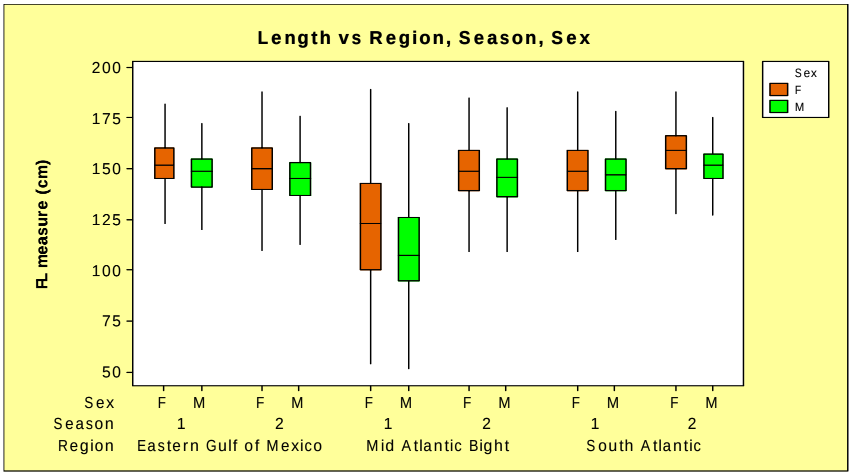


Figure 5. Median size by BLOP Region, Season 1 = Jan-Jun, 2 = July-Dec, and sex

<u>Sex ratio differences.</u>

Figure 6 indicates that bottom longline gear is selective of females. The overall ratio from the BLOP is 1:1.31 male to female. Whether this reflects a true sex ratio difference in the population or a targeting and/or segregation by sex deserves further investigation.

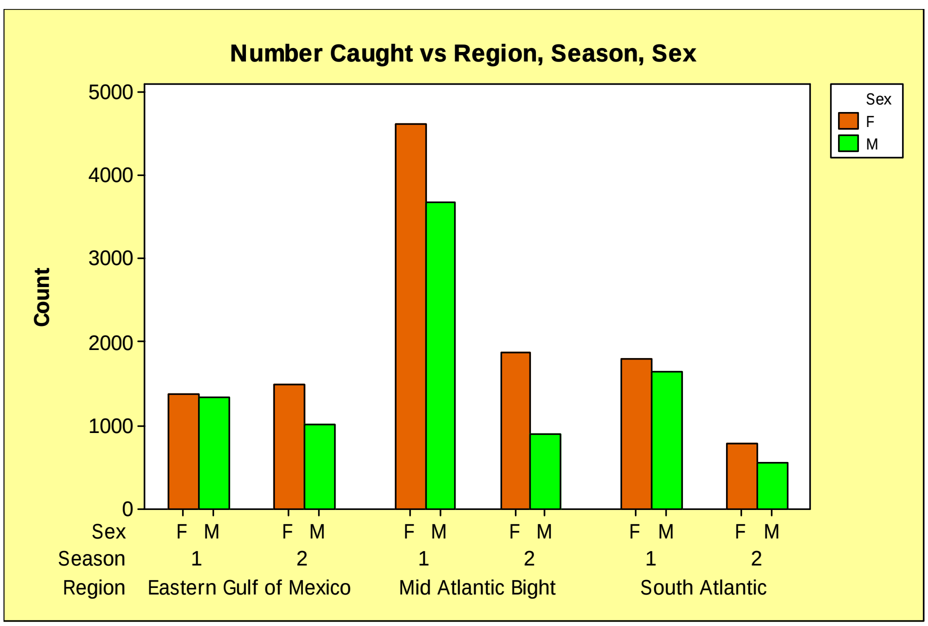


Figure 6. BLOP catches showing a preponderance of females, especially in the Mid-Atlantic Bight

2. SPASM Model

In this section, we will look at the modeling and consider how some changes in the inputs effect the perception of the status of the sandbar stock, as well as look briefly at the model itself. The model of interest for the sandbar assessment is Shark_SPASM.

"This model is [with some modification] the model used in the 2002 Large Coastal Shark was a state space, age structured production model (SSASPM, Porch 2002). Unlike a production model, the SSASPM can incorporate age-specific differences in model parameters such as growth, fecundity, and gear vulnerability (selectivity). In the case of long-lived, late-maturing fish or when there are multiple fisheries that exploit different age classes, having the flexibility to incorporate age-specific information could lead to a better fit to observed data. Age specific vectors for fecundity, maturity, and selectivity are specified by the user, and length and weight at age are calculated within the model based on user-specified growth functions. Natural mortality at age and a stock recruitment function are additional model parameters. The stock recruit function is parameterized in terms of virgin recruitment (R0) and pup survival. To derive the initial age structure for the first year that data is available, the model estimates a level of historic fishing (Fhist) and calculates the corresponding equilibrium population age structure. A historic selectivity vector is specified by the user, which is multiplied by Fhist to arrive at the historic age-specific fishing mortality rate. A historic selectivity vector of 1 for all ages was assumed.

"Continuity Model Inputs

"*Data*
"Data inputted to the model included maturity at age, fecundity at age (pups per mature female), spawning season, catches, indices, and selectivity functions …. Catches were made by the commercial sector, the recreational sector, and the Mexican fishery. In addition, unreported commercial catches were estimated, as were menhaden discards. Because of similar selectivity functions, the commercial and unreported catches were combined, and recreational catches were combined with Mexican catches, yielding a model with 3 distinct "fleets". A total of 13 indices were made available after the data workshop. The "DEL age 0" index was not used, as this model began with age class 1, which means that the stock recruitment relationship governed the number of one year olds to survive from the initial number of pups produced in a given year. Catch data begin in 1981, while the earliest data for the indices is 1975 (VA-LL). The missing catch for years 1975-1980 was treated several ways: the model estimated the missing catch; the missing catch was filled in with either the series-specific average, or series-specific assumptions were made….

"*Parameters*

"Estimated model parameters were pup survival, natural mortality (ages 1+), virgin recruitment (R0), catchabilities associated with catches and indices, and fleet-specific effort. In some models, a level of historic fishing (F_{hist}) was estimated, while other models fixed this parameter at 0 (assumes virgin conditions in 1975)."

(Quoted from SEDAR11-AW-03)

We investigated the sensitivity of the stock assessment model's results to assumptions about 1) the catch data, 2) the indexes, and 3) the mechanics of the model with the assumed biological parameter such as natural mortality (M) and fecundity,. The catches are of two sorts, the level of historical fishing and the estimated catches for which there are data. However, it quickly became apparent that this would be too large a task for this type of report, and instead will highlight a few examples that will indicate where there appear to be problems that need to be addressed.

i. Catch data As set forth in Liz's explanation of Shark_SPASM, the catch data comes in two parts, the historic catch that the model estimates, and the recorded catches starting in 1981. The catch before 1981 was assumed while from 1981 on it was based on estimates (recreational surveys of catch) or from recorded landings (commercial). The historic catch is estimated from the model. The recorded catches are for several sectors: commercial, recreational, scientific, Mexico, menhaden by catch, and discards. Most are estimated from sample data and dealers' reports.

The commercial catches are probably as good as can be had, but the recent discovery that there was major problem with the recording of the dealers' landing reports may result in some modifications of the estimates for the past few years.

There is no reason at this time to expect that adjustments can be made to catches for the other five sectors. The recreational catches are known to be highly uncertain, and should be subjected to more extensive sensitivity runs than has been the case. The other catch estimates are relatively minor in numbers and any changes unlikely to have any significant effect on the assessment.

Although recorded catches are assumed to begin in 1981, the model base case result (Fig. 7) assumes the stock biomass was virgin in 1975 because the first year for which there was an indexing value (the Virginia Longline or VA LL) was said to be 1975. However, when the VA LL index was standardized for SEDAR 11 to use in the model it was found that the earlier years lacked the information needed for the standardization. This complicated the modeling, as the first year having a standardized index now was 1981and, since F_{hist} was assumed to end with 1975, some way had to be found to bridge the gap to 1981.

For modeling the stock from 1975 to 1981, catch information was used from 1975 to 1981. This was estimated assuming that the recreational catches were zero in 1975 and increased linearly from 0 in 1975 to the estimated number in 1981and that the commercial catches were as in 1981. The slow decline in SSB/B0 between 1975 and 1981 shown in Figure 7 results from the recreational catches, which are the only appreciable catches assumed. Catch is the only thing that makes this model decline as there is no annual random variation in recruitment (and no catch-at-age data to estimate it). Recreational catch is believed to target young sharks and therefore some time must elapse before the effect of taking young fish shows up in the biomass of older fish. The commercial fishery, which targets larger fish, begins in the mid-1980's and, combined with the effect of the removals of the younger fish earlier on, is followed by an immediate and more rapid decline in SSB/B0 reaching a depletion level of 0.31 in 2004.

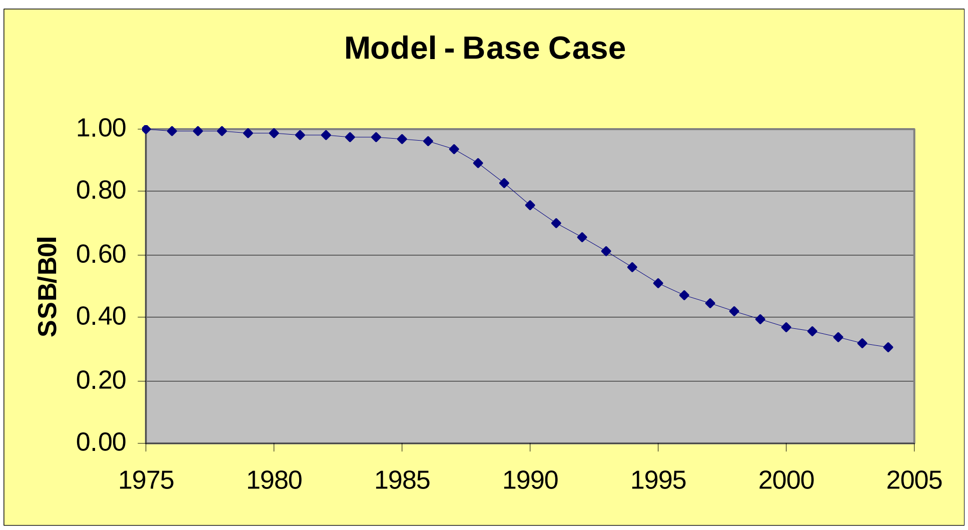


Figure 7. Trajectory for Model Base Case.

ii. Indices The eight indices used in the model are plotted in Figure 8 along with trajectory for the ratio of the Spawning Stock Biomass each year to Virgin Spawning Stock Biomass in 1975 (SSB/B0). The VA LL index, with some years missing, begins with 1981. The second longest time-series index is the Large Pelagic Survey index for recreational catch, which starts in 1985. The other indices start in 1993 when regulations for LCS first were implemented, and include indices from the commercial fishery.

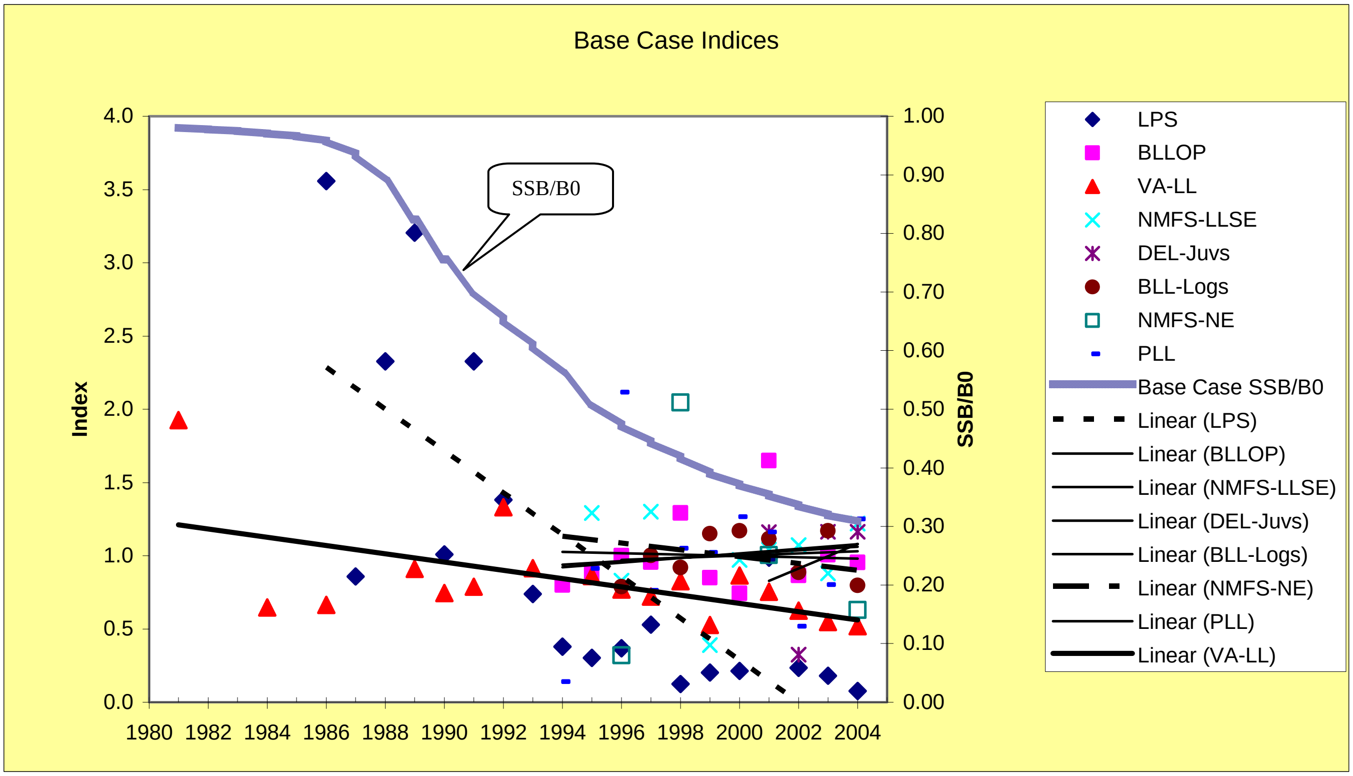
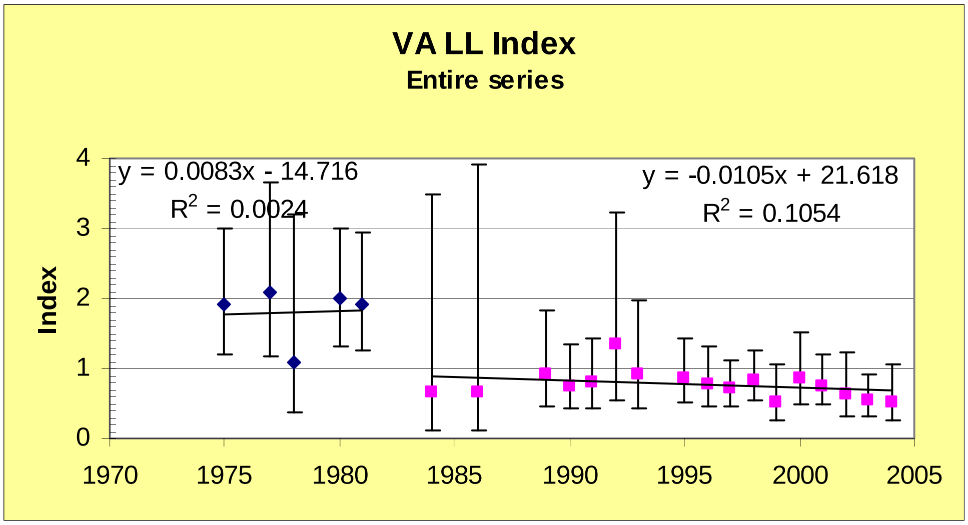


Figure 8. The eight base case indices plotted and showing their liner trends with the trajectory of the ratio of the spawning stock biomass to the virgin spawning stock biomass (SSB/B0) shown for comparison.

For the Base case, all indices are given equal weight in the analysis. This means that any index in which the points may have a trend, even though the variability (CV's or standard deviations) are very large, and the trend or slope is statistically not different from zero, will be seen by the model to be as good as an index that may have a statistically significant slope. The result is that a "bad" index (large CV) such as the LPS or NMFS NE is given equal weight to a "good" index such as the BLL-Logs.

Another problem with some indices is that they are not consistent throughout their lives. The assumption is that an index is proportional to stock abundance over time and that other factors such as fishing methods, area fished, environment, regulations, etc., remain constant or can be controlled in the course of standardizing the index. This may not be true, yet the index may be used even when some factor other than abundance is known to have changed over the course of time, as is the case with the LPS and, perhaps the VA LL.

The nominal trends for the VA LL, the LPS and the NMFS NE indices all are negative and roughly, in agreement with the biomass trajectory, which is not surprising since the trajectory is, in part, determined by the indices. Beginning with the VA LL, figures 9a and 9b show that the series consists of two parts that are essentially without a trend, an early period from 1975 through 1981, and a recent period from 1984 to present. The Index value for the early period 1975-1981 is roughly twice that for the recent period 1984-2004. The index used for SEDAR 11 omits all the years of the early part and begins with the final year 1981. Combining 1981 with the recent years causes the index o develop a negative slope that, though not statistically different from zero (flat), is perceived in the model to indicate a decline in abundance over the entire period 1981 to 2004. Why there is a difference in index level between two periods is unclear. We lack the data on size (age) and sex of the fish that might answer the question.



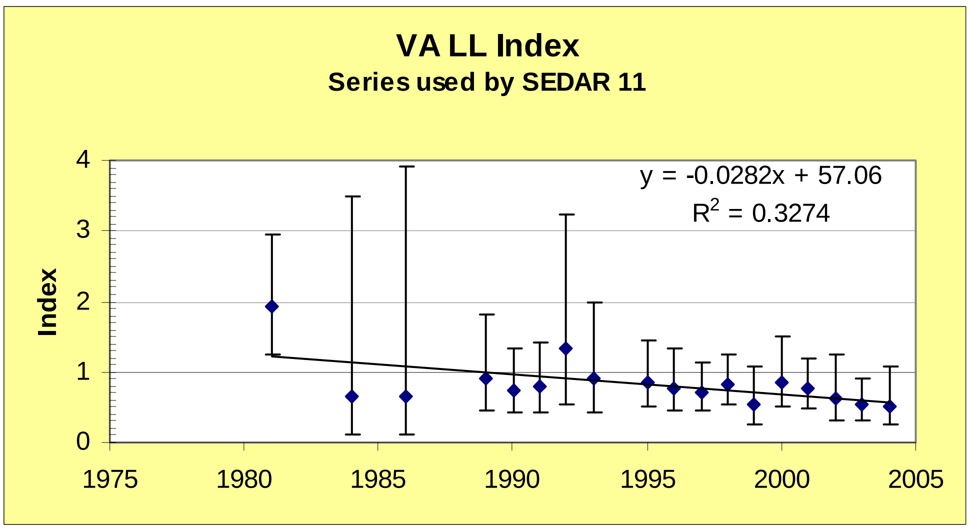


Figure 9a (top) and 9b (below). The Virginia Longline Index with trend line(s) and 95% C.I. None of the trend lines shown has a slope that differs from zero. Note that the full series beginning in 1975 appears to have an early part and a late part. The trend for each part is statistically flat. SEDAR 11, by beginning the series with 1981, produces a combined series with the 1981 point giving a larger (though still not significant) negative slope to the linear trend for the index.

The LPS index (Figure 10) has the same difficulty as the VA LL index in that it consists of two periods with high values in the early period and lower values in the recent period and addition problem that it has a very high degree of uncertainty associated with the second (recent) period. However, in the case of the LPS index we know a bit more about why the early period differs from the recent period. The LPS Index is for recreational catches off the NE Atlantic coast. The selectivity for this index was assumed the same as for the commercial catch, but no age or size information was available to confirm this supposition. This index has been used in previous assessments, but each time it was split into two indices: 1986-92 and 1993 to most recent year available. This was in recognition of the fact that the sportfishing regulations (size and bag limit) that went into effect in 1993 changed the way this fishery operated. One of us argued during SEDAR 11 DW that this should continue to be the case, or the index should not be included in the base case. That argument was dismissed out of hand. **We emphasize here that it is important to note that the LPS index is clearly two essentially flat indexes (slopes do not differ from zero), and to use the entire series to establish a trend that receives equal weighting in the assessment is not scientifically defensible.**

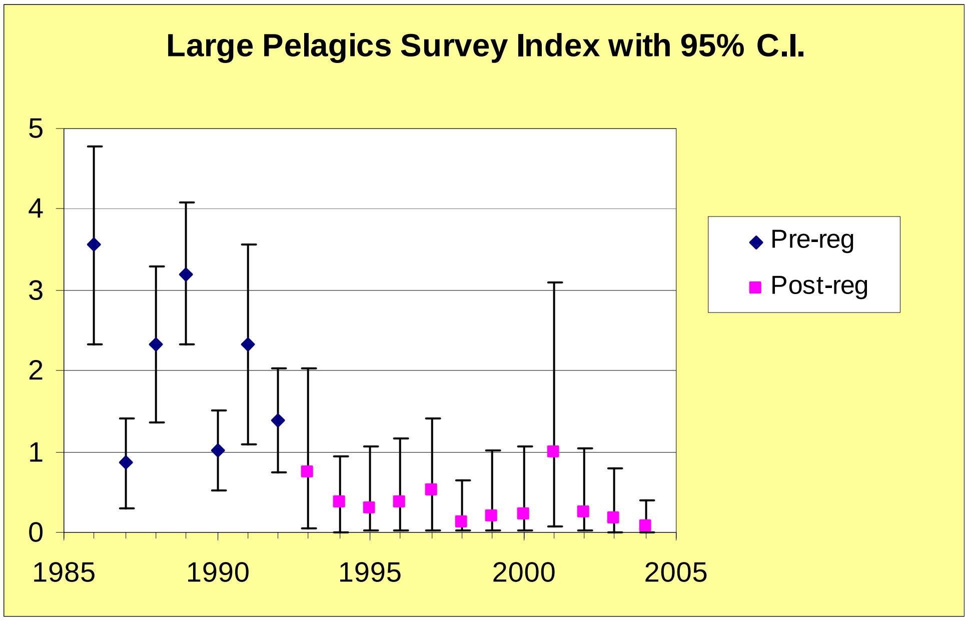


Figure 10. LPS index divided into to periods: Pre- and Post implementation of angling bag limit for Large Coastal Sharks that began in 1993. A reduced bag limit and size restrictions were added in 1999. The trend for the entire combined series is negative and significant, whereas the trends for the two separate periods are not different from zero.

The third index the NMFS-NE is a different matter (Figure 11). It is a puzzle why this index was selected as a Base Case index other than it has a negative slope when given equal weight. It has such enormous coefficients of variation that it is takes a leap of faith to accept that it contains any reliable or useful information about stock abundance. We believe that there is no valid reason to include it even as a sensitivity index.

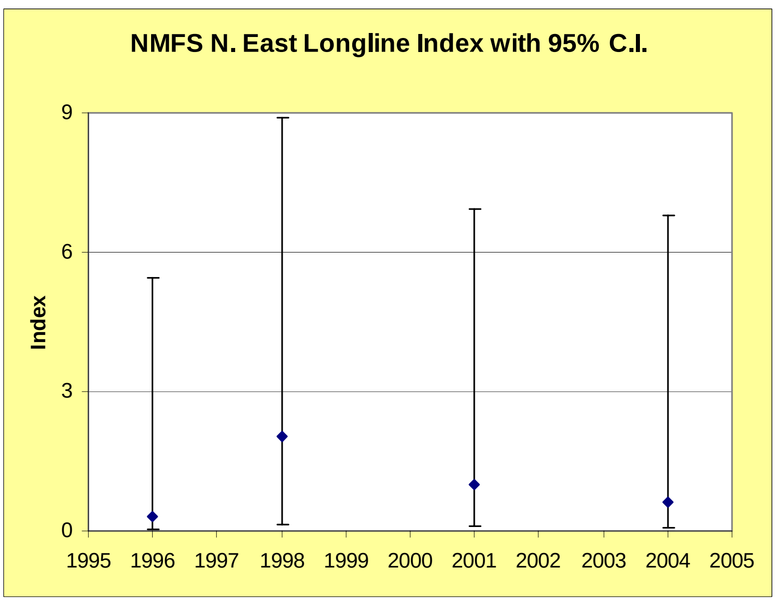


Figure 11. NMFS-NE longline index. The question is why an index with only four points and such an extreme range of uncertainty was included in the Base Case analysis. The index has no statistical trend other than zero, but when given equal weight in the assessment has considerable influence on the outcome. NMFS-NE index should not have been included as a base case index. Aside from the fact that there are only four observations, the enormous CV's should have precluded its use even as a sensitivity index.

The VA LL index may or may not be usable when and if it is properly standardized. As with the LPS and NMFS NE it samples only a fraction of the sandbar stock during the summertime when some fish have moved north to the Atlantic pupping grounds; however, large summer catches occur in waters south of Cape Hatteras and in the Gulf of Mexico at this time, thus these indices sample only a fraction of the population. None of these indices sample the areas where the majority of the fish are located and how representative these samples are of the population needs to be determined. Second, the VA LL index has in the course of sampling collected size and sex information. So far, the author has refused to make this information available. Thus, it impossible to know what size or sex selectivity to apply to the series – what segment of the population it is monitoring – a flaw with the LPS data as well. Until that information is provided, the use of this index should be restricted to a sensitivity run.

The remaining five indices are plotted in Figure 12. Three are from the commercial fishery, sample the entire range of the fishery, and begin when mandated by LCS Fishery Management Plan in 1994. What is of interest is the fact that all five indices are stable or have a positive trend over the ten-year period, whereas the model predicts the spawning stock has declined over 40-percent. **The inconsistency between the model prediction and the stable or increasing trend in abundance indicated by the five indices taken together with the failure for the average age of the catch to decline should have been a red flag to the CIE that the model has a problem that has to be corrected.**

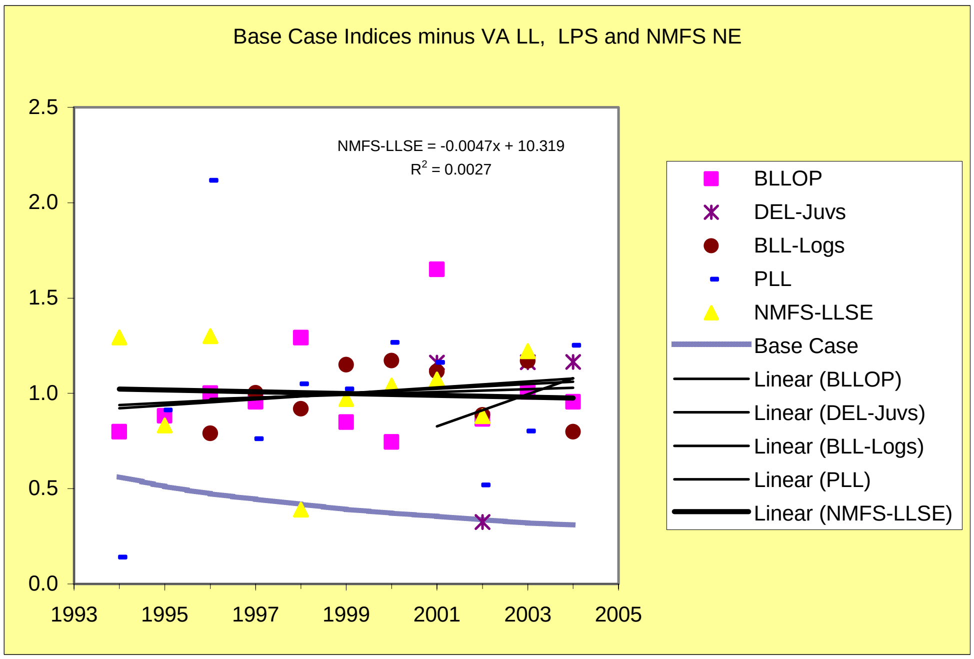


Figure 12. The five base case indices plotted and showing their liner trends with the trajectory of the ratio of the spawning stock biomass to the virgin spawning stock biomass (SSB/B0) shown for comparison. Note that one, NMFS-SE, has a very slight and non-significant negative slope.

<u>ii (a) Testing the indices.</u> In an assessment model, the indices establish a trend in abundance, which together with the catches and the workings in the model estimate the present condition of the stock. How much influence the indices have depends in part on the model. We tried several combinations of the indices to see how the output of the model changed depending on the combinations we selected. The different trajectories for SSB/B0 are shown in Figure 13.

<u>ii (a) (1) Base Case and ii (a) (2) No VA LL</u> The first trajectory to locate is the base case trajectory. If Figure 10 is not in color, the easiest way to identify the different trajectories will be to look at about the year 1995 and move up vertically. The base case is marked only by open square symbols and these are the second set of symbols from the bottom. What makes them difficult is that when we plotted the trajectory with The VA LL index heavily down weighted (the line labeled No VA LL) the trajectories are nearly identical with the base case, and the square symbols appear to be part the No VA LL curve. The final output levels for both trajectories is 31-pecent of the virgin spawning biomass This result was surprising as in past assessments the VA LL index alone had a major impact on the perception of the status of the stock. However, the re-standardization of the index done this year combined with omitting the years prior to 1981 resulted in a less steep decline than in the past. With this assessment, down weighting this index alone has essentially no effect on the model outcome.

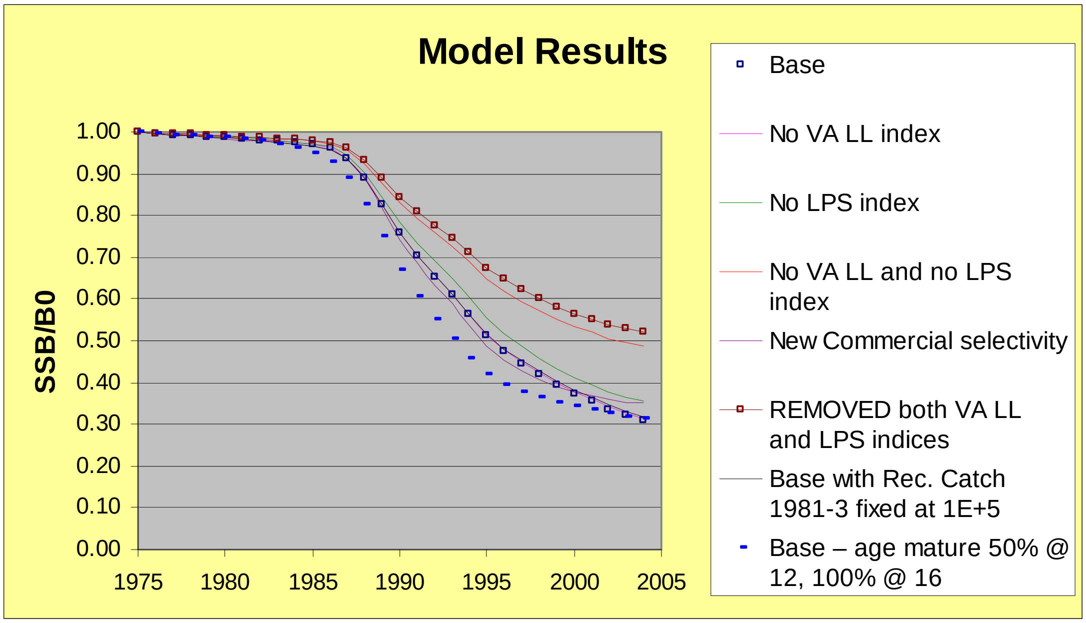


Figure 13. Experiments with the indices. See text for explanation of trajectories.

ii (a) (3) No LPS Our next experiment was to heavily down weight the LPS index. This is about equivalent to using inverse variance weighting for this index. The resulting trajectory appears as the fourth curve up from 1995 as the Base Case and No VA LL appear together as a single line. Down weighting the LPS index results in a more optimistic outcome.

ii (a) (4) No VA LL and No LPS In this experiment, both the VA LL and the LPS indices were heavily down weighted. The resulting curve is the next to the top. The result is much more optimistic, with SSB/B0 near the 50-percnet level although the stock continues to decline. Since the remaining indices are nearly flat in trend, the failure to flatten is likely driven by the biological parameters assumed in the model.

ii (a)(5) remove VA LL and LPS We then re-ran the experiment this time removing these two indices from the data file rather than merely down weighting them. The trajectory is the top curve with the closed square symbols. The final ratio is a bit above the 50-percent level and fishing mortality is less than F_{MSY} – the stock is not overfished and overfishing is not occurring. From a technical standpoint, the difference between this run and run 4 is interesting because it demonstrates that down weighting an index, which is easier to do than removing it form the data input file, is not exactly equivalent to removing it. This is mainly when the index stands alone for the first part of the time series. In the case of the VA LL and LPS they start about a decade before the other indices, therefore the small signal that remains after down weighting the index still affect the model.

ii(a)(6) Base Case using a different selectivity curve The next experiment we tried was to modify the commercial selectivity curve to be closer to what was observed in the BLOP data base. The trajectory is the second curve from the bottom. Using this selectivity curve results in a slightly more optimistic outlook, and more interesting is that here the trajectory flattens out in the recent years instead of continuing to decline as with the other runs so far. Why this happens is worth further investigation.

ii(a)(7) Base with Rec. Catch 1981-3 fixed at 1E+5 Here we chopped the early recreational catches down to a low level to see how sensitive the model is to what is a very uncertain estimate of catches. The trajectory is essentially the same as with runs 1 and 2 and overlies these two runs. This and the next run were done also by SEDAR 11.

ii(a)(8) Base case with age mature 50% @ 12, 100% @ 16 The last run in this series of experiments looks for the effect of using a young age at maturity ogive. A similar run was done by SEDAR 11and in both cases the final depletion level is the same as with the Base Case. However, we need to point out that the trajectory, which was not plotted by SEDAR 11 (this is the bottom line in the figure) shows a steeper decline than the Base Case followed by a leveling off in the last years. As the leveling off implies, fishing mortally is lower (by about half) in the terminal year than in the Base Case.

The resulting reference points for these runs are given in Table 2 along with runs 9 through 12 that are not plotted in Figure 13.

Case	SSB_{2004}/SSB_{virgin}	SSB_{2004}	F_{2004}/F_{MSY}	Pup survival	Steepness
1. Base Case – files received from Liz Brooks	0.31	428,000	3.72	0.62	0.32
2. Base down wt. VA LL	0.31	435,000	3.69	0.62	0.32
3. Base down wt. LPS	0.36	570,000	1.41	0.98	0.42
4. Base down wt. VA LL and LPS	0.49	936,000	0.98	0.97	0.42
5. Base remove both VA LL and LPS	0.52	1,080,000	0.87	0.95	0.42
6. Base with modified commercial selectivity	0.35	796,000	2.46	0.68	0.34
7. Base with Rec. Catch 1981-3 fixed at 1E+5	0.32	424,000	3.52	0.65	0.33
8. Base – age mature 50% @ 12, 100% @ 16	0.31	678,000	1.76	0.57	0.41
9. Base down wt. LPS, NMFS-NE, and VALL	0.67	1,011,000	0.92	0.97	0.42
10. As in 9 with the modified maturity	0.51	1,525,000	0.55	0.93	0.53
11. Base (1) with modified maturity and commercial selectivity	0.45	1,616,000	0.94	0.69	0.46
12. As 10 with modified commercial selectivity	0.58	2,751,000	0.48	0.85	0.51

Table 1. Reference points from experimental runs for Shark_SPASM

Runs 1 through 5 explore the effect the two long time series indices VA LL and LPS have on the model outcome. As noted above, down weighting the VA LL (2) has slight effect on the outcome whereas down weighting LPS (3) results in a more optimistic outcome with the F ratio and SSB being improved considerably, but accompanied by an estimate of pup survival that is quite high, and an increase in the estimate for steepness. Runs 4 and 5 reduce or remove the effect of both VA LL and LPS from the model and, as previously noted, provide a much more optimistic outcome, but again with a very high estimated pup survival and increased steepness.

To conclude our exploration of the negative indices, we made Run 9 that down weighted NMFS-NE as well as VA LL and LPS. As expected, there is further improvement over the optimistic outcome seem for Run 4. Again, pup survival is estimated to be quite high and steepness increases. We did not try actually removing all three indices, but we anticipate that the result would be an improvement over Run 5 with a lower F ratio and slightly lower estimated pup survival. This run has leaves the model with information mainly from indices that cover the period from 1993 through 2004 and are all essentially flat. (The down weighted indices still have a slight effect.) Thus, the outcome is the result of the catch information, the biological assumptions and the selectivity curves combined with indices that indicate stock abundance has been stable in recent years.

Run 6 investigates the Base Case using a modified commercial selectivity that is based on observational data in the BLOP data set. The outcome is similar to what we got by down weighting the LPS index: the F ratio is improved as is stock size, but with the estimate for pup survival much lower and perhaps more realistic than when LPS was down weighted.

Run 7 investigates the Base Case using a modified recreational catch that reduces the large catches in the early years to a perhaps more believable level. The outcome is slightly more optimistic, but because recreational catches are so poorly accounted, any changes to the data base are speculative. Further exploration and sensitivity runs should be done after examining the origin of the estimated catches, but that was not something we could do at this time.

Run 8 investigates the Base Case using a modified maturity ogive that is based on observational data other than the Merson study used by SEDAR 11. As noted by SEDAR 11 when it made this sensitivity run, the outcome is unchanged with respect to the final biomass ratio. However, the spawning biomass is considerably great – as might be expected since the number of mature animals would be increased by the addition of younger fish – and the F ration is much more optimistic. Pup survival and steepness are acceptable.

We then used the modified maturity ogive in Run 10 that also down weighted the negative indices. The result is very optimistic but pup survival is estimated to be high.

For Run 11 we returned to the Base Case inputs but used both the modified maturity ogive and the modified commercial selectivity. The result is optimistic with F_{2004}/F_{MSY} ratio less than 1.0 and pup survival (0.69) believable.

Run 12, the last we did, down weights the negative indices and uses the modified maturity ogive and commercial selectivity. The result is optimistic and pup survival is arguably acceptable. In this run and five other runs the stock is not overfished and/or overfishing is not occurring. In ten of the twelve cases examined, the model estimates that steepness lies outside the bounds (0.2 to 0.4) set by SEDAR 11 but there are no quantitative data to support this range. Density dependence response is presumed to exist for SB, perhaps mediated through a change in age at maturity and a lowering of natural mortality for both adults and pups, and the biological basis for fixing the upper bound for steepness at 0.4 needs to be examined.

iii. The Model

The CIE has this to say about the model: "Ultimately, the methods used for estimating stock status were found to have been much more sensitive to assumptions about life history parameters than the catch and catch-rate data used in the model.

"Size and maturity stage information was reported as being collected from the VIMS longline and some of the other series, but those data were not supplied to the stock assessment scientists. Given that the VIMS survey was a designed fishery-independent survey, it would have been helpful to have the size information to see if the component of the population that it was monitoring had been changing over time.

"An age-structured population model with state-space dynamics for some of the components and prior distributions assigned to some of the parameters was fitted to the data. No age data were used in the model, and the age structure was used mainly to incorporate different natural mortalities- and selectivities-at-age for the different fisheries (i.e. commercial, recreational, bycatch in menhaden fishery). Catch-rate indices were assumed proportional to population size, albeit with series-specific catchabilities and selection curves dependent upon whether they were commercial- or recreational-fishery-dependent, or fishery-independent series.

"The model adequately incorporated the information from the available catch-rate indices and was the best available for the data provided. However, while catch-rate indices can inform on trends, they do not necessarily help generate understanding of the life history patterns that underpin stock status estimation. Pup survival was the only life history parameter to be estimated in the model, and other parameters such as natural mortality-at-age and the prior mode for pup survival had to be adjusted so that the steepness parameter remained within a reasonable range for the species."

We have covered some of these comments above. The CIE comment about the failure to use age data in the model deserves additional comment in that the model in its present form cannot incorporated size data except indirectly[2], and then it got it wrong in the case of the selectivity curve. There are other stock assessment models

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[2] Size has to be converted to age, which was done using a von Bertalanffy equation.

available that are able to use size data directly, and it would be useful to employ one or more along with the corrections to the indices and compare results.

The CIE also notes: "Ultimately, the methods used for estimating stock status were found to have been much more sensitive to assumptions about life history parameters than the catch and catch-rate data used in the model." This is a very serious defect. The use of biological parameters in the modeling would be quite useful if these parameters were estimated from data. In practice, only the average number of pups and age at maturity were based on sample data. The former comes from several studies and is consistent with the BLOP data. The age at maturity study, however, is seriously flawed. The animals were not aged, rather length was estimated using a von Bertalanffy equation that may not be correct, and in any event introduces a second source of error that was not accounted for. There is evidence that age at maturity has decreased in recent years. Unfortunately, the study material was discarded, and there is no way to redo the work except collect new specimens.

The other biological parameters used by the model are natural mortality M, pup survival and steepness. Pup survival is estimated by the model, which is a circular process, or fixed by the modeler, which in subjective. The values for M that were decided by SEDAR 11 BW were changed for the final assessment. Steepness was likewise manipulated in order to achieve a credible model output. The fact that these parameters were derived subjectively is disturbing as these are the assumptions the CIE point to as being more influential on the estimate of the status of the stock than are catch and catch-rate data.

3. **Projections**

We did not explore the projections. The future status of the stock is dependent upon the biological parameters, particularly the maturity ogive. Further work needs to be done to include the additional size/age at maturity information and to resolve the inconsistencies in the model results before projections may make sense. In particular, the biological parameters have to be carefully re-examined as they alone control the modeling for the future condition of the stock. Projections need to consider density dependent effects on age (size) at maturity, fecundity and natural mortality. Projections that do not recognize the variability of environmental conditions on growth rate and species interactions such as predation on pups will be misleading over the long term.

4. Conclusions and recommendations

To sum up our conclusions:

- ***The assessment proceeded without using the largest data set available, the BLOP data, which inter alia shows that average age of the catch has not declined over time, as it should if the stock were being overfished.***

- ***The BLOP data also show that the selectivity curve used for the commercial catch is wrong and needs to be re-examined.***

- ***Catch-rates for recent years remain level indicating a population in equilibrium; overfishing is not occurring, whereas the model trajectory indicates a continuing decline in abundance.***

- ***The assessment used several catch-rate series (LPS and NMFS – NE) that were either inappropriate, or did not include the available (but withheld) size and sex data (VA LL).***

- ***The age-at-maturity ogive was derived from a study that is technically flawed.***

- ***The biological parameters used in the model were selected subjectively and there may be some evidence that different values are more appropriate.***

The problem now is that NMFS has used this technically flawed assessment to make the formal finding that the stock is overfished and overfishing is occurring. This starts a legal process that may require a severe reduction in TAC. There is time yet to revisit the assessment before that reduction is in place if NMFS is willing to devote the effort and address most of the concerns the CIE and we have raised. Redoing the maturity ogive study may not fit into this period, but the other work could be done a matter of months.