STATUS OF ATLANTIC LARGE COASTAL SHARK STOCKS

Evaluation of the US Atlantic Large Coastal Shark Stock Assessment

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Statement of Review.

I have reviewed the US Atlantic Large Coastal Shark Stock Assessment. I do not find that the scientific conclusions and scientific management recommendations contained in the 1998 SEW Report are based on scientifically reasonable uses of appropriate fisheries stock assessment techniques and the best available (at the time of the 1998 SEW Report) biological and fishery information relating to large coastal sharks.

I confirm receipt of the Atlantic Shark Industry Position Paper and acknowledge that it was considered in the course of my review.

I find that the stock assessments and the scientific information behind them overall do not support the conclusions of the assessment as to the current status of the stocks and projections under different harvesting regimes. In my opinion the projections for *C. plumbeus* and *C. limbatus*, which comprise about 80% of the catch, are biased towards a stock recovery projection.

Several recommendations were made by the review committee in the assessment (SEW 1998) as to how current harvest levels might be reduced in order to achieve projections for stock recovery. These were not prioritized or considered adequately in the light of cost to the commercial fishery or feasibility of implementation in the recreational fishery. Future stock assessments could consider in more detail how reductions in fishing mortality could be best achieved, particularly considering costs to the commercial fishery and feasibility of introduction, and provide this advice to management. Particular attention should be given to protection of juveniles and inshore nursery habitat as a means of increasing numbers of large coastal sharks.

Peter Hale, September 2001.

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Review of background material and an analytical model used to assess the status of Atlantic coastal large shark stocks.

1. Review the analytical model(s) used to assess the status of large shark stocks in Atlantic coastal waters, including the modelling approaches used in recent prior shark evaluation workshops. Consider, *inter alia*:

- **The reliability of estimates of current abundance, recent trends, and demographic structure (including uncertainties);**
- **The reliability of population projections from the assessment results;**
- **The appropriateness of the weighting of the various indices of abundance for the different ages and species/stocks of shark;**
- **The appropriateness of the Bayesian methods used in evaluating population status;**
- **The appropriateness of the non-age-structured methods used to estimate status of shark populations;**

The report of the 1998 Shark Evaluation Workshop (SEW) comprises a comprehensive analysis of stock projections under different harvesting regimes to estimate levels of fishing mortality that will ensure stock recovery. The analysis is based upon available data for catch rates in the various fisheries that contribute to mortality in the large coastal shark aggregate (4 primary species) and on estimates of demographic parameters for the species concerned, especially intrinsic rates of increase. In the assessment, results from demographic modelling and catch rates were evaluated as input to a production model within a Bayesian framework.

Abundance and trends

Analysis of the large coastal aggregate (LCS), as well as *C. limbatus* and *C. plumbeus* separately, relies on data from 17 catch rate series, mostly from commercial and recreational fisheries. Data from fishery independent surveys reflect that seen from the fisheries data (see further). The data are extensive and were scrutinised to ensure they were collected in a manner whereby they could be standardised across series without accruing additional error (SEW-1998). Relative abundance estimates were calculated from the catch rate data. Data for catch series of the large coastal aggregate analysed over at least 10 years show the same downward trend in catch rate. Several concerns were raised in SEW-1998 and previous stock assessments about the use of some catch series. Some of these concerns were addressed while others were not. In particular, the Crooke LL series and various shark tournament series remained in the assessment despite concerns raised about the accuracy of the data. This may have been because these series were from early years and for these years it was important to try and establish baseline (pre-commercial exploitation) CPUE indices.

The 1998 SEW separates species of the large coastal aggregate for the first time to make projections for stock recovery and provide advice for ongoing management.

Thus 8 catch series were used in the assessment for *C. plumbeus* and 6 for *C. limbatus*. These species together comprise 80% of the fishing mortality. It makes sense to do this because species of large coastal shark differ in their rates of increase.

Population projections

The catch rate data show a decline since exploitation of LCS at high levels began in the late 1970's. For the large coastal aggregate a single decline without any subsequent increase was identified. Individual catch series for LCS, and for *C. limbatus* and *C. plumbeus* separately, show significant ($p<0.1$) positive and negative slopes. General Linear Modelling of the series shows a declining trend for LCS but not for *C. limbatus* and *C. plumbeus*. The population projections from the production model under different harvest rates reflect the influence of the early catch series in the model. are optimistic given the optimistic values of intrinsic rates of increase (see further). The harvest rates suggested to achieve stock recovery (as a percentage of the 1995 harvest) are not too conservative and effort should be made to achieve the reductions in fishing mortality suggested from those projections.

Analytical methods

Generalised linear modelling of CPUE data from numerous sources; commercial, recreational and fishery independent data, has been employed to analyse catch rate data, covering all sources of fishing mortality on the large coastal aggregate. Data have been standardised where appropriate. From these data estimates of relative abundance have been made. The stock assessment uses a surplus production model to determine Maximum Sustainable Yield (MSY), population levels and fishing mortality.

The rationale behind the analytical approach adopted is explained in SEW-1998. The concern I have about the approach is that, given the general poor quality of the catch series and uncertainty about intrinsic rates of increase (large variance in estimates in SEW-1998), why use a model that carries with it very explicit assumptions about which there is uncertainty. The maximum likelihood (MLE) approach used in SEW-1996 makes no assumptions about the data. The longer catch series (1986-95) used with this model in SEW-1996 gave quite optimistic projections for recovery. MLE was not used in SEW-1998 with no justification.

The production model is not an age-structured model, which would be more appropriate for analysis of shark populations. The Bayesian analysis based on a non-age structured population model does not accommodate time lags in the response to changes in fishing practice. So changes in CPUE will be slower in an age-structured production model whereas in the simple production model changes are assumed to be instantaneous.

Non-age structured methods

It is argued in SB-4-27 that use of an age-structured model, where time lags in responses to changes in fishing mortality are considered, would give results at least as pessimistic as those obtained using a surplus production model, because such a simple model ignores time lags in population responses to changes in fishing mortality. I think such a conclusion is correct. However, the population is age structured, so changes in harvest rate will take time before they are seen in the CPUE estimates.

Bayesian methods

Bayesian methods in a production model could be helpful when the analysis calls for consideration of management options. They allow prior probability distributions for population parameters (eg, intrinsic rate of increase 'r') to be incorporated into the assessment together with the stock assessment data. These distributions can be tested in the model to assess various management options, such as the outcomes of different harvest rates (see SB-4-26 & SB-4-27). For this reason Bayesian methods are now used widely in fisheries stock assessment (Hilborn and Walters 1992, Punt and Hilborn 1997), and their use here is appropriate. However, it is the production modelling approach that in my opinion is inappropriate here because of uncertainties in the data

2. Review the quantity and quality of data available for assessment of status of the large coast shark stocks, particularly that from the MRFSS, and how these data were used in assessment of the large coastal shark stocks.

The data available for the SEW 1998 assessment of large coastal shark stocks include 17 time series for the large coastal aggregate, 8 for *C. plumbeus* alone and 6 for *C. limbatus* alone. An additional 2 years of data were available for some of the time series analysed in the 1996 assessment and new series were added. Separate time series for *C. plumbeus* and *C. limbatus,* including extra 2 years of data, enabled the status of and projections for these species to be assessed with greater confidence. Time series for inclusion in the 1998 assessment were scrutinized prior to the analysis and where they did not satisfy criteria for sample size, uniformity of effort and correct species identification, were excluded (SEW 1998). The 1998 assessment has attempted to assemble as many time series and over as long a period as possible. The 17 time series used in the GLM for LCS reveal a clear decline since they were first fished heavily in the mid-1970's, but no two years are significantly different.

The catch series covering years from the mid-1970's to mid-1980's are important for the MSY calculations and projections. There are problems with these series. They are: Virginia LL, MRFSS-HBOAT-TX1, Crooke LL. Recreational shark fishing tournaments.

Previous SEW's expressed concern about the small sample sizes in the early Virginia Longline survey data, for LCS and *C. plumbeus.* This data is for Chesapeake Bay and nearby offshore areas at the mouth of the Bay. It is unlikely to be representative as this inshore nursery area is only one of many for LCS and fishing activity may not be representative of the range of the fishery. Sample sizes for the years '74-'79 and '82-'89 are 'extremely small' and should be excluded (SEW-1998) although it appears they were included in the analysis.

MRFSS-HBOAT-TX1 for LCS, *C. plumbeus* and *C. limbatus*. Standard methods are now employed such as those used to collect catch rate data for the recreational fishery in SB-4-25 (Pollock *et al.* 1994, NRC 1998). However I have concerns about the collection of this data. Recreational fishers do not target sharks and know very little about species identification. Records are not kept. Dockside interviews of fishers with and without their catch were combined with results of telephone interviews. Three distinct data collection projects were combined to produce this data. The coefficients of variation (cv's) on the data are 1, which says a lot about the reliability. Concerns were recorded in the SEW about the reliability of recreational shark tournament catch series but it was used in the assessment without justification.

Crooke Longline for LCS. This data is from an individual recreational fisherman and is discussed in SB-4-39. This fisherman did not record sets where no sharks were caught

Fishery independent surveys reflected the trends in the total time series, which contain mainly time series from the commercial and recreational sectors. For example, the decline in catch rate is evident in the Virginia longline survey [SB-4-13], where a marked decline in CPUE for large coastal sharks is demonstrated between 1980 and 1992. The possibility that this decline is due to natural causes, perhaps operating on a

single species such as *C. plumbeus*, the most numerous LCS in the area, was not discussed. *C. plumbeus* show an increase CPUE 1992 – 1996, consistent with the conclusion of the SEW 1998, regarding *C. plumbeus,* from the analysis of all catch series and model projections, but likely to be before the bag limits and quota cut of the 1993 Fisheries Management Plan would have had any effect. The analysis of the Virginia LL survey for *C. obscurus* reflects the conclusions of SEW-1998 that the species has been severely depleted and not shown any sign of recovery.

The availability of separate data for *C. plumbeus* and *C. limbatus* allows projections for each species to be modeled. The two species are thought to have different intrinsic rates of increase. The result is a more optimistic projection for harvest rates of *C. plumbeus* to achieve stock recovery than if the large coastal aggregate is analysed as a group (e.g., in SB-4-26 & 27). On the other hand, the projection for *C. obscurus* is worse than the LCS aggregate because its vital rate is very low.

In the SEW 1996 an intrinsic rate of increase of 0.26 for the large coastal aggregate was used in the model. This estimate was revised in the SEW 1998 to an upper estimate of .113, with upper estimates for individual rates also determined from the literature of .117 for *C. plumbeus*, .136 for *C. limbatus* and .041 for *C. obscurus.* These were used as priors in the model and may be somewhat pessimistic. The rate for the large coastal aggregate used in SB-4-27 was .07, and resulted in considerably more pessimistic projections than the results presented in SEW 1998.

The calculation of the Mexican catch of *C. limbatus* originating in US waters is reasonable given the data presented in SB-4-8. Whether the western Gulf estuaries can be considered as natural source areas for *C. limbatus,* which migrate south late in the year (where many are harvested) is unlikely; it is more likely is that these sharks migrate north during the summer months. Their harvest in Mexican waters will deplete US stocks.

The 1998 SEW, furthering the conclusions of the 1996 SEW, has most likely considered all the available data that could be relevant in assessing the status of the stocks, including data on exploitation levels, demography and life history of large coastal shark stocks.

3. Review the support for and consequences of assumptions made about whether the shark stocks represent open or closed populations.

C. plumbeus and *C. limbatus* are two species of LCS for which data are available to make an assessment of population structure. Both species are found in tropical and warm temperate waters, where they pup in estuaries and move into deeper waters as they mature. Females return to estuarine waters to pup.

Catch data

Data on catches of *C. limbatus* and other shark species in Mexican waters [SB-4-8] are compelling evidence that juvenile *C. limbatus* move south from US waters in winter where they boost the local fishery. The stock assessment area for *C. limbatus* includes that part of the Mexican fishery (in the two western-most States of Mexico) that us attributed to the US stock. *C. limbatus* are taken throughout the Mexican fishery, but only in large numbers in the west (Tamaulipas), in October / November. They are assumed to have migrated south from U.S waters. Few of this species are taken in the more eastern states of Mexico, the Yucatan Peninsula. The range of the stock assessment is from Mexico to the North-east US Atlantic coast, the northern extremity of the coastal range of the species in the region. *C. limbatus* is also taken offshore, in the pelagic longline fishery (SB-4-11, SB-4-33), and these catches are included in the analysis. It is rarely caught far offshore, for example by the offshore US Atlantic Fleet targeting tuna and tuna-like species (SB-4-22).

For the purposes of stock assessment it is reasonable to conclude that *C. limbatus* is a closed population, meaning that there is unlikely to be any net immigration or emigration of sharks in the region covered by the assessment.

C. plumbeus is harvested from the Northeast US Atlantic coast to the Northeast US Gulf coast. Nursery areas have been identified on both coasts.. The catch of this species in the Mexican artisanal fishery is negligible. As with *C. limbatus*, *C. plumbeus* is also taken offshore, in the pelagic longline fishery (SB-4-11, SB-4-33), and these catches are included in the analysis. This species is rarely caught far offshore, for example by the offshore US Atlantic Fleet targeting tuna and tuna-like species (SB-4-22).

For the purposes of stock assessment it is reasonable to conclude that *C. plumbeus* is a closed population, to the extent that there is unlikely to be any net immigration or emigration in the region covered by the assessment.

Genetic population structure

A study of geographic variation in *C. plumbeus* from the Gulf of Mexico and mid-Atlantic bight (Heist-Edward *et al.* 1995, Heist-Edward & Gold 1999a) using nuclear allozyme electrophoresis techniques and mitochondrial DNA analysis revealed limited genetic variability and showed no genetic variation among sampling locations. In a study using mitochondrial DNA analysis over the same region, the spinner shark (*C. brevipinna*) was the only one of several species in the large coastal aggregate to exhibit genetic variation among sampling locations (Heist-Edward *et al.* 1996, Heist-Edward & Gold 1999a).

Nuclear microsatellite loci generally show greater polymorphism than nuclear allozyme loci. *C. plumbeus* from the Gulf of Mexico and mid-Atlantic bight was tested for geographic variation at nuclear microsatellite loci (Heist-Edward & Gold 1999b) and no significant differences in microsatellite allele frequencies among locations were found. A problem with this study was the low level of gene diversity at the 3 microsatellite loci tested.

Levels of genetic diversity within individual species of shark are generally low. However, in *C. brevipinna* (Heist-Edward & Gold 1999a) and the Australian gummy shark *Mustelus antarcticus* (Gardner and Ward 1998) genetic variation has been found (using comparable techniques) amongst sampling localities over similar geographic distances to those of interest for *C. plumbeus* and *C. limbatus* in the present stock assessment. Genetic variation was not found however in the school shark (*Galeorhinus galeus*) in Australasian waters over similar geographic distances (Ward and Gardner 1997). The available data for *C. plumbeus* cannot be used to draw a conclusion that it comprises a single genetic population in the region of the stock assessment [1].

Tagging studies

The results of the few tagging studies conducted in the region (SB-4-13, SB-4-24, SB-4-28) do not contradict a conclusion that the stock assessment covers the geographic range of the populations of *C. limbatus* and *C. plumbeus.* The problem with this data is that there have been few studies and these have involved predominantly juvenile individuals, which would not be expected to undertake large migrations. Some large-scale movements have been detected, which support the possibility that *C. limbatus* and *C. plumbeus* each comprise single stocks in the fishery rather than the fishery comprising a number of discrete stocks. As suggested in SEW 1998, further tagging studies are needed to help resolve stock structure.

Fishing mortality

The data analysed for fishing mortality of the large coastal aggregate are comprehensive; i.e., all the likely sources of fishing mortality in the fishery appear to have been examined. On examining many of the time series it is not clear whether fishing effort has changed during the time series; has the skill of fishers changed, has there been gear changes that would alter CPUE. Any changes in the mix of species being fished and fleet composition should have been accounted for in the analysis, for example with the exit of large vessels from the fishery when trip limits on the US Atlantic coast were introduced in 1990.

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[1] Studies using 6-10 microsatellite loci with reasonable levels of gene diversity are needed to test the null hypothesis of panmixia in species of the large coastal aggregate with sufficient statistical power. If it were shown that there is more than one genetic population in the region of the assessment, this would be strong evidence that gene flow is restricted and that more than one stock comprises the fishery. Several other marine species found over the range of the fishery have been found to comprise genetically distinct populations between the Gulf of Mexico and the U.S Atlantic coast (Avise 1994). If this proved to be the case for *C. plumbeus,* as has been suggested (see reference to Springer 1960 in SB-4-7), then *C. plumbeus* in the Gulf of Mexico should be managed as a separate stock to that on the U.S. Atlantic coast.

4. Consider the degree to which the scientific conclusions and management recommendations in the assessment documents are supported by the analytical results, and if alternative conclusions would be equally consistent with the analytical results.

Scientific conclusions.
The scientific conclusions of SEW 1998, based on the Bayesian analysis (the model), model projections and CPUE data, are:

1. That 'projections (of the model) indicated that the large coastal aggregate complex might still require additional reductions in effective fishing mortality rate in order to ensure increases of the resource towards MSY' (p.29).
2. That 'evidence is still equivocal regarding stock rebuilding or further depletion' (p.31).
3. That 'sufficient observational data is not yet available to detect changes in stock size since the most recent management measures were implemented with any certainty' (p.31).
4. That 'the balance of data indicate that there is a need for substantial reductions in catches of the large coastal species, exclusive of sandbar and blacktip. For sandbar, analyses indicate that small reductions are needed to ensure recovery. For blacktip, large reductions in catches may be needed, but it is unclear whether reductions in the U.S. alone would achieve the intended goals (p.31 & p.33).

Support for the first and the fourth of the scientific conclusions listed above is taken from the results of the Bayesian modeling exercise in SEW-1998, and elsewhere (SB-4-26 / 27). These conclusions in my view directly contradict the second and third conclusions listed above. If the evidence at present is equivocal then it is only a value judgement on the part of the authors that the projections of the model indicate a need for further reductions in catch. This is especially the case with blacktip sharks, where the data do not indicate any recent decline.

Management regulations to limit fishing mortality were first implemented in 1993. Further regulations were implemented in 1997. The Bayesian modeling exercise was undertaken for the 1998 assessment to incorporate demographic information (intrinsic rate of increase) into the production model and predict population projections based on different harvest rates. The scientific conclusions are said to be based on the model projections. It is accepted in SEW-1998 that there will be a time lag before the effects of management implemented in previous years (1993 and 1996) will affect CPUE and the model projections.

The CPUE analysis shows declines in catch rate since the late 1970's. The GLM analysis shows a decline in average catch (SEW-1998 p.101) for LCS between 1974 and 1997, although no two years are significantly different. No decline is evident in the GLM analysis for sandbar and blacktip sharks when analysed separately. However, the previously discussed problems with the data used in the CPUE analysis, the GLM and then the production model, especially the data from the early years, means that the decline identified for sandbar and blacktip sharks in the production model used in SEW-1998, and the projections, may not be real. In fact, the catch

series for sandbar and blacktip shark analysed in SEW-1998 are consistent with a sustainable harvest at pre-1997 levels. The scientific conclusions of a need for further reductions in catch of sandbar and blacktip sharks are not supported by the analytical results. The production model is not appropriate for generating projections where there are distinct uncertainties about the inputs and the assumptions.

The conclusions that it is too early to tell whether previous management measures have worked do not depend on the projections but on an interpretation of the catch series and the GLM analysis and in SEW-1998. Time lags in the response to previous management measures means it is too early to tell (at the time of SEW-1998) whether these measures have placed the LCS stocks on an upwards trajectory.

Management recommendations

Overall, it was recommended in SEW-1998 that species of the large coastal aggregate should be managed separately (p.33); because values for the intrinsic rates of increase ('r'), differ for individual species. *C. limbatus* and *C. plumbeus* together comprise 80% of fishing mortality in the large coastal aggregate and recommendations for these species will have the largest effect on the fisheries.

A number of management recommendations were made in SEW 1998 for *C. plumbeus* and *C. limbatus*, without having priority assigned to them.

C. plumbeus: (and other ridgeback species).

- Introduce recreational minimum size limit of 140cm FL (fork length) so that only mature individuals would be harvested. The aim is to remove fishing effort from nearshore areas where smaller sharks of this and other species are abundant (data show that larger *C. plumbeus* are more likely to be taken in deeper water; (SB-4-1)
- Introduce a commercial minimum size limit of 140cm FL.
- Consider further lowering recreational bag limits or move to recreational catch and release only (as the survival of sharks caught on rod and reel is high).
- Not to introduce time / area closures for nursery areas due to problem of State jurisdictions.

C. limbatus: [and other non-ridgeback species]

- Do not introduce a commercial minimum size limit as size / depth segregation pattern might incur bycatch of small sharks (because large and small sharks occur in mixed schools).
- Introduce a reduction in commercial total allowable catch.
- Achieve regulation of effort (total allowable catch) in the Mexican shark fishery (as evidence is good that young *C. limbatus* from western US Gulf migrate south into the Mexican fishery during winter.
- Introduce a recreational minimum size limit (post release survivorship of young sharks caught on rod and reel appears high).
- Consider further lowering recreational bag limits or move to recreational catch and release only.

It was recommended in SEW-1998 that recreational fisheries for Atlantic sharks be subject to lower bag limits than currently exist, or subject to catch and release only rules.

A harvesting regime to promote stock recovery would target adult sharks and protect younger age classes. Protection of nursery grounds would also be a priority. Time / area closures may not be effective from a biological perspective (in addition to the State / Federal jurisdiction perspective outlined in SEW-1998) unless they specifically target nursery areas. Seasonal closures of these grounds, such as in Chesapeake Bay (SB-4-13) should be considered. Considerable work has already been done to identify these areas on the Gulf and Atlantic coasts. Little is known about the detailed movements of *C. plumbeus* and *C. limbatus* but they are estimated to move over reasonable distances per year and to take several years to reach maturity. It is argued in SEW-1998 that size limits are a good way to achieve protection of juveniles, which seems reasonable.

In the light of the analytical results the management recommendations are reasonable. They reflect concerns raised by the model projections. However, as there are serious concerns with the validity of the projections, discussed in SEW-1998 as well as herein, the proposed new management measures are not supported by the data.

The recommendations could be considered from the perspective of improving existing management of the LCS fisheries without undue penalty to the recreational or commercial fisheries. If priority had been assigned to the management recommendations then there may be cause for detailed review of their relative importance in stock conservation. This should be undertaken.

5. Consider the degree to which the assessment methods and the advice on management:

- **Took account of effects of current management regulations on population trajectories**
- **Took account of the risks to the resource of maintaining status quo management versus the costs to industry of immediate reductions in permitted landings of large coastal sharks before evaluation of recent new management regulations could be evaluated fully.**

Effects of current management regulations on population trajectories

It is argued in SEW-1998 that the effect of the 1993 and 1997 management regulations is apparent in the CPUE analysis and model projections for *C. plumbeus*., with the conclusion in SEW 1998 that only small further reductions in fishing mortality for *C. plumbeus* will be necessary to ensure recovery. It is argued in SEW 1998 that there is no indication in the CPUE analysis and model projections for *C. limbatus* that the management regulations have had any effect on stock projections. It was recognised that the intrinsic rate of increase for *C. limbatus* is likely to be lower than that for *C. plumbeus*, and this was offered as an explanation for the difference between the two species.

Additional data from 1996 and 1997 was incorporated in the 1998 stock assessment; the time series on CPUE for the commercial logbook data, recreational creel surveys and observer programs could be therefore be extended. This is important, it gave the assessment 2 years of extra data with which to assess the reliability of the CPUE analysis for the projection model. In the

Data for *C. limbatus* and *C. plumbeus* fishing mortality, which comprise 80% of the large coastal mortality, was assessed separately. Estimates of intrinsic rates of increase for these species were applied to production models for each species. Therefore it was possible in SEW 1998 assessment to determine recovery scenarios for the two species separately, and consider management options for each. The projections for the large coastal aggregate are more pessimistic, presumably due to unfavourable catch series for species with low rates of increase such as *C. obscurus*.

SEW 1998 considered the effects of current management regulations on population trajectories; it was argued that it was too early to tell whether current management had been effective in reversing the downward trend in catch rates they identified (SEW-1998 p.31). The advice on management, although not prioritised, proposed further reductions in commercial and recreational catch. It is not clear on what basis the decision to propose further reductions in catch was made when it was acknowledged that it was too early to tell whether previous management measures had been effective. SEW-1998 took no account of the effect this might have on industry.

Risks to the resource versus costs to industry

The results of the SEW 1998 analysis, incorporating life history parameters in a projection analysis, has permitted consideration of the likely impact of new management regulations (1993 & 1996) on LCS, and in particular on *C. limbatus* and *C. plumbeus*. Projections for these species are crucial to considerations about LCS

management. It was recognised that the effect of the new management regulations (1993 & 1997) could take several years to become apparent (SEW-1998).

It is argued in SEW-1998 that the effect of the 1993 and 1997 management regulations is apparent in the CPUE analysis and model projections for *C. plumbeus*, with the conclusion that only small reductions in fishing mortality for *C. plumbeus* will be necessary to ensure recovery. The impact of any further reductions on the industry was not considered and the management recommendations were not prioritised within any framework of the Fisheries Management Plan.

In considering how to achieve a reduction in fishing mortality of *C. limbatus*, SEW 1998 made several suggestions (see section 4 above), which were not prioritised. The efficacy of implementing a TAC for *C. limbatus* in the commercial sector when it may not be possible to achieve a similar outcome in the Mexican artisanal shark fishery for *C. limbatus* was discussed. However the impact on the commercial sector of any further reduction in the commercial take was not considered.

SEW 1998 recognised that *C. limbatus* fishing mortality in the recreational sector was almost as high in 1997 as fishing mortality in the commercial sector. A no-take policy for *C. limbatus* in the recreational sector with no reduction in the commercial sector would reduce future harvests to about 50% of the 1995 level, where the recommended reduction is to 10% of the 1995 level. A 50% reduction in the Mexican harvest of *C. limbatus* with no US recreational harvest and the US commercial harvest held at the 1997 level would reduce fishing mortality to 40% of the 1995 harvest. Considerable reductions in the TAC for the US commercial and Mexican *C. limbatus* fisheries, with a no take policy in the US recreational sector, would be needed to reduce fishing mortality to a level that the model predicts will ensure growth of stocks towards MSY. SEW 1998 recognised that it would be inappropriate to seek large reductions in *C. limbatus* mortality in the US commercial fishery unless similar reductions could be achieved in the Mexican fishery.

APPENDIX 1.

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APPENDIX 2

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APPENDIX 3

Center for Independent Experts Statement of Work

CENTER FOR INDEPENDENT EXPERTS STATEMENT OF WORK

Consulting Agreement Between the University of Miami and Dr. Peter Hale

March 1, 2001

A. General

The review, which shall analyze background material and an analytical model to assess the status of Atlantic coastal shark stocks, shall address the following issues:

1. Review the analytical model(s) used to assess the status of large shark stocks in Atlantic coastal waters, including the modelling approaches used in recent prior shark evaluation workshops. Consider, *inter alia*:
   - The reliability of estimates of current abundance, recent trends, and demographic structure (including uncertainties);
   - The reliability of population projections from the assessment results;
   - The appropriateness of the weighting of the various indices of abundance for the different ages and species/stocks of shark;
   - The appropriateness of the Bayesian methods used in evaluating population status;
   - The appropriateness of the non-age-structured methods used to estimate status of shark populations;

2. Review the quantity and quality of data available for assessment of status of the large coast shark stocks, particularly the data from the MRFSS, and how the data were used in assessment of the large coastal shark stocks.

3. Review the support for and consequences of assumptions made about whether the shark stocks represent open or closed populations.

4. Consider the degree to which the scientific conclusions and management recommendations in the assessment documents are supported by the analytical results, and if alternative conclusions would be equally consistent with the analytical results.

5. Consider the degree to which the assessment methods and the advice on management:
   - took account of effects of current management regulations on population trajectories
   - took account of the risks to the resource of maintaining status quo management versus the costs to industry of immediate reductions in permitted landings of large coastal sharks before evaluation of recent new management regulations could be evaluated fully.

B. Specific Products and Deadlines

Reviewers may communicate among themselves as they choose. However, each reviewer will prepare an independent report addressing each of the Terms of Reference. No consensus opinion among reviewers is required.

Each reviewer's report will include a specific statement on whether or not the assessments and scientific information behind them supports the conclusions of the stock assessment. If the reviewer concludes that only some conclusions are supported by the assessment and others are not, the review should point out which ones are supported, which ones are not, and why. If the model(s) used are inappropriate, the reviewer should suggest better alternatives and explain why they are more suitable for assessing large coast shark stocks. If the assessments did not consider fully all the relevant data, the reviewer should point out which data sets were treated inappropriately (either by exclusion or by weighting too heavily) and if possible suggest how more appropriate treatment of the data sets might have affected assessment results and conclusions. The reviewer should include a listing of changes that should be included in future assessments of these stocks.

A set of 41 documents used in recent NMFS assessments of large coastal shark stocks will be provided to each reviewer. The documents are intended to provide full information on the background of these recent assessments and scientific advice . Reviewers are not asked to provide a detailed critique of the individual documents. Rather review should consider the information and knowledge base as a whole. as it relates to the assessments and advice based on them. In doing so, reviewers may find it helpful to reference individual documents, and are welcome to consider additional documentation as appropriate.