REPORT OF THE ATLANTIC COASTAL SHARK FISHERY ANALYSIS REVIEW September 30, 1992

INTRODUCTION

On September 30, 1992 a Shark Fishery Management Plan Regulatory Review Meeting was held in Miami, Florida to reach conclusions regarding the resource assessment of the Atlantic coastal shark resource. Meeting participants included Dr. Donald McCaughran, Director, International Pacific Halibut Commission; Dr. Grant Gilmore, Director, Harbor Branch Oceanographic Institution, Inc., Dr. Andrew Rosenburg of the National Marine Fisheries Service Woods Hole Laboratory, Dr. Michael Parrack of the National Marine Fisheries Service Miami Laboratory, and Dr. Jose Castro, also of the National Marine Fisheries Service Miami Laboratory. The meeting participants are hereafter referred to as the Committee.

A major charge placed on the Committee was to determine an appropriate fishery analysis procedure for the 1993 coastal shark fishery. After careful consideration the Committee concludes that the available data is meager and uncertain; but that an analysis of those data does yield statistics comprehensive enough to allow the initialization of fishery regulations. The committee strongly believes that the continuance of a regulatory regime rests on a vast improvement in the quality and extent of shark fishery statistics. The Committee is very concerned as to the inordinately limited extent and quality of the existing shark fisheries statistics.

The Committee considered shark life history characteristics relevant to resource production, a complete description of the fishery, and an inventory of available coastal shark fishery statistics. Analysis methods appropriate to the shark fishery were discussed and decisions reached as to the method to be used and calculations to be employed to investigate the status of the resource and to recommend a 1993 removal level.

LIFE HISTORY PATTERNS

Most commercially important sharks are best characterized by the two most important species in the landings. Sandbar sharks, which compose about 80% of the landings, grow very slowly reaching maturity after about 20 years of life. Bull sharks, a species that is sometimes a significant component of landings, particularly in the Gulf of Mexico, have very similar characteristics. Blacktip shark, the second most important species in the coastal shark landings, reach maturity at about age seven. These species do not produce young every year, rather they "pup" on alternate years. On the average, a female sandbar shark gives birth to nine pups every second year. On the average, an adult female blacktip gives birth to four pups every second year. Adults of most important food fish species spawn hundreds of thousands of offspring every year. Coastal shark reproductive characteristics are similar to predatory mammals rather than fishes.

These reproductive characteristics are germane. The exploitation level that large coastal sharks might support was roughly approximated by assuming that the natural life span is about three times the age at maturity as for other vertebrates and that the rate of natural mortality is on the order of the reciprocal of half the life span. For the two most important species, these two assumptions and the life history characteristics indicate that

	Sandbar	Blacktip
Age at Maturity	20	7
Litter Size	9	4
Pupping Frequency - Every	2 years	2 years
Survival	0.97	0.91
Reproductive rate	2.25	1.00
Life span	60	21
Pups produced	26.25	4.30
Living Juvenile offspring	6.18	0.98
Living Adult offspring	5.89	0.86
Living Total offspring	12.08	1.85
per year of life	0.20	0.09

so 0.2 sandbar are replaced for each individual alive in the population each year and 0.09 black tip sharks are replaced. The Committee stresses that these theoretical replacement rates (1.20 and 1.09) are extremely low as compared to those of almost all fisheries resources of commercial importance.

The species of commercial importance undergo seasonal migrations from south to north in the spring. These species pup in shallow estuarine waters along the Atlantic coast and Gulf of Mexico. The fish then migrate back south when fall temperatures cool coastal waters. Sandbar sharks undergo lengthy northward migrations reaching Southern New England waters by late summer. Sandbar sharks are caught as far north as Nantucket Shoal and the southern Georges Bank. Blacktip sharks are not believed to exhibit as extensive northward movements and travel in shallower, more coastal waters. The extent of southern movements is not established beyond doubt, but mark-recapture data suggest no movement south of the Yucatan.

Field observations by both scientists and fishermen indicate that migratory movements of individual sharks might not be completely random in time and space. It has been observed that if fish are encountered on a particular date at a specific geographical location, they will likely return to near that location at that time year after year. Fishermen depend on that information to a large degree for success. It is also true that the locations of migratory routes to pupping areas

and the locations of pupping concentrations are known to fishermen and that significant removals occurred in these locations.

FISHERY DESCRIPTION

Sharks of United States Atlantic coastal waters have been exploited for many years. The original fishery that began in 1936 for hides and livers (vitamin A) ceased in 1950. The recent fishery existed at a very low level until 1985 because the market value of and sport fishing interest in sharks was low. Due to successful food product marketing and increased sport fishing interest, exploitation increased dramatically after the first half of 1985. An intensive fishery has developed in both the Atlantic and Gulf of Mexico coastal waters Southern New England to Louisiana. The fishery provides shark meat to domestic markets and fins for export to Asian markets. It is the first large scale commercial shark fishery in the area in over four decades.

Shark meat was not a popular food item in the United States prior to the 1970's, although small quantities were sold in coastal areas throughout the southeastern states. These markets were supplied by small local fisheries. During the early 1970's shark meat consumption increased. In the mid-1970's, political and economic changes in the Asia opened the Asian shark fin market to the United States. Commercial marketing links between U.S. fishermen and consumers of shark fin in China and Hong Kong were established over a five to seven year period. A tremendous demand and high market value in Asia for shark fins encouraged the expansion of the U.S. Atlantic coastal shark fishery. The fleet targeting coastal sharks expanded quickly. In addition, due to escalating shark fin prices, vessels engaged in tuna and swordfish as well as other fisheries started removing the fins of sharks caught incidental to target species; before, the sharks were released unharmed. Thus, both the increased popularity of sharks as food and the demand for shark fins caused a very rapid increase in shark removals.

The southeastern United States directed coastal shark fleet employs longlines and gill nets from boats 20-120 feet in length, although most boats are about 40-55 feet. Monofilament mainlines are used when ever possible, but since fishing is carried out near the bottom, steel cable main line is used in waters deeper than about 180 feet. The cable longline is heavier and requires heavier handling equipment, so that gear is used on larger boats, usually those 52 feet in length and larger. Economic factors up to the present time are such that most fishermen prefer boats of about 42 feet. These boats use monofilament longlines usually in waters of 120 feet and less. Smaller boats use two to three man crews and larger boats use five or six man crews. Longliners operate during most of the year and the more successful boats following migrating sharks as they move north in the spring and summer and south in the fall. The majority of the longline catch is composed of sandbar, blacktip, bull, spinner, dusky, bignose, night, lemon, tiger, sand tiger, silky, scalloped hammerhead and great hammerhead sharks. Nurse and sand tiger sharks are also occasionally taken. Other species of smaller sharks including fine tooth, black nose, and Atlantic sharp nose are also caught, but the existing fishery targets the larger species.

Two distinctly different shark gill net fleets exist. A small boat fishery manually sets and retrieves nets in shallow coastal waters. A modern fleet with mechanized highly efficient gear fish on schools of sharks as they seasonally migrate along the coast.

Fishermen using small boats from 18-22 feet in length operate in very shallow waters with one or two man crews. They often fish in estuaries. They usually fish during May through November when sharks are in the shallows pupping or are migrating through. They catch the same species as the longline fishermen the proportional composition of their catches reflects the shallow waters where they fish. Recent legislation in several states has stopped the use commercial gill nets in state waters, so these fishermen now attempt to fish in deeper waters beyond 3 miles from the shore where their nets are much less effective.

The modern gill net fleet is composed of boats 36 to 55 feet in length. Hydraulic setting and retrieval machinery is employed as are spotter aircraft. Seven of these vessels directed their operations at blacktip sharks during 1991 off the Atlantic coast. These boats do not fish sharks year around, rather they opportunistically target peak concentrations of migrating schools close to shore in the spring and fall. Recently, legislation by several states has forced their operations, into deeper waters. These boats removed very large quantities of sharks from shallow, coastal waters and continued to do so this year (1992).

The number of boats targeting sharks increased rapidly until 1989, then decreased. After 1989 the larger vessels left the fishery until less than 100 remained in 1991. However, these and more boats entered in 1992 due to high fin prices and landings restrictions in other fisheries. The major ports for these vessels were Morehead City, North Carolina; Port Orange on the Atlantic coast of Florida, and Madeira Beach on the Gulf of Mexico coast of Florida; and Bayou LaBatre, Alabama. Currently (1992), ports in Louisiana, the Atlantic coast of northern Florida, and north of North Carolina are becoming major landing points.

Recreational fisheries also exist for Atlantic sharks in the United States. Although landings are small and sporadic, there has been an increasing interest in shark sport fishing during the 1980's. Decreasing recreational catches, particularly in shark fishing tournaments in the southern United States, has prompted concern by the sport fishing community for the status of the resource. Several shark fishing tournaments no longer occur due to the absence of success by tournament entries in recent years.

FISHERY STATISTICS

More than ten large coastal species are common in the landings, but the heads, guts, and fins were removed at sea so accurate shore identification was not attempted. The species landed therefore were not recorded nor were species composition samples collected. Lengths of fish in commercial landings were not comprehensively or consistently sampled during the fisheries history. A research cruise fishing success rate (CPUE) time series, or other consistent measure of relative abundance covering the geographical expanse of the fishery were not collected so fishery independent abundance indices are not yet developed. Some samplings do exist, however, and the possibility exists that these may be analytically equated to form an index. The data, however, reside in several different locations under different custodians and formats. Somatic samples (to interpret ages of landed fish) were not collected. Methods to interpret the age of sharks from body parts are not developed for many of the species taken by the fishery. Growth rates are not estimated for many species. Interview samples of commercial fishing trips were not collected so fishing time, location, and the gear employed were not recorded. In some instances, landings from several trips were recorded on a single sales receipt so the number of fishing trips can not be recovered. Finally, very large sharks ($\geq$ 60 pounds dressed weight) and certain species caught by the directed shark fleet often are not accepted by fish brokers. The fins are valuable, so those sharks were often fined and discarded at sea. In addition, in southern areas, swordfish longline vessels fishing in shallow waters west of the Florida Current often catch large numbers of coastal sharks, but do not land them; they fin the fish and dump them at sea. The data were not collected to compute the magnitude, size frequency, or species composition of the discards.

Three data elements existed from the commercial fishery. First, the total brokered yield was available from fish buyers. These landings were gathered by a voluntary dealer reporting method. The Committee observed that theses statistics are documented to have been in large error in the recent past and that there is indication problems still exist. The extent of error in the past (68% low in one year and 138% low in another) was large enough to render any past analysis result erroneous. Second, the number of fish in weighed bins was recorded on some sales slips. Also, several logbooks were obtained that recorded the dressed weights of individual fish on several trips. It was therefore possible to compute the sample average weight (and its variance) of commercial landings during latter years. Last, boats were identified that were targeting coastal sharks during all months of each year the boat fished. Almost all were longline boats. The number of boats operating full time in the fishery was used as a measure of the amount of commercial fishing (time fished).

Recreational fisheries data were different. The number of person-fishing-trips, both in total and directed at sharks, were estimated from telephone interviews. The Committee noted that the sample survey used estimated the numbers landed (catch) rather than the weight landed (yield) and that the estimator, a stratified mean catch per interviewed trip prorated to the total number of trips estimated from telephone interviews, should be distributed Gaussian (normal). Weight frequency sampling coverage was very sufficient for some portions of the recreational fishery, but not others. Enough weight frequencies were collected to compute sample average weights and variances.

After the assessment results based on the data available in 1990 were made public, shark fishermen became concerned. During the period between December, 1990 and July, 1992 several fishermen and two dealers supplied as much information regarding their activities as they could. Although some of the information was verbal, extensive written documents was also provided. These documents greatly affected the database. During this period those individuals made the contributions described below.

The personal fishing records of several fishermen are now available. These contain complete information as to number of sets, numbers of each species caught, location, total dressed weight landed, fish tagged and released etc.). The amount of detail included in these records and the willingness and interest shown by several fishermen indicate that a logbook system could successfully be the main bases for future analysis of the fishery.

Through verification with dealers and fishermen, it was determined that, several boats counted as shark boats in the past analysis where not fishing for sharks at all or did so occasionally, or (in one case) did not exist. It was also shown that the landings data were in large error because (1) the ex-vessel fish buyers did not report the transactions and (2) misclassification of reported landings. Under reporting resulted in the landed yield being low by at least 68% in 1986. Misclassification resulted in the landed yield of large coastal sharks being low by 138% in 1988. The landed yields used in the previous analysis are now known to have been biased low by at least 68% in 1986, 18% in 1987, 138% in 1988, and 34% in 1989. Dealer under reporting still seems to be occurring; so far 10% under reporting has been found in 1990 and 7% in 1991.

In addition, shark fin dealers indicated that "finning", i.e., cutting the fins off and dumping the carcass, might be of considerable magnitude. Apparently, in the area south of the Virginia coast, swordfish fishermen catch large coastal sharks, but they have not often landed these fish. They did, however, sell the fins. Information from 15 trips during April through August of 1992 suggest that on the average 56 large coastal sharks were dumped per swordfish trip in the southern area. In 1991 there were about 3300 trips so as many as 200,000 sharks might have been finned. If the average dressed weight of these fish is about 45 to 50 pounds, as much as 4,000 mt might have been finned. The 1991 large coastal shark landings were about 4000 mt. In 1987 there were about 2300 southern area swordfish trips which is equivalent to a discard of roughly 2800 mt, dressed weight; the landings were about 2450 mt. These very rough computations suggest that the amount finned might well be on the same order as that landed.

The Committee points out that interest and involvement by fishermen greatly strengthened the available data, perhaps to the point that analysis results might now be useful. The Committee believes that constant contact with and involvement by fishermen in the data used to formulate resource assessment and consequent regulations will increase the reliability and extent of fishery statistics over that now available and, most importantly, improve the credibility of analysis results.

ANALYSIS

After reviewing the available data, the Committee discussed the simple likelihood method of analysis described in attachment 1. The method combines the standard statistical method of obtaining dependable estimates with a simple, conventional fishery population model. The Committee concluded that the method efficiently subtracted all relevant information contained within the available data. It was pointed out that although the method estimated only a few statistics, those were the ones most germane to establishing the status of a resource and that the estimates were accurate, usefully precise, and seemed to be robust to common data deficiencies. Most importantly, Monte Carlo tests indicate the method is successful even if the time series of fishery statistics is very short and growth rates (or ages) of individual fish are not predictable.

The Committee decided that all computer code must be checked so the code was independently rewritten and results compared with results obtained from the previous code to insure against programming errors. The Committee decided that the variance of the removal ratios would be required so the computer output was modified to include it. Last, the Committee believed that variance estimates might be biased low because the re- sampling did not include drawing the variances of the Y variable (mean weights) or catch estimates), only the Y variable. The problem is that although the Y variable can be drawn Gaussian (the observed Y is a proxy for the expectation and the estimated variance is the proxy for the variance), since a proxy for the variance of the variance of the Y variable is not available, drawing that statistic is not possible so the resampling did not include it. The Committee thought that the components of the Y variable might be drawn since the Y variable and its estimated variance were available. Both the Y variable and its variance could then be computed from the draw. This method will work if the underlaying distribution(s) of the components of Y variable are known and is (are) defined by the first two moments, but in this case this requires further development. The underlaying distributions of the components of the Y variable are unknown. For instance, in the case of observations where the Y variable is sample mean weight, the estimator is not restricted to a specific distribution of individual weights, and in fact, accuracy seems to be unaffected by that distribution as theory predicts.

Data. The Committee decided to use all available data from 1986 through 1991. Statistics were combined to characterize a single commercial fishery and a single recreational fishery (Table 1). The commercial shark landings by all gears other then pelagic longline were assumed to be large coastal sharks. Directed shark boat years were used as an index of commercial fishing time. This statistic was simply an annual enumeration of boats that targeted sharks at least one trip each month that the vessel fished. These lists where formulated by fisheries statistics personnel from North Carolina through Louisiana. In most cases, the lists were verified, to the extent possible, with fishermen and dealers in each local area. The sample average weight of landed sharks and its sample variance were computed from the available dealer "tally sheets" and fishermen logbooks.

The recreational fishery is characterized by two data collections: the national Marine Recreational Fishery Statistics (MRFS) survey and the National Marine Fisheries Service Beaufort Laboratory Headboat Survey. The headboat survey covers the southern area recreational fishery that occurs on boats for hire that carry nine or more paying clients; the MRFS covers the rest of the recreational fishery.

The MRFS survey data was accessed for annual estimates of the number of large coastal sharks landed, the estimated variance of the catch estimate, and the number of total-angler-days-fished (TADs) and directed (at coastal sharks)

angler-days-fished (DADs). TADs are presented in the published statistics. The Committee estimated DADs from species sought information obtained on the survey's interview samples. Although these indices of recreational fishing time were estimates, they were assumed to be enumerations for the purpose of stock assessment. The Committee also obtained sample average weights from the survey's weight frequency samples; 1991 weight frequencies were not made available to the Committee.

Almost all headboats make complete reports of every trip. The species and weight of almost all sharks landed, the number of fishermen, and the target species are recorded. This data provided the total catch of coastal sharks, two indices of fishing time (TADs and DADs), and sample average weights. Some estimation occurs (simple proration) due to a very small amount of non-reporting, but the Committee assumed that landings and TADs measured without error for the purpose of estimation. The DADs all occurred on trips from just one port, Port Aransas, TX.

Models. The Committee decided that the results from both Model 1 (variant replacement rate as described in the attachment) and Model 2 (invariant replacement rate) would be considered. Since Model 1 accounted for annual variation in the rates of reproduction, finning, migration, and natural death, the Committee believes it is the best choice. The Committee also considered the results obtained by entering the two sets of recreational fisheries data (MFRS and Headboat) separately and from entering them as a single combined recreational fishery. The MRFS survey did not enumerate yields (weight caught), rather estimates of catch were the available statistic so, for the combined recreational fishery, the Y variable was estimated catch, not sample average weight as for the commercial fishery. In addition to these options, the Committee also used both directed recreational effort (DADs) and total recreational effort (TADs). Therefore, the Committee considered the results from eight combinations of population models and data groupings.

Results. The Committee concluded that analytic results with low probability of fit should be discarded. That statistic is, in simple terms, the probability that the model (including the parameter estimates) and the data all came from the same shark resource and fishery. That result (below) indicates that combining the MRFS and Headboat data into a single set of

Recreational Data		Replacement Rate	
MRFS, Headboat	Fishing Time	Model 1: Variant	Model 2: Invariant
Separate	DADs	< 0.001	< 0.001
Separate	TADs	0.110	< 0.001
Combined	DADs	0.014	0.020
Combined	TADs	0.536	0.932

recreational fishery statistics and using total anger days (TADs) to measure recreational fishing time is most appropriate (last line in the table).

The probability of fit for Model 1 and Model 2 were similar, however, in the case of Model 2, estimates were very imprecise (below), so imprecise that the lower bound of the

	Model 1 Variant Replacement Rate			Model 2 Invariant Replacement Rate		
		54 Resamples			46 Resamples	
ß(k)	MLE	√s²[ß(k)]	cv	MLE	√s²[ß(k)]	cv
N(92)	1338262	160193	.12	2781695	16350130	5.88
s(86)	.88	.3522	.40			
s(87)	1.59	.2422	.15			
s(88)	1.18	.1756	.15			
s(89)	1.29	.1644	.13			
s(90)	1.54	.2350	.15			
s(91)	1.25	.1932	.15			
s	(avg=1.29)			1.12	.1221	.11
q(1)	.0016835480	.000251417	.15	.0007449800	.000470541	.63
q(2)	.0000019840	.000000228	.11	.0000009320	.000000595	.64

0.80 confidence interval on the estimates of stocksizes was less than zero for all years, 1986-92. The coefficient of variation of the 1992 estimate is particularly disturbing (588%). Even though the constant replacement rate model almost certainly (with 93% probably) fits the data, the resulting estimates are too uncertain to be used. The Committee decided that these results were not useful. The Committee decided to base its advice on the results of Model 1 (variable replacement rate). The variant replacement rate model probably does fit the data (53% probable) and the estimates are usefully certain. These results are detailed in Table 2. The Committee points out the following results:

1) 1991 landings are estimated to have been 0.370 million fish (4319 mt, Table 3), considerably less than the peak of 0.448 million in 1989 (5629 mt) and much more than the 1986 landing of 0.215 million fish (2057 mt). Commercial boats directing at sharks decreased from the peak in 1989 to 1991. The 1992 kill probably exceeded that of 1991. During 1992 there was a significant increase in fin prices, anticipation of a fishery closure, a displacement of boats from closed fisheries into the shark fleet, a higher than usual availability of fish during the spring, and an increase in dressed meat prices in the fall.

2) Abundance, in numbers of sharks regardless of size and species (of the large coastal group), has been relatively stable, 1986-92. If these fishery statistics are not biased (the commercial fishery landings available for the 1990 analysis where in huge error), with 80% confidence, there were between 1.1 and 1.5 million individuals (all sizes and species of the group combined) alive on January 1, 1992.

3) The annual replacement rate is estimated to have fluctuated between 0.88 and 1.59 during 1986-91. The average of annual point estimates is 1.29. These rates are precisely estimated (cv $\leq$ 0.15 for most years). This rate includes additions and subtractions of sharks from reproduction, natural death, migration, and finning. As explained above in the relevant section, life history characteristics indicate that theoretically, the replacement rate from reproduction and accounting for natural death (but not considering migration and finning) of the main commercial species (sandbar shark) is about 1.20 annually.

4) The (exponential) fishing mortality rate increased from about 0.2 in 1986 to the current level of about 0.3. These estimates are precise (cv $\leq$ 0.11). The average of estimates for 1988-91 is 0.30. F(rep) is about 0.25; therefore, the current level might be slowely depleting abundance.

5) Analysis results indicate that overfishing occured (landed removals exceeded production) in all years except 1987 and 1990; removal ratios (landings/replacement) indicate the resource was overfished in 1986, 1988, 1989, and 1991. However, removal ratios and production estimates are particularly uncertain in years where overfishing is indicated.

7) Projection of the fishery through 1992 indicate the landed yield (dressed weight) at the replacement level (F(rep)=0.2546) would have been 3733 mt. This is 586 mt (about 30,000 fish) less than the 1991 landed yield of 4319 mt. As explained in 1) above, 1992 landings probably increased, not decreased. Stock abundance therefore probably decreased during 1992 due to fishing removals, i.e., the resource was probably overfished in 1992.

8) The effect of 1993 removals cannot be projected without 1992 landings. 1992 landings will not be compiled until mid 1993 or latter, so for the reasons in 1) above, 1992 landings were assumed to be 10% more than that of 1991. Projecting the average of 1986-91 replacement rates, the 1993 stocksize is 6% less than that of 1992. Projection of that stocksize (Table 4) indicates a 1993 landed removal of 3520 mt at the F(rep)=.2546 fishing level. A fishing level that allows 5% annual abundance increase results in a 2916 mt landed yield (quota) in 1993 and a 5% increase each year thereafter (F(5%)=.2059). The projection for F(10%) results in a 2311 mt quota in 1993 and large (10%) increases thereafter.

RECOMMENDATIONS

1. The simple likelihood method used to analyze the coastal shark fishery efficiently extracted all relevant information contained within the data. The method estimates the few statistics most germane to resource management. The estimates are accurate, precise, and seemed to be minimally affected by common data deficiencies. The Committee recommends use of the method for the Atlantic shark fishery and other cases where the statistical time series is short or where the growth rates or ages of individual fish are not known with certainty.

2. The Committee recommends that future stock assessments be based on statistics from a fishermen reporting system requiring fishermen submit two kinds of information:

   (1) A copy of each sales transaction receipt when sharks are sold. The sales receipts must contain the dressed weight and species of each individual shark landed. The correct species identification of landed sharks will be difficult because sharks are beheaded, tailed, gutted, and finned at sea, but the separate assessments of each individual species requires the numbers landed *of each species*.

   (2) Written records (logbooks) of fishing activities. The record must contain the date, species, sex, size (eye estimate of weight or measured total length), and disposition (landed, released alive or discarded dead) of each shark caught. The kind and amount of gear set, amount of time the gear fished, and supplementary information (gill net size, composition of mainline, bait, use of spotter aircraft, etc.) must also be included.

3. Extremely preliminary and scant data indicates that the coastal shark catch by the swordfish fleet in southern U.S. coastal waters might be extensive. Even though future regulations might prevent finning, the discarding of these fish might continue to be significant. In the future, a portion of these fish might be landed rather than dumped so that some of the kill will be included in the landings statistics, but dumping probably still will occur. Therefore, the Committee recommends an at sea observer sampling program to monitor the amount, sizes and species of those discards.

4. The Committee recommends reducing the 1993 landings below the 1991 level.

The F(rep) level (3520 mt in 1993) will reduce fishing mortality about 15% below the 1991 level and abundance will be stabilized.

The F(5%) level (2916 mt in 1993) will reduce landings 34% from the 1991 level and fishing mortality will be reduced from the current (overfishing) level of 0.3 to 0.2. This level will increase abundance by 5% each year back to the 1986 level by January 1, 1998.

The F(10%) level (2311 mt in 1993) will reduce 1993 landings to about half of the 1991 level. Fishing mortality will be substantially reduced; abundance will increase 10% each year. An abundance level 30% higher than the 1986 estimate is projected by 1998 with that fishing level.

5. The Committee did not deliberate the impact of drift gill nets nor was it presented data to analyze that specific gear. Drift gill nets are extremely efficient and often kill non-target species (turtles, dolphins, etc.) so the continued use of that gear is questionable.

6. The Committee was not presented data that would allow it to explicitly define nursery and mating locations for sharks. If existing studies document nursery grounds and or mating locations well enough to define their geographical boundries, the areas could be closed to directed shark fishing.

7. The Committee recommends granting shark fishing permits to **only** those persons who have demonstrated knowledge and sensitivity to the management and longevity of the fishery.

Table 1. Statistics of the United States Atlantic large coastal shark fishery.

		Fishing Time			Landings			Dressed		
			Angler Days			Estimates				
Fishery	Yr	Directed Nos of Boats	Directed	Total	Dressed Pounds	Numbers	variance	wt	s²[wt]	n
Commercial	86	42			2868619			46.92	213.00	161
	87	55			5403658			46.03	323.54	64
	88	110			8944963			28.21	123.41	614
	89	132			11051596			28.89	468.41	3723
	90	123			8443853			28.75	343.35	1474
	91	96			8839573			40.66	446.81	154
Recreation (MRFS)	86		341300	53241000		150921	475381174	10.76	6.72	185
	87		282600	58266000		49332	748008566	10.74	1.63	240
	88		406300	57803000		153604	487203456	7.25	2.23	134
	89		189200	42693000		99328	301958950	10.37	4.07	153
	90		237900	47829000		120716	367763921	18.67	0.98	149
	91		170200	55105000		148456	232462032			
Recreation (Headboat)	86		1875	718000	40047	3278		11.11	6.22	25
	87		5039	733100	45069	4141		17.95	2.65	112
	88		6783	694700	72511	6099		12.35	1.32	84
	89		6757	695500	65055	6432		16.71	2.48	98
	90		4092	702200	34941	4350		5.06	93.93	180
	91		3291	629600	27556	4600		4.46	55.87	91
Combined Recreation (MRFS + Headboat)	86		343175	53959000		154199	475381174	10.80	5.30	210
	87		287639	58999100		153473	748008566	13.03	1.06	352
	88		413083	58497700		159703	487203456	9.22	1.06	218
	89		195957	43388500		105760	301958950	12.85	1.92	251
	90		241992	48531200		125074	367763921	11.22	28.39	329
	91		173491	55734600		153056	232462032	4.46	55.87	91

Table 2. Analysis results for U.S. Atlantic large coastal shark fishery, 1986 through 1991.

Solution Point for Model 1: Variant Replacement Rate
X^2 — 2.181278
Pr[X^2] — .536
Equality Deffinition — .0089 over the 8 best solutions.

The model fits.

ß(k)	d[LL]/d[ß(k)]	MLE	54 Resamples √s²[ß(k)]	54 Resamples cv	Solution Precision
N(92)	.04	1338262	160193	.12	.023
s(86)	-41436.23	.88	.3522	.40	.107
s(87)	-43564.87	1.59	.2422	.15	.078
s(88)	-58418.33	1.18	.1756	.15	.073
s(89)	-53589.17	1.29	.1644	.13	.021
s(90)	-39840.44	1.54	.2350	.15	.022
s(91)	-44239.14	1.25	.1932	.15	.046
q(1)	68789901.93	.0016835480	.000251417000	.15	.009
q(2)	19138854843.58	.0000019840	.000000227998	.11	.008

Variance Estimation Equality Deffition: 2.723

Solution Precision = [ß(largest) - ß(smallest)] / ß(MLE)
where X^2[ß(largest)] and X^2[ß(smallest)] are within the Equality Deffinition of X^2[ß(MLE)]

Table 2 cont. Analysis results for U.S. Atlantic large coastal shark fishery, 1986 through 1991.

		86	87	88	89	90	91	92
N(t)		1578368.	1158144.	1489091.	1302961.	1234302.	1406042.	1338262.
.8 CI	lower	941593.	885299.	1209733.	996496.	976371.	1090625.	1133215.
	upper	2215144.	1430989.	1768450.	1609427.	1492234.	1721459.	1543309.
√var		497481.	213160.	218249.	239426.	201509.	246420.	160193.
cv		.32	.18	.15	.18	.16	.18	.12
s(t)		.88	1.59	1.18	1.29	1.54	1.25	
.8 CI	lower	.43	1.28	.96	1.08	1.24	1.00	
	upper	1.33	1.90	1.41	1.50	1.84	1.50	
√var		.35	.24	.18	.16	.23	.19	
cv		.40	.15	.15	.13	.15	.15	
S(t)		.73	1.29	.88	.95	1.14	.95	
.8 CI	lower	.36	1.04	.71	.80	.93	.77	
	upper	1.11	1.53	1.04	1.10	1.35	1.13	
√var		.29	.19	.13	.12	.17	.14	
cv		.40	.15	.15	.13	.14	.15	
F(t)		.18	.21	.30	.31	.30	.27	
.8 CI	lower	.16	.18	.26	.26	.26	.24	
	upper	.20	.23	.34	.35	.35	.31	
√var		.02	.02	.03	.03	.03	.03	
cv		.09	.09	.10	.11	.11	.10	
P(t)		-194916.	678271.	271921.	377078.	670047.	350891.	
.8 CI	lower	0.	0.	0.	0.	0.	0.	
	upper	505316.	1616173.	752221.	940094.	1678399.	896102.	
√var		547057.	732736.	375235.	439857.	787775.	425946.	
cv		-2.81	1.08	1.38	1.17	1.18	1.21	
G(t)		-4103999.	18538680.	5941250.	9583777.	15755730.	9019248.	
.8 CI	lower	0.	10858400.	0.	2958388.	7725736.	1284891.	
	upper	9368149.	26218960.	13552900.	16209160.	23785710.	16753600.	
√var		10525120.	6000221.	5946599.	5176085.	6273430.	6042466.	
cv		-2.56	.32	1.00	.54	.40	.67	
r(t)		-1.10	.40	1.75	1.29	.62	1.06	
.8 CI	lower	.00	.15	.00	.00	.31	.00	
	upper	3.35	.65	11.15	6.70	.94	47.58	
√var		3.48	.20	7.34	4.22	.25	36.35	
cv		-3.15	.49	4.19	3.26	.40	34.43	

N(t) = Initial Abundance. s(t) = Replacement Rate.
P(t) = Replacement: production in numbers. G(t) = Stock Growth: production in weight.
r(t) = Removal Ratio: landings|production. F(t) = Instantaneous Fishing Rate

Table 3. Estimated landings (dressed weights) of large coastal sharks.

Year	Fishery	Yield pounds	Yield mt	Catch (nos.)	pounds avg.wt.
1986	Commercial	2868619	1301	61139	46.92
	Recreational	1665349	755	154199	10.80
	Total	4533968	2057	215338	21.06
1987	Commercial	5403658	2451	117394	46.03
	Recreational	1999753	907	153473	13.03
	Total	7403411	3358	270867	27.33
1988	Commercial	8944964	4057	317085	28.21
	Recreational	1472462	668	159703	9.22
	Total	10417420	4725	476788	21.85
1989	Commercial	11051600	5013	382541	28.89
	Recreational	1359016	616	105760	12.85
	Total	12410610	5629	488301	25.42
1990	Commercial	8443854	3830	293699	28.75
	Recreational	1403330	637	125074	11.22
	Total	9847184	4467	418773	23.51
1991	Commercial	8839573	4010	217402	40.66
	Recreational	682630	310	153056	4.46
	Total	9522204	4319	370458	25.70

Table 4. Fishery projections for large coastal sharks. The 1992 landed catch is assumed to be 10% larger than that of 1991. The average of estimated annual replacement rates (s = 1.29) and of annual average weights (24.14 pounds dressed) is projected.

Fishing Mortality Rate (F)	Year	January 1 Exploited Stock Numbers	January 1 Exploited Stock Biomass(mt)	landed Catch	landed Yield(mt)
F(assumed)= .3133	92	1338262	14660	407252	4461 mt
F(rep)= .2546	93	1261981	13824	321353	3520 mt
.2546	94	1261981	13824	321353	3520 mt
.2546	95	1261981	13824	321353	3520 mt
.2546	96	1261981	13824	321353	3520 mt
.2546	97	1261981	13824	321353	3520 mt
	98	1261981	13824		
F(assumed)= .3133	92	1338262	14660	407252	4461 mt
F(5%)= .2059	93	1261981	13824	266223	2916 mt
.2059	94	1325080	14515	279534	3062 mt
.2059	95	1391334	15241	293510	3215 mt
.2059	96	1460901	16003	308186	3376 mt
.2059	97	1533946	16803	323595	3545 mt
	98	1610643	17643		
F(assumed)= .3133	92	1338262	14660	407252	4461 mt
F(10%)= .1593	93	1261981	13824	210968	2311 mt
.1593	94	1388179	15206	232064	2542 mt
.1593	95	1526997	16727	255271	2796 mt
.1593	96	1679697	18400	280798	3076 mt
.1593	97	1847667	20240	308878	3384 mt
	98	2032434	22264		