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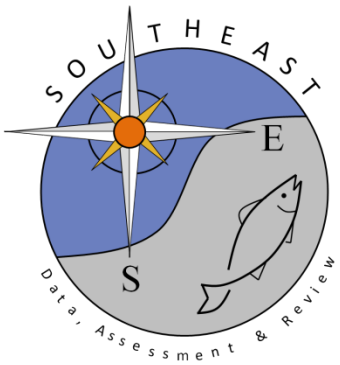

A STUDY OF SHARK EXPLOITATION IN U.S. ATLANTIC COASTAL WATERS DURING 1986-1989

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SHARK ASSESSMENT SUMMARY

Shark catches substantially increased in recent years. Verbal reports from commercial and recreational sectors and sport fishing tournament records show a decrease in fishing success rates, particularly near shore, since 1987. This study estimated shark abundance and production levels during 1986-89 and considered the implications of the estimates.

SPECIES GROUPS USED IN THE ASSESSMENT:

Large Coastal Sharks. These sharks make extensive migrations on the continental shelf, often into Caribbean waters; some make transatlantic migrations. These species are recorded in logbooks of shark directed longline fishermen and most commonly occur in shark tournament catches. Sandbar, blacktip, dusky, bull, tigers, hammerheads, lemon, white, spinner, bignose, silky, and night shark compose this group.

Small Coastal Sharks. This group is dominated by sharpnose shark and includes other common small species (sharpnose, bonnet, blacknose, finetooth, smalltail). Sharpnose sharks do not make extensive migrations along the coast. These sharks are common in recreational catches, but not tournament catches. They do occur in commercial catches, but they are not targeted. The Gulf of Mexico shrimp trawl bycatch (discarded) is the largest portion of removals of this group.

Pelagic Sharks. All commonly make transatlantic migrations. They are a bycatch of the tuna and swordfish longline fishery and are targeted by the recreational fishery from Virginia through New York. This group includes makos, threshers, blue, oceanic whitetip, and porebeagle.

CURRENT SHARK FISHERIES:

Fishery	Species Group Caught
Commercial shark longline	Large Coastal Sharks
Commercial drift gillnet	Large Coastal Sharks
Commercial rod and reel	Large Coastal Sharks
Commercial shrimp trawl bycatch	Small Coastal Sharks
Commercial pelagic longline bycatch	Pelagic Sharks
Recreational headboat	Small Coastal Sharks and blacktip
Recreational private & charter	Small Coastal Sharks
Recreational tournament	Large Coastal Sharks

CONCLUSIONS OF THE ASSESSMENT:

1) Large Coastal Sharks.
   a) The maximum of large coastal sharks annual production estimates for 1986-1990 is about 3400 mt.; the average is 3000 mt..
   b) Catches were more than production in 1988 and 1989; the yield was about 25% higher than the estimated production in 1988 and about 80% higher in 1989. This result indicates abundance is now decreasing due to overfishing.
   c) The potential for abundance to increase is low, about 25% of numbers annually. The majority of any increase will be in very young sharks that are too small to be of commercial or shark tournament fishing value. Recovery will therefore not occur for many years until the small sharks grow to larger sizes.
2) Small Coastal Sharks.
   a) The maximum of production estimates for small coastal sharks during 1986-1990 is about 3600 mt.; the average is 3000 mt..
   b) Catches were greater than production in 1987 and 1988, but not in 1989, and probably will not occur in 1990. There is no evidence that stock abundance decreased during 1986-90.
   c) The proportion of estimated abundance that is caught annually (about 40%) is extremely high. The stock is likely stressed by fishing to the point that the risk of abundance decrease is significant.
3) Pelagic Sharks.
   a) Production is not yet estimated.
   b) Landings of pelagic sharks during 1986-1989 were about 2800 mt. whole weight; the amount discarded may be significant.

INTRODUCTION

Directed commercial shark fisheries have existed on the North American Atlantic shelf for several years (Springer 1952, Assen 1961) and significant indirect catches have probably occurred since the introduction of shrimp trawling in the Gulf of Mexico and longlines in the swordfish fishery. Recreational fisheries have also removed significant catches for many years. Catches by both commercial and recreational fisheries have substantially increased in recent years. Verbal reports from both sectors and sport fishing tournament records show a decrease in fishing success rates, particularly near shore, since 1987.

Anderson (1980) assessed shark production (excluding dogfish) in FAO areas 21 and 31 (west of 42° west and north of 5° north) concluding that MSY for the mixed species resource was about 25,000 mt., round weight, annually. This estimate was based on both estimated discards and reported yields during 1965-1978 and Japanese (tuna directed) longline catch per unit effort. As emphasized by the Anderson, it was necessary to estimate a considerable portion of the removals for this period from very sparse data. Anderson used the equilibrium population and sustainable yield model of Graham (1935) as generalized by Pella and Tomlinson (1969) and as applied by Fox (1975) to estimate potential resource production.

Anderson wrote that the U.S. FCZ (Fisheries Conservation Zone, i.e., 200 mile territorial sea) covered 65% of the FAO area so "65% of the MSY could be attributed to the FCZ" under the assumption that sharks are distributed over the entire of FAO areas 21 and 31 in equal proportion to the yields. Anderson mentioned that 65% of 25000 mt. was 16,250 mt.

The Anderson analysis was based on 1965-78 statistics, but fisheries removing sharks have significantly changed since then. The U.S. FCZ foreign trawl and longline bycatch is now absent. Rod and reel removals have become a very significant portion of total removals. A directed longline shark fishery now exists along the U.S. Atlantic coast from North Carolina south to Mexico. The bycatch of pelagic sharks from the U.S. swordfish and tuna longline fleet is probably much larger than before the late 1970's because that fishery expanded.

The Anderson analysis was based on Japanese longline fishery catch and effort reports. That fishery no longer exists in the U.S. FCZ, thus the analysis cannot be updated with recent fisheries statistics. The inability to include recent statistics is unfortunate; use of the results of Anderson is vulnerable to allegations that actions are not based on the best available (recent) data. This study estimates shark production levels (excluding dogfish) within the U.S. FCZ from recent statistics of currently existing fisheries. The objective was to investigate the hypothesis that current removal levels in the U.S. Atlantic FCZ are more than stock production.

FISHERIES

Two directed shark fisheries exist in the Atlantic U.S. FCZ. Although poorly documented in the past, a substantial recreational fishery occurs along the Atlantic coast to Mexico. A directed shark longline fishery also exists in the same area. Both fisheries target coastal semi-demersal sharks. Pelagic sharks are targeted by shark tournaments off mid-Atlantic states and are taken as bycatch in the swordfish and tuna longline fisheries.

Recreational. Sharks are sometimes targeted by recreational rod and reel fishermen, although other species are usually sought. There are three main components of the recreational fishery.

Fishermen using private, rental and charter boats or fishing from shore are the largest component. This segment most often catches species of small coastal semi-demersal sharks, particularly sharpnose shark, but including bonnethead, finetooth, blacknose, and smalltail. The catch from this group is almost entirely sharpnose. The recreational shark catch off Texas is considered to be entirely sharpnose. Sharpnose do not make extensive migrations along the contenental shelf, although seasonal offshore-inshore movements occur. These species do not appear to be a large component of landings from the directed commercial fishery, but the Gulf of Mexico shrimp trawl removes and discards a large bycatch of sharpnose sharks.

A headboat fishery is also a major component of the recreational fishery, particularly in the western Gulf of Mexico, although it occurs to a lesser degree over the entire Gulf and off the southern Atlantic states. Headboats carry seven or more clients on each (usually day) trip. This fishery takes these same species of small coastal semi-demersal sharks (listed above) as the rest of the recreational fishery, but a very substantial proportion of the catch is black tip shark. The catch is predominantly sharpnose and blacktip shark. Blacktip sharks are also the seasonal target of extensive commercial longline and drift gillnet fishing operations.

Many shark fishing tournaments also occur. Although rods and reels are used, fishing is directed at a completely different group of species. In the southern area, shark tournaments depend on most of the same species taken by the directed commercial fishery. These coastal species reach large sizes and most make extensive migrations along the contenental shelf and into Caribean waters;

they commonly include sandbar, dusky, hammerheads, tigers, bull, lemon, and bignose sharks. In the northern area (central Atlantic states and southern New England) tournaments target shortfin mako and blue shark and these are bycatch species of pelagic longline fishing activities.

Sharks taken by rod and reel fishermen are commonly sold to commercial fish buyers. In many years such catches are significant. For instance, in 1986 about 9% of the commercial landings (by weight) were taken by rod and reel. The National Marine Fisheries Service Marine Recreational Fishery Statistics Survey data do not include catches that were sold (and the corresponding fishing effort), hence rod and reel catches that were sold are included in the commercial landings and are not classified as recreational catches.

Shark Longline Fishery. A directed shark fishery specifically targets larger species of coastal sharks in shallow (300 ft. and less) water with longlines specifically constructed for the purpose. This fleet is apparently very mobile with some boats fishing both Atlantic and Gulf waters annually. These boats direct at sandbar and, at times, black tip shark. Spinner shark is often landed as blacktip. Smaller bull sharks are targeted in the Gulf of Mexico. Logbooks show that several species are common in catches including Sandbar, blacktip, dusky, spinner, silky, bull, bignose, tiger, sandtiger, lemon, night, great hammerhead, and scalloped hammerhead; these sharks make extensive annual migrations along the contenental shelf and into Caribean waters.

Sharks are landed dressed (headless and gutted). Fish brokers prefer to buy sharks from 15 to 50 pounds dressed weight. Sharks larger than this size are not as marketable, so they are not often landed, but the fins are valuable. If a fish is alive and vigorous when the line is tended, the fisherman may cut the fish loose unharmed because it is too difficult to remove the fins, or he might shoot, fin, and discard the shark. If the larger sharks are dead when the line is retrieved, the fins are removed and the body is discarded. This commonly occurs when large hammerhead (particularly great hammerhead), dusky, tiger, and bull sharks are caught. If these species are about 50 pounds or less, dressed weight, they are landed.

Seasonal and Incidental Fisheries. Some boats seasonally direct drift gillnets (including "stab nets") at blacktip shark near shore in the late summer and early autumn. Some of these boats are very small, less than 30 ft. in length. Incidental catches by Gulf of Mexico snapper-grouper boats, particularly bottom longline boats, commonly enter the commercial statistics. Some landings are also made by shrimp trawls. It seems reasonable that the shrimp and snapper-grouper boats land incidentally caught sharks of species and sizes that are of reasonable market value and probably fin and discard the rest at sea. The Gulf of Mexico shrimp trawl shark bycatch is mostly sharpnose shark and is discarded at sea.

Pelagic Fisheries. Pelagic sharks are a major bycatch of the pelagic longline fishery for swordfish and tuna. Pelagic longline boats regularly land shortfin mako shark because there is a significant market demand for the species. Commercial swordfish bills of sale suggest that a large portion of this species may have been discarded at sea before 1985, but that the shortfin mako bycatch is now landed. Other pelagic species including thresher, oceanic whitetip, silky, and porbeagle, are landed, but not often. (A significant directed porebeagle fishery existed in the Northwest Atlantic in the past, but collapsed. Apparently this fishery has again been recently initiated and may again become significant.) Several of these species (blue shark, longfin mako, thresher, bigeye thresher) are either not usually marketable or are worth little and so are most often discarded at sea. Several other species referred to in this study as coastal sharks such as hammerheads, tiger, bull, sandbar, and dusky shark, are taken on pelagic longline; however, samples suggest these sharks compose a very small portion (3%) of the landed shark bycatch by weight during 1986-89.

FISHERIES STATISTICS

Statistics before 1986 were not used in this study because the time required to assemble and verify correct complete statistics on all fisheries was not available (in fact, it is not certain that the historical records required to complete that task even exist). This study did not use statistics previous to 1986 for the following reasons. Statistics are sparse and not complete so that they may be difficult to interpret without careful study and historical knowledge of the fishery. The sampling of recreational fisheries was extremely sparse. Several agencies were involved and sometimes surveys overlapped and segments of various fisheries were not covered at all; yield and effort estimation methods varied between agencies. Commercial landings might not be complete for earlier years and might contain other species. A measure of the amount of commercial fishing and an estimate of the size of sharks landed commercially was not available for the years before 1986. Statistics for years before 1986 have been recovered from several fisheries, but reasonably complete statistics for all major fisheries have not yet been compiled for the earlier period.

Commercial Statistics. The landed weight sold to fish brokers was collected by the National Marine Fisheries Service (Table 1). The fishing method used and port of landing were also recorded. The species was not often recorded. The weights of individual fish were not recorded except in a sample of pelagic longline trips. Samples of species composition or size composition were not collected. A measure of the time fished was not recorded.

Port samplers reported the existence of a fleet of boats targeting sharks during all seasons and landing at ports from North Carolina to Texas. A few boats apparently targeted sharks off central Atlantic coastal states during the summer season of some years, but a persistent shark fleet was not identified in the northern area. Copies of bills of sale ("trip tickets") containing boat names were available from the southern area (North Carolina through Texas) for all but one port for 1986-89, thus a list of boats directing at sharks during those years was derived for that period (Table 2). These trip tickets also contained the port of landing. A survey of these data indicated that particular boats sometimes fished in both the Gulf of Mexico and North Atlantic in the same year implying that partitioning fishing effort into area classifications might be difficult.

A fish buyer who recorded the number and weight of sharks per shipping container for some trips in the southern area during 1988 and 1989 allowed the information to be used in this research. Also, logbooks for two boats of the shark fleet fishing in the southern area were provided to the study, one for 1985 through 1988 and one for 1986 through 1989. These logs contained the total weight and number of fish sold on each trip so it was possible to compute the average weight of landed fish in the commercial fishery (Table 3).

As mentioned above, commercial landings by species was not recorded, but the species taken in the directed longline fishery were recorded in the two logbooks. These species include most of the large, semi-demersal sharks inhabiting coastal waters (Table 4). These logbooks showed that pelagic sharks were not often caught in the directed longline fishery.

Commercial shark landings are reportedly caught with gears other than shark (or bottom) longlines. Some shark directed boats use gillnets and bycatch from the snapper-grouper fishery and other kinds of gear is common. Species composition information from these gears was not found. Therefore, commercial landings in the southern area (North Carolina through Texas) for all gears, except the swordfish and tuna pelagic longline bycatch, were assumed to be the same large coastal sharks taken by the directed longline fishery.

A sample of swordfish and tuna pelagic longline trip tickets, 1980-1989, was used to describe the species composition of the pelagic longline bycatch landings. The sample is extensive; for example, it contains records from 408 vessels and 1723 trips in 1989. Usually the dressed weight and species of each landed shark was recorded, but sometimes the species of shark was not recorded. For instance, in 1989, the sample included 5157 sharks and only 571 were not identified to species. Usually shortfin mako sharks were landed although other pelagic sharks occurred. These records were used to compile a list of pelagic sharks landed commercially (Table 4). Only 3%, of the pelagic longline fishery shark landings during 1986-1989 were coastal species. This study therefore assumed that all pelagic longline landings were pelagic sharks.

In 1989, 53% of all commercial shark landings from Virginia to Maine were classified to species. Of these landings that were classified, 2% were large coastal sharks; the rest (98%) were pelagic sharks. This study therefore assumed that all commercial landings from Virginia and north were pelagic sharks.

Recreational Fisheries Survey Data. Sample surveys and estimates of recreational fisheries statistics were carried out by three different groups during 1986-1989. The National Marine Fisheries Service Marine Recreational Fishery Statistics Survey (MRFSS), Atlantic and Gulf Coast data collected by the National Marine Fisheries Service National Fishery Statistics Program is the most comprehensive covering all but the headboat fishery and the state of Texas. By definition, headboats carry seven or more fishermen. A headboat fishery survey in the southern area, including Texas, was carried out by the National Marine Fishery Service Beaufort, N. C. laboratory. The state of Texas also carries out a survey of recreational fishing. These surveys provide yield estimates, weight frequency samples, and species composition samples. The two National Marine Fisheries Service surveys (MRFSS and the headboat survey) provide estimates of total angler trips (effort) and the species sought based on interviewed trips. The Texas survey provides an estimate of the total number of hours fished. All recreational fisheries data was reported in whole kilograms. That measure was converted to pounds, dressed weight to achieve compatibility with the commercial landings data. Original statistics were converted from whole weight to dressed weight by dividing whole weight by 1.39 (whole weight = 1.39 x dressed weight).

The MRFSS samples from the Gulf of Mexico and "South Atlantic" areas showed that most of the catch was of large, coastal shark species (Table 5), but significant catches of small coastal sharks also occurred. Pelagic sharks did not often occur in samples from these areas. The weight frequency samples were classified by species, so these were used as species composition samples. Weight

frequency samples classified by species for the Gulf of Mexico and South Atlantic survey areas were used to allot the yield estimates reported in the surveys into two groups: small and large coastal sharks. These samples were also used to compute the average weight of catches. The estimated total angler trips in each of these two areas (Gulf and South Atlantic) were multiplied by the proportion of interviewed trips where sharks were recorded as the main species sought.

MRFSS recreational fishery yield estimates in the northern area (Virginia and north) are very large (Table 6). The survey reports no significant recreational catch north of New York. Species compositions in the MRFSS weight samples from this northern area were very different from those of the southern area; as in the commercial landings, pelagic species dominate in the northern area. However, they do not conform to the species composition of the 1989 commercial landings where 98% were pelagic species. These samples show that as much as 50% of recreational landings in the northern area are of coastal species; 2% were coastal species in the commercial landings. The weight frequencies indicated that these fish were extremely large, much larger than the southern area and in commercial landings. However, very few fish are in the weight samples, too few to estimate the species composition or average size with any reasonable degree of certainty. Recreational yield estimates from this area were not included in the stock size estimates.

The recreational headboat fishery statistics were obtained from the survey carried out by the National Marine Fisheries Service Beaufort, N. C. laboratory. The headboat survey covered the entire area from North Carolina through Texas. Estimates of yields, average weights and their variances, and fishing effort directed at sharks were available from that survey (Table 7).

Very similar statistics were obtained from the Recreational Fisheries Survey carried out by the Texas Parks and Wildlife Department in that state. Apparently only sharpnose sharks appeared in species composition samples from this fishery. Catch estimates and weight frequency samples were obtained. The species sought was not collected in the survey. Effort was measured as the total man hours fished, not the effort directed at sharks (Table 8).

Shark tournament data from the southern area was also considered. Records from the Destin, Florida and Port Salerno, Florida tournaments during 1979-89 contained weight frequencies, species compositions and a measure of fishing effort. Records from the Tampa Bay, Florida Sharkers tournament contained weight frequencies and species compositions for 1985-1989.

Shrimp Bycatch. The Gulf of Mexico shrimp fishery incidentally catches sharks. This bycatch of sharpnose sharks has been estimated from at sea observer samples and research cruise samples (Nichols et al. 1990). The number of sharks per weight in samples was also available from the same data so that estimates of average weight were also calculated. Corresponding shrimp fishery effort was also reported by Nichols (Table 9).

ESTIMATION METHOD

Common stock assessment methods are not well suited for this circumstance. Only landings were recorded; the amount of sharks fined and discarded is unknown. The data series is short spanning only four years. Size frequency samples of the commercial landings do not exist although average weights can be estimated from summations of the total numbers and total weight landed on some trips. The landings are composed of an unknown mix of species; for estimation purposes this equates to an absence of growth information. A fishery independent index of abundance does not exist (except in the Gulf of Mexico for sharpnose shark), although a measure of the amount of fishing in each fishery does.

A maximum likelihood estimator was derived for this problem. For each of T periods of equal length ($1 \le t \le T$) and each of Q fisheries ($1 \le k \le Q$) four items are observed: the yield, Y(t,k); some measure of the amount of fishing, f(t,k); the average weight of the catch, w(t,k); and its variance, $\sigma^2(t,k)$. Let $s^2(t,k)$ be the maximum likelihood estimate (MLE) of $\sigma^2(t,k)$. The assumptions that: 1) catches, C(t,k), occur at t+0.5, always; 2) emigration, recruitment, immigration, unreported catch, fatal accident, and predation death are Poisson events with combined parameter z; and 3) $C = q \cdot f \cdot N$ where C is catch (numbers) and q is the efficiency coefficient of the measure of fishing (f) imply the population model:

$$N_t = N_{t+1} \cdot e^{-z_t} \cdot \left(1 - \sum_{k=1}^{Q} q_t \cdot f_{t,k}\right)^{-1}$$

that simplifies to:

$$(1) \qquad N_t = N_{T+1} \cdot e^{-\sum_{i=t}^{T} z_i} \cdot \pi_t ,$$

$$\pi_t = \prod_{t \le j \le T} \left(1 - \sum_{l=1}^{Q} q_l \cdot f_{j,l}\right)^{-1}$$

Since C = Y ÷ w, a model of average weight is:

$$\hat{w}_{t,k} = \frac{Y_{t,k} \cdot \pi_t \cdot S_t}{q_k \cdot f_{t,k} \cdot N_{T+1}}$$

$$S_t = e^{0.5 \cdot z_t + \sum_{i=t+1}^{T} z_i},$$

or, if z is constant,

$$S_t = e^{z \cdot (T-t+0.5)}.$$

According to the central limit theorem,

$$w_{t,k} \sim N (\mu_{t,k}, \sigma^2_{t,k})$$

so the likelihood equation is

$$\ln\{ L[w_{t,k}] \} \approx - \sum_{t}^{T} \sum_{k}^{Q} \left[\frac{\hat{w}_{t,k} - w_{t,k}}{s_{t,k}} \right]^2$$

where $s^2(t,k)$ refers to the sampling variance of the observed average weight, w(t,k). Maximizing the likelihood equation w.r.t. N(T+1), the z(t), and the q(k) yields MLE's of these variables. The resulting evaluation is distributed chi-square (Press et al. 1986) with T•Q-(Q+2) degrees of freedom if z is assumed constant and T•Q-(1+T+Q) degrees of freedom if z is assumed temporally variable. This allows calculation of the probability of obtaining the realized sample of average weights given that the model and parameters are correct and, since a ratio of chi-square statistics is distributed F, a statistical test procedure for comparing models.

Maximization is done most conveniently by minimizing the negative of this function because analytical methods are available for minimization rather than maximization. The simplex method (Nelder and Mead 1965) was used to minimize the negative of the likelihood equation. Variances were approximated by the usual method as the inverse of the curvature matrix (see Press et al. 1986) and cv's (coefficients of variation) computed as the square root of the approximate variance divided by the estimate.

This method was developed and applied very rapidly; Monte Carlo performance tests were not carried out. The effect of sampling variation on this estimator is thus not quantified. In addition, as in this study, the data might not be extensive enough to estimate separate intrinsic rates of population change (z) for each period. In such cases, if the species composition of the resource, recruitment rate, or another unobserved phenomena changes greatly during the period of data, estimation bias is certain.

Several statistics are calculable from the resulting MLE's. Stock sizes for periods previous to the last period may be obtained from (1). Resource production, in numbers, for a specific period is calculable from the same expression by solving for the catch that will not change the abundance from the first of the period to the first of the next period. Writing (1) with the same stocksize on both sides of the equation and solving for the catch gives:

$$N = N \cdot e^{z} - C\, e^{\frac{1}{2} \cdot z},$$

$$C = N \cdot e^{z} \cdot e^{\frac{1}{2} \cdot z} - N \cdot e^{\frac{1}{2} \cdot z} = N (e^{\frac{1}{2} \cdot z} - e^{-\frac{1}{2} \cdot z}). \quad (2)$$

Equation (2) is resource production in numbers, i.e., the maximum catch (numbers) in a particular period that would not theoretically decrease numerical stock abundance. The calculation of various other statistics is straight forward. For instance, the proportion of abundance that can be removed without changing abundance follows from (2):

$$C/N = (e^{\frac{1}{2} \cdot z} - e^{-\frac{1}{2} \cdot z}).$$

Since the proportion caught is $C/(N \cdot e^{\frac{1}{2} \cdot z})$,

$$\tilde{F} = e^{\frac{1}{2} \cdot z} \left[C/N = (e^{\frac{1}{2} \cdot z} - e^{-\frac{1}{2} \cdot z}) \right] = 1 - e^{-z} \quad (3)$$

Equation (3) is the expression for the equilibrum fishing mortality rate, i.e., the ratio of resource production to abundance. It is also useful to recal that annual fishing effort averaged over several fisheries (gears) is equivalent to the fishing mortality rate.

RESULTS - LARGE COASTAL SHARKS

Two major fisheries for large coastal sharks were identified on the U.S. Atlantic coast from North Carolina through Texas. A commercial catch was defined as brokered landings taken by all gear except pelagic longlines. Commercial fishing effort was measured by the number of full time directed shark boats. The average weight information from all commercial fishery sources described above was combined together (i.e. variance estimates were not pooled, they were computed over all measurements). All recreational fishery statistics for large coastal shark species were combined to define a single recreational fishery in the southern area. The result (Table 10) was used to investigate the resource with the result listed in Table 11.

Although test statistics suggest an acceptable fit, the chi-square probability is low thus indicating an improvement in the data or model is desirable. The cv's also indicate that estimates are very uncertain. The diagnostics and the authors experience with this data indicate that the results might change, perhaps substantially, with small changes in the data. Average weight estimates are based on sparse samples so sampling variations due to species composition variability are suspect.

This result suggests that the annual intrinsic rate of numerical increase for large coastal sharks off the U.S. Atlantic coast is on the order of 26% per year. Most shark species caught in this category pup every other year with a litter size of from four to 10 implying a reproductive rate of increase of roughly 75% annually. Natural losses and discard mortality could easily equate these two rates. This implies that the discard (finning) mortality is huge.

All factors except the recorded catch (i.e., recruitment, immigration, emigration, expansion of the fishery into new areas, natural death, unrecorded landings, discards, etc.) are included in this rate (z). The rate is in numbers of fish and includes all sharks regardless of size. If large individuals are fished out, most of annual replacement will occur as newly born fish. These might require several years to grow into sizes large enough to be of interest to fishermen. The period required for the recovery of the abundance of large individuals and the intrensic rate of increase are therefore not closely related unless growth rates for each species are considered.

The results support the hypothesis that the resource of large, coastal sharks in the U.S. FCZ has become depressed since 1987, yet the uncertainty of these estimates is large. The estimates suggest that production was overfished in 1989; the catch is calculated to have been about 80% larger than production. The 1990 abundance, and thus 1990 production, might be depressed below the 1989 level. Catch to production ratios suggest a trend of such events that began in 1987 and is gradually increasing in magnitude. These calculations lend support to the hypothesis that current removal levels in the FCZ are greater than stock production. These calculations suggest that a reduction in 1990 catch to 50% of the 1989 level would have stabilized abundance and that stock abundance would have increased 25% if no catch had occurred.

RESULTS - SMALL COASTAL SHARKS

Two fisheries remove small shark species. The Gulf of Mexico shrimp bycatch of sharpnose shark is much larger than the recreational catch. It was necessary to separate the Texas recreational fishery statistics from that of other areas because the measure of effort (total hours fished) was different from that of the National Recreational and Headboat surveys (directed angler trips). Statistics from the National Recreational Survey and Headboat Survey were combined to form a summary of the recreational fisheries excluding Texas. Summarized statistics of the small coastal shark fisheries are shown in Table 12.

Analysis results (Table 13) show a high degree of estimation uncertainty, even more so than the large coastal shark results. Inspection of the weight and species composition samples indicated a huge sampling variability that most likely adversely affected estimation.

Estimates suggest that catches exceeded production in 1987 and 1988, but not in 1986 and 1989. These stock size estimates do not indicate a reduction in abundance during 1986-1990. The estimate of the annual intrinsic rate of increase (exponent of z) is high suggesting that resource abundance would rapidly increase if fishing did not occur, perhaps almost doubling each year. 1990 production is estimated to be greater than the 1989 catch thus the stock probably will not be reduced by fishing during 1990.

These results do not clearly show that current removals are greater than current stock production. Groundfish survey research cruise samples (Nichols and Pellegrin 1989) also suggest that abundance probably has been stable for several years (Figure 1). This does not imply that the stock is not depressed by fishing. These results indicate exploitation may be approaching extreme levels; annual catches are about 40% of the standing stock. The analysis indicates the opposet, i.e., that if fishing were reduced abundance would increase very rapidly. The results only indicate that abundance did not decrease during 1986-90.

PELAGIC SHARK LANDINGS

An assessment of pelagic species was not carried out. Since these sharks are highly migratory (transatlantic migrations of marked fish are not unusual), an assessment should encompass Atlantic wide data and such is not yet available. Insight of current production may be obtained from estimated landings from the U.S. FCZ (Table 14). All pelagic longline landings are assumed to be pelagic sharks (samples show 97% are) as are all commercial shark landings north of North Carolina (1989 records show 98% are). Current landings indicate significant exploitation with annual levels from 1600 to 3800 mt. whole weight (whole weight = 1.39 times dressed weight).

TOTAL U.S. FCZ SHARK PRODUCTION

Production estimates and average weights caught for coastal sharks (below) suggest that the

	Large			Small			Total
	avg wt lbs	production		avg wt lbs	production		production
yr	dressed	nos.	mt.	dressed	nos.	mt.	mt.
86	24.85	175197	2745	2.66	2018181	3385	6130
87	28.91	186112	3392	1.88	2213767	2624	6016
88	24.54	185859	2876	1.32	2215334	1844	4720
89	29.36	167387	3099	2.35	2454415	3637	6736
90		154973	2630		2757904	3565	6165
avg	26.92		2948	2.05		3005	5953

average coastal shark production in the U.S. FCZ was about 6,000 mt. (whole weight) annually during 1986-1989. The average production of species that become large was about 3,000 mt. and that of small species was about 3000 mt. The average annual pelagic shark landings were 2,800 mt, whole weight, during this period, but an unknown amount was discarded. The sum of these might be used as an approximation of recent average shark production, exclusive of discards, in the U.S. FCZ. The maximum of estimated annual productions for each group of sharks might also be used as a minimum estimate of resource potential. These estimates show that the large coastal shark resource will produce at least 3400 mt. (186,000 fish) annually from an initial abundance of 814,400 fish. The small coastal shark resource will produce at least 3600 mt. (2,454,000 fish) annually from an initial abundance of 3,737,000 fish. These estimates of potential production are biased low because they do not encompus discards and because peak production might not have occurred during the period of data (1986-90).

This analysis is based on the best available data with a method derived by standard statistical methodology specifically for this problem. When this study began, the author hoped that reasonably sufficient weight frequency information existed for all major fisheries and that yields from each fishery had been measured. As it turned out, recreational fisheries removals were estimated in terms of numbers (catch), not weight (yield), and weight frequency sample sizes were too low to yield accurate precise measures of the average weight of caught fish. The first problem created autocorrelation in the objective function. The second problem caused large estimation error; changes in observed average size probably were the result of extreme sampling variation rather than a change in the population. Another likelihood equation should be considered since average weight information is too incomplete. The joint likelihood of catch or yield instead of just yield might be best (if it can be correctly defined) since removals are recorded as both catch and yield. Separate assessments for each major species also might be considered.

LIST OF REFERENCES

Anderson 1987 ICES report

Anderson, E.D. 1980. Analysis of various sources of pelagic shark catches in the Northwest and Western Central Atlantic Ocean and Gulf of Mexico. NMFS, NEFC, Woods Hole Lab. Ref. No. 79-56, 37 p.

Anderson, E.D. 1980. MSY estimate of pelagic sharks in the western North Atlantic. NMFS, NEFC, Woods Hole Lab. Ref. No. 80-18, 12 p.

Springer, S. 1952. The effect of fluctuations in the availability of sharks on a shark fishery. Proceedings of the Gulf and Caribbean Fisheries Institute Fourth Annual Session, Nov. 1951:140-145

AAsen, O. 1961. Some observations on the biology of the porbeagle shark (Lamna nasus L.). ICES North Sea Comm. C.M. 1961/No. 109.

Fox, W.W. 1975. Fitting the generalized stock production model by least-squares and equilibrium approximation. Fish.Bull. 73(1):23-37.

Graham, M. 1935. Modern theory of exploiting a fishery, and application to North Sea trawling. J. Cons. 10:264-274.

Pella, J.J., and P.K. Tomlinson. 1969. A generalized stock production model. Inter-Am. Trop. Tuna Comm., Bull. 13:419-496.

Nichols, S., A. Shah, G.J. Pellegrin, Jr., and K. Mullin. 1990. Updated Estimates of shrimp fleet bycatch in the offshore waters of the US Gulf of Mexico 1972-1989. NMFS, Mississippi Laboratory, Pascagoula Mississippi. 25p.

Nichols, S., and G. Pellegrin, Jr. 1989. Trends in catch per unit effort for 157 taxa caught in the Gulf of Mexico fall groundfish survey 1972-1988. NMFS, Mississippi Laboratory, Pascagoula Mississippi.

Nelder, J.A., and R. Mead. 1965. A simplex method for function minimization. Computer Journal 5:308-313.

Press, W.H., B.P. Flannery, S. A. Teukolsky, and W.T. Vetterling. 1986. Numerical Recipes, The Art of Scientific Computing. Cambride University Press, Cambridge. 818 pp.

Figure 1. Gulf of Mexico research cruise catch per effort indices of abundance for sharpnose shark (from Nichols and Pellegrin 1989).

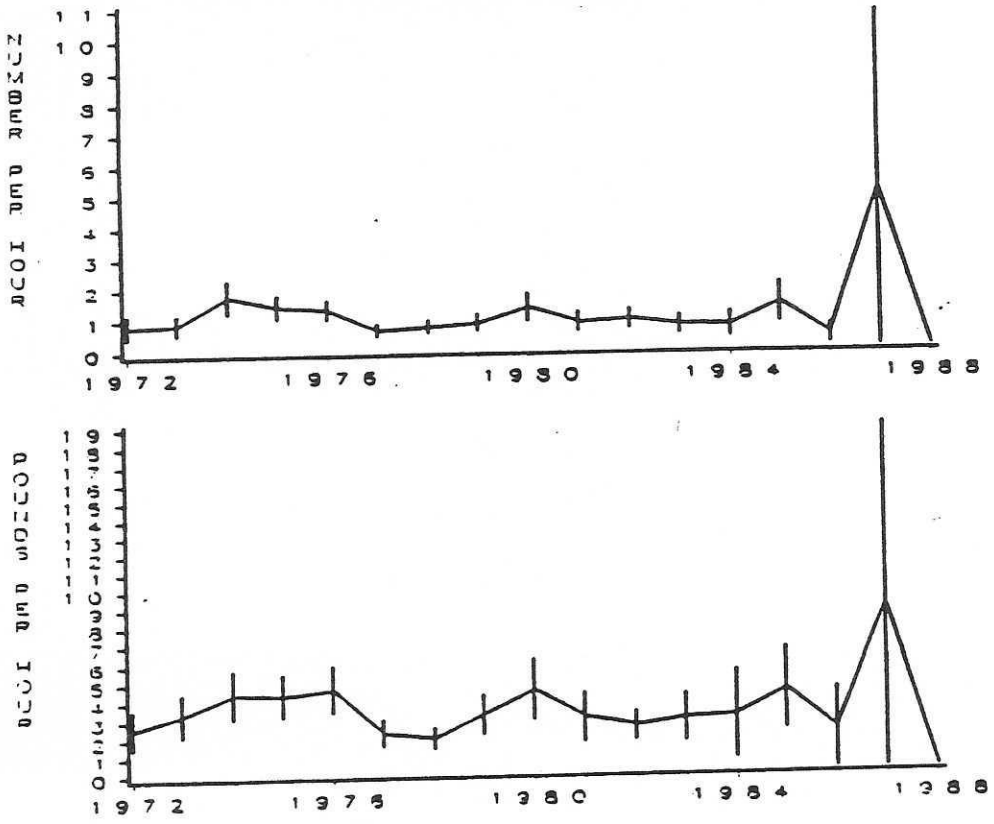

Table 1. Commercial landings of sharks, 1986-1989.

Year	State	Landings (dressed pounds) Except Pelagic Longline	Only Pelagic Longline	Bottom Longline	Gillnet	Rod-reel	Total
1986	North C	86613	7913	3605	31189	31389	94526
1986	South C	65325	4041	9012	31678	7928	69366
1986	Georiqa	4955	0	102	0	1204	4955
1986	Atl FL	536527	469854	37232	377132	73632	1006381
1986	Gulf FL	750925	56675	452420	206215	82116	807600
1986	Alabama	17000	82134	7546	8512	851	99134
1986	Miss	16786	0	3165	1459	4712	16786
1986	Louisian	99075	15765	8338	76360	2236	114840
1986	Texas	81154	964	0	0	0	82118
1986	TOT South	1658360	637346	521420	732545	204068	2296359
1986	Virqina	9996	791	0	6186	2949	10787
1986	Delaware	2661	0	0	2446	215	2661
1986	Marylnd	5177	12158	0	1725	0	17335
1986	N.Jersy	11216	73380	0	4747	0	84596
1986	N. York	21507	38919	0	71	20430	60426
1986	Connect	861	0	0	143	575	861
1986	RhodeIl	19061	6762	0	5971	575	25823
1986	Massasc	17189	30215	0	10358	1726	47404
1986	N.Hamps	574	0	0	215	0	574
1986	Maine	16903	2877	0	12373	0	19780
1986	TOT North	105145	165102	0	44235	26470	270247
1987	North C	182517	7427	14257	58368	43587	189944
1987	South C	118747	11326	37811	31212	18984	130073
1987	Georiqa	21246	0	10	0	890	21246
1987	Atl FL	818575	632101	0	509506	72704	1450676
1987	Gulf FL	1970335	59032	1456523	287421	126425	2029367
1987	Alabama	1191714	0	1191714	0	0	1191714
1987	Miss	20545	97645	0	994	1074	118190
1987	Louisian	129932	57885	27839	55005	42765	187817
1987	Texas	33774	5160	3687	0	0	38934
1987	TOT South	4487385	870576	2731841	942506	306821	5359091
1987	Virqina	16976	4316	0	14100	1870	21292
1987	Delaware	8057	0	0	8057	0	8057
1987	Marylnd	502	14748	0	71	0	15250
1987	N.Jersy	1718	77696	0	286	214	79414
1987	N. York	31650	33308	0	2804	21150	64958
1987	Connect	18701	0	0	7265	286	18701
1987	RhodeIl	17471	3524	0	2300	214	20995
1987	Massasc	42728	28416	0	35539	1653	71144
1987	N.Hamps	1294	0	0	1294	0	1294
1987	Maine	48120	7552	0	42515	0	55672
1987	TOT North	187217	169560	0	114231	25387	356777

Year	State	Landings (dressed pounds) Except Pelagic Longline	Only Pelagic Longline	Bottom Longline	Gillnet	Rod-reel	Total
1988	North C	202677	34243	19552	86403	44000	236920
1988	South C	286438	19427	207706	46669	21184	305865
1988	Georiqa	7913	125	0	0	2334	8038
1988	Atl FL	637763	1102563	80304	411974	57254	1740326
1988	Gulf FL	2179221	86320	1729804	187135	198343	2265541
1988	Alabama	4147	1640	542	1186	990	5787
1988	Miss	15868	189600	0	5365	3020	205468
1988	Louisian	364501	2850070	143689	178440	39305	3214571
1988	Texas	37476	12711	6511	0	0	50187
1988	TOT South	3736004	4296699	2188919	917347	366945	8035080
1988	Virqina	11863	11580	0	7984	2660	23443
1988	Delaware						
1988	Marylnd	2510	13664	0	1434	143	16174
1988	N.Jersy	4743	100356	0	2516	0	105099
1988	N. York	9851	24890	0	2228	7623	34741
1988	Connect						
1988	RhodeIl	14086	1797	0	3955	214	15883
1988	Massasc	16541	35394	0	13882	0	51935
1988	N.Hamps	4603	0	0	4388	0	4603
1988	Maine	68696	11581	0	62082	2230	80277
1988	TOT North	132893	199262	0	98469	12870	332155
1989	North C	644558	97383	531763	43679	35504	741941
1989	South C	242808	23649	105736	87903	29637	266457
1989	Georiqa	3899	0	0	0	3771	3899
1989	Atl FL	463740	1083445	81065	301095	46333	1547185
1989	Gulf FL	2586079	160621	2282302	203143	96517	2746700
1989	Alabama	1304630	744	1293477	599	1939	1305374
1989	Miss	27553	67972	0	3412	9736	95525
1989	Louisian	2731200	1297774	2430510	123543	176072	4028974
1989	Texas	32417	33114	22684	0	9733	65531
1989	TOT South	8036884	2764702	6747725	779234	411887	10820685
1989	Virqina	9045	3000	0	63	3693	12045
1989	Delaware						
1989	Marylnd	3839	9980	0	696	64	13819
1989	N.Jersy	99610	73757	619	93217	0	173367
1989	N. York	2820	2820	12315	0	0	15135
1989	Connect						
1989	RhodeIl	31508	1482	0	18554	6254	32990
1989	Massasc	24705	92617	712	19551	2222	117322
1989	N.Hamps	2390	0	0	2390	0	2390
1989	Maine	77894	29558	479	72587	0	107452
1989	TOT North	251811	213214	14125	207058	12233	474520

Table 6. Shark recreational fishery statistics developed from NMFS Marine Recreational Fishery Statistics Survey data from Virgina to New York. Yields are converted to pounds, dressed weight.

Year	Fishing Effort (total trips)	Yield (pounds, dressed weight) Total	Yield (pounds, dressed weight) Pelagic Species	Number of Sharks Weighed Total	Number of Sharks Weighed Pelagic Species
1980	24913000	308654	78892	25	2
1981	14771000	666145	373041	30	7
1982	17029000	1985746	1777273	22	5
1983	23012000	2068222	519124	43	3
1984	21090000	2233172	1826735	13	5
1985	17816000	3433819	1815117	39	9
1986	20561000	4667773	3938667	116	37
1987	18856000	6112673	1251875	46	6
1988	19502000	2407638	1461918	19	8
1989	13545000	2053947	1169928	54	13

Table 7. Recreational headboat fishery statistics (pounds dressed weight).

Year	Area	Total Yield	fishing effort angler trips total	fishing effort angler trips directed	Large Coastal Sharks Yield	Large Coastal Sharks w	Large Coastal Sharks s^2w	Large Coastal Sharks n	Small Coastal Sharks Yield	Small Coastal Sharks w	Small Coastal Sharks s^2w	Small Coastal Sharks n
1986	SAT	3	415472	0	3			0	0			0
	GMX	96382	302536	28573	63122	18.37	14.23	25	33206	5.42	0.03	258
1987	SAT	3862	446404	0	3734			0	128	3.08	0.15	2
	GMX	178717	286744	55691	67474	28.42	6.64	112	111243	5.81	0.08	297
1988	SAT	38230	420663	0	36825	8.83	2.52	2	1405	5.46	1.01	2
	GMX	211206	274035	68859	77200	19.79	3.45	82	134006	7.15	0.78	1038
1989	SAT	53350	420899	0	31393	6.11	1.46	21	21957	3.36	0.03	5
	GMX	160113	274581	65244	71573	30.88	7.90	80	88540	6.72	0.01	635

Table 8. Texas recreational sharpnose shark fishery statistics.

Year	Yield, pounds Dressed	Hours Fished	Average Weight	Variance of Average Weight	Sample Size
1986	36503	6915862	6.93	0.68	46
1987	47640	8996167	5.69	0.86	9
1988	53221	7500197	7.98	0.75	9
*1989	26372	4442830	6.26	1.23	14

* January through August only.

Table 9. Gulf of Mexico Shrimp trawl sharpnose shark bycatch estimates.

Year	Yield, pounds Dressed	Days Fished	Average Weight	Variance of Average Weight	Sample Size
1986	4130935	223793	2.59	0.23	61
1987	5339568	250299	1.81	0.08	149
1988	3897842	218524	1.17	0.03	109
1989	4249640	217697	2.29	0.16	85

Table 2. The number of boats directing fishing operations at sharks, 1986-89.

Fishing Gear	1986	1987	1988	1989
longline	36	62	102	124
gillnet	10	12	12	11
longline & gillnet	3	4	4	4
total	49	78	118	139

Table 3. The average dressed weight (pounds) of sharks sold.

	Sampled			
Year	Trips	Boats	Average Weight	Variance of Average Weight
1986	30	2	45.15	127.20
1987	51	2	35.62	517.65
1988	79	7	29.97	180.06
1989	330	16	31.55	192.12

Table 4. Sharks frequently caught in commercial and recreational fisheries.

Coastal Species			
Large		Small	Pelagic Species
sandbar	tiger	sharpnose	shorfin mako
blacktip	sandtiger	bonnet	longfin mako
dusky	lemon	blacknose	thresher
spinner	night	finetooth	bigeye thresher
silky	nurse	smalltail	oceanic whitetip
bull	great hammerhead		porebeagle
bignose	scalloped hammerhead		blue

Table 5. Recreational fishery statistics of coastal sharks for North Carolina and south from NMFS Marine Recreational Fishery Statistics Survey data. Yields, average weights (w), and variances of average weights (s^2w) are given in expressed in pounds, dressed weight; sample sizes (n) is numbers of fish.

			fishing effort angler trips		Large Coastal Sharks				Small Coastal Sharks			
		Total Yield	total	directed	Yield	w	s^2w	n	Yield	w	s^2w	n
1986	SAT	1097553	14783000	183539	1076197	15.91	23.62	59	21356	2.85	00.50	7
	GMX	964341	17897000	148043	851897	19.89	100.25	67	112444	4.96	00.15	43
1987	SAT	832681	20924000	201771	726306	11.69	7.75	67	106375	4.54	00.13	72
	GMX	360035	18486000	140414	315251	8.64	1.66	135	44784	4.50	00.05	37
1988	SAT	429650	19139000	202068	390117	7.76	3.90	40	39533	4.25	00.25	6
	GMX	1265675	19162000	214875	87415	6.96	1.46	83	393260	5.35	00.08	80
1989	SAT	366380	15469000	85481	305030	15.12	49.36	26	61350	3.36	00.63	24
	GMX	361621	13679000	111903	336359	6.93	1.66	88	25262	5.76	1.26	8

Table 10. Statistics of large, coastal shark fisheries off the Atlantic coast of the southern United States.

	Commercial Fishery				Recreational Fishery			
Year	Yield (pounds dressed)	Fishing Effort (Boats)	Average Weight	Variance of Average Weight	Yield (pounds dressed)	Effort (Directed (Trips)	Average Weight	Variance of Average Weight
1986	1658360	50	45.15	127.20	1991219	360156	18.08	23.54
1987	4487385	79	35.62	517.65	1112765	397876	16.43	1.76
1988	3736004	119	29.97	180.06	1376557	485802	12.22	1.09
1989	8036884	140	31.55	192.12	0744355	262628	16.77	2.65

Table 11. Results for large, coastal sharks.

Estimate	MLE	CV
January 1, 1990 stock abundance (numbers)	678,208 sharks	1.23
Annual intrinsic rate of increase (exponent of e)	1.256097886	0.04
Commercial fishery efficiency coefficient (q)	0.001452803	0.99
Recreational fishery efficiency coefficient (q)	0.000000227	0.96

Likelihood: 0.2851E-12

Model	df	Chi-Square	Pr[Chi-Square]
no model	8	439.0350211	0.0000000000
average	7	252.5383099	0.0000000000
model	4	16.73779034	0.0021733186

period	fishery	expcted	1) error	2) weighting	C/N	F=qf	Catch Estimate
1986	comm	26.57	0.699	0.007862	0.042744	0.072639	36730
1986	rec	28.38	-0.363	0.042481	0.128166	0.081642	110134
1987	comm	42.83	-0.168	0.001932	0.138008	0.114770	125979
1987	rec	13.52	0.216	0.568182	0.074194	0.090193	67728
1988	comm	23.71	0.264	0.005554	0.136746	0.172882	124658
1988	rec	13.71	-0.109	0.917431	0.123571	0.110125	112648
1989	comm	48.13	-0.344	0.005205	0.310274	0.203390	254735
1989	rec	15.23	0.101	0.377358	0.054063	0.059534	44386

1) Proportional error, residual/expected.
2) The recipical of variance of mean weight.

	Abundance Initial	Abundance Midperiod	Production	Catch	Standardized f	Standardized C/f	F=qf	F=C/N	Catch to Production
1986	766721	859307	175197	146864	106	1383.152	0.1543	0.1709	0.84
1987	814489	912843	186112	193707	141	1373.217	0.2050	0.2122	1.04
1988	813382	911603	185859	237306	195	1218.379	0.2830	0.2603	1.28
1989	732541	821000	167387	299121	181	1653.049	0.2629	0.3643	1.79
1990	678213	760112	154973						

Options For 1990: Catch	% of Production	% Abundance Change
0	0.0	25.6
38743	25.0	19.2
77486	50.0	12.8
116230	75.0	6.4
154973	100.0	0.0

Table 12. Statistics of small, coastal shark fisheries centered in the Gulf of Mexico (dressed pounds).

	Fishery	Yield	Fishing Effort	Average Weight	Variance of Average Wt
1986	Texas Recreational	36503	6916 thousand hours	6.93	0.68
1987		47640	8996 thousand hours	5.69	0.86
1988		53221	7500 thousand hours	7.98	0.75
1989		26372	4443 thousand hours	6.26	1.23
1986	Shrimp Bycatch	4130935	223793 days fished	2.59	0.23
1987		5339568	250299 days fished	1.81	0.08
1988		3897842	218524 days fished	1.17	0.03
1989		4249640	217697 days fished	2.29	0.16
1986	Recreational	167006	360156 directed trips	5.30	0.02
1987		262530	397876 directed trips	5.45	0.04
1988		568204	530802 directed trips	7.01	0.67
1989		197109	262628 directed trips	6.56	0.01

Table 13. Results for small coastal shark fisheries.

Estimate	MLE	CV
January 1, 1990 stock abundance (numbers)	4,199,000	0.67
Annual intrinsic rate of increase (exponent of z)	1.906954	0.64
Texas Rec fishery efficiency coefficient (q)	0.000000198	0.54
Shrimp fishery bycatch efficiency coefficient (q)	0.000001855	0.53
National Rec fishery efficiency coefficient (q)	0.000000023	0.51

Likelihood: 0.9301E-17

Model	df	Chi-Square
no model	12	6897.3269780
average	11	966.7832198
model	7	78.4665325

period	fishery	expcted	1) error	2) weighting	C/N	F=qf	Catch Est
1986	Tex Rec	6.27	0.105	1.470588	0.001241	0.001371	5267
	Bicatch	2.34	0.105	4.347826	0.375866	0.415209	1594956
	Nat Rec	4.80	0.105	50.000000	0.007426	0.008203	31511
1987	Tex Rec	5.74	-0.008	1.162791	0.001799	0.001784	8373
	Bicatch	2.47	-0.267	12.500000	0.633783	0.464386	2950038
	Nat Rec	6.22	-0.124	25.000000	0.010349	0.009062	48171
1988	Tex Rec	7.68	0.039	1.333333	0.001432	0.001487	6669
	Bicatch	2.06	-0.433	33.333333	0.715227	0.405433	3331489
	Nat Rec	10.09	-0.305	1.492537	0.017402	0.012090	81056
1989	Tex Rec	5.80	0.079	0.813008	0.000816	0.000881	4213
	Bicatch	2.04	0.123	6.250000	0.359595	0.403899	1855738
	Nat Rec	6.39	0.027	100.000000	0.005822	0.005982	30047

1) Proportional error, residual/expected.
2) The recipical of variance of mean weight.

Period	Abundance Initial	Abundance Midperiod	Production	Catch Estimate	Standardized f	Standardized C/f	F=q*f	F=C/N	Catch to production
1986	3072877	4243413	2018181	1631734	204579	7.976	0.4248	0.3845	0.81
1987	3370674	4654648	2213767	3006581	228876	13.136	0.4752	0.6459	1.36
1988	3373061	4657944	2215334	3419214	201799	16.944	0.4190	0.7341	1.54
1989	3737084	5160633	2454415	1889998	197826	9.554	0.4108	0.3662	0.77
1990	4199176	5798747	2757904						

Options For 1990:

Catch	% of production	% Abundance Change
0	0.0	90.7
689476	25.0	68.0
1378952	50.0	45.3
2068428	75.0	22.7
2757904	100.0	0.0

Table 14. Estimates of the pelagic shark landings (pounds, dressed weight) from the U.S. FCZ during 1986-89.

Year	Commercial Landings: Southern Area Pelagic Longline	Commercial Landings: Virginia and North	Recreational Landings: Virginia and North	FCZ Total
1980	109,415	3,747,735	78,892	3,936,042
1981	301,525	5,398,671	373,041	6,073,237
1982	253,019	196,077	1,777,273	2,226,369
1983	312,019	195,214	519,124	1,026,357
1984	449,210	201,405	1,826,735	2,477,350
1985	771,519	236,385	1,815,117	2,823,021
1986	637,346	270,247	3,938,667	4,846,260
1987	870,576	356,777	1,251,875	2,479,228
1988	4,296,699	332,155	1,461,918	6,090,772
1989	2,764,702	474,520	1,169,928	4,409,150