1996 REPORT OF THE SHARK EVALUATION WORKSHOP

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SUMMARY

This report was prepared in support of the Atlantic Shark Fishery Management Plan. The information presented herein represents a summary of the information presented at the Shark Evaluation Workshop held at the Southeast Fisheries Science Center, Miami Laboratory, 4-6 June 1996. The 1996 Workshop Committee, which focused on the large coastal shark grouping, found that for many species considered, shark abundance in waters off the U.S. Atlantic and Gulf of Mexico coasts is depressed due to fishing removals. The available catch rate information indicated that the abundance of many of the species and species groups could have declined by about 50 to 75% from the early 1970's to the mid 1980's. The evidence is not unequivocal to indicate that rebuilding has been initiated or that the stocks are declining further under the recent catch restrictions. The fishery has been regulated for just three years and since the expected rates of change in shark abundance are low, and our measures of stock abundance are uncertain, sufficient observational data are not yet available to test hypotheses about change in stock size after management measures were implemented. However, in balance, if there is to be a reasonable probability of stock increases for Large Coastals over the next two years, then a reduction in catches are in order.

The Workshop Committee concluded that the greatest impediments to improving shark stock assessments continue to be the general lack of species- and size-specific catch (landed and discarded) and effort data, as well as only limited fishery-independent measures of shark abundance and productivity. While notable improvements in species-specific catch information has been made for a portion of the recent catches through observer data collections, improved assessment advise will only result if these efforts are increased and maintained for a reasonably long time period. In addition, improvements in fishery independent measures of species-specific abundance are still required.

BACKGROUND

The Fishery Management Plan (FMP) for Sharks of the Atlantic Ocean was implemented on 26 April 1993. The objectives of the FMP (p 76) are to: 1) prevent overfishing of shark resources; 2) encourage management of shark resources throughout their range; 3) establish a shark resource data collection, research, and monitoring program; and 4) increase the benefits from shark resources to the U.S. while reducing waste, consistent with the other objectives. During preparation of the FMP, it was determined that stocks of Atlantic large coastal sharks were below the level required to produce the maximum sustainable yield (MSY). Accordingly, the FMP included a recovery plan designed to rebuild the resource to the MSY level, with annual total allowable catch (TAC) increasing as the rebuilding plan progressed.

A number of regulations were implemented to limit fishing mortality of sharks resources in the US western Atlantic and achieve FMP objectives. These include quotas for the large coastal and pelagic categories, recreational bag limits, a trip limit for large coastal species of 4,000 lbs per trip, and prohibition of the practice of removing the fins from a shark and discarding the carcass. In addition, the FMP calls for an annual evaluation of information on shark landings, current stock condition, MSY, and information on which to base the TAC. This information is to be developed by the National Marine Fisheries Service (NMFS) and submitted to the Operations Team as specified in the FMP.

To facilitate the evaluation in 1994, NMFS convened a group of scientists to examine the available shark data and provide appropriate scientific advice. The Shark Evaluation Workshop was held in Miami in the Southeast Fisheries Science Center (SEFSC) in March 1994. The most important conclusion from the Workshop Committee was that **"the weight of the evidence does not support the previous (FMP) recommendation that the 1994 or 1995 TAC should automatically increase"**. The SEW committee therefore recommended that **"the projected quota increase for 1995 should be delayed indefinitely"**. Based on this recommendation, the FMP rebuilding plan, particularly the projected 1995 quota increases for large coastal sharks, were rejected. The large coastal quota for 1995 and 1996 remained at the 1994 level of 2,570 mt. This quota would also apply in future years, unless future scientific analyses indicate otherwise in order to meet FMP objectives and/or to promote rebuilding of the shark resource.

The Shark Evaluation Workshop was not reconvened in 1995, because the amount of new information collected since implementation of the FMP was not sufficient to warrant a full new evaluation. However, an annual report was prepared to represent the 1995 evaluation required by the FMP; this was an update to the Workshop Committee Report prepared in 1994.

A second meeting of the Shark Evaluation Workshop was held Jun 4-6, 1996 at the Southeast Fisheries Science Center in Miami, FL. The objectives of the workshop were to review the additional data that has accumulated since the implementation of the FMP and to evaluate changes in status of the shark Large Coastal Group. The following report summarizes the findings of this evaluation.

1. TRENDS IN ABUNDANCE

An array of catch rate information for sharks was examined; a total of 58 time series of CPUE data were available for evaluation (Appendix Table 1). This represents an increase from the 31 time series available for the 1995 Shark Evaluation Report (SB-III-15) The available CPUE series were of different quantity and quality, *i.e.* some were nominal, highly aggregated averages from very localized fishing operations while others were based on analysis designed to adjust for area, season, and fishing practices for set-by-set catch and effort from fisheries operating over a broad area of the ocean. With this in mind, the CPUE data were examined, in aggregate, for evidence of trend in catch rates.

The procedure used for evaluating trend in the data was as conducted previously; *i.e.* to apply a generalized linear model to the available data to scale each independent time series into a single series representing an average species or species group catch rate trajectory. The model applied to the natural log-transformed data, controlled for source of data, and was used to test for a significant tendency in modeled catch rates between years. Only numbers per unit effort were combined in this way because most of the available series were of this form. The annual CPUE values were weighted in the analysis by the inverse of the precision of the value (*i.e.* weight = 1/coefficient of variation). In cases where only nominal information was available, or where no measure of the uncertainty in the annual CPUE series was available, a coefficient of variation of 100% (weight of 1.0) was assumed. Need figures (Figures 1 to 7 show the available CPUE observations, with estimated variance measures, when available and except as noted, for the large coastal sharks considered. An alternative in which all the indices were weighted equally (unweighted) was also generated; it was only marginally different than the weighted.

73%

In 19 of 26 cases, the resulting linear fits to the log-transformed CPUE values over the species and species groups considered had significant (90% probability) negative slopes (indicating a negative trend in the catch rates over the time series. Seven cases resulted in either positive slope estimates or slope estimates which could not be differentiated from zero at a 90% significance level, an indication there was no decrease in abundance. These included blacktip sharks for the 1981-1995 time period (Appendix Table 1, Figure 3); silky and night sharks for the 1992-1995 time period (Appendix Table 1, see also SB-III-3); Atlantic sharpnose sharks for the period 1986 - 1995 (Appendix Table 1, see also SB-III-24); bonnethead sharks for the period 1986-1995 (Appendix Table 1, see also SB-III-24; and blue sharks for the 1978-1995 and 1986-1995 time periods (Appendix Table 1). In the case of blacktip sharks, there is a significant negative tendency in catch rates for this species since 1986. And, for bonnetheads, catch rates for the period prior to 1986 showed a significant negative tendency to the very low levels observed since 1986.

Table 1 summarizes the results of these model fits in terms of the predicted ratios of catch rates in 1986 with respect to the beginning of the time series of observations and the predicted ratio of catch rates in the most recent year (1995) with respect to 1986. These model predictions, considering the variability in the ratios (Table 2), indicate that the abundance of many of the large coastal species and species groups for which catch rate information is available, could have declined by more than 50% from the early 1970's to the mid 1980's. However, there could also be factors, such as gear changes, not accounted for in these data (*e.g.* lighter leaders in pelagic longline gear), which could explain at least part of the modeled trends. For the large coastal sharks considered, the model predicted catch rates in 1986 are generally in the range of 15-60% of their levels in the mid- to late-1970's, other than for blacktip sharks. In most cases (except as noted above), the available data also indicate negative trends in CPUE since 1986. US shark catches dramatically increased in 1986 and there was no quota until 1993, thus the downward trend in CPUE probably accurately reflects shark abundance decrease since 1986. However, although CPUE observations show relatively large declines from 1970's levels to the current levels, in the most recent years since implementation of fishery restrictions in 1993, the CPUE data do not show statistically significant evidence that the stocks are either increasing or decreasing under the current US allowable catch level for Atlantic sharks. For the large coastal and sandbar sharks, this is illustrated in Figures 1-2 and Figures 8-9. The first figures represent the CPUE observations, adjusted to a common scale via the procedure described above. The latter figure represents the estimated annual average catch rate based on these data as described in SB-III-17.

As indicated, the available catch rate information represents a mixture of data time series. Some of these time series are based on analyses designed to adjust the catch rates for spatio-temporal, fishing strategy (*e.g.* fishing depth, temperature, soak duration, and time of fishing, bait type, *etc.*), and other effects, not related to shark abundance. Other time series data sets are highly nominal sets of information and might be highly influenced by factors other than shark relative abundance patterns. It is believed that more detailed analyses of the more nominal time series would help to reduce the uncertainty about use of these data sets for indicators of shark abundance patterns. The Workshop recommended conducting such analyses and applying these catch rate series to modelling efforts for stock assessments into the future.

The US Atlantic fisheries landings of sharks have been regulated for only a few years and since the expected rates of change in shark abundance are low, and measures of stock abundance are uncertain, sufficient observations of relative abundance levels are not yet available to test, with high power, hypotheses about change in stock size after management measures were implemented. In fact, given reasonably precise measures of abundance (cv's in catch rate indices of 20%), doubling or halving in these indices could be statistically detected with high probability. However, under a catch limit that might allow for a 5-10% annual change rate, a doubling or halving would not be expected to occur before about 7-14 years. Because of the uncertainty of historical catch and low potential rates of increase in sharks, any non-zero TAC might be considered risk-prone with respect to recovery of shark resources, especially for individual species in the Large Coastal grouping.

align values in this Table

Table 1. Predicted catch rate ratios from log-linear model ($\ln(CPUE) = \beta_0 + \beta_1 Year + \beta_{2..I} Series_i + \epsilon$) fits to the available time series of CPUE (in numbers of sharks caught per effort unit). Values shown are approximate 95% confidence bounds and the model predicted mean ratio of catch rate (CR; $Lower_{95\ CI\ Bound}$, Mean, $Upper_{95\ CI\ Bound}$) in one year with respect to another, as indicated (note that I represents the initial year and E the ending year in the available time series of observations).

Species or Group	Years of CPUE Data	All Data: CR_{84}/CR_I	All Data: CR_E/CR_{84}	All Data: Slope	All Data: P(t)	86-95 Data: CR_E/CR_{84}	86-95 Data: Slope	86-95 Data: P(t)
Large Coastal Sharks	1975-1995	.30,.38,.47	.38,.45,.54	-0.088	.0001	.39,.51,.68	-0.074	.0001
Sandbar	1975-1995	.18,.26,.36	.22,.29,.40	-0.136	.0001	.13,.24,.44	-0.160	.0001
Blacktip	1981-1995	.78,1.1,1.4	.64,1.1,1.9	0.012	.7128	.18,.40,.86	-0.102	.0370
Dusky	1975-1995	.16,.25,.37	.20,.29,.42	-0.139	.0001	.20,.36,.62	-0.115	.0014
Hammerheads	1981-1995	.31,.50,.80	.12,.28,.67	-0.140	.0069	.10,.26,.72	-0.150	.0152
Tiger	1976-1995	.39,.57,.82	.44,.60,.83	-0.056	.0065	.33,.54,.88	-0.068	.0265
Sand Tiger	1976-1995	.06,.17,.44	.08,.20,.48	-0.179	.0015	.02,.12,.82	-0.233	.0495
Silky	1992-1995	N/A	N/A	-	-	N/A	0.012	.9217
Night	1992-1995	N/A	N/A	-	-	N/A	-0.160	.4523
Pelagic Sharks								
Mako	1978-1995	.50,.65,.84	.46,.62,.82	-0.054	.0030	.50,.71,1.0	-0.038	.0741
Blue	1978-1995	.49,.73,1.1	.44,.70,1.1	-0.039	.1415	.44,.77,1.4	-0.029	.3898
Thresher	1986-1995	N/A	.41,.57,.82	-0.061	.0148	.41,.57,.82	-0.061	.0148
Oceanic Whitetip	1992-1995	N/A	N/A	-	-	N/A	-	
Small Coastal Sharks								
Atlantic Sharpnose	1973-1995	.41,.64,1.0	.56,.75,1.0	-0.031	.0683	.52,1.8,6.5	0.068	.3579
Bonnethead	1973-1995	.001,.004,.02	.01,.03,.08	-0.385	.0001	.01,.99,>10	-0.002	.9969

Model Parameters: β_0, intercept; β_1, slope; $\beta_{2..I}$, scale effect adjustment for each of the I CPUE Series in the fit; ϵ, assumed normally distributed random error.

Slope: Model slope (β_1) parameter estimate.

P(t): Probability of larger Student's t-statistic due to chance under null hypothesis that model slope (β_1) parameter equals 0.

N/A: not applicable

2. BIOLOGICAL PARAMETERS

2.1. Vital Rates

To assess biological productivity of key species in the large coastal fishery, the committee focused on improving and extending the demographic models developed in the 1994 Shark Evaluation Workshop. Since sandbar and blacktip sharks comprise approximately 75% of the landings, these species were chosen for further analysis. The purpose of the demographic runs was to develop a range for *r*, the intrinsic rate of increase, for the sandbar and blacktip in the western Atlantic, based on the best available biological information. With a range of *r* values, stock rebuilding schedules can be examined for their biological realism based on current levels of F, target goals for the stock, and rebuilding time frames.

A series of scenarios was developed to reflect the biological database and some of its uncertainties. This was composed of six scenarios for the sandbar shark (SB-1 through SB-6) and two for the blacktip shark (BT-1 and BT-2), as follows:

Table 2.

	SCENARIO	t_{mat}	t_{max}	m_x	S_0	S_1	S_n	r	
SANDBAR	SB-1	15	35	2	0.5	0.7	0.9	0.022	
	SB-2	15	35	2	0.9	0.9	0.9	0.063	← (23.9% dive)
	SB-3	15	35	2	0.95	0.95	0.95	0.117	No (16.6% dive)
	SB-4	30	60	2	0.5	0.7	0.9	-0.030	
	SB-5	30	60	2	0.9	0.9	0.9	-0.008	
	SB-6	30	60	2	0.95	0.95	0.95	0.046	(4.6% dive)
BLACKTIP	BT-1	6	15	1.25	0.5	0.65	0.8	-0.058	
	BT-2	6	15	1.25	0.9	0.9	0.9	0.136	No (20.6% dive)
								0.066	← Max; with t_{max}=20, m_x=1.5, S_n=0.8

The need for the breadth of scenarios examined above was due primarily to two sources of uncertainty:

1) Age and growth information on the sandbar shark from three sources (Casey et al., 1985; Casey and Natanson, 1992; Sminkey and Musick, 1995) has provided evidence of two ageing patterns, one of maturity at 15 yr and longevity to 35 yr (vertebral centra analyses) and one of 30 yr at maturity and 60 yr longevity (tag-recapture studies). Given the negative r's generated by the second pattern except under the most optimistic survivorship scenario, it appears that the 15/35 ageing pattern is more likely for the sandbar.

2) Survivorship of age-classes is uncertain, so the committee selected survivorship patterns based on the scant literature and on the most optimistic scenarios, *i.e.* the committee sought to construct the upper bounds of biological productivity of these two species. This generated a series of r values for the various age pattern/survivorship combinations. From this series, r ranged from a negative number (not acceptable in a stable population) up to a maximum value, r_{max}, for each species. The r_{max} sets the absolute biological upper limit (given the inherent variabilities and uncertainties in the data set) for each species' ability to increase stock size on an annual basis.

The Workshop Committee recognizes the need for evaluating the above scenarios in a stochastic framework; such an analysis may provide information to evaluate the effects of the uncertainties in the knowledge of vital rates. Nevertheless, the above summary shows that our present knowledge would indicate that maximum annual intrinsic rates of increase do not exceed approximately 12% for sandbars and 14% for blacktips.

6%
10%
(8%)
[10%]

2.2. Nursery Areas

The Workshop Committee discussed the importance of increasing survivorship of the early life stages of shark species. Since the demographic models reflect a need to have high survivorship of the first few age-classes, fishing mortality of the young sharks should be minimized. Progress has been made since 1994 to identify pupping and nursery areas and characterize juvenile habitat. For the sandbar and blacktip sharks, these areas lie primarily in inshore waters of the mid-Atlantic (sandbar) and the south Atlantic and Gulf (blacktip). Overwintering areas for the juveniles, however, are less well known at this time.

3. CATCH AND LANDINGS

U.S. Atlantic shark catches increased rapidly over the late 1980's and early 1990's to more than 9,500 mt, but have recently been limited by a suite of regulations including a commercial quota. Because species-specific catches of sharks were not documented until 1994, they are grouped by similar life-history and habitat characteristics for the purpose of management. Most of the recent U.S. catch of sharks for the market are of species grouped as large coastal sharks (*e.g.* sandbar, blacktip, dusky, spinner sharks, *etc.*). Some pelagic sharks (*e.g.* mako, thresher, porbeagle) are also highly valued by U.S. fishers targeting tunas and swordfish.

The U.S. commercial shark fishery is primarily a southern coastal (Atlantic and Gulf of Mexico) fishery extending from North Carolina to Texas. About 75% of recent U.S. Atlantic shark landings came from the southeastern region. The most sought after species in this fishery are sandbar and blacktip sharks, although others are also taken (SB-III-1). Recreational fishing for sharks also results in significant harvests of large coastal (and other) shark species (SB-III-5). Recreational harvests of sharks occur all along the U.S. Atlantic and Gulf of Mexico coasts.

In 1995 the documented U.S. commercial landings of Atlantic large coastal sharks were 3,117 mt dressed weight (about 160,000 fish; SB-III-6; these included sharks identified as large coastal sharks landed in the northeastern US and those either identified as large coastal sharks or as unclassified sharks landed in the southeastern US and Gulf of Mexico). Although preliminary, the 1995 level represents a reduction from peak recorded commercial landings (about 4,600mt, approximately 350,000 fish in 1989; SB-III-6) of this grouping of sharks. Additionally, about 120 mt of fins of all shark groups were recorded landed in the southeastern US and US Gulf of Mexico coastal states in 1995 (SB-III-6). Recorded fin landings in northeastern US states during 1994 were about 15mt (SB-III-6) and a similar amount may also have been landed from that region in 1995. Prior to implementation of the FMP, sharks were frequently "finned" and the carcasses were discarded at sea. Thus, earlier fin landings, the reported levels of which ranged to about 130 mt per year, represented only a small fraction (perhaps 5%) of the biomass of sharks harvested. Regulations implemented in 1993 required that both fins and carcasses of harvested sharks be landed.

Recreational harvests of the large coastal grouping of sharks in 1995 were estimated to be on the order of 180,000 fish (about 780mt; SB-III-5). This represents a reduction from the mid-1980 level of 375,000 fish (about 3,000 mt). About 23,000 sharks (45 mt) of unknown species were estimated to have been harvested in 1995 by the recreational fishery, some of which might have been from the large coastal grouping.

Bycatch of sharks is also known to occur in trawl, set-net and hook and line fisheries. For instance, in the Gulf of Mexico, shark bycatch by the US shrimp trawl fleet consists mainly of sharks too small to be highly valued in the commercial market (SB-III-23). Bycatch of sharks in trawl and other fisheries outside of the Gulf of Mexico also likely occurs with regularity. Pelagic fisheries targeting swordfish and tunas can, at times have shark bycatches which exceed the targeted species catch. In the US longline and drift gillnet fisheries, logbook and scientific observer reports indicate shark bycatch varies with the species of concern, gear characteristics and fishing season. Estimates of the annual dead discarded tonnage of large coastal sharks by these US fisheries since 1987 range from about 140-875 mt (approximately 6,000-21,000 fish; SB-III-4).

Additionally, the Workshop Committee attempted to reconstruct historical landings of large coastal sharks by compiling best-estimates of the numbers of sharks that have been recorded as landed or discarded dead for the entire management area (i.e., Atlantic Ocean and Gulf of Mexico). The group did not have sufficient information to estimate the number of sharks harvested solely for the sale of fins with carcasses being discarded at sea. The Workshop Committee recommends that a separate project be initiated to collect and reconstruct historical data from known fin dealers.

The estimated numbers of sharks landed or discarded dead for the period 1981 through 1995 are presented in Table 3. An explanation of each column follows the table.

Table 3. Estimates of Total Landings and Dead Discards for Large Coastal Sharks (numbers of fish).
in thousands

Year	Col 1 Commercial Landings	Col 2 Longline Discards	Col 3 Rec. Catches	Col 4 Unre-ported	Col 5 Coastal Discards	Col 6 Total
81	16.2	0.9	265.0			282.1
82	16.2	0.9	413.9			431.0
83	17.5	0.9	746.6			765.0
84	23.9	1.3	254.6			279.8
85	22.2	1.2	366.1			389.6
86	54.0	2.9	426.1	24.9		508.0
87	104.7	9.7	314.4	70.3		499.0
88	274.6	11.4	300.6	113.3		699.9
89	351.0	10.5	221.1	96.3		678.8
90	267.5	8.0	213.2	52.1		540.8
91	200.2	7.5	293.3	11.3		512.3
92	215.2	20.9	304.9			541.1
93	169.4	7.3	249.0		17.6	443.3
94	190.1	8.8	160.9		19.1	378.9
95	160.4	6.1	183.4		17.3	367.2

Column 1, commercial landings - These data are the landings reported under the established NMFS cooperative statistics program. (See document #6 for a description of this data collection program.) The data are collected in landed or dressed weight. Various sources of weight per fish estimates were used to convert pounds to numbers of fish. For the period 1981 through 1985, a generic factor of 45 pounds dressed weight per fish was used. For 1986 through 1991, an average weight for all species was used. These averages are the ones that were used in the 1992 assessment. For 1992 and 1993, average weights for coastal species observed in longline catches were used in document #6, but the group felt that these weights were too high to apply to fish caught nearer shore in the directed large coastal fishery. Therefore, a weight of 40 pounds per fish was used for these two years. For 1993 through 1995, weights per fish for individual species based on the observer program (SB-III-1) and data from the pelagic longline data base were used.

Column 2, pelagic longline discards - The data for this column are from the analyses of the discards by pelagic longline vessels (see document #4). The estimates prior to 1987 are calculated using the average ratio of the discards to commercial landings for the data for 1987 through 1992 (discards as a fraction of combined landings and discards averaged 5.12% over this period).

Column 3, recreational harvest - These data are reproduced from document #5 and include estimated catches from the NMFS MRFSS, headboat and charter boat surveys and the Texas Parks and Wildlife recreational creel survey.

Column 4, unreported catches - These data are from a single dealer in Alabama that owned a fleet of vessels that fished in the Gulf of Mexico and off the coast of North Carolina. The estimate for 1988 was determined from company landings records. The estimates for other years were prorated based on the 1988 landings record and financial statements indexing income from shark fishing (SB-III-30). The group determined that most of these data are probably not included in the commercial landings presented in Column 1. Thus, the data are labelled as unreported.

Column 5, discards by coastal fishery - These data are from the South Atlantic Fisheries Foundation observer program (SB-III-1) and show that slightly more than 10% of large coastal species were discarded by the directed fishery in 1994 and 1995. The calculated percentages for 1994 and 1995 were averaged and applied to the recorded landings for 1993 to give an estimate of the discards in 1993. The discarded species are non-marketable animals that are included in the large coastal management unit.

Column 6, total - The numbers in this column are the sum of columns 1-5.

It is acknowledged that commercial landings prior to mid-1993 are likely to be substantially underestimated, due non-reporting (which was not illegal at that time) and due to the practice of finning sharks and discarding the carcasses at sea, with the latter not being included in landings statistics. However, examination of data available to the workshop (import/export statistics and scattered data about fin production in various years) was inadequate to reconstruct a meaningful historical time series of at-sea discards or of non-reporting. As an alternative, it was proposed that a simple sensitivity scenario that would scale up the estimates in columns 1 and 2 by 2.0 for 1981-92, by 1.5 for 1993 (to account for the fact that the FMP was implemented about halfway through 1993) and by 1.0 for 1994-95 also be examined.

4. POPULATION MODELS

Several population modeling approaches were explored including 1) production modeling (SB-III-18, 21), simple likelihood methods (SB-III-10) and demographic approaches (discussed in section 2.1 and in SB-III-8, 25, 26). Each approach has its strengths and weaknesses.

1 The demographic rate approach uses inferred vital rates to determine the capacity that a population has to increase. However, the method cannot allow one to determine actual exploitation rates or actual population levels.

2 The production modeling approach uses information on the catch history and indices of abundance to determine population levels, relative population levels, fishing mortality history and benchmarks such as Maximum Sustainable Yield (or Catch) and fishing mortality rates that achieve the benchmarks. Disadvantages in the method are that it assumes a closed population (no net migration rate), that population parameters are stationary and that the population responds instantaneously to the changes in magnitude of fishing. Weaknesses include that the model parameters are defined in terms of maximum intrinsic rate of increase and carrying capacity and not in terms of natural mortality and recruitment. Also, model fits are often sensitive to short time series of catch and CPUE, especially when there are lags between birth and maturity and the data do not span the period where maximum production occurs. However, with qualifications they have been useful in interpreting dynamics of other long-lived species such as whales.

3 The simple likelihood is based upon sampling probability theory (which are well-known to yield precise estimates). The approach estimates abundance and mortality based upon catch histories, sampled average weights and fishing effort indices. However, it makes no closed populations assumptions, only that the migration, recruitment and natural mortality parameters are stationary within specified time periods of the observed data series. Since the method uses a variety of inputs, it is possible to obtain stable estimates with a limited time series. Disadvantages are that no fishery benchmarks can be computed directly and that one cannot separate the processes of migration, recruitment and natural mortality in the estimates.

Of course beyond the pros and cons of the modeling approaches themselves, they all require inputs that should represent what they are supposed to represent, i.e. CPUE, average weight, effort and catch histories should be unbiased measures of their true quantities. While some models are robust to errors in some inputs, the models themselves cannot make up entirely for lack of accuracy and precision in the basic data.

4.1. Model Applications

4.1.a. Demographic Method

Using the demographic approach in the case of Large Coastal sharks, one can argue~~s~~ that the observed vital rates are a manifestation of the dynamics when density-dependence has already occurred. Then by comparing derived r values to F values derived from the catch data, and also to the various rates of increase required by different stock rebuilding schedules, the appropriateness of management measures can be assessed. In simple terms, if $F > r$ the stock will not be able to rebuild. In fact, the fishery science literature often recommends an F equal to one half of the maximum r for parabolic production curves in order to achieve MSY for the stock. Production curves whose maximums occur closer to the carrying capacity than to the origin (SB-III-21) imply that the F which yields maximum production occurs at a higher proportion of r than one-half and that there is proportionally less flexibility between the F at maximum production and an F greater than the value of r_{max}, at which the population cannot persist.

One should be aware that the above arguments are void if the fishing mortality rates are using an "open" stock scenario, i.e. where there is migration of the stock available to the fishery (note this migration includes migration of fish and/or fishers). The estimated F is for the known fishery, whereas the r is for the whole resource.

Nevertheless, the above examination of the parameters in Section 2.1 indicated maximum annual intrinsic rates of increase of about ~~12-14%~~. 8 10%.
6-10%.

4.1.b. Production Model

Since most of the CPUE's and catches original units were in numbers of fish rather than in biomass or yield in weight the production modeling and simple likelihood methods were used to estimate numbers of fish rather than biomass. Also, the production model fits used in the following scenarios assumed a parabolic model where the maximum net production in numbers occurs at half of equilibrium carrying capacity and the fishing rate that produces it occurs at half of the maximum intrinsic rate of increase (maximum r). This assumption may not be appropriate for long-lived sharks (SB-III-21); maximum production may occur at more than half of carrying capacity and the F may occur at more than half of the maximum r.

Production model fits were done on the aggregate Large Coastal CPUE data (Section 1) both weighted and unweighted and using the catch history in Table 3. Results are in the Appendix. A bootstrap analysis was conducted to generate confidence limits on estimates, since the approximations obtained from the original fits were probably underestimated. The results of the analyses using these two CPUE scenarios indicated that the maximum sustainable catch in numbers (MSC) was estimated to be 305,000 and 313,000; the 1995 catch was approximately 370,000 fish; the maximum rates of intrinsic increase were approximately 0.25; 1995 fishing mortality rates were approximately 1.7 to 2 times that which would produce a maximum sustainable catch in numbers (MSC); stock size continuously declined from 1981 through 1995 (although recently at a slower rate); the stock size at the beginning of 1996 was 59-65% of that which would produce a maximum sustainable catch; and the stock size which could have produced MSC occurred in 1990. These fits also estimated that stock size in 1981 was 25 - 34% higher than the equilibrium carrying capacity. The detailed results are in the Appendix.

Variation in the above production model fits were evaluated using a bootstrapping procedure in which the observed residuals of the CPUE fits were randomly resampled and the analysis repeated. This was repeated a number of times. The variation resulting from the bootstrapping showed that the CV on 1996 stock sizes was about 80% and that one could not show statistically significant differences between the 1996 stock level and any other year's level throughout the time series.

Additional production model fits for the Large Coastal Group were attempted using the sensitivity scenario for under-reporting of catches prior to the FMP. This scenario was introduced in Section 3, above. No reasonable solutions were obtained with this model fit. Essentially, the only way the production model could consistently interpret both the large catches of this scenario and the large CPUE decline was to estimate that there was an unreasonably large number of sharks in the sea in 1981 and throughout the time series.

4.1.c. Simple Likelihood Method

The maximum likelihood estimate (MLE) that corresponds best to the production model scenario above (Large Coastal Group, 1986-95 data) document a fall in abundance of an average of 10% per year until FMP regulations, then an increase of about 5% per year during 1994 and 1995. Abundance is estimated to have decreased about 60% from January, 1986 to January, 1994; fishing mortality rates ranged from 0.22 - 0.45. The analysis estimates that the 5% per year rebuilding during 1994 and 1995 occurred at a fishing mortality rate of 0.17.

Since the likelihood method does not demand a long time series of data, it was applied to 1994 and 1995 data only. Statistics of these two years are vastly superior because 1) the discarding of finned sharks at sea was curtailed by regulations thus the reported landings included most of the catch in those two years; 2) The reporting of all shark landings was legally mandatory in those two years only thus, in the absence of non-reporting, reported landings were accurate; 3) the species of sharks landed was recorded both by fish brokers and on mandatory logbooks by fishermen; 4) the number of vessels targeting sharks ("effort") was derived for these two years from lists of shark fishing permit holders and their corresponding landings history rather than by anecdotal information; 5) at sea samples of the sizes and species of sharks caught and landed or discarded were available for those two years. These data (1994-95) clearly are the best available.

The maximum likelihood method allows the calculation of exact confidence limits through resampling. The ranges given in this paragraph are 90% confidence limits, i.e., unless a one in nine chance has occurred and the sample the estimate is based on is not representative, the intervals given bracket the actual quantity. MLEs of blacktip population parameters show abundance dropped from 3% - 11% per year in 1994 and in 1995; the fishing mortality rate each year was 0.20 - 0.26. MLEs for sandbar show a 8% - 15% abundance decrease per year in 1994 and 1995 with a fishing mortality rate of 0.18 - 0.23 each year. MLEs for the large coastal group show abundance decreased 8% - 12% per year in 1994 and in 1995 with a fishing mortality rate of 0.10 - 0.12 each year.

The MLE results for the large coastal group for 1986-95 data are very different from the results for 1994-95 data mostly for two reasons. First, the longer time series of commercial landings data is well known to be very incomplete and thus inaccurate. Second, fishing efficiency coefficients (q's) and the rate of natural population change (m) are assumed temporally invariant from 1986 though 1995 in the 1986-95 analysis; it is unlikely that assumption is valid. The 1994-95 analysis assumes these rates were constant during 1994 and 1995 only.

4.2. Projections

Short term projections were conducted in order to evaluate management opportunities. The projections used estimated stock sizes at the beginning of 1996 as the initial point of the projection and then projected through 1996, 1997 and 1998 to the beginning of 1999. Then comparisons were made between the beginning 1999 stock size and that at the beginning of 1996. Production parameters estimated from the production model and MLE analyses were assumed to be invariant throughout 1996-98 for the corresponding projection analyses.

Three catch scenarios were examined. All three assumed the 1996 catch to be the same as that in 1995. Then the 1997 and 1998 catches were as follows: Scenario I assumes 1997-98 catch is equal to 1995 (status quo scenario); Scenario II assumes 1997-98 catch equal one half of that in 1995 (50% reduction); and Scenario III assumes no catch mortality in 1997-98 (Zero Catch). These provide a range of outcomes between status quo and maximum stock recovery between which one can interpolate.

4.2.a. Demographic Method

Since the demographic method does not result in stock size estimates, no projections using this method can be done.

4.2.b. Production Model

More detailed results of the projections are given in the Appendix and are summarized in Table 4. The probability that the beginning year 1999 stock size was larger than that at the beginning of 1996 was approximated using the following procedures: the CV on the 1996 stock size estimate from the bootstrapping (78% which is quite large) was assumed to occur in 1999, as well. Then comparisons between 1996 and 1995 were made assuming normality and independence of the estimates. It is unlikely that the latter assumption is valid.

The projections (Table 4b) indicate that the status quo projection would be expected to result in a reduction in stock level of 30% through 1998; the 50% reduction would approximately stabilize stock levels; and the maximum growth potential for the stock over these years is expected to be about 30% (Zero Catch scenario). Due to the large variation in the estimates, one would not conclude that there is a high probability of detecting the stock either increasing or decreasing from these data.

4.2.c. Simple Likelihood Method

The probability that 1999 shark abundance (numbers) will be greater than that of January 1, 1996 (i.e., the probability of the stock recovering) is shown below (Table 4) for the three regulatory options: current (1995) catch, one half the current catch, and a zero catch (a catch moratorium including the recreational and bycatch fisheries). The detailed statistics of these projections as well as the results of several other possible removal levels are in the appendix.

The large coastal 86-95 analysis shows that, with 90% confidence, regulations in 1993 caused a recovery beginning in 1994 that is ongoing, although slow (.90 CI bounds are 1% - 9% per year); the result of the current catch would be a continuing (slow) increase in abundance. This analysis contains incomplete data and doubtful assumptions.

All three analyses based on the "best available data" (i.e., blacktip, sandbar, and large coastals, 94 and 95 data) show continued decline in abundance in 94 and 95 (with 90% confidence) and that abundance decline will continue under the 1995 catch level. Stock rebuilding under these scenarios requires that very low or no fishing mortality occur.

4.3. Summary of Model, Projection and CPUE Results

A discussion is needed to compare the three modeling approaches in the context of the specific results which have been obtained and to compare these with the CPUE results in Section I.

Perhaps, the largest difference in the three modeling approaches is how they deal with the "open population" issue. Remember that when we talk about open populations we are discussing the possibility that what we call a population could in fact is affected by immigration, emmigration of the fish, migration of fishers or change in fishers behavior (including reporting of the catch) which could affect the magnitude and species mix of the Large Coastal Group catch and CPUE. The demographic method bypasses the open population question by evaluating the basic vital rate information directly. However, one should be circumspect in comparing the demographic results to fishing mortality rates estimated from other methods. The production model fits ~~assumes~~ assume that there are no open population effects; thus, when in fact there are, the model attempts to interpret the results in terms of benchmarks, as if the open population effects had not occurred. The MLE approach does not assume that the population is closed. It allows for open populations by incorporating any effects of such into the production parameter. Clearly, the MLE approach deals with open population questions more directly.

The problems with the catch history estimates have been noted (Section 3). Therefore, the Workshop Committee is more uncertain about results when the models use the longer time series (production models and MLE's using 1986-95 data). If underreporting were a constant proportion then the MLE applications using the longer time series with an invariant production parameter might be appropriate. But given the sensitivity scenario in Section 3, we cannot draw this conclusion. The MLE approach with the short time series of catch (1994-95 data) appears to alleviate many of the reporting problems and, thus, is probably the most appropriate approach at this time.

However, it should be noted that using the short time series MLE estimates has connotations for doing projections. Ideally when one has a long time series, the production parameters that are estimated are effectively averaged over the time series. Therefore, projections using those production parameters are assuming "average" production conditions. In contrast, when projections are made using the short data series from MLE's, the production parameter was based on only two years of data and the parameter itself is an amalgamation of population and fishery effects. Therefore, it is unclear how stable that parameter might be during the projection years; this form of uncertainty was not included in the probability statements in Table 4.

In balance the modeling results and the CPUE trend analyses are remarkably consistent given the uncertainties in the basic data. The analyses show reasonably consistent declines in abundance through the 1980's with some flattening of the trend in the 1990's. The data did not allow the Workshop Committee to conclude that the trend since the advent of the FMP was statistically significant either up or down. A few of the individual CPUE's showed increases in the most recent year as did the 86-95 MLE analysis. Whereas, other CPUE's and the 94-95 MLE analysis (which was less tainted by underreporting of catches) did not. The models are, also, consistent in that the ability for Large Coastal shark populations to grow are limited.

Table 4a. Projections of the probability that abundance at the beginning of 1999 is greater than the abundance at the beginning of 1996, i.e. $\Pr[N_{99} > N_{96}]$ the probability that the recovery process has been initiated. Projections made using three future catch scenarios and using assessments results from alternative models.

Scenario I: Status Quo: Project Using 1995 Catch (367223) for 1996-1998
Scenario II: 50% Reduction: Project Using 1995 Catch for 1996 and One-Half 1995 Catch for 97-98
Scenario III: Zero Catch: Project Using 1995 Catch for 1996 and no catch for 97-98.

	I: Status Quo $\Pr[N_{99}>N_{96}]$	II: 50% Reduction $\Pr[N_{99}>N_{96}]$	III: Zero Catch $\Pr[N_{99}>N_{96}]$
LARGE COASTALS			
Prod Model Wted CPUE	0.38	0.50	0.59
Prod Model Unwted CPUE	0.42	0.52	0.59
Simple Likelihood, 94-95	0.14	0.14	0.29
Simple Likelihood, 86-95	0.83	0.92	0.96
BLACKTIP			
Simple Likelihood, 94-95	0.004	0.22	$\boxed{0.89}$
SANDBAR			
Simple Likelihood, 94-95	0.001	0.06	$\boxed{0.66}$

More certain

Table 4b. The ratio of estimated stock numbers, N_{99}/N_{96}, the amount of recovery that is projected. Projections made using three future catch scenarios and using assessments results from alternative models.

Scenario I: Status Quo: Project Using 1995 Catch (367223) for 1996-1998
Scenario II: 50% Reduction: Project Using 1995 Catch for 1996 and One-Half 1995 Catch for 97-98
Scenario III: Zero Catch: Project Using 1995 Catch for 1996 and no catch for 97-98.

	I: Status Quo N_{99}/N_{96}	II: 50% Reduction N_{99}/N_{96}	III: Zero Catch N_{99}/N_{96}
LARGE COASTALS			
Prod Model Wted CPUE	0.69	1.00	1.30
Prod Model Unwted CPUE	0.79	1.05	1.30
Simple Likelihood, 94-95	0.66	0.77	0.88
Simple Likelihood, 86-95	1.42	1.60	1.70
BLACKTIP			
Simple Likelihood, 94-95	0.63	0.90	1.16
SANDBAR			
Simple Likelihood, 94-95	0.53	0.77	1.01

More certain

5. RESOURCE STATUS

5.1. Large Coastal Sharks

5.1.a. Maximum Sustainable Yield

The Fishery Management Plan (FMP) developed an argument for maximum sustainable yield (MSY) based upon the analytical results a 1992 Review Committee. That approach used maximum likelihood estimation procedures to compute various statistics of interest including stock sizes, fishing mortality rates and production. The FMP used the maximum of annual production estimates during the period of the data as a biological reference point by assuming that any annual production, including the maximum, is sustainable. Therefore, first approximations of maximum sustainable yield were taken as the maximum of the annual production estimates during the period of the data. In doing so it was recognized that a recovery plan was to be implemented through the FMP which was designed to return the resources to a more biologically optimal level. It was also recognized that this first approximation of the resource level that might produce MSY was likely to be an underestimate. Given the implementation of a recovery plan, the underestimate of this statistic was deemed acceptable in that in order for the resource to recover to MSY it would have to pass through the "first approximation" levels. In the ensuing time period some new information was brought to bear to improve the estimate of the MSY resource level. However, the resulting predicted equilibrium catch at maximum net productivity (approximately 300,000 fish) was not felt to be of sufficient accuracy to alter the present estimate of MSY. ?

As in 1994, Workshop Committee considered the implications of large change in CPUE (*i.e.* relative abundance) with respect to population levels which could produce MSY. In the absence of more certain information about species-specific catch history and information on the degree population closure with respect to the fishery catches, improved estimates of MSY could not be derived due to data constraints. However, the Workshop Committee concluded that an estimated MSY which could be substantially below the actual level is not in conflict with the general strategy in the FMP to recover the resource, in that the FMP recognized that any recovery strategy would have to achieve the "first approximation" target on the resource recovery trajectory. The Workshop Committee also concluded that recovery is likely to be a lengthy process under the best of circumstances, and felt it was unlikely that full recovery of the resource to MSY stock level would occur. the 1986 stock size) would occur before 1999 under any catch scenario.

5.1.b. Total Allowable Catch

The 1994 Workshop Committee noted that in the case of sharks it was unreasonable to expect that sufficient additional data had accumulated since the implementation of the FMP to provide much more precise information to adjust the TAC at that time. Therefore, 1994 Workshop Committee's approach to evaluate the TAC was to examine evidence that would suggest if the exploitation rate and replacement yield originally chosen in the FMP as the target were risk-averse or risk-prone, given inexact information on current abundance, productivity rates, and harvest levels. As concluded in the 1994 Workshop Committee report, although CPUE observations show substantial declines from mid-1970's levels to the current levels, in the most recent years since 1991, the CPUE data are too few and variable to show statistically significant evidence that the stocks are either increasing or decreasing under the allowable catch level. That approach was continued here.

Thus, the evidence is not unequivocal to indicate that rebuilding has been initiated or that the stocks are declining further under the recent catch restrictions. The fishery has been regulated for just three years and since the expected rates of change in shark abundance are low, and our measures of stock abundance are uncertain, sufficient observational data are not yet available to test hypotheses about change in stock size after management measures were implemented. However, in balance, if there is to be a reasonable probability of stock increases for Large Coastals over the next two years, then a reduction in catches are in order Table 4 provides a guide to that decision. Nevertheless, one should be aware of the basic uncertainties in the data (as indicated in Table 4). There is a chance that stocks could increase or decline under any of the catch scenarios (including zero and the status quo).

5.2. Small Coastal Sharks

No new analyses were available with which to modify estimated MSY or TAC of the small coastal sharks.

5.3. Pelagics

No new analyses were available with which to modify estimated MSY or TAC of the pelagic sharks.

6. MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

In April 1993, the U.S. Fishery Management Plan for Sharks of the Atlantic Ocean (FMP) was put into effect. This plan aims at stabilizing and regulating the rapidly growing shark fishery. The plan includes management measures for 39 of the most frequently caught sharks and divides them into three groups: large coastal sharks (22 species), small coastal sharks (7 species),and pelagic sharks (10 species). The objectives of the FMP are to: 1) prevent overfishing of shark resources; 2) encourage management of shark resources throughout their range; 3) establish a shark resource data collection, research, and monitoring program; and 4) increase the benefits from shark resources to the U.S. while reducing waste, consistent with the other objectives. During preparation of the FMP, it was determined that stocks of Atlantic large coastal sharks were below the level required to produce the maximum sustainable yield (MSY). Accordingly, the FMP included a recovery plan designed to rebuild the resource toward the MSY level.

One shortcoming of the FMP, which could limit success in achieving the plan objective of preventing overfishing and promoting rebuilding of the large coastal shark resource, is in use for management purposes, multispecies aggregations (e.g. "large coastal, small coastal, and pelagic sharks") without consideration of species-specific population responses. The FMP was developed in this way out of necessity because of the lack of species-specific information and is in many ways, analogous of the early attempts by the International Whaling Commission (IWC) to limit fishing mortality on whale stocks using the Blue Whale Unit (BWU). The BWU method of management was abandoned by the IWC because it provided inadequate safeguards against overharvest of individual species stocks.

The Workshop Committee concluded that stocks of Large Coastal sharks appear to have been substantially depleted since the mid-late 1970's and it is likely that, at least in aggregate, Large Coastal sharks are below the biomass associated with MSY. The Workshop Committee also found the sustainability of the current TAC is more difficult to evaluate, since ~~there are~~ the data available to test hypotheses about change in stock abundance under the current TAC are few and uncertain. Based on these types of information, the Workshop Committee judged that the 1995 TAC would not lead to a strong probability of stock rebuilding.

The Workshop Committee also discussed the use of supplemental management measures that could promote rebuilding. The main measures discussed were those related to size, sex and season. The Workshop Committee noted from the demographic analyses, the importance of juvenile mortality on stock production. It was recognized that reductions in juvenile mortality could be an effective method of enhancing rebuilding. This might be achieved by a variety of measures including minimum sizes, strategies to differentially reduce fishing mortality on females, and seasonal closures to protect reproductive females and young of the year. It was generally agreed that such an approach (or combination of approaches) could address the need to reduce mortality in the nursery grounds during pupping season.

7. RESEARCH RECOMMENDATIONS

The following recommendations were made by the panel. The panel agreed that the following topics must be addressed so that shark management may be improved. The order below does not indicate priority order.

Resolve the age uncertainties in the sandbar and blacktip sharks. There is great disagreement in the age at maturity and longevity of the sandbar sharks. Maturity estimates range from 15 to 30 years and longevity ranges from 30 to 60 years. There are also uncertainties regarding the blacktip. Accurate ageing of specimens is of paramount importance for stock assessment, and these uncertainties must be resolved.

Determine the survival of rates for young sharks in the nurseries. The mortality rate of the young sharks in the nursery appears to be one of the key factors in the overall survival. Studies should be conducted to determine the survival of young sharks during their first years in the nursery.

Conduct tagging studies in the western Gulf of Mexico. Tagging studies in the western Gulf of Mexico would elucidate whether blacktip and sandbar sharks travel from the U.S. to Mexico or vice-versa, and would clarify the origin of sharks taken in various fisheries in both countries.

Determination of the winter nurseries for economically important sharks. Although the general summer nursery areas for many species are known, the winter nursery areas are not known for most species. Tagging studies should be conducted to reveal the location of the winter nursery areas, or the location of juvenile sharks in winter.

Conduct long term tagging studies in the nurseries. These studies should reveal if sharks will return to their birth areas to give birth. Long term tagging studies should reveal the limits of the nursery and site specificity of the animals using them.

Obtain set by set data on the shark fishery. Studies should focus on locating and compiling whatever set by set data may exist.

Rescue whatever old data sets and fin dealer data may be available. Fin dealers have offered their available records. There may be other data sets available. These data should be obtained and analyzed.

Increase levels of fishery independent monitoring of sharks. Monitoring by fishery independent means should be increased to provide more data.

Characterize the Mexican and Canadian shark catches. Fisheries management requires an understanding of shark catches in adjacent areas. Available data on Mexican and Canadian shark catches should be obtained and analyzed. Cooperation with foreign scientists should be developed and cooperative management should be encouraged.

Standardization of catch rate time series for factors thought to influence catch rates, but not related to abundance. This requires detailed, set by set information from commercial fishing and fishery independent surveys, in many cases. More detailed catch and effort records (e.g. daily catch and effort by fishing method, area and platform) from recreational angler surveys will also be needed. It was recommended that future assessments rely mainly on standardized catch rate patterns and catch information.

Increase observer sampling. Current fishery observer programs have yielded much needed data on the commercial shark fishery. Triple directed shark fishery observed sets (about 1,000 per year needed); increase pelagic longline sampling from present levels (FY96, about 500 days at sea) to the target sampling level (about 1600 days at sea per year).

9. LIST OF PARTICIPANTS

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Kelley, G.	International Gamefish Association
Schirrippi, M.	NMFS, Miami
Wilkins, C.	National Coalition for Marine Conservation

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SB-III-3. 1996. Cramer, J. Large pelagic logbook catch rate indices for sharks.

SB-III-4. 1996. Cramer, J. Estimates of the numbers and metric tons of sharks discarded dead by pelagic longline vessels.

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SB-III-6. 1996. Poffenberger, J. Commercial shark landings.

SB-III-7. 1996. Poffenberger, J. Shark logbook data.

SB-III-8. 1996. Sminkey, T. Demographic analyses of natural and exploited populations of three large coastal sharks.

SB-III-9. 1996. Ulrich, G. Fishery independent monitoring of large coastal sharks in South Carolina (1993-95).

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SB-III-14. 1996. Parrack, M. A simple likelihood method of estimating fish abundance.

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SB-III-29. 1996. Hester, F. Graphs of shark catch and effort.

SB-III-30. 1996. Hester, F. Shark fin landings and conversions from selected dealers.

SB-III-31. 1996. Kohler, N. Summary of tag and recapture data for 33 species of sharks.

APPENDICES

Appendix 1. CPUE SERIES

Appendix Table 1 The CPUE series for sharks considered in the 1996 shark evaluation report. Series are listed by species or species group with source of new information indicated. The index is the estimated mean CPUE and the CV is the estimated precision of the mean value. Also indicated is if the series represents a number based or biomass based catch per unit effort. Observations with CV of 1.0 are nominal data for which no measure of precision of the estimate was available (in these cases, the CV was assumed to equal 100%). Sources of prior information listed in 1994 and 1995 shark workshop reports...

SPECIES	SERIES	TYPE	YEAR	INDEX	CV	SOURCE
large coastal	Gulf Reef 90	Biomass	90	280.41	0.39096	c, 1
large coastal	Gulf Reef 90	Biomass	91	335.78	0.24266	c
large coastal	Gulf Reef 90	Biomass	92	281.70	0.27111	c
large coastal	Gulf Reef 90	Biomass	93	155.17	0.26968	c
large coastal	Gulf Reef 90	Biomass	94	145.34	0.27074	c
large coastal	Gulf Reef 90	Biomass	95	181.58	0.36975	c
large coastal	Brannon	Numbers	86	162.00	1.00000	c ,2
large coastal	Brannon	Numbers	87	332.29	1.00000	c
large coastal	Brannon	Numbers	88	282.56	1.00000	c
large coastal	Brannon	Numbers	89	205.41	1.00000	c
large coastal	Brannon	Numbers	90	245.07	1.00000	c
large coastal	Brannon	Numbers	91	251.44	1.00000	c
large coastal	Brannon	Biomass	86	3244.00	1.00000	c, 2
large coastal	Brannon	Biomass	87	9450.52	1.00000	c
large coastal	Brannon	Biomass	88	7882.87	1.00000	c
large coastal	Brannon	Biomass	89	5746.35	1.00000	c
large coastal	Brannon	Biomass	90	6547.36	1.00000	c
large coastal	Brannon	Biomass	91	6448.84	1.00000	c
large coastal	Hudson	Numbers	85	0.22	1.00000	r, 2
large coastal	Hudson	Numbers	86	0.10	1.00000	r
large coastal	Hudson	Numbers	87	0.12	1.00000	r
large coastal	Hudson	Numbers	88	0.10	1.00000	r
large coastal	Hudson	Numbers	89	0.05	1.00000	r
large coastal	Hudson	Numbers	90	0.02	1.00000	r
large coastal	Hudson	Numbers	91	0.02	1.00000	r
large coastal	Crooke LL	Numbers	75	0.11	1.00000	c, 3
large coastal	Crooke LL	Numbers	76	0.08	1.00000	c
large coastal	Crooke LL	Numbers	77	0.13	1.00000	c
large coastal	Crooke LL	Numbers	78	0.25	1.00000	c
large coastal	Crooke LL	Numbers	79	0.12	1.00000	c
large coastal	Crooke LL	Numbers	80	0.16	1.00000	c
large coastal	Crooke LL	Numbers	81	0.13	1.00000	c
large coastal	Crooke LL	Numbers	82	0.13	1.00000	c
large coastal	Crooke LL	Numbers	83	0.14	1.00000	c
large coastal	Crooke LL	Numbers	84	0.12	1.00000	c
large coastal	Crooke LL	Numbers	85	0.14	1.00000	c
large coastal	Crooke LL	Numbers	86	0.11	1.00000	c
large coastal	Crooke LL	Numbers	87	0.08	1.00000	c
large coastal	Crooke LL	Numbers	88	0.08	1.00000	c
large coastal	Crooke LL	Numbers	89	0.09	1.00000	c
large coastal	SHK Obs	Numbers	94	21.54	1.00000	c, 4
large coastal	SHK Obs	Numbers	95	31.93	1.00000	c
large coastal	Jax	Numbers	79	0.59	1.00000	r, 3
large coastal	Jax	Numbers	84	,0.71	1.00000	r
large coastal	Jax	Numbers	90	0.16	1.00000	r
large coastal	NC #	Numbers	88	999.10	0.42199	c, 3
large coastal	NC #	Numbers	89	1637.36	0.23219	c
large coastal	NC #	Numbers	90	549.10	0.13766	c
large coastal	NC #	Numbers	91	625.52	0.12714	c
large coastal	NC #	Numbers	92	721.60	0.17409	c
large coastal	NC KG	Biomass	88	837.85	0.50421	c, 3
large coastal	NC KG	Biomass	89	2398.68	0.28493	c
large coastal	NC KG	Biomass	90	1121.99	0.16420	c
large coastal	NC KG	Biomass	91	1207.04	0.15886	c
large coastal	NC KG	Biomass	92	1163.71	0.16692	c
large coastal	SC LL	Numbers	83	6.22	1.00000	I, 5
large coastal	SC LL	Numbers	94	2.44	1.00000	i
large coastal	SC LL	Numbers	95	1.75	1.00000	i
large coastal	Port Salerno	Numbers	76	0.18	1.00000	r, 3
large coastal	Port Salerno	Numbers	77	0.81	1.00000	r
large coastal	Port Salerno	Numbers	79	0.89	1.00000	r
large coastal	Port Salerno	Numbers	80	0.82	1.00000	r
large coastal	Port Salerno	Numbers	81	0.39	1.00000	r
large coastal	Port Salerno	Numbers	82	0.50	1.00000	r
large coastal	Port Salerno	Numbers	83	0.12	1.00000	r
large coastal	Port Salerno	Numbers	84	0.10	1.00000	r
large coastal	Port Salerno	Numbers	85	0.15	1.00000	r, 3
large coastal	Port Salerno	Numbers	86	0.50	1.00000	r
large coastal	Port Salerno	Numbers	87	0.32	1.00000	r
large coastal	Port Salerno	Numbers	88	0.20	1.00000	r
large coastal	Port Salerno	Numbers	89	0.12	1.00000	r
large coastal	Port Salerno	Numbers	90	0.20	1.00000	r
large coastal	Tampa Bay	Numbers	85	0.16	1.00000	r, 3
large coastal	Tampa Bay	Numbers	86	0.09	1.00000	r
large coastal	Tampa Bay	Numbers	87	0.03	1.00000	r
large coastal	Tampa Bay	Numbers	88	0.14	1.00000	r
large coastal	Tampa Bay	Numbers	89	0.06	1.00000	r
large coastal	Tampa Bay	Numbers	90	0.05	1.00000	r
large coastal	Virginia LL	Numbers	76	7.84	0.23000	I, 6
large coastal	Virginia LL	Numbers	80	8.15	0.22000	i

large coastal	Virginia LL	Numbers	81	4.61	0.32000	i
large coastal	Virginia LL	Numbers	86	3.65	0.19000	i
large coastal	Virginia LL	Numbers	90	1.72	0.21000	i
large coastal	Virginia LL	Numbers	91	1.38	0.24000	i
large coastal	Virginia LL	Numbers	92	0.71	0.32000	i
large coastal	Virginia LL	Numbers	93	1.09	0.50000	i
large coastal	Virginia LL	Numbers	95	1.73	0.34000	i
large coastal	charter boat	Numbers	89	411.44	0.12503	r, 7
large coastal	charter boat	Numbers	90	370.33	0.12126	r
large coastal	charter boat	Numbers	91	387.92	0.11813	r
large coastal	charter boat	Numbers	92	300.56	0.12485	r
large coastal	charter boat	Numbers	93	339.37	0.15622	r
large coastal	charter boat	Numbers	94	333.26	0.15174	r
large coastal	charter boat	Numbers	95	372.11	0.12218	r
large coastal	pelagic logbook	Numbers	86	10.39	0.23896	c, 8
large coastal	pelagic logbook	Numbers	87	6.62	0.13889	c
large coastal	pelagic logbook	Numbers	88	8.44	0.12658	c
large coastal	pelagic logbook	Numbers	89	6.96	0.11946	c
large coastal	pelagic logbook	Numbers	90	8.58	0.10991	c
large coastal	pelagic logbook	Numbers	91	7.81	0.12477	c
large coastal	pelagic logbook	Numbers	92	9.00	0.06727	c
large coastal	pelagic logbook	Numbers	93	8.25	0.06835	c
large coastal	pelagic logbook	Numbers	94	5.07	0.07147	c
large coastal	pelagic logbook	Numbers	95	4.11	0.07891	c
large coastal	MRFSS,HBOAT,TX	Numbers	81	4.60	1.00000	r, 9
large coastal	MRFSS,HBOAT,TX	Numbers	82	5.88	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	83	10.52	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	84	4.79	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	85	5.18	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	86	4.78	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	87	4.24	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	88	4.16	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	89	3.32	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	90	3.09	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	91	3.62	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	92	4.23	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	93	3.22	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	94	2.07	1.00000	r
large coastal	MRFSS,HBOAT,TX	Numbers	95	2.30	1.00000	r
sandbar	Virginia LL	Numbers	76	4.16	0.25000	I, 6
sandbar	Virginia LL	Numbers	80	4.45	0.22000	i
sandbar	Virginia LL	Numbers	81	3.49	0.32000	i
sandbar	Virginia LL	Numbers	86	1.99	0.28000	i
sandbar	Virginia LL	Numbers	90	0.84	0.28000	i
sandbar	Virginia LL	Numbers	91	0.81	0.32000	i
sandbar	Virginia LL	Numbers	92	0.34	0.42000	i
sandbar	Virginia LL	Numbers	93	0.75	0.61000	i
sandbar	Virginia LL	Numbers	95	1.28	0.35000	i
sandbar	LPS	Numbers	86	15.83	0.44000	r, 10
sandbar	LPS	Numbers	87	15.31	0.34000	r
sandbar	LPS	Numbers	88	29.12	0.23000	r
sandbar	LPS	Numbers	89	26.11	0.22000	r
sandbar	LPS	Numbers	90	8.09	0.52000	r
sandbar	LPS	Numbers	91	7.94	0.65000	r
sandbar	LPS	Numbers	92	14.75	0.34000	r
sandbar	LPS	Numbers	93	2.40	1.59000	r, 10
sandbar	LPS	Numbers	94	2.29	1.50655	r
sandbar	LPS	Numbers	95	4.43	1.37472	r
sandbar	MRFSS,HBOAT,TX	Numbers	81	2.24	1.00000	r, 9
sandbar	MRFSS,HBOAT,TX	Numbers	82	0.47	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	83	5.86	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	84	1.06	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	85	0.95	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	86	1.39	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	87	0.44	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	88	0.90	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	89	0.41	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	90	0.85	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	91	0.45	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	92	0.50	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	93	0.34	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	94	0.19	1.00000	r
sandbar	MRFSS,HBOAT,TX	Numbers	95	0.32	1.00000	r
sandbar	NMFS LL	Numbers	86	447.74	0.13500	I, 11
sandbar	NMFS LL	Numbers	89	214.25	0.17200	i
sandbar	NMFS LL	Numbers	91	107.41	0.23500	I
sandbar	SC LL	Numbers	83	4.73	1.00000	I, 5
sandbar	SC LL	Numbers	94	0.41	1.00000	i
sandbar	SC LL	Numbers	95	0.39	1.00000	i
sandbar	SHK Obs	Numbers	94	14.29	1.00000	c, 4
sandbar	SHK Obs	Numbers	95	15.91	1.00000	c
blacktip	pelagic logbook	Numbers	92	4.83	0.27050	c, 8
blacktip	pelagic logbook	Numbers	93	3.44	0.14610	c
blacktip	pelagic logbook	Numbers	94	2.67	0.15090	c
blacktip	pelagic logbook	Numbers	95	2.39	0.17850	c
blacktip	MRFSS,HBOAT,TX	Numbers	81	9.52	1.00000	r, 9
blacktip	MRFSS,HBOAT,TX	Numbers	82	10.04	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	83	4.74	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	84	7.12	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	85	13.77	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	86	18.23	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	87	17.46	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	88	19.35	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	89	16.73	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	90	13.63	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	91	18.60	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	92	21.87	1.00000	r

blacktip	MRFSS,HBOAT,TX	Numbers	93	14.09	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	94	8.48	1.00000	r
blacktip	MRFSS,HBOAT,TX	Numbers	95	8.40	1.00000	r
blacktip	SHK Obs	Numbers	94	0.89	1.00000	c , 4
blacktip	SHK Obs	Numbers	95	4.29	1.00000	c
dusky	Virginia LL	Numbers	76	2.54	0.54471	I, 6
dusky	Virginia LL	Numbers	80	4.04	0.79273	i
dusky	Virginia LL	Numbers	81	1.63	0.53650	i
dusky	Virginia LL	Numbers	86	0.55	0.58993	i
dusky	Virginia LL	Numbers	90	0.08	0.79886	i
dusky	Virginia LL	Numbers	91	0.10	0.85700	i
dusky	Virginia LL	Numbers	92	0.44	1.11336	i
dusky	Virginia LL	Numbers	93	0.38	0.90493	i
dusky	Virginia LL	Numbers	95	0.19	0.98798	i
dusky	LPS	Numbers	86	30.69	0.17500	r, 10
dusky	LPS	Numbers	87	25.80	0.21600	r
dusky	LPS	Numbers	88	13.21	0.43000	r
dusky	LPS	Numbers	89	24.13	0.21900	r
dusky	LPS	Numbers	90	12.15	0.44300	r
dusky	LPS	Numbers	91	23.33	0.22000	r
dusky	LPS	Numbers	92	6.21	0.69800	r
dusky	LPS	Numbers	93	11.77	0.47600	r
dusky	LPS	Numbers	94	4.76	0.94223	r
dusky	LPS	Numbers	95	16.06	0.33873	r
dusky	MRFSS,HBOAT,TX	Numbers	81	6.30	1.00000	r, 9
dusky	MRFSS,HBOAT,TX	Numbers	82	1.28	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	83	3.01	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	84	5.74	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	85	2.15	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	86	2.34	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	87	3.53	1.00000	r, 9
dusky	MRFSS,HBOAT,TX	Numbers	88	2.09	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	89	1.82	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	90	1.50	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	91	1.66	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	92	3.92	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	93	0.48	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	94	1.21	1.00000	r
dusky	MRFSS,HBOAT,TX	Numbers	95	1.04	1.00000	r
dusky	pelagic logbook	Numbers	92	1.52	0.24300	c, 8
dusky	pelagic logbook	Numbers	93	1.25	0.18980	c
dusky	pelagic logbook	Numbers	94	0.89	0.18019	c
dusky	pelagic logbook	Numbers	95	0.67	0.23569	c
tiger	Virginia LL	Numbers	76	2.47	0.46521	I, 6
tiger	Virginia LL	Numbers	80	1.03	0.85054	i
tiger	Virginia LL	Numbers	81	1.67	0.54822	i
tiger	Virginia LL	Numbers	86	2.33	0.37324	i
tiger	Virginia LL	Numbers	90	0.48	0.78341	i
tiger	Virginia LL	Numbers	91	0.77	0.58496	i
tiger	Virginia LL	Numbers	92	0.22	1.07707	i
tiger	Virginia LL	Numbers	93	0.00	1.00000	i
tiger	Virginia LL	Numbers	95	0.83	0.63429	i
tiger	SC LL	Numbers	83	1.08	1.00000	I, 5
tiger	SC LL	Numbers	94	1.93	1.00000	i
tiger	SC LL	Numbers	95	1.29	1.00000	i
tiger	pelagic logbook	Numbers	86	4.13	0.36720	c, 8
tiger	pelagic logbook	Numbers	87	2.45	0.47680	c
tiger	pelagic logbook	Numbers	88	1.94	0.56970	c
tiger	pelagic logbook	Numbers	89	2.93	0.35840	c
tiger	pelagic logbook	Numbers	90	3.30	0.29290	c
tiger	pelagic logbook	Numbers	91	2.89	0.37410	c
tiger	pelagic logbook	Numbers	92	2.17	0.21470	c
tiger	pelagic logbook	Numbers	93	2.40	0.18770	c
tiger	pelagic logbook	Numbers	94	2.75	0.15550	c
tiger	pelagic logbook	Numbers	95	2.23	0.20000	c
tiger	NMFS LL	Numbers	86	49.87	0.18900	I, 11
tiger	NMFS LL	Numbers	89	30.28	0.25600	i
tiger	NMFS LL	Numbers	91	30.98	0.29800	i
sand tiger	Virginia LL	Numbers	76	4.45	0.44142	I, 6
sand tiger	Virginia LL	Numbers	80	4.63	0.41805	i
sand tiger	Virginia LL	Numbers	81	1.73	0.58150	i
sand tiger	Virginia LL	Numbers	86	2.25	0.44401	i
sand tiger	Virginia LL	Numbers	90	2.04	0.47503	i
sand tiger	Virginia LL	Numbers	91	1.20	0.50641	i
sand tiger	Virginia LL	Numbers	92	1.10	0.75105	i
sand tiger	Virginia LL	Numbers	93	0.85	0.81886	i
sand tiger	Virginia LL	Numbers	95	0.83	0.63429	i
sand tiger	MRFSS,HBOAT,TX	Numbers	81	2.35	1.00000	r, 9
sand tiger	MRFSS,HBOAT,TX	Numbers	82	11.92	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	83	11.98	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	84	2.34	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	85	2.97	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	86	2.28	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	87	1.79	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	88	0.13	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	89	0.41	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	90	0.043	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	91	0.030	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	92	0.12	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	93	0.92	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	94	0.005	1.00000	r
sand tiger	MRFSS,HBOAT,TX	Numbers	95	0.19	1.00000	r
night	pelagic logbook	Numbers	92	1.42	0.72390	c, 8
night	pelagic logbook	Numbers	93	2.30	0.44530	c
night	pelagic logbook	Numbers	94	1.15	0.71970	c
night	pelagic logbook	Numbers	95	1.13	0.67180	c

silky	pelagic logbook	Numbers	92	3.76	0.17850	c, 8
silky	pelagic logbook	Numbers	93	3.76	0.14830	c
silky	pelagic logbook	Numbers	94	2.68	0.16350	c
silky	pelagic logbook	Numbers	95	4.26	0.14090	c
hammerhead	pelagic logbook	Numbers	86	2.92	0.30680	c, 8
hammerhead	pelagic logbook	Numbers	87	1.48	0.25380	c
hammerhead	pelagic logbook	Numbers	88	2.44	0.19250	c
hammerhead	pelagic logbook	Numbers	89	1.65	0.20380	c, 8
hammerhead	pelagic logbook	Numbers	90	1.76	0.20310	c
hammerhead	pelagic logbook	Numbers	91	1.28	0.24940	c
hammerhead	pelagic logbook	Numbers	92	1.48	0.12190	c
hammerhead	pelagic logbook	Numbers	93	1.07	0.14110	c
hammerhead	pelagic logbook	Numbers	94	0.89	0.13990	c
hammerhead	pelagic logbook	Numbers	95	0.64	0.17340	c
hammerhead	LPS	Numbers	86	5.49	1.00000	r, 10
hammerhead	LPS	Numbers	87	3.41	1.00000	r
hammerhead	LPS	Numbers	88	0.85	1.00000	r
hammerhead	LPS	Numbers	89	3.34	1.00000	r
hammerhead	LPS	Numbers	90	2.47	1.00000	r
hammerhead	LPS	Numbers	91	6.03	1.00000	r
hammerhead	LPS	Numbers	92	2.10	1.00000	r
hammerhead	LPS	Numbers	93	0.69	1.00000	r
hammerhead	LPS	Numbers	94	1.12	1.00000	r
hammerhead	LPS	Numbers	95	0.00	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	81	1.02	1.00000	r, 9
hammerhead	MRFSS,HBOAT,TX	Numbers	82	11.43	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	83	14.51	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	84	10.28	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	85	8.40	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	86	2.97	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	87	1.86	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	88	1.79	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	89	1.48	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	90	3.18	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	91	4.39	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	92	2.39	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	93	3.90	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	94	1.41	1.00000	r
hammerhead	MRFSS,HBOAT,TX	Numbers	95	2.22	1.00000	r
sc hammerh	NMFS LL	Numbers	86	26.33	0.32300	I, 11
sc hammerh	NMFS LL	Numbers	89	70.75	0.20100	i
sc hammerh	NMFS LL	Numbers	91	50.99	0.23500	i
pelagic sharks	pelagic logbook	Numbers	86	11.89	0.24599	c, 8
pelagic sharks	pelagic logbook	Numbers	87	8.34	0.11864	c
pelagic sharks	pelagic logbook	Numbers	88	6.17	0.12584	c
pelagic sharks	pelagic logbook	Numbers	89	4.98	0.12166	c
pelagic sharks	pelagic logbook	Numbers	90	5.79	0.11809	c
pelagic sharks	pelagic logbook	Numbers	91	6.04	0.12460	c
pelagic sharks	pelagic logbook	Numbers	92	4.38	0.07182	c
pelagic sharks	pelagic logbook	Numbers	93	3.97	0.07618	c
pelagic sharks	pelagic logbook	Numbers	94	3.60	0.07586	c
pelagic sharks	pelagic logbook	Numbers	95	3.52	0.07118	c
blue	Japanese obs	Numbers	78	2.43	0.22000	c, 3
blue	Japanese obs	Numbers	79	1.77	0.19000	c
blue	Japanese obs	Numbers	80	1.55	0.17000	c
blue	Japanese obs	Numbers	81	1.09	0.18000	c
blue	Japanese obs	Numbers	82	0.45	0.40000	c
blue	Japanese obs	Numbers	83	1.08	0.35000	c
blue	Japanese obs	Numbers	84	1.89	0.23000	c
blue	Japanese obs	Numbers	85	1.62	0.22000	c
blue	Japanese obs	Numbers	86	1.34	0.24000	c
blue	Japanese obs	Numbers	87	1.00	0.27000	c
blue	Japanese obs	Numbers	88	0.40	0.58000	c
blue	pelagic logbook	Numbers	86	6.52	0.27470	c, 8
blue	pelagic logbook	Numbers	87	3.82	0.16763	c
blue	pelagic logbook	Numbers	88	2.95	0.17177	c
blue	pelagic logbook	Numbers	89	1.98	0.18193	c
blue	pelagic logbook	Numbers	90	2.54	0.16259	c
blue	pelagic logbook	Numbers	91	2.43	0.17528	c
blue	pelagic logbook	Numbers	92	1.86	0.11736	c
blue	pelagic logbook	Numbers	93	1.78	0.12396	c
blue	pelagic logbook	Numbers	94	1.66	0.11951	c
blue	pelagic logbook	Numbers	95	1.58	0.11562	c
blue	LPS	Numbers	86	77.69	0.22500	r, 10
blue	LPS	Numbers	87	45.47	0.37500	r
blue	LPS	Numbers	88	91.03	0.23800	r
blue	LPS	Numbers	89	50.50	0.31000	r
blue	LPS	Numbers	90	57.96	0.29400	r
blue	LPS	Numbers	91	118.46	0.19800	r
blue	LPS	Numbers	92	146.92	0.18500	r
blue	LPS	Numbers	93	133.33	0.22400	r
blue	LPS	Numbers	94	160.70	0.19378	r
blue	LPS	Numbers	95	141.42	0.24148	r
mako	Japanese obs	Numbers	78	0.60	0.19000	c, 3
mako	Japanese obs	Numbers	79	0.42	0.19000	c
mako	Japanese obs	Numbers	80	0.36	0.18000	c
mako	Japanese obs	Numbers	81	0.30	0.19000	c
mako	Japanese obs	Numbers	82	0.16	0.44000	c
mako	Japanese obs	Numbers	83	0.22	0.40000	c
mako	Japanese obs	Numbers	84	0.30	0.25000	c
mako	Japanese obs	Numbers	85	0.23	0.25000	c
mako	Japanese obs	Numbers	86	0.27	0.27000	c
mako	Japanese obs	Numbers	87	0.26	0.30000	c
mako	Japanese obs	Numbers	88	0.17	0.65000	c
mako	pelagic logbook	Numbers	86	9.57	0.24145	c, 8
mako	pelagic logbook	Numbers	87	8.03	0.15924	c
mako	pelagic logbook	Numbers	88	5.50	0.19514	c
mako	pelagic logbook	Numbers	89	5.74	0.17913	c

mako	pelagic logbook	Numbers	90	4.52	0.21415	c
mako	pelagic logbook	Numbers	91	5.41	0.19121	c
mako	pelagic logbook	Numbers	92	6.43	0.12212	c
mako	pelagic logbook	Numbers	93	5.04	0.15092	c
mako	pelagic logbook	Numbers	94	4.22	0.16402	c
mako	pelagic logbook	Numbers	95	4.26	0.15698	c
mako	weighout	Biomass	85	60.84	0.11800	c, 3
mako	weighout	Biomass	86	76.87	0.08800	c
mako	weighout	Biomass	87	55.63	0.06600	c
mako	weighout	Biomass	88	53.03	0.05900	c
mako	weighout	Biomass	89	49.57	0.06400	c
mako	weighout	Biomass	90	41.70	0.06400	c
mako	weighout	Biomass	91	38.12	0.05600	c
mako	weighout	Biomass	92	24.47	0.05300	c
mako	weighout	Biomass	93	32.73	0.04400	c
mako	LPS	Numbers	86	40.48	0.18500	r, 10
mako	LPS	Numbers	87	26.67	0.26400	r
mako	LPS	Numbers	88	11.11	0.50200	r
mako	LPS	Numbers	89	17.95	0.34800	r
mako	LPS	Numbers	90	20.55	0.31100	r
mako	LPS	Numbers	91	33.32	0.20900	r
mako	LPS	Numbers	92	31.84	0.22200	r
mako	LPS	Numbers	93	32.97	0.26700	r
mako	LPS	Numbers	94	29.62	0.25355	r
mako	LPS	Numbers	95	27.30	0.27106	r
thresher	pelagic logbook	Numbers	86	2.66	0.34540	c, 8
thresher	pelagic logbook	Numbers	87	3.83	0.18830	c
thresher	pelagic logbook	Numbers	88	4.16	0.18580	c
thresher	pelagic logbook	Numbers	89	3.72	0.18840	c
thresher	pelagic logbook	Numbers	90	3.05	0.21020	c
thresher	pelagic logbook	Numbers	91	2.28	0.24660	c
thresher	pelagic logbook	Numbers	92	2.86	0.20330	c
thresher	pelagic logbook	Numbers	93	3.01	0.16480	c
thresher	pelagic logbook	Numbers	94	2.19	0.20160	c
thresher	pelagic logbook	Numbers	95	2.12	0.19810	c
thresher	weighout	Biomass	85	2.21	0.60200	c, 3
thresher	weighout	Biomass	86	3.10	0.33300	c
thresher	weighout	Biomass	87	4.08	0.19700	c
thresher	weighout	Biomass	88	8.80	0.16600	c
thresher	weighout	Biomass	89	2.72	0.23800	c
thresher	weighout	Biomass	90	2.19	0.24400	c
thresher	weighout	Biomass	91	1.23	0.24500	c
thresher	weighout	Biomass	92	1.67	0.17500	c
thresher	weighout	Biomass	93	4.76	0.13500	c
ocean whitetip	pelagic logbook	Numbers	92	2.18	0.20256	c, 8
ocean whitetip	pelagic logbook	Numbers	93	1.35	0.27204	c
ocean whitetip	pelagic logbook	Numbers	94	1.18	0.27528	c
ocean whitetip	pelagic logbook	Numbers	95	0.88	0.34387	c
small coastal	SC LL	Numbers	83	1.81	1.00000	I, 5
small coastal	SC LL	Numbers	94	2.22	1.00000	i
small coastal	SC LL	Numbers	95	1.75	1.00000	i
sharpnose	Oregon II	Numbers	72	0.40	0.34000	I, 12
sharpnose	Oregon II	Numbers	73	0.41	0.26000	i
sharpnose	Oregon II	Numbers	74	1.69	0.19000	i
sharpnose	Oregon II	Numbers	75	1.28	0.18000	i
sharpnose	Oregon II	Numbers	76	1.21	0.15000	i
sharpnose	Oregon II	Numbers	77	0.63	0.21000	i
sharpnose	Oregon II	Numbers	78	0.69	0.21000	i
sharpnose	Oregon II	Numbers	79	0.80	0.21000	i
sharpnose	Oregon II	Numbers	80	1.33	0.22000	I
sharpnose	Oregon II	Numbers	81	0.85	0.20000	I, 12
sharpnose	Oregon II	Numbers	82	0.89	0.20000	i
sharpnose	Oregon II	Numbers	83	0.73	0.28000	i
sharpnose	Oregon II	Numbers	84	0.66	0.23000	i
sharpnose	Oregon II	Numbers	85	1.03	0.39000	i
sharpnose	Oregon II	Numbers	86	0.30	0.59000	i
sharpnose	Oregon II	Numbers	87	4.65	0.90000	i
sharpnose	Oregon II	Numbers	88	0.27	0.50000	i
sharpnose	Oregon II	Numbers	89	0.41	0.53000	i
sharpnose	Oregon II	Numbers	90	0.11	0.67000	i
sharpnose	Oregon II	Numbers	91	0.19	0.47000	i
sharpnose	Oregon II	Numbers	92	0.19	0.50000	i
sharpnose	Oregon II	Numbers	93	0.28	0.50000	i
sharpnose	Oregon II	Numbers	94	1.08	0.42000	i
sharpnose	Oregon II	Numbers	95	0.48	0.57000	i
sharpnose	Virginia LL	Numbers	76	4.84	0.46854	I, 6
sharpnose	Virginia LL	Numbers	80	8.02	0.50577	i
sharpnose	Virginia LL	Numbers	81	11.51	0.39218	i
sharpnose	Virginia LL	Numbers	86	4.42	0.45467	i
sharpnose	Virginia LL	Numbers	90	6.15	0.43610	i
sharpnose	Virginia LL	Numbers	91	3.18	0.54780	i
sharpnose	Virginia LL	Numbers	92	6.65	0.48736	i
sharpnose	Virginia LL	Numbers	93	12.93	0.62490	i
sharpnose	Virginia LL	Numbers	95	18.57	0.43888	i

sharpnose	SC LL	Numbers	83	0.84	1.00000	I, 5
sharpnose	SC LL	Numbers	94	1.96	1.00000	i
sharpnose	SC LL	Numbers	95	1.71	1.00000	i
bonnethead	Oregon II	Numbers	72	1.64	0.36000	I, 12
bonnethead	Oregon II	Numbers	73	5.48	0.25000	i
bonnethead	Oregon II	Numbers	74	2.99	0.25000	i
bonnethead	Oregon II	Numbers	75	1.63	0.43000	i
bonnethead	Oregon II	Numbers	76	3.28	0.25000	i
bonnethead	Oregon II	Numbers	77	2.60	0.50000	i
bonnethead	Oregon II	Numbers	78	1.09	0.38000	i
bonnethead	Oregon II	Numbers	79	1.88	0.67000	i
bonnethead	Oregon II	Numbers	80	0.86	0.52000	i
bonnethead	Oregon II	Numbers	81	0.37	0.49000	i
bonnethead	Oregon II	Numbers	82	0.48	0.40000	i
bonnethead	Oregon II	Numbers	83	0.63	0.56000	i
bonnethead	Oregon II	Numbers	84	0.00	1.00000	i
bonnethead	Oregon II	Numbers	85	0.34	1.00000	i
bonnethead	Oregon II	Numbers	86	0.00	1.00000	i
bonnethead	Oregon II	Numbers	87	0.00	1.00000	i
bonnethead	Oregon II	Numbers	88	0.51	1.00000	i
bonnethead	Oregon II	Numbers	89	0.00	1.00000	i
bonnethead	Oregon II	Numbers	90	0.00	1.00000	i
bonnethead	Oregon II	Numbers	91	0.00	1.00000	i
bonnethead	Oregon II	Numbers	92	0.00	1.00000	i
bonnethead	Oregon II	Numbers	93	0.49	1.00000	i
bonnethead	Oregon II	Numbers	94	0.00	1.00000	i
bonnethead	Oregon II	Numbers	95	0.00	1.00000	i

Sources c, commercial fishery catch rate;
r, recreational fishery catch rate.
i, resource survey catch rate.
1, document SB-III-22
2, SB-III-13
3, see 1994&1995 Shark Evaluation Reports, SB-III-16 & SB-III-15
4, SB-III-1
5, SB-III-9
6, SB-III-10
7, SB-III-19
8, SB-III-3
9, SB-III-5
10, SB-III-2
11, SB-II/95/05
12, SB-III-24

APPENDIX

Production Model Results and Projections

Large Coastal Sharks 96 | Test Using Unweighted CPUE
DATE: 06-06-1996 | TIME: 09:10:56

Initial Parameter Estimates

	Estimate	Lower Bound	Upper Bound
1. N(96)	400000	300000	2E+07
2. MSC	300000	100	1E+08
3. r	.5	.01	1

It= 1 SSQHigh= 171.3577 SSQLow= .6631783 No.Rewt= 0
Iteration= 708
Sum of Squares Before = .2130275 After = .2041181
lambda = .1 omega = 0
Convergence in Simplex Search: tolerance RSS = .0001 ; parameter = .0005

EQUILIBRIUM PRODUCTION MODEL PARAMETERS

Virgin Stock	4856653.000
Stock at MSC	2428326.500
MSC	312968.406
F at MSC	0.129

PRODUCTION MODEL STATISTICS BY YEAR

	Stock	F	Obs C	Equil C	Surp Prod (#)	
81	6462842.000	0.046	282107.000	184414.328	-402868.000	81
82	5777867.000	0.079	431017.000	266116.281	-174782.000	82
83	5172068.000	0.160	764958.000	294427.375	18617.500	83
84	4425727.500	0.064	279821.000	234753.594	118584.500	84
85	4264491.000	0.094	389579.000	290094.000	156737.000	85
86	4031649.000	0.131	507956.000	312866.688	202023.500	86
87	3725716.500	0.139	498951.000	311061.344	240918.000	87
88	3467683.500	0.216	699941.000	171056.563	276746.000	88
89	3044488.500	0.258	678844.000	-1.013	204262.500	89
90	2569907.000	0.221	540815.000	154490.094	312710.750	90
91	2341802.750	0.229	512294.000	124299.336	310858.000	91
92	2140366.750	0.268	541083.000	-51729.762	304145.250	92
93	1903429.000	0.243	443327.000	68717.836	293635.125	93
94	1753737.125	0.222	378926.000	149083.891	285219.375	94
95	1660030.500	0.227	367223.000	129767.195	277758.500	95
96	1570566.000	0.000	0.000	0.000	0.000	96

RELATIVE PRODUCTION MODEL STATISTICS BY YEAR

	N/N MSC	F/F MSC	C Ob/MSC	C Eq/MSC	C Ob/C Eq	Surplus/N	
81	2.661	0.359	0.901	0.589	1.530	-0.062	81
82	2.379	0.613	1.377	0.850	1.620	-0.030	82
83	2.130	1.243	2.444	0.941	2.598	0.004	83
84	1.823	0.500	0.894	0.750	1.192	0.027	84
85	1.756	0.730	1.245	0.927	1.343	0.037	85
86	1.660	1.018	1.623	1.000	1.624	0.050	86
87	1.534	1.078	1.594	0.994	1.604	0.065	87
88	1.428	1.673	2.236	0.547	4.092	0.080	88
89	1.254	2.000	2.169	-0.000	0.000	0.067	89
90	1.058	1.712	1.728	0.494	3.501	0.122	90
91	0.964	1.776	1.637	0.397	4.121	0.133	91
92	0.881	2.079	1.729	-0.165	0.000	0.142	92
93	0.784	1.883	1.417	0.220	6.451	0.154	93
94	0.722	1.724	1.211	0.476	2.542	0.163	94
95	0.684	1.765	1.173	0.415	2.830	0.167	95
96	0.647	0.000	0.000	0.000	0.000	0.000	96

INDEX RESULTS
Index No. 3 Comb Prod Model Index: Applied to ages 0 to 1
Index Fitted to Mid-Year Stock Size in NUMBERS

Index Data: Observed, Scaled (and/or Transformed), Predicted

	Obs Index	Yr Weights	Scaled Index	Pred Index	Wted Resid	
81	1.1103	1.0000	0.1046	0.2598	-0.1552	81
82	1.2681	1.0000	0.2375	0.1488	0.0887	82

83	0.9977	1.0000	-0.0023	0.0154	-0.0177	83
84	0.8133	1.0000	-0.2067	-0.0795	-0.1272	84
85	1.1346	1.0000	0.1263	-0.1264	0.2527	85
86	0.8678	1.0000	-0.1417	-0.1941	0.0523	86
87	0.6866	1.0000	-0.3760	-0.2693	-0.1068	87
88	0.7600	1.0000	-0.2744	-0.3705	0.0960	88
89	0.5675	1.0000	-0.5666	-0.5794	0.0128	89
90	0.4359	1.0000	-0.8304	-0.6510	-0.1794	90
91	0.4276	1.0000	-0.8497	-0.7423	-0.1073	91
92	0.4205	1.0000	-0.8663	-0.8452	-0.0211	92
93	0.4378	1.0000	-0.8259	-0.9454	0.1195	93
94	0.3605	1.0000	-1.0202	-1.0137	-0.0065	94
95	0.3792	1.0000	-0.9698	-1.0689	0.0991	95

```
          Stock  : Model & Scaled Index          Standardized Residuals
Year      Model Stock        Index Stock         ------------|------------
81          6095500            5219101               ########|
82          5454810            5961020                       |####
83          4773469            4689749                      #|
84          4341514            3822978                #######|
85          4142733            5333658                       |############
86          3871436            4079498                       |##
87          3591047            3227393                 ######|
88          3245442            3572569                       |####
89          2633578            2667487                       |
90          2451622            2049009              #########|
91          2237581            2009852                 ######|
92          2018900            1976759                     ##|
93          1826348            2058129                       |#####
94          1705753            1694761                      #|
95          1614243            1782383                       |####
```

Q = 2.127321E-07
Residuals Squared Weighted by 1 ; Percent of Total RSS =100.000

Total Residual Analysis

	Sorted Weighted Residuals	Index	Year	Cumul Prob	Normal Z
1	-0.17939	Comb	90	0.0667	-1.4857
2	-0.15523	Comb	81	0.1333	-1.2855
3	-0.12719	Comb	84	0.2000	-1.0534
4	-0.10733	Comb	91	0.2667	-0.8889
5	-0.10677	Comb	87	0.3333	-0.8842
6	-0.02109	Comb	92	0.4000	-0.1747
7	-0.01769	Comb	83	0.4667	-0.1465
8	-0.00646	Comb	94	0.5333	-0.0535
9	0.01279	Comb	89	0.6000	0.1060
10	0.05235	Comb	86	0.6667	0.4335
11	0.08874	Comb	82	0.7333	0.7350
12	0.09603	Comb	88	0.8000	0.7953
13	0.09909	Comb	95	0.8667	0.8206
14	0.11948	Comb	93	0.9333	0.9895
15	0.25268	Comb	85	1.0000	2.0927

Residual Sum of Squares = .2041182
Number of Parameters = 4
Number of Data Points = 15
Mean Squared Error = .0185562

Parameter Estimates

	Estimate	Std Error	Coeff of Var
1. N(96)	1570566	358503.3	0.22826
2. MSC	312968.4	3734.541	0.01193
3. r	.2577647	5.829659E-02	0.22616

Correlation Matrix of Parameters

	N(96)	MSC	r
N(96)	1.000000	-0.886164	-0.999889
MSC	-0.886164	1.000000	0.879622
r	-0.999889	0.879622	1.000000

Large Coastal Sharks 96 DATE: 06-06-1996

Test using Weighted CPUE TIME: 08:02:36

Initial Parameter Estimates

	Estimate	Lower Bound	Upper Bound
1. N(96)	1000000	300000	2E+08
2. MSC	300000	100	1E+08
3. r	.5	.01	1

It= 1 SSQHigh= 96.15959 SSQLow= 88.15889 No.Rewt= 0
Iteration= 175
Sum of Squares Before = .3094364 After = .2895375
lambda = .1 omega = 0
Convergence in Simplex Search: tolerance RSS = .0001 ; parameter = .0005

EQUILIBRIUM PRODUCTION MODEL PARAMETERS

Virgin Stock	4682665.500
Stock at MSC	2341332.750
MSC	304777.500
F at MSC	0.130

PRODUCTION MODEL STATISTICS BY YEAR

	Stock	F	Obs C	Equil C	Surp Prod	(#)
81	5802914.500	0.051	282107.000	192457.625	-256693.000	81
82	5264114.500	0.086	431017.000	270301.063	-86231.000	82
83	4746866.500	0.175	764958.000	269026.500	72099.250	83
84	4054007.750	0.070	279821.000	239997.641	153879.750	84
85	3928066.500	0.102	389579.000	290479.750	182989.750	85
86	3721477.250	0.142	507956.000	302155.813	220328.250	86
87	3433849.500	0.151	498951.000	297015.625	252813.500	87
88	3187712.000	0.236	699941.000	104046.836	282127.500	88
89	2769898.500	0.264	678844.000	-18638.131	300434.250	89
90	2391488.750	0.238	540815.000	94157.406	304225.750	90
91	2154899.500	0.251	512294.000	44168.332	299675.125	91
92	1942280.625	0.260	541083.000	-166.511	351871.875	92
93	1753069.500	0.266	443327.000	-26332.002	279251.250	93
94	1588993.750	0.247	378926.000	58021.133	268325.625	94
95	1478393.375	0.258	367223.000	9958.919	257756.625	95
96	1368927.000	0.000	0.000	0.000	0.000	96

RELATIVE PRODUCTION MODEL STATISTICS BY YEAR

	N/N MSC	F/F MSC	C Ob/MSC	C Eq/MSC	C Ob/C Eq	Surplus/N	
81	2.478	0.393	0.926	0.631	1.466	-0.044	81
82	2.248	0.664	1.414	0.887	1.595	-0.016	82
83	2.027	1.342	2.510	0.883	2.843	0.015	83
84	1.731	0.539	0.918	0.787	1.166	0.038	84
85	1.678	0.783	1.278	0.953	1.341	0.047	85
86	1.589	1.093	1.667	0.991	1.681	0.059	86
87	1.467	1.160	1.637	0.975	1.680	0.074	87
88	1.361	1.812	2.297	0.341	6.727	0.089	88
89	1.183	2.030	2.227	-0.061	0.000	0.108	89
90	1.021	1.831	1.774	0.309	5.744	0.127	90
91	0.920	1.925	1.681	0.145	11.599	0.139	91
92	0.830	2.000	1.775	-0.001	0.000	0.181	92
93	0.749	2.042	1.455	-0.086	0.000	0.159	93
94	0.679	1.900	1.243	0.190	6.531	0.169	94
95	0.631	1.984	1.205	0.033	36.874	0.174	95
96	0.585	0.000	0.000	0.000	0.000	0.000	96

INDEX RESULTS
Index No. 3 Comb Prod Model Index: Applied to ages 0 to 1
Index Fitted to Mid-Year Stock Size in NUMBERS

Index Data: Observed, Scaled (and/or Transformed), Predicted

	Obs Index	Yr Weights	Scaled Index	Pred Index	Wted Resid	
81	1.1286	1.0000	0.1210	0.1772	-0.0562	81
82	1.2423	1.0000	0.2170	0.0769	0.1400	82
83	0.9635	1.0000	-0.0372	-0.0539	0.0167	83

84	0.7951	1.0000	-0.2294	-0.1470	-0.0824	84
85	1.0722	1.0000	0.0697	-0.1900	0.2597	85
86	0.8115	1.0000	-0.2089	-0.2575	0.0486	86
87	0.5204	1.0000	-0.6532	-0.3348	-0.3184	87
88	0.6179	1.0000	-0.4814	-0.4424	-0.0390	88
89	0.5268	1.0000	-0.6410	-0.5869	-0.0540	89
90	0.4273	1.0000	-0.8504	-0.7112	-0.1392	90
91	0.4200	1.0000	-0.8675	-0.8151	-0.0525	91
92	0.4320	1.0000	-0.8394	-0.7989	-0.0405	92
93	0.4566	1.0000	-0.7841	-1.0190	0.2349	93
94	0.3356	1.0000	-1.0917	-1.1036	0.0119	94
95	0.3303	1.0000	-1.1078	-1.1781	0.0703	95

```
        Stock  : Model & Scaled Index          Standardized Residuals
Year    Model Stock      Index Stock           ------------|------------
81        5515387          5213808                      ###|
82        4989127          5739125                         |#####
83        4377293          4451034                         |
84        3988370          3672968                     ####|
85        3820214          4953159                         |#########
86        3570975          3748779                         |#
87        3305488          2404049             ############|
88        2968187          2854710                       ##|
89        2568786          2433662                      ###|
90        2268659          1973854                   ######|
91        2044727          1940221                       ##|
92        2078044          1995566                       ##|
93        1667570          2109167                         |########
94        1532245          1550634                         |
95        1422238          1525826                         |##
```

Q = 2.164598E-07
Residuals Squared Weighted by 1 ; Percent of Total RSS =100.000

Total Residual Analysis

	Sorted Weighted Residuals	Index	Year	Cumul Prob	Normal Z		Sorted Weighted Residuals	Index	Year	Cumul Prob	Normal Z
1	-0.31843	Comb	87	0.0667	-2.2142	9	0.01193	Comb	94	0.6000	0.0830
2	-0.13920	Comb	90	0.1333	-0.9680	10	0.01671	Comb	83	0.6667	0.1162
3	-0.08238	Comb	84	0.2000	-0.5729	11	0.04859	Comb	86	0.7333	0.3379
4	-0.05623	Comb	81	0.2667	-0.3910	12	0.07030	Comb	95	0.8000	0.4889
5	-0.05404	Comb	89	0.3333	-0.3757	13	0.14005	Comb	82	0.8667	0.9738
6	-0.05246	Comb	91	0.4000	-0.3648	14	0.23493	Comb	93	0.9333	1.6336
7	-0.04050	Comb	92	0.4667	-0.2816	15	0.25972	Comb	85	1.0000	1.8060
8	-0.03898	Comb	88	0.5333	-0.2711						

Residual Sum of Squares = .2895375
Number of Parameters = 4
Number of Data Points = 15
Mean Squared Error = 2.632159E-02

Parameter Estimates

	Estimate	Std Error	Coeff of Var
1. N(96)	1368927	80923.17	0.05911
2. MSC	304777.5	15264.97	0.05009
3. r	.2603453	3.461204E-03	0.01329

Correlation Matrix of Parameters

	N(96)	MSC	r
N(96)	1.000000	-0.983757	-0.767898
MSC	-0.983757	1.000000	0.641604
r	-0.767898	0.641604	1.000000

Projections

unweighted prod fit		Catch projection		Status Quo
Year	Begin Yr N	Catch	F	N(Year)/N(96)
96	1570566	367223	0.242	1.00
97	1472515	367223	0.259	0.94
98	1363905	367223	0.282	0.87
99	1242182	367223	0.314	0.79

Prob (N(99) > N(96)) = 0.419

unweighted prod fit		Catch projection		Half Status Quo
Year	Begin Yr N	Catch	F	N(Year)/N(96)
96	1570566	367223	0.242	1.00

97	1472515	183612	0.121	0.94
98	1557588	183612	0.114	0.99
99	1650881	183612	0.108	1.05

Prob (N(99) > N(96)) = 0.518

unweighted prod fit Catch projection No Catch

Year	Begin Yr N	Catch	F	N(Year)/N(96)
96	1570566	367223	0.242	1.00
97	1472515	0	0.000	0.94
98	1749516	0	0.000	1.11
99	2047104	0	0.000	1.30

Prob (N(99) > N(96)) = 0.591

weighted prod fit Catch projection Status Quo

Year	Begin Yr N	Catch	F	N(Year)/N(96)
96	1368927	367223	0.281	1.00
97	1246840	367223	0.312	0.91
98	1108767	367223	0.358	0.81
99	950110	367223	0.430	0.69

Prob (N(99) > N(96)) = 0.377

weighted prod fit Catch projection Half Status Quo

Year	Begin Yr N	Catch	F	N(Year)/N(96)
96	1368927	367223	0.281	1.00
97	1246840	183612	0.144	0.91
98	1304889	183612	0.137	0.95
99	1370021	183612	0.131	1.00

Prob (N(99) > N(96)) = 0.500

weighted prod fit Catch projection No Catch

Year	Begin Yr N	Catch	F	N(Year)/N(96)
96	1368927	367223	0.281	1.00
97	1246840	0	0.000	0.91
98	1498934	0	0.000	1.09
99	1775657	0	0.000	1.30

Prob (N(99) > N(96)) = 0.590

APPENDIX

Simple Likelihood Method Assessments and Projections

Large Coastal 86-95 data:

2500000 .90 .5 1.0 3 150 0.05 32897 N-wag, S-wag, E-wag, tol, nv, limit, Vstop, iseed

86	1	42	3233492	0	0	46.92	213.00	
87	1	55	6797293	0	0	46.03	323.54	
88	1	110	10917849	0	0	28.21	123.41	
89	1	132	12851149	0	0	28.89	468.41	
90	1	123	9161300	0	0	28.75	343.35	
91	1	96	8459134	0	0	40.66	446.81	
92	1	73	8609981	0	0	0	0	
93	1	50	6775795	0	0	0	0	
94	1	27	8438581	0	0	38.81	0.22	
95	1	26	6870848	0	0	49.46	0.71	
86	2	8910.633	4465727	426119	2513307698	10.48	2.43	0
87	2	7417.136	4300705	314379	1859082575	13.68	1.40	0
88	2	7226.015	3562015	300592	877008177	11.85	3.12	0
89	2	6656.828	3079254	221052	642410709	13.93	2.70	0
90	2	6907.863	1332600	213216	643395350	6.25	0.84	0
91	2	8103.268	1307935	293259	2247820229	4.46	0.08	0
92	2	7208.910	1527524	304895	694592551	5.01	0.60	0
93	2	7740.120	1115466	248988	592245136	4.48	0.12	0
94	2	7787.265	936258	160869	207805807	5.82	0.28	0
95	2	7977.755	1173978	183434	463051977	6.40	0.38	0

Starting Statistics:

t :	86	87	88	89	90	91	92	93	94	95	96
N :	7169930	6452937	5807643	5226879	4704191	4233772	3810395	3429355	3086420	2777778	2500000
m :	.2134	.2062	.3284	.3650	.3505	.3179	.2426	.2027	.1508	.1533	.2531
Σ q·f :	.3188	.3116	.4337	.4703	.4558	.4233	.3479	.3081	.2562	.2586	
q·f(1):	.0969	.1269	.2538	.3046	.2838	.2215	.1685	.1154	.0623	.0600	
q·f(2):	.2219	.1847	.1799	.1657	.1720	.2018	.1795	.1927	.1939	.1986	

q(1): .00230755
q(2): .00002490

m	.22	.29	.28
q(1)	.00278534	.00281801	.00299334
q(2)	.00001188	.00001290	.00001403
N(86)	5865969	3441759	4239574
N(87)	5823682	3643579	4357492
N(88)	5675935	3790791	4398972
N(89)	4756990	3386025	3776861
N(90)	3775305	2863608	3060407
N(91)	3063115	2475972	2538620
N(92)	2641595	2274716	2245081
N(93)	2454747	2255619	2153851
N(94)	2416729	2370160	2197163
N(95)	2535292	2655671	2399503
N(96)	2661060	2976651	2621318
s(86)	.99	1.06	1.03
s(87)	.97	1.04	1.01
s(88)	.84	.89	.86
s(89)	.79	.85	.81
s(90)	.81	.86	.83
s(91)	.86	.92	.88
s(92)	.93	.99	.96
s(93)	.98	1.05	1.02
s(94)	1.05	1.12	1.09
s(95)	1.05	1.12	1.09
F(86)	.2229	.2333	.2507
F(87)	.2413	.2506	.2687
F(88)	.3923	.4032	.4306
F(89)	.4468	.4578	.4885
F(90)	.4247	.4357	.4651
F(91)	.3637	.3750	.4011
F(92)	.2890	.2987	.3197
F(93)	.2312	.2407	.2583
F(94)	.1677	.1765	.1901
F(95)	.1672	.1761	.1898
ƒ[LL]	646.	653.	690.

ƒ[LL] = 646.020682
Pr[ƒ(LL)] = 0.000000000 at 24 df.

	M L E	cv	var	CI(90)'s		CI(80)'s	
m	.22	.111	0.57674098E-03	.18	.26	.18	.25
q(1)	.00278534	.074	0.42251665E-07	-.03672005	.04229073	-.02800244	.03357312
q(2)	.00001188	.054	0.40524006E-12	-.03949350	.03951727	-.03077590	.03079967
N(86)	5865969	.125	0.53874167E+12	4658555	7073383	4924993	6806944
N(87)	5823682	.115	0.44819374E+12	4722399	6924965	4965418	6681946
N(88)	5675935	.103	0.33870986E+12	4718565	6633305	4929826	6422043
N(89)	4756990	.086	0.16570346E+12	4087365	5426616	4235131	5278850
N(90)	3775305	.070	0.69442270E+11	3341816	4208794	3437474	4113136

N(91)	3063115	.060	0.33791784E+11	2760722	3365507	2827450	3298779
N(92)	2641595	.057	0.22474182E+11	2394986	2888203	2449405	2833784
N(93)	2454747	.058	0.20346477E+11	2220102	2689391	2271881	2637612
N(94)	2416729	.063	0.23181996E+11	2166267	2667190	2221536	2611921
N(95)	2535292	.070	0.31717895E+11	2242325	2828258	2306974	2763610
N(96)	2661060	.083	0.48759924E+11	2297817	3024303	2377973	2944147
s(86)	.99	.021	0.45512583E-03	.96	1.03	.97	1.02
s(87)	.97	.023	0.50545281E-03	.94	1.01	.95	1.00
s(88)	.84	.029	0.60760695E-03	.80	.88	.81	.87
s(89)	.79	.033	0.67702042E-03	.75	.84	.76	.83
s(90)	.81	.031	0.64790273E-03	.77	.85	.78	.84
s(91)	.86	.027	0.55158729E-03	.82	.90	.83	.89
s(92)	.93	.025	0.53239413E-03	.89	.97	.90	.96
s(93)	.98	.023	0.49257770E-03	.95	1.02	.96	1.01
s(94)	1.05	.021	0.50038850E-03	1.01	1.09	1.02	1.08
s(95)	1.05	.021	0.49522791E-03	1.01	1.09	1.02	1.08
F(86)	.2229	.049	0.11903321E-03	.2049	.2408	.2089	.2369
F(87)	.2413	.053	0.16354033E-03	.2203	.2624	.2249	.2577
F(88)	.3923	.060	0.55858291E-03	.3534	.4311	.3620	.4226
F(89)	.4468	.063	0.78308978E-03	.4007	.4928	.4109	.4826
F(90)	.4247	.062	0.68654592E-03	.3816	.4678	.3911	.4583
F(91)	.3637	.058	0.44162048E-03	.3291	.3983	.3367	.3906
F(92)	.2890	.056	0.26355037E-03	.2623	.3157	.2682	.3098
F(93)	.2312	.052	0.14265256E-03	.2116	.2509	.2159	.2466
F(94)	.1677	.047	0.62300419E-04	.1548	.1807	.1576	.1779
F(95)	.1672	.047	0.61184696E-04	.1543	.1801	.1572	.1772

Period	F	N	Landings (Numbers)	Growth (Surplus)	^^ N	$\bar{w}$	$\bar{B}$	Growth (Weight)
86	.22	5865969	495034	1411625	-42286	25.78	150701687	36397266
87	.24	5823682	462050	1401448	-147746	33.49	192566475	46939682
88	.39	5675935	687613	1365894	-918943	24.19	125672274	33034796
89	.45	4756990	665882	1144753	-981684	26.00	110176112	29761654
90	.42	3775305	531870	908514	-712189	25.89	88051376	23523943
91	.36	3063115	501305	737128	-421519	35.81	101870311	26398292
92	.29	2641595	2023454	635690	-186847	5.01	12757751	3184807
93	.23	2454747	1761442	590726	-38017	4.48	10911772	2646452
94	.17	2416729	378302	581577	118563	35.52	87911073	20654890
95	.17	2535292	322351	610109	125768	43.18	112146685	26342233
96		2661060						

P R O J E C T I O N S : 96 Landings Are Assumed Equal To 95 Landings (Quota).

No Landings (Moratorium).

96	.12	2661060	322351	640375	281279
97		2942338		708064	708063
98		3650402		878457	878456
99		4528858		1089854	1089854

Landings Equal Half The Surplus.

96	.12	2661060	322351	640375	281279
97	.11	2942338	354032	708064	313681
98	.11	3256019	391775	783550	347123
99	.11	3603142	433542	867084	384129

Landings Equal To The Surplus.

96	.12	2661060	322351	640375	281279
97	.22	2942338	610109	610109	0
98	.22	2942338	610109	610109	0
99	.22	2942338	610109	610109	0

Qutoa (95 Landings) Projection

96	.12	2661060	322351	640375	281279
97	.10	2942338	322351	708064	349042
98	.09	3291381	322351	792060	433113
99	.08	3724493	322351	896287	537412

F(95) Projection

96	.12	2661060	322351	640375	281279
97	.17	2942338	504113	708064	145960
98	.17	3088299	529121	743189	153201
99	.17	3241499	555369	780056	160801

Large Coastal 94-95 data:

```
 5000000 .95  0.5  5.0  3  150 0.05  32490       N-wag, S-wag, E-wag, tol, nv, limit, Vstop, iseed
94 1      27           8863897   228392             0     38.81      0.22
95 1      26           7023926   142012             0     49.46      0.71                 L(94) = 389261
94 2    7787.265        936258   160869     207805807      5.82      0          0.28    L(94) = 325446
95 2    7977.755       1173978   183434     463051977      6.40      0          0.38
```

Starting Statistics:

t :	94	95	96
N :	5540166	5263158	5000000
m :	.0223	.0217	.0220
Σ q·f :	.0736	.0730	

q·f(1):	.0388	.0374
q·f(2):	.0348	.0357

q(1):	.00143662
q(2):	.00000447

m	.01	0.00	.02
q(1)	.00225027	.00211756	.00247024
q(2)	.00000661	.00000623	.00000714
N(94)	3684946	3911921	3356689
N(95)	3313034	3525803	3029167
N(96)	2981613	3180753	2736638
s(94)	.90	.90	.90
s(95)	.90	.90	.90
F(94)	.1122	.1057	.1223
F(95)	.1112	.1048	.1212
ƒ[LL]	220.	224.	225.

ƒ[LL] = 220.497875
Pr[ƒ(LL)] = .000000000 at 0 df.

	M L E	cv	var	CI(90)'s		CI(80)'s	
m	.01	2.128	0.15288638E-03	-.01	.03	-.01	.02
q(1)	.00225027	.049	0.12200028E-07	-.01808970	.02259024	-.01360130	.01810185
q(2)	.00000661	.072	0.22450010E-12	-.02033336	.02034658	-.01584497	.01585818
N(94)	3684946	.052	0.36173498E+11	3372078	3997814	3441118	3928774
N(95)	3313034	.058	0.37255958E+11	2995519	3630548	3065585	3560483
N(96)	2981613	.068	0.41656746E+11	2645869	3317357	2719957	3243269
s(94)	.90	.016	0.19454400E-03	.88	.92	.88	.92
s(95)	.90	.016	0.19494535E-03	.88	.92	.88	.92
F(94)	.1122	.055	0.38410266E-04	.1020	.1224	.1043	.1201
F(95)	.1112	.056	0.38223471E-04	.1010	.1214	.1033	.1191

Period	F	N	Landings (Numbers)	Growth (Surplus)	^^ N	$\bar{w}$	$\bar{B}$	Growth (Weight)
94	.11	3684946	389261	21474	-371912	35.66	124591705	765726
95	.11	3313034	325446	19306	-331420	43.29	136069986	835826
96		2981613						

P R O J E C T I O N S : 96 Landings Are Assumed Equal To 95 Landings (Quota).

No Landings (Moratorium).

96	.12	2981613	325446	17375	-309035
97		2672577		15575	15574
98		2688152		15665	15665
99		2703816		15757	15756

Landings Equal Half The Surplus.

96	.12	2981613	325446	17375	-309035
97	0.00	2672577	7787	15575	7764
98	0.00	2680342	7810	15620	7787
99	0.00	2688129	7833	15665	7809

Landings Equal To The Surplus.

96	.12	2981613	325446	17375	-309035
97	.01	2672577	19306	19306	0
98	.01	2672577	19306	19306	0
99	.01	2672577	19306	19306	0

Qutoa (95 Landings) Projection

96	.12	2981613	325446	17375	-309035
97	.13	2672577	325446	15575	-310839
98	.15	2361739	325446	13763	-312653
99	.17	2049086	325446	11941	-314479

F(95) Projection

96	.12	2981613	325446	17375	-309035
97	.11	2672577	282090	15575	-267352
98	.11	2405225	253871	14017	-240608
99	.11	2164618	228475	12615	-216538

Blacktip 94-95 data:

```
500000 0.90  0.25  5.0  3  150  0.025   2349      N-wag, S-wag, E-wag, tol, nv, limit, Vstop, iseed
94 1        27  1437192 54050         0 26.59 0.6450   (Y=1436013, d=1179)
95 1        26  1113014 47626         0 23.37 0.0141   (Y=1112694, d= 320)
94 2 7.787265   241287 66106 64175360  3.65 0.4700    L(94) = 120,156
95 2 7.977755   361378 67046 60976885  5.39 0.3700    L(95) = 114,672
```

Starting Statistics:

t :	94	95	96
N :	617284	555556	500000

m :	.1430	.1424	.1427
Σ q·f :	.2484	.2478	
q·f(1):	.1095	.1055	
q·f(2):	.1389	.1423	
q(1):	.00405605		
q(2):	.01783633		

m	.15	.15	.20
q(1)	.00371367	.00414622	.00364919
q(2)	.01660716	.01952288	.01713689
N(94)	555834	523709	527928
N(95)	513165	465983	510990
N(96)	474032	414797	494786
s(94)	.92	.89	.97
s(95)	.92	.89	.97
F(94)	.2296	.2640	.2320
F(95)	.2290	.2636	.2316
ƒ[LL]	0.	3.	4.

ƒ[LL] = .381070
Pr[ƒ(LL)] = .826516814 at 2 df.

	M L E	cv	var	CI(90)'s		CI(80)'s	
m	.15	.164	0.60599087E-03	.11	.19	.12	.18
q(1)	.00371367	.096	0.12759878E-06	-.03678110	.04420844	-.02784518	.03527251
q(2)	.01660716	.094	0.24427775E-05	-.02388761	.05710193	-.01495168	.04816600
N(94)	555834	.076	0.17818272E+10	486396	625273	501719	609950
N(95)	513165	.087	0.19920165E+10	439745	586584	455947	570383
N(96)	474032	.107	0.25523103E+10	390926	557138	409264	538799
s(94)	.92	.030	0.76179378E-03	.88	.97	.89	.96
s(95)	.92	.030	0.75924326E-03	.88	.97	.89	.96
F(94)	.2296	.089	0.41620172E-03	.1960	.2632	.2034	.2557
F(95)	.2290	.089	0.41441495E-03	.1956	.2625	.2029	.2551

Period	F	N	Landings (Numbers)	Growth (Surplus)	^^ N	$\bar{w}$	$\bar{B}$	Growth (Weight)
94	.23	555834	120156	89772	-42669	23.29	12439801	2090996
95	.23	513165	114672	82881	-39132	18.96	9352768	1571676
96		474032						

P R O J E C T I O N S : 96 Landings Are Assumed Equal To 95 Landings (Quota).

No Landings (Moratorium).

96	.25	474032	114672	76560	-47302
97		426729		68921	68921
98		495649		80052	80052
99		575701		92981	92981

Landings Equal Half The Surplus.

96	.25	474032	114672	76560	-47302
97	.08	426729	34461	68921	31779
98	.08	458508	37027	74054	34146
99	.08	492654	39784	79569	36690

Landings Equal To The Surplus.

96	.25	474032	114672	76560	-47302
97	.15	426729	82881	82881	0
98	.15	426729	82881	82881	0
99	.15	426729	82881	82881	0

Qutoa (95 Landings) Projection

96	.25	474032	114672	76560	-47302
97	.29	426729	114672	68921	-54994
98	.34	371735	114672	60039	-63954
99	.43	307781	114672	49710	-74419

F(95) Projection

96	.25	474032	114672	76560	-47302
97	.23	426729	93963	68921	-32542
98	.23	394187	86797	63665	-30060
99	.23	364127	80178	58810	-27768

Sandbar 94-95 data:

```
750000  0.90    .25   10.0        3   1.0   0.05  5231    N-wag, S-wag, E-wag, tol, nv, limit, Vstop, iseed
94 1   27     4462785      0        0 34.54 0.0042  (Y=4450935; d=11850)     w(94) = 34.20; w(95) = 40.78
95 1   26     4260938 101999        0 41.75 0.0007  (Y=4258447; d= 2491)     L(95) = 126,868
```

94	2	7.787265	48513	14973	9173724	3.24	0.10
95	2	7.977755	113900	24869	18422779	4.58	0.39

Starting Statistics:

t :	94	95	96
N :	925926	833333	750000
m :	.0882	.0827	.0855
Σ q·f :	.1936	.1881	
q·f(1):	.1663	.1602	
q·f(2):	.0273	.0279	
q(1):	.00616011		
q(2):	.00350246		

m	.09	.10	.12
q(1)	.00645635	.00618493	.00550963
q(2)	.00417467	.00426743	.00334913
N(94)	726183	733442	793348
N(95)	649172	664340	748173
N(96)	583622	604989	709016
s(94)	.89	.91	.94
s(95)	.90	.91	.95
F(94)	.2068	.2002	.1748
F(95)	.2012	.1949	.1700
f[LL]	2195.	3335.	5809.

f[LL] = 2194.710449
Pr[*f*(LL)] = .000000000 at 2 df.

	M L E	cv	var	CI(90)'s		CI(80)'s	
m	.09	.106	0.10092108E-03	.08	.11	.08	.11
q(1)	.00645635	.085	0.30115687E-06	-.01006923	.02298194	-.00642255	.01933526
q(2)	.00417467	.125	0.27134173E-06	-.01235091	.02070026	-.00870423	.01705358
N(94)	726183	.095	0.47803157E+10	612448	839918	637546	814821
N(95)	649172	.114	0.55008929E+10	527166	771179	554089	744256
N(96)	583622	.134	0.61592905E+10	454521	712724	483010	684235
s(94)	.89	.018	0.25693209E-03	.87	.92	.87	.91
s(95)	.90	.017	0.24622556E-03	.87	.92	.88	.92
F(94)	.2068	.078	0.25707487E-03	.1805	.2332	.1863	.2274
F(95)	.2012	.077	0.24164427E-03	.1756	.2267	.1812	.2211

Period	F	N	Landings (Numbers)	Growth (Surplus)	^^ N	$\bar{w}$	$\bar{B}$	Growth (Weight)
94	.21	726183	144179	72152	-77010	34.20	23484025	2467844
95	.20	649172	126868	64500	-65549	40.78	25102520	2630456
96		583622						

P R O J E C T I O N S : 96 Landings Are Assumed Equal To 95 Landings (Quota).

No Landings (Moratorium).

96	.23	583622	126868	57987	-75228
97		508394		50513	50513
98		558906		55532	55532
99		614438		61050	61049

Landings Equal Half The Surplus.

96	.23	583622	126868	57987	-75228
97	.05	508394	25257	50513	24030
98	.05	532424	26450	52901	25167
99	.05	557591	27701	55401	26356

Landings Equal To The Surplus.

96	.23	583622	126868	57987	-75228
97	.09	508394	64500	64500	0
98	.09	508394	64500	64500	0
99	.09	508394	64500	64500	0

Qutoa (95 Landings) Projection

96	.23	583622	126868	57987	-75228
97	.27	508394	126868	50513	-82745
98	.34	425649	126868	42292	-91032
99	.45	334616	126868	33247	-100198

F(95) Projection

96	.23	583622	126868	57987	-75228
97	.20	508394	97018	50513	-51335
98	.20	457059	87221	45413	-46151
99	.20	410908	78414	40827	-41491

"Sensitivity Run"

350000000 .90 .5 1.0 3 150 0.05 32897 N-wag, S-wag, E-wag, tol, nv, limit, Vstop, iseed

86	1	42	3233492	0	0	46.92	213.00	
87	1	55	6797293	0	0	46.03	323.54	
88	1	110	10917849	0	0	28.21	123.41	
89	1	132	12851149	0	0	28.89	468.41	
90	1	123	9161300	0	0	28.75	343.35	
91	1	96	8459134	0	0	40.66	446.81	
92	1	73	8609981	0	0	0	0	
93	1	50	6775795	0	0	0	0	
94	1	27	8438581	0	0	38.81	0.22	
95	1	26	6870848	0	0	49.46	0.71	
86	2	8910.633	4465727	426119	2513307698	10.48	2.43	0
87	2	7417.136	4300705	314379	1859082575	13.68	1.40	0
88	2	7226.015	3562015	300592	877008177	11.85	3.12	0
89	2	6656.828	3079254	221052	642410709	13.93	2.70	0
90	2	6907.863	1332600	213216	643395350	6.25	0.84	0
91	2	8103.268	1307935	293259	2247820229	4.46	0.08	0
92	2	7208.910	1527524	304895	694592551	5.01	0.60	0
93	2	7740.120	1115466	248988	592245136	4.48	0.12	0
94	2	7787.265	936258	160869	207805807	5.82	0.28	0
95	2	7977.755	1173978	183434	463051977	6.40	0.38	0

Starting Statistics:

t :	86	87	88	89	90	91	92	93	94	95	96
N :	1003790197	903411177	813070059	731763053	658586748	592728073	533455266	480109739	432098765	388888889	350000000
m :	-.1031	-.1031	-.1023	-.1020	-.1021	-.1023	-.1029	-.1032	-.1035	-.1035	-.1028
Σ q·f :	.0023	.0022	.0031	.0034	.0033	.0030	.0025	.0022	.0018	.0018	
q·f(1) :	.0007	.0009	.0018	.0022	.0020	.0016	.0012	.0008	.0004	.0004	
q·f(2) :	.0016	.0013	.0013	.0012	.0012	.0014	.0013	.0014	.0014	.0014	

q(1) : .00001648
q(2) : .00000018

ß Matrix

m	-.07	-.07	-.06
q(1)	.00002703	.00002238	.00002692
q(2)	.00000010	.00000009	.00000011
N(86)	519583984	589674536	453916009
N(87)	482614619	550687553	428475218
N(88)	448182292	514197905	404382527
N(89)	415595890	479543836	381087502
N(90)	385170676	447028084	358943326
N(91)	357051116	416791582	338158872
N(92)	331188163	388793188	318769376
N(93)	307415947	362891597	300706171
N(94)	285512992	338873725	283826322
N(95)	265334292	316607035	268058619
N(96)	246583895	295804981	253168600
s(86)	.93	.93	.94
s(87)	.93	.93	.94
s(88)	.93	.93	.94
s(89)	.93	.93	.94
s(90)	.93	.93	.94
s(91)	.93	.93	.94
s(92)	.93	.93	.94
s(93)	.93	.93	.94
s(94)	.93	.93	.94
s(95)	.93	.93	.94
F(86)	.0020	.0017	.0021
F(87)	.0022	.0019	.0023
F(88)	.0037	.0031	.0037
F(89)	.0042	.0036	.0043
F(90)	.0040	.0034	.0040
F(91)	.0034	.0029	.0034
F(92)	.0027	.0023	.0027
F(93)	.0021	.0018	.0022
F(94)	.0015	.0013	.0015
F(95)	.0015	.0013	.0015
ƒ[LL]	289.	319.	319.

ƒ[LL] = 289.408158
Pr[ƒ(LL)] = 0.000000000 at 24 df.

	M L E	cv	var	CI(90)'s		CI(80)'s	
m	-.07	-.166	0.14148127E-03	-.09	-.05	-.09	-.06
q(1)	.00002703	.148	0.16082125E-10	-.01953957	.01959363	-.01522184	.01527589
q(2)	.00000010	.105	0.10172896E-15	-.01956650	.01956670	-.01524877	.01524896
N(86)	519583984	.158	0.67358872E+16	384574802	654593166	414367102	624800866
N(87)	482614619	.151	0.53358234E+16	362452764	602776474	388968723	576260514

N(88)	448182292	.146	0.42727056E+16	340655327	555709257	364383162	531981422
N(89)	415595890	.142	0.34676273E+16	318727494	512464286	340103316	491088464
N(90)	385170676	.139	0.28600264E+16	297197367	473143985	316610322	453731030
N(91)	357051116	.137	0.24012279E+16	276442292	437659941	294230136	419872097
N(92)	331188163	.137	0.20536233E+16	256641829	405734497	273091871	389284455
N(93)	307415947	.138	0.17892992E+16	237832268	376999626	253187208	361644686
N(94)	285512992	.140	0.15865952E+16	219989209	351036775	234448256	336577727
N(95)	265334292	.142	0.14294809E+16	203139347	327529237	216863825	313804760
N(96)	246583895	.147	0.13058366E+16	187139582	306028208	200257081	292910709
s(86)	.93	.012	0.12185274E-03	.91	.95	.91	.94
s(87)	.93	.012	0.12206985E-03	.91	.95	.91	.94
s(88)	.93	.012	0.12271712E-03	.91	.95	.91	.94
s(89)	.93	.012	0.12302088E-03	.91	.95	.91	.94
s(90)	.93	.012	0.12289439E-03	.91	.95	.91	.94
s(91)	.93	.012	0.12250427E-03	.91	.95	.91	.94
s(92)	.93	.012	0.12228058E-03	.91	.95	.91	.94
s(93)	.93	.012	0.12199902E-03	.91	.95	.91	.94
s(94)	.93	.012	0.12175550E-03	.91	.95	.92	.94
s(95)	.93	.012	0.12173524E-03	.91	.95	.92	.94
F(86)	.0020	.123	0.60024122E-07	.0016	.0024	.0017	.0023
F(87)	.0022	.129	0.79945859E-07	.0017	.0027	.0018	.0026
F(88)	.0037	.136	0.24998287E-06	.0028	.0045	.0030	.0043
F(89)	.0042	.139	0.34008226E-06	.0032	.0052	.0035	.0050
F(90)	.0040	.138	0.30169100E-06	.0031	.0049	.0033	.0047
F(91)	.0034	.134	0.20390230E-06	.0026	.0041	.0028	.0039
F(92)	.0027	.132	0.12414282E-06	.0021	.0032	.0022	.0031
F(93)	.0021	.127	0.70681737E-07	.0017	.0025	.0018	.0024
F(94)	.0015	.120	0.31139285E-07	.0012	.0018	.0012	.0017
F(95)	.0015	.119	0.30413854E-07	.0012	.0018	.0012	.0017

APPENDIX

Calculation of $Pr[N_{99} > N_{96}]$ from Likelihood Method

Projections: 96 Landings = 95 Landings (quota)
Scenario #1 - 97 to 99 Landings = 95 Landings (quota)
Scenario #2 - 97 to 99 Landings = ½ 95 Landings (50% quota cut)
Scenario #3 - 97 to 99 Landings = 0 (landings moratorium)

			z	Pr [N(99) > N(96)]
Large Coastals	86-95 Data:	Scenario #1	0.97	0.83
		Scenario #2	1.39	0.92
		Scenario #3	1.79	0.96
Large Coastals	94-95 Data:	Scenario #1	-1.09	0.14
		Scenario #2	-1.10	0.14
		Scenario #3	-0.56	0.29
Blacktip	94-95 Data:	Scenario #1	-2.67	0.004
		Scenario #2	-0.76	0.22
		Scenario #3	1.23	0.89
Sandbar	94-95 Data:	Scenario #1	-3.14	0.0008
		Scenario #2	-1.55	0.06
		Scenario #3	0.40	0.66

BlackTip: 94-95

```
500000 0.90  0.25  5.0  3  150 0.025   2349       N-wag, S-wag, E-wag, tol, nv, limit, Vstop, iseed
94 1        27  1437192 54050         0 26.59 0.6450   (Y=1436013, d=1179)
95 1        26  1113014 47626         0 23.37 0.0141   (Y=1112694, d= 320)
94 2 7.787265   241287 66106 64175360  3.65 0.4700    L(94) = 120,156
95 2 7.977755   361378 67046 60976885  5.39 0.3700    L(95) = 114,672
```

Starting Statistics:

t :	94	95	96
N :	617284	555556	500000
m :	.1430	.1424	.1427
Σ q·f :	.2484	.2478	
q·f(1):	.1095	.1055	
q·f(2):	.1389	.1423	
q(1):	.00405605		
q(2):	.01783633		

m	.15	.15	.20
q(1)	.00371367	.00414622	.00364919
q(2)	.01660716	.01952288	.01713689
N(94)	555834	523709	527928
N(95)	513165	465983	510990
N(96)	474032	414797	494786
s(94)	.92	.89	.97
s(95)	.92	.89	.97
F(94)	.2296	.2640	.2320
F(95)	.2290	.2636	.2316
ƒ[LL]	0.	3.	4.

ƒ[LL] = .381070
Pr[ƒ(LL)] = .826516814 at 2 df.

	M L E	cv	var	CI(90)'s		CI(80)'s	
m	.15	.173	0.67461256E-03	.11	.19	.12	.18
q(1)	.00371367	.097	0.13071718E-06	-.03901242	.04643975	-.02958411	.03701144
q(2)	.01660716	.113	0.34965172E-05	-.02611893	.05933325	-.01669062	.04990494
N(94)	555834	.088	0.23924204E+10	475373	636295	493129	618540
N(95)	513165	.096	0.24028829E+10	432528	593801	450322	576007
N(96)	474032	.112	0.28270085E+10	386568	561496	405868	542195
s(94)	.92	.032	0.85044470E-03	.88	.97	.89	.96
s(95)	.92	.032	0.85119433E-03	.88	.97	.89	.96
F(94)	.2296	.096	0.49063386E-03	.1932	.2660	.2012	.2580
F(95)	.2290	.097	0.49173495E-03	.1926	.2655	.2006	.2575

Projection 1: 96 = 95Landings; 97 to 99 Landings = 95 Landings
Projection 2: 96 = 95Landings; 97 to 99 Landings = ½ Of 95 Landings
Projection 3: 96 = 95Landings; 97 to 99 Landings = 0

N(99)	300839	.124	0.13946463E+10	239407	362271	252963	348715
N(99)	426152	.079	0.11468565E+10	370444	481861	382737	469567
N(99)	551026	.059	0.10706497E+10	497201	604853	509079	592975

Sand Bar: 94-95

```
750000  0.90     .25   10.0         3   1.0   0.05  5231     N-wag, S-wag, E-wag, tol, nv, limit, Vstop, iseed
94 1    27     4462785      0         0 34.54 0.0042  (Y=4450935; d=11850)     w(94) = 34.20; w(95) = 40.78
95 1    26     4260938 101999         0 41.75 0.0007  (Y=4258447; d= 2491)     L(95) = 126,868
94 2 7.787265    48513  14973  9173724  3.24 0.10
95 2 7.977755   113900  24869 18422779  4.58 0.39
```

Starting Statistics:

t :	94	95	96
N :	925926	833333	750000
m :	.0882	.0827	.0855
Σ q·f :	.1936	.1881	
q·f(1):	.1663	.1602	
q·f(2):	.0273	.0279	
q(1):	.00616011		
q(2):	.00350246		

m	.09	.10	.12
q(1)	.00645635	.00618493	.00550963
q(2)	.00417467	.00426743	.00334913
N(94)	726183	733442	793348
N(95)	649172	664340	748173
N(96)	583622	604989	709016
s(94)	.89	.91	.94
s(95)	.90	.91	.95
F(94)	.2068	.2002	.1748
F(95)	.2012	.1949	.1700
f [LL]	2195.	3335.	5809.

f [LL] = 2194.710449
Pr[*f* (LL)] = .000000000 at 2 df.

	M L E	cv	var	CI(90)'s		CI(80)'s	
m	.09	.160	0.23072883E-03	.07	.12	.08	.11
q(1)	.00645635	.086	0.30767335E-06	-.01853081	.03144351	-.01301692	.02592962
q(2)	.00417467	.134	0.31457458E-06	-.02081248	.02916183	-.01529860	.02364795
N(94)	726183	.090	0.42687462E+10	618706	833661	642423	809944
N(95)	649172	.116	0.56631932E+10	525379	772965	552696	745648
N(96)	583622	.145	0.72096897E+10	443946	723299	474768	692477
s(94)	.89	.027	0.60276015E-03	.85	.93	.86	.93
s(95)	.90	.027	0.58979249E-03	.86	.94	.87	.93
F(94)	.2068	.080	0.27492368E-03	.1796	.2341	.1856	.2281
F(95)	.2012	.080	0.25913630E-03	.1747	.2277	.1805	.2218

Projection 1: 96 = 95Landings; 97 to 99 Landings = 95 Landings
Projection 2: 96 = 95Landings; 97 to 99 Landings = ½ Of 95 Landings
Projection 3: 96 = 95Landings; 97 to 99 Landings = 0

N(99)	308680	.068	0.44551956E+09	273959	343402	281621	335741
N(99)	448075	.045	0.39911744E+09	415212	480939	422464	473687
N(99)	587151	.034	0.39715239E+09	554369	619935	561603	612700

Large Coastals 94-95

5000000 .95	0.5	5.0 3 150	0.05	32897	N-wag,	S-wag,	E-wag,	tol, nv,	limit, Vstop, iseed
94 1	27	8863897	228392		0	38.81	0.22		
95 1	26	7023926	142012		0	49.46	0.71		L(94) = 389261
94 2	7787.265	936258	160869	207805807	5.82	0	0.28		L(94) = 325446
95 2	7977.755	1173978	183434	463051977	6.40	0	0.38		

Starting Statistics:

t :	94	95	96
N :	5540166	5263158	5000000
m :	.0223	.0217	.0220
Σ q·f :	.0736	.0730	
q·f(1):	.0388	.0374	
q·f(2):	.0348	.0357	
q(1):	.00143662		
q(2):	.00000447		

m	0.00	-.01	-.01
q(1)	.00233050	.00217135	.00213562
q(2)	.00000683	.00000642	.00000644
N(94)	3571394	3826835	3821541
N(95)	3170719	3409636	3406899
N(96)	2817895	3040805	3040005
s(94)	.89	.89	.89
s(95)	.89	.89	.89
F(94)	.1161	.1086	.1078
F(95)	.1151	.1076	.1069
f[LL]	205.	210.	213.

f[LL] = 205.449489
Pr[*f*(LL)] = .000000000 at 0 df.

	M L E	cv	var	CI(90)'s		CI(80)'s	
m	0.00	-8.739	0.63582439E-03	-.04	.04	-.04	.03
q(1)	.00233050	.134	0.98096158E-07	-.03914909	.04381010	-.02999584	.03465685
q(2)	.00000683	.107	0.53249862E-12	-.04147276	.04148642	-.03231952	.03233318
N(94)	3571394	.189	0.45535876E+12	2461344	4681445	2706297	4436492
N(95)	3170719	.195	0.38296520E+12	2152724	4188714	2377364	3964074
N(96)	2817895	.206	0.33641932E+12	1863768	3772022	2074314	3561476
s(94)	.89	.023	0.42743922E-03	.85	.92	.86	.91
s(95)	.89	.023	0.42629979E-03	.85	.92	.86	.92
F(94)	.1161	.117	0.18553366E-03	.0937	.1385	.0987	.1336
F(95)	.1151	.117	0.18083188E-03	.0930	.1372	.0978	.1323

Projection 1: 96 = 95Landings; 97 to 99 Landings = 95 Landings
Projection 2: 96 = 95Landings; 97 to 99 Landings = ½ Of 95 Landings
Projection 3: 96 = 95Landings; 97 to 99 Landings = 0

N(99)	1871170	.053	0.98698951E+10	1707744	2034597	1743807	1998534
N(99)	2178697	.048	0.10946520E+11	2006589	2350807	2044568	2312828
N(99)	2486237	.046	0.12984202E+11	2298793	2673682	2340156	2632319

Large Coastals 86-95:

```
2500000 .90 .5  1.0  3  150 0.05  32897       N-wag, S-wag, E-wag, tol, nv, limit, Vstop, iseed
86 1      42          3233492          0            0    46.92    213.00
87 1      55          6797293          0            0    46.03    323.54
88 1     110         10917849          0            0    28.21    123.41
89 1     132         12851149          0            0    28.89    468.41
90 1     123          9161300          0            0    28.75    343.35
91 1      96          8459134          0            0    40.66    446.81
92 1      73          8609981          0            0    0          0
93 1      50          6775795          0            0    0          0
94 1      27          8438581          0            0    38.81       0.22
95 1      26          6870848          0            0    49.46       0.71
86 2   8910.633       4465727    426119   2513307698   10.48       2.43  0
87 2   7417.136       4300705    314379   1859082575   13.68       1.40  0
88 2   7226.015       3562015    300592    877008177   11.85       3.12  0
89 2   6656.828       3079254    221052    642410709   13.93       2.70  0
90 2   6907.863       1332600    213216    643395350    6.25       0.84  0
91 2   8103.268       1307935    293259   2247820229    4.46       0.08  0
92 2   7208.910       1527524    304895    694592551    5.01       0.60  0
93 2   7740.120       1115466    248988    592245136    4.48       0.12  0
94 2   7787.265        936258    160869    207805807    5.82       0.28  0
95 2   7977.755       1173978    183434    463051977    6.40       0.38  0
```

Starting Statistics:

t :	86	87	88	89	90	91	92	93	94	95	96
N :	7169930	6452937	5807643	5226879	4704191	4233772	3810395	3429355	3086420	2777778	2500000
m :	.2134	.2062	.3284	.3650	.3505	.3179	.2426	.2027	.1508	.1533	.2531
Σ q·f :	.3188	.3116	.4337	.4703	.4558	.4233	.3479	.3081	.2562	.2586	
q·f(1):	.0969	.1269	.2538	.3046	.2838	.2215	.1685	.1154	.0623	.0600	
q·f(2):	.2219	.1847	.1799	.1657	.1720	.2018	.1795	.1927	.1939	.1986	

q(1): .00230755
q(2): .00002490

m	.22	.29	.28
q(1)	.00278534	.00281801	.00299334
q(2)	.00001188	.00001290	.00001403
N(86)	5865969	3441759	4239574
N(87)	5823682	3643579	4357492
N(88)	5675935	3790791	4398972
N(89)	4756990	3386025	3776861
N(90)	3775305	2863608	3060407
N(91)	3063115	2475972	2538620
N(92)	2641595	2274716	2245081
N(93)	2454747	2255619	2153851
N(94)	2416729	2370160	2197163
N(95)	2535292	2655671	2399503
N(96)	2661060	2976651	2621318
s(86)	.99	1.06	1.03
s(87)	.97	1.04	1.01
s(88)	.84	.89	.86
s(89)	.79	.85	.81
s(90)	.81	.86	.83
s(91)	.86	.92	.88
s(92)	.93	.99	.96
s(93)	.98	1.05	1.02
s(94)	1.05	1.12	1.09
s(95)	1.05	1.12	1.09
F(86)	.2229	.2333	.2507
F(87)	.2413	.2506	.2687
F(88)	.3923	.4032	.4306
F(89)	.4468	.4578	.4885
F(90)	.4247	.4357	.4651
F(91)	.3637	.3750	.4011
F(92)	.2890	.2987	.3197
F(93)	.2312	.2407	.2583
F(94)	.1677	.1765	.1901
F(95)	.1672	.1761	.1898
ƒ[LL]	646.	653.	690.

ƒ[LL] = 646.020682
Pr[ƒ(LL)] = 0.000000000 at 24 df.

	M L E	cv	var	CI(90)'s		CI(80)'s	
m	.22	.321	0.48021555E-02	.10	.33	.13	.30
q(1)	.00278534	.185	0.26694110E-06	-.11120919	.11677987	-.08605417	.09162485
q(2)	.00001188	.227	0.72580705E-11	-.11398265	.11400641	-.08882762	.08885139
N(86)	5865969	.356	0.43653687E+13	2428994	9302944	3187426	8544511
N(87)	5823682	.338	0.38668139E+13	2588918	9058446	3302729	8344634
N(88)	5675935	.323	0.33575146E+13	2661715	8690154	3326859	8025010
N(89)	4756990	.353	0.28184377E+13	1995331	7518650	2604743	6909238
N(90)	3775305	.406	0.23441794E+13	1256693	6293917	1812472	5738139
N(91)	3063115	.458	0.19645250E+13	757458	5368772	1266244	4859985
N(92)	2641595	.491	0.16822346E+13	508013	4775176	978828	4304361

N(93)	2454747	.493	0.14664232E+13	462718	4446775	902296	4007197
N(94)	2416729	.471	0.12937503E+13	545654	4287803	958542	3874916
N(95)	2535292	.421	0.11389119E+13	779751	4290833	1167144	3903440
N(96)	2661060	.373	0.98412135E+12	1029172	4292947	1389279	3932841
s(86)	.99	.029	0.82542939E-03	.95	1.04	.96	1.03
s(87)	.97	.027	0.71306697E-03	.93	1.02	.94	1.01
s(88)	.84	.023	0.36999510E-03	.81	.87	.81	.86
s(89)	.79	.030	0.55754773E-03	.75	.83	.76	.82
s(90)	.81	.027	0.46772115E-03	.78	.85	.78	.84
s(91)	.86	.021	0.31528869E-03	.83	.89	.84	.89
s(92)	.93	.022	0.43655648E-03	.89	.96	.90	.96
s(93)	.98	.029	0.78734528E-03	.94	1.03	.95	1.02
s(94)	1.05	.038	0.15586110E-02	.98	1.11	1.00	1.10
s(95)	1.05	.038	0.15581385E-02	.98	1.11	1.00	1.10
F(86)	.2229	.202	0.20328983E-02	.1487	.2970	.1651	.2807
F(87)	.2413	.198	0.22812712E-02	.1628	.3199	.1801	.3026
F(88)	.3923	.193	0.57025553E-02	.2680	.5165	.2954	.4891
F(89)	.4468	.191	0.72872222E-02	.3063	.5872	.3373	.5562
F(90)	.4247	.192	0.66228346E-02	.2908	.5586	.3204	.5290
F(91)	.3637	.194	0.49856621E-02	.2475	.4798	.2732	.4542
F(92)	.2890	.195	0.31858101E-02	.1961	.3818	.2166	.3614
F(93)	.2312	.199	0.21215148E-02	.1555	.3070	.1722	.2903
F(94)	.1677	.206	0.11885339E-02	.1110	.2245	.1235	.2119
F(95)	.1672	.206	0.11887167E-02	.1105	.2239	.1230	.2114

Projection 1: 96 = 95Landings; 97 to 99 Landings = 95 Landings
Projection 2: 96 = 95Landings; 97 to 99 Landings = ½ Of 95 Landings
Projection 3: 96 = 95Landings; 97 to 99 Landings = 0

N(99)	3766370	.147	0.30651412E+12	2855638	4677104	3056608	4476134
N(99)	4256076	.136	0.33707171E+12	3301024	5211128	3511774	5000378
N(99)	4744533	.128	0.37049380E+12	3743251	5745815	3964203	5524864