REPORT OF THE SHARK EVALUATION WORKSHOP
March 14-18, 1994

NOAA, National Marine Fisheries Service

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NOAA, National Marine Fisheries Service
Southeast Fisheries Science Center
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Miami, FL 33149

SUMMARY

In conducting this evaluation, the 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. Catch rate information indicates 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. As shark catches dramatically increased in 1986 and there was no quota until 1993, the downward trend in available CPUE observations probably accurately reflects further shark abundance decrease since 1986. Recovery of this resource to levels of the 1970's will be slow (perhaps 30 years or more in some cases), due to the relatively low intrinsic rates of increase exhibited by most shark species. Measuring recovery or decline under a TAC implemented in 1993, even with precise abundance indices, may not be possible for a decade or more. Given the information available, increases in the TAC for sharks were considered risk-prone with respect to promoting stock recovery. In fact, considering the reproductive profiles of sharks and the general insufficiency of fishery data upon which to base analyses, any TAC might be considered risk prone relative to stock recovery of large coastals. In order to increase the probability of recovery, the single most important measure, supplemental to controlling the annual harvest level, that might be implemented is a closure of nursery grounds to directed fishing during the pupping season. 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.

BACKGROUND

The Fishery Management Plan (FMP) for Sharks of the Atlantic Ocean, completed in late 1992, has the following four goals: 1) to prevent overfishing of shark resources; 2) to encourage management of shark stocks throughout their ranges; 3) to establish a shark resource data collection, research and monitoring program; and 4) to increase the benefits from shark resources to the US while reducing waste, consistent with the other objectives. In order to achieve these objectives a number of regulations were implemented in 1993 and 1994 designed to limit fishing mortality of shark resources in the US western Atlantic. Additionally, the FMP calls for an annual evaluation of shark information in regards to a number of relevant characteristics including current stock status, current landings, maximum sustainable yield (MSY) and information on which to base total allowable catch (TAC). This information is to be developed by the National Marine Fisheries Service (NMFS) and submitted to the FMP Operations Team. In order to facilitate the evaluation, NMFS convened a group of scientists to examine the available shark data in order to provide scientific advice in this process. The workshop was held in

Miami at the Southeast Fisheries Science Center (SEFSC). The following is the report of the Workshop.

The Workshop activities, which mainly focussed on the large coastal grouping of sharks, fell into six major areas, used also to organize the Report: 1. Trends in Abundance, 2. Vital Rates, 3. Estimation of Catches and Landings, 4. Resource Status Versus Target Levels, 5. Monitoring Measures, and 6. Management Implications and Recommendations.

1. TRENDS IN ABUNDANCE

A major emphasis in this Workshop was to integrate the information that was available on trends in abundance of individual shark species and species groups. In particular the Workshop Committee felt there was a need to provide a more historical perspective to shark trends so that recent assessments could be interpreted in that light. In order to achieve this, a number of catch-per-unit-effort and research sampling effort data bases were analyzed and compared to determine consistent information in trends in shark abundance.

The Workshop Committee examined an array of catch rate information for sharks, some species-specific and others for groups of species according to the shark FMP management unit definitions. Analyses and summaries of catch rate information were presented (see List of Documents). The Committee also identified several data sets with which to conduct further analysis at the meeting. These are described in the Appendix.

The catch per unit effort patterns from 21 time series presented in working documents at the meeting or calculated from the available data were examined (see Appendix report). The Committee considered a range of CPUE series that were expressed in either numbers of sharks per effort unit or in biomass of sharks per effort unit. 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 Committee proceeded to examine the CPUE data, in aggregate, for evidence of trend in catch rates.

In order to combine the various catch and effort data into a single series representing an average species or species group catch rate trajectory, a General Linear Model, controlling for source of data, and testing for a significant tendency between years, was applied to the log-transformed CPUE data. Only CPUE in the form of numbers per unit effort were combined in this way since most of the available series were of this form (see Appendix table). 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. Figures 1.1 and 1.2 show the available CPUE observations, with estimated variance measures, when available, for the large coastal and pelagic sharks considered.

In most cases, the resulting linear fits to the log-transformed CPUE values over the species and species groups considered had significant negative slopes (indicating a negative trend in the catch rates over the time series; see Appendix for specific probability levels). In every case but two, there was less than a 10% probability of a larger t-statistic due to chance in the test for significance of the model slope parameter (see Appendix and Table 1.1; *i.e.* dusky shark and Atlantic sharpnose, in the recent time period: 1986-1993). In the case of the dusky shark, the largest decline in catch rate occurred before 1986. The more recent dusky shark catch rates remained low, but were variable, with no obvious trend.

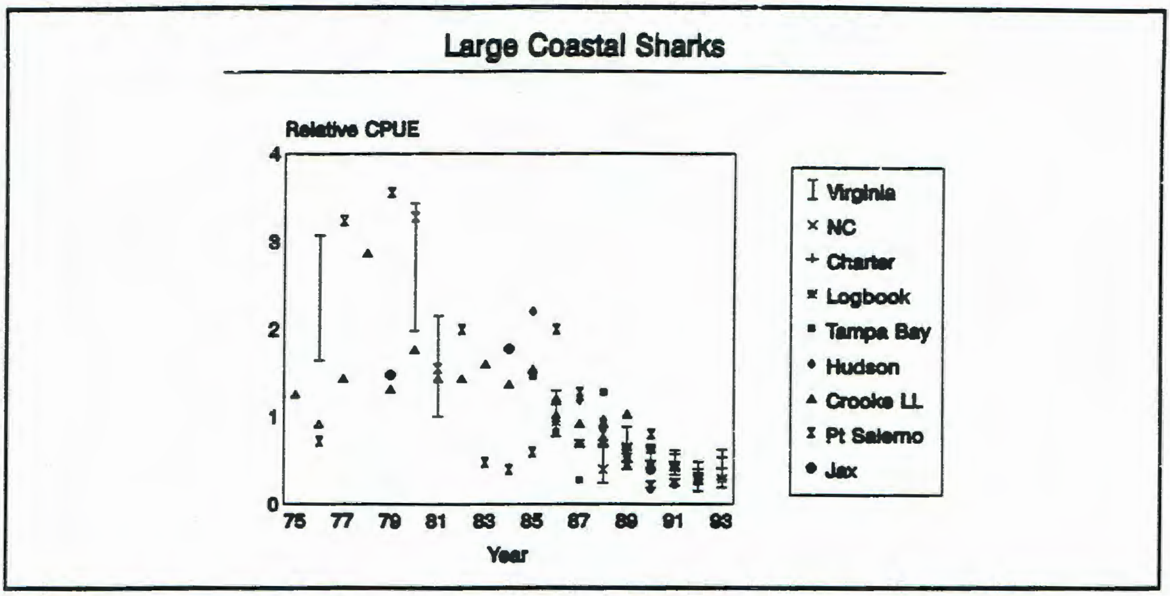
Table 1.1 summarizes the results of these model fits in terms of the predicted ratios of catch rates in 1986 with respect to the beginning of the time series of observations and the predicted ratio of catch rates in 1993 with respect to 1986. These model predictions, considering the variability in the ratios (Table 1.1), indicate that the abundance of many of the species and species groups for which catch rate information is available, could have declined by about 50 to 75% from the early 1970's to the mid 1980's. For the large coastal sharks considered, the model predicted catch rates in 1986 are generally in the range of 12-25% of their levels in the mid- to late-1970's. In most cases (except as noted above), the available data also indicate negative trends in CPUE since 1986. As shark catches dramatically increased in 1986 and there was no quota until 1993, 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 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.

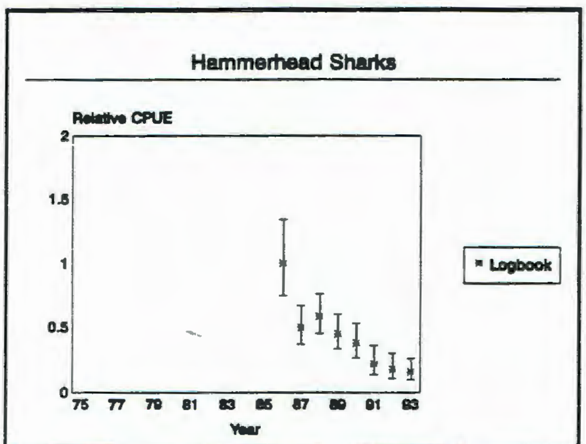
Table 1.1. Predicted catch rate ratios from log-linear model ($\ln(CPUE) = \beta_0 + \beta_1 Year + \beta_{2,i} Series_i + \epsilon$) fits to the available time series of CPUE (in numbers of sharks caught per effort unit). Values shown are approximate 95% confidence bounds and the model predicted mean 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 in the available time series of observations).

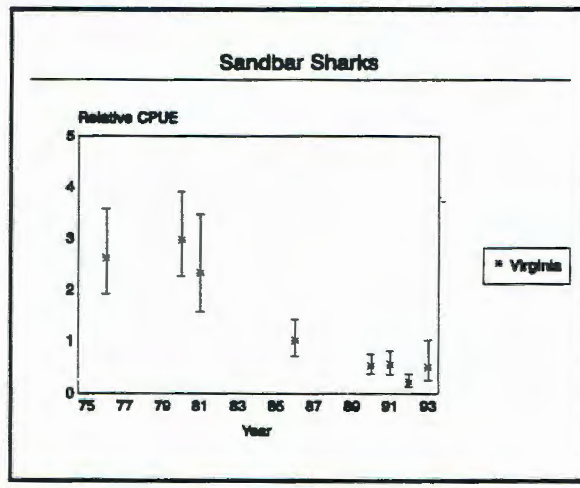
Species or Group	Years of CPUE Data	All Data CR_{86}/CR_I	All Data CR_{93}/CR_{86}	86-93 Data CR_{93}/CR_{86}
Large Coastal Sharks	1975-1993	***.20,.25,.33	***.36,.42,.49	***.26,.33, .41
Sandbar	1975-1993	***.14,.22,.34	***.29,.38,.50	*.14,.33, .84
Dusky	1975-1993	***.05,.12,.32	***.15,.27,.49	NS.04,.35,3.32
Hammerheads	1986-1993	N/A	***.11,.17,.26	***.11,.17, .26
Pelagic Sharks				
Makos	1978-1993	***.40,.50,.62	***.45,.54,.65	***.46,.54, .63
Blue	1978-1993	***.31,.47,.70	***.36,.51,.73	***.29,.43, .63
Small Coastal Sharks				
Atlantic Sharpnose	1973-1993	**.29,.51,.90	**.54,.71,.95	NS.16,.63,2.48

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.

*** Model slope (β_1) parameter estimate negative and significantly different from 0 at α=0.01.
** Model slope (β_1) parameter estimate negative and significantly different from 0 at α=0.05.
* Model slope (β_1) parameter estimate negative and significantly different from 0 at α=0.1.
NS Model slope (β_1) parameter estimate negative, **but not** significantly different from 0 at α=0.25.







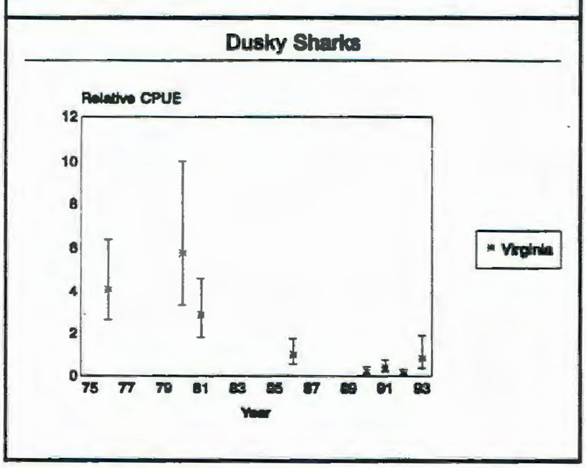
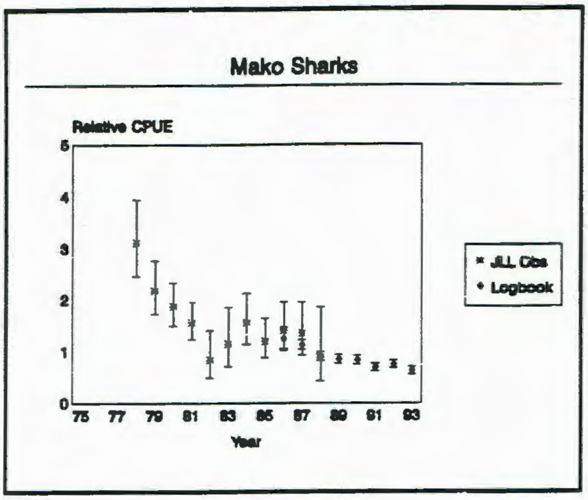


Figure 1.1. CPUE observations, adjusted for difference in scale, for species in the large coastal shark grouping. Error bars (approximate 80% confidence ranges) are shown for those CPUE series for which variability in CPUE was estimated. Sources of data are indicated (also see Appendix).



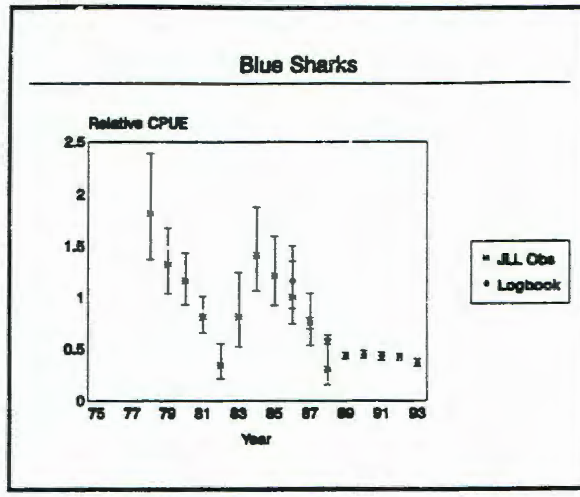


Figure 1.2. CPUE observations, adjusted for difference in scale, for species in the pelagic shark grouping. Error bars (approximate 80% confidence ranges) are shown for those CPUE series for which variability in CPUE was estimated. Sources of data are indicated (also see Appendix).

2. VITAL RATES

An evaluation of available information on the vital rates of sharks was undertaken by the Committee to determine either qualitatively or quantitatively, the intrinsic rate of increase that shark stocks can exhibit, *i.e.* the amount of resilience a shark stock has to an external source of mortality such as fishing. Doing this required an assimilation of what may be derived for specific species of sharks in the fishery, *i.e.* which species life history parameters such as age at maturity and fecundity can be characterized. Additionally, the Committee considered alternative species groupings different from those in the FMP for which the species have similar life history patterns. In evaluating the above, practical aspects including species identification, habitat and fishery differences were also considered.

Based on the available data and literature, the Committee attempted to characterize the following parameters for selected species:

a) female minimum age at maturity,
b) minimum longevity,
c) total litter size, and
d) reproductive periodicity.

Since (a) and (b) rely on ageing methods, the confidence of these values vary with ageing methodology and whether or not ages have been validated using more than one method. In the case of two studies yielding different results for (a) and (b), both numbers are included to give a range.

"Model" species were chosen that reflect life history patterns, and present knowledge of shark biology. Survivorship (S) was derived for each species based on longevity.

Table 2.1 Summary of life history characteristics for "model" species

FMP GROUP	Species	Minimum Female Age at Maturity (Years)	Minimum Longevity (Years)	Total Litter Size* (Mean)	Reprod. Period (Years)	S**
Large Coastal	Sandbar	15/30	30/60	6-10 (8)	2	.87/.93
	Blacktip	6	12	3-9 (5)	2	.70
	Dusky	21	45	6-14 (9)	2	.91
	Silky	9/12	22	6-14 (9)	2	.83
Small Coastal	Atlantic Sharpnose	4	10	1-8 (5)	1	.66
Pelagic	Shortfin Mako	7	20	12-21(16)	2	.81
	Blue	5	16	50	1	.77

* Total litter size = male and female pups. For female pups only, assume sex ratio is 1:1 and divide litter size by 2.

** S was derived from life history parameters using Hoenig's (1983) equation: $\ln(Z) = 1.46 - 1.01 \ln(t_{max})$, where $S = e^{-Z}$

The following results of the above evaluation should be noted:

Sandbar - Age ranges in sandbar are due to two methods of ageing: vertebral centra (15 yrs at maturity, 30 yrs longevity) vs. tag returns (30 yrs maturity, 60 yrs longevity). Modelling should only pair similarly derived values, i.e. 15 with 30 and 30 with 60 (not 15 with 60, etc.). The sandbar was viewed as a "slow-growing/large coastal" model species that is also the predominant species in the east coast and Gulf fishery.

Blacktip - A " fast-growing/large coastal" model that is the second-most dominant species in the fishery for large coastal sharks.

Dusky - Slow-growing/large coastal that is a species of special concern.

Silky - Fast-growing/large coastal that is more pelagic and tropical in its distribution. Range in age at maturity due to two studies, both using vertebral centra.

Atlantic sharpnose - Fast-growing/small coastal with both targeted and bycatch fishery components.

Shortfin mako - Fast-growing/pelagic that is a predominant targeted shark species in the pelagic fishery.

Blue - Fast-growing/pelagic that is a predominant bycatch species and an increasing landed component of the pelagic fishery.

The Committee proposes a new species grouping, based on similarities in life history and habitat, comprised of the blacktip, spinner, finetooth, and blacknose sharks. These four species are "fast-growing/large coastal" sharks showing similar k values from von Bertalanffy growth functions fit to age and growth data. In the future, when species-specific catch data allow, this group should be treated separately from both the relatively slow-growing large coastal species and the relatively fast-growing small coastal species.

The intrinsic rate of increase (r) of a species is dependent on age (size) at maturity, longevity, and fecundity. However, values of r are also interdependent with survivorship (S), including survivorship of pups in the first year (S_0). In a theoretically stable, virgin population, the rate of increase is 0, and survivorship can be calculated from a Leslie matrix algorithm, for instance. But survivorship is affected by fishing mortality, which may not be obtainable from current catch and effort data, and so calculations of S and r for sharks may be impractical at this time. However, since age at maturity appears to be the most important, and perhaps the most immutable, factor separating the productivity of one shark species from another, age at maturity can be used to construct a best first approximation of the dynamics of stock recovery.

In this context, therefore, it appears that certain species of sharks would have faster stock recovery rates than others, but in no case would recovery rate be fast in any large coastal shark species. The sandbar shark, with a minimum age at maturity of 15 years, would have a very slow recovery rate; the blacktip, with a minimum age at maturity of 6 years, would be somewhat faster; and the sharpnose, with a minimum age at maturity of 4 years, would have the fastest recovery rate, based on age at maturity alone. The difference in growth rates between the blacktip and the sandbar provides the basis for separating out the blacktip (along with spinner, finetooth, and blacknose) as a separate species group of relatively fast-growing, large coastal sharks. This proposal is made to help facilitate modelling when, and if, species composition of the shark catch is determined.

Ageing methodology for sharks is still evolving and so the numbers in Table 2.1 may change in the future. Any changes in ages at maturity, however, will most likely be upward (older), based on how this field is evolving. Thus, modelling based on the ages in the table should set upper limits on production from the standpoint of age at maturity alone.

In conclusion, life history characteristics of certain keystone or model species of sharks are moderately well known, so that species-specific analyses and management are not limited by a lack of biological knowledge in these cases, but rather by other factors, such as species-specific delineation of the catch. When these other factors are resolved, species-specific management can then proceed.

3. ESTIMATION OF CATCH AND LANDINGS

Recreational and commercial landings from 1986 through 1993 were reviewed for species composition data (SB-2). Within this time period, the reported landings were comprised of a very significant proportion that was not identified to species. This was especially true for the South Atlantic and Gulf of Mexico regions. Northeast landings indicated a greater prevalence of pelagic species in the reported landings. With respect to the available estimates of recreational catch, a greater proportion of the total was identified to species.

Discussions on revising the landings focused on how to apportion the unidentified catch by species and how to account for landed fins and dead discards at sea. Several options were discussed, including prorating the unidentified catch based on the species composition of the identified catch. Examination of the species composition by region raised the possibility that the identified catch might reflect species composition from the bycatch of pelagic longline fisheries for swordfish and tuna. This might partially explain the prevalence of pelagic species in the identified catch. The unidentified catch in contrast was thought to reflect reported landings from the directed shark fishery. The Committee clearly favored an approach that would apportion the unidentified catch based on regional and seasonal application of ancillary data (independent of landings, i.e. personal logbooks, research fishing effort, etc.) on the species composition for shark directed effort.

With respect to reported landings of fins, concern was expressed about the potential for double counting if an unknown portion of the fins were associated with landings designated as unidentified. The Committee felt that a minimum estimate of the discarded shark biomass could be developed by subtracting the weight of the unidentified landings from an estimate of the total biomass produced by raising the fin weight to total shark weight (i.e. dry fin weight = 2.5% of total weight).

These tasks will require considerable amount of work and could not be completed during this workshop. The Committee utilized the available time to discuss options and outline the work necessary to revise the landings before the next assessment. Participants indicated that priority should be placed on gathering the ancillary species specific data to apportion unidentified catch from directed fisheries. The Committee also recognized that the existing landings data represent a minimum estimate of total catch and that additional research would be required to cross check these records against other sources of information (i.e. private logbooks, size frequency samples, etc.). This effort could improve the reliability of the existing estimates of total catch from 1986 through 1993. The Committee also supported research efforts to provide qualitative estimates of the scale of the total catch (both landed and discarded catch) prior to 1986, including the recreational catch time series to at least 1979.

4. RESOURCE STATUS VERSUS TARGET LEVELS

4.1. Large Coastal Sharks

4.1.a. Maximum Sustainable Yield

The Fishery Management Plan (FMP) developed an argument for maximum sustainable yield (MSY) based upon the analytical results of the 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, underestimation of this statistic was deemed acceptable since, in order for the resource to recover to its MSY level, it would have to pass through the "first approximation" level and, in the ensuing time period, new information could be brought to bear on improving the estimate of the resource MSY level.

In this meeting it was determined that an improvement could indeed be made in defining the resource levels that could produce MSY, by incorporating the longer term index information into the analysis. This was done in the following manner: the population trend index in year t (I_t) was scaled to the stock size estimates from the previous Committee Report using $N_t = \{N_r/I_r\}I_t$ where stock sizes N_r and index I_r are from a selected reference period (1986). Then the initial period of the index (1975) was specified as being representative of a stable period which was equivalent to a resource level similar to an unfished condition ($I_{virgin} = I_{75}$). Secondly, the relative level at which MSY might occur was specified as 50 percent of virgin based on a logistic relationship. This leads to a characterization of stock size at MSY of $N_{MSY} = (I_{75}(0.5)N_{86}/[I_{86}] = N_{86}(1.0)(0.5)/0.25 = 2N_{86}$, where the index levels are taken from Table 1.1. This characterization implies that the stock size at MSY could be twice as high as that in 1986, hence twice as high as that in the FMP. Also, if the exploitation rate at MSY is the same as in the FMP, then this characterization also implies that MSY could be twice as high as that in the FMP. The validity of the estimates of F_{MSY} ($F_{MSY} = 0.25$ for large coastal sharks and 0.48 for small coastal sharks, p. 56 in the FMP) was questioned. These values, in a closed population context, seem to be more appropriate for moderate to highly productive teleosts, rather than the shark species considered here, all of which in a comparative sense, have extremely low fecundity, slow growth and high age at maturity. It should be noted that the FMP analysis does not make closed population assumptions. However, the Committee was not able to derive better estimates at present, due to data constraints.

This simple characterization makes a number of unverified assumptions including the constancy of selectivity in the fishery and that the dynamics in average weight in the catch is small relative to the index changes. However, the implications of a large decline in these abundance indices in terms of MSY are as follows: 1) the result is not in conflict with the general strategy in the FMP to recover the resource levels. As mentioned before, it was always recognized that the recovery strategy would have to achieve the "first approximation" target on its recovery trajectory; 2) however, these results do imply that recovery is likely to be a lengthy process under the best of circumstances. Given the differences between the estimates of current stock size and the stock size which could produce MSY and given the information on life history characteristics outlined above, the Committee felt it was extremely unlikely that full recovery of the resource to MSY stock level (about twice the 1986 stock size, by the above characterization) would occur by the projection year of 1995, or even by the end of the century.

4.1.b. Total Allowable Catch

The FMP specifies a rebuilding strategy based upon a constant exploitation rate, where the exploitation rate was one of three options outlined by the previous committee. The manner in which this exploitation rate was to be achieved was by the implementation of a total allowable catch (TAC) through a combination of quotas and bag limits. In doing so, the FMP outlines a trajectory of subsequent TAC's which might have ensued if the TAC's were perfectly implemented, if we knew exactly what resource levels were now in the sea and if we knew the vital rate parameters exactly. Of course this is not the case for any fishery, much less sharks. Therefore, it is expected that TAC's will be adjusted as stock size levels are reevaluated and target exploitation rates redetermined. However, in the case of sharks it is unreasonable to expect that enough additional information has accumulated since the implementation of the FMP to provide much more precise information to adjust the TAC. Instead it was our Committee's approach to evaluate the evidence that would suggest that the exploitation rate and replacement yield originally chosen as the target was risk-averse or risk-prone.

The 1992 commercial landings were 4002 mt dressed weight (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). Additionally, 431 mt of fins of all shark groups were landed in the northeast in 1992 and 127 mt of fins were landed in the southeast and Gulf. Additionally, recreational landings of large coastal sharks have averaged approximately 400 mt in recent years. From the magnitude of these landings, it appears most likely that the 1992 yield was in excess of the estimated 1992 replacement yield of 3733 mt (see previous Committee Report in FMP). The 1992 landings were probably similar in magnitude to those assumed for 1992 in the FMP (10% more than 1991). Hence, under the stock dynamics model assumed, estimated stock size of large coastal sharks would have declined in 1992.

In 1993 the preliminary commercial landings were 2715 mt dressed weight (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). Additionally, 303 mt of fins of all shark groups were landed in the northeast in 1993 and 69 mt of fins were landed in the southeast and Gulf. These commercial landings coupled with the average recreational landings over recent years indicates that 1993 yield was probably near the projected 1993 replacement yield of 3520 mt. Therefore, under this scenario it is unlikely that there would have been unused surplus in 1993 and also unlikely that recovery would have been initiated.

Additionally, the variability in the estimate of replacement yield in 1993 is large. The coefficients of variation on stock production in weight were 100%, 54%, 40% and 67% for 1988 to 91, respectively. It is likely that similar variability occurs in the 1993 estimate of replacement yield of 3520 mt. Thus, it is relevant to examine the probability that a 1993 yield of 2916 mt is, indeed, less than the estimated replacement yield. Given the above levels of variability and assuming a normal distribution of error about the estimate, there is better than even odds (estimated between a 56% and a 67% chance) that the 1993 allocation of 2916 mt was less than the estimated 1993 replacement yield and might actually have allowed for some surplus buildup. On the other hand, this line of reasoning also implies that there is also between an estimated 46% and 33% chance that the allocation of 2916 mt for 1993 might have resulted in no surplus or in further stock decline.

Finally, 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. Thus, there is not strong evidence at hand to indicate that rebuilding has been initiated or if the stocks are declining further under the recent catch restrictions. Given the fishery has been regulated for just one year, 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. In fact, given reasonably precise measures of abundance (cv's in catch rate indices of 20%), doubling or halving in shark abundance could be statistically detected with high probability. However, under a catch limit that might allow for a 5-10% annual increase, this degree of change would not likely occur for a decade or more.

As discussed, the CPUE observations suggest substantial declines in large coastal shark abundance since the 1970's. This feature is consistent across the available observations which span the time period. An alternative method for evaluating the TAC involves considering the change in relative abundance levels with respect to landing levels was proposed in a document distributed to the Committee via correspondence[1]. Over the period 1980-1985, average annual landings of sharks were assumed as 4773 mt. Although these represent large coastal and other species, the majority of the landings were thought to be large coastals. During this period, a fishery-independent CPUE measure from off the Virginia coast for large coastal sharks decreased an average of 9.3% per year (SB-8, SB-19). Assuming these catch rates accurately and without error, measured change in abundance of the closed population and ignoring possible change in stock productivity due to time lags or other phemomena and further assuming no change in reporting rates for shark catches over time, an estimate of the exploitable standing stock of sharks in 1980 is taken as 4773/0.093 = 51,323 mt. In 1990, CPUE was about 20% of the 1980

[1] Presented to the Committee via correspondence (April 1994) in a document entitled "An evaluation of the T.A.C.'s in the Fisheries Management Plan for sharks of the Atlantic Ocean" by J. A. Musick, Virginia Institute of Marine Science. Copies are available from Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, FL 33149.

level. Applying this fraction to the 1980 stock estimate results in an estimate of the standing stock in 1991 of 10,265 mt. In order for removals equivalent to a TAC of 2916 from a standing stock of this, or a lower level (if the stock were reduced further in 1991-1992 and the estimate includes other shark groupings), to result in an increase in standing stock, the annual average replacement rate (in biomass) required would be greater than 28%. Demographic considerations (see Table 2.1), under closed population assumptions, suggest that replacement rates this large are not likely for large coastal sharks. Replacement rates of this magnitude would require considerable immigration into the exploited stocks. However, it was noted that estimated annual average replacement rate via this method is sensitive to, among other factors (identified above), the presumed historical catch levels. If actual mortality were higher than the assumed level (*e.g.* due to finning or proportionally larger unreported or misidentified catches), then by this method, the estimated replacement rate required to support an annual removal of 2916 mt would be lower in proportion to the change in presumed historical catch. It was further noted that without full consideration of these sensitivities and characterization of the uncertainty in the approach, this should not be viewed as an improvement over, or a replacement for, the statistically-based model in the FMP.

While there are a number of uncertainties in the above discussion, the **Committee believes that the weight of the evidence does not support the previous (FMP) recommendation that the 1994 or 1995 TAC should automatically increase.** Given the information available, increases in the TAC for sharks were considered risk-prone with respect to promoting stock recovery. In fact, considering the reproductive profiles of sharks and the general insufficiency of fishery data upon which to base analyses, any TAC might be considered risk-prone relative to stock recovery of large coastals.

4.2. Small Coastal Sharks

No new analyses were presented with which to modify MSY or TAC of the small coastal sharks. While it appears that resource survey estimates of relative abundance of Atlantic sharpnose in the Gulf of Mexico may have been higher in the 1970's and early 1980's than in later years, there has not been a trend either up or down since the mid-1980's. This would argue that the stocks may be stabilized. An analysis of Atlantic sharpnose presented at this Workshop provided a range of intrinsic rates of increase of these sharks based on possible ranges of demographic parameters. The analysis indicated that the intrinsic rate of increase (or conversely the replacement fishing mortality rate) was less than previously estimated for the small coastal shark group as a whole. However, the demographic analysis assumes a closed population, *i.e.* it does not allow for migrations of sharks into and out of the areas where they are subject to fishing pressure, whereas the methods used to estimate replacement rates in the FMP did include replacement from that mechanism. At this point the lines of evidence for recommending change in TAC are ambiguous.

4.3. Pelagics

No new analyses were presented with which to modify MSY of the pelagic sharks or the TAC. However, it should be noted that the available catch rate data indicates that mako and blue shark relative catch rates may have declined to approximately 25% of their late 1970's levels. At this juncture, it is unclear if this decline in catch rate observed in these data sets represents an equivalent abundance decline. The Committee recommended that additional research on this topic be conducted.

5. MONITORING MEASURES

5.1. Catches and Landings

There is a need to monitor the total catch by species and size or age, including total removals, discard mortality and other forms of mortality. The Committee reiterates this overall goal.

In previous meetings similar to the present Workshop (1986, 1988 and 1992) the participants at those meetings have continuously emphasized the need for species identification in catches. Still this remains a problem. There will only be marginal improvements in shark assessment and management while a large proportion of the shark catch is unidentified to species. Improvements in characterization of landed shark catch could be made by increasing the level of dockside intercepts of shark catch by trained port agents. The Committee recommends increasing these intercept rates.

The Committee discussed the present overlap of the different logbooks being issued. It was pointed out that some directed shark fishermen do not have specific shark logbooks, either being covered under reef fish or pelagic logbooks (on which shark data can be recorded) or not having any at all. It is suggested additional effort be made to identify directed shark fisherman, i.e. that all directed shark fishermen be supplied with a shark log book. It was also suggested that since size data were integral to improvements in assessments that reporting of the weight of each individual shark carcass is needed, perhaps by using dealer weighout sheets.

The Committee felt that logbook data collection methods required a means of verification of the data reported. The Committee recommended further use of scientifically designed observer sampling programs for this purpose. The Committee noted that scientific observers are being deployed in certain fisheries which provide species-specific information for a portion of the landed and discarded catch. The Committee further noted that current observer sampling for most of the shark-directed effort was either not in place or likely at too low a sampling fraction to provide representative and precise information about catch and effort.

There remains a serious loophole in data collection requirements due to incompatibility between Federal regulations and those of some States. This needs to be resolved.

Recreational catches and landings must continue to be monitored including catch rates as measures of relative abundance. Although the importance of tournaments has decreased in recent years, there is still a need to monitor their catch and catch rates. Direct sampling and/or tournament reporting may be required.

Effort should be expended in monitoring the small gillnet fisheries directed at small coastal sharks. It appears that a substantial number of juvenile large coastal sharks are being caught and discarded by those fishing for small coastal species when the season on large coastal sharks is closed. Some research (e.g. SB-18) indicates that mortality of this bycatch could be relatively high (greater than 50%).

In addition to improvements in domestic landings and species composition information, improved information on catches of sharks by other nations is required, especially for those species known or believed to be exploited by the high-seas fishing fleets or which are exploited by our neighboring fishing nations. The Committee believes that improvements in this area might be attained through the appropriate international fishery research and management bodies.

5.2. Nurseries

The Committee noted the importance of nursery areas and the monitoring of the stocks in these areas. This requires the delineation of the nursery areas. Additionally, scientific monitoring of the relative abundance of juveniles in these areas is feasible and would provide useful information on shark status.

5.3. Fishery Independent Measures

In addition to fishery-based catch rate information, the Committee noted the importance of developing and continuing the available consistent, time-series data bases of fishery independent measures of shark abundance and productivity. Scientific sampling designs in nursery areas (see above) provides a basis for monitoring productivity, both through measures of juvenile shark density and measures of maturity and natality. Application of research vessel sampling designs to provide precise catch rate indices should also be further developed and utilized.

6. MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

As mentioned in the above sections, stocks of large coastal sharks appear to have been substantially depleted since the mid-late 1970s and it is likely that, at least in aggregate, large coastal sharks are well below the biomass associated with MSY. The sustainability of the current TAC is more difficult to evaluate, since there are not yet data available to test hypotheses about change in stock abundance under the current TAC. Catch per unit effort indices, average weights and species richness have declined throughout the period of data availability. Estimates of longevity and age at maturity have generally increased as ageing techniques have improved. In 1992, just after the draft FMP was released, but prior to implementation of the final FMP, there was considerable finning of sharks and shark mortality during that period is believed to have escalated, probably resulting in further reductions in stock biomass. Based on these types of information, the Committee judged that the current TAC will not lead to stock rebuilding by the end of this century. Extending the logic, **the Committee felt that the projected quota increase for 1995 should be delayed indefinitely**, at least until and if the stocks exhibit signs of rebuilding.

6.1. Other Measures

The Working Group 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 Working Group discussed the benefits of 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 **the single most important supplementary measure that might be implemented is a closure of nursery grounds to directed fishing during the pupping season**. This measure, provided it is both sufficiently long and covers the known geographical range of nursery areas, is likely to result in reduced fishing pressure on the stocks if done in concert with, rather than in place of, a ceiling on allowable catch (*i.e.* TAC) apportioned throughout the year. Alternatives to the semi-annual allocation scheme (e.g. tri-annual or quarterly allocations) may be reasonable alternatives to use in conjunction with a nursery closure measure. Since most nursery grounds occur in coastal waters, this recommended measure generally comes under the jurisdiction of the States. The Committee believes that nursery ground closures would also provide benefits in terms of reduced fishing pressure on small sharks and on females during closure periods. However, such measures might impact other fisheries which have shark bycatch. Additional supplemental management measures are probably not practical at this time.

Closure of coastal nursery grounds will not promote conservation of the pelagic species, which apparently pup offshore. For this reason, minimum sizes for species such as mako should continue to be investigated in anticipation of possible future implementation.

The possible benefits and drawbacks of finer subdivisions of the annual quota were also discussed; this issue is likely to become increasingly important to certain fleet components if the abundance of preferred stocks continues to decline.

6.2. Species Composition

The greatest impediment to management, monitoring and stock assessment is the need to collect more accurate and more complete information on species composition of the catch. Approximately 80% of commercial shark landings are classified as "unidentified", and it is believed that a sizable proportion of the remainder may be misidentified. While 20% "identified" is an improvement from previous years, it must still be noted that **the primary limiting factor to improvement of shark stock assessments is the paucity of species catch composition data**. Unless data on landings by species improve substantially, it will not be possible to produce credible species-specific assessments, or to effectively manage the stocks in the future. Dealers and fishermen need to be encouraged to learn and apply correct species identification techniques. The composition of the discarded catch is also needed. This could best be obtained through observer programs.

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LIST OF DOCUMENTS

SB-1. Castro, J.I. Shark species synopses for stock assessment purposes.

SB-2. Powers, J.E., J. Poffenberger and B. Slater. Recreational and commercial shark landings, recreational effort and average sizes from the recreational fisheries.

SB-3. Schirripa, M.J. Analysis of shark catches from the Gulf of Mexico - reeffish logbooks.

SB-4. Powers, J.E. Analysis of shark catches from the southeast US coast - snapper-grouper logbooks.

SB-5. Pellegrin, G. Estimates of shark bycatch from shrimp trawling in the Gulf of Mexico and indices of relative abundance.

SB-6. Trent, L. Evaluation of shark by-catch in commercial shark fisheries.

SB-7. Musick, J.A., S. Branstetter and J. Graves. Distribution, abundance, and stock composition of sharks important to recreational fisheries in Virginia.

SB-8. Musick, J.A., S. Branstetter and J. A. Colvocoresses. Trends in shark abundance from 1974 to 1991 for the Chesapeake Bight region of the US mid-Atlantic coast.

SB-9. Cramer, J. Large pelagic logbook catch rate indices for sharks.

SB-10. Scott, G. Shark logbooks data summary

SB-11. Scott, G. Charterboat catch rate indices for sharks.

SB-12. Scott, G. Preliminary landed catch rate indices for large pelagic sharks from US fleet longline trip weighout records.

SB-13. Francesconi, J. North Caroiina Commercial CPUE.

SB-14. Gilmore, G. Comments on shark assessment and management.

SB-15. Cortes, E. Demographic analysis of the Atlantic sharpnose shark Rhizoprionodon terranovae in the Gulf of Mexico.

SB-16. Hueter, R. Survey of the Florida recreational shark fishery utilizing shark tournament and selected longline data.

SB-17. Scott, G. Recreational catch rate information for sharks.

SB-18. Hueter, R. Bycatch and catch-release mortality of small sharks in the Gulf Coast nursery grounds of Tampa Bay and Charlotte Harbor, Florida.

SB-19. Musick, J., S. Branstetter and T. Sminkey. Trends in shark abundance from 1974 to 1993 for the Chesapeake Bight region of the U.S. mid-Atlantic coast.

Appendix

Catch Rate Indices.

The Working Group examined an array of catch rate information for sharks, some species-specific and others for groups of species according to the shark FMP management unit definitions. Analyses and summaries of catch rate information were presented in documents (list of the SB CPUE documents). The group also identified several data sets with which to conduct further analysis at the meeting. These are described below.

Pelagic Longline Indices

Catch rate indices, standardized for various effects thought to influence catch rate independent of shark abundance, for large coastal and pelagic sharks in the the Atlantic, Caribbean and Gulf of Mexico were developed using mandatory reports from longline vessels in Document SB-9 and from trip weighout records from longline vessels in Document SB-11. Indices from logbook records were also compared to available observer data on catch rates from Gulf of Mexico observed and self-reported fishing effort in Document SB-9. The catch rates estimated from trip weighout records (SB-12) used in subsequent analysis, were those since 1985, a period during which the proportion of trips landing the sharks of interest was not increasing.

Daily catch and effort reports by U.S. fishing vessels fishing in the Atlantic, Caribbean and Gulf of Mexico which land swordfish have been required since October 1986. Large coastal and pelagic sharks are caught as bycatch and less frequently as targeted catch by these vessels. Although a variety of gear types are represented, the predominant gear type (90% of vessels reporting) is longline gear. In order to standardize the type of effort used in analysis, only records from boats known to use longline gear and/or bottom longline gear are used in the analyses presented in SB-9. Eight years of data (1986 to 1993) were available.

Shark categories available for the full time span in the LPL included hammerhead, tiger, white, blue, mako, thresher, and unclassified sharks. A high proportion of the catch of sharks was reported as unclassified. For these analyses, unclassified sharks were assumed to come from the category large coastals. Due to very low reported catch rates, white shark was not considered for analysis; similarly blue sharks and thresher sharks were not included in analyses specific to the Gulf of Mexico. In all cases, catch rate was taken as the reported number of sharks kept, discarded dead and discarded alive.

Charterboat Logbooks

Document SB-11 describes the analyses conducted on the Charterboat logbook data compiled by the NMFS Panama City Laboratory. The data available for analysis was from shark-directed effort which spanned the period 1987-1992. Most of the shark catch was not classified to species level and the estimated catch rates were assumed to represent the large coastal grouping. The model estimated catch rates are shown in the table below.

Reef Fish Logbooks

Documents SB-3 and SB-4 described the nominal catch rate and species proportions in the Gulf of Mexico (Document SB-3) and Southeastern US Atlantic (Document SB-4) logbook data sets. In document SB-3, the data summarized were from the Gulf of Mexico reeffish logbook program. This program was phased in in 1989 and was in full operation in 1990. From 1989 to 1992, all participants in all states (Florida, Alabama, Mississippi, Louisiana, and Texas) except Florida were required to report on a per trip basis; 20% of the Florida fishermen were required to report and 100% of Florida trap fishermen. In 1993, a phasing in of 100% reporting for Florida fisherman was started. Therefore, catch (in pounds) is to be interpreted not as total estimated catch, but rather total reported catch (except for those states in which total participation is required). Furthermore, any data analyzed on a "by vessel" basis will only include those Florida fishermen selected to participate (new participants were selected each year). Any data concerned with rates (catch/trip, catch/day. etc.) or species composition should not be effected by the sub-sampling design however.

Catch as reported here is the condition in which the sharks are landed by the fisherman (i.e. there is no conversion to gutted or cored weight or any other weight). Species composition was derived from an "as reported" basis as well.

Estimates of catch-per-unit-effort (CPUE in pounds/hook hour) were derived from trips which reported at least 50% of that trip as shark. Monthly estimates of CPUE were obtained by calculating CPUE by trip and taking an averaging of these for the month. Furthermore, only the middle 50th percentile of the monthly CPUE distribution was used for the calculations (i.e. the upper and lower 25 percentile was dropped). Annual estimates followed the same method only averaged for the year rather than month.

During the working group meeting, further analysis of the Gulf reef fish log reports was undertaken. A GLM of the bottom longline reported catch rates was used to standardize for the effects of bi-month and area of fishing to produce an annual index (sharks/1000 hooks fished). The mean index values from this analysis are presented below. The ANOVA calculations are presented at the end of the Appendix.

Large Pelagic Survey Data.

Catch per unit effort (CPUE) data on rod and reel (RR) and handline (HL) fisheries off the coast of the United States from Virginia through Massachusetts were collected between 1980 and 1993. Fishermen were interviewed as they returned to the dock and by phone to determine if the trip was directed at large pelagic game fish (sharks, tunas, billfishes). Interviewers recorded the number of fish caught and the methods employed for each trip.

Each trip interview record includes data on: target species, date, boat type, fishing method and state. For this analysis data were restricted to only those trips which targeted sharks and which employed the chumming method. The analysis was also limited to months May through September. Nominal catch rates within these restrictions appeared to be higher than those outside. The nominal catch rates, by species are shown in the table below.

Nominal average shark catch from the Large Pelagic Survey.

	Species or Species Group Average Catch per Trip				
Year	Makos	Blue	Sandbar	Dusky	Hammerheads
86	0.49	1.04	0.22	0.32	0.05
87	0.36	0.75	0.11	0.27	0.03
88	0.16	1.87	0.21	0.09	0.01
89	0.24	1.03	0.33	0.17	0.03
90	0.26	0.73	0.12	0.17	0.02
91	0.46	1.63	0.16	0.18	0.07
92	0.01	0.01	<0.01	<0.01	0.01

The variation in factors such as area fished, time of year, interview type (phone or dockside) and boat type (private/charter) likely make it inappropriate to compare nominal CPUE across years. A general linear model (GLM) approach could be used to develop standardized indices of abundance for mako, sandbar, dusky, blue and hammerhead sharks in the RR fishery during 1986-1993 (the available time period for which shark targeted effort was covered). Analysis of this data set was initiated at the working meeting. However, the working group was not able to fully consider these data, and additional analysis of these data is needed to examine the question of patterning in shark CPUE. The group recommended that further analyses of these data be undertaken.

Scientific Observers on Japanese Longline Vessels.

The Japanese longline observer database consists of data collected by US observers aboard Japanese longline vessels which fished in US EEZ waters between 1978 and 1988. The database examined by the working group provided summaries of catch and effort from nearly 5,500 longline sets made by these vessels during this period. Three broad areas were fished: Gulf of Mexico (GOM), Mid-Atlantic (MAT) and Northwest (NAT). The distribution of observed sets over areas and years is shown below:

	78	79	80	81	82	83	84	85	86	87	88
GOM	168	199	145	253	-	-	-	-	-	-	-
MAT	104	158	91	159	95	37	38	63	23	10	-
NAT	97	82	229	577	752	233	300	480	397	490	290

Japanese longliners were excluded from the Gulf of Mexico beginning in 1982. Although more than 20 different species of sharks are included in the database, there are only two species for which the total numbers of sets with positive catch exceeds 1,000: mako sharks (over 2,100 observations) and blue sharks (over 4,400 observations).

A GLM of positive catches showed significant effects of year, area, wave (bi-month), swordfish catch rate, and fishing depth. These variables, along with bluefin tuna catch rates, were also significant for blue sharks. Proportions of zero catch sets were included in the final indices using the Lo method (see Working Documents SB-9 and SB-11). The standardized catch rates indicate an overall significant decline for both species. The catch rates estimated for 1982 in both species analyses are quite low, with respect to surrounding years, and may have been affected by fishing pattern changes not adequately accounted for in the modelling. This pattern persists in the analysis limited to Atlantic fishing areas only, is also evident in catch rate analyses of species other than sharks and is not thought to be an area fishing effect. Results of the GLM model fits to these data are presented in the Appendix. Mean catch rate index values computed from these data are presented below.

Shark Tournament Data

Document SB-16 presented a synopsis of work completed under Florida Department of Natural Resources contract to assess historical trends in the shark fisheries of Florida through analysis of data available through organized sportfishing tournaments (also called "derbies" or "rodeos") for sharks. From the mid-1970's to about 1989, the number of tournaments that include or are directed solely toward sharks along the U.S. Atlantic and Gulf coasts steadily increased. Such tournaments in this region have been conservatively estimated by NMFS to number about 65 per year as of 1989 (NMFS, 1989).

Over the past decade, shark tournaments became popular as fishing contests and fund-raisers in many fishing communities of the southeast U.S. In recent years, declining catches of sharks, both in number and size, have been reported in these tournaments via anecdotal sources. Although tournament directors have pointed to years of logbook information containing catch records, prior to those present in Document SB-__, no formal attempt has been made previously to compile and analyze these records on a statewide basis. In light of the relative lack of published information on Florida's recreational shark fishery, these tournament records represent important historical data.

A total of 34 sportfishing tournaments devoted strictly to sharks and operating in Florida waters sometime between 1971 and 1991 was identified. (This survey did not include other tournaments that had sharks as a category of catch--only dedicated shark tournaments are considered). In 25 (74%) of these, the tournament director or co-director was identified, located and interviewed. General information was collected on each tournament as follows:

--Official name of the tournament and its base location.
--Years of operation and current status (active or discontinued).
--Number of participating anglers and/or boats per year.
--Status of tournament record.

If written catch records of a tournament were located, the status of those records fell into one of three categories: 1) records provided to this study and suitable for analysis--9 tournaments (26%); 2) records incomplete and not suitable for analysis--6 (18%); or 3) records may have been suitable but were not provided, due either to passive noncompliance or deliberate noncooperation of record curators--5 (15%). For the rest of the tournaments (14/41%), no existing records were located.

Tournaments with suitable records were analyzed for catch by year. Primary data consisted of species and size (by total weight in pounds) of catch. Unfortunately, data on sex and length of sharks caught were rarely recorded, so these could not be included in the analysis. Given that the information came from competitive tournaments, it was assumed that weight measurements were accurate. On the other hand, it was not necessarily assumed that species identifications were accurate. The record-holders were interviewed to gauge the relative accuracy of the species ID's, and adjustments in the data were made where justified. However, some errors in species identification likely exist in the tournament data set, due to the inherent difficulties that anglers have in distinguishing between closely related species of sharks.

Catch per unit effort (catch per registered angler in the tournament) was calculated and plotted where possible. In general, the available catch and effort information from the tournaments show decline in CPUE and in the average size of sharks caught over the years available. Four of these tournaments provided some time series information (over a span of 4 or more years) about catch rates. For 2 of these tournaments, the unit of effort used to calculate CPUE was the average number of registered anglers in the tournament for periods when registry was thought to be more or less constant from year to year, but for which annual counts of anglers were not available. For the other data sets, the actual number of registered anglers for each year was used. The working group assumed these catch rates to be representative of the large coastal group in aggregate. These catch rates are shown below.

Crooke Longline Data

Document SB-16 also presented analyses of longline catch rates made by Mr. C.F. Crooke, Jr. of Warrington (near Pensacola), Florida. The Crooke data pertain to small but remarkably consistent longlining operations for large, inshore sharks over 15 years, from 1975 through 1989. The records include species, sex, water temperature, and other information for sharks caught in the waters off Pensacola.

Beginning in 1975 and ending in 1989, Mr. Crooke set a small longline regularly in the waters south of Pensacola, specifically to catch large sharks for supply of shark meat to local restaurants. His typical fishing year ran from late March/early April to late November/early December. Since these activities were incidental to Mr. Crooke's regular line of work, he fished usually on weekends or holidays. Through the 15 years, he averaged just over 18 successful sets of the gear per year ("successful" - at least one shark was caught and recorded), with a range of 9 successful sets in some years to 32 in his most active year (1978). One unfortunate drawback of the database was that data were taken only when sharks were caught, i.e. only on successful sets. Sets that caught no sharks were not recorded. and there appears to be no way to recover this information accurately. This compromises to some extent the catch/effort data, limiting the quantitative analysis to successful sets only.

Document SB-18 plotted the 15 years of Crooke data as number of sharks caught per hook vs. year of fishing, for successful sets of the gear. After removing the data assumed to represent the "learning period" (1975-76; the start-up period in which Mr. Crooke set the line only nine times each year), the resulting regression shows a negative trend. In the later years of the Crooke longline operation, size of sharks caught and CPUE in sharks per hook were both declining. SB-18 concluded that it appeared that one partial explanation for both phenomena is the near-complete disappearance of dusky and great hammerhead from the catch after 1985. Both of these are large-bodied species.

North Carolina Division of Marine Fisheries Data

North Carolina, Division of Marine Fisheries, conducted a fishery dependent survey of directed shark longline trips from March 1988 through April 1992. The survey data have 53 observations (trips) and consist of total weight (kg), number of sharks, total fin weight (kg), days fished, number of sets, number of hooks, miles per set, soak time, location, depth, and discard information. Data were collected from 6 vessels. These data are presented at the end of this report.

A General Linear Model Procedure was performed upon the data testing for year, wave (2 month periods), miles per set, and hooks per mile of longline set. CPUE was computed either as kg or number of fish per 10,000 hook hours. One observation (trip) was omitted due to inconsistent gear and methods used in fishing. Results of these analyses are presented at the end of this Appendix. The indices resulting were believed to represent the large coastal shark complex fished by these vessels. For the index based on kg, the estimated mean catch rate in 1989 was greater than in other years. For the index based on number of fish, the 1989 value was again higher than subsequent years; in addition, the 1988 value was higher than 1990-1992. In this analysis, there appeared some tendency for an increase in the number of fish caught per unit effort over the last years of the time period (1990-92), although the catch rate values were not statistically different from one another. A result similar to this (constant biomass/effort and increasing numbers/effort) could be consistent with a tendency to land more small sharks in 1992 compared to 1990.

Recreational Surveys Data

Estimated catch and estimated effort data from the MRFSS, Headboat, and TX Parks and Wildlife recreational fisheries survey were summarized in Document SB-17. After review, the working group recommended that the analysis of these data be based on interview observations rather than state by wave estimated effort and catch. This was recommended since modelling the highly aggregated data does not likely allow for adequate adjustment for targeting effects by the different fisheries surveyed.

VIMS Fishery Independent Survey Data

The Virginia Institute of Marine Science (VIMS) has conducted a longline sampling program since 1974 examining the distribution, abundance, and biology of sharks and large pelagic teleosts off Virginia. This long-term program provides information on catch, effort, and species composition from 1974 through 1993 for the Chesapeake Bight region. A synopsis of these data and available CPUE analyses is presented in the Appendix.

Low-effort years were combined into multi-year categories by grouping 1974-79 and 1982-89. Although combining data from consecutive years reduced the information available for a given year, it provided a more equitable basis of effort to illustrate the long-term continuum in catch and effort trends around the comprehensive high-effort survey periods 1980-1981 and 1990-1991 in SB-8 and SB-19.

Catch per unit of effort (CPUE) was defined as the total number of sharks caught for the total number of hooks fished, multiplied by 100 within each sampling category, although the number of hooks per set increased over time. CPUE was analyzed for total catch and by individual species in designated year categories. Because sharks segregate by sex and size, and may be distributed disjunctly by depth on a seasonal basis, CPUE was analyzed for each time-series by depth strata and by month. The majority of species considered were coastal sharks; thus, because of the relatively higher percentage of hooks fished in offshore (>100 m) waters during the 1980's and in 1990, species-specific CPUE analyses were restricted to efforts from the Bay to the 100-m depth contour to avoid negatively biasing results for these species. Efforts in the >100-m depth category were included only for total CPUE and CPUE for more widely distributed dusky and scalloped hammerhead sharks. Additionally, after 1981, new sampling areas -- offshore (>100 m) areas away from the standard station at Norfolk Canyon, and a lagoon within the Virginia eastern shore peninsula -- were fished for very specific purposes. These efforts were not directly comparable with previous data, and were excluded from analyses.

Mean log-transformed CPUE values are given and 95% confidence intervals and re-transformed means are given in Table 1 and Fig. 1 of working document SB-19. Both presentations show decline from the 1974-79, 1980 period to the early 1990s. The ANOVA of the log transformed data (see Table 2 in working document SB-19 and other information in the Appendix) was significant and the multiple range test showed clear differences between the 1974-81 data sets and the 1990-93 data sets.

Results were similar for the sandbar shark (Table 4, Fig. 2 in SB-19). There was a decline in CPUE from the 1974-81 period to the 1990-1993 period (Table 4 - SB-19). The ANOVA was significant and the results of the multiple range test clearly separated these two time periods (SB-19, Tables 5 and 6).

The decline in dusky sharks was even more pronounced than that for sandbar sharks (working document Table 7, Fig. 3). Values for CPUE (working document Table 9) from 1974-1980 were different from those from 1992-1993, but 1981 was grouped with later periods 1982-89 and 1993. Musick *et al.* (1993a) pointed out that the decline in the dusky shark population appears to have begun earlier in the Mid-Atlantic than for most other species.

The Mid-Atlantic long-line survey data show declines in dusky and sandbar sharks from the late 1970's and early 1980's to the early 1990's. A similar decline has been noted for other large coastal species as well (Musick *et al.*, 1993a), and for large coastal sharks in general (Fig. 1 - SB-19). A more complete analysis of this data set is given in Musick *et al.* (1993a and 1993b).

Are Trends Evident in the Various CPUE Data Series?

The available CPUE data were examined for evidence of trend in catch rates by fitting linear models to the log transformed CPUE series. Fits were made to individual series with a linear regression and to combined CPUE series through the application of a General Linear Model to control for the scale effects (different measures of effort) of the different series investigated. In total, 21 index CPUE series were available. The associated single series fits and combined series fits are provided later in the Appendix.

Table 1. The CPUE series for sharks considered by the working group. Series are listed by species or species group with source of the 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%).

SPECIES	SERIES	TYPE	YEAR	INDEX	CV
large coastal	[1]Gulf Reef	Biomass	90	1781.12	0.20390
large coastal	Gulf Reef	Biomass	91	2131.30	0.11264
large coastal	Gulf Reef	Biomass	92	1628.98	0.10782
large coastal	Gulf Reef	Biomass	93	1419.18	0.13575
large coastal	[2]Hudson	Numbers	85	0.22	1.00000
large coastal	Hudson	Numbers	86	0.10	1.00000
large coastal	Hudson	Numbers	87	0.12	1.00000
large coastal	Hudson	Numbers	88	0.10	1.00000
large coastal	Hudson	Numbers	89	0.05	1.00000
large coastal	Hudson	Numbers	90	0.02	1.00000
large coastal	Hudson	Numbers	91	0.02	1.00000
large coastal	[3]Crooke LL	Numbers	75	0.11	1.00000
large coastal	Crooke LL	Numbers	76	0.08	1.00000
large coastal	Crooke LL	Numbers	77	0.13	1.00000
large coastal	Crooke LL	Numbers	78	0.25	1.00000
large coastal	Crooke LL	Numbers	79	0.12	1.00000
large coastal	Crooke LL	Numbers	80	0.16	1.00000
large coastal	Crooke LL	Numbers	81	0.13	1.00000
large coastal	Crooke LL	Numbers	82	0.13	1.00000
large coastal	Crooke LL	Numbers	83	0.14	1.00000
large coastal	Crooke LL	Numbers	84	0.12	1.00000
large coastal	Crooke LL	Numbers	85	0.14	1.00000
large coastal	Crooke LL	Numbers	86	0.11	1.00000
large coastal	Crooke LL	Numbers	87	0.08	1.00000
large coastal	Crooke LL	Numbers	88	0.08	1.00000
large coastal	Crooke LL	Numbers	89	0.09	1.00000
large coastal	[4]Jax	Numbers	79	0.59	1.00000
large coastal	Jax	Numbers	84	0.71	1.00000
large coastal	Jax	Numbers	90	0.16	1.00000
large coastal	[5]NC #	Numbers	88	999.10	0.42199
large coastal	NC #	Numbers	89	1637.36	0.23219
large coastal	NC #	Numbers	90	549.10	0.13766
large coastal	NC #	Numbers	91	625.52	0.12714
large coastal	NC #	Numbers	92	721.60	0.17409
large coastal	[6]NC KG	Biomass	88	837.85	0.50421
large coastal	NC KG	Biomass	89	2398.68	0.28493
large coastal	NC KG	Biomass	90	1121.99	0.16420
large coastal	NC KG	Biomass	91	1207.04	0.15886
large coastal	NC KG	Biomass	92	1163.71	0.16692
large coastal	[7]Port Salerno	Numbers	76	0.18	1.00000
large coastal	Port Salerno	Numbers	77	0.81	1.00000
large coastal	Port Salerno	Numbers	79	0.89	1.00000
large coastal	Port Salerno	Numbers	80	0.82	1.00000
large coastal	Port Salerno	Numbers	81	0.39	1.00000
large coastal	Port Salerno	Numbers	82	0.50	1.00000
large coastal	Port Salerno	Numbers	83	0.12	1.00000
large coastal	Port Salerno	Numbers	84	0.10	1.00000
large coastal	Port Salerno	Numbers	85	0.15	1.00000
large coastal	Port Salerno	Numbers	86	0.50	1.00000
large coastal	Port Salerno	Numbers	87	0.32	1.00000
large coastal	Port Salerno	Numbers	88	0.20	1.00000
large coastal	Port Salerno	Numbers	89	0.12	1.00000
large coastal	Port Salerno	Numbers	90	0.20	1.00000
large coastal	[8]Tampa Bay	Numbers	85	0.16	1.00000
large coastal	Tampa Bay	Numbers	86	0.09	1.00000
large coastal	Tampa Bay	Numbers	87	0.03	1.00000
large coastal	Tampa Bay	Numbers	88	0.14	1.00000
large coastal	Tampa Bay	Numbers	89	0.06	1.00000
large coastal	Tampa Bay	Numbers	90	0.05	1.00000
large coastal	[9]Virginia LL	Numbers	76	7.14	0.25000
large coastal	Virginia LL	Numbers	80	8.26	0.22000
large coastal	Virginia LL	Numbers	81	4.65	0.31000
large coastal	Virginia LL	Numbers	86	3.17	0.21000
large coastal	Virginia LL	Numbers	90	1.69	0.20000
large coastal	Virginia LL	Numbers	91	1.44	0.24000
large coastal	Virginia LL	Numbers	92	0.71	0.31000
large coastal	Virginia LL	Numbers	93	1.09	0.49000
large coastal	[10]charter boat	Numbers	89	403.00	0.15000
large coastal	charter boat	Numbers	90	420.00	0.14000
large coastal	charter boat	Numbers	91	402.00	0.14000
large coastal	charter boat	Numbers	92	335.00	0.15000
large coastal	charter boat	Numbers	93	347.00	0.21000
large coastal	[11]pelagic logbook	Numbers	86	13.02	0.16000
large coastal	pelagic logbook	Numbers	87	9.59	0.04000
large coastal	pelagic logbook	Numbers	88	9.56	0.04000
large coastal	pelagic logbook	Numbers	89	8.99	0.04000
large coastal	pelagic logbook	Numbers	90	8.57	0.04000
large coastal	pelagic logbook	Numbers	91	5.82	0.05000
large coastal	pelagic logbook	Numbers	92	4.33	0.05000
large coastal	pelagic logbook	Numbers	93	4.08	0.05000
sandbar	[12]Virginia LL	Numbers	76	3.92	0.25000
sandbar	Virginia LL	Numbers	80	4.45	0.22000
sandbar	Virginia LL	Numbers	81	3.49	0.32000
sandbar	Virginia LL	Numbers	86	1.50	0.28000
sandbar	Virginia LL	Numbers	90	0.79	0.28000
sandbar	Virginia LL	Numbers	91	0.82	0.32000
sandbar	Virginia LL	Numbers	92	0.34	0.42000
sandbar	Virginia LL	Numbers	93	0.75	0.60000
dusky	[13]Virginia LL	Numbers	76	0.88	0.36000
dusky	Virginia LL	Numbers	80	1.24	0.46000
dusky	Virginia LL	Numbers	81	0.62	0.38000
dusky	Virginia LL	Numbers	86	0.22	0.48000

dusky	Virginia LL	Numbers	90	0.04	0.75000
dusky	Virginia LL	Numbers	91	0.08	0.57000
dusky	Virginia LL	Numbers	92	0.02	1.08000
dusky	Virginia LL	Numbers	93	0.18	0.75000
hammerhead	[14]pelagic logbook	Numbers	86	4.36	0.24000
hammerhead	pelagic logbook	Numbers	87	2.16	0.24000
hammerhead	pelagic logbook	Numbers	88	2.55	0.21000
hammerhead	pelagic logbook	Numbers	89	1.94	0.24000
hammerhead	pelagic logbook	Numbers	90	1.64	0.27000
hammerhead	pelagic logbook	Numbers	91	0.95	0.40000
hammerhead	pelagic logbook	Numbers	92	0.77	0.43000
hammerhead	pelagic logbook	Numbers	93	0.68	0.42000
blue	[15]Japanese obs	Numbers	78	2.43	0.22000
blue	Japanese obs	Numbers	79	1.77	0.19000
blue	Japanese obs	Numbers	80	1.55	0.17000
blue	Japanese obs	Numbers	81	1.09	0.18000
blue	Japanese obs	Numbers	82	0.45	0.40000
blue	Japanese obs	Numbers	83	1.08	0.35000
blue	Japanese obs	Numbers	84	1.89	0.23000
blue	Japanese obs	Numbers	85	1.62	0.22000
blue	Japanese obs	Numbers	86	1.34	0.24000
blue	Japanese obs	Numbers	87	1.00	0.27000
blue	Japanese obs	Numbers	88	0.40	0.58000
blue	[16]pelagic logbook	Numbers	86	16.95	0.21000
blue	pelagic logbook	Numbers	87	10.94	0.06000
blue	pelagic logbook	Numbers	88	8.55	0.06000
blue	pelagic logbook	Numbers	89	6.30	0.06000
blue	pelagic logbook	Numbers	90	6.46	0.06000
blue	pelagic logbook	Numbers	91	6.26	0.06000
blue	pelagic logbook	Numbers	92	6.15	0.06000
blue	pelagic logbook	Numbers	93	5.35	0.07000
mako	[17]Japanese obs	Numbers	78	0.60	0.19000
mako	Japanese obs	Numbers	79	0.42	0.19000
mako	Japanese obs	Numbers	80	0.36	0.18000
mako	Japanese obs	Numbers	81	0.30	0.19000
mako	Japanese obs	Numbers	82	0.16	0.44000
mako	Japanese obs	Numbers	83	0.22	0.40000
mako	Japanese obs	Numbers	84	0.30	0.25000
mako	Japanese obs	Numbers	85	0.23	0.25000
mako	Japanese obs	Numbers	86	0.27	0.27000
mako	Japanese obs	Numbers	87	0.26	0.30000
mako	Japanese obs	Numbers	88	0.17	0.65000
mako	[18]pelagic logbook	Numbers	86	1.24	0.13000
mako	pelagic logbook	Numbers	87	1.12	0.07000
mako	pelagic logbook	Numbers	88	0.90	0.07000
mako	pelagic logbook	Numbers	89	0.85	0.08000
mako	pelagic logbook	Numbers	90	0.83	0.08000
mako	pelagic logbook	Numbers	91	0.69	0.08000
mako	pelagic logbook	Numbers	92	0.75	0.08000
mako	pelagic logbook	Numbers	93	0.63	0.09000

mako	[19]weighout	Biomass	85	52.00	0.15000
mako	weighout	Biomass	86	61.00	0.12000
mako	weighout	Biomass	87	55.00	0.11000
mako	weighout	Biomass	88	54.00	0.10000
mako	weighout	Biomass	89	51.00	0.10000
mako	weighout	Biomass	90	38.00	0.11000
mako	weighout	Biomass	91	43.00	0.10000
mako	weighout	Biomass	92	30.00	0.13000
sharpnose	[20]Oregon II	Numbers	72	1.32	0.35000
sharpnose	Oregon II	Numbers	73	0.95	0.25000
sharpnose	Oregon II	Numbers	74	4.17	0.19000
sharpnose	Oregon II	Numbers	75	3.76	0.18000
sharpnose	Oregon II	Numbers	76	3.66	0.15000
sharpnose	Oregon II	Numbers	77	1.94	0.21000
sharpnose	Oregon II	Numbers	78	1.67	0.21000
sharpnose	Oregon II	Numbers	79	2.74	0.21000
sharpnose	Oregon II	Numbers	80	4.50	0.22000
sharpnose	Oregon II	Numbers	81	2.31	0.20000
sharpnose	Oregon II	Numbers	82	2.31	0.20000
sharpnose	Oregon II	Numbers	83	2.71	0.28000
sharpnose	Oregon II	Numbers	84	1.36	0.23000
sharpnose	Oregon II	Numbers	85	3.18	0.39000
sharpnose	Oregon II	Numbers	86	0.78	0.59000
sharpnose	Oregon II	Numbers	87	8.25	0.90000
sharpnose	Oregon II	Numbers	88	0.71	0.50000
sharpnose	Oregon II	Numbers	89	1.17	0.53000
sharpnose	Oregon II	Numbers	90	0.28	0.67000
sharpnose	Oregon II	Numbers	91	0.39	0.47000
sharpnose	Oregon II	Numbers	92	0.77	0.50000
sharpnose	Oregon II	Numbers	93	0.78	0.50000
sharpnose	[21]Virginia LL	Numbers	75	2.10	1.00000
sharpnose	Virginia LL	Numbers	76	2.10	1.00000
sharpnose	Virginia LL	Numbers	79	2.10	1.00000
sharpnose	Virginia LL	Numbers	80	2.50	1.00000
sharpnose	Virginia LL	Numbers	81	2.51	1.00000
sharpnose	Virginia LL	Numbers	86	1.40	1.00000
sharpnose	Virginia LL	Numbers	90	2.40	1.00000
sharpnose	Virginia LL	Numbers	91	2.00	1.00000
sharpnose	Virginia LL	Numbers	92	2.52	1.00000
sharpnose	Virginia LL	Numbers	93	2.90	1.00000

Sources:

1 - document SB-3 and analyses conducted at the meeting.
2, 3, 4, 7, 8 - document SB-16
5, 6 - document SB-13 and analyses conducted at the meeting.
9, 12, 13, 21 - documents SB-8, SB-19
10 - document SB-11
11, 14, 16, 18 - document SB-9
15, 17 - analyses conducted at the meeting
19 - document SB-12
20 - document SB-5

Table 2. Linear regression fits to log-transformed, individual CPUE series to examine the data for trend. Observations are weighted by the inverse of the coefficient of variation in the fits. A significant negative slope (negative year parameter estimate) is indicative of a negative trend in the data (conversely, a positive slope is indicative of a positive trend). The significance of the slope (H0: no slope) is indicated by the t-statistic and associated probability.

--------------------- SPECIES=blue SERIES=Japanese obs ---------------------

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.93615	1.93615	2.466	0.1508
Error	9	7.06652	0.78517		
C Total	10	9.00268			

Root MSE	0.88610	R-square	0.2151
Dep Mean	0.28656	Adj R-sq	0.1278
C.V.	309.21435		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	5.861472	3.55262226	1.650	0.1334
YEAR	1	-0.067631	0.04306847	-1.570	0.1508

------------------- SPECIES=blue SERIES=pelagic logbook --------------------

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	7.19057	7.19057	19.620	0.0044
Error	6	2.19890	0.36648		
C Total	7	9.38947			

Root MSE	0.60538	R-square	0.7658
Dep Mean	1.97979	Adj R-sq	0.7268
C.V.	30.57797		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	12.581518	2.39407964	5.255	0.0019
YEAR	1	-0.118086	0.02665891	-4.430	0.0044

--------------------- SPECIES=dusky SERIES=Virginia LL ---------------------

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	18.94574	18.94574	19.586	0.0044
Error	6	5.80375	0.96729		
C Total	7	24.74949			

Root MSE	0.98351	R-square	0.7655
Dep Mean	-1.26096	Adj R-sq	0.7264
C.V.	-77.99717		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	14.476160	3.56493504	4.061	0.0066
YEAR	1	-0.186601	0.04216342	-4.426	0.0044

---------------- SPECIES=hammerhead SERIES=pelagic logbook -----------------

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	8.25647	8.25647	67.927	0.0002
Error	6	0.72929	0.12155		
C Total	7	8.98576			

Root MSE	0.34864	R-square	0.9188
Dep Mean	0.59423	Adj R-sq	0.9053
C.V.	58.67042		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	22.878852	2.70464998	8.459	0.0001
YEAR	1	-0.250428	0.03038510	-8.242	0.0002

------------------ SPECIES=large coastal SERIES=Gulf Reef ------------------

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.41056	0.41056	2.715	0.2412
Error	2	0.30243	0.15121		
C Total	3	0.71299			

Root MSE	0.38886	R-square	0.5758
Dep Mean	7.45515	Adj R-sq	0.3637
C.V.	5.21600		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	17.891092	6.33379347	2.825	0.1058
YEAR	1	-0.113895	0.06912087	-1.648	0.2412

------------------- SPECIES=large coastal SERIES=Hudson --------------------

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	4.55070	4.55070	42.980	0.0012
Error	5	0.52939	0.10588		
C Total	6	5.08009			

Root MSE	0.32539	R-square	0.8958
Dep Mean	-2.72276	Adj R-sq	0.8749
C.V.	-11.95073		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	32.753904	5.41277715	6.051	0.0018
YEAR	1	-0.403144	0.06149295	-6.556	0.0012

SPECIES=large coastal SERIES=Crooke LL

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.18283	0.18283	2.169	0.1646
Error	13	1.09571	0.08429		
C Total	14	1.27855			

Root MSE	0.29032	R-square	0.1430
Dep Mean	-2.12746	Adj R-sq	0.0771
C.V.	-13.64629		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-0.032084	1.42466845	-0.023	0.9824
YEAR	1	-0.025553	0.01734994	-1.473	0.1646

SPECIES=large coastal SERIES=Jax

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.91645	0.91645	2.276	0.3727
Error	1	0.40273	0.40273		
C Total	2	1.31918			

Root MSE	0.63461	R-square	0.6947
Dep Mean	-0.90090	Adj R-sq	0.3894
C.V.	-70.44128		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	9.464347	6.88090081	1.375	0.4002
YEAR	1	-0.122908	0.08147596	-1.509	0.3727

SPECIES=large coastal SERIES=NC #

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.08160	1.08160	1.196	0.3540
Error	3	2.71195	0.90398		
C Total	4	3.79355			

Root MSE	0.95078	R-square	0.2851
Dep Mean	6.62472	Adj R-sq	0.0468
C.V.	14.35200		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	21.344481	13.45816126	1.586	0.2109
YEAR	1	-0.162876	0.14890259	-1.094	0.3540

SPECIES=large coastal SERIES=NC KG

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.09424	0.09424	0.155	0.7200
Error	3	1.82208	0.60736		
C Total	4	1.91632			

Root MSE	0.77933	R-square	0.0492
Dep Mean	7.13875	Adj R-sq	-0.2678
C.V.	10.91694		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	11.715207	11.61922466	1.008	0.3876
YEAR	1	-0.050595	0.12844455	-0.394	0.7200

SPECIES=large coastal SERIES=Port Salerno

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.85290	1.85290	3.794	0.0752
Error	12	5.85978	0.48832		
C Total	13	7.71268			

Root MSE	0.69880	R-square	0.2402
Dep Mean	-1.24050	Adj R-sq	0.1769
C.V.	-56.33192		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	5.890084	3.66533191	1.607	0.1340
YEAR	1	-0.085543	0.04391430	-1.948	0.0752

SPECIES=large coastal SERIES=Tampa Bay

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.43084	0.43084	1.064	0.3606
Error	4	1.61978	0.40494		
C Total	5	2.05062			

Root MSE	0.63635	R-square	0.2101
Dep Mean	-2.58706	Adj R-sq	0.0126
C.V.	-24.59755		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	11.142204	13.31280659	0.837	0.4497
YEAR	1	-0.156906	0.15211739	-1.031	0.3606

SPECIES=large coastal SERIES=Virginia LL

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	18.62029	18.62029	53.636	0.0003
Error	6	2.08298	0.34716		
C Total	7	20.70327			

Root MSE	0.58921	R-square	0.8994
Dep Mean	1.00575	Adj R-sq	0.8826
C.V.	58.58345		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	12.463490	1.56806756	7.948	0.0002
YEAR	1	-0.133678	0.01825292	-7.324	0.0003

SPECIES=large coastal SERIES=charter boat

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.17074	0.17074	5.694	0.0971
Error	3	0.08995	0.02998		
C Total	4	0.26069			

Root MSE	0.17316	R-square	0.6549
Dep Mean	5.94745	Adj R-sq	0.5399
C.V.	2.91149		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	10.837403	2.04944748	5.288	0.0132
YEAR	1	-0.053814	0.02255172	-2.386	0.0971

SPECIES=large coastal SERIES=pelagic logbook

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	18.26507	18.26507	44.080	0.0006
Error	6	2.48620	0.41437		
C Total	7	20.75127			

Root MSE	0.64371	R-square	0.8802
Dep Mean	1.98657	Adj R-sq	0.8602
C.V.	32.40324		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	16.350505	2.16406553	7.555	0.0003
YEAR	1	-0.160188	0.02412746	-6.639	0.0006

SPECIES=mako SERIES=Japanese obs

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	3.06543	3.06543	12.411	0.0065
Error	9	2.22295	0.24699		
C Total	10	5.28837			

Root MSE	0.49699	R-square	0.5797
Dep Mean	-1.17062	Adj R-sq	0.5329
C.V.	-42.45495		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	5.946908	2.02178349	2.941	0.0164
YEAR	1	-0.086552	0.02456829	-3.523	0.0065

SPECIES=mako SERIES=pelagic logbook

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	3.59703	3.59703	57.283	0.0003
Error	6	0.37677	0.06279		
C Total	7	3.97380			

Root MSE	0.25059	R-square	0.9052
Dep Mean	-0.16390	Adj R-sq	0.8894
C.V.	-152.88725		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	7.720368	1.04202759	7.409	0.0003
YEAR	1	-0.088044	0.01163287	-7.569	0.0003

SPECIES=mako SERIES=weighout

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	2.24593	2.24593	14.768	0.0085
Error	6	0.91248	0.15208		
C Total	7	3.15840			

Root MSE	0.38997	R-square	0.7111
Dep Mean	3.85305	Adj R-sq	0.6629
C.V.	10.12117		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	11.102499	1.88700460	5.884	0.0011
YEAR	1	-0.081814	0.02128933	-3.843	0.0085

SPECIES=sandbar SERIES=Virginia LL

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	17.46494	17.46494	46.946	0.0005
Error	6	2.23215	0.37202		
C Total	7	19.69709			

Root MSE	0.60994	R-square	0.8867
Dep Mean	0.50390	Adj R-sq	0.8678
C.V.	121.04416		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	12.233439	1.71609564	7.129	0.0004
YEAR	1	-0.138060	0.02014979	-6.852	0.0005

SPECIES=sharpnose SERIES=Oregon II

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	10.34754	10.34754	7.757	0.0114
Error	20	26.68039	1.33402		
C Total	21	37.02793			

Root MSE	1.15500	R-square	0.2795
Dep Mean	0.69505	Adj R-sq	0.2434
C.V.	166.17416		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	5.877796	1.86548788	3.151	0.0050
YEAR	1	-0.064477	0.02315085	-2.785	0.0114

SPECIES=sharpnose SERIES=Virginia LL

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.01602	0.01602	0.378	0.5560
Error	8	0.33938	0.04242		
C Total	9	0.35540			

Root MSE	0.20597	R-square	0.0451
Dep Mean	0.79564	Adj R-sq	-0.0743
C.V.	25.88685		

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.279981	0.84170006	0.333	0.7480
YEAR	1	0.006117	0.00995464	0.614	0.5560

SPECIES=blue SERIES=Japanese obs

```
              Plot of LINDEX*YEAR.  Symbol used is 'O'.
              Plot of PRED*YEAR.    Symbol used is 'P'.
              Plot of U95*YEAR.     Symbol used is 'U'.
              Plot of L95*YEAR.     Symbol used is 'L'.

      2 +
        |                         U  U        U                 U
        |                               U  U     U  U
 LINDEX |                         O                    U  U  U
        |                         P  O              O
        |                               O  P  P  P  P  O  O
      0 +                                  O     O     P  P  O  P
        |                         L  L  L
        |                                  L  O
        |                                     L  L  L  L  L     O
        |                                                    L
        |                                                       L
     -2 +
        --+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
         70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93

                                        YEAR
```

NOTE: 3 obs hidden.

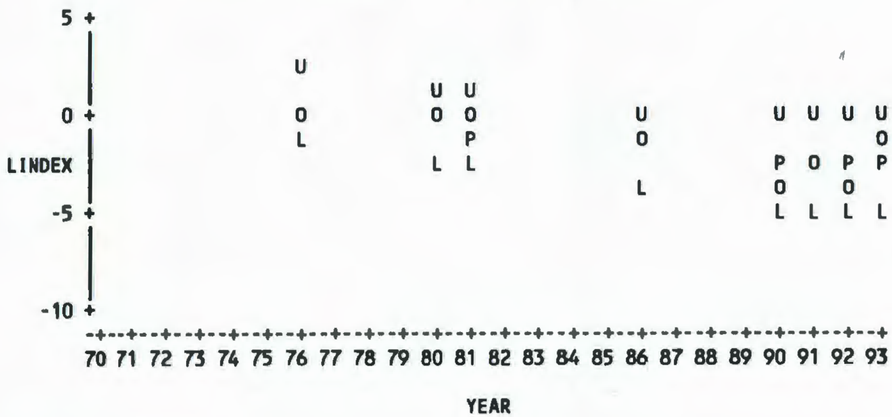
SPECIES=blue SERIES=pelagic logbook

```
              Plot of LINDEX*YEAR.  Symbol used is 'O'.
              Plot of PRED*YEAR.    Symbol used is 'P'.
              Plot of U95*YEAR.     Symbol used is 'U'.
              Plot of L95*YEAR.     Symbol used is 'L'.

      4 +
        |
        |
        |                                                 U
      3 +
        |                                                 O  U
 LINDEX |                                                 P  O  U  U
        |                                                    P  O     U  U  U
      2 +                                                    L     P  P        U
        |                                                 L     L  O  O  O  O  O
        |                                                             L  L     P
        |                                                                   L  L
      1 +
        --+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
         70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93

                                        YEAR
```

NOTE: 4 obs hidden.

-------------------- SPECIES=dusky SERIES=Virginia LL --------------------

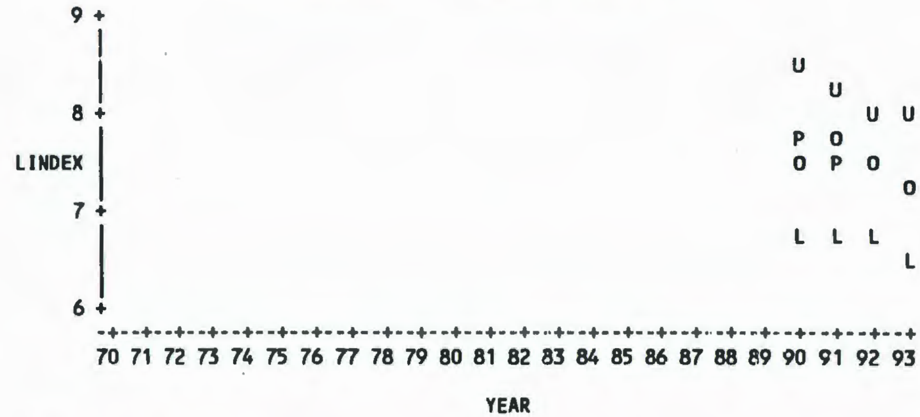
```
Plot of LINDEX*YEAR.  Symbol used is 'O'.
Plot of PRED*YEAR.    Symbol used is 'P'.
Plot of U95*YEAR.     Symbol used is 'U'.
Plot of L95*YEAR.     Symbol used is 'L'.
```



NOTE: 4 obs hidden.

------------------ SPECIES=large coastal SERIES=Gulf Reef ------------------

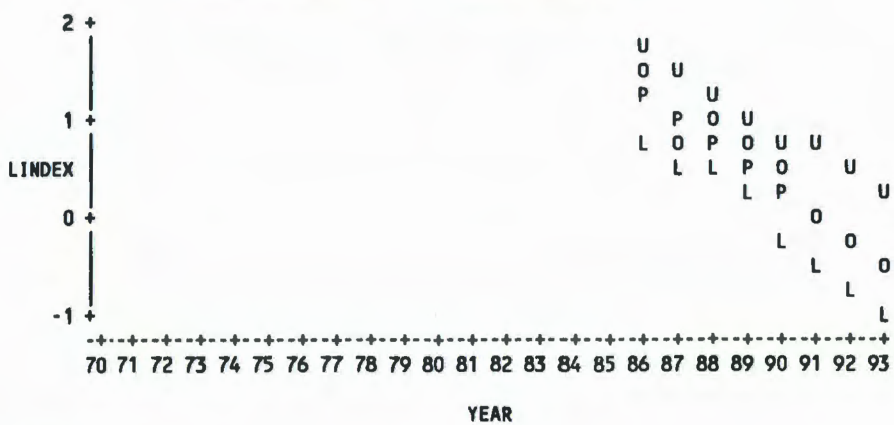
```
Plot of LINDEX*YEAR.  Symbol used is 'O'.
Plot of PRED*YEAR.    Symbol used is 'P'.
Plot of U95*YEAR.     Symbol used is 'U'.
Plot of L95*YEAR.     Symbol used is 'L'.
```



NOTE: 2 obs hidden.

---------------- SPECIES=hammerhead SERIES=pelagic logbook ----------------

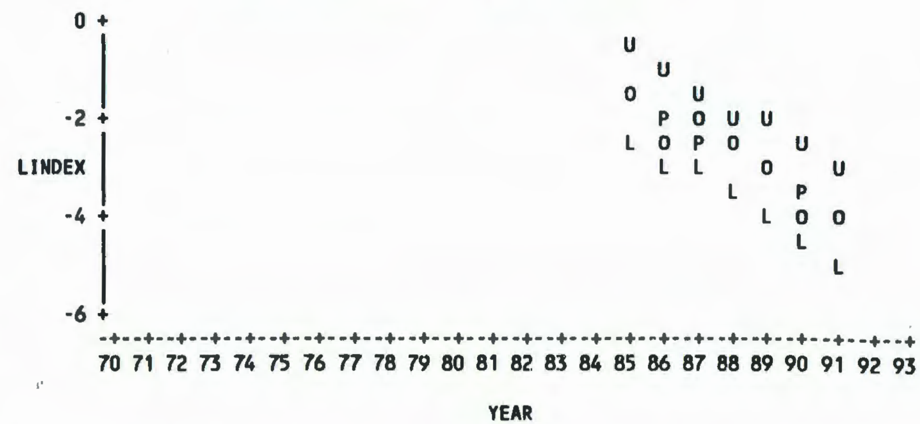
```
Plot of LINDEX*YEAR.  Symbol used is 'O'.
Plot of PRED*YEAR.    Symbol used is 'P'.
Plot of U95*YEAR.     Symbol used is 'U'.
Plot of L95*YEAR.     Symbol used is 'L'.
```



NOTE: 3 obs hidden.

------------------- SPECIES=large coastal SERIES=Hudson -------------------

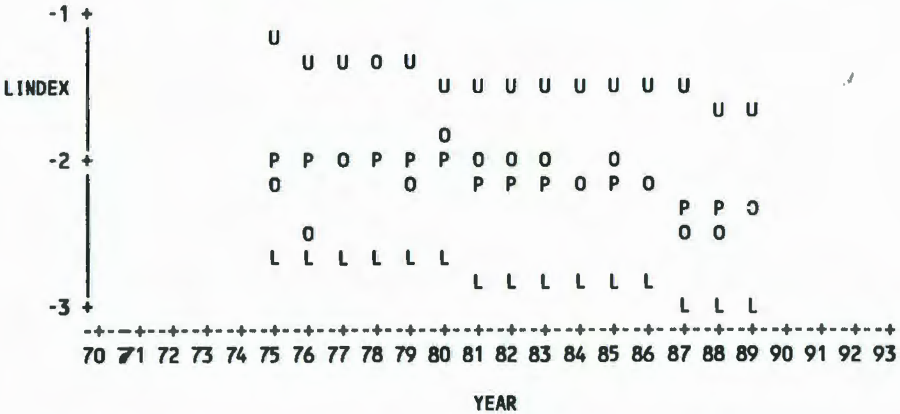
```
Plot of LINDEX*YEAR.  Symbol used is 'O'.
Plot of PRED*YEAR.    Symbol used is 'P'.
Plot of U95*YEAR.     Symbol used is 'U'.
Plot of L95*YEAR.     Symbol used is 'L'.
```



NOTE: 4 obs hidden.

---------------------------- SPECIES=large coastal SERIES=Crooke LL ----------------------------

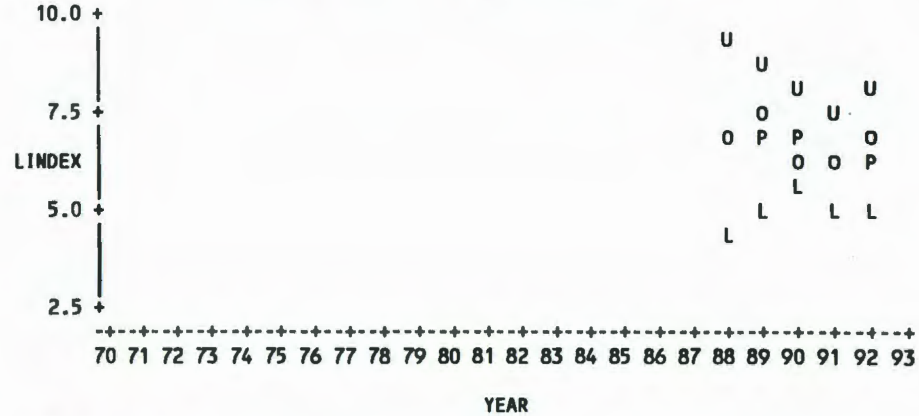
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 5 obs hidden.

---------------------------- SPECIES=large coastal SERIES=NC # ----------------------------

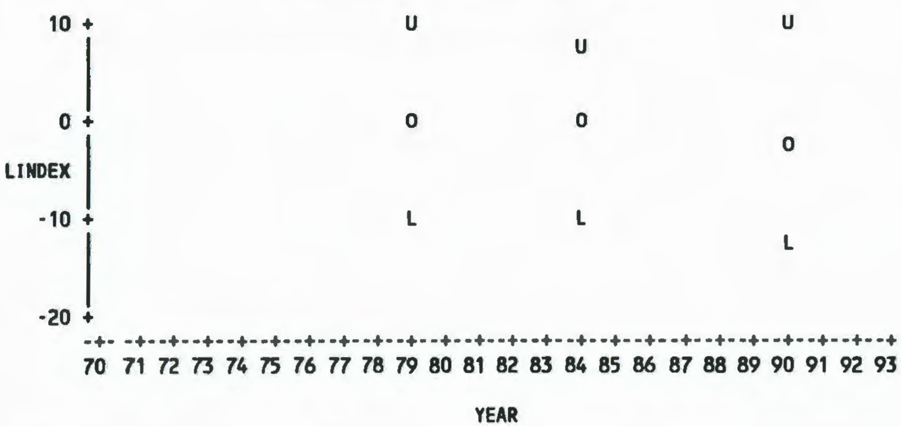
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 2 obs hidden.

---------------------------- SPECIES=large coastal SERIES=Jax ----------------------------

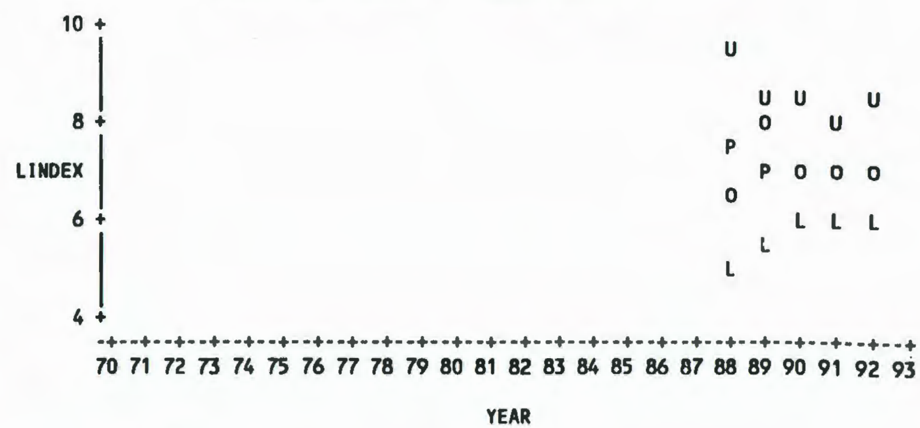
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 3 obs hidden.

---------------------------- SPECIES=large coastal SERIES=NC KG ----------------------------

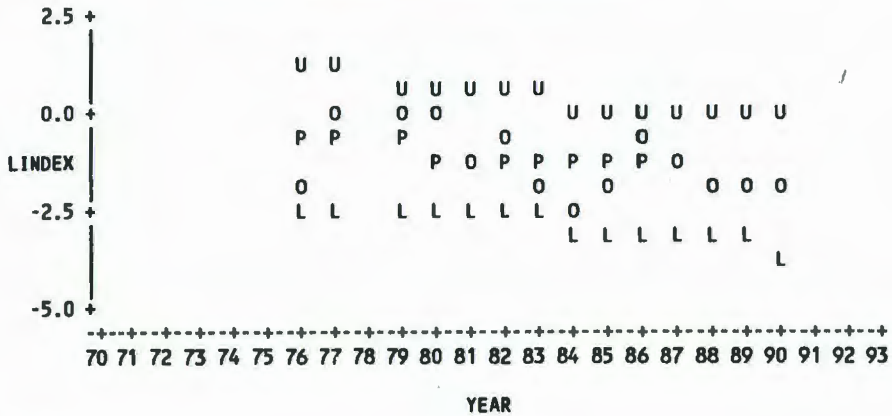
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 3 obs hidden.

---------------- SPECIES=large coastal SERIES=Port Salerno ----------------

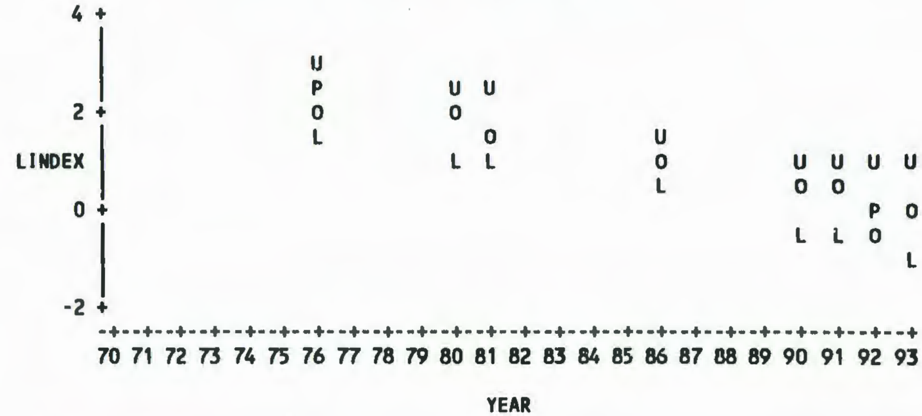
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 5 obs hidden.

---------------- SPECIES=large coastal SERIES=Virginia LL ----------------

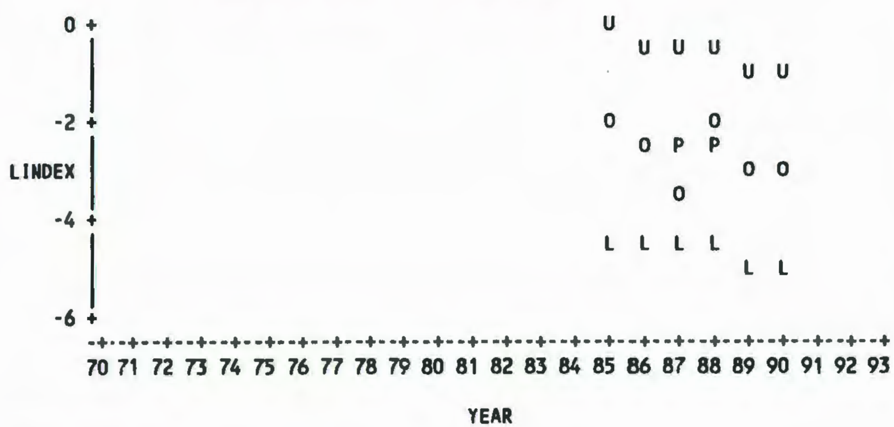
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 7 obs hidden.

---------------- SPECIES=large coastal SERIES=Tampa Bay ----------------

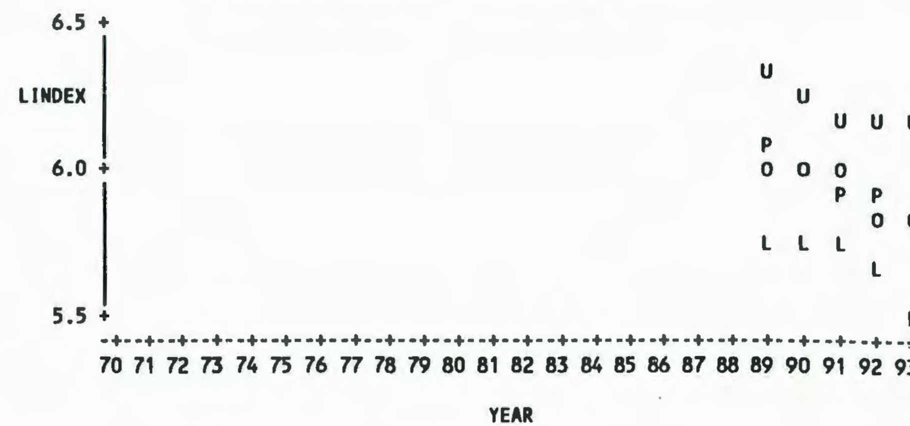
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 4 obs hidden.

---------------- SPECIES=large coastal SERIES=charter boat ----------------

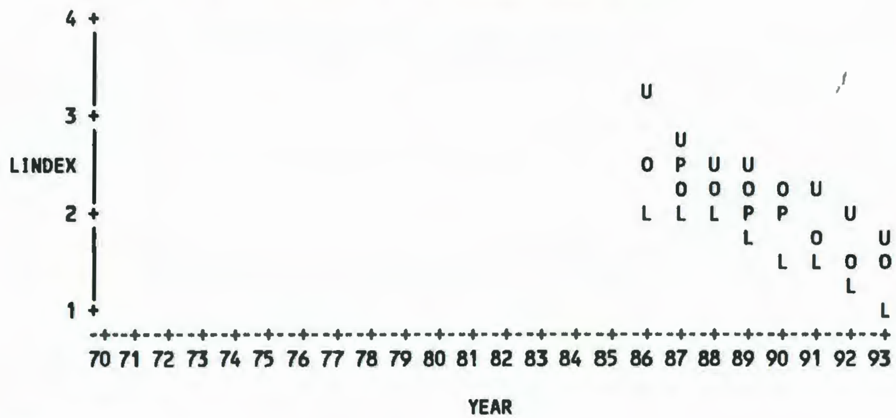
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 2 obs hidden.

--------------- SPECIES=large coastal SERIES=pelagic logbook ---------------

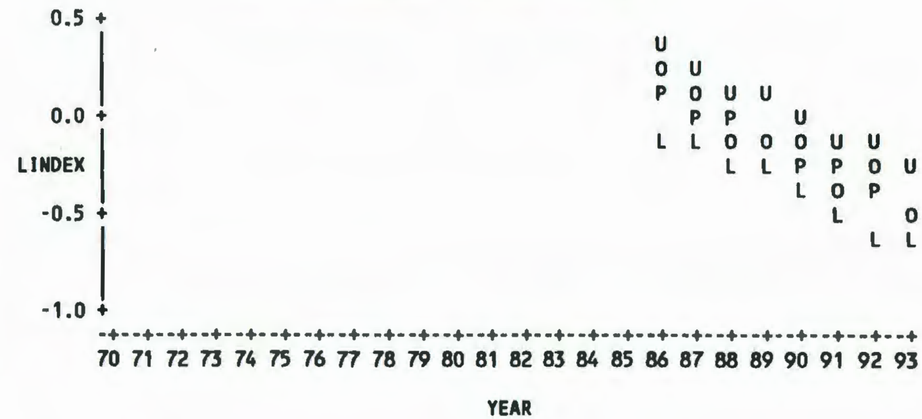
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 6 obs hidden.

------------------- SPECIES=mako SERIES=pelagic logbook -------------------

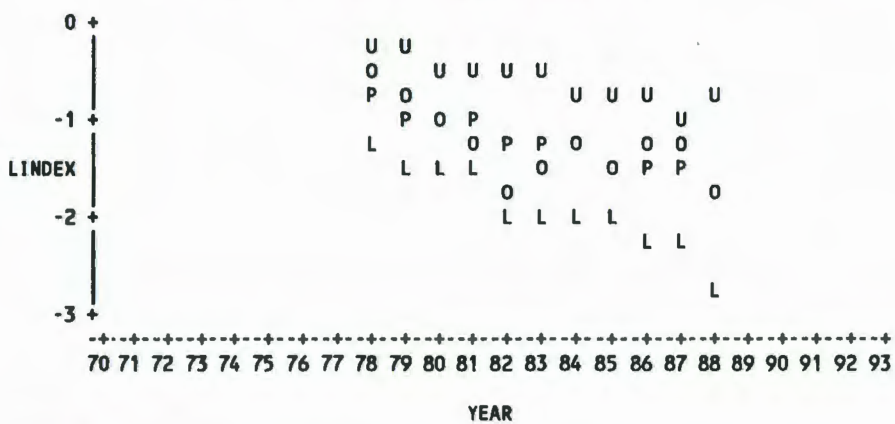
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 2 obs hidden.

-------------------- SPECIES=mako SERIES=Japanese obs --------------------

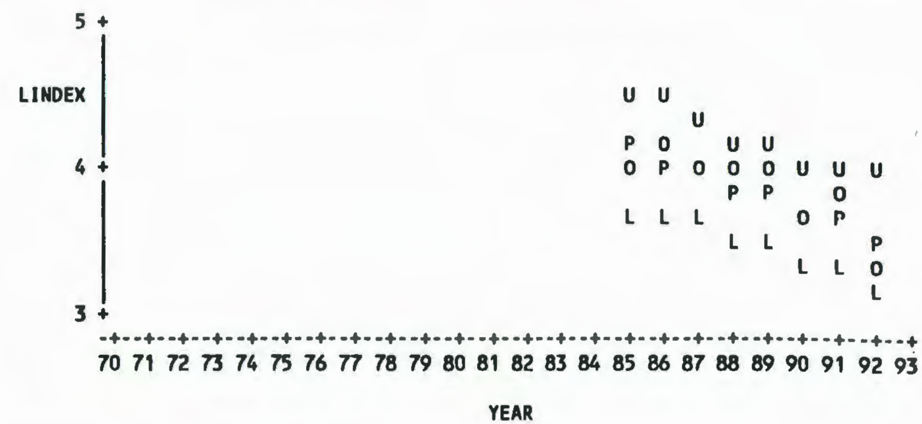
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 4 obs hidden.

---------------------- SPECIES=mako SERIES=weighout ----------------------

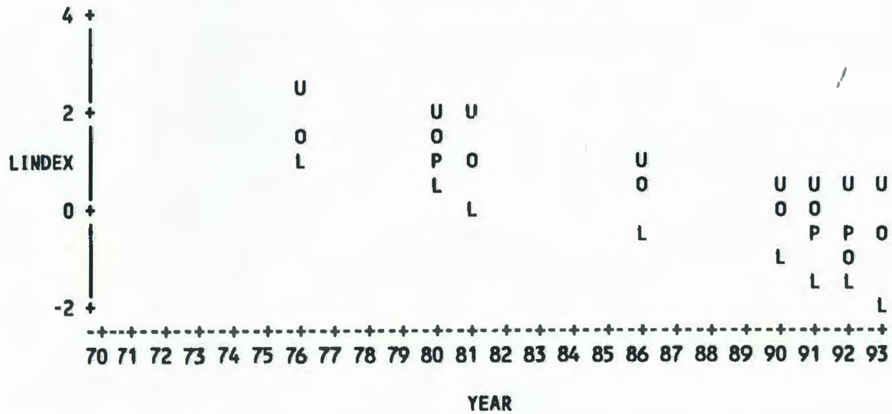
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 2 obs hidden.

-------------------- SPECIES=sandbar SERIES=Virginia LL --------------------

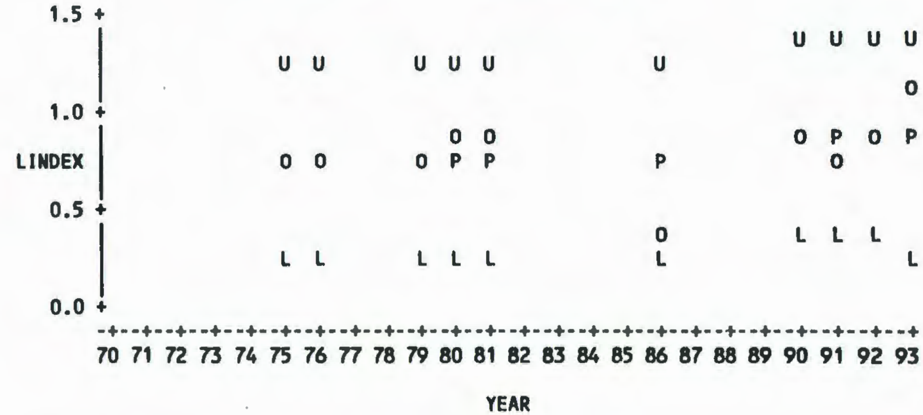
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 5 obs hidden.

-------------------- SPECIES=sharpnose SERIES=Virginia LL --------------------

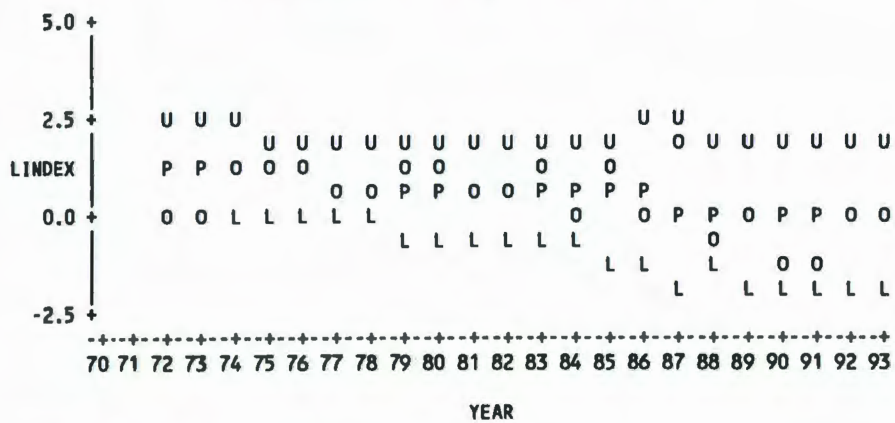
Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 5 obs hidden.

-------------------- SPECIES=sharpnose SERIES=Oregon II --------------------

Plot of LINDEX*YEAR. Symbol used is 'O'.
Plot of PRED*YEAR. Symbol used is 'P'.
Plot of U95*YEAR. Symbol used is 'U'.
Plot of L95*YEAR. Symbol used is 'L'.



NOTE: 12 obs hidden.

Table 3. General Linear Model applied to the available CPUE data, weighted by the inverse of the estimated precision, controlling for the scale effect introduced by the use of different CPUE data with different measures of catch and effort. The analysis is constructed to test the hypothesis of no trend in CPUE versus the alternative of a negative trend. The sign and approximate significance level of the model parameter estimate for the year covariate term is a test of this hypothesis.

---------------------------------- SPECIES=blue ----------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
SERIES	2	Japanese obs pelagic logbook

Number of observations in by group = 19

Dependent Variable: Log(CPUE)
Weight: 1/CV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	102.29775264	51.14887632	83.02	0.0001
Error	16	9.85720100	0.61607506		
Corrected Total	18	112.15495364			

R-Square	C.V.	Root MSE	LINDEX Mean
0.912111	51.82144	0.7849045	1.51463260

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	8.53494565	8.53494565	13.85	0.0019
SERIES	1	65.04926504	65.04926504	105.59	0.0001

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	10.53943193 B	4.58	0.0003	2.30083047
YEAR	-0.09534023	-3.72	0.0019	0.02561490
SERIES Japanese obs	-2.39389140 B	-10.28	0.0001	0.23297003
pelagic logbook	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

---------------------------------- SPECIES=dusky ----------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
SERIES	1	Virginia LL

Number of observations in by group = 8

Dependent Variable: Log(CPUE)
Weight: 1/CV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	18.94574277	18.94574277	19.59	0.0044
Error	6	5.80374821	0.96729137		
Corrected Total	7	24.74949098			

R-Square	C.V.	Root MSE	LINDEX Mean
0.765500	-77.99717	0.9835097	-1.26095559

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	18.94574277	18.94574277	19.59	0.0044
SERIES	0	0.00000000	.	.	.

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	14.47616031 B	4.06	0.0066	3.56493504
YEAR	-0.18660057	-4.43	0.0044	0.04216342
SERIES Virginia LL	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

------------------------------ SPECIES=hammerhead ------------------------------

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	1	pelagic logbook

Number of observations in by group = 8

Dependent Variable: Log(CPUE)
Weight: 1/CV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	8.25647057	8.25647057	67.93	0.0002
Error	6	0.72929145	0.12154857		
Corrected Total	7	8.98576201			

R-Square	C.V.	Root MSE	LINDEX Mean
0.918839	58.67042	0.3486382	0.59423162

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	8.25647057	8.25647057	67.93	0.0002
SERIES	0	0.00000000	.	.	.

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	22.87885200 B	8.46	0.0001	2.70464998
YEAR	-0.25042804	-8.24	0.0002	0.03038510
SERIES pelagic logbook	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

------------------------------ SPECIES=large coastal ------------------------------

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	9	Hudson,Crooke LL,Jax,NC #,Port Salerno,Tampa Bay, Virginia LL,charter boat,pelagic logbook

Number of observations in by group = 71

Dependent Variable: Log(CPUE)
Weight: 1/CV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	1404.3912098	156.0434678	442.24	0.0001
Error	61	21.5237586	0.3528485		
Corrected Total	70	1425.9149685			

R-Square	C.V.	Root MSE	LINDEX Mean
0.984905	33.01049	0.5940105	1.79945967

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	38.2351887	38.2351887	108.36	0.0001
SERIES	8	1238.3457624	154.7932203	438.70	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		13.16080752 B	12.25	0.0001	1.07443478
YEAR		-0.12461628	-10.41	0.0001	0.01197119
SERIES	Hudson	-4.91733777 B	-21.37	0.0001	0.23006218
	Crooke LL	-5.06973745 B	-27.46	0.0001	0.18459292
	Jax	-3.55240281 B	-10.10	0.0001	0.35187889
	NC #	5.19299100 B	19.26	0.0001	0.26964381
	Port Salerno	-4.01364691 B	-22.08	0.0001	0.18175685
	Tampa Bay	-4.84393989 B	-19.52	0.0001	0.24820313
	Virginia LL	-1.47398101 B	-11.74	0.0001	0.12554441
	charter boat	4.11023334 B	35.74	0.0001	0.11500013
	pelagic logbook	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

SPECIES=mako

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	2	Japanese obs pelagic logbook

Number of observations in by group = 19

Dependent Variable: Log(CPUE)
Weight: 1/CV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	36.74203402	18.37101701	113.04	0.0001
Error	16	2.60019883	0.16251243		
Corrected Total	18	39.34223285			

R-Square	C.V.	Root MSE	LINDEX Mean
0.933908	-85.63463	0.4031283	-0.47075384

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	6.66197212	6.66197212	40.99	0.0001
SERIES	1	28.51494995	28.51494995	175.46	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		7.657770001 B	6.26	0.0001	1.22231823
YEAR		-0.087344668	-6.40	0.0001	0.01364201
SERIES	Japanese obs	-1.645674599 B	-13.25	0.0001	0.12423700
	pelagic logbook	0.000000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

SPECIES=sandbar

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	1	Virginia LL

Number of observations in by group = 8

Dependent Variable: Log(CPUE)
Weight: 1/CV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	17.46493975	17.46493975	46.95	0.0005
Error	6	2.23214724	0.37202454		
Corrected Total	7	19.69708699			

R-Square	C.V.	Root MSE	LINDEX Mean
0.886676	121.0442	0.6099381	0.50389720

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	17.46493975	17.46493975	46.95	0.0005
SERIES	0	0.00000000	.	.	.

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		12.23343915 B	7.13	0.0004	1.71609564
YEAR		-0.13806016	-6.85	0.0005	0.02014979
SERIES	Virginia LL	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

SPECIES=sharpnose

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	2	Oregon II Virginia LL

Number of observations in by group = 32

Dependent Variable: Log(CPUE)
Weight: 1/CV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	3.00065122	1.50032561	3.33	0.0498
Error	29	13.05384245	0.45013250		
Corrected Total	31	16.05449367			

R-Square	C.V.	Root MSE	LINDEX Mean
0.186904	112.9505	0.6709191	0.59399379

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	2.40919027	2.40919027	5.35	0.0280
SERIES	1	0.92747606	0.92747606	2.06	0.1619

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		4.405846771 B	2.80	0.0091	1.57486526
YEAR		-0.042825652	-2.31	0.0280	0.01851137
SERIES	Oregon II	-0.370396049 B	-1.44	0.1619	0.25803890
	Virginia LL	0.000000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

Analyses Restricted to period 1986-1993:

Linear trend in log(CPUE), 1986-present?

SPECIES=blue

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	2	Japanese obs pelagic logbook

Number of observations in by group = 11

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	43.94410843	21.97205422	52.15	0.0001
Error	8	3.37064571	0.42133071		
Corrected Total	10	47.31475415			

R-Square	C.V.	Root MSE	LINDEX Mean
0.928761	35.48300	0.6490999	1.82932639

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	7.80975560	7.80975560	18.54	0.0026
SERIES	1	43.79659470	43.79659470	103.95	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		12.97253400 B	5.08	0.0010	2.55397692
YEAR		-0.12244095	-4.31	0.0026	0.02843934
SERIES	Japanese obs	-2.38890064 B	-10.20	0.0001	0.23430927
	pelagic logbook	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

SPECIES=dusky

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	1	Virginia LL

Number of observations in by group = 5

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.15609460	1.15609460	0.84	0.4277
Error	3	4.14322387	1.38107462		
Corrected Total	4	5.29931847			

R-Square	C.V.	Root MSE	LINDEX Mean
0.218159	-49.09498	1.1751913	-2.39370995

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	1.15609460	1.15609460	0.84	0.4277
SERIES	0	0.00000000	.	.	.

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		11.17929314 B	0.75	0.5060	14.84127295
YEAR		-0.15097530 B	-0.91	0.4277	0.16501286
SERIES	Virginia LL	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

SPECIES=hammerhead

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	1	pelagic logbook

Number of observations in by group = 8

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	8.25647057	8.25647057	67.93	0.0002
Error	6	0.72929145	0.12154857		
Corrected Total	7	8.98576201			

R-Square	C.V.	Root MSE	LINDEX Mean
0.918839	58.67042	0.3486382	0.59423162

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	8.25647057	8.25647057	67.93	0.0002
SERIES	0	0.00000000	.	.	.

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		22.87885200 B	8.46	0.0001	2.70464998
YEAR		-0.25042804	-8.24	0.0002	0.03038510
SERIES	pelagic logbook	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

SPECIES=large coastal

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	9	Hudson,Crooke LL,Jax,NC #,Port Salerno,Tampa Bay, Virginia LL,charter boat,pelagic logbook

Number of observations in by group = 44

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	1112.0078011	123.5564223	490.79	0.0001
Error	34	8.5594916	0.2517498		
Corrected Total	43	1120.5672927			

R-Square	C.V.	Root MSE	LINDEX Mean
0.992361	23.64678	0.5017467	2.12183898

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	23.7416125	23.7416125	94.31	0.0001
SERIES	8	1091.7957737	136.4744717	542.10	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		16.27822946 B	11.06	0.0001	1.47219007
YEAR		-0.15938209	-9.71	0.0001	0.01641228
SERIES	Hudson	-5.09711606 B	-24.34	0.0001	0.20938191
	Crooke LL	-4.74896560 B	-18.52	0.0001	0.25635748
	Jax	-3.76642238 B	-7.48	0.0001	0.50328274
	NC #	5.20449247 B	22.85	0.0001	0.22780192
	Port Salerno	-3.68694927 B	-16.07	0.0001	0.22937898
	Tampa Bay	-4.99055697 B	-21.76	0.0001	0.22937898
	Virginia LL	-1.49856648 B	-12.38	0.0001	0.12100201
	charter boat	4.15189927 B	42.21	0.0001	0.09836567
	pelagic logbook	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

SPECIES=mako

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	2	Japanese obs pelagic logbook

Number of observations in by group = 11

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	15.90276891	7.95138445	126.65	0.0001
Error	8	0.50225903	0.06278238		
Corrected Total	10	16.40502794			

R-Square	C.V.	Root MSE	LINDEX Mean
0.969384	-94.72458	0.2505641	-0.26451860

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	3.72375072	3.72375072	59.31	0.0001
SERIES	1	15.51598205	15.51598205	247.14	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		7.817763148 B	7.54	0.0001	1.03669857
YEAR		-0.089131312	-7.70	0.0001	0.01157334
SERIES	Japanese obs	-1.492842636 B	-15.72	0.0001	0.09496056
	pelagic logbook	0.000000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

SPECIES=sandbar

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	1	Virginia LL

Number of observations in by group = 5

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.08555620	2.08555620	5.81	0.0950
Error	3	1.07712633	0.35904211		
Corrected Total	4	3.16268253			

R-Square	C.V.	Root MSE	LINDEX Mean
0.659426	-280.1389	0.5992012	-0.21389435

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	2.08555620	2.08555620	5.81	0.0950
SERIES	0	0.00000000	.	.	.

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		13.89702859 B	2.37	0.0983	5.85701025
YEAR		-0.15695844 B	-2.41	0.0950	0.06512480
SERIES	Virginia LL	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

SPECIES=sharpnose

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SERIES	2	Oregon II Virginia LL

Number of observations in by group = 13

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	2.85865638	1.42932819	2.00	0.1864
Error	10	7.16009336	0.71600934		
Corrected Total	12	10.01874974			

R-Square	C.V.	Root MSE	LINDEX Mean
0.285331	386.5268	0.8461733	0.21891713

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	0.31161702	0.31161702	0.44	0.5243
SERIES	1	2.79352623	2.79352623	3.90	0.0765

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		6.759332545 B	0.74	0.4734	9.07331161
YEAR		-0.066156206	-0.66	0.5243	0.10028116
SERIES	Oregon II	-0.969369026 B	-1.98	0.0765	0.49076333
	Virginia LL	0.000000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

Appendix Table. GLM Analysis of JLL Observer data - Mako Sharks

Class	Levels	Values
YEAR	11	78 79 80 81 82 83 84 85 86 87 88
AREA	3	GOM MAT NAT
WAVE	6	1 2 3 4 5 6

Number of observations in data set = 90

GLM on proportion positives, JLL Makos

Dependent Variable: POS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	0.43885541	0.02581502	1.04	0.4302
Error	72	1.79096211	0.02487447		
Corrected Total	89	2.22981752			

R-Square	C.V.	Root MSE	POS Mean
0.196812	47.22415	0.1577164	0.33397410

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	10	0.26093771	0.02609377	1.05	0.4126
AREA	2	0.09875893	0.04937947	1.99	0.1448
WAVE	5	0.09878534	0.01975707	0.79	0.5573

Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		0.2030158557	B	1.77	0.0815	0.11492286
YEAR	78	0.1596037049	B	1.23	0.2228	0.12978571
	79	0.1312600248	B	1.05	0.2994	0.12558650
	80	0.1179093935	B	0.95	0.3457	0.12421579
	81	0.0620885801	B	0.50	0.6203	0.12479424
	82	-.0324170782	B	-0.24	0.8117	0.13559281
	83	-.0223387371	B	-0.17	0.8659	0.13185483
	84	0.1146973689	B	0.89	0.3757	0.12867414
	85	0.0410378072	B	0.32	0.7476	0.12704192
	86	0.0876564471	B	0.68	0.4979	0.12867414
	87	0.0701885319	B	0.54	0.5913	0.13011606
	88	0.0000000000	B	.	.	.
AREA	GOM	-.0733765342	B	-1.19	0.2383	0.06171317
	MAT	0.0420647103	B	1.14	0.2571	0.03682387
	NAT	0.0000000000	B	.	.	.
WAVE	1	0.0089494303	B	0.16	0.8723	0.05549871
	2	0.1089659205	B	1.49	0.1413	0.07326820
	3	0.0701163572	B	0.96	0.3417	0.07325969
	4	0.0726771399	B	1.41	0.1621	0.05145297
	5	0.0496387968	B	0.90	0.3728	0.05535045
	6	0.0000000000	B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

Dependent Variable: LMAK

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	21	73.95488125	3.52166101	11.18	0.0001
Error	1980	623.76931387	0.31503501		
Corrected Total	2001	697.72419512			

R-Square	C.V.	Root MSE	LMAK Mean
0.105994	-128.1935	0.5612798	-0.43783782

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	10	31.87377642	3.18737764	10.12	0.0001
AREA	2	4.17328562	2.08664281	6.62	0.0014
WAVE	5	4.33544280	0.86708856	2.75	0.0175
BILCR	1	0.64116824	0.64116824	2.04	0.1538
BFTCR	1	0.50759438	0.50759438	1.61	0.2045
SWOCR	1	4.81851805	4.81851805	15.30	0.0001
FDEPTH	1	3.26178095	3.26178095	10.35	0.0013

Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-.9779616952	B	-10.50	0.0001	0.09315948
YEAR	78	0.6686304652	B	6.68	0.0001	0.10014539
	79	0.4090251712	B	4.53	0.0001	0.09028650
	80	0.2761289274	B	3.14	0.0017	0.08805571
	81	0.2979484859	B	3.46	0.0006	0.08619732
	82	0.0675507211	B	0.76	0.4445	0.08832310
	83	0.3418643402	B	3.48	0.0005	0.09814396
	84	0.1296538048	B	1.45	0.1465	0.08926548
	85	0.1149833155	B	1.31	0.1897	0.08763740
	86	0.1180231810	B	1.34	0.1810	0.08819591
	87	0.1107965435	B	1.30	0.1952	0.08551284
	88	0.0000000000	B	.	.	.
AREA	GOM	-.1116317528	B	-1.70	0.0898	0.06577094
	MAT	0.0918739028	B	2.28	0.0230	0.04037705
	NAT	0.0000000000	B	.	.	.
WAVE	1	0.1717664016	B	2.90	0.0037	0.05915509
	2	0.1953652445	B	2.68	0.0074	0.07281126
	3	0.1111593104	B	1.41	0.1573	0.07856514
	4	0.1144341218	B	2.62	0.0088	0.04362309
	5	0.1128890459	B	2.71	0.0068	0.04167384
	6	0.0000000000	B	.	.	.
BILCR		0.0136961234		1.43	0.1538	0.00960044
BFTCR		0.0024357492		1.27	0.2045	0.00191891
SWOCR		0.0318167236		3.91	0.0001	0.00813539
FDEPTH		0.0029316285		3.22	0.0013	0.00091109

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

CORRELATION ANALYSIS
2 'VAR' Variables: PPOS CPUE

Simple Statistics

Variable	N	Mean	Std Dev	Median	Minimum	Maximum
PPOS	11	0.36980	0.08596	0.37278	0.23943	0.49983
CPUE	11	0.65436	0.13895	0.58108	0.51139	0.99616

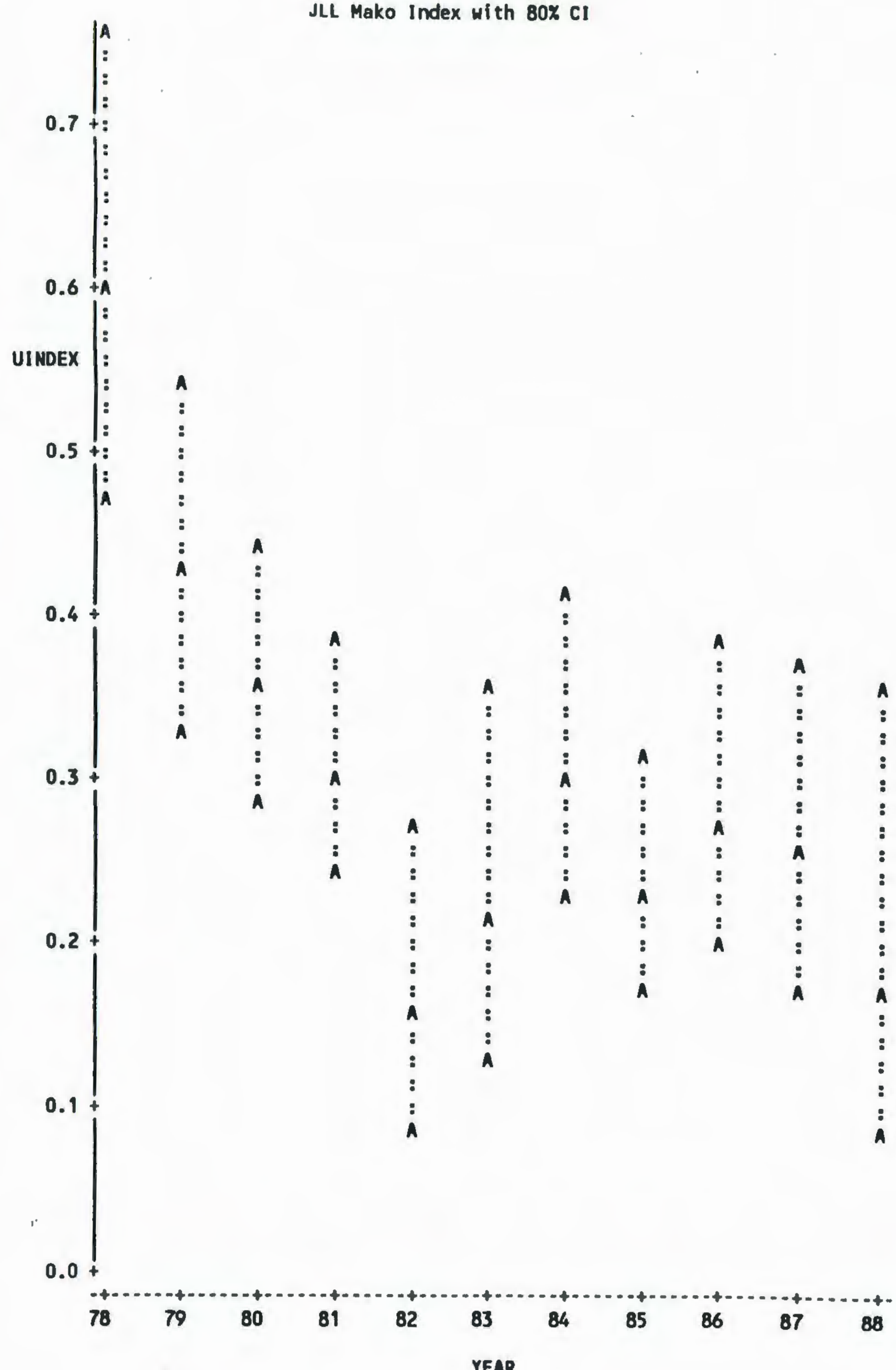
Kendall Tau b Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 11

	PPOS	CPUE
PPOS	1.00000	0.52727
	0.0	0.0240

Compute Index Values using Lo Method

YEAR	CPUE	PPOS	BC_CPU	BC_POS	INDEX	SE_I	CV_I
78	0.99616	0.49983	1.16290	0.51421	0.59798	0.11295	0.18888
79	0.76802	0.45776	0.89747	0.47206	0.42366	0.08059	0.19022
80	0.67245	0.43799	0.78578	0.45297	0.35594	0.06391	0.17956
81	0.68707	0.35974	0.80337	0.37428	0.30068	0.05598	0.18618
82	0.54589	0.23943	0.63780	0.24802	0.15819	0.07001	0.44258
83	0.71890	0.25140	0.83827	0.26124	0.21899	0.08764	0.40018
84	0.58108	0.43479	0.67842	0.44689	0.30318	0.07625	0.25150
85	0.57251	0.33198	0.66866	0.34507	0.23074	0.05859	0.25394
86	0.57432	0.39651	0.67062	0.40829	0.27381	0.07329	0.26768
87	0.57016	0.37278	0.66581	0.38345	0.25531	0.07601	0.29770
88	0.51139	0.28553	0.59479	0.28386	0.16884	0.10914	0.64643

JLL Mako Index with 80% CI



Analysis of JLL Observer Data - Blue Sharks

General Linear Models Procedure

Class Level Information

Class	Levels	Values
YEAR	11	78 79 80 81 82 83 84 85 86 87 88
AREA	3	GOM MAT NAT
WAVE	6	1 2 3 4 5 6

Number of observations in data set = 90

Dependent Variable: POS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	0.43885541	0.02581502	1.04	0.4302
Error	72	1.79096211	0.02487447		
Corrected Total	89	2.22981752			

R-Square	C.V.	Root MSE	POS Mean
0.196812	47.22415	0.1577164	0.33397410

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	10	0.26093771	0.02609377	1.05	0.4126
AREA	2	0.09875893	0.04937947	1.99	0.1448
WAVE	5	0.09878534	0.01975707	0.79	0.5573

Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		0.2030158557	B	1.77	0.0815	0.11492286
YEAR	78	0.1596037049	B	1.23	0.2228	0.12978571
	79	0.1312600248	B	1.05	0.2994	0.12558650
	80	0.1179093935	B	0.95	0.3457	0.12421579
	81	0.0620885801	B	0.50	0.6203	0.12479424
	82	-.0324170782	B	-0.24	0.8117	0.13559281
	83	-.0223387371	B	-0.17	0.8659	0.13185483
	84	0.1146973689	B	0.89	0.3757	0.12867414
	85	0.0410378072	B	0.32	0.7476	0.12704192
	86	0.0876564471	B	0.68	0.4979	0.12867414
	87	0.0701885319	B	0.54	0.5913	0.13011606
	88	0.0000000000	B	.	.	.
AREA	GOM	-.0733765342	B	-1.19	0.2383	0.06171317
	MAT	0.0420647103	B	1.14	0.2571	0.03682387
	NAT	0.0000000000	B	.	.	.
WAVE	1	0.0089494303	B	0.16	0.8723	0.05549871
	2	0.1089659205	B	1.49	0.1413	0.07326820
	3	0.0701163572	B	0.96	0.3417	0.07325969
	4	0.0726771399	B	1.41	0.1621	0.05145297
	5	0.0496387968	B	0.90	0.3728	0.05535045
	6	0.0000000000	B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

GLM on positive catches, JLL Blues

Dependent Variable: LBLU

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	21	885.31523204	42.15786819	42.16	0.0001
Error	4434	4433.86048702	0.99996854		
Corrected Total	4455	5319.17571906			

R-Square	C.V.	Root MSE	LBLU Mean
0.166438	80.85455	0.9999843	1.23676937

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	10	508.30234898	50.83023490	50.83	0.0001
AREA	2	217.30887853	108.65443927	108.66	0.0001
WAVE	5	68.39748327	13.67949665	13.68	0.0001
BILCR	1	1.38720619	1.38720619	1.39	0.2389
BFTCR	1	74.67019632	74.67019632	74.67	0.0001
SWOCR	1	9.00001166	9.00001166	9.00	0.0027
FDEPTH	1	15.35644755	15.35644755	15.36	0.0001

Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		0.560127532	B	6.18	0.0001	0.09068752
YEAR	78	1.208376161	B	11.33	0.0001	0.10661307
	79	0.976725706	B	9.41	0.0001	0.10382664
	80	0.880817079	B	9.30	0.0001	0.09466922
	81	0.718160488	B	8.34	0.0001	0.08612559
	82	0.239787269	B	2.82	0.0048	0.08501653
	83	1.070693651	B	11.04	0.0001	0.09696873
	84	1.094505241	B	12.05	0.0001	0.09083142
	85	1.197547350	B	13.82	0.0001	0.08662529
	86	0.841419378	B	9.71	0.0001	0.08663551
	87	0.613347860	B	7.23	0.0001	0.08485256
	88	0.000000000	B	.	.	.
AREA	GOM	-1.852132747	B	-13.85	0.0001	0.13371485
	MAT	-0.378892315	B	-7.84	0.0001	0.04833827
	NAT	0.000000000	B	.	.	.
WAVE	1	-0.053184023	B	-0.85	0.3936	0.06233786
	2	-0.121913506	B	-1.03	0.3038	0.11853129
	3	-0.153433147	B	-1.47	0.1418	0.10441020
	4	-0.385168607	B	-7.92	0.0001	0.04862783
	5	-0.154404453	B	-3.35	0.0008	0.04609269
	6	0.000000000	B	.	.	.
BILCR		0.017346727		1.18	0.2389	0.01472788
BFTCR		-0.015936559		-8.64	0.0001	0.00184423
SWOCR		0.035413767		3.00	0.0027	0.01180440
FDEPTH		0.003634420		3.92	0.0001	0.00092743

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

CORRELATION ANALYSIS

2 'VAR' Variables: PPOS CPUE

Simple Statistics

Variable	N	Mean	Std Dev	Median	Minimum	Maximum
PPOS	11	0.36980	0.08596	0.37278	0.23943	0.49983
CPUE	11	2.05089	0.67315	2.08368	0.86471	2.89272

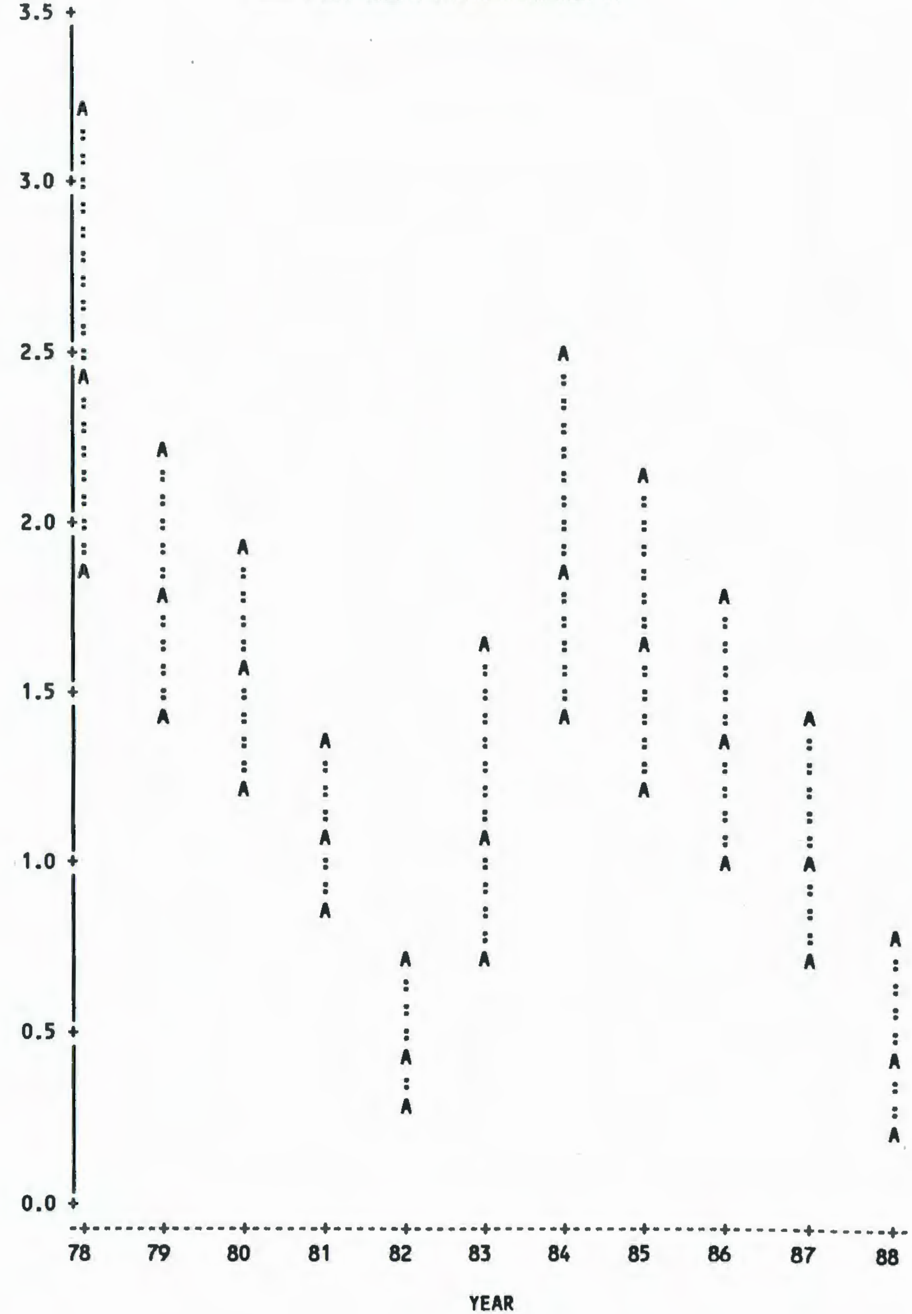
Kendall Tau b Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 11

	PPOS	CPUE
PPOS	1.00000	0.41818
	0.0	0.0734

Compute Index Values using Lo Method

YEAR	CPUE	PPOS	BC_CPU	BC_POS	INDEX	SE_I	CV_I
78	2.89272	0.49983	4.73216	0.51421	2.43334	0.54332	0.22328
79	2.29522	0.45776	3.75902	0.47206	1.77448	0.33559	0.18912
80	2.08368	0.43799	3.41793	0.45297	1.54823	0.26494	0.17112
81	1.76909	0.35974	2.90778	0.37428	1.08832	0.19071	0.17524
82	1.09672	0.23943	1.80179	0.24802	0.44689	0.18094	0.40490
83	2.52063	0.25140	4.13057	0.26124	1.07909	0.37855	0.35081
84	2.58046	0.43479	4.23159	0.44689	1.89106	0.42712	0.22586
85	2.85917	0.33198	4.69313	0.34507	1.61947	0.35574	0.21966
86	2.00289	0.39651	3.28638	0.40829	1.34179	0.32183	0.23985
87	1.59447	0.37278	2.61612	0.38345	1.00315	0.27113	0.27028
88	0.86471	0.28553	1.41467	0.28386	0.40157	0.23247	0.57890

JLL Blue Shark Index with 80% CI



Shark Bowl 1, the NC data

Nominal average CPUE (numbers/1000 hooks)

YEAR	AVE_CPU	OBS_CPU	SE_CPU
88	772.62	2	144.048
89	841.55	3	199.587
90	602.57	11	83.188
91	1089.27	16	302.330
92	824.19	8	241.358

Shark Bowl 1, the NC data

GLM on catches +1, NC Shark Numbers

Dependent Variable: LCPUE
Frequency: SETS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	15.35266029	1.39569639	6.10	0.0001
Error	126	28.84754643	0.22894878		
Corrected Total	137	44.20020671			

R-Square	C.V.	Root MSE	LCPUE Mean
0.347344	7.629597	0.478486	6.27144466

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	4	7.23596124	1.80899031	7.90	0.0001
WAVE	5	7.48514500	1.49702900	6.54	0.0001
MPS	1	0.02876154	0.02876154	0.13	0.7236
HPM	1	1.48976492	1.48976492	6.51	0.0119

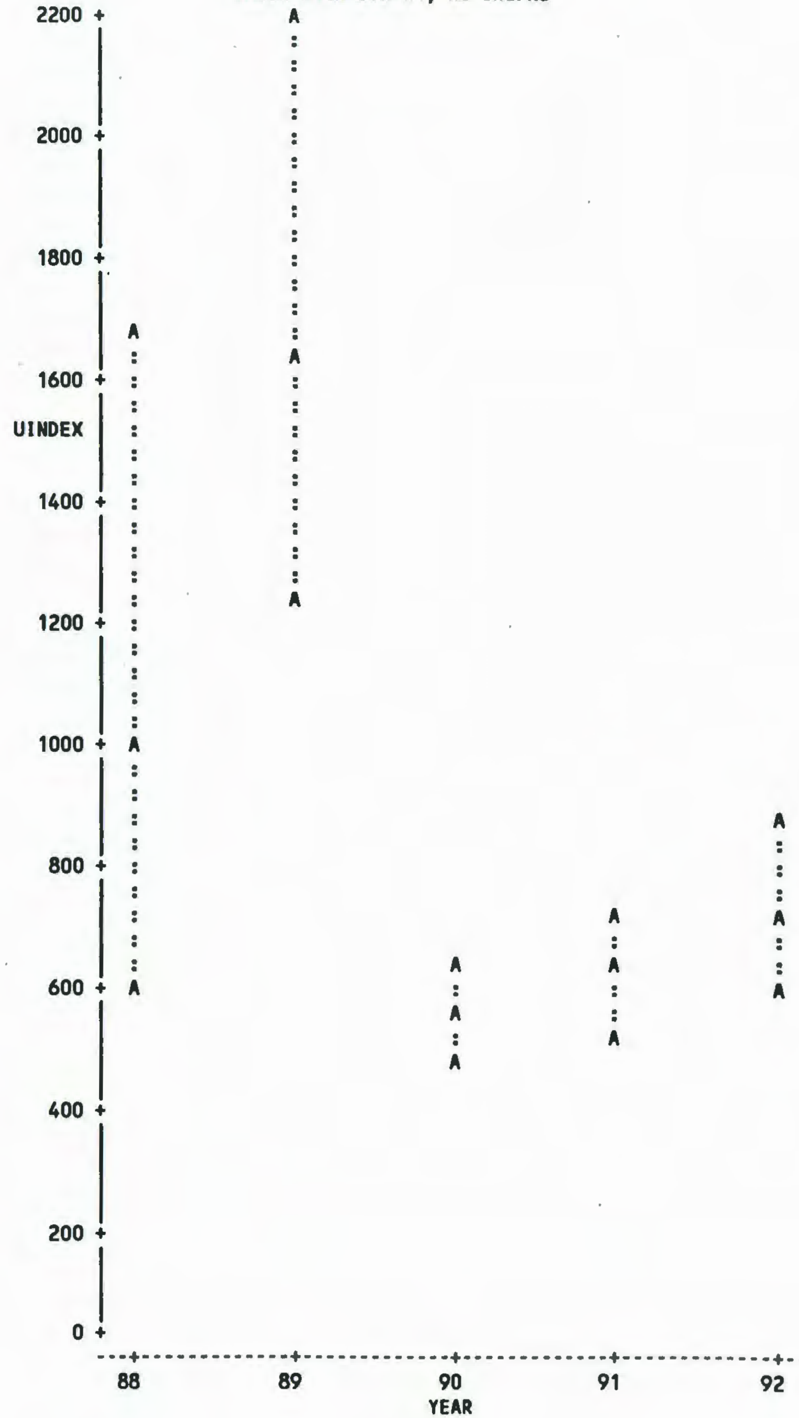
Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		7.185225571	B	16.23	0.0001	0.44260657
YEAR	88	0.407325764	B	0.79	0.4337	0.51867418
	89	0.830944647	B	3.53	0.0006	0.23524854
	90	-0.278578770	B	-1.61	0.1091	0.17263459
	91	-0.149914622	B	-1.11	0.2709	0.13557104
	92	0.000000000	B	.	.	.
WAVE	1	-0.141071127	B	-0.99	0.3260	0.14305564
	2	-0.430776093	B	-3.43	0.0008	0.12556543
	3	-0.357570940	B	-2.00	0.0472	0.17841066
	4	-0.883071500	B	-4.53	0.0001	0.19492085
	5	1.072646845	B	1.46	0.1458	0.73296622
	6	0.000000000	B	.	.	.
MPS		-0.010881055		-0.35	0.7236	0.03069970
HPM		-0.003797520		-2.55	0.0119	0.00148871

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

Index and variance calculations - NC Sharks

OBS	LCPUE	UC_CPU	INDEX	VAR_CP	CV
1	6.89110	982.48	999.10	177750.80	0.42199
2	7.31472	1501.25	1637.36	144540.73	0.23219
3	6.20520	494.32	549.10	5713.98	0.13766
4	6.33386	562.33	625.52	6324.66	0.12714
5	6.48377	653.44	721.60	15781.62	0.17409

Index with 80% ci, NC Sharks



Shark Bowl 1, the NC data

Nominal average CPUE (kg/1000 hooks)

YEAR	AVE_CPU	OBS_CPU	SE_CPU
88	908.47	2	250.387
89	1031.40	3	312.238
90	864.06	13	131.134
91	1715.67	16	446.894
92	1037.14	17	210.444

Shark Bowl 1, the NC data

GLM on catches +1, NC Shark Weight

Dependent Variable: LCPUE

Frequency: SETS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	16.45349491	1.49577226	4.40	0.0001
Error	167	56.80765485	0.34016560		
Corrected Total	178	73.26114976			

R-Square	C.V.	Root MSE	LCPUE Mean
0.224587	8.857615	0.583237	6.58458512

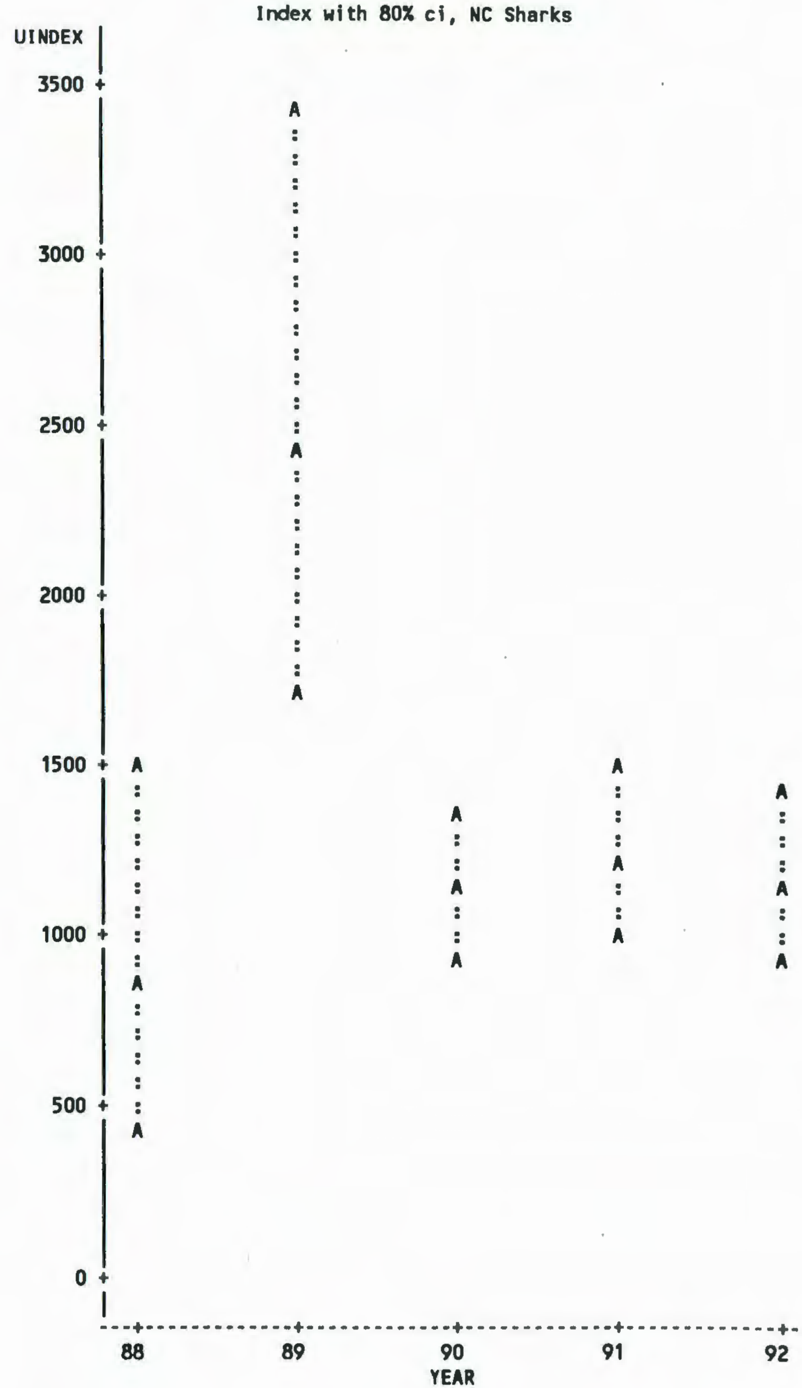
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	4	3.75992970	0.93998242	2.76	0.0293
WAVE	5	8.26622560	1.65324512	4.86	0.0004
MPS	1	0.31131957	0.31131957	0.92	0.3401
HPM	1	1.40752791	1.40752791	4.14	0.0435

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		7.139058997 B	19.66	0.0001	0.36308517
YEAR	88	-0.196340635 B	-0.32	0.7522	0.62083489
	89	0.751110793 B	2.99	0.0033	0.25154269
	90	-0.036947522 B	-0.27	0.7851	0.13526706
	91	0.035172364 B	0.28	0.7802	0.12582491
	92	0.000000000 B	.	.	.
WAVE	1	-0.617005875 B	-3.78	0.0002	0.16326822
	2	-0.445104449 B	-3.03	0.0028	0.14694078
	3	-0.322963911 B	-1.65	0.1006	0.19560930
	4	-0.645043269 B	-2.77	0.0062	0.23270982
	5	2.071635704 B	2.36	0.0195	0.87827775
	6	0.000000000 B	.	.	.
MPS		0.026411026	0.96	0.3401	0.02760751
HPM		-0.003385733	-2.03	0.0435	0.00166444

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

Index and variance calculations - NC Sharks

OBS	LCPUE	UC_CPU	INDEX	VAR_CP	CV
1	6.70796	817.90	837.85	178468.94	0.50421
2	7.65541	2111.04	2398.68	467104.19	0.28493
3	6.86735	959.40	1121.99	33940.91	0.16420
4	6.93947	1031.23	1207.04	36766.64	0.15886
5	6.90430	995.55	1163.71	37731.15	0.16692



Shark Bowl 1, the Reeffish Logbook data

Nominal average CPUE (kg/hook-hour)

YEAR	AVE_CPU	OBS_CPU	SE_CPU
90	1735.59	67	217.421
91	1667.43	132	127.476
92	1559.16	177	129.122
93	1546.36	122	175.148

GLM on catches +1, Reef Fish Logbook Shark Kg

Dependent Variable: LCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	27	87.69947509	3.24812871	2.64	0.0001
Error	470	577.19184550	1.22806776		
Corrected Total	497	664.89132059			

R-Square	C.V.	Root MSE	LCPUE Mean
0.131900	16.05570	1.108182	6.90210903

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	3	7.12294619	2.37431540	1.93	0.1233
WAVE	5	10.26086540	2.05217308	1.67	0.1400
GRID	19	71.45606561	3.76084556	3.06	0.0001

Parameter		Estimate		T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		7.008122510	B	6.23	0.0001	1.12427125
YEAR	90	0.214733917	B	1.08	0.2789	0.19807462
	91	0.336649584	B	2.18	0.0296	0.15432512
	92	0.071050625	B	0.49	0.6271	0.14615470
	93	0.000000000	B	.	.	.
WAVE	1	-0.391381346	B	-1.80	0.0722	0.21723793
	2	0.025637934	B	0.13	0.8986	0.20100144
	3	0.080825622	B	0.41	0.6844	0.19873599
	4	0.032851613	B	0.17	0.8625	0.18952066
	5	0.114817520	B	0.58	0.5626	0.19816913
	6	0.000000000	B	.	.	.
GRID	0	-0.024515208	B	-0.02	0.9826	1.12134686
	1	0.178877961	B	0.15	0.8811	1.19493467
	2	-0.505360562	B	-0.44	0.6623	1.15622443
	3	-0.018089102	B	-0.02	0.9872	1.12954281
	4	-0.196491276	B	-0.17	0.8616	1.12659808
	5	-0.479902886	B	-0.43	0.6693	1.12295859
	6	-0.497172203	B	-0.44	0.6615	1.13464046
	7	-0.278536201	B	-0.24	0.8093	1.15335311
	8	-0.050019408	B	-0.04	0.9651	1.14169035
	9	-0.354503802	B	-0.31	0.7564	1.14189708
	10	-0.167214133	B	-0.14	0.8851	1.15680501
	11	-1.008002451	B	-0.83	0.4049	1.20906245
	12	0.399697088	B	0.31	0.7559	1.28519872
	13	0.367968996	B	0.31	0.7537	1.17210811
	14	-0.450360987	B	-0.38	0.7071	1.19776599
	15	-0.594170168	B	-0.49	0.6278	1.22481188
	16	-3.309017697	B	-2.56	0.0107	1.29149855
	17	-2.500653316	B	-1.93	0.0540	1.29458206
	19	-2.127152438	B	-1.34	0.1808	1.58705978
	20	0.000000000	B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

Shark Bowl 1, the Reeffish Logbook data

Index and variance calculations - Reeffish Logbook - Sharks

OBS	LCPUE	UC_CPU	INDEX	VAR_CP	CV
1	6.61925	748.383	1355.22	104821.22	0.23890
2	6.74117	845.548	1547.52	47909.62	0.14144
3	6.47557	648.087	1185.48	30067.75	0.14627
4	6.40452	603.570	1101.94	30626.46	0.15881

Index with 80% ci, Reeffish Logbooks - Sharks