MSAP/03/#

# Stock Assessment Analyses on Spanish and King Mackerel Stocks

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by
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Since 1985 the Mackerel Stock Assessment Panel (MSAP) has met annually to review the status of mackerel and other coastal pelagic stocks within the jurisdiction of the Gulf of Mexico and South Atlantic Fishery Management Councils and to recommend Acceptable Biological Catches (ABC's) for mackerels. The most recent full assessments of the Gulf and Atlantic Spanish mackerel as well the Atlantic king mackerel migratory groups were on March 1998 (Legault *et al.* 1998). This document provides: updated baseline analyses considering catch and effort through 2001/02 fishing year, comparison of evaluation results with the prior assessments, and measures of uncertainty in the results for the MSAP to use in advising the Gulf Council of resource risk for the evaluated mackerel migratory groups under different levels of catch for the 2003 management season.

The report is organized into sections dealing with discussions of the catch, biological characteristics, indices, and assessment methods and results. Emphasis in the presentation is on changes of data and methodology from those used in 1998 stock assessment. Comparison of the 1998 and 2002 results are presented for discussion. Based on prior history, further exploration by the Mackerel Stock Assessment Panel is expected at the panel meeting in order to build upon the record of MSAP reports and supporting documentation provided since 1985.

## CATCH

Directed Catch

U.S. commercial landings, recreational catches, and size-frequency data for calendar years 1997, 1998, 1999, 2000, 2001 and 2002* are updated in this assessment. Estimates through the 2001/2002 fishing year (April 1st to March 31st for Spanish Atlantic and Gulf stocks, and king Atlantic) are incorporated into these analyses. Table 1 gives the directed catch by the sectors (commercial and recreational) during each fishing year in both numbers and weight of fish landed for Atlantic king mackerel (Fig 1), and by sector and state (Table 2, Fig 2). Similarly, catch summary tables are presented for both Atlantic and Gulf Spanish mackerel stocks (Tables 4 to 6, Figs 3 to 6).

Shrimp Trawl Bycatch

Estimates of annual bycatch of Spanish mackerel in the Gulf of Mexico shrimp trawl fishery were updated using the same general linear model (GLM) as in year 1998. The updated GLM analysis not only added two more years of observations but also re-estimated bycatch for all previous years. The updated bycatch estimates were nearly identical to those from the previous assessment (Fig 7, Table 7). The estimation models took into account the use of bycatch reduction devices (BRDs) in the Gulf of Mexico. This was accomplished by adding another level (BRD) in the factor = dataset of the GLM matrix that accounts for bycatch reduction devices used in the commercial fishery. The estimated bycatch rate for those combinations of season, area and depth zone that were required to use BRDs since 1997 used the BRD estimates, while the prior years used the commercial estimates. For years 1999 to 2001, the area season distribution of BRDs was assumed similar as in 1998 (Ortiz 2002). In prior evaluations, an alternative method to estimate bycatch, the delta lognormal approach, was also considered for sensitivity trials (Legault and Ortiz 1998, Legault *et al.* 2000, Ortiz *et al.* 2000).

In the 1998 stock assessment, estimates of shrimp bycatch were presented and evaluated for the South Atlantic king and Spanish mackerel stocks (Vaughan and Nance MSAP 98/04, Harris and Dean MSAP/98/01, and Harris and Dean MSAP/98/02). However, the MSAP chose not to include bycatch estimates in the final model selected for both Spanish and King mackerel Atlantic stocks, due in part to the large uncertainty of these estimates (MSAP-98). For this evaluation no new data on shrimp bycatch for the South Atlantic were available, therefore no bycatch was included for Atlantic king and Atlantic Spanish stocks following the final model(s) adopted by the MSAP in 1998.

Size and Age Distribution of the Catches

Procedures and protocols used for matching length samples to catch by migratory group, year, month, sector, and gear strata were developed at the 1989 MSAP workshop held in Panama City, Florida and have been since discussed in detail (MSAP 1997). Briefly, all samples within a catch stratum are combined into a composite sample and then matched to the catches by strata. Document MSAP/03/## (N Cummings) presents a complete description of the data and procedures used for converting catch to catch-at-age for the Spanish Atlantic and Gulf stocks and the King Atlantic stock. The aged catches are maintained at the year, month, area, and gear stratum level so that they can be aggregated to conform to various management schemes in later analyses.

* Data for year 2002 are provisional NMFS SEFSC Miami

Catch at age for the directed fisheries for Atlantic king, Atlantic Spanish and Gulf Spanish mackerel are presented in Tables 8, 9 and 10. Figures 8, 9 and 10 show in color schematic the proportion of catch by each age and year for Atlantic king, Atlantic Spanish and Gulf Spanish mackerel stocks, respectively.

## BIOLOGICAL CHARACTERISTICS

### Natural Mortality

The natural mortality rate (M) used for the analyses in this report were the same as used in previous assessments: 0.15 for Atlantic king mackerel, and 0.3 for both Atlantic and Gulf Spanish mackerel. The stochastic analyses allowed the value of M to vary over both years and ages using a random draw from a uniform distribution of 0.10 to 0.20 for Atlantic king, and from 0.25 to 0.35 for Spanish mackerel stocks. The M point estimates have been selected by the MSAP based upon the longevity and growth rates of the mackerels and by analogy with other species with similar life history characteristics.

### Fecundity

The fecundity at age vectors are the same as used in prior assessments. For Atlantic king mackerel the age specific fecundity values correspond to millions of eggs. The derivation of the egg values came from an age-length relationship (Collins *et al*. 1989), a linear spline fit to maturity at age data (data from Finucane *et al.* 1986), and an eggs-length relationship (Finucane *et al.* 1986). The values of age specific fecundity that reported spawning stock are in trillions ($10^{12}$) of eggs. For the Spanish mackerel stocks (Gulf and Atlantic), the age specific fecundity was estimated as the biomass of females times the probability of maturity by age (Fable et al 1987) times 0.5.

## ABUNDANCE TRENDS FROM INDICES

### Standardization Methods

In prior assessments, the General Linear Modeling (GLM) approach was used to standardize several catch-per-unit-effort (CPUE) series (Legault *et al.* 2000). Briefly, the model may be expressed as:

$$\text{Log(CPUE)} = a + \Sigma_i \, b_i \, I_i + e$$

where a and the $b_i$ are parameters, the $I_i$ are categorical variables and e is the error term assumed to be normally distributed with mean 0 and variance $v^2$. The categorical variables include year and other factors which contribute to the variation in log(CPUE) independently of abundance. However, this model requires modifying values of zero catch (to make the logarithmic transformation). Traditionally a value of 1 or other constant positive value was added to all observations prior to the standardization procedure. In cases where the proportion of zero catch values to the total observations is relatively high, the standardized catch rates may depend largely on the selection of the constant value (Ortiz *et al*. 2000). Following, Cooke and Lankester (1996) suggestions for alternative statistical models for catch-effort standardization, and Punt *et al.* (2000) protocols, some of the CPUE indices for king mackerel were standardized using Generalized Linear Models, specifically the delta lognormal model. Briefly, the delta model separates the estimation process into two components: the probability of encountering king mackerel and the density to fish given that at least one fish was encountered. Standardized catch rates for Gulf Spanish mackerel using the delta model have been presented previously to the MSAP working group (Ortiz and Scott 2001).

Indices

As in previous mackerel stock assessments conducted since 1985, catch per unit of effort (CPUE) data from multiple sources were evaluated as indices of stock abundance. CPUE indices affect assessment results by calibrating estimates of population size to annual trends in CPUE, assuming direct proportionality to abundance. The annual trends in CPUE were assumed to represent age-specific abundance trends. The procedures used to derive annual indices of abundance were similar to those of previous assessments and take into consideration technical decisions made by the Panel during the 1996 Panel Review of Gulf king mackerel and the 1997, and 1998 Panel Reviews of Atlantic king mackerel and Gulf Spanish mackerel stocks (Cummings 1996, MSAP 1996, MSAP Supplemental 1996, MSAP 1997, MSAP 1998). During those meetings, after consideration by the Panel of the available historical CPUE data for indexing abundance of mackerels, recommendations were made regarding the continued use of specific data sets and the data to be included in the analysis. Emphasis was placed on analyses that accounted for possible biases in the index due impacts of regulations (*e.g.*, bag limits, state trip limits, regulated seasons). For this assessment, each set of CPUE data was analyzed separately using general linear modeling theory as in earlier assessments, and information on area of catch, amount landed, month of capture, vessel, and other available auxiliary information incorporated into the index to adjust for changes in CPUE while applying the rationale specified by the MSAP 1996, MSAP 1997, and MSAP 1998 reviews. Indices updated for this Stock Assessment analyses are described below. All tuning indices available for the VPA analyses of Atlantic king, Atlantic Spanish and Gulf Spanish are listed in Tables 11,12 and 13, respectively. In addition, the tables provide information regarding the time of the year when the index was related to abundance, whether the index was compared to estimated numbers or biomass, and the age range used for tuning.

**ATLANTIC KING MACKEREL**

*A. Florida Fish and Wildlife Conservation Commission (FWC) Marine Fisheries Trip Ticket Program.* Following recommendations of the MSAP 1997 review, this index included changes due to catch restrictions imposed on the Atlantic migratory group from a State trip limit of 50 fish after 1987, separating the landings into areas (north and south of Palm Beach county), and inclusion of catches between April and October when catches were considered to be unrestricted by catch limits. The abundance index was the standard catch (lbs) per trip adjusted for month and county and was applied to ages two through eleven. The standard index was provided by scientists from the FWC Marine Fisheries Division.

*B. North Carolina Division of Marine Fisheries (NCDENR) Trip Ticket Program.* The NCDENR implemented the Trip Ticket Program on 1994. For the last assessment in 1998, the NCDENR provided a standard index based in their preliminary data collection system (MSAP-98). For this assessment, NCDENR provided Trip Ticket Program data and the standardization was done at the NMFS SEFSC Miami laboratory, there is a supporting document fully describing the standardization process, data restrictions and conclusions (Ortiz and Sabo 2003). However, the new index started in 1994, while for the 1998 stock assessment the prior index started in 1984. Because the level of summary and data aggregation differs between the two data collection programs, and as the new index was base on single trip observations, rather than monthly cumulative summarized as the prior one, it was decided to use the trip ticket Program as a separate index.

*C. NMFS Beaufort Laboratory HeadBoat Survey*. CPUE data from the Headboat Survey for the Atlantic king mackerel migratory group covered from North Carolina to the Florida east coast. For the king Atlantic stock in the Florida east coast, the data were restricted to the months of April though October. The index is the standardized numbers of fish caught per trip, adjusted by area, season, and vessel. A detailed report of the standardization procedure was presented in Ortiz (2003). The index was applied to ages two through eleven.

*D. MRFSS Recreational.* This index included trips that indicated king mackerel or other likely associated species as primary target for private and charter recreational trips. Data included the North Carolina and Florida east coast with restrictions to the months of April thought December. Index was the total number of fish caught (A1+B1+B2) per angler-trip. A detailed report of protocols was also presented in Ortiz (2003). The index was applied to ages two through eleven.

*E. Southeast Area Monitoring and Assessment Program South Atlantic (SEAMAP-SA).* This was a fishery independent survey program conducted by the South Carolina Department of Natural Resources Marine Resources Division (SCDNR-MRD) since 1986. The survey used a shallow water trawl that samples coastal habitats from Cape Hatteras (NC) to the Cape Cañaveral area (FL). Survey design and estimation protocols were specified in the appendix A. The index expressed the number of fish per hectare, adjusted for season, and area. Figure 11 presents a comparison of 1998 stock assessment and 2003 stock assessment standard indices of abundance, for Atlantic king mackerel.

Figure 12 summarized all available indices in 2003 using a common scale, defined as their respective mean for the overlapping years in all series.

## ATLANTIC SPANISH MACKEREL

*A. Florida Fish and Wildlife Conservation Commission (FWC) Marine Fisheries Trip Ticket Program.* The analysis of the FWC CPUE index included all trips without landing weight limit, from 1985 to 2001, and months January through December. This index was applied to fish age one through six (Table 12).

*B. MRFSS Recreational.* This index included trips that indicated Spanish mackerel or other likely associated species as primary target for private and charter recreational trips, or shore sector. Data included the North Carolina and Florida east coast with restrictions to the months of April thought December. Index was the total number of fish caught (A1+B1+B2) per angler-trip. A detailed report of protocols was also presented in Ortiz (2003). The index was applied to ages one through six.

*C. NMFS Beaufort Laboratory HeadBoat Survey*. CPUE data from the Headboat Survey for the Atlantic Spanish mackerel migratory group covered from North Carolina to the Florida east coast. For the Spanish Atlantic stock in the Florida east coast, the data was restricted to trips of 24 hours or less. The index was the standardized numbers of fish caught per trip, adjusted by area, season, and vessel. A detailed report of the standardization procedure was presented in Ortiz (2003). The index was applied to one through six.

*D. North Carolina Division of Marine Fisheries Pamlico Sound Survey.* This is a fishery independent survey started in 1987 with emphasis on sampling of juvenile abundance in the Pamlico Sound, eastern Albemarle Sound and the lower Neuse and Pamlico rivers (See Appendix 2 for further details). Sampling was conducted quarterly for a period of two weeks, with random sampling of 52 fixed stations. Sampling gear was a double rigged demersal mongoose trawls, towed for 20 minutes at 2.5 knots. Juvenile index was the annual geometric mean (weighted by strata) of the number of individuals per tow for young of the year (YOY). The index was provided by Dr. K. West of the NCDMD, and was the first time that is available for the MSAP evaluation of Atlantic Spanish mackerel stock.

*E. North Carolina Division of Marine Fisheries (NCDENR) Trip Ticket Program.* As previously mention, The NCDENR implemented the Trip Ticket Program on 1994. The NCDENR provided Trip commercial catch data for Spanish mackerel and the standardization was done at the NMFS SEFSC Miami laboratory. There was a supporting document fully describing the standardization process, data restrictions and conclusions (Ortiz and Sabo 2003). This index started in 1994 and was applied to ages one through six.

*F. Southeast Area Monitoring and Assessment Program South Atlantic (SEAMAP-SA).* This is a fishery independent survey program conducted by the South Carolina Department of Natural Resources Marine Resources Division (SCDNR-MRD) since 1986. The survey used a shallow water trawl that samples coastal habitats from Cape Hatteras (NC) to the Cape Cañaveral area (FL). Survey design and estimation protocols were specified in the appendix A. The index expressed the number of fish per hectare, adjusted for season, and area.

Figure 13 presents a comparison of 1998 stock assessment and 2003 stock assessment standard indices of abundance, for Atlantic Spanish mackerel. Figure 14 summarized all available indices in 2003 using a common scale, defined as their respective mean for the overlapping years in all series.

**GULF SPANISH MACKEREL**

*A. Florida Fish and Wildlife Conservation Commission (FWC) Marine Fisheries Trip Ticket Program.* The analysis of the FWC CPUE index included all trips with landings over 500 lbs, from 1985 to 2001, and months July through December. This index was applied to fish age one through seven (Table 13).

*B. MRFSS Recreational.* This index included trips that indicated Spanish mackerel or other likely associated species as primary target for private and charter recreational trips. Data were included from the Gulf of Mexico area with restrictions to the months of March thought December. Index was the total number of fish caught (A1+B1+B2) per angler-trip. A detailed report of protocols was also presented in Ortiz (2003). The index was applied to ages one through three.

*C. Texas Parks and Wildlife Department (TPWD) Recreational Angler Creel Survey.* Successful recreational anglers in Texas that caught Spanish mackerel were also used to develop standardized CPUE. The data used included observations between the months of May and October from the private mode, with trips of 24 hours or less. A detailed report of the standardization procedure was presented in Ortiz (2003). The index was applied to ages one through three.

*D. NMFS Beaufort Laboratory HeadBoat Survey*. CPUE data from the Headboat Survey for the Gulf Spanish mackerel migratory group covers from the Florida west coast to Texas. For the Spanish Gulf, stock the data was also restricted to trips of 24 hours or less. The index was the standardized numbers of fish caught per trip, adjusted by area, season, and vessel. A detailed report of the standardization procedure was presented in Ortiz (2003). The index was applied to one through three.

*E. Shrimp bycatch index*. This index was derived from the estimates of Spanish mackerel bycatch in the Gulf shrimp fishery. The index was estimated as the total number of bycatch fish per year divided by the annual shrimp fishing effort. When estimating total bycatch for use in this tuning index, areas that used BRDs were instead assigned the commercial catch rate in order to have a consistent time series. The bycatch index used for the base case analyses was derived using the GLM method (Nichols et al 1987). An alternative model (Delta lognormal approach) was used for sensitivity analyses. The index was applied to ages 0 through two. Age allocation for the partial catch at age of this index used Spanish mackerel length frequency distributions of bycatch samples (MSAP 1998). Most of the length data were prior to 1996, thus the bycatch age proportions of 1996 year was also applied to years 1997 through 2001.

*F. Southeast Area Monitoring and Assessment Program (SEAMAP).* This was a fishery independent larval sampling survey Gulf wide (Gledhill and Lyczkowski-Shultz 2000). The index expressed the percent of occurrence of Spanish mackerel, rather than the estimates of density as per recommendation of the authors.

*G. Other indices*. In prior assessments another index of abundance was included in the tuning of VPA analyses: the Florida Charter Northwest Panhandle area index (MSAP 98/01). This index covers from 1984 to 1991 and was applied to ages one and two.

Figure 15 presents a comparison of 1998 stock assessment and 2003 stock assessment standard indices of abundance, for Gulf Spanish mackerel. Figure 16 summarized all available indices in 2003 using a common scale, defined as their respective mean for the overlapping years in all series.

## METHODS

Virtual Population Analysis

As in previous mackerel stock assessments, a tuned VPA (Fadapt) method (Powers and Restrepo 1992, Restrepo 1996) was used to obtain statistical estimates of population parameters. The method is a non-linear least squares (LS) estimation process in which observed indices of abundance are fit by population estimates from cohort analyses for appropriate age groups:

$$\min_p LS = \Sigma_{it} [X_{it} - q_i \Sigma_j (b_{ijt} N_{ijt})]^2$$

where $X_{it}$ is the index i in year t, $N_{ijt}$ is the abundance in year t of the j ages represented in index i and the $b_{ijt}$ are appropriate conversion factors for that index and age (for example conversion from numbers to weight, conversion of the abundance from the beginning of the year to mid-year, or conversion of selectivity by age within the age group). For the index series, there is an option to assign a weight factor that in theory will translate the level of uncertainty of each index into the VPA's fitting procedure. Although in the past the working group suggested the evaluation of alternative weighting for each index, it was concluded that at the present was not possible to assign an equivalent variance estimate among all indices (MSAP 2000, 2001). In the present analysis, for each index maximum likelihood estimates of variance were estimated, similar as in the 1998 stock assessment for all three migratory groups.

The scaling parameters $q_i$ were computed by maximum likelihood during the minimization process in both situations, they were not estimated directly. Since all indices were scaled to their own-mean, prior to fitting in the VPA, the absolute values of the $q_i$ were not meaningful relative to the original data used to create the index. In each analysis, the fishing mortality rates at age in the 2001/2002 fishing year (terminal year) were the parameters estimated. Note that this is analytically equivalent to estimating the population abundance in the next year at the next age but allows estimation for the plus group. An additional assumption made in each analysis was that the fishing mortality rate was the same in the plus group as the previous age class for all years except for the terminal year. As many ages as possible were estimated in each analysis using the positive-defined information matrix solution as the determining factors for a 'successful' solution (Restrepo 1996). The VPA algorithms also included a re-start solution process, in order to avoid 'local minima' as solutions.

In these analyses, selectivity at age for each index by year was computed based on the partial catch at age associated with the index during that year. The catch at age for a particular index year was first used to find the proportion of total fishing mortality due to that amount of catch as:

$$F_{y,a,i} = F_{y,a} * Catch_{y,a,i} / Catch_{y,a}$$

where y, a and i denote year, age and index, respectively. The selectivity at age is then formed by dividing each $F_{y,a,i}$ by the maximum value over age for that year and index. This use of partial catches to form the selectivity patterns for the tuning indices added stability to the solutions by allowing different indices to tune to the same ages but at differing levels of importance over the ages.

Additional assumptions were made in each analysis regarding the fishing mortality rate of the plus group in the terminal year: for Atlantic king the age plus group was Age-11+, in the VPA model it was assumed that the terminal F's of ages 10 and 11+ were fixed ratios of the F at age-9 ($F_{10}/F_9 = 1.0$, $F_{11+}F/F_9 = 1.0$). For Atlantic Spanish the age plus group was Age-6+, in the VPA model it was assumed that the terminal $F_{6+}$ is a fixed ratio of F at age-5 ($F_{6+}/F_5 = 1.0$). For Gulf Spanish, the VPA model estimated F for the plus group (Age-7+) in the terminal year.

The fishing mortality rate on the plus group in years before the terminal year is assumed to be equal to the fishing mortality of the next younger age: for Atlantic king F of 11+ is fixed ratios of F at age 10 ($F_{11+}/F_{10} = 1.0$); for Atlantic Spanish $F_{6+}$ is a fixed ratio of F at age 5 ($F_{6+}/F_5 = 1.0$), and for Gulf Spanish $F_{7+}$ is a fixed ratio of F at age 6 ($F_{7+}/F_6 = 1.0$).

Characterization of Uncertainty

The uncertainty in the assessment estimation was characterized as in the past by both sensitivity analyses on selected components and by mixed Monte Carlo/bootstrap simulations of the tuned VPA. The simulation method repeats the VPA a number of times (500) randomly selecting from 1) a uniform distribution of natural mortality rate for each age and year; 2) a lognormal distribution of directed catch at age assuming the point estimate represented the mean and the variance was characterized by a CV of 25%; 3) a lognormal distribution of bycatch at age assuming the point estimate represented the mean and the variance was characterized by a CV of 25%; and 4) the observed deviations between the indices of abundance and the predicted population model from the original VPA fit. The results were accumulated and sorted to provide probability statements of relevant statistics. Projections were made using each iteration such that benchmarks, stock trends and ABC could be evaluated on an absolute or relative scale. Probability distributions from these observations were used to construct 80% pseudo-confidence intervals (removing the 10% lowest and highest observations).

The stochastic simulations estimated the same number of parameters as the deterministic case. The final estimates from the deterministic case were used as initial guesses for the terminal year fishing mortality rates at age. Thus, the potential existed for highly different VPA estimates in each simulation, especially given that all the random selections described above were uncorrelated. This use of uncorrelated random selections could be a problem for the catch and index generated from the bycatch data as well as other indices tuning to young ages.

Projections

Population abundances at age in the terminal year of the VPA (2001/02 fishing year) were projected into the 2003/04 fishing year according to the estimated F and M at age values in the terminal year. Recruitment in the projection years came from a stock recruitment model specific within each bootstrap. The point estimate was projected deterministically following this stock recruitment model while the bootstraps used the estimated variability about the model to create a lognormal distribution from which recruitment was randomly chosen. The stock recruitment model was developed during the 1998 MSAP meeting according to the following rules. Only years for which both, the stock and recruitment estimated values had tuning index information were used to create the relationship. In the case of Atlantic king mackerel, this means that only years 1989-1999 are used. For Atlantic Spanish stock recruitment relationship was estimated from the year 1989 to 1999, and for Gulf Spanish from the year 1985 to 1999. The maximum recruitment was set at the average recruitment estimated during these years and declines linearly to the origin when the spawning stock size drops below the “break point”. The “break point” was determined by the average of the five lowest spawning stock sizes within the years included (Fig 17).

In the present analysis, bycatch mortality was included only for the Gulf Spanish mackerel stock. The bycatch fishing mortality rate for the projection years was computed as the average of the F at age due to bycatch during the period 1993-1997, modified by the expected bycatch reduction due to full implementation of BRDs. The year 1998 was not included in this average because BRDs were partially implemented then. The bycatch reduction due to BRDs implementation was estimated as 35% for Gulf Spanish mackerel (S. Nichols, MSAP 2000), starting in year 1998 and beyond. The directed fishing mortality rates at age were assumed separable by sector (commercial and recreational) with the selectivity at age pattern for each sector computed as the average over the last five years and the year multipliers specific to each sector. For the 2002/2003 fishing year, the two fishing mortality rate multipliers were estimated simultaneously such that the observed total catch in weight for the commercial sector[1] and the 2002/03 total catch in numbers for the recreational sector[2] was achieved. The total fishing mortality rate at age was computed as the sum of the bycatch F at age, the product of the commercial multiplier and

1 The Atlantic Spanish commercial catch 2002/03 was set to 2,940,351 lbs. From the Preliminary Landings, Status of Quotas, and daily vessel trip/landing limit report as of April 15, 2003. While, the commercial catch for Atlantic king mackerel fishing year 2002/03 was set to the catch of 2001/02 (2,017,056 lbs) and, for Gulf Spanish commercial catch was also set to the catch of 2001/02 (788,437 lbs) due to incomplete reports for these two stocks.
2 The Atlantic king recreational catch for fishing year 2002/03 was set to 283,099 fish (3,389,565 lbs). For Atlantic Spanish recreational catch of 2002/03 FY was set to 1,389,184 fish (2,370,183 lbs). And, for Gulf Spanish recreational catch of 2002/03 FY was set to 1,906,759 fish (3,082,437 lbs). From the Preliminary Landings, Status of Quotas, and daily vessel trip/landing limit report as of April 15, 2003.

selectivity at age, and the product of the recreational multiplier and selectivity at age. The two multipliers were unique values assuming both catches are smaller than the estimated population.

The population abundances were then projected into the 2003/2004 fishing year according to the total fishing mortality rate at age and the natural mortality rate at age. The two fishing mortality rate multipliers (commercial and recreational) for the 2003/2004 fishing year were estimated simultaneously such that a desired spawning potential ratio (SPR transitional unweighted) was achieved and the ratio of catches in weight by the two sectors equaled the allocation for the specific migratory group. These F multipliers were again unique assuming the SPR could be achieved in that year. The yield resulting from application of the directed fishing mortality rates on the estimated population abundance generated the ABC value. This approach of treating separately the commercial and recreational sectors was used in prior assessments.

The recent reauthorization of the Magnuson-Stevens Fishery Management and Conservation Act (MFMCA) requires the use of both biomass and fishing mortality rate limits to classify the status of stocks. Following the decisions made by the MSAP, the recommended proxy for $F_{MSY}$ is $F_{30\%SPR}$ and the proxy for $B_{MSY}$ was the spawning stock that resulted in equilibrium under the $F_{MSY}$ proxy according to the stock recruitment relationship. The default control rule of Restrepo et al (1998) was accepted by the MSAP at the last meeting. This default control rule sets the minimum stock size threshold (MSST) to (1-M)* $B_{MSY}$ and the maximum fishing mortality threshold (MFMT) to $F_{MSY}$ for SS>MSST and decreasing linearly to the origin for SS<MSST. Risks associated with overfishing, *P* (F>MFMT), and being overfished, *P* (SS<MSST), can be calculated from the results of the bootstraps for constant catch projections.

## RESULTS AND DISCUSSION

In the current stock evaluation, the models adopted by the Mackerel Stock Assessment Panel (MSAP) in 1998 (last full stock assessment for all three stocks) (MSAP-98) were defined as the base model(s). The models adopted in 1998 have been used in projections and for estimation of targets and threshold benchmarks (GMFMC 2003, Ortiz 2002, Ortiz and Legault 2001, Legault 1999).

### ATLANTIC KING MACKEREL

For Atlantic king mackerel briefly; the 1998 MSAP adopted the model with maximum likelihood (ML) estimates option and normal error assumption for all 5 indices of abundance available (with the same age coverage and time of year application as presented in the indices section), not including bycatch estimates, and eliminating the early time series for the SEAMAP index (1988 and prior) (MSAP-98). In this model, the VPA-program estimated 10 parameters, i.e. the terminal F's for age-0 to age-9, and assumed an F ratio of one for $F_{10}/F_9$, and $F_{11+}/F_9$. Thus for the 2003 evaluation, the "Base model" was defined as similar as possible. Initially, the Base model tried to estimate 10 parameters, however the model failed to converge to a successful solution. A successful solution was achieved for the 2003 VPA Base model when it estimated eight fishing mortality rates in the last year, corresponding to the age classes 2 through 9, with fixed F ratios for $F_0$, $F_1$, $F_{10}$ and $F_{11+}$. F ratios where defined as: $F_0$ = 0.0108 of $F_2$, $F_1$ = 0.4716 of $F_2$, $F_{10}$=1.0 of $F_9$ and $F_{11+}$ = 1.0 of $F_9$. F ratios for ages 0 and 1 were estimated using separable VPA algorithm (SVPA), with the 1997-2001 catch at age as input. Similar process has been done in the past assessments, for example with Gulf king mackerel in 2002 stock assessment (Ortiz et al 2002). The updated NC commercial index was not included in the Base model as it was considered sufficiently different the data input and standardization procedure compared to the NC commercial index used in 1998 SA. Table 14 shows the results of the Base model; stock size at age at the beginning of the year, F at age during the year, parameter estimates with associated variance estimators, and the observed and predicted index results.

The alternative VPA model for Atlantic king mackerel or "Full Index model" simply added the new NC Commercial standard CPUE as a separate index of abundance, with all other settings similar as the Base model. Table 15 shows the results of the Full index model; stock size, F at age, parameter estimates and index results, respectively. A comparison of the results from the Base and Full index models for Atlantic king are shown in figure 18 for the estimated F at age, figure 19 for estimated stock size by age, and figure 20 for the observed vs. predicted indices of abundance. In general, the Base model estimated a higher stock size with lower fishing mortality rates in particular since 1990, and for ages 6, 7, 8, 10 and 11+. However, when the estimated 80% pseudo-confidence intervals were included (Fig 21) is clear that both the Base and Full index model provide similar estimates. The confidence intervals were generated by bootstrapping. Overall the VPA indicated a extremely large mortality of older fish ($F_{7-10}$) at the beginning of the time series 1981, the F increased during the mid 80's up to mid 90's in particular for ages 2 to 6, with decreasing trend for the older age classes. In terms of the stock, a large cohort entered in 1989, but the overall stock in numbers indicated a downward trend, with the lowest point estimated in the latest year (2002). The predicted indices of abundance showed similar trends for both models. The largest residuals were observed for the MRFSS index, in particular for the early years of the series (1982/83/87).

Figure 22 shows a comparison of the 1998 stock assessment results and the present one (Full index model). Major departures started in 1989 with the estimates of recruits for that year, that can be follow through the time series. In 1998-SA the VPA estimated a recruitment of about 5 million fish, while in the 2003-SA this recruitment was estimated at about 3 million fish (Age 0). Ages 7-10 differed in the 1981 estimates only. In terms of F, the 1998 SA estimated a drop in $F_{3-6}$ from 0.15 to 0.05, this was much less in the 2003 SA, and subsequently there was an increase in $F_{3-6}$ starting in 1995/96. In terms of stock size, the 1998 SA estimated a much larger stock biomass for Ages 3-6 with an increasing trend in the 93-96 period, this was not the case in the 2003 SA, instead, the stock biomass remained low during much of the 1990's and increased slightly in the latest years (1997-2001).

The impact of each index value on the VPA results can be determined from a jackknife analysis. The jackknife systematically removes each index point and runs the VPA without that one tuning index value. The most influential points for tuning index according to the jackknife analysis is the 1982 MRFSS and the 1998 NC Commercial indices (Fig 23). The impact of the different scenarios can also be seen in the estimate of spawning potential ratios (SPR). The Base model estimates higher SPR values [Static SPR =0.46, Transitional unweighted SPR = 0.38] due to lower estimated F overall relative to the Full Index model [Static SPR =0.42, Transitional unweighted SPR = 0.33] (Fig 24). The trends from the two models were similar; the transitional SPR trends showed a decrease since 1985, with an increase in 1997/98 fishing years. The static SPR trends showed an overall decrease since 1984, with values below 30% in most of the 80's and early 90's, follow by a peak in 1993, and increase trend since 1997/98. Both models, however indicated that the stock was above the 30% SPR threshold in year 2002/03, either for static or transitional unweighted estimators.

As stated in the king mackerel evaluation report (Legault *et al.* 2000), in order to determine the stock status under the new rule definitions, the maximum sustainable yield fishing mortality rate and associated spawning stock proxies must first be calculated. These proxies were based upon $F_{30\%SPR}$ and the two-line model of stock recruitment relationship described previously. These proxies were computed by projecting each bootstrap to the year 2070 under constant recruitment and $F_{30\%SPR}$, both specific to that bootstrap. The same proxies for optimum yield (OY) were computed using $F_{40\%SPR}$. The median and 80% confidence intervals for these MSY and OY related benchmarks were given in Table 16. The Base model scenario produced slightly higher estimates for all of these benchmarks compared to the Full index model scenario, but the confidence bounds clearly overlapped for both models (Fig 25).

Using the bootstrap specific estimates of MFMT and MSST, the probability of being classified as undergoing overfishing or being overfished in fishing year 2002 were calculated. For the Base model, 34 of the 500 bootstraps (7%) produced F>MFMT, while 65 of the 500 bootstraps (13%) produced SS<MSST (Fig 26). For the Full Index model, 60 of the 500 bootstraps (12%) produced F>MFMT, while 132 of the 500 bootstraps (26%) produced SS<MSST (Fig 27). Since currently, the acceptable resource risk of being overfished or undergoing overfishing is not defined by the Council, no definite statement about stock status can be made. However, the Technical Guidelines (Restrepo et al 1998) recommend low risk of exceeding threshold levels, suggesting this value not be greater than 20-30% and certainly less than 50%. Phase plots for the Atlantic king mackerel stock status in fishing year 2002/2003 are shown for both models in Figure 28.

The fishing year 2003/2004 acceptable biological catch (ABC) for the two models have different median values and estimated 80% pseudo confidence interval (Table 17 and Figure 29).

## ATLANTIC SPANISH MACKEREL

For Atlantic Spanish mackerel the 1998 MSAP adopted the model with maximum likelihood (ML) estimates option and normal error assumption for all 5 indices of abundance available (with the same age coverage and time of year application as presented in the indices section, with exception of the MRFSS index which was split in two: Florida MRFSS and NC MRFSS[3]), not including bycatch estimates, and eliminating the early time series for the SEAMAP index (1988 and prior) (MSAP-98). In this model, the VPA-program estimated 7 parameters, corresponding to the terminal F's for each age class (Age 0 to Age 6+). Thus for the 2003 evaluation, the "Base model" was defined as similarly as possible. Initially, the Base model tried to estimate all 7 parameters, however the model failed to converge to a successful solution (i.e. a solution with a positive definite information matrix). The 2003 VPA Base model estimated 6 fishing mortality rates in the last year, corresponding to the age classes 0 through 5, with fixed F ratio for $F_{6+}$, which was defined as: $F_{6+} = 1.0$ of $F_5$. The updated MRFSS index was not split between states, because no particular reason justified such partition, and to avoid giving more weight in the tuning process to a single index source. Table 18 shows the results of the Base model; stock size at age at the beginning of the year, F at age during the year, parameter estimates with associated variance estimators, and the observed and predicted index results.

The alternative VPA model for Atlantic Spanish mackerel or "Full Index model" added two new indices of abundance; the NC Commercial standard CPUE derived from the Trip ticket program (Ortiz and Sabo 2003), and the NC Pamlico Sound Survey a fishery independent survey of juvenile fish primarily. All other settings in the Full index model were similar as in the Base model. Table 19 shows the results of the Full index model; stock size, F at age, parameter estimates and index results,

3 The 1998 SA MRFSS index was split for the Florida and North Carolina states and used as two different tuning indices in the VPA model, each one with independent q estimates and partial catch at age inputs (MSAP 98/02)

respectively. A comparison of the results from the Base and Full index models for Atlantic Spanish are shown in figure 30 for the estimated F at age, figure 31 for estimated stock size by age, and figure 32 for the observed vs. predicted indices of abundance. In general, the Full index model estimated a higher stock size with lower fishing mortality rates through the all time series and for all ages. However, when the estimated 80% pseudo-confidence intervals are included (Fig 33) was clear that both the Base and Full index models provided similar estimates. The confidence intervals were generated by bootstrapping. Overall the VPA indicated a high F mortality rates of ages 2 and 3 ($F_{2\text{-}3}$) at the beginning of the time series 1984, the F increased during the late 80's up to mid 90's in particular for ages 3 to 6+, with the highest peak in 1993, then it followed a substantial decrease for all age classes in 1995. In terms of the stock, the largest cohort entered in 1998, but the overall stock in numbers indicated an upward trend, with the highest point estimated in the latest year (2001). It is particularly notable the increasing trends of older ages (Age 4, 5 and 6+) in the latest 5 years. The predicted indices of abundance showed similar trends for both models. The largest residuals were observed for the Headboat index, in particular for the early years of the series (1987/92), the MRFSS index (1984/85/93) and the Pamlico Sound index (1992).

Figure 34 shows a comparison of the 1998 stock assessment results and the present one (Full index model). Major departures started in 1993 with the estimates of recruits for that year that can be followed through the time series. The 1998-SA VPA estimated a recruitment of about 15 million fish for 1993, while in the 2003-SA this recruitment was estimated at about 8 million fish (Age 0). Ages 2-6+ differed since 1990 and forward. In terms of F, the 1998 SA estimated lower fishing mortality rates particularly for older ages ($F_{5\text{-}6+}$ from 1990 on). In terms of stock biomass, the 1998-SA estimated a much larger stock biomass for Ages 2-6+ with an increasing trend in the 1994-96 period, this was not the case in the 2003 SA, instead, the stock biomass remained low during much of the early 1990's and started increasing by 1996 and the latest years.

The jackknife analysis indicated that the most influential points for tuning index fitting were the 1982 MRFSS and the 1998 NC Commercial indices (Fig 35). The results of the different scenarios can also be seen in the estimates of spawning potential ratios (SPR). The Base model [Static SPR =0.46, Transitional unweighted SPR = 0.37] and the Full index model [Static SPR =0.45, Transitional unweighted SPR = 0.37] estimated similar SPR values (Fig 36). The trends from the two models were similar; the transitional SPR trends show a decrease since 1988, with an increase in 1995 that continued to the last year (2002). The static SPR trends showed an overall decrease since 1987, with values below 30% in most of the late 80's and early 90's, followed by a peak in 1995, and an increased trend since then. Both models indicated that the stock was above the 30% SPR threshold in year 2002/03, either for static or transitional unweighted estimators.

The proxies for determining the stock status under the new rule definitions were also based upon $F_{30\%SPR}$ and the two-line model of stock recruitment relationship described previously. These proxies were computed by projecting each bootstrap to the year 2070 under constant recruitment and $F_{30\%SPR}$, both specific to that bootstrap. The same proxies for optimum yield (OY) were computed using $F_{40\%SPR}$. The median and 80% confidence intervals for these MSY and OY related benchmarks are given in Table 20. The Full index model produced slightly higher estimates for all of these benchmarks compared to the Base model scenario, but the confidence bounds clearly overlapped for both models (Fig 37).

Using the bootstrap specific estimates of MFMT and MSST, the probability of being classified as undergoing overfishing or being overfished in fishing year 2002 was calculated. For the Base model, 14 of the 500 bootstraps (3%) produced F>MFMT, while 22 of the 500 bootstraps (4%) produced SS<MSST (Fig 38). For the Full Index model, 17 of the 500 bootstraps (3%) produced F>MFMT, while 30 of the 500 bootstraps (6%) produced SS<MSST (Fig 39). Following the Technical Guidelines (Restrepo et al

1998) recommendations, for Atlantic Spanish there was low risk of exceeding threshold levels (values not greater than 20-30%). Phase plots for the Atlantic Spanish mackerel stock status in fishing year 2002/2003 are shown for both models in Figure 40.

The fishing year 2003/2004 acceptable biological catch (ABC) for the two models had similar median values and estimated 80% pseudo confidence interval (Table 21 and Figure 41).

## GULF SPANISH MACKEREL

For Gulf Spanish mackerel the 1998 MSAP adopted the model with maximum likelihood (ML) estimates option and normal error assumption with 5 indices of abundance (with the same age coverage and time of year application as presented in the indices section), including bycatch estimates (GLM shrimp bycatch estimates, Nichols et al 1987), and excluding the years 1995-96 from the Florida DEP Trip Ticket Index (MSAP-98). In this model, the VPA-program estimated 8 parameters, corresponding to the terminal F's for each age class (Age 0 to Age 7+). Thus for the 2003 evaluation, the "Base model" was defined as similarly as possible. The 2003 VPA Base model estimated 8 fishing mortality rates in the last year, corresponding to the age classes 0 through 7+. And included five indices of abundance (MRFSS, FWC[4], Charter NW FL, Bycatch GLM and Texas PWD). Table 22 shows the results of the Base model; stock size at age at the beginning of the year, F at age during the year, parameter estimates with associated variance estimators, and the observed and predicted index results.

The alternative VPA model for Gulf Spanish mackerel or "Full Index model" added two indices of abundance; the Headboat CPUE derived from the Headboat Survey Program (Ortiz 2003), and the SEAMAP index a fishery independent survey of juvenile fish primarily. All other settings in the Full index model were similar as in the Base model. Table 23 shows the results of the Full index model; stock size, F at age, parameter estimates and index results, respectively. A comparison of the results from the Base and Full index models for Gulf Spanish are shown in figure 42 for the estimated F at age, figure 43 for estimated stock size by age, and figure 44 for the observed vs. predicted indices of abundance. In general, both models estimated similar stock sizes; with slightly lower values for the Base model for total stock in the latest years. Accordingly, the Base model estimated slight higher overall F mortality from 1998 and forward. However, when the estimated 80% pseudo-confidence intervals were included (Fig 45) it was clear that both the Base and Full index models provided similar estimates. The confidence intervals were generated by bootstrapping. Overall the VPA indicated a high F mortality rates of ages 2 to 4 ($F_{2\text{-}4}$) at the beginning of the time series 1984, the F increased during the late 1980's up to early 1990's in particular for ages 2 to 7+, with the highest peak in 1991, then it followed a substantial decreased for all age classes in 1993/94. In terms of the stock, the largest cohort entered in 1990, with a prior one in 1986. The overall stock in numbers dropped to the lowest level in 1988, but since 1994, the stock (particularly for ages 2 to 7+) showed an increasing trend, with the highest point estimated in the latest year (2001). It is particularly noteworthy the increasing trends of older ages (Age 5, 6 and 7+) in the latest 5 years. The predicted indices of abundance showed similar trends for both models. The largest residuals were observed for the Headboat index for the early years of the series (1987/91), the MRFSS index (1988/89/91) and the Texas PWD index (1995/96).

Figure 46 shows a comparison of the 1998 stock assessment results and the present one (Full

[4] The Florida FWC index for Gulf Spanish mackerel included standardized indices for the 1995 and 1996 years, and they were included in the Base model for 2003 assessment analysis.

index model). Ages 2-7+ differed since 1992 and forward. In terms of F, the 1998 SA estimated lower fishing mortality rates particularly for older ages ($F_{5\text{-}7+}$ from 1992 on). In terms of stock biomass, the 1998-SA estimated a much larger stock biomass for Ages 2-7+ with an increasing trend in the 1993-96 period, this was not the case in the 2003 SA, instead, the stock biomass remained stable during much of the early 1990's and started increasing by 1996 and the latest years.

The jackknife analysis indicated that the most influential points for tuning index fitting were the 1991 Headboat and the 1989 MRFSS (Fig 47). The results of the different scenarios can also be seen in the estimates of spawning potential ratios (SPR). The Base model [Static SPR =0.44, Transitional unweighted SPR = 0.34] and the Full index model [Static SPR =0.42, Transitional unweighted SPR = 0.33] estimated slightly different SPR values (Fig 48). However, the trends from the two models were similar; the transitional SPR trends showed a decrease since 1985 with values below 30% SPR for most of the late 1980's and early 1990's, followed by an upward trend since 1995, raising the SPR above 30% by 1998. The static SPR trends showed an overall decrease since 1985, with values below 30% in most of the late 1980's and early 1990's, follow by a peak in 1997, and a decrease trend in 1998 to 2000, reversing in the latest year 2001. Both models indicated that the stock was above the 30% SPR threshold in year 2002/03, either for static or transitional unweighted estimators.

The proxies for determining the stock status under the new rule definitions were also based upon $F_{30\%SPR}$ and the two-line model of stock recruitment relationship described previously. These proxies were computed by projecting each bootstrap to the year 2070 under constant recruitment and $F_{30\%SPR}$, both specific to that bootstrap. The same proxies for optimum yield (OY) were computed using $F_{40\%SPR}$. The median and 80% confidence intervals for these MSY and OY related benchmarks are given in Table 24. The Base model produces slightly higher estimates for all of these benchmarks compared to the Full Index model scenario, but the confidence bounds clearly overlapped for both models (Fig 49).

Using the bootstrap specific estimates of MFMT and MSST, the probability of being classified as undergoing overfishing or being overfished in fishing year 2002 was calculated. For the Base model, 44 of the 500 bootstraps (9%) produced F>MFMT, while 125 of the 500 bootstraps (25%) produced SS<MSST (Fig 50). For the Full Index model, 56 of the 500 bootstraps (11%) produced F>MFMT, while 127 of the 500 bootstraps (25%) produced SS<MSST (Fig 51). Following the Technical Guidelines (Restrepo et al 1998) recommendations, for Gulf Spanish mackerel there was a low risk of exceeding threshold levels (values not greater than 20-30%). Phase plots for the Gulf Spanish mackerel stock status in fishing year 2002/2003 are shown for both models in Figure 52.

The fishing year 2003/2004 acceptable biological catch (ABC) for the two models had similar median values and estimated 80% pseudo confidence interval (Table 25 and Figure 53).

## SENSITIVITY ANALYSES

### RETROSPECTIVE ANALYSIS

For all three mackerel migratory groups retrospective analyses were performed. The objective was to identify possible patterns in stock size estimation or fishing mortality rates that suggested consistent bias in the VPA tuning results. The retrospective analysis was done by removing the last year data from the CAA and all index series, for the last 5 years (1996-2001), and using the same VPA settings as the Full index models for all three migratory groups.

In the case of Atlantic king mackerel, the retrospective analysis was possible only for the 1998-2001 years, the model did not converge to a solution for the 1996 or 1997 years. Figure 54 shows the estimated stock size for the year 1998/99/00/01 by age and age-groups. Figure 55 shows equivalent results for the estimate F mortality rates. The results did not indicate a strong retrospective pattern either in the stock size or F mortality rates.

For Atlantic Spanish mackerel, the retrospective analysis for years 1999 and 1996 did required to remove the NC Com New index in order to obtain a converging solution of the model, for all other years no modifications were necessary. The retrospective patterns of Atlantic Spanish stock estimates and F mortality rates are shown in figure 56 and 57, respectively. The results did show retrospective patterns for Atlantic Spanish, particularly for fishing mortality rates (F) of ages 4, 5 and 6, and the stock size of the age plus group (Age-6+). The patterns indicated that with more catch and index information the model estimates higher F mortality rates for the older ages especially. Therefore, the stock sizes of older age classes tend to be overestimated. In general, the perception is bias towards a more optimistic stock size in the final years, than the "true" size if more data were available.

For Gulf Spanish the retrospective analysis for 1997 year required removing the Charter NWF index in order to get a converging solution. Retrospective patterns of Gulf Spanish stock size and F mortality rates are shown in figures 58 and 59, respectively. The results also indicated retrospective patterns for F mortality rates of ages 5, 6 and 7+. However, the trends were not consistent by years, as more information was available, the trend increased (1998-97) or decreased (1996). This result may indicate more the effect of particular indices in the overall model fitting, rather than a bias in the VPA model.

## GULF SPANISH BYCATCH DELTA LOGNORMAL

For Gulf of Mexico Spanish mackerel there were alternative estimates of shrimp trawl bycatch based in a delta lognormal model (Ortiz et al 2000). In prior assessments, the bycatch delta lognormal have been used as sensitivity analyses, and in this evaluation updated estimates as well update index of abundance based on this bycatch estimates were also used as input for a sensitivity analysis for the Gulf Spanish migratory group. The sensitivity evaluation was applied to the Full index model for Gulf Spanish. Figure 60 shows a comparison of the stock size, F mortality rates and stock biomass results from the Bycatch Delta logN and the Full index models. Overall, the main difference is the stock size of Age 0 and Age1, and their corresponding F and stock biomass. For older age groups (2 and above) there were minor changes, and both models median estimates were between the 80% estimated confidence intervals. Figure 61 presents the estimated SPR trajectories for the Bycatch delta LogN and the Full index models, main differences showed in the 1984-1996 period when the stock was below the 30% SPR point. The bycatch delta logN estimated high SPR values compared to the Full model index. However, for the latest years both models estimated similar SPR values either static or transitional unweighted SPR (Fig 61). Figure 62 presents the estimated long term projections of MSY, OY, $SS_{MSY}$ , $SS_{OY}$ $F_{MSY}$, $F_{OY}$, from the Bycatch delta logN and the Full Index and Base models for Gulf Spanish. Bycatch delta LogN tend to estimate higher spawning stocks and MYS/OY yields. However, it is important to notice that these estimates included the fixed reduction of bycatch starting in the 2003/04 of 35% annually for Gulf Spanish.

## ATLANTIC KING MACKEREL INDEX REMOVAL

An additional sensitivity analysis for Atlantic king mackerel included the removal of complete indices of abundance to evaluate the influence of particular indices in the overall VPA results. In this case, the Full Index model was use as started point, from which each of the six available indices was removed one at the time. In two cases, the model failed to converge to a solution (when the HeadBoat index or the SEAMAP SA index was removed). Further bootstraps were done for those cases when a solution was achieved. Figures 63, 64, 65 and 66 summarized the estimated population trends for Atlantic king when the Florida FWC, MRFSS, North Carolina Commercial New (1994-2001), and North Carolina Commercial Old (1982-1996) were removed, respectively against the Full Index model. Figure 67 presents the same information but combining all scenarios and removing confidence bounds. From the results, the greatest differences with respect to the Full index model were obtained with the removal of the Florida FWC index. In this case, by removing the FWC index the VPA model estimated larger stock size and stock biomass, particularly for older ages (Age 7-11+) in the last 10 years, and corresponding lower fishing mortality rates for the same ages. However, removing the FWC index also increased substantially the estimates of confidence intervals for stock size and stock biomass (Fig 63), in some cases by 2 to 3 times compare to those obtained in the Full index model, and 30%-50% for confidence intervals of F mortality rates. Only in the older age groups (Age7 –11+) there was a reduction in the confidence intervals of $F_{7-11+}$. In addition, the removal of the North Carolina Commercial New index increased the confidence bounds estimators for biomass and stock size (Fig 65). On the other hand, by removing the MRFSS index, there were not major changes in the median points estimates, but confidence bounds were much tighter, in some cases by 2-3 fold decrease compared with the Full Index model confidence intervals.

## GENERAL DISCUSSION

In summary, the 2003 stock assessment for the Atlantic king, Atlantic Spanish and Gulf Spanish mackerel migratory groups included the update of catch for five fishing years (1997-2001), update of most indices of abundance present at the 1998 assessment, and the inclusion of at least two new indices of abundance.

The catch at age (CAA) tables for Atlantic king, Atlantic Spanish and Gulf Spanish did not present changes compare to the CAA inputs of the 1998 assessments. Review of the proportions of catch at age for the updated years (1997-2001) indicated that there were some shifts in the average proportions. Atlantic king showed a shift towards older age classes in the 1997-01 period compared to the 1981-96 average, meaning ages 2-4 decreased in their percent of contribution to the total catch, while the ages 6-11+ increased their proportion of the total catch, in both the commercial and recreational sectors (Fig 68). No changes were noticed for Atlantic Spanish (Fig 69), while for Gulf Spanish there was also a shift towards older ages showing higher proportion of the total catch compare to the 1984-96 period (Fig 70). For Gulf Spanish, the shift was more obvious in the recreational sector, with ages 2 and 3 being the predominant age classes in the 1997-01 catch, compared to the 1984-96 period when ages 1 and 2 were the predominant classes.

Indices of abundance that were available in both the 1998 assessment and the 2003 assessment were not only updated in terms of year-data but also in the standardization protocols, following recommendations by the Mackerel Stock Assessment Panel (MASP 1998). For Atlantic king the Florida FWC was the only index that was updated only in data input, and the trend for the 1998 index and 2003 index remained very similar (Fig 11). In contrast, the MRFSS, HeadBoat, Seamap and North Carolina Commercial indices varied in the standardization protocols and input data. The most prominent changes in the standardization is the inclusion of 'zero' catch records, and the level of aggregation of the data (see Ortiz 2003 for further details). These changes required the use of alternative models such the Delta lognormal, that better conformed to the assumptions of the standardization process. In general, these indices showed higher variation in their yearly estimates (Fig 11), compared to the prior GLM standardized indices. In the case of Atlantic Spanish, again the Florida FWC index was only updated in terms of year-data. For the Atlantic Spanish MRFSS, Headboat, and Seamap indices the standardization protocols and data were updated (Fig 13). In addition, for Atlantic Spanish two new indices were available; a fishery-independent index from the NC Pamlico Sound Survey, and the fishery dependent North Carolina commercial index. For Gulf Spanish, also the MRFSS and Texas PWD indices were updated in both protocols and data input (Fig 15a). A new index based on the Headboat survey was available for Gulf Spanish.

Tuned VPA results show relatively minor differences in terms of stock size and fishing mortality rates between the Base models (only indices used in 1998 assessment) and the Full index models for all three mackerel migratory groups. However, compared to the 1998 VPA results, the 2003 VPA results showed different trends, in particular for the 1992-96 years in the case of Atlantic king (Fig 22), 1990-96 for Atlantic Spanish (Fig 34), and 1993-96 for Gulf Spanish (Fig 46). In all cases, the 1998 stock assessments estimated higher stock biomass of all three migratory groups for those years compare to similar estimates in the 2003 assessments. At least, for Atlantic Spanish there was an indication of retrospective patterns, with tendency to overestimate the stock biomass of older ages in the latest years of the VPA analysis (Fig 56 and 57). Phase plots, on the other hand indicated that all three migratory groups are not either overfished or under overfishing rates (Fig 28, 40, and 52). In the case of Atlantic king, the bootstrapping results indicated a high level of uncertainty, in both the Base and Full index models, the deterministic results diverged from the median of the bootstraps, suggesting a likely bias in the VPA results due to the non-linearity of population model. For Atlantic Spanish and Gulf Spanish, the median estimates from bootstrapping results and deterministic runs were close to each other.

The projections of stock status and ranges of ABC for upcoming fishing year (2003/04) indicated for all three migratory groups catch targets greater than MSY and OY (Tables 16, 20 and 24). However, it is important to clarify that these ABC estimates (either at $F_{30\%SPR}$ or $F_{40\%SPR}$) are NOT sustainable in the long term. These ABC's include a surplus immediately available that will require the reduction of catch after the upcoming years, (if the ABC is fully removed in 2003/04 FY). In addition, another important consideration for the Atlantic migratory groups is that the current (as in 1998 assessment) estimates do not include bycatch mortality associated with the shrimp fishery. Thus, following a precautionary approach the allocation of catch quotas for the King and Atlantic Spanish stocks should take into account the ignored fishing mortality associated with shrimp bycatch.

Following recommendations of the MSAP, the present assessment included a review and re-evaluation of the standardization procedures for fishery dependent CPUE data. As discussed in the supporting documents (Ortiz 2003, Ortiz and Sabo 2003), there is a need to identify and better account for effort directed at mackerels, but with zero catches. This implied a need to revise all the processes from data collection, to selection of data subsets that better reflect a consistent sampling of the stocks. In the case of the Headboat survey, there is a need to account for individual vessel characteristics, as well for improvements of the fleet that may reflect higher fishing power in recent years. Similarly, the commercial catch analysis from the North Carolina trip ticket data, revealed the importance of individual vessels, as consistent units of sampling, and by recognizing those vessels that are transitory or 'occasional' mackerel fishing, a large part of the variability in catch rates can be accounted for. These analyses should also extend to all other indices used in the mackerel stock assessment evaluations.

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Table 1. Atlantic king mackerel stock catch summary by sector.

| Fishing Year | Commercial | | Recreational | | Total | |
|---|---|---|---|---|---|---|
| | Num fish | Weight | Num fish | Weight | Num | Wgt |
| 1981/82 | 275533 | 2390000 | 496615 | 4422000 | 772148 | 6812000 |
| 1982/83 | 381811 | 3938000 | 529589 | 5246000 | 911400 | 9184000 |
| 1983/84 | 234868 | 2441000 | 671061 | 6253000 | 905928 | 8694000 |
| 1984/85 | 181589 | 1947000 | 612578 | 6131000 | 794167 | 8078000 |
| 1985/86 | 232906 | 2495000 | 818300 | 7121000 | 1051206 | 9616000 |
| 1986/87 | 277185 | 2837000 | 699975 | 5979000 | 977160 | 8816000 |
| 1987/88 | 348135 | 3453000 | 543630 | 3905000 | 891766 | 7358000 |
| 1988/89 | 340152 | 3091000 | 556379 | 4881000 | 896530 | 7972000 |
| 1989/90 | 283360 | 2635000 | 380225 | 3400000 | 663585 | 6035000 |
| 1990/91 | 310030 | 2676000 | 439470 | 3718000 | 749500 | 6394000 |
| 1991/92 | 295505 | 2516000 | 638514 | 5822000 | 934019 | 8338000 |
| 1992/93 | 269774 | 2227000 | 672727 | 6251000 | 942501 | 8478000 |
| 1993/94 | 225137 | 2018000 | 374989 | 4438000 | 600127 | 6456000 |
| 1994/95 | 225874 | 2197000 | 381693 | 3728000 | 607567 | 5925000 |
| 1995/96 | 180136 | 1870000 | 463489 | 4153000 | 643625 | 6023000 |
| 1996/97 | 314795 | 2702000 | 382320 | 3990000 | 697115 | 6692000 |
| 1997/98 | 287245 | 2684000 | 521302 | 5154000 | 808547 | 7838000 |
| 1998/99 | 287987 | 2549000 | 438392 | 4308000 | 726379 | 6857000 |
| 1999/00 | 250482 | 2236000 | 359176 | 3424000 | 609659 | 5660000 |
| 2000/01 | 220630 | 2106000 | 551404 | 5338000 | 772035 | 7444000 |
| 2001/02 | 189554 | 2017000 | 336573 | 4037000 | 526127 | 6054000 |

Table 2. Atlantic king mackerel stock catch summary by sector and state.

| Fishing Year | Commercial | | | | | | Recreational | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FLE | FLW | N_NC | NC | SCGA | Total Com | FLE | FLW | N_NC | NC | SCGA | Total Rec |
| 1981/82 | 172883.59 | 1587.44 | 233.93 | 84426.73 | 16400.84 | 275533 | 114286.93 | 0 | 2873.9 | 358420.51 | 21033.9 | 496615 |
| 1982/83 | 246616.45 | 1063.65 | 1664.3 | 112095.74 | 20371.32 | 381811 | 321972.15 | 0 | 0 | 148566.5 | 59050.04 | 529589 |
| 1983/84 | 130888.56 | 948.21 | 637.47 | 85694.56 | 16698.8 | 234868 | 341591.85 | 0 | 0 | 221299.59 | 108169.38 | 671061 |
| 1984/85 | 106243.5 | 609.71 | 282.62 | 61012.13 | 13440.78 | 181589 | 283554.41 | 0 | 0 | 266243.52 | 62780.38 | 612578 |
| 1985/86 | 138570.22 | 613.23 | 988.99 | 77916.8 | 14816.7 | 232906 | 216125.02 | 0 | 369.05 | 427913.93 | 173892.32 | 818300 |
| 1986/87 | 143617.98 | 780.56 | 406.83 | 105878.41 | 26501.39 | 277185 | 166318.25 | 1883.94 | 9661.02 | 278890.46 | 243221.55 | 699975 |
| 1987/88 | 186591.88 | 7500.46 | 2324.08 | 134123 | 17595.84 | 348135 | 141019.5 | 2674.97 | 6932.88 | 303606.9 | 89396.06 | 543630 |
| 1988/89 | 227063.24 | 10430.51 | 1636.42 | 85892.93 | 15128.51 | 340152 | 163668.8 | 518.03 | 13143.06 | 218118.79 | 160930.14 | 556379 |
| 1989/90 | 158211.86 | 7140.39 | 1100.99 | 98173.35 | 18733.44 | 283360 | 159352.73 | 1025.02 | 7288.12 | 125780.91 | 86777.93 | 380225 |
| 1990/91 | 124790.3 | 13394.78 | 2106.1 | 148972.63 | 20766.46 | 310030 | 192571.32 | 1330.09 | 2463.14 | 173985.47 | 69119.71 | 439470 |
| 1991/92 | 125923.22 | 4709.33 | 2744.7 | 127731.92 | 34395.77 | 295505 | 244227.04 | 2430.9 | 10308.82 | 179897.26 | 201650.21 | 638514 |
| 1992/93 | 101322.59 | 10564.22 | 4289.64 | 126270.83 | 27327.08 | 269774 | 297380.79 | 1623.06 | 12791.32 | 157976.37 | 202955.18 | 672727 |
| 1993/94 | 123099.09 | 5211.58 | 2152.95 | 78626.63 | 16047.09 | 225137 | 180928.09 | 2615.93 | 17447.34 | 109081.79 | 64916.2 | 374989 |
| 1994/95 | 109195.2 | 17472.38 | 113.27 | 90878.13 | 8215.14 | 225874 | 204062.93 | 2231.06 | 2400.18 | 103640.37 | 69358.67 | 381693 |
| 1995/96 | 84458.49 | 4182.58 | 1124.07 | 81751.2 | 8619.61 | 180136 | 280257.37 | 1131.03 | 1294.93 | 115077.92 | 65727.63 | 463489 |
| 1996/97 | 128021.82 | 27557.06 | 479.59 | 148533.15 | 10203.19 | 314795 | 222120.28 | 1302.92 | 1423.14 | 93784.82 | 63688.68 | 382320 |
| 1997/98 | 164096.47 | 4488.75 | 1783.45 | 111097.04 | 5779.23 | 287245 | 229035.97 | 1315.95 | 16131.08 | 192440.7 | 82378.67 | 521302 |
| 1998/99 | 114704.6 | 19805.13 | 618.59 | 144427.88 | 8430.91 | 287987 | 222505.42 | 821.83 | 6379.5 | 89942.97 | 118741.88 | 438392 |
| 1999/00 | 122577.24 | 2245.48 | 506.16 | 117295.11 | 7858.24 | 250482 | 251070.05 | 351.03 | 3290 | 76553.52 | 27911.78 | 359176 |
| 2000/01 | 118655.97 | 2743.71 | 941.77 | 91297.3 | 6991.74 | 220630 | 330419.38 | 520.01 | 19743.1 | 139366.98 | 61354.77 | 551404 |
| 2001/02 | 105997.62 | 6452.29 | 64.17 | 72656.79 | 4383 | 189554 | 193481.9 | 1390.21 | 4436.84 | 111059.64 | 26204.6 | 336573 |

Table 3. Atlantic Spanish mackerel stock catch summary by sector

| | Commercial | | Recreational | | Total | |
|---|---|---|---|---|---|---|
| Fishing Year | Num fish | Weight | Num fish | Weight | Num | Wgt |
| 1984/85 | 2184049 | 3292000 | 941988 | 1311000 | 3126037 | 4603000 |
| 1985/86 | 2346208 | 4192000 | 495930 | 747000 | 2842138 | 4939000 |
| 1986/87 | 1906702 | 2565000 | 797711 | 1196000 | 2704412 | 3761000 |
| 1987/88 | 2445730 | 3559000 | 1052700 | 1474000 | 3498430 | 5033000 |
| 1988/89 | 2647418 | 3524000 | 1725958 | 2740000 | 4373375 | 6264000 |
| 1989/90 | 2234457 | 3963000 | 1102991 | 1569000 | 3337448 | 5532000 |
| 1990/91 | 2066826 | 3560000 | 1323466 | 2075000 | 3390292 | 5635000 |
| 1991/92 | 2913427 | 4736000 | 1463640 | 2287000 | 4377068 | 7023000 |
| 1992/93 | 2274401 | 3716000 | 1209970 | 1995000 | 3484372 | 5711000 |
| 1993/94 | 2524855 | 4813000 | 919972 | 1493000 | 3444827 | 6306000 |
| 1994/95 | 3169051 | 5233000 | 1084534 | 1378000 | 4253585 | 6611000 |
| 1995/96 | 1475620 | 2009000 | 784636 | 1089000 | 2260256 | 3098000 |
| 1996/97 | 2224714 | 3099000 | 658906 | 849000 | 2883620 | 3948000 |
| 1997/98 | 1931389 | 3056000 | 1072338 | 1669000 | 3003727 | 4725000 |
| 1998/99 | 2274318 | 3271000 | 689164 | 1182000 | 2963482 | 4453000 |
| 1999/00 | 1699830 | 2336000 | 949099 | 1217000 | 2648928 | 3553000 |
| 2000/01 | 1964327 | 2805000 | 1678613 | 2382000 | 3642940 | 5187000 |
| 2001/02 | 2150757 | 3058000 | 1235506 | 2019000 | 3386263 | 5077000 |

Table 4. Atlantic Spanish mackerel stock catch summary by sector and state.

| | Commercial | | | | | Recreational | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fishing Year | FLE | N_NC | NC | SCGA | Total Com | FLE | N_NC | NC | SCGA | Total Rec |
| 1984/85 | 2077616.9 | 10057.96 | 95322.13 | 1051.47 | 2184049 | 240100.47 | 0 | 618313.88 | 83574.07 | 941988 |
| 1985/86 | 2014712.4 | 37732.49 | 292658.82 | 1104.1 | 2346208 | 107059.96 | 0 | 344964.81 | 43905.32 | 495930 |
| 1986/87 | 1346618.3 | 245583.35 | 305905.71 | 8594.35 | 1906702 | 187464.8 | 8878.08 | 431039.24 | 170328.44 | 797711 |
| 1987/88 | 1020158.2 | 577767.4 | 845949.37 | 1855 | 2445730 | 138074.6 | 10972.84 | 816371.17 | 87281.21 | 1052700 |
| 1988/89 | 1499216.6 | 553439.5 | 592086.16 | 2675.53 | 2647418 | 226155.19 | 101691.96 | 1311880.7 | 86229.87 | 1725958 |
| 1989/90 | 953733.39 | 450661.71 | 827052.98 | 3009.13 | 2234457 | 198268.68 | 96630.02 | 679505.43 | 128586.66 | 1102991 |
| 1990/91 | 824521.66 | 539842.29 | 702034.87 | 426.73 | 2066826 | 316438.55 | 70118.92 | 823706.36 | 113202.55 | 1323466 |
| 1991/92 | 1309519.2 | 737419.92 | 866029.56 | 458.61 | 2913427 | 493829.6 | 155408.22 | 677985.77 | 136416.68 | 1463640 |
| 1992/93 | 1178898.8 | 356471.74 | 737364.86 | 1666.1 | 2274401 | 335829.28 | 88198.2 | 698115.17 | 87827.43 | 1209970 |
| 1993/94 | 1983418.2 | 63212.13 | 477936.86 | 288.26 | 2524855 | 229427.89 | 123210.1 | 461216.08 | 106117.63 | 919972 |
| 1994/95 | 2236718 | 475940.83 | 456004.1 | 387.87 | 3169051 | 219862.94 | 197491.02 | 527945.94 | 139234.53 | 1084534 |
| 1995/96 | 807119.84 | 380709.39 | 287662.51 | 128.43 | 1475620 | 352498.32 | 113055.8 | 284092.97 | 34988.81 | 784636 |
| 1996/97 | 1597670.5 | 291604.51 | 335256.9 | 182.17 | 2224714 | 95441.84 | 70785 | 343652.05 | 149027.38 | 658906 |
| 1997/98 | 1217442.5 | 168017.48 | 545929.52 | 0 | 1931389 | 279759.87 | 68516.78 | 585871.22 | 138189.94 | 1072338 |
| 1998/99 | 1887337.4 | 137374.28 | 249509.16 | 97.41 | 2274318 | 320203.44 | 41005 | 239129.03 | 88826.13 | 689164 |
| 1999/00 | 1025292.5 | 323943.87 | 350593.59 | 0 | 1699830 | 346097.19 | 79189.98 | 480802.12 | 43009.26 | 949099 |
| 2000/01 | 1296929.5 | 225724.01 | 441520.9 | 152.09 | 1964327 | 862240.07 | 93374.06 | 667627.95 | 55371.02 | 1678613 |
| 2001/02 | 1503881 | 174189.41 | 472686.72 | 0 | 2150757 | 740530.06 | 40979.04 | 400992.99 | 53004.01 | 1235506 |

Table 5. Gulf Spanish mackerel stock catch summary by sector.

| | Commercial | | Recreational | | Total | |
|---|---|---|---|---|---|---|
| Fishing Year | Num fish | Weight | Num fish | Weight | Num | Wgt |
| 1984/85 | 1856976 | 3445000 | 865259 | 56000 | 2722235 | 3501000 |
| 1985/86 | 1705998 | 3298000 | 1060184 | 1178000 | 2766182 | 4476000 |
| 1986/87 | 1250013 | 2053000 | 6334346 | 1355000 | 7584360 | 3408000 |
| 1987/88 | 1488242 | 2581000 | 1882045 | 7520000 | 3370287 | 10101000 |
| 1988/89 | 2466381 | 3902000 | 1340012 | 3124000 | 3806392 | 7026000 |
| 1989/90 | 1100892 | 2145000 | 1249756 | 2177000 | 2350648 | 4322000 |
| 1990/91 | 1123914 | 2074000 | 1595946 | 1856000 | 2719860 | 3930000 |
| 1991/92 | 2074997 | 4163000 | 2014018 | 2138000 | 4089015 | 6301000 |
| 1992/93 | 1804166 | 3113000 | 2008049 | 2889000 | 3812215 | 6002000 |
| 1993/94 | 1431772 | 2614000 | 1794840 | 3130000 | 3226612 | 5744000 |
| 1994/95 | 1528695 | 2553000 | 1137575 | 2696000 | 2666270 | 5249000 |
| 1995/96 | 730522 | 1075000 | 1092398 | 1562000 | 1822920 | 2637000 |
| 1996/97 | 316351 | 617000 | 1264637 | 1575000 | 1580988 | 2192000 |
| 1997/98 | 199835 | 356000 | 1200195 | 2042000 | 1400030 | 2398000 |
| 1998/99 | 555321 | 1082000 | 1320903 | 2454000 | 1876224 | 3536000 |
| 1999/00 | 515899 | 1067000 | 1882067 | 2396000 | 2397966 | 3463000 |
| 2000/01 | 571770 | 1053000 | 1692822 | 3353000 | 2264592 | 4406000 |
| 2001/02 | 450170 | 788000 | 2306054 | 3038000 | 2756224 | 3826000 |

Table 6. Gulf Spanish mackerel stock catch summary by sector and state.

| | Commercial | | | | | Recreational | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fishing Year | AL-MS | FLW | LA | TX | Total Com | AL-MS | FLW | LA | TX | Total Rec |
| 1984/85 | 20581.44 | 1817313.9 | 18834.16 | 246.19 | 1856976 | 459256.42 | 387688.86 | 10119.09 | 8195.04 | 865259 |
| 1985/86 | 59338.75 | 1612850.8 | 33473.68 | 334.45 | 1705998 | 419373.53 | 512899.92 | 118423.78 | 9487.08 | 1060184 |
| 1986/87 | 127519.74 | 1107950.6 | 14542.84 | 0 | 1250013 | 387331.44 | 5926303.9 | 10136.99 | 10574.09 | 6334346 |
| 1987/88 | 122988.83 | 1330661.9 | 34590.76 | 0 | 1488242 | 329002.01 | 1414423.3 | 78912.95 | 59707.03 | 1882045 |
| 1988/89 | 125054.73 | 2325411.9 | 15914.09 | 0 | 2466381 | 168886.37 | 1122753 | 36267.57 | 12104.83 | 1340012 |
| 1989/90 | 121944.86 | 968167.13 | 10779.69 | 0 | 1100892 | 255354.28 | 873860.44 | 88767.42 | 31774.13 | 1249756 |
| 1990/91 | 111950.28 | 1005370.8 | 6564.96 | 28.33 | 1123914 | 419480.08 | 1085877.5 | 63984.1 | 26604.05 | 1595946 |
| 1991/92 | 136411.36 | 1922438.4 | 16147.31 | 0 | 2074997 | 359861.33 | 1508983.6 | 106584.97 | 38588.21 | 2014018 |
| 1992/93 | 86841.43 | 1689792.7 | 27532.19 | 0 | 1804166 | 227121.13 | 1612708.5 | 97866.29 | 70353.08 | 2008049 |
| 1993/94 | 97934.75 | 1325815.6 | 8021.71 | 0 | 1431772 | 183210.01 | 1445965.5 | 32024.09 | 133640.57 | 1794840 |
| 1994/95 | 214836.41 | 1281378.1 | 32480.05 | 0 | 1528695 | 134707.45 | 962597.07 | 14760.17 | 25510.51 | 1137575 |
| 1995/96 | 241485.08 | 482727.76 | 6308.92 | 0 | 730522 | 342881.67 | 692335.68 | 32837.46 | 24343.24 | 1092398 |
| 1996/97 | 205020.92 | 108404.19 | 2907.23 | 19 | 316351 | 201184.48 | 1009967.8 | 11191.82 | 42292.66 | 1264637 |
| 1997/98 | 162921.1 | 35345.67 | 1568.67 | 0 | 199835 | 282298 | 841655.1 | 53263.3 | 22978.55 | 1200195 |
| 1998/99 | 123230.22 | 430635.87 | 1454.81 | 0 | 555321 | 198078.06 | 1063545 | 10584.95 | 48695.01 | 1320903 |
| 1999/00 | 223763.29 | 290705.11 | 1430.39 | 0 | 515899 | 417989.05 | 1399037.3 | 46547.97 | 18492.72 | 1882067 |
| 2000/01 | 192077.3 | 376539.22 | 3067.49 | 85.69 | 571770 | 200477.98 | 1329476.9 | 135245.76 | 27621.51 | 1692822 |
| 2001/02 | 275618.12 | 168902.95 | 5649.08 | 0 | 450170 | 359748.6 | 1926620.1 | 13897.03 | 5787.9 | 2306054 |

Table 7. Gulf Spanish mackerel shrimp bycatch estimates from two methods, GLM and Delta lognormal models.

| Fishing Year | GLM | Delta LogN |
|---|---|---|
| 1984/85 | 2725481 | 7488518 |
| 1985/86 | 2405822 | 2169908 |
| 1986/87 | 2805150 | 5043971 |
| 1987/88 | 3260901 | 2391127 |
| 1988/89 | 3763907 | 7118517 |
| 1989/90 | 4015349 | 7365603 |
| 1990/91 | 3619399 | 6184479 |
| 1991/92 | 4024155 | 6396335 |
| 1992/93 | 4972809 | 10065703 |
| 1993/94 | 4685047 | 13515387 |
| 1994/95 | 3003448 | 4745991 |
| 1995/96 | 2634136 | 4054823 |
| 1996/97 | 2692366 | 2778926 |
| 1997/98 | 2542275 | 1697377 |
| 1998/99 | 2293324 | 2051294 |
| 1999/00 | 2033372 | 1926717 |
| 2000/01 | 2669093 | 2769849 |
| 2001/02 | 2773159 | 4189117 |

Table 8. Atlantic king mackerel catch at age (CAA) directed fisheries.

| YEAR | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981/82 | 589 | 5,854 | 14,335 | 55,954 | 154,113 | 131,162 | 101,579 | 134,702 | 52,511 | 72,985 | 21,095 | 27,268 |
| 1982/83 | 2,809 | 5,519 | 5,750 | 20,653 | 72,035 | 170,069 | 168,341 | 163,125 | 154,633 | 27,181 | 2,197 | 119,087 |
| 1983/84 | 3,693 | 29,287 | 60,259 | 100,524 | 70,141 | 138,440 | 72,811 | 128,809 | 137,135 | 68,940 | 31,200 | 64,689 |
| 1984/85 | 1,175 | 4,165 | 10,079 | 19,651 | 102,212 | 135,161 | 119,135 | 143,957 | 54,025 | 67,192 | 57,805 | 79,610 |
| 1985/86 | 1,117 | 86,459 | 126,498 | 25,568 | 64,835 | 98,826 | 133,340 | 168,219 | 201,313 | 59,323 | 18,480 | 67,229 |
| 1986/87 | 1,441 | 118,293 | 221,907 | 115,697 | 141,440 | 63,702 | 62,910 | 92,827 | 56,918 | 17,873 | 26,756 | 57,397 |
| 1987/88 | 6,151 | 197,819 | 212,012 | 139,893 | 95,072 | 73,755 | 40,807 | 33,794 | 23,014 | 13,912 | 11,902 | 43,636 |
| 1988/89 | 1,757 | 19,394 | 217,480 | 192,579 | 113,240 | 60,041 | 60,993 | 62,595 | 22,416 | 46,998 | 21,218 | 77,820 |
| 1989/90 | 997 | 69,084 | 101,676 | 137,946 | 98,881 | 69,187 | 45,231 | 31,705 | 16,741 | 9,812 | 41,949 | 40,376 |
| 1990/91 | 608 | 134,813 | 162,794 | 78,594 | 91,287 | 81,532 | 60,087 | 26,524 | 15,597 | 27,181 | 14,470 | 56,011 |
| 1991/92 | 243 | 95,988 | 321,248 | 103,736 | 70,365 | 99,802 | 83,573 | 45,919 | 30,852 | 11,985 | 8,084 | 62,225 |
| 1992/93 | 546 | 77,386 | 259,453 | 279,931 | 70,900 | 43,701 | 52,411 | 46,267 | 18,954 | 18,360 | 12,191 | 62,402 |
| 1993/94 | 1,081 | 48,764 | 85,149 | 129,163 | 110,448 | 32,380 | 34,361 | 34,026 | 42,321 | 18,569 | 17,947 | 45,917 |
| 1994/95 | 3 | 90,443 | 140,721 | 64,185 | 75,289 | 88,968 | 42,433 | 15,378 | 20,874 | 32,298 | 13,322 | 23,653 |
| 1995/96 | 59 | 112,772 | 149,017 | 88,812 | 52,138 | 61,113 | 75,642 | 20,364 | 18,560 | 20,178 | 18,805 | 26,164 |
| 1996/97 | 947 | 52,539 | 184,572 | 136,549 | 93,209 | 62,161 | 34,062 | 63,735 | 25,325 | 13,652 | 5,925 | 24,440 |
| 1997/98 | 2,817 | 93,357 | 282,753 | 134,056 | 83,879 | 52,738 | 29,568 | 40,470 | 40,788 | 16,502 | 5,161 | 26,457 |
| 1998/99 | 7,541 | 58,509 | 177,637 | 181,958 | 100,693 | 63,645 | 35,261 | 19,778 | 27,048 | 26,661 | 6,916 | 20,731 |
| 1999/00 | 1,479 | 81,223 | 104,992 | 139,062 | 127,862 | 57,181 | 29,670 | 11,608 | 11,058 | 17,606 | 15,539 | 12,377 |
| 2000/01 | 888 | 17,601 | 278,528 | 99,655 | 161,877 | 88,430 | 38,838 | 13,537 | 9,906 | 9,399 | 17,209 | 36,169 |
| 2001/02 | - | 16,448 | 94,105 | 134,327 | 65,729 | 85,686 | 45,851 | 19,220 | 8,596 | 5,596 | 7,650 | 42,919 |

Table 9. Atlantic Spanish mackerel catch at age (CAA) directed fisheries.

| YEAR | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6+ |
|---|---|---|---|---|---|---|---|
| 1981/82 | 168 | 371,280 | 1,896,721 | 808,815 | 7,935 | 34,471 | 6,646 |
| 1982/83 | 22,289 | 820,209 | 1,188,593 | 570,154 | 34,749 | 112,904 | 93,241 |
| 1983/84 | 25,506 | 1,296,390 | 1,165,685 | 110,271 | 19,351 | 46,339 | 40,870 |
| 1984/85 | 231,217 | 2,130,039 | 653,276 | 261,532 | 103,351 | 66,886 | 52,130 |
| 1985/86 | 324,727 | 1,311,346 | 1,505,112 | 916,872 | 130,698 | 124,075 | 60,545 |
| 1986/87 | 105,253 | 1,302,996 | 600,706 | 599,284 | 404,511 | 203,864 | 120,834 |
| 1987/88 | 349,105 | 1,244,154 | 832,785 | 402,204 | 250,783 | 204,098 | 107,163 |
| 1988/89 | 338,472 | 2,131,969 | 818,422 | 430,718 | 295,458 | 163,893 | 198,135 |
| 1989/90 | 66,622 | 1,538,548 | 972,061 | 427,718 | 217,874 | 120,374 | 141,175 |
| 1990/91 | 156,823 | 1,111,941 | 899,318 | 645,288 | 276,774 | 201,677 | 153,005 |
| 1991/92 | 203,713 | 1,954,427 | 998,925 | 651,560 | 333,483 | 49,348 | 62,130 |
| 1992/93 | 432,840 | 934,790 | 506,756 | 236,881 | 109,366 | 19,108 | 20,516 |
| 1993/94 | 173,332 | 1,136,617 | 840,320 | 510,440 | 139,515 | 52,784 | 30,613 |
| 1994/95 | 146,585 | 1,080,260 | 949,045 | 498,022 | 212,150 | 58,039 | 59,626 |
| 1995/96 | 465,473 | 811,166 | 833,402 | 429,500 | 220,103 | 119,293 | 84,544 |
| 1996/97 | 267,398 | 1,241,859 | 496,125 | 294,560 | 158,107 | 117,108 | 73,770 |
| 1997/98 | 172,594 | 1,426,372 | 1,150,170 | 471,734 | 239,646 | 84,895 | 97,528 |
| 1998/99 | 269,605 | 820,784 | 1,051,589 | 938,696 | 187,753 | 44,921 | 72,916 |

Table 10. Gulf Spanish mackerel catch at age (CAA) directed fisheries.

| YEAR | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7+ |
|---|---|---|---|---|---|---|---|---|
| 1984/85 | 316 | 449,378 | 1,598,924 | 578,215 | 90,071 | 3,165 | 583 | 1,582 |
| 1985/86 | 713 | 595,047 | 1,317,875 | 558,431 | 277,517 | 2,587 | 10,513 | 3,499 |
| 1986/87 | 5,028 | 4,643,805 | 2,314,286 | 330,269 | 168,846 | 67,364 | 33,608 | 21,154 |
| 1987/88 | 43,794 | 1,036,127 | 1,030,649 | 537,629 | 435,375 | 180,511 | 66,475 | 39,725 |
| 1988/89 | 136,116 | 1,048,983 | 1,334,348 | 562,215 | 445,112 | 173,356 | 51,318 | 54,944 |
| 1989/90 | 299,509 | 833,494 | 399,659 | 319,058 | 263,756 | 180,830 | 36,460 | 17,881 |
| 1990/91 | 67,179 | 1,212,598 | 655,372 | 363,279 | 219,438 | 132,863 | 46,492 | 22,638 |
| 1991/92 | 51,326 | 1,360,033 | 1,398,312 | 677,836 | 315,765 | 149,918 | 67,895 | 67,930 |
| 1992/93 | 23,970 | 924,293 | 1,587,491 | 804,324 | 297,156 | 94,060 | 18,988 | 61,932 |
| 1993/94 | 56,870 | 650,215 | 1,108,431 | 909,311 | 373,987 | 72,143 | 21,575 | 34,081 |
| 1994/95 | 42,650 | 975,363 | 626,901 | 602,247 | 312,072 | 66,671 | 24,730 | 15,635 |
| 1995/96 | 339,141 | 389,469 | 704,232 | 198,630 | 123,931 | 41,191 | 18,338 | 7,987 |
| 1996/97 | 77,722 | 551,414 | 348,971 | 421,758 | 94,562 | 49,786 | 27,823 | 8,952 |
| 1997/98 | 0 | 190,608 | 439,637 | 626,489 | 108,117 | 17,310 | 5,957 | 11,913 |
| 1998/99 | 6,383 | 252,088 | 734,951 | 634,890 | 190,247 | 27,680 | 17,619 | 12,366 |
| 1999/00 | 18,533 | 787,415 | 588,250 | 654,075 | 260,068 | 54,481 | 10,920 | 24,226 |
| 2000/01 | 0 | 286,144 | 956,081 | 666,083 | 309,202 | 31,785 | 8,133 | 7,164 |
| 2001/02 | 0 | 89,390 | 1,559,554 | 870,159 | 165,787 | 27,985 | 28,535 | 14,814 |

Table 11. Tuning indices for Atlantic king mackerel VPA analyses. Time of comparison between observed and predicted values is either mid-year (MID) or at the start of the year (BEG), and the stock is measured in biomass or numbers.

| | INDICES OF ABUNDANCE | | | | | |
|---|---|---|---|---|---|---|
| **Fishing Year** | **HeadBoat** | **MRFSS** | **Florida FWC** | **North Carolina Comm New** | **SEAMAP SA** | **North Carolina Comm Old** |
| 1981/82 | 91.498 | 45.244 | | | | 317.016 |
| 1982/83 | 58.742 | 119.827 | | | | 338.056 |
| 1983/84 | 95.127 | 82.246 | | | | 213.643 |
| 1984/85 | 108.327 | 46.753 | | | | 266.580 |
| 1985/86 | 70.348 | 41.854 | 69.2753 | | | 340.220 |
| 1986/87 | 83.981 | 34.842 | 76.5425 | | | 444.645 |
| 1987/88 | 114.916 | 124.624 | 76.3871 | | | 507.271 |
| 1988/89 | 70.087 | 44.156 | 88.5947 | | | 392.935 |
| 1989/90 | 92.610 | 34.823 | 85.717 | | | 363.528 |
| 1990/91 | 103.767 | 68.628 | 71.4816 | | 1.088 | 398.190 |
| 1991/92 | 211.592 | 44.015 | 66.9968 | | 0.184 | 410.734 |
| 1992/93 | 158.969 | 42.649 | 61.2749 | | 1.002 | 501.526 |
| 1993/94 | 108.528 | 21.689 | 61.9369 | | 0.309 | 424.651 |
| 1994/95 | 112.896 | 24.247 | 60.3759 | 8.436 | 0.385 | 328.862 |
| 1995/96 | 115.262 | 35.394 | 57.5917 | 8.917 | 1.008 | 280.087 |
| 1996/97 | 82.606 | 24.878 | 71.589 | 7.765 | 1.373 | 351.746 |
| 1997/98 | 107.377 | 53.795 | 71.9977 | 12.257 | 0.214 | |
| 1998/99 | 102.904 | 38.355 | 66.3753 | 9.449 | 1.470 | |
| 1999/00 | 113.081 | 35.036 | 69.065 | 6.884 | 0.398 | |
| 2000/01 | 143.679 | 55.291 | 60.0275 | 7.065 | 0.548 | |
| 2001/02 | 109.433 | 18.258 | 62.1065 | 6.246 | 0.409 | |
| 2002/03 | | 29.440 | | 5.521 | 0.247 | |
| Time | MID | MID | BEG | MID | MID | MID |
| Stock | Number | Number | Biomass | Biomass | Number | Biomass |
| Ages | 2-11 | 2-11 | 2-11 | 2-11 | 0 | 2-11 |

Table 12. Tuning indices available for Atlantic Spanish mackerel VPA analyses.

| | INDICES OF ABUNDANCE | | | | | |
|---|---|---|---|---|---|---|
| **Fishing Year** | **HeadBoat** | **MRFSS** | **Florida FWC** | **North Carolina Pamlico** | **North Carolina Comm** | **SEAMAP SA** |
| 1984/85 | 3.537 | 161.162 | | | | |
| 1985/86 | 3.397 | 334.869 | 9.1579 | | | |
| 1986/87 | 7.227 | 216.703 | 12.036 | | | |
| 1987/88 | 5.213 | 432.377 | 17.01 | | | |
| 1988/89 | 2.685 | 234.303 | 17.3521 | 0.240 | | |
| 1989/90 | 5.164 | 470.299 | 21.4339 | 0.140 | | |
| 1990/91 | 5.453 | 363.159 | 15.4959 | 0.100 | | 1.742 |
| 1991/92 | 7.871 | 263.034 | 13.4977 | 0.220 | | 2.228 |
| 1992/93 | 4.329 | 353.111 | 18.1096 | 0.490 | | 1.904 |
| 1993/94 | 3.472 | 167.872 | 27.8657 | 0.080 | | 0.889 |
| 1994/95 | 5.364 | 154.968 | 25.9909 | 0.050 | 1.036 | 1.156 |
| 1995/96 | 2.193 | 358.088 | 23.998 | 0.210 | 0.760 | 1.463 |
| 1996/97 | 4.040 | 289.923 | 40.538 | 0.080 | 0.664 | 1.108 |
| 1997/98 | 5.402 | 364.519 | 39.3126 | 0.250 | 1.029 | 0.651 |
| 1998/99 | 6.082 | 277.459 | 45.829 | 0.250 | 0.686 | 1.611 |
| 1999/00 | 7.337 | 377.402 | 42.3728 | 0.020 | 0.816 | 1.456 |
| 2000/01 | 5.136 | 228.848 | 45.6184 | 0.110 | 1.304 | 1.868 |
| 2001/02 | 8.518 | 103.440 | 53.5448 | 0.090 | 1.089 | 2.097 |
| 2002/03 | | 325.687 | | 0.020 | 1.608 | 1.238 |
| Time | MID | MID | MID | MID | MID | MID |
| Stock | Number | Number | Biomass | Number | Biomass | Freq occurrence |
| Ages | 0 - 6+ | 0 - 6+ | 0 - 6+ | 0 | 0 - 6+ | 0 |

Table 13. Tuning indices available for Gulf Spanish mackerel VPA analyses.

| | INDICES OF ABUNDANCE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Fishing Year** | **HeadBoat** | **MRFSS** | **Texas PWD** | **Florida FWC** | **Shrimp Bycatch GLM** | **Shrimp Bycatch Delta LogN** | **SEAMAP SA** | **Charter NW Florida** |
| 1984/85 | 2.748 | 167.365 | 1.635 | #N/A | 14.336 | 39.388 | 0.233 | 1.150 |
| 1985/86 | 1.055 | 147.855 | 3.444 | 1623.800 | 12.541 | 11.311 | 0.176 | 1.617 |
| 1986/87 | 4.529 | 548.412 | 1.079 | 1063.640 | 12.535 | 22.539 | 0.126 | 3.983 |
| 1987/88 | 8.626 | 238.526 | 3.646 | 1733.270 | 13.028 | 9.553 | 0.199 | 1.261 |
| 1988/89 | 2.284 | 605.099 | 1.589 | 934.450 | 17.224 | 32.575 | 0.135 | |
| 1989/90 | 5.568 | 720.047 | 3.274 | 708.480 | 18.445 | 33.834 | 0.209 | 0.664 |
| 1990/91 | 4.509 | 313.915 | 2.613 | 1039.590 | 17.693 | 30.232 | 0.172 | |
| 1991/92 | 14.589 | 626.124 | 4.415 | 1462.290 | 18.305 | 29.096 | 0.178 | 2.331 |
| 1992/93 | 5.315 | 445.528 | 2.776 | 1199.700 | 20.862 | 42.228 | 0.204 | |
| 1993/94 | 3.225 | 324.377 | 2.760 | 1268.900 | 23.091 | 66.612 | 0.183 | |
| 1994/95 | 5.559 | 337.054 | 3.008 | 1119.330 | 15.217 | 24.045 | 0.125 | |
| 1995/96 | 5.305 | 178.957 | 4.641 | 616.960 | 14.845 | 22.852 | 0.183 | |
| 1996/97 | 5.561 | 408.150 | 5.235 | 688.950 | 13.848 | 14.293 | 0.100 | |
| 1997/98 | 3.564 | 139.638 | 2.931 | 892.850 | 12.880 | 8.600 | 0.174 | |
| 1998/99 | 3.141 | 431.306 | 2.041 | 1331.140 | 13.444 | 14.015 | 0.111 | |
| 1999/00 | 4.316 | 332.567 | 1.967 | 625.620 | 13.742 | 15.236 | 0.167 | |
| 2000/01 | 4.201 | 240.485 | 2.917 | 527.440 | 16.353 | 19.037 | | |
| 2001/02 | 3.081 | 373.888 | 1.871 | 1166.770 | 15.593 | 27.071 | | |
| 2002/03 | | 314.899 | | | | | | |
| Time | MID | BEG | BEG | BEG | BEG | BEG | BEG | BEG |
| Stock | Number | Number | Number | Biomass | Number | Number | Number | Number |
| Ages | 1 - 6 | 1 - 3 | 1 - 3 | 1 - 7 | 0 - 2 | 0 - 2 | 0 | 1 - 2 |

Table 14. Atlantic king mackerel tuned VPA results for model Base,

**Stock at Age at beginning of year**

| | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1047031 | 1104831 | 1388353 | 1843286 | 2304339 | 1804701 | 958103 | 1264311 | 2982773 | 1922082 | 1005473 | 1016905 | 1223194 | 1427967 |
| 1 | 1198602 | 900642 | 948333 | 1191544 | 1585442 | 1982327 | 1551985 | 818946 | 1086574 | 2566373 | 1653788 | 865194 | 874752 | 1051811 |
| 2 | 1863727 | 1026220 | 770075 | 789104 | 1021711 | 1284526 | 1596653 | 1152790 | 686903 | 871248 | 2084034 | 1334531 | 673043 | 707743 |
| 3 | 1278296 | 1590839 | 877947 | 607019 | 669848 | 762356 | 900448 | 1178121 | 791207 | 497186 | 599421 | 1496660 | 908863 | 500515 |
| 4 | 1371725 | 1048409 | 1350108 | 662636 | 504260 | 552858 | 549167 | 645655 | 835951 | 553470 | 355254 | 420023 | 1029451 | 662795 |
| 5 | 1055530 | 1038041 | 835670 | 1097084 | 475812 | 374038 | 345275 | 384779 | 451034 | 628015 | 391970 | 240745 | 295965 | 783842 |
| 6 | 803328 | 787150 | 736198 | 591265 | 819214 | 318224 | 263042 | 229041 | 275659 | 324225 | 465109 | 245235 | 166815 | 224774 |
| 7 | 810080 | 597451 | 521982 | 566259 | 398819 | 581810 | 215761 | 188666 | 140841 | 195440 | 223524 | 323069 | 162655 | 111830 |
| 8 | 302630 | 572697 | 363686 | 330341 | 354482 | 188502 | 414931 | 154457 | 104684 | 91937 | 143680 | 149960 | 235273 | 108560 |
| 9 | 2036308 | 211930 | 350208 | 186733 | 234373 | 120628 | 109746 | 335820 | 112209 | 74622 | 64711 | 95164 | 111536 | 163380 |
| 10 | 275943 | 9219 | 157263 | 237717 | 98819 | 146958 | 87295 | 81588 | 245570 | 87496 | 39189 | 44619 | 64940 | 78831 |
| 11+ | 356691 | 499735 | 326059 | 327388 | 359503 | 315261 | 320047 | 299228 | 236350 | 338683 | 301648 | 228396 | 166145 | 139963 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 |
|---|---|---|---|---|---|---|---|---|
| 0 | 2261274 | 1835061 | 1073102 | 3010244 | 1067260 | 322267 | 1 | 0 |
| 1 | 1229060 | 1946242 | 1578573 | 921016 | 2583952 | 917228 | 276555 | 1 |
| 2 | 821575 | 953472 | 1626468 | 1272232 | 738543 | 2148777 | 773156 | 222801 |
| 3 | 479119 | 569389 | 650082 | 1138512 | 930707 | 538557 | 1591792 | 578390 |
| 4 | 371415 | 330292 | 363982 | 435665 | 811670 | 672455 | 371428 | 1245712 |
| 5 | 500803 | 271453 | 198279 | 235812 | 281981 | 580373 | 429305 | 258928 |
| 6 | 592331 | 374500 | 176229 | 121983 | 144224 | 189866 | 417751 | 290325 |
| 7 | 154246 | 439842 | 290805 | 124344 | 72459 | 96720 | 127532 | 317130 |
| 8 | 82028 | 113922 | 319626 | 212863 | 88735 | 51633 | 70726 | 91993 |
| 9 | 74147 | 53459 | 74660 | 237369 | 158189 | 66144 | 35285 | 52921 |
| 10 | 110776 | 45196 | 33409 | 49017 | 179634 | 119862 | 48237 | 25196 |
| 11+ | 154131 | 186431 | 171272 | 146930 | 143080 | 251919 | 270624 | 227684 |

**F at Age during year**

| | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.0006 | 0.0027 | 0.0029 | 0.0007 | 0.0005 | 0.0009 | 0.0069 | 0.0015 | 0.0004 | 0.0003 | 0.0003 | 0.0006 | 0.001 | 0 |
| 1 | 0.0053 | 0.0066 | 0.0338 | 0.0038 | 0.0605 | 0.0664 | 0.1474 | 0.0258 | 0.0709 | 0.0582 | 0.0645 | 0.1011 | 0.0619 | 0.097 |
| 2 | 0.0083 | 0.0061 | 0.0879 | 0.0138 | 0.1428 | 0.2053 | 0.154 | 0.2264 | 0.1732 | 0.224 | 0.1811 | 0.2341 | 0.1462 | 0.2401 |
| 3 | 0.0483 | 0.0141 | 0.1314 | 0.0355 | 0.042 | 0.178 | 0.1826 | 0.1931 | 0.2074 | 0.1861 | 0.2057 | 0.2242 | 0.1657 | 0.1483 |
| 4 | 0.1287 | 0.0768 | 0.0575 | 0.1812 | 0.1487 | 0.3208 | 0.2057 | 0.2087 | 0.136 | 0.195 | 0.2391 | 0.2001 | 0.1226 | 0.1303 |
| 5 | 0.1434 | 0.1936 | 0.196 | 0.1421 | 0.2523 | 0.202 | 0.2604 | 0.1835 | 0.1801 | 0.1503 | 0.319 | 0.2169 | 0.1251 | 0.1301 |
| 6 | 0.1461 | 0.2608 | 0.1124 | 0.2438 | 0.1922 | 0.2386 | 0.1823 | 0.3363 | 0.1939 | 0.2219 | 0.2144 | 0.2606 | 0.2499 | 0.2265 |
| 7 | 0.1968 | 0.3464 | 0.3075 | 0.3184 | 0.5994 | 0.188 | 0.1843 | 0.439 | 0.2765 | 0.1577 | 0.2492 | 0.1671 | 0.2543 | 0.1599 |
| 8 | 0.2063 | 0.3418 | 0.5166 | 0.1932 | 0.9279 | 0.3909 | 0.0615 | 0.1695 | 0.1885 | 0.2012 | 0.262 | 0.146 | 0.2147 | 0.2313 |
| 9 | 5.2476 | 0.1483 | 0.2374 | 0.4864 | 0.3168 | 0.1734 | 0.1465 | 0.163 | 0.0988 | 0.494 | 0.2218 | 0.2321 | 0.197 | 0.2386 |
| 10 | 0.0858 | 0.2953 | 0.2395 | 0.3023 | 0.2242 | 0.2176 | 0.1584 | 0.327 | 0.2027 | 0.1956 | 0.2503 | 0.3467 | 0.3514 | 0.2003 |
| 11+ | 0.0858 | 0.2953 | 0.2395 | 0.3023 | 0.2242 | 0.2176 | 0.1584 | 0.327 | 0.2027 | 0.1956 | 0.2503 | 0.3467 | 0.3514 | 0.2003 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0.0006 | 0.0028 | 0.0027 | 0.0015 | 0.003 | 0.0015 |
| 1 | 0.1039 | 0.0295 | 0.0657 | 0.0708 | 0.0344 | 0.0209 | 0.0661 |
| 2 | 0.2167 | 0.233 | 0.2067 | 0.1626 | 0.1658 | 0.15 | 0.1402 |
| 3 | 0.222 | 0.2975 | 0.2502 | 0.1884 | 0.175 | 0.2215 | 0.0952 |
| 4 | 0.1635 | 0.3603 | 0.2841 | 0.285 | 0.1854 | 0.2988 | 0.2108 |
| 5 | 0.1406 | 0.282 | 0.3358 | 0.3417 | 0.2455 | 0.1788 | 0.2412 |
| 6 | 0.1476 | 0.1029 | 0.1987 | 0.3709 | 0.2495 | 0.2479 | 0.1256 |
| 7 | 0.153 | 0.1693 | 0.162 | 0.1874 | 0.1889 | 0.163 | 0.1767 |
| 8 | 0.2781 | 0.2726 | 0.1475 | 0.1469 | 0.1438 | 0.2307 | 0.14 |
| 9 | 0.345 | 0.3201 | 0.2708 | 0.1287 | 0.1275 | 0.1657 | 0.1868 |
| 10 | 0.2013 | 0.1519 | 0.1815 | 0.1644 | 0.0977 | 0.1676 | 0.1868 |
| 11+ | 0.2013 | 0.1519 | 0.1815 | 0.1644 | 0.0977 | 0.1676 | 0.1868 |

## Parameter Estimates Atlantic King Base Model

```
Update of FADAPT Version 3 (Feb 96) by V. Restrepo

    Input DATA file: Atl1Kng03a.inp
    Input CONTROL file: Atl2Kng03B.inp
    Output Stock Size file: AtlKng.naa
    Output Fishing Mortality file: AtlKng.faa
    Ouput Fitted Indices file: AtlKng.ind
    Output Diagnostics (this) file: AtlKng.par

    Run name: Atl_King-03  Base[wo_NCCommNew]
    No. index values:  87  Parameters:  8
    Mean Squared Error (rss/df) =  0.17474E+00
    Rsquared =  0.0364
    Loglikelihood = -0.30250E+02


 res from indices   =    31.9096226743810
 res from curvature =   0.000000000000000E+000


  Program termination OK

More details of the run can be found in file FADAPT5.RUN

 Parameter   Estimate    S.E.       % C.V.
 F age   2   0.1402     0.09342     66.62
 F age   3   0.0952     0.03317     34.86
 F age   4   0.2108     0.04362     20.69
 F age   5   0.2412     0.04575     18.97
 F age   6   0.1256     0.04705     37.47
 F age   7   0.1767     0.04506     25.51
 F age   8   0.1400     0.03324     23.74
 F age   9   0.1868     0.08982     48.08



 Variances of terminal yr F and survivors
  Age,  SE(F,101)    CV(F)      SE(N,102)     CV(N)
  0   0.10090E-02  66.62022
  1   0.44058E-01  66.62022   0.40772      66.67194
  2   0.93422E-01  66.62022   0.15351E+06  68.90241
  3   0.33169E-01  34.85871   0.41365E+06  71.51698
  4   0.43622E-01  20.69346   0.45574E+06  36.58487
  5   0.45752E-01  18.97082    59568.      23.00545
  6   0.47051E-01  37.46921    62150.      21.40716
  7   0.45062E-01  25.50787   0.12663E+06  39.92970
  8   0.33243E-01  23.74243    25651.      27.88342
  9   0.89820E-01  48.08438    13487.      25.48479
 10   0.89820E-01  48.08438    13310.      52.82698
 11   0.89820E-01  48.08438   0.10369E+06  45.54205

  Obs. and pred. indices in objective function
  0.86267E+00  0.66403E+00
  0.91993E+00  0.11191E+01
  0.58137E+00  0.87780E+00
  0.72543E+00  0.10261E+01
  0.92582E+00  0.85083E+00
  0.12100E+01  0.13834E+01
  0.13804E+01  0.15654E+01
  0.10693E+01  0.63487E+00
  0.98924E+00  0.79005E+00
  0.10836E+01  0.49772E+00
  0.11177E+01  0.11180E+01
  0.13648E+01  0.10422E+01
  0.11556E+01  0.14041E+01
  0.89491E+00  0.69227E+00
  0.76218E+00  0.62892E+00
  0.95718E+00  0.67708E+00
  0.10003E+01  0.60989E+00
  0.11052E+01  0.11092E+01
  0.11030E+01  0.10672E+01
  0.12793E+01  0.13008E+01
  0.12377E+01  0.12063E+01
  0.10322E+01  0.69615E+00
  0.96739E+00  0.11898E+01
  0.88477E+00  0.12033E+01
  0.89433E+00  0.10956E+01
  0.87179E+00  0.87606E+00
  0.83159E+00  0.59503E+00
  0.10337E+01  0.90261E+00
  0.10396E+01  0.10074E+01
  0.95842E+00  0.93632E+00
  0.99726E+00  0.94427E+00
  0.86676E+00  0.90484E+00
  0.89678E+00  0.86340E+00
  0.91657E+00  0.20892E+00
  0.24275E+01  0.99687E+00
  0.16662E+01  0.71640E+00
  0.94715E+00  0.10828E+01
  0.84790E+00  0.47062E+00
  0.70585E+00  0.12175E+01
  0.25247E+01  0.13828E+01
  0.89453E+00  0.11986E+01
  0.70546E+00  0.11989E+01
  0.13903E+01  0.76943E+00
  0.89167E+00  0.14755E+01
  0.86400E+00  0.11172E+01
  0.43939E+00  0.53876E+00
  0.49121E+00  0.83839E+00
  0.71704E+00  0.83522E+00
  0.50399E+00  0.91049E+00
  0.10898E+01  0.89478E+00
  0.77702E+00  0.92155E+00
  0.70977E+00  0.98236E+00
  0.11201E+01  0.11823E+01
  0.36987E+00  0.91923E+00
  0.85181E+00  0.22373E+00
  0.54686E+00  0.12499E+01
  0.88559E+00  0.73864E+00
  0.10085E+01  0.54950E+00
  0.65492E+00  0.46792E+00
  0.78183E+00  0.10146E+01
  0.10698E+01  0.10786E+01
  0.65249E+00  0.13504E+01
  0.86216E+00  0.11526E+01
  0.96603E+00  0.75134E+00
  0.19698E+01  0.15579E+01
  0.14799E+01  0.10933E+01
  0.10104E+01  0.57112E+00
  0.10510E+01  0.77511E+00
  0.10730E+01  0.83604E+00
  0.76903E+00  0.92563E+00
  0.99964E+00  0.93968E+00
  0.95800E+00  0.10471E+01
  0.10527E+01  0.10503E+01
  0.13376E+01  0.12565E+01
  0.10188E+01  0.10172E+01
  0.15562E+01  0.13446E+01
  0.26350E+00  0.70341E+00
  0.14337E+01  0.71130E+00
  0.44143E+00  0.85543E+00
  0.55088E+00  0.99910E+00
  0.14422E+01  0.15821E+01
  0.19641E+01  0.12836E+01
  0.30636E+00  0.74978E+00
  0.21030E+01  0.21034E+01
  0.56997E+00  0.74618E+00
  0.78395E+00  0.22515E+00
  0.58478E+00  0.49749E-06
```

## INDEX RESULTS

Maximum likelihood weighting for indices

Fit results for index = NC Com Old
Index Fitted to Mid-Year Stock Size in BIOMASS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 81/82 | 0.8627 | 0.8627 | 0.6640 | 0.1986 | 0.7247 |
| 82/83 | 0.9199 | 0.9199 | 1.1191 | -0.1992 | -0.7267 |
| 83/84 | 0.5814 | 0.5814 | 0.8778 | -0.2964 | -1.0815 |
| 84/85 | 0.7254 | 0.7254 | 1.0261 | -0.3007 | -1.0970 |
| 85/86 | 0.9258 | 0.9258 | 0.8508 | 0.0750 | 0.2736 |
| 86/87 | 1.2100 | 1.2100 | 1.3834 | -0.1735 | -0.6328 |
| 87/88 | 1.3804 | 1.3804 | 1.5654 | -0.1850 | -0.6748 |
| 88/89 | 1.0693 | 1.0693 | 0.6349 | 0.4344 | 1.5848 |
| 89/90 | 0.9892 | 0.9892 | 0.7901 | 0.1992 | 0.7267 |
| 90/91 | 1.0836 | 1.0836 | 0.4977 | 0.5859 | 2.1374 |
| 91/92 | 1.1177 | 1.1177 | 1.1180 | -0.0003 | -0.0011 |
| 92/93 | 1.3648 | 1.3648 | 1.0422 | 0.3226 | 1.1770 |
| 93/94 | 1.1556 | 1.1556 | 1.4041 | -0.2485 | -0.9067 |
| 94/95 | 0.8949 | 0.8949 | 0.6923 | 0.2026 | 0.7393 |
| 95/96 | 0.7622 | 0.7622 | 0.6289 | 0.1333 | 0.4862 |
| 96/97 | 0.9572 | 0.9572 | 0.6771 | 0.2801 | 1.0219 |

Index ML estimate of the variance: 0.0751 (S.E.: 0.2741)
ML estimate of catchability: 0.86102E-07
Pearsons (parametric) correlation: 0.525 P= 0.0010
Kendalls (nonparametric) Tau: 0.300 P= 0.0155

Selectivity at age from Partial Catches

| year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 81/82 | 0.003 | 0.013 | 0.065 | 0.042 | 0.171 | 0.023 | 0.010 | 1.000 | 0.026 | 0.071 |
| 82/83 | 0.017 | 0.043 | 0.146 | 0.201 | 0.066 | 0.548 | 0.091 | 0.001 | 0.262 | 1.000 |
| 83/84 | 0.028 | 0.023 | 0.061 | 0.112 | 0.280 | 0.568 | 0.111 | 0.448 | 1.000 | 0.133 |
| 84/85 | 0.028 | 0.059 | 0.032 | 0.037 | 0.571 | 0.318 | 0.329 | 1.000 | 0.295 | 0.772 |
| 85/86 | 0.036 | 0.136 | 0.072 | 0.141 | 0.137 | 0.657 | 0.685 | 0.579 | 1.000 | 0.271 |
| 86/87 | 0.265 | 0.287 | 0.541 | 0.349 | 0.284 | 0.702 | 0.296 | 0.953 | 1.000 | 0.773 |
| 87/88 | 0.273 | 0.624 | 0.801 | 0.881 | 0.711 | 1.000 | 0.235 | 0.890 | 0.726 | 0.662 |
| 88/89 | 0.091 | 0.077 | 0.113 | 0.626 | 0.569 | 1.000 | 0.248 | 0.085 | 0.334 | 0.235 |
| 89/90 | 0.346 | 0.379 | 0.228 | 0.481 | 0.580 | 1.000 | 0.207 | 0.107 | 0.222 | 0.224 |
| 90/91 | 0.264 | 0.275 | 0.234 | 0.185 | 0.261 | 0.208 | 0.278 | 1.000 | 0.281 | 0.093 |
| 91/92 | 0.394 | 0.513 | 0.588 | 1.000 | 0.457 | 0.470 | 0.651 | 0.452 | 0.173 | 0.234 |
| 92/93 | 0.398 | 0.445 | 0.708 | 0.562 | 1.000 | 0.210 | 0.152 | 0.630 | 0.303 | 0.336 |
| 93/94 | 0.539 | 0.782 | 0.453 | 0.368 | 1.000 | 0.920 | 0.930 | 0.627 | 0.744 | 0.900 |
| 94/95 | 0.243 | 0.163 | 0.181 | 0.240 | 0.656 | 0.382 | 0.624 | 1.000 | 0.265 | 0.359 |
| 95/96 | 0.204 | 0.334 | 0.284 | 0.333 | 0.304 | 0.322 | 1.000 | 0.591 | 0.308 | 0.256 |
| 96/97 | 0.159 | 0.491 | 1.000 | 0.868 | 0.100 | 0.433 | 0.127 | 0.285 | 0.255 | 0.075 |

Fit results for index = FWC
Index Fitted to Beginning Stock Size in BIOMASS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 85/86 | 1.0003 | 1.0003 | 0.6099 | 0.3904 | 2.1913 |
| 86/87 | 1.1052 | 1.1052 | 1.1092 | -0.0040 | -0.0224 |
| 87/88 | 1.1030 | 1.1030 | 1.0672 | 0.0357 | 0.2006 |
| 88/89 | 1.2793 | 1.2793 | 1.3008 | -0.0215 | -0.1207 |
| 89/90 | 1.2377 | 1.2377 | 1.2063 | 0.0314 | 0.1761 |
| 90/91 | 1.0322 | 1.0322 | 0.6961 | 0.3360 | 1.8860 |
| 91/92 | 0.9674 | 0.9674 | 1.1898 | -0.2224 | -1.2485 |
| 92/93 | 0.8848 | 0.8848 | 1.2033 | -0.3186 | -1.7880 |
| 93/94 | 0.8943 | 0.8943 | 1.0956 | -0.2013 | -1.1299 |
| 94/95 | 0.8718 | 0.8718 | 0.8761 | -0.0043 | -0.0240 |
| 95/96 | 0.8316 | 0.8316 | 0.5950 | 0.2366 | 1.3278 |
| 96/97 | 1.0337 | 1.0337 | 0.9026 | 0.1311 | 0.7358 |
| 97/98 | 1.0396 | 1.0396 | 1.0074 | 0.0322 | 0.1810 |
| 98/99 | 0.9584 | 0.9584 | 0.9363 | 0.0221 | 0.1241 |
| 99/00 | 0.9973 | 0.9973 | 0.9443 | 0.0530 | 0.2974 |
| 00/01 | 0.8668 | 0.8668 | 0.9048 | -0.0381 | -0.2137 |
| 01/02 | 0.8968 | 0.8968 | 0.8634 | 0.0334 | 0.1873 |

Index ML estimate of the variance: 0.0317 (S.E.: 0.1782)
ML estimate of catchability: 0.53819E-07
Pearsons (parametric) correlation: 0.501 P= 0.0013
Kendalls (nonparametric) Tau: 0.382 P= 0.0017

Selectivity at age from Partial Catches

| year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 85/86 | 0.001 | 0.019 | 0.120 | 0.314 | 0.240 | 0.275 | 1.000 | 0.164 | 0.460 | 0.184 |
| 86/87 | 0.263 | 0.450 | 1.000 | 0.628 | 0.709 | 0.486 | 0.981 | 0.181 | 0.464 | 0.563 |
| 87/88 | 0.347 | 0.623 | 0.709 | 1.000 | 0.674 | 0.654 | 0.239 | 0.467 | 0.586 | 0.604 |
| 88/89 | 0.756 | 0.692 | 0.548 | 0.228 | 0.642 | 1.000 | 0.576 | 0.621 | 0.847 | 0.985 |
| 89/90 | 0.600 | 0.801 | 0.571 | 0.585 | 0.673 | 0.610 | 0.914 | 0.476 | 0.982 | 1.000 |
| 90/91 | 0.399 | 0.343 | 0.402 | 0.317 | 0.570 | 0.379 | 0.520 | 1.000 | 0.402 | 0.508 |
| 91/92 | 0.476 | 0.672 | 0.557 | 0.983 | 0.736 | 0.911 | 1.000 | 0.579 | 0.408 | 0.686 |
| 92/93 | 0.856 | 0.718 | 0.528 | 0.658 | 0.600 | 0.463 | 0.488 | 0.606 | 1.000 | 0.998 |
| 93/94 | 0.855 | 0.950 | 0.550 | 0.464 | 0.870 | 0.736 | 0.570 | 0.717 | 1.000 | 0.726 |
| 94/95 | 1.000 | 0.665 | 0.556 | 0.466 | 0.683 | 0.565 | 0.700 | 0.553 | 0.744 | 0.392 |
| 95/96 | 0.241 | 0.450 | 0.402 | 0.349 | 0.380 | 0.475 | 0.608 | 1.000 | 0.535 | 0.483 |
| 96/97 | 0.990 | 1.000 | 0.968 | 0.782 | 0.333 | 0.452 | 0.501 | 0.774 | 0.299 | 0.345 |
| 97/98 | 1.000 | 0.917 | 0.819 | 0.844 | 0.457 | 0.396 | 0.350 | 0.551 | 0.388 | 0.455 |
| 98/99 | 0.559 | 0.791 | 1.000 | 1.000 | 0.790 | 0.371 | 0.420 | 0.335 | 0.419 | 0.315 |
| 99/00 | 0.633 | 0.706 | 0.778 | 1.000 | 0.886 | 0.725 | 0.548 | 0.537 | 0.415 | 0.334 |
| 00/01 | 0.388 | 0.717 | 1.000 | 0.592 | 0.647 | 0.364 | 0.405 | 0.290 | 0.409 | 0.255 |
| 01/02 | 0.609 | 0.461 | 1.000 | 0.971 | 0.459 | 0.452 | 0.339 | 0.318 | 0.366 | 0.211 |

Fit results for index = MRFSS
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 81/82 | 0.9166 | 0.9166 | 0.2089 | 0.7077 | 1.2213 |
| 82/83 | 2.4275 | 2.4275 | 0.9969 | 1.4306 | 2.4690 |
| 83/84 | 1.6662 | 1.6662 | 0.7164 | 0.9498 | 1.6391 |
| 84/85 | 0.9471 | 0.9471 | 1.0828 | -0.1357 | -0.2342 |
| 85/86 | 0.8479 | 0.8479 | 0.4706 | 0.3773 | 0.6511 |
| 86/87 | 0.7058 | 0.7058 | 1.2175 | -0.5117 | -0.8830 |
| 87/88 | 2.5247 | 2.5247 | 1.3828 | 1.1419 | 1.9706 |
| 88/89 | 0.8945 | 0.8945 | 1.1986 | -0.3041 | -0.5248 |
| 89/90 | 0.7055 | 0.7055 | 1.1989 | -0.4934 | -0.8515 |
| 90/91 | 1.3903 | 1.3903 | 0.7694 | 0.6209 | 1.0715 |
| 91/92 | 0.8917 | 0.8917 | 1.4755 | -0.5838 | -1.0075 |
| 92/93 | 0.8640 | 0.8640 | 1.1172 | -0.2532 | -0.4370 |
| 93/94 | 0.4394 | 0.4394 | 0.5388 | -0.0994 | -0.1715 |
| 94/95 | 0.4912 | 0.4912 | 0.8384 | -0.3472 | -0.5992 |
| 95/96 | 0.7170 | 0.7170 | 0.8352 | -0.1182 | -0.2040 |
| 96/97 | 0.5040 | 0.5040 | 0.9105 | -0.4065 | -0.7015 |
| 97/98 | 1.0898 | 1.0898 | 0.8948 | 0.1950 | 0.3366 |
| 98/99 | 0.7770 | 0.7770 | 0.9215 | -0.1445 | -0.2494 |
| 99/00 | 0.7098 | 0.7098 | 0.9824 | -0.2726 | -0.4704 |
| 00/01 | 1.1201 | 1.1201 | 1.1823 | -0.0622 | -0.1074 |
| 01/02 | 0.3699 | 0.3699 | 0.9192 | -0.5494 | -0.9481 |

Index ML estimate of the variance: 0.3358 (S.E.: 0.5794)
ML estimate of catchability: 0.44282E-06
Pearsons (parametric) correlation: 0.215 P= 0.1186
Kendalls (nonparametric) Tau: 0.076 P= 0.3496

Selectivity at age from Partial Catches

| year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 81/82 | 0.002 | 0.007 | 0.016 | 0.023 | 0.007 | 0.034 | 0.029 | 1.000 | 0.021 | 0.013 |
| 82/83 | 0.012 | 0.038 | 0.160 | 0.550 | 0.597 | 1.000 | 0.854 | 0.338 | 0.005 | 0.611 |
| 83/84 | 0.220 | 0.312 | 0.135 | 0.424 | 0.202 | 0.504 | 1.000 | 0.129 | 0.205 | 0.340 |
| 84/85 | 0.048 | 0.119 | 0.625 | 0.550 | 0.774 | 0.998 | 0.356 | 0.852 | 1.000 | 0.875 |
| 85/86 | 0.213 | 0.021 | 0.162 | 0.288 | 0.196 | 0.687 | 1.000 | 0.350 | 0.068 | 0.204 |
| 86/87 | 0.936 | 0.617 | 1.000 | 0.565 | 0.569 | 0.431 | 0.983 | 0.300 | 0.426 | 0.485 |
| 87/88 | 0.993 | 0.794 | 0.765 | 1.000 | 0.616 | 0.489 | 0.211 | 0.366 | 0.448 | 0.496 |
| 88/89 | 0.828 | 0.669 | 0.668 | 0.452 | 0.666 | 0.902 | 0.431 | 0.477 | 0.797 | 1.000 |
| 89/90 | 0.877 | 1.000 | 0.676 | 0.710 | 0.759 | 0.720 | 0.896 | 0.483 | 0.956 | 0.895 |
| 90/91 | 0.710 | 0.515 | 0.552 | 0.414 | 0.558 | 0.386 | 0.474 | 1.000 | 0.478 | 0.620 |
| 91/92 | 0.840 | 0.857 | 0.631 | 0.994 | 0.746 | 1.000 | 0.976 | 0.895 | 0.927 | 0.983 |
| 92/93 | 0.757 | 0.665 | 0.484 | 0.574 | 0.602 | 0.504 | 0.418 | 0.539 | 1.000 | 0.963 |
| 93/94 | 0.338 | 0.328 | 0.265 | 0.262 | 0.454 | 0.553 | 0.536 | 0.487 | 0.754 | 1.000 |
| 94/95 | 1.000 | 0.572 | 0.480 | 0.458 | 0.727 | 0.444 | 0.665 | 0.626 | 0.726 | 0.822 |
| 95/96 | 1.000 | 0.848 | 0.542 | 0.415 | 0.430 | 0.430 | 0.582 | 0.954 | 0.610 | 0.591 |
| 96/97 | 0.897 | 1.000 | 0.932 | 0.647 | 0.399 | 0.479 | 0.650 | 0.758 | 0.606 | 0.462 |
| 97/98 | 0.558 | 0.671 | 0.801 | 1.000 | 0.621 | 0.508 | 0.459 | 0.813 | 0.573 | 0.629 |
| 98/99 | 0.530 | 0.594 | 0.918 | 1.000 | 0.860 | 0.507 | 0.479 | 0.437 | 0.669 | 0.604 |
| 99/00 | 0.736 | 0.763 | 0.796 | 1.000 | 0.835 | 0.641 | 0.487 | 0.488 | 0.439 | 0.398 |
| 00/01 | 0.583 | 0.776 | 1.000 | 0.580 | 0.787 | 0.545 | 0.655 | 0.548 | 0.618 | 0.550 |
| 01/02 | 0.581 | 0.388 | 0.870 | 1.000 | 0.505 | 0.774 | 0.531 | 0.572 | 0.871 | 0.686 |

Fit results for index = Headboat
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 81/82 | 0.8518 | 0.8518 | 0.2237 | 0.6281 | 1.8150 |
| 82/83 | 0.5469 | 0.5469 | 1.2499 | -0.7030 | -2.0315 |
| 83/84 | 0.8856 | 0.8856 | 0.7386 | 0.1469 | 0.4246 |
| 84/85 | 1.0085 | 1.0085 | 0.5495 | 0.4590 | 1.3264 |
| 85/86 | 0.6549 | 0.6549 | 0.4679 | 0.1870 | 0.5404 |
| 86/87 | 0.7818 | 0.7818 | 1.0146 | -0.2327 | -0.6725 |
| 87/88 | 1.0698 | 1.0698 | 1.0786 | -0.0088 | -0.0254 |
| 88/89 | 0.6525 | 0.6525 | 1.3504 | -0.6979 | -2.0168 |
| 89/90 | 0.8622 | 0.8622 | 1.1526 | -0.2905 | -0.8394 |
| 90/91 | 0.9660 | 0.9660 | 0.7513 | 0.2147 | 0.6204 |
| 91/92 | 1.9698 | 1.9698 | 1.5579 | 0.4119 | 1.1904 |
| 92/93 | 1.4799 | 1.4799 | 1.0933 | 0.3866 | 1.1172 |
| 93/94 | 1.0104 | 1.0104 | 0.5711 | 0.4392 | 1.2693 |
| 94/95 | 1.0510 | 1.0510 | 0.7751 | 0.2759 | 0.7973 |
| 95/96 | 1.0730 | 1.0730 | 0.8360 | 0.2370 | 0.6849 |
| 96/97 | 0.7690 | 0.7690 | 0.9256 | -0.1566 | -0.4525 |
| 97/98 | 0.9996 | 0.9996 | 0.9397 | 0.0600 | 0.1733 |
| 98/99 | 0.9580 | 0.9580 | 1.0471 | -0.0891 | -0.2574 |
| 99/00 | 1.0527 | 1.0527 | 1.0503 | 0.0024 | 0.0070 |
| 00/01 | 1.3376 | 1.3376 | 1.2565 | 0.0811 | 0.2343 |
| 01/02 | 1.0188 | 1.0188 | 1.0172 | 0.0015 | 0.0045 |

Index ML estimate of the variance: 0.1197 (S.E.: 0.3460)
ML estimate of catchability: 0.46959E-06
Pearsons (parametric) correlation: 0.380 P= 0.0081
Kendalls (nonparametric) Tau: 0.210 P= 0.0426

Selectivity at age from Partial Catches

| year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 81/82 | 0.001 | 0.007 | 0.021 | 0.024 | 0.011 | 0.035 | 0.007 | 1.000 | 0.023 | 0.012 |
| 82/83 | 0.023 | 0.104 | 0.531 | 0.404 | 1.000 | 0.635 | 0.627 | 0.309 | 0.953 | 0.848 |
| 83/84 | 0.203 | 0.107 | 0.104 | 0.611 | 0.069 | 1.000 | 0.717 | 0.043 | 0.463 | 0.249 |
| 84/85 | 0.046 | 0.071 | 0.214 | 0.183 | 0.510 | 0.273 | 0.255 | 1.000 | 0.625 | 0.386 |
| 85/86 | 0.189 | 0.009 | 0.119 | 0.273 | 0.160 | 0.713 | 1.000 | 0.341 | 0.065 | 0.224 |
| 86/87 | 0.406 | 0.696 | 1.000 | 0.572 | 0.533 | 0.370 | 0.893 | 0.327 | 0.352 | 0.444 |
| 87/88 | 0.498 | 0.738 | 0.725 | 1.000 | 0.578 | 0.372 | 0.187 | 0.318 | 0.365 | 0.374 |
| 88/89 | 0.833 | 0.747 | 0.651 | 0.432 | 0.875 | 0.976 | 0.546 | 0.586 | 0.914 | 1.000 |
| 89/90 | 1.000 | 0.919 | 0.585 | 0.593 | 0.626 | 0.561 | 0.696 | 0.390 | 0.762 | 0.673 |
| 90/91 | 0.590 | 0.428 | 0.510 | 0.408 | 0.566 | 0.386 | 0.471 | 1.000 | 0.470 | 0.649 |
| 91/92 | 0.904 | 0.934 | 0.680 | 1.000 | 0.679 | 0.869 | 0.832 | 0.604 | 0.579 | 0.624 |
| 92/93 | 0.696 | 0.589 | 0.442 | 0.534 | 0.586 | 0.495 | 0.407 | 0.525 | 1.000 | 0.959 |
| 93/94 | 0.399 | 0.331 | 0.252 | 0.240 | 0.418 | 0.507 | 0.510 | 0.457 | 0.727 | 1.000 |
| 94/95 | 1.000 | 0.534 | 0.416 | 0.372 | 0.574 | 0.316 | 0.485 | 0.435 | 0.535 | 0.526 |
| 95/96 | 1.000 | 0.852 | 0.513 | 0.371 | 0.379 | 0.374 | 0.479 | 0.771 | 0.482 | 0.471 |
| 96/97 | 0.935 | 1.000 | 0.815 | 0.568 | 0.337 | 0.410 | 0.578 | 0.649 | 0.581 | 0.409 |
| 97/98 | 0.555 | 0.654 | 0.792 | 1.000 | 0.613 | 0.521 | 0.462 | 0.805 | 0.533 | 0.604 |
| 98/99 | 0.637 | 0.641 | 0.940 | 1.000 | 0.844 | 0.489 | 0.475 | 0.413 | 0.614 | 0.518 |
| 99/00 | 1.000 | 0.735 | 0.713 | 0.864 | 0.721 | 0.553 | 0.447 | 0.427 | 0.403 | 0.389 |
| 00/01 | 0.627 | 0.767 | 1.000 | 0.578 | 0.714 | 0.465 | 0.534 | 0.436 | 0.494 | 0.415 |
| 01/02 | 0.676 | 0.447 | 0.950 | 1.000 | 0.482 | 0.663 | 0.486 | 0.465 | 0.640 | 0.487 |

Fit results for index = Seamap SA
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 90/91 | 1.5562 | 1.5562 | 1.3446 | 0.2116 | 0.4638 |
| 91/92 | 0.2635 | 0.2635 | 0.7034 | -0.4399 | -0.9644 |
| 92/93 | 1.4337 | 1.4337 | 0.7113 | 0.7224 | 1.5836 |
| 93/94 | 0.4414 | 0.4414 | 0.8554 | -0.4140 | -0.9076 |
| 94/95 | 0.5509 | 0.5509 | 0.9991 | -0.4482 | -0.9826 |
| 95/96 | 1.4422 | 1.4422 | 1.5821 | -0.1399 | -0.3066 |
| 96/97 | 1.9641 | 1.9641 | 1.2836 | 0.6805 | 1.4918 |
| 97/98 | 0.3064 | 0.3064 | 0.7498 | -0.4434 | -0.9721 |
| 98/99 | 2.1030 | 2.1030 | 2.1034 | -0.0004 | -0.0010 |
| 99/00 | 0.5700 | 0.5700 | 0.7462 | -0.1762 | -0.3863 |
| 00/01 | 0.7839 | 0.7839 | 0.2252 | 0.5588 | 1.2250 |
| 01/02 | 0.5848 | 0.5848 | 0.0000 | 0.5848 | 1.2820 |

Index ML estimate of the variance: 0.2081 (S.E.: 0.4562)
ML estimate of catchability: 0.75346E-06
Pearsons (parametric) correlation: 0.715 P= 0.0000
Kendalls (nonparametric) Tau: 0.394 P= 0.0083

Selectivities set to 1.0

| year | 0 |
|---|---|
| 90/91 | 1.000 |
| 91/92 | 1.000 |
| 92/93 | 1.000 |
| 93/94 | 1.000 |
| 94/95 | 1.000 |
| 95/96 | 1.000 |
| 96/97 | 1.000 |
| 97/98 | 1.000 |
| 98/99 | 1.000 |
| 99/00 | 1.000 |
| 00/01 | 1.000 |
| 01/02 | 1.000 |

Table 15. Atlantic king mackerel tuned VPA results for Full Index Model.

**Stock at Age at beginning of year**

| | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 1039593 | 1093978 | 1366087 | 1804932 | 2238558 | 1771774 | 929824 | 1214626 | 2768728 | 1764646 | 930493 | 969496 | 1133051 | 1324636 |
| **1** | 1186890 | 894240 | 938992 | 1172379 | 1552430 | 1925709 | 1523644 | 794606 | 1043810 | 2382142 | 1518282 | 800657 | 833947 | 974224 |
| **2** | 1840649 | 1016140 | 764564 | 781064 | 1005216 | 1256114 | 1547924 | 1128403 | 665954 | 834442 | 1925472 | 1217907 | 617503 | 672624 |
| **3** | 1273500 | 1570976 | 869271 | 602276 | 662928 | 748162 | 876007 | 1136193 | 770231 | 479161 | 567763 | 1360246 | 808559 | 452725 |
| **4** | 1367934 | 1044281 | 1333012 | 655170 | 500178 | 546902 | 536955 | 624627 | 799880 | 535426 | 339747 | 392790 | 912120 | 576496 |
| **5** | 1051150 | 1034779 | 832118 | 1082369 | 469389 | 370525 | 340155 | 374273 | 432945 | 596976 | 376447 | 227408 | 272538 | 682876 |
| **6** | 801292 | 783381 | 733391 | 588209 | 806552 | 312700 | 260021 | 224638 | 266621 | 308662 | 438402 | 231892 | 155343 | 204615 |
| **7** | 806978 | 595700 | 518740 | 563844 | 396190 | 570918 | 211010 | 186066 | 137057 | 187664 | 210138 | 300095 | 151181 | 101964 |
| **8** | 301241 | 570028 | 362180 | 327554 | 352406 | 186250 | 405560 | 150369 | 102452 | 88683 | 136990 | 138448 | 215508 | 98693 |
| **9** | 2328517 | 210736 | 347915 | 185442 | 231976 | 118860 | 107811 | 327755 | 108692 | 72702 | 61912 | 89411 | 101630 | 146379 |
| **10** | 274709 | 9175 | 156235 | 235745 | 97711 | 144898 | 85774 | 79923 | 238631 | 84469 | 37541 | 42212 | 59992 | 70309 |
| **11+** | 355097 | 497301 | 323928 | 324671 | 355472 | 310840 | 314472 | 293122 | 229671 | 326967 | 288965 | 216072 | 153486 | 124833 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 |
|---|---|---|---|---|---|---|---|---|
| **0** | 2107349 | 1829852 | 1028558 | 2824436 | 1000334 | 300892 | 1 | |
| **1** | 1140122 | 1813757 | 1574091 | 882677 | 2424025 | 859625 | 258157 | 1 |
| **2** | 754803 | 876934 | 1512439 | 1268373 | 705547 | 2011129 | 723577 | 206966 |
| **3** | 448915 | 511955 | 584254 | 1040423 | 927387 | 510167 | 1473353 | 535728 |
| **4** | 330296 | 304312 | 314610 | 379056 | 727285 | 669599 | 347008 | 1143783 |
| **5** | 426543 | 236075 | 175957 | 193368 | 233316 | 507777 | 426850 | 237923 |
| **6** | 505450 | 310603 | 145814 | 102801 | 107760 | 148018 | 355296 | 288213 |
| **7** | 136907 | 365087 | 235817 | 98181 | 55985 | 65369 | 91551 | 263387 |
| **8** | 73539 | 99003 | 255312 | 165554 | 66229 | 37461 | 43756 | 61040 |
| **9** | 65660 | 46161 | 61833 | 182032 | 117484 | 46780 | 23100 | 29717 |
| **10** | 96154 | 37905 | 27137 | 37989 | 132018 | 84836 | 31578 | 14715 |
| **11+** | 133787 | 156352 | 139119 | 113874 | 105154 | 178305 | 177164 | 132971 |

**F at Age during year**

| | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0.0006 | 0.0028 | 0.0029 | 0.0007 | 0.0005 | 0.0009 | 0.0071 | 0.0016 | 0.0004 | 0.0004 | 0.0003 | 0.0006 | 0.001 | 0 |
| **1** | 0.0053 | 0.0067 | 0.0341 | 0.0038 | 0.0618 | 0.0684 | 0.1503 | 0.0266 | 0.0739 | 0.0628 | 0.0704 | 0.1097 | 0.065 | 0.1052 |
| **2** | 0.0084 | 0.0061 | 0.0886 | 0.014 | 0.1453 | 0.2104 | 0.1592 | 0.2319 | 0.1792 | 0.2351 | 0.1975 | 0.2596 | 0.1604 | 0.2544 |
| **3** | 0.0484 | 0.0143 | 0.1328 | 0.0358 | 0.0424 | 0.1817 | 0.1882 | 0.201 | 0.2136 | 0.1938 | 0.2184 | 0.2496 | 0.1883 | 0.1653 |
| **4** | 0.1291 | 0.0771 | 0.0583 | 0.1835 | 0.15 | 0.3249 | 0.2109 | 0.2165 | 0.1426 | 0.2023 | 0.2515 | 0.2155 | 0.1395 | 0.1513 |
| **5** | 0.144 | 0.1943 | 0.1969 | 0.1441 | 0.2562 | 0.2042 | 0.2649 | 0.1892 | 0.1884 | 0.1587 | 0.3345 | 0.2311 | 0.1366 | 0.1509 |
| **6** | 0.1465 | 0.2622 | 0.1129 | 0.2452 | 0.1955 | 0.2433 | 0.1847 | 0.3441 | 0.2012 | 0.2345 | 0.229 | 0.2778 | 0.271 | 0.2518 |
| **7** | 0.1976 | 0.3476 | 0.3098 | 0.32 | 0.6048 | 0.192 | 0.1888 | 0.4467 | 0.2853 | 0.1647 | 0.2673 | 0.1811 | 0.2765 | 0.1768 |
| **8** | 0.2073 | 0.3437 | 0.5194 | 0.195 | 0.9368 | 0.3967 | 0.063 | 0.1746 | 0.193 | 0.2094 | 0.2767 | 0.1592 | 0.2368 | 0.2575 |
| **9** | 5.3866 | 0.1492 | 0.2392 | 0.4907 | 0.3206 | 0.1762 | 0.1493 | 0.1673 | 0.1021 | 0.5109 | 0.233 | 0.249 | 0.2184 | 0.2702 |
| **10** | 0.0862 | 0.297 | 0.2413 | 0.3052 | 0.227 | 0.221 | 0.1615 | 0.3351 | 0.2093 | 0.2033 | 0.2628 | 0.3705 | 0.3866 | 0.2275 |
| **11+** | 0.0862 | 0.297 | 0.2413 | 0.3052 | 0.227 | 0.221 | 0.1615 | 0.3351 | 0.2093 | 0.2033 | 0.2628 | 0.3705 | 0.3866 | 0.2275 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 |
|---|---|---|---|---|---|---|---|
| **0** | 0 | 0.0006 | 0.003 | 0.0029 | 0.0016 | 0.0032 | 0.0016 |
| **1** | 0.1125 | 0.0317 | 0.0659 | 0.074 | 0.0367 | 0.0223 | 0.071 |
| **2** | 0.2382 | 0.2561 | 0.2241 | 0.1631 | 0.1742 | 0.1612 | 0.1506 |
| **3** | 0.2388 | 0.3369 | 0.2827 | 0.2081 | 0.1757 | 0.2354 | 0.1032 |
| **4** | 0.1858 | 0.3978 | 0.3367 | 0.3353 | 0.2093 | 0.3002 | 0.2274 |
| **5** | 0.1672 | 0.3318 | 0.3874 | 0.4347 | 0.3051 | 0.2071 | 0.2427 |
| **6** | 0.1753 | 0.1255 | 0.2455 | 0.4577 | 0.3499 | 0.3304 | 0.1493 |
| **7** | 0.1742 | 0.2077 | 0.2038 | 0.2437 | 0.2518 | 0.2514 | 0.2554 |
| **8** | 0.3157 | 0.3207 | 0.1883 | 0.193 | 0.1977 | 0.3335 | 0.2369 |
| **9** | 0.3994 | 0.3812 | 0.3371 | 0.1712 | 0.1756 | 0.243 | 0.301 |
| **10** | 0.2357 | 0.1839 | 0.2284 | 0.2176 | 0.1353 | 0.2456 | 0.301 |
| **11+** | 0.2357 | 0.1839 | 0.2284 | 0.2176 | 0.1353 | 0.2456 | 0.301 |

## Parameter Estimates Atlantic King Model Full Index

```
Update of FADAPT Version 3 (Feb 96) by V. Restrepo

    Input DATA file: Atl1Kng03.inp
    Input CONTROL file: Atl2Kng03B.inp
    Output Stock Size file: AtlKng.naa
    Output Fishing Mortality file: AtlKng.faa
    Ouput Fitted Indices file: AtlKng.ind
    Output Diagnostics (this) file: AtlKng.par

    Run name: Atl_King-03  Full_Index
    No. index values:  95  Parameters:  8
    Mean Squared Error (rss/df) =  0.15561E+00
    Rsquared =  0.0782
    Loglikelihood = -0.27006E+02


 res from indices   =    25.6317369126214
 res from curvature =   0.000000000000000E+000


  Program termination OK

More details of the run can be found in file FADAPT5.RUN

 Parameter   Estimate    S.E.       % C.V.
 F age   2   0.1506     0.09771     64.89
 F age   3   0.1032     0.03534     34.25
 F age   4   0.2274     0.05227     22.99
 F age   5   0.2427     0.05547     22.85
 F age   6   0.1493     0.06285     42.09
 F age   7   0.2554     0.06247     24.46
 F age   8   0.2369     0.05425     22.90
 F age   9   0.3010     0.05255     17.46



 Variances of terminal yr F and survivors
  Age,  SE(F,101)    CV(F)      SE(N,102)     CV(N)
  0   0.10552E-02  64.88683
  1   0.46078E-01  64.88683   0.36982      64.94093
  2   0.97706E-01  64.88683   0.13924E+06  67.27554
  3   0.35341E-01  34.24535   0.37510E+06  70.01650
  4   0.52274E-01  22.98724   0.41276E+06  36.08689
  5   0.55470E-01  22.85225    61301.      25.76493
  6   0.62852E-01  42.09023    74379.      25.80682
  7   0.62466E-01  24.46218   0.11955E+06  45.38936
  8   0.54249E-01  22.89935    16967.      27.79589
  9   0.52553E-01  17.46092    7663.0      25.78627
 10   0.52553E-01  17.46092    2984.9      20.28538
 11   0.52553E-01  17.46092    23254.      17.48799

  Obs. and pred. indices in objective function
  0.86267E+00  0.73057E+00
  0.91993E+00  0.11496E+01
  0.58137E+00  0.90016E+00
  0.72543E+00  0.10507E+01
  0.92582E+00  0.86796E+00
  0.12100E+01  0.14069E+01
  0.13804E+01  0.15782E+01
  0.10693E+01  0.64460E+00
  0.98924E+00  0.79102E+00
  0.10836E+01  0.49719E+00
  0.11177E+01  0.11013E+01
  0.13648E+01  0.10099E+01
  0.11556E+01  0.13376E+01
  0.89491E+00  0.63135E+00
  0.76218E+00  0.57246E+00
  0.95718E+00  0.63353E+00
  0.10069E+01  0.10054E+01
  0.10644E+01  0.91157E+00
  0.92690E+00  0.10088E+01
  0.14630E+01  0.15164E+01
  0.11280E+01  0.80060E+00
  0.82174E+00  0.95701E+00
  0.84340E+00  0.92018E+00
  0.74561E+00  0.79507E+00
  0.10003E+01  0.64005E+00
  0.11052E+01  0.11597E+01
  0.11030E+01  0.11111E+01
  0.12793E+01  0.13556E+01
  0.12377E+01  0.12390E+01
  0.10322E+01  0.71464E+00
  0.96739E+00  0.11991E+01
  0.88477E+00  0.12023E+01
  0.89433E+00  0.10634E+01
  0.87179E+00  0.88298E+00
  0.83159E+00  0.55073E+00
  0.10337E+01  0.85641E+00
  0.10396E+01  0.99805E+00
  0.95842E+00  0.79236E+00
  0.99726E+00  0.81579E+00
  0.86676E+00  0.96421E+00
  0.89678E+00  0.85532E+00
  0.91657E+00  0.24666E+00
  0.24275E+01  0.10793E+01
  0.16662E+01  0.77419E+00
  0.94715E+00  0.11652E+01
  0.84790E+00  0.50648E+00
  0.70585E+00  0.13061E+01
  0.25247E+01  0.14639E+01
  0.89453E+00  0.12711E+01
  0.70546E+00  0.12643E+01
  0.13903E+01  0.80838E+00
  0.89167E+00  0.14945E+01
  0.86400E+00  0.11359E+01
  0.43939E+00  0.53216E+00
  0.49121E+00  0.86000E+00
  0.71704E+00  0.82200E+00
  0.50399E+00  0.87345E+00
  0.10898E+01  0.84260E+00
  0.77702E+00  0.78700E+00
  0.70977E+00  0.85905E+00
  0.11201E+01  0.12244E+01
  0.36987E+00  0.71162E+00
  0.85181E+00  0.25460E+00
  0.54686E+00  0.13031E+01
  0.88559E+00  0.76872E+00
  0.10085E+01  0.57096E+00
  0.65492E+00  0.48587E+00
  0.78183E+00  0.10501E+01
  0.10698E+01  0.11116E+01
  0.65249E+00  0.13816E+01
  0.86216E+00  0.11682E+01
  0.96603E+00  0.76161E+00
  0.19698E+01  0.15573E+01
  0.14799E+01  0.10726E+01
  0.10104E+01  0.54428E+00
  0.10510E+01  0.76713E+00
  0.10730E+01  0.79711E+00
  0.76903E+00  0.85674E+00
  0.99964E+00  0.85377E+00
  0.95800E+00  0.86275E+00
  0.10527E+01  0.10259E+01
  0.13376E+01  0.13107E+01
  0.10188E+01  0.10343E+01
  0.15562E+01  0.13172E+01
  0.26350E+00  0.69461E+00
  0.14337E+01  0.72361E+00
  0.44143E+00  0.84551E+00
  0.55088E+00  0.98897E+00
  0.14422E+01  0.15733E+01
  0.19641E+01  0.13658E+01
  0.30636E+00  0.76682E+00
  0.21030E+01  0.21058E+01
  0.56997E+00  0.74627E+00
  0.78395E+00  0.22430E+00
  0.58478E+00  0.49439E-06
```

## INDEX RESULTS

Maximum likelihood weighting for indices

Fit results for index = NC Com Old
Index Fitted to Mid-Year Stock Size in BIOMASS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 81/82 | 0.8627 | 0.8627 | 0.7306 | 0.1321 | 0.4649 |
| 82/83 | 0.9199 | 0.9199 | 1.1496 | -0.2297 | -0.8083 |
| 83/84 | 0.5814 | 0.5814 | 0.9002 | -0.3188 | -1.1219 |
| 84/85 | 0.7254 | 0.7254 | 1.0507 | -0.3253 | -1.1447 |
| 85/86 | 0.9258 | 0.9258 | 0.8680 | 0.0579 | 0.2036 |
| 86/87 | 1.2100 | 1.2100 | 1.4069 | -0.1969 | -0.6929 |
| 87/88 | 1.3804 | 1.3804 | 1.5782 | -0.1977 | -0.6959 |
| 88/89 | 1.0693 | 1.0693 | 0.6446 | 0.4247 | 1.4946 |
| 89/90 | 0.9892 | 0.9892 | 0.7910 | 0.1982 | 0.6976 |
| 90/91 | 1.0836 | 1.0836 | 0.4972 | 0.5864 | 2.0636 |
| 91/92 | 1.1177 | 1.1177 | 1.1013 | 0.0164 | 0.0576 |
| 92/93 | 1.3648 | 1.3648 | 1.0099 | 0.3548 | 1.2488 |
| 93/94 | 1.1556 | 1.1556 | 1.3376 | -0.1820 | -0.6405 |
| 94/95 | 0.8949 | 0.8949 | 0.6313 | 0.2636 | 0.9276 |
| 95/96 | 0.7622 | 0.7622 | 0.5725 | 0.1897 | 0.6677 |
| 96/97 | 0.9572 | 0.9572 | 0.6335 | 0.3237 | 1.1391 |

Index ML estimate of the variance: 0.0807 (S.E.: 0.2841)
ML estimate of catchability: 0.88951E-07
Pearsons (parametric) correlation: 0.499 P= 0.0019
Kendalls (nonparametric) Tau: 0.317 P= 0.0110

Selectivity at age from Partial Catches

| year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 81/82 | 0.003 | 0.013 | 0.064 | 0.041 | 0.167 | 0.022 | 0.010 | 1.000 | 0.025 | 0.069 |
| 82/83 | 0.017 | 0.044 | 0.146 | 0.200 | 0.066 | 0.547 | 0.091 | 0.001 | 0.262 | 1.000 |
| 83/84 | 0.028 | 0.023 | 0.062 | 0.112 | 0.279 | 0.568 | 0.111 | 0.448 | 1.000 | 0.133 |
| 84/85 | 0.028 | 0.059 | 0.032 | 0.037 | 0.569 | 0.317 | 0.329 | 1.000 | 0.295 | 0.772 |
| 85/86 | 0.036 | 0.136 | 0.071 | 0.141 | 0.137 | 0.654 | 0.683 | 0.579 | 1.000 | 0.271 |
| 86/87 | 0.267 | 0.288 | 0.540 | 0.347 | 0.285 | 0.706 | 0.296 | 0.953 | 1.000 | 0.773 |
| 87/88 | 0.276 | 0.628 | 0.802 | 0.875 | 0.703 | 1.000 | 0.234 | 0.885 | 0.722 | 0.659 |
| 88/89 | 0.092 | 0.079 | 0.115 | 0.635 | 0.572 | 1.000 | 0.251 | 0.085 | 0.337 | 0.236 |
| 89/90 | 0.347 | 0.379 | 0.232 | 0.487 | 0.584 | 1.000 | 0.205 | 0.108 | 0.222 | 0.224 |
| 90/91 | 0.268 | 0.277 | 0.235 | 0.189 | 0.267 | 0.210 | 0.280 | 1.000 | 0.283 | 0.093 |
| 91/92 | 0.409 | 0.519 | 0.589 | 1.000 | 0.466 | 0.481 | 0.655 | 0.453 | 0.173 | 0.234 |
| 92/93 | 0.414 | 0.464 | 0.716 | 0.562 | 1.000 | 0.214 | 0.156 | 0.634 | 0.304 | 0.337 |
| 93/94 | 0.545 | 0.819 | 0.475 | 0.370 | 1.000 | 0.922 | 0.946 | 0.640 | 0.755 | 0.913 |
| 94/95 | 0.228 | 0.161 | 0.186 | 0.246 | 0.644 | 0.373 | 0.614 | 1.000 | 0.266 | 0.360 |
| 95/96 | 0.197 | 0.316 | 0.284 | 0.349 | 0.318 | 0.323 | 1.000 | 0.602 | 0.318 | 0.264 |
| 96/97 | 0.159 | 0.504 | 1.000 | 0.924 | 0.111 | 0.481 | 0.136 | 0.308 | 0.279 | 0.083 |

Fit results for index = NC Com New
Index Fitted to Mid-Year Stock Size in BIOMASS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 94/95 | 1.0069 | 1.0069 | 1.0054 | 0.0016 | 0.0110 |
| 95/96 | 1.0644 | 1.0644 | 0.9116 | 0.1528 | 1.0587 |
| 96/97 | 0.9269 | 0.9269 | 1.0088 | -0.0819 | -0.5674 |
| 97/98 | 1.4630 | 1.4630 | 1.5164 | -0.0534 | -0.3697 |
| 98/99 | 1.1280 | 1.1280 | 0.8006 | 0.3274 | 2.2676 |
| 99/00 | 0.8217 | 0.8217 | 0.9570 | -0.1353 | -0.9370 |
| 00/01 | 0.8434 | 0.8434 | 0.9202 | -0.0768 | -0.5319 |
| 01/02 | 0.7456 | 0.7456 | 0.7951 | -0.0495 | -0.3426 |

Index ML estimate of the variance: 0.0208 (S.E.: 0.1444)
ML estimate of catchability: 0.14164E-06
Pearsons (parametric) correlation: 0.771 P= 0.0001
Kendalls (nonparametric) Tau: 0.214 P= 0.2078

Selectivity at age from Partial Catches

| year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 94/95 | 0.228 | 0.161 | 0.186 | 0.246 | 0.644 | 0.373 | 0.614 | 1.000 | 0.266 | 0.360 |
| 95/96 | 0.197 | 0.316 | 0.284 | 0.349 | 0.318 | 0.323 | 1.000 | 0.602 | 0.318 | 0.264 |
| 96/97 | 0.159 | 0.504 | 1.000 | 0.924 | 0.111 | 0.481 | 0.136 | 0.308 | 0.279 | 0.083 |
| 97/98 | 0.342 | 0.682 | 0.881 | 1.000 | 0.644 | 0.480 | 0.490 | 0.918 | 0.523 | 0.375 |
| 98/99 | 0.184 | 0.241 | 0.345 | 0.614 | 1.000 | 0.478 | 0.158 | 0.180 | 0.112 | 0.238 |
| 99/00 | 0.312 | 0.298 | 0.340 | 0.562 | 1.000 | 0.647 | 0.541 | 0.322 | 0.115 | 0.180 |
| 00/01 | 0.122 | 0.268 | 0.394 | 0.308 | 0.596 | 0.433 | 1.000 | 0.524 | 0.252 | 0.276 |
| 01/02 | 0.163 | 0.096 | 0.203 | 0.279 | 0.210 | 0.357 | 0.469 | 1.000 | 0.352 | 0.791 |

Fit results for index = FWC
Index Fitted to Beginning Stock Size in BIOMASS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 85/86 | 1.0003 | 1.0003 | 0.6400 | 0.3602 | 1.9074 |
| 86/87 | 1.1052 | 1.1052 | 1.1597 | -0.0545 | -0.2886 |
| 87/88 | 1.1030 | 1.1030 | 1.1111 | -0.0082 | -0.0432 |
| 88/89 | 1.2793 | 1.2793 | 1.3556 | -0.0763 | -0.4041 |
| 89/90 | 1.2377 | 1.2377 | 1.2390 | -0.0013 | -0.0070 |
| 90/91 | 1.0322 | 1.0322 | 0.7146 | 0.3175 | 1.6811 |
| 91/92 | 0.9674 | 0.9674 | 1.1991 | -0.2317 | -1.2268 |
| 92/93 | 0.8848 | 0.8848 | 1.2023 | -0.3175 | -1.6811 |
| 93/94 | 0.8943 | 0.8943 | 1.0634 | -0.1691 | -0.8951 |
| 94/95 | 0.8718 | 0.8718 | 0.8830 | -0.0112 | -0.0592 |
| 95/96 | 0.8316 | 0.8316 | 0.5507 | 0.2809 | 1.4871 |
| 96/97 | 1.0337 | 1.0337 | 0.8564 | 0.1773 | 0.9387 |
| 97/98 | 1.0396 | 1.0396 | 0.9981 | 0.0416 | 0.2200 |
| 98/99 | 0.9584 | 0.9584 | 0.7924 | 0.1661 | 0.8793 |
| 99/00 | 0.9973 | 0.9973 | 0.8158 | 0.1815 | 0.9608 |
| 00/01 | 0.8668 | 0.8668 | 0.9642 | -0.0975 | -0.5160 |
| 01/02 | 0.8968 | 0.8968 | 0.8553 | 0.0415 | 0.2195 |

Index ML estimate of the variance: 0.0357 (S.E.: 0.1889)
ML estimate of catchability: 0.56884E-07
Pearsons (parametric) correlation: 0.544 P= 0.0004
Kendalls (nonparametric) Tau: 0.324 P= 0.0073

Selectivity at age from Partial Catches

| year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 85/86 | 0.001 | 0.020 | 0.120 | 0.316 | 0.242 | 0.275 | 1.000 | 0.164 | 0.462 | 0.185 |
| 86/87 | 0.266 | 0.453 | 1.000 | 0.627 | 0.714 | 0.490 | 0.982 | 0.181 | 0.466 | 0.565 |
| 87/88 | 0.353 | 0.632 | 0.715 | 1.000 | 0.671 | 0.659 | 0.241 | 0.468 | 0.588 | 0.605 |
| 88/89 | 0.761 | 0.708 | 0.558 | 0.231 | 0.645 | 1.000 | 0.582 | 0.626 | 0.853 | 0.992 |
| 89/90 | 0.601 | 0.799 | 0.580 | 0.593 | 0.677 | 0.610 | 0.907 | 0.476 | 0.982 | 1.000 |
| 90/91 | 0.405 | 0.346 | 0.404 | 0.323 | 0.582 | 0.383 | 0.523 | 1.000 | 0.404 | 0.511 |
| 91/92 | 0.492 | 0.676 | 0.555 | 0.976 | 0.744 | 0.925 | 1.000 | 0.576 | 0.406 | 0.682 |
| 92/93 | 0.888 | 0.748 | 0.533 | 0.656 | 0.598 | 0.470 | 0.498 | 0.608 | 1.000 | 0.998 |
| 93/94 | 0.853 | 0.981 | 0.569 | 0.461 | 0.857 | 0.728 | 0.572 | 0.723 | 1.000 | 0.726 |
| 94/95 | 1.000 | 0.700 | 0.609 | 0.510 | 0.716 | 0.590 | 0.736 | 0.592 | 0.797 | 0.420 |
| 95/96 | 0.229 | 0.419 | 0.394 | 0.359 | 0.390 | 0.467 | 0.596 | 1.000 | 0.541 | 0.489 |
| 96/97 | 0.961 | 1.000 | 0.943 | 0.812 | 0.358 | 0.489 | 0.520 | 0.814 | 0.320 | 0.368 |
| 97/98 | 1.000 | 0.955 | 0.896 | 0.899 | 0.520 | 0.460 | 0.412 | 0.633 | 0.451 | 0.528 |
| 98/99 | 0.440 | 0.687 | 0.925 | 1.000 | 0.767 | 0.379 | 0.433 | 0.350 | 0.436 | 0.328 |
| 99/00 | 0.535 | 0.570 | 0.707 | 1.000 | 1.000 | 0.778 | 0.606 | 0.595 | 0.462 | 0.373 |
| 00/01 | 0.415 | 0.758 | 1.000 | 0.682 | 0.859 | 0.559 | 0.583 | 0.423 | 0.596 | 0.371 |
| 01/02 | 0.606 | 0.463 | 1.000 | 0.906 | 0.506 | 0.606 | 0.532 | 0.474 | 0.547 | 0.315 |

Fit results for index = MRFSS
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 81/82 | 0.9166 | 0.9166 | 0.2467 | 0.6699 | 1.2093 |
| 82/83 | 2.4275 | 2.4275 | 1.0793 | 1.3482 | 2.4336 |
| 83/84 | 1.6662 | 1.6662 | 0.7742 | 0.8920 | 1.6101 |
| 84/85 | 0.9471 | 0.9471 | 1.1652 | -0.2180 | -0.3935 |
| 85/86 | 0.8479 | 0.8479 | 0.5065 | 0.3414 | 0.6163 |
| 86/87 | 0.7058 | 0.7058 | 1.3061 | -0.6003 | -1.0836 |
| 87/88 | 2.5247 | 2.5247 | 1.4639 | 1.0608 | 1.9148 |
| 88/89 | 0.8945 | 0.8945 | 1.2711 | -0.3765 | -0.6797 |
| 89/90 | 0.7055 | 0.7055 | 1.2643 | -0.5589 | -1.0088 |
| 90/91 | 1.3903 | 1.3903 | 0.8084 | 0.5819 | 1.0504 |
| 91/92 | 0.8917 | 0.8917 | 1.4945 | -0.6028 | -1.0881 |
| 92/93 | 0.8640 | 0.8640 | 1.1359 | -0.2719 | -0.4908 |
| 93/94 | 0.4394 | 0.4394 | 0.5322 | -0.0928 | -0.1674 |
| 94/95 | 0.4912 | 0.4912 | 0.8600 | -0.3688 | -0.6657 |
| 95/96 | 0.7170 | 0.7170 | 0.8220 | -0.1050 | -0.1895 |
| 96/97 | 0.5040 | 0.5040 | 0.8734 | -0.3695 | -0.6669 |
| 97/98 | 1.0898 | 1.0898 | 0.8426 | 0.2472 | 0.4462 |
| 98/99 | 0.7770 | 0.7770 | 0.7870 | -0.0100 | -0.0180 |
| 99/00 | 0.7098 | 0.7098 | 0.8590 | -0.1493 | -0.2695 |
| 00/01 | 1.1201 | 1.1201 | 1.2244 | -0.1043 | -0.1882 |
| 01/02 | 0.3699 | 0.3699 | 0.7116 | -0.3418 | -0.6169 |

Index ML estimate of the variance: 0.3069 (S.E.: 0.5540)
ML estimate of catchability: 0.48113E-06
Pearsons (parametric) correlation: 0.316 P= 0.0272
Kendalls (nonparametric) Tau: 0.114 P= 0.2160

Selectivity at age from Partial Catches

| year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 81/82 | 0.002 | 0.007 | 0.016 | 0.023 | 0.007 | 0.033 | 0.028 | 1.000 | 0.021 | 0.012 |
| 82/83 | 0.012 | 0.038 | 0.160 | 0.550 | 0.598 | 1.000 | 0.856 | 0.339 | 0.005 | 0.612 |
| 83/84 | 0.221 | 0.314 | 0.136 | 0.424 | 0.202 | 0.505 | 1.000 | 0.130 | 0.205 | 0.341 |
| 84/85 | 0.048 | 0.119 | 0.626 | 0.553 | 0.771 | 0.993 | 0.356 | 0.852 | 1.000 | 0.875 |
| 85/86 | 0.215 | 0.021 | 0.162 | 0.289 | 0.198 | 0.687 | 1.000 | 0.351 | 0.068 | 0.205 |
| 86/87 | 0.948 | 0.622 | 1.000 | 0.564 | 0.573 | 0.434 | 0.984 | 0.301 | 0.427 | 0.487 |
| 87/88 | 1.000 | 0.797 | 0.764 | 0.991 | 0.608 | 0.488 | 0.210 | 0.364 | 0.444 | 0.493 |
| 88/89 | 0.828 | 0.680 | 0.677 | 0.455 | 0.665 | 0.896 | 0.433 | 0.478 | 0.797 | 1.000 |
| 89/90 | 0.880 | 1.000 | 0.688 | 0.721 | 0.765 | 0.721 | 0.891 | 0.485 | 0.958 | 0.897 |
| 90/91 | 0.721 | 0.519 | 0.554 | 0.423 | 0.570 | 0.390 | 0.477 | 1.000 | 0.481 | 0.624 |
| 91/92 | 0.854 | 0.848 | 0.619 | 0.972 | 0.743 | 1.000 | 0.961 | 0.877 | 0.907 | 0.962 |
| 92/93 | 0.786 | 0.693 | 0.488 | 0.572 | 0.601 | 0.511 | 0.426 | 0.541 | 1.000 | 0.963 |
| 93/94 | 0.337 | 0.339 | 0.274 | 0.260 | 0.448 | 0.547 | 0.538 | 0.491 | 0.754 | 1.000 |
| 94/95 | 1.000 | 0.602 | 0.527 | 0.501 | 0.763 | 0.464 | 0.700 | 0.670 | 0.778 | 0.881 |
| 95/96 | 0.996 | 0.826 | 0.558 | 0.447 | 0.462 | 0.444 | 0.598 | 1.000 | 0.647 | 0.626 |
| 96/97 | 0.870 | 1.000 | 0.909 | 0.672 | 0.429 | 0.519 | 0.675 | 0.797 | 0.648 | 0.494 |
| 97/98 | 0.525 | 0.657 | 0.823 | 1.000 | 0.665 | 0.554 | 0.508 | 0.877 | 0.625 | 0.686 |
| 98/99 | 0.418 | 0.515 | 0.849 | 1.000 | 0.834 | 0.518 | 0.495 | 0.457 | 0.696 | 0.628 |
| 99/00 | 0.623 | 0.617 | 0.723 | 1.000 | 0.942 | 0.688 | 0.539 | 0.541 | 0.490 | 0.444 |
| 00/01 | 0.597 | 0.786 | 0.958 | 0.641 | 1.000 | 0.801 | 0.902 | 0.766 | 0.863 | 0.768 |
| 01/02 | 0.444 | 0.300 | 0.669 | 0.717 | 0.428 | 0.797 | 0.640 | 0.657 | 1.000 | 0.787 |

Fit results for index = Headboat
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 81/82 | 0.8518 | 0.8518 | 0.2546 | 0.5972 | 1.6803 |
| 82/83 | 0.5469 | 0.5469 | 1.3031 | -0.7563 | -2.1277 |
| 83/84 | 0.8856 | 0.8856 | 0.7687 | 0.1169 | 0.3288 |
| 84/85 | 1.0085 | 1.0085 | 0.5710 | 0.4375 | 1.2310 |
| 85/86 | 0.6549 | 0.6549 | 0.4859 | 0.1690 | 0.4756 |
| 86/87 | 0.7818 | 0.7818 | 1.0501 | -0.2683 | -0.7549 |
| 87/88 | 1.0698 | 1.0698 | 1.1116 | -0.0418 | -0.1176 |
| 88/89 | 0.6525 | 0.6525 | 1.3816 | -0.7291 | -2.0514 |
| 89/90 | 0.8622 | 0.8622 | 1.1682 | -0.3060 | -0.8610 |
| 90/91 | 0.9660 | 0.9660 | 0.7616 | 0.2044 | 0.5751 |
| 91/92 | 1.9698 | 1.9698 | 1.5573 | 0.4125 | 1.1607 |
| 92/93 | 1.4799 | 1.4799 | 1.0726 | 0.4074 | 1.1462 |
| 93/94 | 1.0104 | 1.0104 | 0.5443 | 0.4661 | 1.3113 |
| 94/95 | 1.0510 | 1.0510 | 0.7671 | 0.2839 | 0.7987 |
| 95/96 | 1.0730 | 1.0730 | 0.7971 | 0.2759 | 0.7764 |
| 96/97 | 0.7690 | 0.7690 | 0.8567 | -0.0877 | -0.2468 |
| 97/98 | 0.9996 | 0.9996 | 0.8538 | 0.1459 | 0.4104 |
| 98/99 | 0.9580 | 0.9580 | 0.8628 | 0.0952 | 0.2680 |
| 99/00 | 1.0527 | 1.0527 | 1.0259 | 0.0268 | 0.0754 |
| 00/01 | 1.3376 | 1.3376 | 1.3107 | 0.0269 | 0.0756 |
| 01/02 | 1.0188 | 1.0188 | 1.0343 | -0.0155 | -0.0437 |

Index ML estimate of the variance: 0.1263 (S.E.: 0.3554)
ML estimate of catchability: 0.49228E-06
Pearsons (parametric) correlation: 0.359 P= 0.0125
Kendalls (nonparametric) Tau: 0.133 P= 0.1639

Selectivity at age from Partial Catches

| year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 81/82 | 0.001 | 0.007 | 0.020 | 0.024 | 0.011 | 0.035 | 0.007 | 1.000 | 0.023 | 0.012 |
| 82/83 | 0.023 | 0.105 | 0.530 | 0.403 | 1.000 | 0.634 | 0.627 | 0.309 | 0.954 | 0.848 |
| 83/84 | 0.203 | 0.108 | 0.104 | 0.609 | 0.068 | 1.000 | 0.716 | 0.043 | 0.463 | 0.249 |
| 84/85 | 0.046 | 0.071 | 0.215 | 0.184 | 0.508 | 0.272 | 0.255 | 1.000 | 0.626 | 0.386 |
| 85/86 | 0.191 | 0.009 | 0.119 | 0.274 | 0.161 | 0.713 | 1.000 | 0.342 | 0.065 | 0.225 |
| 86/87 | 0.411 | 0.702 | 1.000 | 0.571 | 0.536 | 0.373 | 0.895 | 0.328 | 0.353 | 0.446 |
| 87/88 | 0.506 | 0.748 | 0.731 | 1.000 | 0.575 | 0.375 | 0.188 | 0.319 | 0.365 | 0.375 |
| 88/89 | 0.833 | 0.759 | 0.659 | 0.434 | 0.874 | 0.969 | 0.549 | 0.587 | 0.914 | 1.000 |
| 89/90 | 1.000 | 0.916 | 0.593 | 0.600 | 0.628 | 0.559 | 0.689 | 0.390 | 0.760 | 0.672 |
| 90/91 | 0.599 | 0.431 | 0.511 | 0.417 | 0.578 | 0.390 | 0.474 | 1.000 | 0.473 | 0.652 |
| 91/92 | 0.941 | 0.945 | 0.682 | 1.000 | 0.691 | 0.889 | 0.837 | 0.605 | 0.580 | 0.624 |
| 92/93 | 0.722 | 0.614 | 0.446 | 0.532 | 0.585 | 0.502 | 0.415 | 0.527 | 1.000 | 0.959 |
| 93/94 | 0.398 | 0.342 | 0.260 | 0.239 | 0.412 | 0.501 | 0.512 | 0.460 | 0.727 | 1.000 |
| 94/95 | 1.000 | 0.562 | 0.456 | 0.407 | 0.602 | 0.330 | 0.510 | 0.465 | 0.573 | 0.564 |
| 95/96 | 1.000 | 0.834 | 0.530 | 0.401 | 0.409 | 0.387 | 0.494 | 0.812 | 0.513 | 0.501 |
| 96/97 | 0.907 | 1.000 | 0.795 | 0.590 | 0.363 | 0.444 | 0.600 | 0.682 | 0.621 | 0.437 |
| 97/98 | 0.521 | 0.640 | 0.814 | 1.000 | 0.657 | 0.567 | 0.511 | 0.869 | 0.581 | 0.659 |
| 98/99 | 0.502 | 0.557 | 0.869 | 1.000 | 0.819 | 0.500 | 0.491 | 0.432 | 0.638 | 0.538 |
| 99/00 | 0.979 | 0.687 | 0.750 | 1.000 | 0.942 | 0.687 | 0.572 | 0.548 | 0.520 | 0.502 |
| 00/01 | 0.671 | 0.811 | 1.000 | 0.666 | 0.947 | 0.713 | 0.768 | 0.636 | 0.720 | 0.606 |
| 01/02 | 0.705 | 0.470 | 0.994 | 0.976 | 0.556 | 0.929 | 0.797 | 0.727 | 1.000 | 0.761 |

Fit results for index = Seamap SA
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 90/91 | 1.5562 | 1.5562 | 1.3172 | 0.2389 | 0.5370 |
| 91/92 | 0.2635 | 0.2635 | 0.6946 | -0.4311 | -0.9689 |
| 92/93 | 1.4337 | 1.4337 | 0.7236 | 0.7101 | 1.5958 |
| 93/94 | 0.4414 | 0.4414 | 0.8455 | -0.4041 | -0.9082 |
| 94/95 | 0.5509 | 0.5509 | 0.9890 | -0.4381 | -0.9846 |
| 95/96 | 1.4422 | 1.4422 | 1.5733 | -0.1311 | -0.2946 |
| 96/97 | 1.9641 | 1.9641 | 1.3658 | 0.5983 | 1.3446 |
| 97/98 | 0.3064 | 0.3064 | 0.7668 | -0.4605 | -1.0349 |
| 98/99 | 2.1030 | 2.1030 | 2.1058 | -0.0028 | -0.0063 |
| 99/00 | 0.5700 | 0.5700 | 0.7463 | -0.1763 | -0.3962 |
| 00/01 | 0.7839 | 0.7839 | 0.2243 | 0.5596 | 1.2578 |
| 01/02 | 0.5848 | 0.5848 | 0.0000 | 0.5848 | 1.3143 |

Index ML estimate of the variance: 0.1980 (S.E.: 0.4449)
ML estimate of catchability: 0.80400E-06
Pearsons (parametric) correlation: 0.729 P= 0.0000
Kendalls (nonparametric) Tau: 0.424 P= 0.0047

Selectivities set to 1.0

| year | 0 |
|---|---|
| 90/91 | 1.000 |
| 91/92 | 1.000 |
| 92/93 | 1.000 |
| 93/94 | 1.000 |
| 94/95 | 1.000 |
| 95/96 | 1.000 |
| 96/97 | 1.000 |
| 97/98 | 1.000 |
| 98/99 | 1.000 |
| 99/00 | 1.000 |
| 00/01 | 1.000 |
| 01/02 | 1.000 |

Table 16. Maximum sustainable yield (MSY) and optimum yield (OY) related values from the Base model and the Full index model for Atlantic king mackerel 2003 stock evaluation. SS is spawning stock biomass in trillions of yolked eggs, F values are associated with the fully selected age, and yields are given in millions of pounds. 80% confidence intervals generated from 500 bootstrap projections.

**MODEL BASE**

| | SS MSY | F MSY | MSY | SS OY | F OY | OY |
|---|---|---|---|---|---|---|
| Median | 2.681 | 0.298 | 5.216 | 4.190 | 0.213 | 5.534 |
| low 80% | 0.741 | 0.257 | 1.364 | 3.170 | 0.182 | 4.115 |
| upp 80% | 4.793 | 0.359 | 9.060 | 9.890 | 0.256 | 11.653 |
| Deterministic | 2.669 | 0.271 | 5.169 | 3.559 | 0.193 | 4.776 |

**MODEL Full Index**

| | SS MSY | F MSY | MSY | SS OY | F OY | OY |
|---|---|---|---|---|---|---|
| Median | 2.573 | 0.300 | 5.021 | 3.901 | 0.211 | 5.304 |
| low 80% | 0.869 | 0.262 | 1.545 | 3.034 | 0.186 | 4.030 |
| upp 80% | 3.649 | 0.353 | 7.338 | 6.586 | 0.254 | 8.121 |
| Deterministic | 2.507 | 0.269 | 4.953 | 3.342 | 0.189 | 4.598 |

Table 17. Estimated acceptable biological catch (ABC) in millions of pounds for the Atlantic king mackerel 2003/04 fishing year under a projected F of $F_{30\%SPR}$ or $F_{40\%SPR}$ from the Base and Full index models evaluated. Probability denotes the likelihood of exceeding the desired F mortality rates.

| | Base Model | | Full Index Model | |
|---|---|---|---|---|
| **Probability** | $F_{30\%SPR}$ | $F_{40\%SPR}$ | $F_{30\%SPR}$ | $F_{40\%SPR}$ |
| 50% Median | 6.378 | 4.673 | 5.750 | 4.164 |
| 10% lower CI | 3.872 | 2.816 | 3.522 | 2.581 |
| 90% upper CI | 16.161 | 12.151 | 11.805 | 8.764 |

Table 18. Atlantic Spanish mackerel tuned VPA results for Base Model.

**Stock at Age at beginning of year**

| | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 7326408 | 10544690 | 10937021 | 7203097 | 7828083 | 6646082 | 9398729 | 8270273 | 6336725 | 8548465 | 8556578 |
| 1 | 4201660 | 5427393 | 7792587 | 8080475 | 5138107 | 5521078 | 4833327 | 6663724 | 5836883 | 4637251 | 6198457 |
| 2 | 3638954 | 2795151 | 3320735 | 4667122 | 4175944 | 2691579 | 2981558 | 2523008 | 3129018 | 3016532 | 2489486 |
| 3 | 1299879 | 1104524 | 1068000 | 1473110 | 2899762 | 1819836 | 1482654 | 1501499 | 1175327 | 1493541 | 1471500 |
| 4 | 344968 | 289301 | 339762 | 696937 | 868319 | 1370700 | 840274 | 756669 | 746639 | 508784 | 562272 |
| 5 | 272229 | 248759 | 184633 | 235137 | 428094 | 531725 | 672110 | 409668 | 310867 | 368177 | 145056 |
| 6+ | 52486 | 205436 | 162838 | 183262 | 208897 | 315163 | 352897 | 495257 | 364585 | 279321 | 182628 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 |
|---|---|---|---|---|---|---|---|---|
| 0 | 8436508 | 7259885 | 6840303 | 12915287 | 8689278 | 12714638 | 11552987 | 0 |
| 1 | 6164309 | 5879329 | 5229729 | 4941804 | 9169166 | 6208092 | 9271297 | 8327638 |
| 2 | 2934535 | 3768885 | 3386960 | 2954196 | 2969032 | 5732299 | 3385253 | 6166422 |
| 3 | 1000530 | 1741811 | 2076778 | 1703118 | 1480787 | 1776349 | 3266752 | 1615908 |
| 4 | 540969 | 539684 | 857090 | 1114873 | 896523 | 846040 | 915080 | 1623090 |
| 5 | 138144 | 307595 | 281216 | 454537 | 638388 | 529349 | 423261 | 517986 |
| 6+ | 148323 | 178389 | 288906 | 322138 | 402135 | 608127 | 687030 | 721809 |

**F at age during year**

| | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0.0024 | 0.0027 | 0.0378 | 0.0491 | 0.0185 | 0.0439 | 0.0485 | 0.0122 | 0.0215 | 0.0279 |
| 1 | 0.1076 | 0.1913 | 0.2126 | 0.3601 | 0.3466 | 0.3161 | 0.3501 | 0.456 | 0.3601 | 0.322 | 0.4478 |
| 2 | 0.8923 | 0.6621 | 0.5128 | 0.1759 | 0.5306 | 0.2963 | 0.386 | 0.4639 | 0.4396 | 0.4178 | 0.6115 |
| 3 | 1.2026 | 0.8789 | 0.1268 | 0.2286 | 0.4493 | 0.4728 | 0.3727 | 0.3986 | 0.5373 | 0.6769 | 0.7007 |
| 4 | 0.027 | 0.1491 | 0.0681 | 0.1874 | 0.1904 | 0.4127 | 0.4184 | 0.5896 | 0.407 | 0.9549 | 1.1037 |
| 5 | 0.1578 | 0.7258 | 0.3398 | 0.3946 | 0.4037 | 0.5754 | 0.4274 | 0.6091 | 0.583 | 0.9657 | 0.4927 |
| 6+ | 0.1578 | 0.7258 | 0.3398 | 0.3946 | 0.4037 | 0.5754 | 0.4274 | 0.6091 | 0.583 | 0.9657 | 0.4927 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 |
|---|---|---|---|---|---|---|---|
| 0 | 0.0611 | 0.028 | 0.0251 | 0.0426 | 0.0362 | 0.0158 | 0.0274 |
| 1 | 0.192 | 0.2515 | 0.2711 | 0.2095 | 0.1697 | 0.3064 | 0.1078 |
| 2 | 0.2216 | 0.296 | 0.3875 | 0.3907 | 0.2137 | 0.2623 | 0.4395 |
| 3 | 0.3173 | 0.4091 | 0.3221 | 0.3417 | 0.2598 | 0.3633 | 0.3995 |
| 4 | 0.2646 | 0.3519 | 0.3343 | 0.2575 | 0.2269 | 0.3926 | 0.2691 |
| 5 | 0.1737 | 0.2201 | 0.2709 | 0.3582 | 0.2371 | 0.2042 | 0.1306 |
| 6+ | 0.1737 | 0.2201 | 0.2709 | 0.3582 | 0.2371 | 0.2042 | 0.1306 |

## Parameter Estimates Atlantic Spanish Base Model

```
Update of FADAPT Version 3 (Feb 96) by V. Restrepo

    Input DATA file: Atl1Spn03A.inp
    Input CONTROL file: Atl2Spn03A.inp
    Output Stock Size file: AtlSPa.naa
    Output Fishing Mortality file: AtlSPa.faa
    Ouput Fitted Indices file: AtlSPa.ind
    Output Diagnostics (this) file: AtlSPa.par

    Run name: Atl Spanish 03 NoByc NoSeaMap early
    No. index values:  65  Parameters:  6
    Mean Squared Error (rss/df) =  0.20348E+00
    Rsquared = -0.3373
    Loglikelihood = -0.33056E+02


 res from indices   =    31.8437574533369
 res from curvature =   0.000000000000000E+000


  Program termination OK

More details of the run can be found in file FADAPT5.RUN

 Parameter   Estimate    S.E.      % C.V.
 F age   0   0.0274     0.01222     44.64
 F age   1   0.1078     0.03968     36.81
 F age   2   0.4395     0.10115     23.01
 F age   3   0.3995     0.09193     23.01
 F age   4   0.2691     0.08805     32.72
 F age   5   0.1306     0.03716     28.45



 Variances of terminal yr F and survivors
  Age,  SE(F,101)    CV(F)      SE(N,102)     CV(N)
  0   0.12215E-01  44.63933
  1   0.39680E-01  36.80717   0.37710E+07  45.28336
  2   0.10115      23.01348   0.24003E+07  38.92564
  3   0.91931E-01  23.01367   0.46358E+06  28.68882
  4   0.88047E-01  32.72348   0.45677E+06  28.14178
  5   0.37156E-01  28.44642   0.19446E+06  37.54112
  6   0.37156E-01  28.44642   0.15967E+06  22.12130

  Obs. and pred. indices in objective function
  0.33183E+00  0.51666E+00
  0.43612E+00  0.76543E+00
  0.61635E+00  0.69677E+00
  0.62875E+00  0.13669E+01
  0.77665E+00  0.75051E+00
  0.56149E+00  0.99530E+00
  0.48909E+00  0.83425E+00
  0.65620E+00  0.76562E+00
  0.10097E+01  0.65797E+00
  0.94177E+00  0.53403E+00
  0.86956E+00  0.78069E+00
  0.14689E+01  0.11054E+01
  0.14245E+01  0.13350E+01
  0.16606E+01  0.13100E+01
  0.15354E+01  0.16190E+01
  0.16530E+01  0.15521E+01
  0.19402E+01  0.14849E+01
  0.85345E+00  0.46867E+00
  0.72276E+00  0.87883E-01
  0.69413E+00  0.73810E+00
  0.14770E+01  0.32257E+00
  0.10653E+01  0.70263E+00
  0.54870E+00  0.68364E+00
  0.10553E+01  0.58226E+00
  0.11145E+01  0.11151E+01
  0.16086E+01  0.42218E+00
  0.88480E+00  0.32120E+00
  0.70957E+00  0.56659E+00
  0.10962E+01  0.57952E+00
  0.44809E+00  0.10327E+01
  0.82560E+00  0.11830E+01
  0.11039E+01  0.10042E+01
  0.12430E+01  0.18058E+01
  0.14993E+01  0.13929E+01
  0.10497E+01  0.12711E+01
  0.13086E+01  0.42718E+00
  0.11397E+01  0.48652E+00
  0.46685E+00  0.53760E+00
  0.54732E+00  0.11512E+01
  0.11372E+01  0.10260E+01
  0.73594E+00  0.92856E+00
  0.14684E+01  0.99956E+00
  0.79571E+00  0.95797E+00
  0.15972E+01  0.89281E+00
  0.12333E+01  0.39040E+00
  0.89329E+00  0.79442E+00
  0.11992E+01  0.70061E+00
  0.57011E+00  0.11210E+01
  0.52629E+00  0.99777E+00
  0.12161E+01  0.82685E+00
  0.98460E+00  0.13784E+01
  0.12379E+01  0.13225E+01
  0.94228E+00  0.11009E+01
  0.11505E+01  0.91236E+00
  0.14710E+01  0.92441E+00
  0.12571E+01  0.77033E+00
  0.58681E+00  0.85341E+00
  0.76358E+00  0.92451E+00
  0.96603E+00  0.94749E+00
  0.73183E+00  0.84906E+00
  0.43014E+00  0.77892E+00
  0.10635E+01  0.11741E+01
  0.96117E+00  0.11652E+01
  0.12335E+01  0.12335E+01
  0.13849E+01  0.13849E+01
```

## INDEX RESULTS

Maximum likelihood weighting for indices

Fit results for index = FDEP
Index Fitted to Mid-Year Stock Size in BIOMASS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 85/86 | 0.3318 | 0.3318 | 0.5167 | -0.1848 | -0.5681 |
| 86/87 | 0.4361 | 0.4361 | 0.7654 | -0.3293 | -1.0122 |
| 87/88 | 0.6164 | 0.6164 | 0.6968 | -0.0804 | -0.2472 |
| 88/89 | 0.6287 | 0.6287 | 1.3669 | -0.7381 | -2.2689 |
| 89/90 | 0.7767 | 0.7767 | 0.7505 | 0.0261 | 0.0804 |
| 90/91 | 0.5615 | 0.5615 | 0.9953 | -0.4338 | -1.3335 |
| 91/92 | 0.4891 | 0.4891 | 0.8343 | -0.3452 | -1.0610 |
| 92/93 | 0.6562 | 0.6562 | 0.7656 | -0.1094 | -0.3363 |
| 93/94 | 1.0097 | 1.0097 | 0.6580 | 0.3517 | 1.0812 |
| 94/95 | 0.9418 | 0.9418 | 0.5340 | 0.4077 | 1.2533 |
| 95/96 | 0.8696 | 0.8696 | 0.7807 | 0.0889 | 0.2732 |
| 96/97 | 1.4689 | 1.4689 | 1.1054 | 0.3634 | 1.1171 |
| 97/98 | 1.4245 | 1.4245 | 1.3350 | 0.0895 | 0.2752 |
| 98/99 | 1.6606 | 1.6606 | 1.3100 | 0.3506 | 1.0778 |
| 99/00 | 1.5354 | 1.5354 | 1.6190 | -0.0836 | -0.2569 |
| 00/01 | 1.6530 | 1.6530 | 1.5521 | 0.1009 | 0.3101 |
| 01/02 | 1.9402 | 1.9402 | 1.4849 | 0.4552 | 1.3993 |

Index ML estimate of the variance: 0.1058 (S.E.: 0.3253)
ML estimate of catchability: 0.11702E-06
Pearsons (parametric) correlation: 0.751 P= 0.0000
Kendalls (nonparametric) Tau: 0.412 P= 0.0008

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 85/86 | 0.091 | 0.598 | 1.000 | 0.153 | 0.770 | 0.535 |
| 86/87 | 0.377 | 0.997 | 0.319 | 0.126 | 1.000 | 0.669 |
| 87/88 | 0.172 | 0.317 | 0.490 | 0.453 | 1.000 | 0.866 |
| 88/89 | 0.173 | 1.000 | 0.921 | 0.401 | 0.844 | 0.639 |
| 89/90 | 0.033 | 0.135 | 0.467 | 0.553 | 0.900 | 1.000 |
| 90/91 | 0.125 | 0.402 | 0.575 | 0.935 | 0.992 | 1.000 |
| 91/92 | 0.163 | 0.444 | 0.432 | 0.831 | 0.851 | 1.000 |
| 92/93 | 0.156 | 0.438 | 0.723 | 0.640 | 1.000 | 0.866 |
| 93/94 | 0.191 | 0.339 | 0.655 | 1.000 | 0.937 | 0.851 |
| 94/95 | 0.216 | 0.488 | 0.551 | 1.000 | 0.427 | 0.505 |
| 95/96 | 0.406 | 0.616 | 1.000 | 0.717 | 0.576 | 0.484 |
| 96/97 | 0.444 | 0.694 | 1.000 | 0.889 | 0.575 | 0.669 |
| 97/98 | 0.601 | 0.796 | 0.811 | 1.000 | 0.816 | 0.883 |
| 98/99 | 0.532 | 1.000 | 0.909 | 0.619 | 0.801 | 0.797 |
| 99/00 | 0.483 | 0.928 | 0.914 | 1.000 | 0.916 | 0.921 |
| 00/01 | 0.664 | 0.631 | 1.000 | 0.957 | 0.494 | 0.469 |
| 01/02 | 0.240 | 1.000 | 1.000 | 0.742 | 0.144 | 0.135 |

Fit results for index = Headboat
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.8535 | 0.8535 | 0.4687 | 0.3848 | 0.7209 |
| 85/86 | 0.7228 | 0.7228 | 0.0879 | 0.6349 | 1.1894 |
| 86/87 | 0.6941 | 0.6941 | 0.7381 | -0.0440 | -0.0824 |
| 87/88 | 1.4770 | 1.4770 | 0.3226 | 1.1545 | 2.1628 |
| 88/89 | 1.0653 | 1.0653 | 0.7026 | 0.3627 | 0.6795 |
| 89/90 | 0.5487 | 0.5487 | 0.6836 | -0.1349 | -0.2528 |
| 90/91 | 1.0553 | 1.0553 | 0.5823 | 0.4731 | 0.8863 |
| 91/92 | 1.1145 | 1.1145 | 1.1151 | -0.0006 | -0.0012 |
| 92/93 | 1.6086 | 1.6086 | 0.4222 | 1.1864 | 2.2227 |
| 93/94 | 0.8848 | 0.8848 | 0.3212 | 0.5636 | 1.0559 |
| 94/95 | 0.7096 | 0.7096 | 0.5666 | 0.1430 | 0.2679 |
| 95/96 | 1.0962 | 1.0962 | 0.5795 | 0.5167 | 0.9679 |
| 96/97 | 0.4481 | 0.4481 | 1.0327 | -0.5846 | -1.0952 |
| 97/98 | 0.8256 | 0.8256 | 1.1830 | -0.3574 | -0.6696 |
| 98/99 | 1.1039 | 1.1039 | 1.0042 | 0.0997 | 0.1869 |
| 99/00 | 1.2430 | 1.2430 | 1.8058 | -0.5628 | -1.0543 |
| 00/01 | 1.4993 | 1.4993 | 1.3929 | 0.1064 | 0.1994 |
| 01/02 | 1.0497 | 1.0497 | 1.2711 | -0.2214 | -0.4148 |

Index ML estimate of the variance: 0.2849 (S.E.: 0.5338)
ML estimate of catchability: 0.16356E-06
Pearsons (parametric) correlation: 0.152 P= 0.2631
Kendalls (nonparametric) Tau: 0.098 P= 0.2982

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 84/85 | 0.203 | 1.000 | 0.015 | 0.057 | 0.037 | 0.118 |
| 85/86 | 0.033 | 0.143 | 0.001 | 0.037 | 0.001 | 1.000 |
| 86/87 | 0.219 | 0.987 | 0.663 | 0.581 | 1.000 | 0.449 |
| 87/88 | 0.112 | 0.146 | 0.293 | 0.369 | 0.564 | 1.000 |
| 88/89 | 0.194 | 0.450 | 0.655 | 0.731 | 1.000 | 0.927 |
| 89/90 | 0.304 | 0.456 | 0.722 | 0.576 | 1.000 | 0.812 |
| 90/91 | 0.311 | 0.412 | 0.430 | 0.699 | 0.902 | 1.000 |
| 91/92 | 0.782 | 0.831 | 0.671 | 0.914 | 1.000 | 0.748 |
| 92/93 | 0.185 | 0.366 | 0.480 | 0.451 | 0.567 | 1.000 |
| 93/94 | 0.206 | 0.232 | 0.322 | 0.490 | 0.697 | 1.000 |
| 94/95 | 0.350 | 0.532 | 0.727 | 1.000 | 0.509 | 0.316 |
| 95/96 | 0.327 | 0.407 | 0.629 | 1.000 | 0.404 | 0.794 |
| 96/97 | 0.587 | 0.638 | 1.000 | 0.988 | 0.584 | 0.502 |
| 97/98 | 0.727 | 1.000 | 0.776 | 0.716 | 0.556 | 0.515 |
| 98/99 | 0.648 | 1.000 | 0.622 | 0.467 | 0.527 | 0.589 |
| 99/00 | 1.000 | 0.698 | 0.982 | 0.584 | 0.766 | 0.653 |
| 00/01 | 0.863 | 0.547 | 0.574 | 1.000 | 0.881 | 0.792 |
| 01/02 | 0.449 | 1.000 | 0.572 | 0.501 | 0.242 | 0.323 |

Fit results for index = MRFSS
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 1.3086 | 1.3086 | 0.4272 | 0.8814 | 1.8250 |
| 85/86 | 1.1397 | 1.1397 | 0.4865 | 0.6531 | 1.3524 |
| 86/87 | 0.4669 | 0.4669 | 0.5376 | -0.0708 | -0.1465 |
| 87/88 | 0.5473 | 0.5473 | 1.1512 | -0.6038 | -1.2503 |
| 88/89 | 1.1372 | 1.1372 | 1.0260 | 0.1113 | 0.2304 |
| 89/90 | 0.7359 | 0.7359 | 0.9286 | -0.1926 | -0.3988 |
| 90/91 | 1.4684 | 1.4684 | 0.9996 | 0.4688 | 0.9708 |
| 91/92 | 0.7957 | 0.7957 | 0.9580 | -0.1623 | -0.3360 |
| 92/93 | 1.5972 | 1.5972 | 0.8928 | 0.7044 | 1.4585 |
| 93/94 | 1.2333 | 1.2333 | 0.3904 | 0.8429 | 1.7454 |
| 94/95 | 0.8933 | 0.8933 | 0.7944 | 0.0989 | 0.2047 |
| 95/96 | 1.1992 | 1.1992 | 0.7006 | 0.4986 | 1.0324 |
| 96/97 | 0.5701 | 0.5701 | 1.1210 | -0.5509 | -1.1406 |
| 97/98 | 0.5263 | 0.5263 | 0.9978 | -0.4715 | -0.9763 |
| 98/99 | 1.2161 | 1.2161 | 0.8268 | 0.3893 | 0.8060 |
| 99/00 | 0.9846 | 0.9846 | 1.3784 | -0.3938 | -0.8155 |
| 00/01 | 1.2379 | 1.2379 | 1.3225 | -0.0845 | -0.1750 |
| 01/02 | 0.9423 | 0.9423 | 1.1009 | -0.1587 | -0.3285 |

Index ML estimate of the variance: 0.2332 (S.E.: 0.4830)
ML estimate of catchability: 0.14088E-06
Pearsons (parametric) correlation: -0.184 P= 0.1965
Kendalls (nonparametric) Tau: -0.163 P= 0.1276

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 84/85 | 0.240 | 1.000 | 0.012 | 0.044 | 0.252 | 0.067 |
| 85/86 | 0.343 | 1.000 | 0.037 | 0.100 | 0.248 | 0.773 |
| 86/87 | 0.218 | 1.000 | 0.105 | 0.087 | 0.384 | 0.396 |
| 87/88 | 1.000 | 0.417 | 0.334 | 0.265 | 0.429 | 0.799 |
| 88/89 | 0.639 | 0.920 | 0.807 | 0.332 | 0.747 | 1.000 |
| 89/90 | 0.667 | 0.772 | 1.000 | 0.666 | 0.679 | 0.545 |
| 90/91 | 1.000 | 0.821 | 0.700 | 0.705 | 0.830 | 0.778 |
| 91/92 | 0.825 | 0.737 | 0.629 | 0.892 | 1.000 | 0.761 |
| 92/93 | 0.756 | 0.785 | 0.832 | 0.602 | 0.704 | 1.000 |
| 93/94 | 0.352 | 0.338 | 0.392 | 0.510 | 0.713 | 1.000 |
| 94/95 | 0.779 | 0.656 | 0.835 | 1.000 | 0.544 | 0.258 |
| 95/96 | 0.568 | 0.532 | 0.634 | 1.000 | 0.228 | 0.692 |
| 96/97 | 0.908 | 0.744 | 1.000 | 0.828 | 0.522 | 0.294 |
| 97/98 | 0.725 | 1.000 | 0.750 | 0.637 | 0.421 | 0.407 |
| 98/99 | 0.520 | 0.908 | 0.681 | 0.668 | 0.768 | 1.000 |
| 99/00 | 0.831 | 0.594 | 1.000 | 0.644 | 0.955 | 0.874 |
| 00/01 | 0.959 | 0.687 | 0.648 | 1.000 | 0.589 | 0.455 |
| 01/02 | 0.357 | 1.000 | 0.657 | 0.749 | 0.498 | 0.829 |

Fit results for index = SeaMap SA
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 90/91 | 1.1505 | 1.1505 | 0.9124 | 0.2381 | 0.8798 |
| 91/92 | 1.4710 | 1.4710 | 0.9244 | 0.5466 | 2.0195 |
| 92/93 | 1.2571 | 1.2571 | 0.7703 | 0.4868 | 1.7986 |
| 93/94 | 0.5868 | 0.5868 | 0.8534 | -0.2666 | -0.9851 |
| 94/95 | 0.7636 | 0.7636 | 0.9245 | -0.1609 | -0.5947 |
| 95/96 | 0.9660 | 0.9660 | 0.9475 | 0.0185 | 0.0685 |
| 96/97 | 0.7318 | 0.7318 | 0.8491 | -0.1172 | -0.4332 |
| 97/98 | 0.4301 | 0.4301 | 0.7789 | -0.3488 | -1.2887 |
| 98/99 | 1.0635 | 1.0635 | 1.1741 | -0.1105 | -0.4083 |
| 99/00 | 0.9612 | 0.9612 | 1.1652 | -0.2040 | -0.7539 |
| 00/01 | 1.2335 | 1.2335 | 1.2335 | 0.0000 | 0.0000 |
| 01/02 | 1.3849 | 1.3849 | 1.3849 | 0.0000 | 0.0000 |

Index ML estimate of the variance: 0.0732 (S.E.: 0.2706)
ML estimate of catchability: 0.79288E-07
Pearsons (parametric) correlation: 0.495 P= 0.0077
Kendalls (nonparametric) Tau: 0.364 P= 0.0141

Selectivities set to 1.0

| year | 0 | 1 |
|---|---|---|
| 90/91 | 1.000 | 1.000 |
| 91/92 | 1.000 | 1.000 |
| 92/93 | 1.000 | 1.000 |
| 93/94 | 1.000 | 1.000 |
| 94/95 | 1.000 | 1.000 |
| 95/96 | 1.000 | 1.000 |
| 96/97 | 1.000 | 1.000 |
| 97/98 | 1.000 | 1.000 |
| 98/99 | 1.000 | 1.000 |
| 99/00 | 1.000 | 1.000 |
| 00/01 | 1.000 | 1.000 |
| 01/02 | 1.000 | 1.000 |

Table 19. Atlantic Spanish mackerel tuned VPA results for Full Index Model.

**Stock at Age at beginning of year**

| | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 8009096 | 11542986 | 11582612 | 7702579 | 8387119 | 7044592 | 9872637 | 8911483 | 6863257 | 9328465 | 9579213 |
| **1** | 4625352 | 5933140 | 8532143 | 8558740 | 5508119 | 5935199 | 5128548 | 7014787 | 6311877 | 5027315 | 6776289 |
| **2** | 3834969 | 3076547 | 3655143 | 5157550 | 4476176 | 2930526 | 3250020 | 2709167 | 3346352 | 3328129 | 2745945 |
| **3** | 1395241 | 1210052 | 1240989 | 1677004 | 3193177 | 1989703 | 1621947 | 1659921 | 1280653 | 1614021 | 1661167 |
| **4** | 400337 | 339831 | 398724 | 799381 | 986101 | 1530273 | 930511 | 829714 | 833353 | 564451 | 624772 |
| **5** | 315497 | 278290 | 212811 | 267580 | 482603 | 592664 | 753077 | 453973 | 346180 | 412090 | 174688 |
| **6+** | 61108 | 230788 | 188530 | 209472 | 236537 | 352792 | 397150 | 551161 | 407742 | 313899 | 220900 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 |
|---|---|---|---|---|---|---|---|---|
| **0** | 9221375 | 7840311 | 7617776 | 14204090 | 9460880 | 12716573 | 11915062 | 0 |
| **1** | 6921883 | 6460723 | 5659711 | 5517762 | 10123895 | 6779692 | 9272730 | 8595864 |
| **2** | 3320089 | 4282945 | 3774724 | 3235527 | 3358379 | 6370212 | 3764527 | 6102882 |
| **3** | 1158414 | 1983113 | 2401902 | 1943038 | 1648920 | 2019814 | 3655860 | 1850484 |
| **4** | 653233 | 634353 | 999030 | 1309592 | 1037311 | 938407 | 1057359 | 1843607 |
| **5** | 171956 | 373691 | 335352 | 534384 | 748467 | 606314 | 468715 | 595990 |
| **6+** | 185476 | 217711 | 346082 | 380418 | 473620 | 699726 | 764322 | 765802 |

**F at age during year**

| | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0 | 0.0022 | 0.0026 | 0.0353 | 0.0458 | 0.0174 | 0.0417 | 0.0449 | 0.0113 | 0.0196 | 0.0249 |
| **1** | 0.0977 | 0.1744 | 0.1934 | 0.3382 | 0.321 | 0.2922 | 0.3282 | 0.4301 | 0.33 | 0.2948 | 0.4034 |
| **2** | 0.8335 | 0.5879 | 0.4591 | 0.1594 | 0.4908 | 0.2716 | 0.3519 | 0.4293 | 0.4091 | 0.3749 | 0.5431 |
| **3** | 1.0824 | 0.7801 | 0.1098 | 0.201 | 0.4056 | 0.43 | 0.3403 | 0.3591 | 0.4893 | 0.6191 | 0.6033 |
| **4** | 0.0236 | 0.128 | 0.0589 | 0.1646 | 0.1691 | 0.369 | 0.3777 | 0.5341 | 0.3642 | 0.8329 | 0.9501 |
| **5** | 0.1381 | 0.6388 | 0.2955 | 0.3471 | 0.3589 | 0.5136 | 0.3822 | 0.5468 | 0.5208 | 0.8355 | 0.4019 |
| **6+** | 0.1381 | 0.6388 | 0.2955 | 0.3471 | 0.3589 | 0.5136 | 0.3822 | 0.5468 | 0.5208 | 0.8355 | 0.4019 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 |
|---|---|---|---|---|---|---|---|
| **0** | 0.0558 | 0.0259 | 0.0225 | 0.0386 | 0.0332 | 0.0158 | 0.0265 |
| **1** | 0.17 | 0.2274 | 0.2492 | 0.1865 | 0.1533 | 0.2783 | 0.1083 |
| **2** | 0.1953 | 0.2584 | 0.3441 | 0.3541 | 0.1885 | 0.2353 | 0.3902 |
| **3** | 0.2722 | 0.3556 | 0.2765 | 0.2976 | 0.2337 | 0.3172 | 0.3546 |
| **4** | 0.2185 | 0.2974 | 0.2857 | 0.2194 | 0.197 | 0.3542 | 0.2333 |
| **5** | 0.1406 | 0.1822 | 0.2279 | 0.3042 | 0.2038 | 0.1804 | 0.1201 |
| **6+** | 0.1406 | 0.1822 | 0.2279 | 0.3042 | 0.2038 | 0.1804 | 0.1201 |

## Parameter Estimates Atlantic Spanish Full Index Model

```
Update of FADAPT Version 3 (Feb 96) by V. Restrepo

    Input DATA file: Atl1Spn03B.inp
    Input CONTROL file: Atl2Spn03B.inp
    Output Stock Size file: AtlSPa.naa
    Output Fishing Mortality file: AtlSPa.faa
    Ouput Fitted Indices file: AtlSPa.ind
    Output Diagnostics (this) file: AtlSPa.par

    Run name: Atl Spanish 03 Full index
    No. index values:  87  Parameters:  6
    Mean Squared Error (rss/df) =  0.25628E+00
    Rsquared = -0.2687
    Loglikelihood = -0.48030E+02


 res from indices   =    42.3914905177201
 res from curvature =   0.000000000000000E+000


  Program termination OK

More details of the run can be found in fileFADAPT5.RUN

 Parameter   Estimate    S.E.      % C.V.
 F age   0   0.0265     0.01208     45.53
 F age   1   0.1083     0.04168     38.48
 F age   2   0.3902     0.06784     17.39
 F age   3   0.3546     0.06166     17.39
 F age   4   0.2333     0.06840     29.32
 F age   5   0.1201     0.02661     22.15



 Variances of terminal yr F and survivors
  Age,  SE(F,101)    CV(F)      SE(N,102)     CV(N)
  0   0.12077E-01  45.53433
  1   0.41684E-01  38.48361   0.39688E+07  46.17097
  2   0.67841E-01  17.38727   0.24846E+07  40.71271
  3   0.61657E-01  17.38741   0.39189E+06  21.17747
  4   0.68401E-01  29.31838   0.38383E+06  20.81930
  5   0.26610E-01  22.15196   0.19705E+06  33.06347
  6   0.26610E-01  22.15196   0.13121E+06  17.13362

  Obs. and pred. indices in objective function
  0.33183E+00  0.51552E+00
  0.43612E+00  0.75912E+00
  0.61635E+00  0.70145E+00
  0.62875E+00  0.13088E+01
  0.77665E+00  0.74461E+00
  0.56149E+00  0.98557E+00
  0.48909E+00  0.82308E+00
  0.65620E+00  0.75905E+00
  0.10097E+01  0.66813E+00
  0.94177E+00  0.54939E+00
  0.86956E+00  0.80598E+00
  0.14689E+01  0.11263E+01
  0.14245E+01  0.13834E+01
  0.16606E+01  0.12800E+01
  0.15354E+01  0.16514E+01
  0.16530E+01  0.15743E+01
  0.19402E+01  0.14815E+01
  0.85345E+00  0.44813E+00
  0.72276E+00  0.89178E-01
  0.69413E+00  0.74618E+00
  0.14770E+01  0.32749E+00
  0.10653E+01  0.70585E+00
  0.54870E+00  0.68403E+00
  0.10553E+01  0.58146E+00
  0.11145E+01  0.11095E+01
  0.16086E+01  0.42211E+00
  0.88480E+00  0.33157E+00
  0.70957E+00  0.58784E+00
  0.10962E+01  0.62675E+00
  0.44809E+00  0.10611E+01
  0.82560E+00  0.11899E+01
  0.11039E+01  0.98956E+00
  0.12430E+01  0.17862E+01
  0.14993E+01  0.13790E+01
  0.10497E+01  0.12789E+01
  0.13086E+01  0.40963E+00
  0.11397E+01  0.49079E+00
  0.46685E+00  0.53786E+00
  0.54732E+00  0.10980E+01
  0.11372E+01  0.10336E+01
  0.73594E+00  0.91447E+00
  0.14684E+01  0.95510E+00
  0.79571E+00  0.95589E+00
  0.15972E+01  0.89523E+00
  0.12333E+01  0.40417E+00
  0.89329E+00  0.82658E+00
  0.11992E+01  0.75988E+00
  0.57011E+00  0.11552E+01
  0.52629E+00  0.10065E+01
  0.12161E+01  0.87233E+00
  0.98460E+00  0.13725E+01
  0.12379E+01  0.13130E+01
  0.94228E+00  0.11109E+01
  0.11505E+01  0.89381E+00
  0.14710E+01  0.91881E+00
  0.12571E+01  0.77660E+00
  0.58681E+00  0.86464E+00
  0.76358E+00  0.95777E+00
  0.96603E+00  0.97494E+00
  0.73183E+00  0.85964E+00
  0.43014E+00  0.79770E+00
  0.10635E+01  0.12060E+01
  0.96117E+00  0.11876E+01
  0.12335E+01  0.11788E+01
  0.13849E+01  0.13049E+01
  0.14421E+01  0.80137E+00
  0.84120E+00  0.74857E+00
  0.60086E+00  0.86515E+00
  0.13219E+01  0.91850E+00
  0.29442E+01  0.75984E+00
  0.48069E+00  0.82793E+00
  0.30043E+00  0.94326E+00
  0.12618E+01  0.93102E+00
  0.48069E+00  0.82477E+00
  0.15021E+01  0.76574E+00
  0.15021E+01  0.11374E+01
  0.12017E+00  0.11295E+01
  0.66094E+00  0.11244E+01
  0.54077E+00  0.12219E+01
  0.11224E+01  0.78108E+00
  0.82348E+00  0.88549E+00
  0.71907E+00  0.10018E+01
  0.11149E+01  0.95156E+00
  0.74322E+00  0.89190E+00
  0.88434E+00  0.11176E+01
  0.14131E+01  0.11864E+01
  0.11795E+01  0.11441E+01
```

## INDEX RESULTS

Maximum likelihood weighting for indices

Fit results for index = FWC
Index Fitted to Mid-Year Stock Size in BIOMASS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 85/86 | 0.3318 | 0.3318 | 0.5155 | -0.1837 | -0.5844 |
| 86/87 | 0.4361 | 0.4361 | 0.7591 | -0.3230 | -1.0277 |
| 87/88 | 0.6164 | 0.6164 | 0.7014 | -0.0851 | -0.2707 |
| 88/89 | 0.6287 | 0.6287 | 1.3088 | -0.6800 | -2.1636 |
| 89/90 | 0.7767 | 0.7767 | 0.7446 | 0.0320 | 0.1019 |
| 90/91 | 0.5615 | 0.5615 | 0.9856 | -0.4241 | -1.3493 |
| 91/92 | 0.4891 | 0.4891 | 0.8231 | -0.3340 | -1.0627 |
| 92/93 | 0.6562 | 0.6562 | 0.7591 | -0.1029 | -0.3273 |
| 93/94 | 1.0097 | 1.0097 | 0.6681 | 0.3416 | 1.0868 |
| 94/95 | 0.9418 | 0.9418 | 0.5494 | 0.3924 | 1.2484 |
| 95/96 | 0.8696 | 0.8696 | 0.8060 | 0.0636 | 0.2023 |
| 96/97 | 1.4689 | 1.4689 | 1.1263 | 0.3426 | 1.0899 |
| 97/98 | 1.4245 | 1.4245 | 1.3834 | 0.0411 | 0.1306 |
| 98/99 | 1.6606 | 1.6606 | 1.2800 | 0.3806 | 1.2108 |
| 99/00 | 1.5354 | 1.5354 | 1.6514 | -0.1160 | -0.3691 |
| 00/01 | 1.6530 | 1.6530 | 1.5743 | 0.0787 | 0.2504 |
| 01/02 | 1.9402 | 1.9402 | 1.4815 | 0.4587 | 1.4593 |

Index ML estimate of the variance: 0.0988 (S.E.: 0.3143)
ML estimate of catchability: 0.10364E-06
Pearsons (parametric) correlation: 0.771 P= 0.0000
Kendalls (nonparametric) Tau: 0.412 P= 0.0008

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 85/86 | 0.093 | 0.598 | 1.000 | 0.148 | 0.764 | 0.530 |
| 86/87 | 0.384 | 1.000 | 0.309 | 0.122 | 0.974 | 0.652 |
| 87/88 | 0.183 | 0.326 | 0.490 | 0.453 | 1.000 | 0.866 |
| 88/89 | 0.173 | 1.000 | 0.899 | 0.385 | 0.811 | 0.614 |
| 89/90 | 0.034 | 0.139 | 0.476 | 0.554 | 0.900 | 1.000 |
| 90/91 | 0.131 | 0.409 | 0.587 | 0.944 | 0.992 | 1.000 |
| 91/92 | 0.171 | 0.458 | 0.433 | 0.838 | 0.851 | 1.000 |
| 92/93 | 0.160 | 0.457 | 0.737 | 0.641 | 1.000 | 0.866 |
| 93/94 | 0.200 | 0.349 | 0.687 | 1.000 | 0.930 | 0.844 |
| 94/95 | 0.226 | 0.503 | 0.551 | 1.000 | 0.405 | 0.479 |
| 95/96 | 0.420 | 0.633 | 1.000 | 0.691 | 0.544 | 0.457 |
| 96/97 | 0.462 | 0.697 | 1.000 | 0.864 | 0.547 | 0.637 |
| 97/98 | 0.646 | 0.827 | 0.814 | 1.000 | 0.804 | 0.869 |
| 98/99 | 0.522 | 1.000 | 0.873 | 0.582 | 0.750 | 0.747 |
| 99/00 | 0.502 | 0.942 | 0.947 | 1.000 | 0.907 | 0.912 |
| 00/01 | 0.690 | 0.648 | 1.000 | 0.989 | 0.500 | 0.475 |
| 01/02 | 0.271 | 1.000 | 1.000 | 0.725 | 0.149 | 0.140 |

Fit results for index = Headboat
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.8535 | 0.8535 | 0.4481 | 0.4053 | 0.7619 |
| 85/86 | 0.7228 | 0.7228 | 0.0892 | 0.6336 | 1.1909 |
| 86/87 | 0.6941 | 0.6941 | 0.7462 | -0.0520 | -0.0978 |
| 87/88 | 1.4770 | 1.4770 | 0.3275 | 1.1495 | 2.1607 |
| 88/89 | 1.0653 | 1.0653 | 0.7058 | 0.3595 | 0.6757 |
| 89/90 | 0.5487 | 0.5487 | 0.6840 | -0.1353 | -0.2544 |
| 90/91 | 1.0553 | 1.0553 | 0.5815 | 0.4739 | 0.8907 |
| 91/92 | 1.1145 | 1.1145 | 1.1095 | 0.0050 | 0.0094 |
| 92/93 | 1.6086 | 1.6086 | 0.4221 | 1.1865 | 2.2302 |
| 93/94 | 0.8848 | 0.8848 | 0.3316 | 0.5532 | 1.0399 |
| 94/95 | 0.7096 | 0.7096 | 0.5878 | 0.1217 | 0.2288 |
| 95/96 | 1.0962 | 1.0962 | 0.6268 | 0.4694 | 0.8824 |
| 96/97 | 0.4481 | 0.4481 | 1.0611 | -0.6130 | -1.1523 |
| 97/98 | 0.8256 | 0.8256 | 1.1899 | -0.3643 | -0.6847 |
| 98/99 | 1.1039 | 1.1039 | 0.9896 | 0.1144 | 0.2150 |
| 99/00 | 1.2430 | 1.2430 | 1.7862 | -0.5431 | -1.0209 |
| 00/01 | 1.4993 | 1.4993 | 1.3790 | 0.1204 | 0.2263 |
| 01/02 | 1.0497 | 1.0497 | 1.2789 | -0.2292 | -0.4309 |

Index ML estimate of the variance: 0.2830 (S.E.: 0.5320)
ML estimate of catchability: 0.14609E-06
Pearsons (parametric) correlation: 0.141 P= 0.2891
Kendalls (nonparametric) Tau: 0.085 P= 0.3438

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 84/85 | 0.197 | 1.000 | 0.014 | 0.054 | 0.035 | 0.110 |
| 85/86 | 0.034 | 0.145 | 0.001 | 0.036 | 0.001 | 1.000 |
| 86/87 | 0.226 | 1.000 | 0.649 | 0.569 | 0.985 | 0.442 |
| 87/88 | 0.120 | 0.150 | 0.292 | 0.368 | 0.564 | 1.000 |
| 88/89 | 0.202 | 0.468 | 0.665 | 0.730 | 1.000 | 0.927 |
| 89/90 | 0.314 | 0.468 | 0.736 | 0.577 | 1.000 | 0.812 |
| 90/91 | 0.326 | 0.420 | 0.439 | 0.706 | 0.902 | 1.000 |
| 91/92 | 0.822 | 0.857 | 0.674 | 0.923 | 1.000 | 0.748 |
| 92/93 | 0.190 | 0.381 | 0.489 | 0.452 | 0.567 | 1.000 |
| 93/94 | 0.218 | 0.241 | 0.340 | 0.494 | 0.697 | 1.000 |
| 94/95 | 0.366 | 0.548 | 0.727 | 1.000 | 0.482 | 0.299 |
| 95/96 | 0.351 | 0.434 | 0.653 | 1.000 | 0.396 | 0.778 |
| 96/97 | 0.610 | 0.641 | 1.000 | 0.961 | 0.556 | 0.478 |
| 97/98 | 0.752 | 1.000 | 0.751 | 0.689 | 0.527 | 0.488 |
| 98/99 | 0.637 | 1.000 | 0.597 | 0.439 | 0.494 | 0.551 |
| 99/00 | 1.000 | 0.682 | 0.978 | 0.562 | 0.729 | 0.622 |
| 00/01 | 0.869 | 0.544 | 0.556 | 1.000 | 0.863 | 0.776 |
| 01/02 | 0.509 | 1.000 | 0.572 | 0.490 | 0.251 | 0.335 |

Fit results for index = MRFSS
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 1.3086 | 1.3086 | 0.4096 | 0.8989 | 1.8784 |
| 85/86 | 1.1397 | 1.1397 | 0.4908 | 0.6489 | 1.3559 |
| 86/87 | 0.4669 | 0.4669 | 0.5379 | -0.0710 | -0.1484 |
| 87/88 | 0.5473 | 0.5473 | 1.0980 | -0.5507 | -1.1507 |
| 88/89 | 1.1372 | 1.1372 | 1.0336 | 0.1036 | 0.2165 |
| 89/90 | 0.7359 | 0.7359 | 0.9145 | -0.1785 | -0.3730 |
| 90/91 | 1.4684 | 1.4684 | 0.9551 | 0.5133 | 1.0726 |
| 91/92 | 0.7957 | 0.7957 | 0.9559 | -0.1602 | -0.3347 |
| 92/93 | 1.5972 | 1.5972 | 0.8952 | 0.7019 | 1.4668 |
| 93/94 | 1.2333 | 1.2333 | 0.4042 | 0.8292 | 1.7326 |
| 94/95 | 0.8933 | 0.8933 | 0.8266 | 0.0667 | 0.1394 |
| 95/96 | 1.1992 | 1.1992 | 0.7599 | 0.4393 | 0.9180 |
| 96/97 | 0.5701 | 0.5701 | 1.1552 | -0.5851 | -1.2225 |
| 97/98 | 0.5263 | 0.5263 | 1.0065 | -0.4802 | -1.0034 |
| 98/99 | 1.2161 | 1.2161 | 0.8723 | 0.3438 | 0.7184 |
| 99/00 | 0.9846 | 0.9846 | 1.3725 | -0.3879 | -0.8105 |
| 00/01 | 1.2379 | 1.2379 | 1.3130 | -0.0750 | -0.1568 |
| 01/02 | 0.9423 | 0.9423 | 1.1109 | -0.1686 | -0.3523 |

Index ML estimate of the variance: 0.2290 (S.E.: 0.4786)
ML estimate of catchability: 0.12619E-06
Pearsons (parametric) correlation: -0.184 P= 0.1957
Kendalls (nonparametric) Tau: -0.163 P= 0.1276

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 84/85 | 0.233 | 1.000 | 0.012 | 0.041 | 0.236 | 0.062 |
| 85/86 | 0.353 | 1.000 | 0.037 | 0.096 | 0.246 | 0.766 |
| 86/87 | 0.221 | 1.000 | 0.101 | 0.084 | 0.373 | 0.385 |
| 87/88 | 1.000 | 0.403 | 0.313 | 0.248 | 0.402 | 0.749 |
| 88/89 | 0.666 | 0.957 | 0.819 | 0.332 | 0.747 | 1.000 |
| 89/90 | 0.678 | 0.778 | 1.000 | 0.655 | 0.666 | 0.535 |
| 90/91 | 1.000 | 0.798 | 0.682 | 0.679 | 0.792 | 0.743 |
| 91/92 | 0.867 | 0.760 | 0.631 | 0.901 | 1.000 | 0.761 |
| 92/93 | 0.775 | 0.818 | 0.848 | 0.603 | 0.704 | 1.000 |
| 93/94 | 0.372 | 0.351 | 0.414 | 0.514 | 0.713 | 1.000 |
| 94/95 | 0.815 | 0.677 | 0.835 | 1.000 | 0.516 | 0.245 |
| 95/96 | 0.609 | 0.568 | 0.658 | 1.000 | 0.224 | 0.678 |
| 96/97 | 0.945 | 0.747 | 1.000 | 0.805 | 0.497 | 0.280 |
| 97/98 | 0.751 | 1.000 | 0.725 | 0.613 | 0.399 | 0.386 |
| 98/99 | 0.545 | 0.970 | 0.698 | 0.670 | 0.768 | 1.000 |
| 99/00 | 0.834 | 0.582 | 1.000 | 0.621 | 0.913 | 0.835 |
| 00/01 | 0.965 | 0.683 | 0.627 | 1.000 | 0.576 | 0.446 |
| 01/02 | 0.404 | 1.000 | 0.657 | 0.732 | 0.516 | 0.859 |

Fit results for index = SeaMap SA
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 90/91 | 1.1505 | 1.1505 | 0.8938 | 0.2566 | 0.9126 |
| 91/92 | 1.4710 | 1.4710 | 0.9188 | 0.5522 | 1.9635 |
| 92/93 | 1.2571 | 1.2571 | 0.7766 | 0.4805 | 1.7086 |
| 93/94 | 0.5868 | 0.5868 | 0.8646 | -0.2778 | -0.9880 |
| 94/95 | 0.7636 | 0.7636 | 0.9578 | -0.1942 | -0.6905 |
| 95/96 | 0.9660 | 0.9660 | 0.9749 | -0.0089 | -0.0317 |
| 96/97 | 0.7318 | 0.7318 | 0.8596 | -0.1278 | -0.4545 |
| 97/98 | 0.4301 | 0.4301 | 0.7977 | -0.3676 | -1.3070 |
| 98/99 | 1.0635 | 1.0635 | 1.2060 | -0.1424 | -0.5065 |
| 99/00 | 0.9612 | 0.9612 | 1.1876 | -0.2265 | -0.8053 |
| 00/01 | 1.2335 | 1.2335 | 1.1788 | 0.0547 | 0.1944 |
| 01/02 | 1.3849 | 1.3849 | 1.3049 | 0.0800 | 0.2844 |

Index ML estimate of the variance: 0.0791 (S.E.: 0.2812)
ML estimate of catchability: 0.73543E-07
Pearsons (parametric) correlation: 0.431 P= 0.0217
Kendalls (nonparametric) Tau: 0.303 P= 0.0371

Selectivities set to 1.0

| year | 0 | 1 |
|---|---|---|
| 90/91 | 1.000 | 1.000 |
| 91/92 | 1.000 | 1.000 |
| 92/93 | 1.000 | 1.000 |
| 93/94 | 1.000 | 1.000 |
| 94/95 | 1.000 | 1.000 |
| 95/96 | 1.000 | 1.000 |
| 96/97 | 1.000 | 1.000 |

```
97/98 1.000 1.000
98/99 1.000 1.000
99/00 1.000 1.000
00/01 1.000 1.000
01/02 1.000 1.000


 Fit results for index = NCPamlicoSS
 Index Fitted to Beginning Stock Size in NUMBERS
         Scaled  Obj.Function Predicted   Residual Scaled resid
88/89    1.4421     1.4421       0.8014     0.6407     0.8195
89/90    0.8412     0.8412       0.7486     0.0926     0.1185
90/91    0.6009     0.6009       0.8652    -0.2643    -0.3380
91/92    1.3219     1.3219       0.9185     0.4034     0.5160
92/93    2.9442     2.9442       0.7598     2.1844     2.7939
93/94    0.4807     0.4807       0.8279    -0.3472    -0.4441
94/95    0.3004     0.3004       0.9433    -0.6428    -0.8222
95/96    1.2618     1.2618       0.9310     0.3308     0.4231
96/97    0.4807     0.4807       0.8248    -0.3441    -0.4401
97/98    1.5021     1.5021       0.7657     0.7364     0.9419
98/99    1.5021     1.5021       1.1374     0.3647     0.4665
99/00    0.1202     0.1202       1.1295    -1.0093    -1.2910
00/01    0.6609     0.6609       1.1244    -0.4634    -0.5928
01/02    0.5408     0.5408       1.2219    -0.6812    -0.8713

    Index ML estimate of the variance:    0.6113 (S.E.:    0.7818)
    ML estimate of catchability:  0.57672E-07
    Pearsons (parametric) correlation: -0.386 P= 0.0267
    Kendalls (nonparametric) Tau:      -0.300 P= 0.0244

         Selectivities set to 1.0
 year   0     1
88/89 1.000 1.000
89/90 1.000 1.000
90/91 1.000 1.000
91/92 1.000 1.000
92/93 1.000 1.000
93/94 1.000 1.000
94/95 1.000 1.000
95/96 1.000 1.000
96/97 1.000 1.000
97/98 1.000 1.000
98/99 1.000 1.000
99/00 1.000 1.000
00/01 1.000 1.000
01/02 1.000 1.000


 Fit results for index = NC Comm
 Index Fitted to Mid-Year  Stock Size in BIOMASS
         Scaled  Obj.Function Predicted   Residual Scaled resid
94/95    1.1224     1.1224       0.7811     0.3413     1.6177
95/96    0.8235     0.8235       0.8855    -0.0620    -0.2939
96/97    0.7191     0.7191       1.0018    -0.2827    -1.3398
97/98    1.1149     1.1149       0.9516     0.1634     0.7743
98/99    0.7432     0.7432       0.8919    -0.1487    -0.7047
99/00    0.8843     0.8843       1.1176    -0.2333    -1.1058
00/01    1.4131     1.4131       1.1864     0.2267     1.0745
01/02    1.1795     1.1795       1.1441     0.0353     0.1675

    Index ML estimate of the variance:    0.0445 (S.E.:    0.2110)
    ML estimate of catchability:  0.88581E-07
    Pearsons (parametric) correlation:  0.424 P= 0.0640
    Kendalls (nonparametric) Tau:       0.286 P= 0.1143

         Selectivity at age from Partial Catches
 year   1     2     3     4     5     6
94/95 0.884 0.802 0.921 1.000 0.445 0.272
95/96 0.831 0.854 1.000 0.852 0.167 0.419
96/97 0.793 0.731 1.000 0.743 0.421 0.285
97/98 0.605 1.000 0.666 0.528 0.373 0.327
98/99 0.408 1.000 0.694 0.459 0.458 0.488
99/00 0.513 0.470 1.000 0.541 0.817 0.793
00/01 0.695 0.597 0.574 1.000 0.577 0.447
01/02 0.384 1.000 0.644 0.631 0.325 0.237
```

Table 20. Maximum sustainable yield (MSY) and optimum yield (OY) related values from the Base model and the Full index model for Atlantic Spanish mackerel 2003 stock evaluation. SS is spawning stock biomass in weight of mature females (million pounds), F values are associated with the fully selected age, and yields are given in millions of pounds. 80% confidence intervals generated from 500 bootstrap projections.

**MODEL BASE**

| | SS MSY | F MSY | MSY | SS OY | F OY | OY |
|---|---|---|---|---|---|---|
| Median | 10.978 | 0.423 | 5.242 | 14.636 | 0.301 | 5.014 |
| low 80% | 9.164 | 0.376 | 4.372 | 12.445 | 0.270 | 4.258 |
| upp 80% | 13.350 | 0.477 | 6.392 | 17.603 | 0.341 | 6.081 |
| Deterministic | 10.724 | 0.396 | 5.190 | 14.298 | 0.282 | 4.967 |

**MODEL Full Index**

| | SS MSY | F MSY | MSY | SS OY | F OY | OY |
|---|---|---|---|---|---|---|
| Median | 11.053 | 0.425 | 5.289 | 14.787 | 0.303 | 5.063 |
| low 80% | 9.260 | 0.381 | 4.342 | 12.514 | 0.272 | 4.214 |
| upp 80% | 13.441 | 0.483 | 6.356 | 17.843 | 0.343 | 6.025 |
| Deterministic | 11.662 | 0.396 | 5.595 | 15.550 | 0.283 | 5.351 |

Table 21. Estimated acceptable biological catch (ABC) in millions of pounds for the Atlantic Spanish mackerel 2003/04 fishing year under a projected F of $F_{30\%SPR}$ or $F_{40\%SPR}$ from the Base and Full index models evaluated. Probability denotes the likelihood of exceeding the desired F mortality rates.

| | Base Model | | Full Index Model | |
|---|---|---|---|---|
| **Probability** | $F_{30\%SPR}$ | $F_{40\%SPR}$ | $F_{30\%SPR}$ | $F_{40\%SPR}$ |
| 50% Median | 8.917 | 6.672 | 8.462 | 6.351 |
| 10% lower CI | 6.006 | 4.507 | 5.733 | 4.263 |
| 90% upper CI | 12.757 | 9.522 | 12.468 | 9.228 |

Table 22. Gulf Spanish mackerel tuned VPA results for Base Model.

**Stock at Age at beginning of year**

| | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 14732636 | 17372510 | 11928751 | 8953796 | 10088168 | 17612294 | 20480494 | 10631903 | 14426936 | 11190025 | 13400307 |
| 1 | 6999048 | 9488062 | 11609464 | 7366721 | 5042974 | 5333385 | 9574104 | 12993424 | 7431278 | 7680443 | 6230636 |
| 2 | 4129420 | 4090733 | 5892171 | 3970928 | 3648446 | 2136999 | 3062961 | 5221050 | 6132645 | 3965710 | 3689292 |
| 3 | 1644058 | 1523894 | 1749548 | 2220238 | 1778515 | 1128289 | 1222099 | 1585516 | 2015988 | 2712408 | 1484328 |
| 4 | 329620 | 728406 | 656461 | 1014616 | 1187499 | 840803 | 564916 | 597047 | 602825 | 814043 | 1238964 |
| 5 | 125006 | 167672 | 304983 | 342787 | 384437 | 503278 | 399196 | 233038 | 177518 | 196847 | 288144 |
| 6 | 11549 | 89895 | 121997 | 168592 | 102553 | 138756 | 219793 | 183147 | 47993 | 52639 | 84791 |
| 7+ | 31340 | 29919 | 76789 | 100747 | 109801 | 68050 | 107022 | 183241 | 156534 | 83151 | 53607 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 |
|---|---|---|---|---|---|---|---|---|
| 0 | 9921689 | 9201181 | 11534859 | 11738113 | 12024745 | 14360439 | 13674323 | 0 |
| 1 | 8169493 | 5554915 | 5210006 | 7087946 | 7375047 | 7725450 | 9107291 | 8539912 |
| 2 | 3202995 | 5204506 | 3120959 | 3200499 | 4586996 | 4395216 | 4956850 | 6127578 |
| 3 | 1945760 | 1552723 | 3328401 | 1722341 | 1553578 | 2723816 | 2218263 | 2119297 |
| 4 | 591053 | 1271663 | 791971 | 1931787 | 738839 | 599019 | 1451353 | 908035 |
| 5 | 652508 | 332319 | 861166 | 494392 | 1268458 | 327164 | 184274 | 933528 |
| 6 | 156730 | 448136 | 203698 | 623133 | 342559 | 893040 | 215194 | 112631 |
| 7+ | 68263 | 144187 | 407328 | 437350 | 759935 | 786639 | 1231223 | 1034466 |

**F at age during year**

| | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.14 | 0.1031 | 0.182 | 0.2741 | 0.3374 | 0.3095 | 0.155 | 0.0582 | 0.3304 | 0.2855 | 0.1949 |
| 1 | 0.237 | 0.1764 | 0.7728 | 0.4027 | 0.5586 | 0.2546 | 0.3064 | 0.4508 | 0.328 | 0.4332 | 0.3654 |
| 2 | 0.6969 | 0.5494 | 0.676 | 0.5032 | 0.8736 | 0.2588 | 0.3585 | 0.6516 | 0.5158 | 0.6827 | 0.3398 |
| 3 | 0.5141 | 0.5422 | 0.2448 | 0.3258 | 0.4492 | 0.3918 | 0.4163 | 0.667 | 0.6069 | 0.4836 | 0.6208 |
| 4 | 0.3759 | 0.5706 | 0.3498 | 0.6705 | 0.5585 | 0.4449 | 0.5855 | 0.9129 | 0.8192 | 0.7386 | 0.3412 |
| 5 | 0.0297 | 0.018 | 0.2928 | 0.9067 | 0.7191 | 0.5285 | 0.4792 | 1.2801 | 0.9156 | 0.5422 | 0.3089 |
| 6 | 0.0601 | 0.1449 | 0.3796 | 0.5973 | 0.838 | 0.3587 | 0.2786 | 0.5504 | 0.6 | 0.6294 | 0.4068 |
| 7+ | 0.0601 | 0.1449 | 0.3796 | 0.5973 | 0.838 | 0.3587 | 0.2786 | 0.5504 | 0.6 | 0.6294 | 0.4068 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 |
|---|---|---|---|---|---|---|---|
| 0 | 0.28 | 0.2688 | 0.187 | 0.1647 | 0.1424 | 0.1554 | 0.1708 |
| 1 | 0.1509 | 0.2765 | 0.1873 | 0.1352 | 0.2176 | 0.1437 | 0.0963 |
| 2 | 0.4241 | 0.147 | 0.2945 | 0.4227 | 0.2212 | 0.3838 | 0.5497 |
| 3 | 0.1253 | 0.3732 | 0.244 | 0.5464 | 0.653 | 0.3295 | 0.5932 |
| 4 | 0.2758 | 0.0898 | 0.1712 | 0.1206 | 0.5146 | 0.8789 | 0.1413 |
| 5 | 0.0757 | 0.1895 | 0.0235 | 0.0669 | 0.0509 | 0.1189 | 0.1923 |
| 6 | 0.145 | 0.0744 | 0.0344 | 0.0332 | 0.0376 | 0.0106 | 0.1659 |
| 7+ | 0.145 | 0.0744 | 0.0344 | 0.0332 | 0.0376 | 0.0106 | 0.014 |

## Parameter Estimates Gulf Spanish Base Model

```
Update of FADAPT Version 3 (Feb 96) by V. Restrepo

    Input DATA file: glf1spn03a.inp
    Input CONTROL file: glf2spn03a.inp
    Output Stock Size file: GlfSPA.naa
    Output Fishing Mortality file: GlfSPA.faa
    Ouput Fitted Indices file: GlfSPA.ind
    Output Diagnostics (this) file: GlfSPA.par

    Run name: Gulf Spanish-03 Base
    No. index values:  77  Parameters:  8
    Mean Squared Error (rss/df) =  0.21572E+00
    Rsquared = -0.3648
    Loglikelihood = -0.37532E+02


 res from indices   =    35.7715360718823
 res from curvature =   0.000000000000000E+000


  Program termination OK

More details of the run can be found in fileFADAPT5.RUN

 Parameter   Estimate    S.E.       % C.V.
 F age   0   0.1708     0.04995     29.25
 F age   1   0.0963     0.03034     31.51
 F age   2   0.5497     0.29182     53.09
 F age   3   0.5932     0.28220     47.57
 F age   4   0.1413     0.07231     51.18
 F age   5   0.1923     0.07347     38.20
 F age   6   0.1659     0.11673     70.37
 F age   7   0.0140     0.00484     34.52



 Variances of terminal yr F and survivors
  Age,  SE(F,101)    CV(F)      SE(N,102)     CV(N)
  0   0.49950E-01  29.24989
  1   0.30337E-01  31.51026   0.27279E+07  31.94262
  2   0.29182      53.08932   0.20299E+07  33.12701
  3   0.28220      47.57263   0.14776E+07  69.72244
  4   0.72313E-01  51.18404   0.57892E+06  63.75569
  5   0.73469E-01  38.20444   0.51404E+06  55.06476
  6   0.11673      70.37222    47506.      42.17806
  7   0.48394E-02  34.51822   0.32944E+06  31.84663

  Obs. and pred. indices in objective function
  0.15333E+01  0.85364E+00
  0.10044E+01  0.14246E+01
  0.16367E+01  0.89017E+00
  0.88238E+00  0.81086E+00
  0.66900E+00  0.99542E+00
  0.98166E+00  0.83881E+00
  0.13808E+01  0.79200E+00
  0.11328E+01  0.88629E+00
  0.11982E+01  0.10751E+01
  0.10570E+01  0.11099E+01
  0.58258E+00  0.99481E+00
  0.65056E+00  0.10010E+01
  0.84310E+00  0.11969E+01
  0.12570E+01  0.87505E+00
  0.59076E+00  0.96929E+00
  0.49805E+00  0.40781E+00
  0.11018E+01  0.11679E+01
  0.45782E+00  0.86832E+00
  0.40443E+00  0.89816E+00
  0.15003E+01  0.23191E+01
  0.65264E+00  0.85385E+00
  0.16555E+01  0.76626E+00
  0.19699E+01  0.43470E+00
  0.85890E+00  0.68071E+00
  0.17131E+01  0.98806E+00
  0.12188E+01  0.10295E+01
  0.88746E+00  0.10253E+01
  0.92213E+00  0.53789E+00
  0.48953E+00  0.77411E+00
  0.11166E+01  0.56920E+00
  0.38197E+00  0.77302E+00
  0.11800E+01  0.48142E+00
  0.90992E+00  0.47162E+00
  0.65796E+00  0.76516E+00
  0.10230E+01  0.80757E+00
  0.62693E+00  0.10061E+01
  0.88136E+00  0.63546E+00
  0.21716E+01  0.20586E+01
  0.68739E+00  0.76324E+00
  0.36204E+00  0.49328E+00
  0.12707E+01  0.11723E+01
  0.90865E+00  0.10889E+01
  0.79489E+00  0.14021E+01
  0.79450E+00  0.10387E+01
  0.82577E+00  0.79316E+00
  0.10917E+01  0.81188E+00
  0.11691E+01  0.89687E+00
  0.11215E+01  0.14673E+01
  0.11603E+01  0.90918E+00
  0.13223E+01  0.99074E+00
  0.14636E+01  0.99458E+00
  0.96450E+00  0.98251E+00
  0.94096E+00  0.70503E+00
  0.87774E+00  0.65510E+00
  0.81640E+00  0.82918E+00
  0.85216E+00  0.84727E+00
  0.87105E+00  0.87016E+00
  0.10365E+01  0.10370E+01
  0.98836E+00  0.98836E+00
  0.56758E+00  0.13408E+01
  0.11958E+01  0.72848E+00
  0.37459E+00  0.10402E+01
  0.12660E+01  0.11197E+01
  0.55174E+00  0.10295E+01
  0.11368E+01  0.64876E+00
  0.90737E+00  0.68153E+00
  0.15329E+01  0.92087E+00
  0.96381E+00  0.85981E+00
  0.95846E+00  0.14115E+01
  0.10443E+01  0.54577E+00
  0.16112E+01  0.94099E+00
  0.18177E+01  0.65626E+00
  0.10176E+01  0.13645E+01
  0.70861E+00  0.56668E+00
  0.68306E+00  0.61939E+00
  0.10127E+01  0.91848E+00
  0.64972E+00  0.84564E+00
```

# INDEX RESULTS

Maximum likelihood weighting for indices

Fit results for index = FWC
Index Fitted to Beginning Stock Size in BIOMASS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 85/86 | 1.5333 | 1.5333 | 0.8536 | 0.6797 | 1.7820 |
| 86/87 | 1.0044 | 1.0044 | 1.4246 | -0.4202 | -1.1018 |
| 87/88 | 1.6367 | 1.6367 | 0.8902 | 0.7465 | 1.9573 |
| 88/89 | 0.8824 | 0.8824 | 0.8109 | 0.0715 | 0.1875 |
| 89/90 | 0.6690 | 0.6690 | 0.9954 | -0.3264 | -0.8558 |
| 90/91 | 0.9817 | 0.9817 | 0.8388 | 0.1429 | 0.3746 |
| 91/92 | 1.3808 | 1.3808 | 0.7920 | 0.5888 | 1.5438 |
| 92/93 | 1.1328 | 1.1328 | 0.8863 | 0.2466 | 0.6465 |
| 93/94 | 1.1982 | 1.1982 | 1.0751 | 0.1231 | 0.3228 |
| 94/95 | 1.0570 | 1.0570 | 1.1099 | -0.0529 | -0.1388 |
| 95/96 | 0.5826 | 0.5826 | 0.9948 | -0.4122 | -1.0808 |
| 96/97 | 0.6506 | 0.6506 | 1.0010 | -0.3504 | -0.9188 |
| 97/98 | 0.8431 | 0.8431 | 1.1969 | -0.3538 | -0.9276 |
| 98/99 | 1.2570 | 1.2570 | 0.8750 | 0.3819 | 1.0014 |
| 99/00 | 0.5908 | 0.5908 | 0.9693 | -0.3785 | -0.9925 |
| 00/01 | 0.4980 | 0.4980 | 0.4078 | 0.0902 | 0.2366 |
| 01/02 | 1.1018 | 1.1018 | 1.1679 | -0.0661 | -0.1734 |

Index ML estimate of the variance: 0.1455 (S.E.: 0.3814)
ML estimate of catchability: 0.10971E-06
Pearsons (parametric) correlation: 0.062 P= 0.5125
Kendalls (nonparametric) Tau: -0.044 P= 0.5138

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 85/86 | 0.172 | 1.000 | 0.065 | 0.037 | 0.015 | 0.001 | 0.047 |
| 86/87 | 1.000 | 0.449 | 0.203 | 0.088 | 0.103 | 0.008 | 0.101 |
| 87/88 | 0.051 | 0.173 | 0.324 | 0.706 | 1.000 | 0.636 | 0.263 |
| 88/89 | 0.085 | 0.343 | 0.242 | 0.402 | 0.611 | 0.911 | 1.000 |
| 89/90 | 0.090 | 0.274 | 0.724 | 1.000 | 0.844 | 0.507 | 0.753 |
| 90/91 | 0.110 | 0.262 | 0.523 | 1.000 | 0.848 | 0.321 | 0.089 |
| 91/92 | 0.073 | 0.224 | 0.365 | 0.544 | 1.000 | 0.599 | 0.360 |
| 92/93 | 0.077 | 0.232 | 0.452 | 0.747 | 1.000 | 0.582 | 0.501 |
| 93/94 | 0.056 | 0.428 | 0.491 | 0.754 | 0.524 | 0.582 | 1.000 |
| 94/95 | 0.194 | 0.242 | 1.000 | 0.591 | 0.561 | 0.769 | 0.914 |
| 95/96 | 0.118 | 0.694 | 0.319 | 1.000 | 0.221 | 0.506 | 0.307 |
| 96/97 | 0.140 | 0.105 | 0.832 | 0.409 | 1.000 | 0.244 | 0.423 |
| 97/98 | 0.010 | 0.407 | 0.559 | 1.000 | 0.184 | 0.359 | 0.025 |
| 98/99 | 0.006 | 0.518 | 1.000 | 0.100 | 0.074 | 0.008 | 0.004 |
| 99/00 | 0.135 | 0.143 | 0.818 | 1.000 | 0.110 | 0.086 | 0.076 |
| 00/01 | 0.005 | 0.067 | 0.123 | 1.000 | 0.104 | 0.005 | 0.001 |
| 01/02 | 0.196 | 0.452 | 0.790 | 0.049 | 1.000 | 0.284 | 0.003 |

Fit results for index = MRFSS
Index Fitted to Beginning Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.4578 | 0.4578 | 0.8683 | -0.4105 | -0.6937 |
| 85/86 | 0.4044 | 0.4044 | 0.8982 | -0.4937 | -0.8344 |
| 86/87 | 1.5003 | 1.5003 | 2.3191 | -0.8188 | -1.3838 |
| 87/88 | 0.6526 | 0.6526 | 0.8538 | -0.2012 | -0.3400 |
| 88/89 | 1.6555 | 1.6555 | 0.7663 | 0.8893 | 1.5029 |
| 89/90 | 1.9699 | 1.9699 | 0.4347 | 1.5352 | 2.5945 |
| 90/91 | 0.8589 | 0.8589 | 0.6807 | 0.1782 | 0.3011 |
| 91/92 | 1.7131 | 1.7131 | 0.9881 | 0.7250 | 1.2252 |
| 92/93 | 1.2188 | 1.2188 | 1.0295 | 0.1894 | 0.3200 |
| 93/94 | 0.8875 | 0.8875 | 1.0253 | -0.1379 | -0.2330 |
| 94/95 | 0.9221 | 0.9221 | 0.5379 | 0.3842 | 0.6494 |
| 95/96 | 0.4895 | 0.4895 | 0.7741 | -0.2846 | -0.4809 |
| 96/97 | 1.1166 | 1.1166 | 0.5692 | 0.5474 | 0.9250 |
| 97/98 | 0.3820 | 0.3820 | 0.7730 | -0.3911 | -0.6609 |
| 98/99 | 1.1800 | 1.1800 | 0.4814 | 0.6986 | 1.1806 |
| 99/00 | 0.9099 | 0.9099 | 0.4716 | 0.4383 | 0.7407 |
| 00/01 | 0.6580 | 0.6580 | 0.7652 | -0.1072 | -0.1812 |
| 01/02 | 1.0230 | 1.0230 | 0.8076 | 0.2154 | 0.3641 |

Index ML estimate of the variance: 0.3501 (S.E.: 0.5917)
ML estimate of catchability: 0.13403E-06
Pearsons (parametric) correlation: 0.136 P= 0.3007
Kendalls (nonparametric) Tau: -0.111 P= 0.2563

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 |
|---|---|---|---|
| 84/85 | 0.280 | 1.000 | 0.238 |
| 85/86 | 0.245 | 1.000 | 0.187 |
| 86/87 | 1.000 | 0.901 | 0.221 |
| 87/88 | 0.295 | 0.497 | 1.000 |
| 88/89 | 0.267 | 0.711 | 1.000 |
| 89/90 | 0.271 | 0.313 | 1.000 |
| 90/91 | 0.285 | 0.369 | 1.000 |
| 91/92 | 0.259 | 0.464 | 1.000 |
| 92/93 | 0.350 | 0.500 | 1.000 |
| 93/94 | 0.244 | 0.772 | 1.000 |
| 94/95 | 0.293 | 0.191 | 1.000 |
| 95/96 | 0.151 | 1.000 | 0.687 |
| 96/97 | 0.356 | 0.138 | 1.000 |
| 97/98 | 0.140 | 0.549 | 1.000 |
| 98/99 | 0.035 | 0.507 | 1.000 |
| 99/00 | 0.174 | 0.148 | 1.000 |
| 00/01 | 0.030 | 0.626 | 1.000 |
| 01/02 | 0.007 | 0.754 | 1.000 |

Fit results for index = Chart NWF
Index Fitted to Beginning Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.6269 | 0.6269 | 1.0061 | -0.3792 | -1.8589 |
| 85/86 | 0.8814 | 0.8814 | 0.6355 | 0.2459 | 1.2054 |
| 86/87 | 2.1716 | 2.1716 | 2.0586 | 0.1130 | 0.5538 |
| 87/88 | 0.6874 | 0.6874 | 0.7632 | -0.0759 | -0.3719 |
| 89/90 | 0.3620 | 0.3620 | 0.4933 | -0.1312 | -0.6434 |
| 91/92 | 1.2707 | 1.2707 | 1.1723 | 0.0984 | 0.4823 |

Index ML estimate of the variance: 0.0416 (S.E.: 0.2040)
ML estimate of catchability: 0.13402E-06
Pearsons (parametric) correlation: 0.942 P= 0.0000
Kendalls (nonparametric) Tau: 0.600 P= 0.0119

Selectivity at age from Partial Catches

| year | 1 | 2 |
|---|---|---|
| 84/85 | 0.483 | 1.000 |
| 85/86 | 0.069 | 1.000 |
| 86/87 | 1.000 | 0.637 |
| 87/88 | 0.234 | 1.000 |
| 89/90 | 0.289 | 1.000 |
| 91/92 | 0.271 | 1.000 |

Fit results for index = Bycatch GLM
Index Fitted to Beginning Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.9086 | 0.9086 | 1.0889 | -0.1803 | -0.6889 |
| 85/86 | 0.7949 | 0.7949 | 1.4021 | -0.6072 | -2.3204 |
| 86/87 | 0.7945 | 0.7945 | 1.0387 | -0.2442 | -0.9330 |
| 87/88 | 0.8258 | 0.8258 | 0.7932 | 0.0326 | 0.1246 |
| 88/89 | 1.0917 | 1.0917 | 0.8119 | 0.2799 | 1.0695 |
| 89/90 | 1.1691 | 1.1691 | 0.8969 | 0.2722 | 1.0403 |
| 90/91 | 1.1215 | 1.1215 | 1.4673 | -0.3459 | -1.3217 |
| 91/92 | 1.1603 | 1.1603 | 0.9092 | 0.2511 | 0.9595 |
| 92/93 | 1.3223 | 1.3223 | 0.9907 | 0.3316 | 1.2671 |
| 93/94 | 1.4636 | 1.4636 | 0.9946 | 0.4690 | 1.7922 |
| 94/95 | 0.9645 | 0.9645 | 0.9825 | -0.0180 | -0.0688 |
| 95/96 | 0.9410 | 0.9410 | 0.7050 | 0.2359 | 0.9015 |
| 96/97 | 0.8777 | 0.8777 | 0.6551 | 0.2226 | 0.8508 |
| 97/98 | 0.8164 | 0.8164 | 0.8292 | -0.0128 | -0.0488 |
| 98/99 | 0.8522 | 0.8522 | 0.8473 | 0.0049 | 0.0187 |
| 99/00 | 0.8711 | 0.8711 | 0.8702 | 0.0009 | 0.0034 |
| 00/01 | 1.0365 | 1.0365 | 1.0370 | -0.0005 | -0.0018 |
| 01/02 | 0.9884 | 0.9884 | 0.9884 | 0.0000 | 0.0000 |

Index ML estimate of the variance: 0.0685 (S.E.: 0.2617)
ML estimate of catchability: 0.48037E-07
Pearsons (parametric) correlation: 0.107 P= 0.3757
Kendalls (nonparametric) Tau: 0.137 P= 0.1843

Selectivity at age from Partial Catches

| year | 0 | 1 | 2 |
|---|---|---|---|
| 84/85 | 0.909 | 1.000 | 0.553 |
| 85/86 | 1.000 | 0.947 | 0.692 |
| 86/87 | 1.000 | 0.665 | 0.335 |
| 87/88 | 1.000 | 0.773 | 0.469 |
| 88/89 | 1.000 | 0.779 | 0.790 |
| 89/90 | 1.000 | 0.178 | 0.051 |
| 90/91 | 1.000 | 0.911 | 0.440 |
| 91/92 | 0.174 | 1.000 | 0.783 |
| 92/93 | 1.000 | 0.489 | 0.418 |
| 93/94 | 0.889 | 1.000 | 0.777 |
| 94/95 | 1.000 | 0.791 | 0.575 |
| 95/96 | 1.000 | 0.390 | 0.490 |
| 96/97 | 1.000 | 0.566 | 0.248 |
| 97/98 | 1.000 | 0.754 | 0.575 |
| 98/99 | 1.000 | 0.557 | 0.611 |
| 99/00 | 1.000 | 0.575 | 0.403 |
| 00/01 | 1.000 | 0.630 | 0.537 |
| 01/02 | 1.000 | 0.494 | 0.484 |

Fit results for index = TPWD
Index Fitted to Beginning Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.5676 | 0.5676 | 1.3408 | -0.7732 | -1.5250 |
| 85/86 | 1.1958 | 1.1958 | 0.7285 | 0.4673 | 0.9216 |
| 86/87 | 0.3746 | 0.3746 | 1.0402 | -0.6656 | -1.3128 |
| 87/88 | 1.2660 | 1.2660 | 1.1197 | 0.1463 | 0.2886 |
| 88/89 | 0.5517 | 0.5517 | 1.0295 | -0.4777 | -0.9423 |
| 89/90 | 1.1368 | 1.1368 | 0.6488 | 0.4880 | 0.9625 |

| | | | | | |
|---|---|---|---|---|---|
| 90/91 | 0.9074 | 0.9074 | 0.6815 | 0.2258 | 0.4454 |
| 91/92 | 1.5329 | 1.5329 | 0.9209 | 0.6120 | 1.2071 |
| 92/93 | 0.9638 | 0.9638 | 0.8598 | 0.1040 | 0.2051 |
| 93/94 | 0.9585 | 0.9585 | 1.4115 | -0.4530 | -0.8935 |
| 94/95 | 1.0443 | 1.0443 | 0.5458 | 0.4986 | 0.9834 |
| 95/96 | 1.6112 | 1.6112 | 0.9410 | 0.6702 | 1.3220 |
| 96/97 | 1.8177 | 1.8177 | 0.6563 | 1.1614 | 2.2908 |
| 97/98 | 1.0176 | 1.0176 | 1.3645 | -0.3469 | -0.6841 |
| 98/99 | 0.7086 | 0.7086 | 0.5667 | 0.1419 | 0.2799 |
| 99/00 | 0.6831 | 0.6831 | 0.6194 | 0.0637 | 0.1256 |
| 00/01 | 1.0127 | 1.0127 | 0.9185 | 0.0943 | 0.1859 |
| 01/02 | 0.6497 | 0.6497 | 0.8456 | -0.1959 | -0.3864 |

Index ML estimate of the variance: 0.2571 (S.E.: 0.5070)
ML estimate of catchability: 0.26915E-06
Pearsons (parametric) correlation: -0.172 P= 0.2202
Kendalls (nonparametric) Tau: -0.072 P= 0.3929

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 |
|---|---|---|---|
| 84/85 | 0.048 | 0.727 | 1.000 |
| 85/86 | 0.012 | 0.262 | 1.000 |
| 86/87 | 0.056 | 0.249 | 1.000 |
| 87/88 | 0.128 | 0.252 | 1.000 |
| 88/89 | 0.113 | 0.404 | 1.000 |
| 89/90 | 0.146 | 0.235 | 1.000 |
| 90/91 | 0.077 | 0.187 | 1.000 |
| 91/92 | 0.048 | 0.233 | 1.000 |
| 92/93 | 0.037 | 0.147 | 1.000 |
| 93/94 | 0.047 | 0.547 | 1.000 |
| 94/95 | 0.036 | 0.087 | 1.000 |
| 95/96 | 0.040 | 0.383 | 1.000 |
| 96/97 | 0.088 | 0.077 | 1.000 |
| 97/98 | 0.062 | 0.455 | 1.000 |
| 98/99 | 0.010 | 0.096 | 1.000 |
| 99/00 | 0.049 | 0.085 | 1.000 |
| 00/01 | 0.009 | 0.141 | 1.000 |
| 01/02 | 0.044 | 0.105 | 1.000 |

Table 23. Gulf Spanish mackerel tuned VPA results for Full Index Model.

**Stock at Age at beginning of year**

| | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 14737263 | 17377629 | 11931156 | 8958462 | 10101936 | 17650273 | 20603608 | 10692510 | 14615868 | 11297739 | 13688978 |
| **1** | 7000571 | 9491488 | 11613256 | 7368502 | 5046424 | 5343556 | 9602173 | 13084575 | 7476173 | 7820036 | 6310274 |
| **2** | 4129790 | 4091860 | 5894707 | 3973696 | 3649760 | 2139535 | 3070483 | 5241796 | 6199837 | 3998882 | 3792237 |
| **3** | 1644302 | 1524165 | 1750376 | 2222095 | 1780553 | 1129244 | 1223975 | 1591072 | 2031198 | 2761864 | 1508625 |
| **4** | 329709 | 728585 | 656660 | 1015228 | 1188872 | 842305 | 565621 | 598431 | 606896 | 825210 | 1275395 |
| **5** | 125048 | 167737 | 305115 | 342935 | 384886 | 504287 | 400303 | 233556 | 178522 | 199814 | 296308 |
| **6** | 11553 | 89926 | 122045 | 168690 | 102660 | 139084 | 220535 | 183963 | 48361 | 53368 | 86973 |
| **7+** | 31350 | 29930 | 76819 | 100805 | 109915 | 68211 | 107383 | 184058 | 157734 | 84303 | 54987 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 |
|---|---|---|---|---|---|---|---|---|
| **0** | 10182431 | 10023981 | 12307407 | 10717137 | 12709560 | 14446252 | 13828633 | 0 |
| **1** | 8383149 | 5747713 | 5818563 | 7659802 | 6619251 | 8232533 | 9170825 | 8654146 |
| **2** | 3261800 | 5362700 | 3263528 | 3650981 | 5010460 | 3836050 | 5332326 | 6174634 |
| **3** | 2021813 | 1596099 | 3445533 | 1827744 | 1886050 | 3037181 | 1805798 | 2395576 |
| **4** | 608885 | 1327983 | 823997 | 2018438 | 816393 | 843327 | 1682951 | 605990 |
| **5** | 679422 | 345506 | 902882 | 518101 | 1332628 | 384287 | 363151 | 1105027 |
| **6** | 162765 | 468072 | 213459 | 654036 | 360121 | 940575 | 257500 | 245088 |
| **7+** | 70891 | 150601 | 426846 | 459039 | 798895 | 828511 | 1297457 | 1114857 |

**F at age during year**

| | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0.14 | 0.103 | 0.1819 | 0.2739 | 0.3368 | 0.3088 | 0.154 | 0.0578 | 0.3254 | 0.2824 | 0.1904 |
| **1** | 0.237 | 0.1763 | 0.7725 | 0.4026 | 0.5581 | 0.2541 | 0.3053 | 0.4469 | 0.3257 | 0.4237 | 0.3599 |
| **2** | 0.6968 | 0.5492 | 0.6756 | 0.5028 | 0.8731 | 0.2585 | 0.3574 | 0.648 | 0.5086 | 0.6748 | 0.329 |
| **3** | 0.514 | 0.542 | 0.2447 | 0.3254 | 0.4485 | 0.3914 | 0.4155 | 0.6638 | 0.6007 | 0.4726 | 0.6073 |
| **4** | 0.3758 | 0.5704 | 0.3496 | 0.6699 | 0.5576 | 0.4439 | 0.5845 | 0.9096 | 0.811 | 0.7242 | 0.3298 |
| **5** | 0.0297 | 0.018 | 0.2926 | 0.9061 | 0.7179 | 0.5271 | 0.4775 | 1.2747 | 0.9075 | 0.5318 | 0.2991 |
| **6** | 0.0601 | 0.1448 | 0.3794 | 0.5968 | 0.8367 | 0.3577 | 0.2775 | 0.5472 | 0.5939 | 0.6178 | 0.3944 |
| **7+** | 0.0601 | 0.1448 | 0.3794 | 0.5968 | 0.8367 | 0.3577 | 0.2775 | 0.5472 | 0.5939 | 0.6178 | 0.3944 |

| | 95 | 96 | 97 | 98 | 99 | 100 | 101 |
|---|---|---|---|---|---|---|---|
| **0** | 0.2719 | 0.2439 | 0.1742 | 0.1819 | 0.1343 | 0.1544 | 0.1687 |
| **1** | 0.1468 | 0.266 | 0.1661 | 0.1245 | 0.2455 | 0.1343 | 0.0956 |
| **2** | 0.4147 | 0.1424 | 0.2797 | 0.3605 | 0.2006 | 0.4534 | 0.5002 |
| **3** | 0.1203 | 0.3612 | 0.2348 | 0.5059 | 0.5049 | 0.2904 | 0.7919 |
| **4** | 0.2666 | 0.0858 | 0.164 | 0.1152 | 0.4535 | 0.5425 | 0.1207 |
| **5** | 0.0726 | 0.1816 | 0.0224 | 0.0637 | 0.0484 | 0.1004 | 0.0932 |
| **6** | 0.1392 | 0.0712 | 0.0328 | 0.0317 | 0.0357 | 0.0101 | 0.1368 |
| **7+** | 0.1392 | 0.0712 | 0.0328 | 0.0317 | 0.0357 | 0.0101 | 0.0133 |

## Parameter Estimates Gulf Spanish Full Index Model

```
Update of FADAPT Version 3 (Feb 96) by V. Restrepo

    Input DATA file: glf1spn03.inp
    Input CONTROL file: glf2spn03.inp
    Output Stock Size file: GlfSPA.naa
    Output Fishing Mortality file: GlfSPA.faa
    Ouput Fitted Indices file: GlfSPA.ind
    Output Diagnostics (this) file: GlfSPA.par

    Run name: Gulf Spanish-03 Full Index
    No. index values: 111  Parameters:  8
    Mean Squared Error (rss/df) =  0.25132E+00
    Rsquared = -0.4405
    Loglikelihood = -0.58900E+02


 res from indices   =    57.0894191571244
 res from curvature =   0.000000000000000E+000


  Program termination OK

More details of the run can be found in fileFADAPT5.RUN
```

| Parameter | Estimate | S.E. | % C.V. |
|---|---|---|---|
| F age 0 | 0.1687 | 0.04826 | 28.61 |
| F age 1 | 0.0956 | 0.02947 | 30.84 |
| F age 2 | 0.5002 | 0.17179 | 34.35 |
| F age 3 | 0.7919 | 0.26852 | 33.91 |
| F age 4 | 0.1207 | 0.04495 | 37.25 |
| F age 5 | 0.0932 | 0.06047 | 64.88 |
| F age 6 | 0.1368 | 0.08161 | 59.67 |
| F age 7 | 0.0133 | 0.00380 | 28.54 |

Variances of terminal yr F and survivors

| Age, | SE(F,101) | CV(F) | SE(N,102) | CV(N) |
|---|---|---|---|---|
| 0 | 0.48258E-01 | 28.60519 | | |
| 1 | 0.29473E-01 | 30.83623 | 0.27006E+07 | 31.20588 |
| 2 | 0.17179 | 34.34658 | 0.20010E+07 | 32.40676 |
| 3 | 0.26852 | 33.90793 | 0.10557E+07 | 44.06949 |
| 4 | 0.44955E-01 | 37.25155 | 0.30136E+06 | 49.72973 |
| 5 | 0.60465E-01 | 64.87539 | 0.43821E+06 | 39.65642 |
| 6 | 0.81612E-01 | 59.66976 | 0.16690E+06 | 68.09628 |
| 7 | 0.37957E-02 | 28.54027 | 0.29268E+06 | 26.25269 |

Obs. and pred. indices in objective function

| | |
|---|---|
| 0.15333E+01 | 0.83122E+00 |
| 0.10044E+01 | 0.13872E+01 |
| 0.16367E+01 | 0.86695E+00 |
| 0.88238E+00 | 0.79031E+00 |
| 0.66900E+00 | 0.97078E+00 |
| 0.98166E+00 | 0.81751E+00 |
| 0.13808E+01 | 0.77308E+00 |
| 0.11328E+01 | 0.86797E+00 |
| 0.11982E+01 | 0.10614E+01 |
| 0.10570E+01 | 0.10988E+01 |
| 0.58258E+00 | 0.99841E+00 |
| 0.65056E+00 | 0.10131E+01 |
| 0.84310E+00 | 0.12114E+01 |
| 0.12570E+01 | 0.90263E+00 |
| 0.59076E+00 | 0.10373E+01 |
| 0.49805E+00 | 0.59329E+00 |
| 0.11018E+01 | 0.11056E+01 |
| 0.45782E+00 | 0.86134E+00 |
| 0.40443E+00 | 0.89113E+00 |
| 0.15003E+01 | 0.23010E+01 |
| 0.65264E+00 | 0.84763E+00 |
| 0.16555E+01 | 0.76094E+00 |
| 0.19699E+01 | 0.43152E+00 |
| 0.85890E+00 | 0.67615E+00 |
| 0.17131E+01 | 0.98326E+00 |
| 0.12188E+01 | 0.10291E+01 |
| 0.88746E+00 | 0.10363E+01 |
| 0.92213E+00 | 0.54315E+00 |
| 0.48953E+00 | 0.78261E+00 |
| 0.11166E+01 | 0.58083E+00 |
| 0.38197E+00 | 0.79260E+00 |
| 0.11800E+01 | 0.50486E+00 |
| 0.90992E+00 | 0.59038E+00 |
| 0.65796E+00 | 0.86688E+00 |
| 0.10230E+01 | 0.61129E+00 |
| 0.62693E+00 | 0.10053E+01 |
| 0.88136E+00 | 0.63505E+00 |
| 0.21716E+01 | 0.20574E+01 |
| 0.68739E+00 | 0.76311E+00 |
| 0.36204E+00 | 0.49340E+00 |
| 0.12707E+01 | 0.11758E+01 |
| 0.90865E+00 | 0.10794E+01 |
| 0.79489E+00 | 0.13900E+01 |
| 0.79450E+00 | 0.10295E+01 |
| 0.82577E+00 | 0.78646E+00 |
| 0.10917E+01 | 0.80571E+00 |
| 0.11691E+01 | 0.89076E+00 |
| 0.11215E+01 | 0.14629E+01 |
| 0.11603E+01 | 0.90754E+00 |
| 0.13223E+01 | 0.99483E+00 |
| 0.14636E+01 | 0.10050E+01 |
| 0.96450E+00 | 0.99430E+00 |
| 0.94096E+00 | 0.71732E+00 |
| 0.87774E+00 | 0.70896E+00 |
| 0.81640E+00 | 0.87594E+00 |
| 0.85216E+00 | 0.76150E+00 |
| 0.87105E+00 | 0.91451E+00 |
| 0.10365E+01 | 0.10365E+01 |
| 0.98836E+00 | 0.98836E+00 |
| 0.56758E+00 | 0.13229E+01 |
| 0.11958E+01 | 0.71879E+00 |
| 0.37459E+00 | 0.10266E+01 |
| 0.12660E+01 | 0.11056E+01 |
| 0.55174E+00 | 0.10168E+01 |
| 0.11368E+01 | 0.64055E+00 |
| 0.90737E+00 | 0.67334E+00 |
| 0.15329E+01 | 0.91154E+00 |
| 0.96381E+00 | 0.85463E+00 |
| 0.95846E+00 | 0.14187E+01 |
| 0.10443E+01 | 0.54751E+00 |
| 0.16112E+01 | 0.96402E+00 |
| 0.18177E+01 | 0.66593E+00 |
| 0.10176E+01 | 0.13921E+01 |
| 0.70861E+00 | 0.59265E+00 |
| 0.68306E+00 | 0.75791E+00 |
| 0.10127E+01 | 0.10197E+01 |
| 0.64972E+00 | 0.66098E+00 |
| 0.13934E+01 | 0.10917E+01 |
| 0.10520E+01 | 0.12873E+01 |
| 0.75126E+00 | 0.88381E+00 |
| 0.11911E+01 | 0.66361E+00 |
| 0.80727E+00 | 0.74831E+00 |
| 0.12523E+01 | 0.13075E+01 |
| 0.10284E+01 | 0.15262E+01 |
| 0.10668E+01 | 0.79206E+00 |
| 0.12182E+01 | 0.10827E+01 |
| 0.10941E+01 | 0.83689E+00 |
| 0.74791E+00 | 0.10140E+01 |
| 0.10950E+01 | 0.75427E+00 |
| 0.59833E+00 | 0.74254E+00 |
| 0.10420E+01 | 0.91168E+00 |
| 0.66481E+00 | 0.79388E+00 |
| 0.99721E+00 | 0.94147E+00 |
| 0.56733E+00 | 0.12247E+01 |
| 0.21788E+00 | 0.12919E+01 |
| 0.93506E+00 | 0.10442E+01 |
| 0.17811E+01 | 0.66272E+00 |
| 0.47151E+00 | 0.20875E+00 |
| 0.11497E+01 | 0.13110E+01 |
| 0.93098E+00 | 0.10992E+01 |
| 0.30123E+01 | 0.68604E+00 |
| 0.10975E+01 | 0.14736E+00 |
| 0.66587E+00 | 0.57728E+00 |
| 0.11478E+01 | 0.86057E+00 |
| 0.10953E+01 | 0.60141E+00 |
| 0.11483E+01 | 0.10265E+01 |
| 0.73598E+00 | 0.54950E+00 |
| 0.64862E+00 | 0.97108E+00 |
| 0.89123E+00 | 0.10399E+01 |
| 0.86749E+00 | 0.74239E+00 |
| 0.63607E+00 | 0.93286E+00 |

## INDEX RESULTS

Maximum likelihood weighting for indices

Fit results for index = FWC
Index Fitted to Beginning Stock Size in BIOMASS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 85/86 | 1.5333 | 1.5333 | 0.8312 | 0.7021 | 1.7979 |
| 86/87 | 1.0044 | 1.0044 | 1.3872 | -0.3829 | -0.9804 |
| 87/88 | 1.6367 | 1.6367 | 0.8670 | 0.7697 | 1.9711 |
| 88/89 | 0.8824 | 0.8824 | 0.7903 | 0.0921 | 0.2358 |
| 89/90 | 0.6690 | 0.6690 | 0.9708 | -0.3018 | -0.7728 |
| 90/91 | 0.9817 | 0.9817 | 0.8175 | 0.1642 | 0.4203 |
| 91/92 | 1.3808 | 1.3808 | 0.7731 | 0.6077 | 1.5562 |
| 92/93 | 1.1328 | 1.1328 | 0.8680 | 0.2649 | 0.6783 |
| 93/94 | 1.1982 | 1.1982 | 1.0614 | 0.1368 | 0.3504 |
| 94/95 | 1.0570 | 1.0570 | 1.0988 | -0.0419 | -0.1072 |
| 95/96 | 0.5826 | 0.5826 | 0.9984 | -0.4158 | -1.0648 |
| 96/97 | 0.6506 | 0.6506 | 1.0131 | -0.3626 | -0.9284 |
| 97/98 | 0.8431 | 0.8431 | 1.2114 | -0.3683 | -0.9431 |
| 98/99 | 1.2570 | 1.2570 | 0.9026 | 0.3543 | 0.9074 |
| 99/00 | 0.5908 | 0.5908 | 1.0373 | -0.4465 | -1.1434 |
| 00/01 | 0.4980 | 0.4980 | 0.5933 | -0.0952 | -0.2439 |
| 01/02 | 1.1018 | 1.1018 | 1.1056 | -0.0039 | -0.0099 |

Index ML estimate of the variance: 0.1525 (S.E.: 0.3905)
ML estimate of catchability: 0.10680E-06
Pearsons (parametric) correlation: -0.083 P= 0.4521
Kendalls (nonparametric) Tau: -0.088 P= 0.3426

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 85/86 | 0.172 | 1.000 | 0.065 | 0.037 | 0.015 | 0.001 | 0.047 |
| 86/87 | 1.000 | 0.449 | 0.203 | 0.088 | 0.103 | 0.008 | 0.101 |
| 87/88 | 0.051 | 0.173 | 0.324 | 0.706 | 1.000 | 0.636 | 0.263 |
| 88/89 | 0.085 | 0.344 | 0.242 | 0.402 | 0.611 | 0.911 | 1.000 |
| 89/90 | 0.090 | 0.274 | 0.724 | 1.000 | 0.843 | 0.507 | 0.753 |
| 90/91 | 0.110 | 0.262 | 0.523 | 1.000 | 0.846 | 0.320 | 0.089 |
| 91/92 | 0.073 | 0.224 | 0.365 | 0.544 | 1.000 | 0.598 | 0.359 |
| 92/93 | 0.077 | 0.231 | 0.452 | 0.746 | 1.000 | 0.581 | 0.500 |
| 93/94 | 0.056 | 0.431 | 0.489 | 0.753 | 0.524 | 0.582 | 1.000 |
| 94/95 | 0.195 | 0.240 | 1.000 | 0.584 | 0.555 | 0.762 | 0.906 |
| 95/96 | 0.119 | 0.702 | 0.317 | 1.000 | 0.220 | 0.502 | 0.305 |
| 96/97 | 0.141 | 0.106 | 0.840 | 0.408 | 1.000 | 0.243 | 0.422 |
| 97/98 | 0.010 | 0.403 | 0.561 | 1.000 | 0.183 | 0.357 | 0.025 |
| 98/99 | 0.005 | 0.477 | 1.000 | 0.103 | 0.076 | 0.008 | 0.004 |
| 99/00 | 0.172 | 0.147 | 0.717 | 1.000 | 0.119 | 0.092 | 0.081 |
| 00/01 | 0.008 | 0.128 | 0.175 | 1.000 | 0.142 | 0.007 | 0.002 |
| 01/02 | 0.184 | 0.389 | 1.000 | 0.040 | 0.459 | 0.222 | 0.003 |

Fit results for index = MRFSS
Index Fitted to Beginning Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.4578 | 0.4578 | 0.8613 | -0.4035 | -0.6807 |
| 85/86 | 0.4044 | 0.4044 | 0.8911 | -0.4867 | -0.8210 |
| 86/87 | 1.5003 | 1.5003 | 2.3010 | -0.8007 | -1.3506 |
| 87/88 | 0.6526 | 0.6526 | 0.8476 | -0.1950 | -0.3289 |
| 88/89 | 1.6555 | 1.6555 | 0.7609 | 0.8946 | 1.5090 |
| 89/90 | 1.9699 | 1.9699 | 0.4315 | 1.5384 | 2.5950 |
| 90/91 | 0.8589 | 0.8589 | 0.6761 | 0.1827 | 0.3083 |
| 91/92 | 1.7131 | 1.7131 | 0.9833 | 0.7298 | 1.2310 |
| 92/93 | 1.2188 | 1.2188 | 1.0291 | 0.1897 | 0.3200 |
| 93/94 | 0.8875 | 0.8875 | 1.0363 | -0.1488 | -0.2510 |
| 94/95 | 0.9221 | 0.9221 | 0.5431 | 0.3790 | 0.6393 |
| 95/96 | 0.4895 | 0.4895 | 0.7826 | -0.2931 | -0.4944 |
| 96/97 | 1.1166 | 1.1166 | 0.5808 | 0.5357 | 0.9037 |
| 97/98 | 0.3820 | 0.3820 | 0.7926 | -0.4106 | -0.6926 |
| 98/99 | 1.1800 | 1.1800 | 0.5049 | 0.6751 | 1.1388 |
| 99/00 | 0.9099 | 0.9099 | 0.5904 | 0.3195 | 0.5390 |
| 00/01 | 0.6580 | 0.6580 | 0.8669 | -0.2089 | -0.3524 |
| 01/02 | 1.0230 | 1.0230 | 0.6113 | 0.4117 | 0.6945 |

Index ML estimate of the variance: 0.3515 (S.E.: 0.5928)
ML estimate of catchability: 0.13294E-06
Pearsons (parametric) correlation: 0.117 P= 0.3495
Kendalls (nonparametric) Tau: -0.176 P= 0.1047

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 |
|---|---|---|---|
| 84/85 | 0.280 | 1.000 | 0.238 |
| 85/86 | 0.245 | 1.000 | 0.187 |
| 86/87 | 1.000 | 0.901 | 0.221 |
| 87/88 | 0.295 | 0.498 | 1.000 |
| 88/89 | 0.267 | 0.711 | 1.000 |
| 89/90 | 0.271 | 0.313 | 1.000 |
| 90/91 | 0.284 | 0.369 | 1.000 |
| 91/92 | 0.258 | 0.464 | 1.000 |
| 92/93 | 0.351 | 0.498 | 1.000 |
| 93/94 | 0.244 | 0.781 | 1.000 |
| 94/95 | 0.295 | 0.189 | 1.000 |
| 95/96 | 0.151 | 1.000 | 0.674 |
| 96/97 | 0.354 | 0.138 | 1.000 |
| 97/98 | 0.129 | 0.542 | 1.000 |
| 98/99 | 0.035 | 0.467 | 1.000 |
| 99/00 | 0.255 | 0.174 | 1.000 |
| 00/01 | 0.032 | 0.839 | 1.000 |
| 01/02 | 0.005 | 0.514 | 1.000 |

Fit results for index = Chart NWF
Index Fitted to Beginning Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.6269 | 0.6269 | 1.0053 | -0.3784 | -1.8578 |
| 85/86 | 0.8814 | 0.8814 | 0.6351 | 0.2463 | 1.2094 |
| 86/87 | 2.1716 | 2.1716 | 2.0574 | 0.1142 | 0.5607 |
| 87/88 | 0.6874 | 0.6874 | 0.7631 | -0.0757 | -0.3718 |
| 89/90 | 0.3620 | 0.3620 | 0.4934 | -0.1314 | -0.6450 |
| 91/92 | 1.2707 | 1.2707 | 1.1758 | 0.0949 | 0.4660 |

Index ML estimate of the variance: 0.0415 (S.E.: 0.2037)
ML estimate of catchability: 0.13389E-06
Pearsons (parametric) correlation: 0.943 P= 0.0000
Kendalls (nonparametric) Tau: 0.600 P= 0.0119

Selectivity at age from Partial Catches

| year | 1 | 2 |
|---|---|---|
| 84/85 | 0.483 | 1.000 |
| 85/86 | 0.069 | 1.000 |
| 86/87 | 1.000 | 0.637 |
| 87/88 | 0.234 | 1.000 |
| 89/90 | 0.289 | 1.000 |
| 91/92 | 0.271 | 1.000 |

Fit results for index = Bycatch GLM
Index Fitted to Beginning Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.9086 | 0.9086 | 1.0794 | -0.1708 | -0.6640 |
| 85/86 | 0.7949 | 0.7949 | 1.3900 | -0.5951 | -2.3140 |
| 86/87 | 0.7945 | 0.7945 | 1.0295 | -0.2350 | -0.9138 |
| 87/88 | 0.8258 | 0.8258 | 0.7865 | 0.0393 | 0.1529 |
| 88/89 | 1.0917 | 1.0917 | 0.8057 | 0.2860 | 1.1123 |
| 89/90 | 1.1691 | 1.1691 | 0.8908 | 0.2783 | 1.0824 |
| 90/91 | 1.1215 | 1.1215 | 1.4629 | -0.3415 | -1.3279 |
| 91/92 | 1.1603 | 1.1603 | 0.9075 | 0.2527 | 0.9828 |
| 92/93 | 1.3223 | 1.3223 | 0.9948 | 0.3275 | 1.2735 |
| 93/94 | 1.4636 | 1.4636 | 1.0050 | 0.4585 | 1.7831 |
| 94/95 | 0.9645 | 0.9645 | 0.9943 | -0.0298 | -0.1159 |
| 95/96 | 0.9410 | 0.9410 | 0.7173 | 0.2236 | 0.8696 |
| 96/97 | 0.8777 | 0.8777 | 0.7090 | 0.1688 | 0.6563 |
| 97/98 | 0.8164 | 0.8164 | 0.8759 | -0.0595 | -0.2315 |
| 98/99 | 0.8522 | 0.8522 | 0.7615 | 0.0907 | 0.3526 |
| 99/00 | 0.8711 | 0.8711 | 0.9145 | -0.0435 | -0.1690 |
| 00/01 | 1.0365 | 1.0365 | 1.0365 | 0.0000 | 0.0000 |
| 01/02 | 0.9884 | 0.9884 | 0.9884 | 0.0000 | 0.0000 |

Index ML estimate of the variance: 0.0661 (S.E.: 0.2572)
ML estimate of catchability: 0.47607E-07
Pearsons (parametric) correlation: 0.111 P= 0.3646
Kendalls (nonparametric) Tau: 0.098 P= 0.2982

Selectivity at age from Partial Catches

| year | 0 | 1 | 2 |
|---|---|---|---|
| 84/85 | 0.909 | 1.000 | 0.553 |
| 85/86 | 1.000 | 0.947 | 0.692 |
| 86/87 | 1.000 | 0.665 | 0.335 |
| 87/88 | 1.000 | 0.773 | 0.469 |
| 88/89 | 1.000 | 0.780 | 0.791 |
| 89/90 | 1.000 | 0.178 | 0.051 |
| 90/91 | 1.000 | 0.913 | 0.441 |
| 91/92 | 0.174 | 1.000 | 0.785 |
| 92/93 | 1.000 | 0.493 | 0.418 |
| 93/94 | 0.899 | 1.000 | 0.785 |
| 94/95 | 1.000 | 0.798 | 0.570 |
| 95/96 | 1.000 | 0.391 | 0.493 |
| 96/97 | 1.000 | 0.600 | 0.265 |
| 97/98 | 1.000 | 0.718 | 0.587 |
| 98/99 | 1.000 | 0.464 | 0.472 |
| 99/00 | 1.000 | 0.688 | 0.388 |
| 00/01 | 1.000 | 0.592 | 0.639 |
| 01/02 | 1.000 | 0.497 | 0.446 |

Fit results for index = TPWD
Index Fitted to Beginning Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.5676 | 0.5676 | 1.3229 | -0.7553 | -1.5061 |
| 85/86 | 1.1958 | 1.1958 | 0.7188 | 0.4770 | 0.9510 |
| 86/87 | 0.3746 | 0.3746 | 1.0266 | -0.6520 | -1.3000 |
| 87/88 | 1.2660 | 1.2660 | 1.1056 | 0.1605 | 0.3200 |
| 88/89 | 0.5517 | 0.5517 | 1.0168 | -0.4651 | -0.9273 |
| 89/90 | 1.1368 | 1.1368 | 0.6406 | 0.4962 | 0.9894 |

| | | | | | |
|---|---|---|---|---|---|
| 90/91 | 0.9074 | 0.9074 | 0.6733 | 0.2340 | 0.4666 |
| 91/92 | 1.5329 | 1.5329 | 0.9115 | 0.6213 | 1.2388 |
| 92/93 | 0.9638 | 0.9638 | 0.8546 | 0.1092 | 0.2177 |
| 93/94 | 0.9585 | 0.9585 | 1.4187 | -0.4603 | -0.9177 |
| 94/95 | 1.0443 | 1.0443 | 0.5475 | 0.4968 | 0.9906 |
| 95/96 | 1.6112 | 1.6112 | 0.9640 | 0.6472 | 1.2905 |
| 96/97 | 1.8177 | 1.8177 | 0.6659 | 1.1518 | 2.2965 |
| 97/98 | 1.0176 | 1.0176 | 1.3921 | -0.3744 | -0.7466 |
| 98/99 | 0.7086 | 0.7086 | 0.5927 | 0.1160 | 0.2312 |
| 99/00 | 0.6831 | 0.6831 | 0.7579 | -0.0749 | -0.1492 |
| 00/01 | 1.0127 | 1.0127 | 1.0197 | -0.0070 | -0.0139 |
| 01/02 | 0.6497 | 0.6497 | 0.6610 | -0.0113 | -0.0224 |

Index ML estimate of the variance: 0.2515 (S.E.: 0.5015)
ML estimate of catchability: 0.26553E-06
Pearsons (parametric) correlation: -0.145 P= 0.2788
Kendalls (nonparametric) Tau: -0.085 P= 0.3438

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 |
|---|---|---|---|
| 84/85 | 0.048 | 0.727 | 1.000 |
| 85/86 | 0.012 | 0.262 | 1.000 |
| 86/87 | 0.056 | 0.249 | 1.000 |
| 87/88 | 0.128 | 0.252 | 1.000 |
| 88/89 | 0.114 | 0.404 | 1.000 |
| 89/90 | 0.146 | 0.235 | 1.000 |
| 90/91 | 0.077 | 0.187 | 1.000 |
| 91/92 | 0.047 | 0.233 | 1.000 |
| 92/93 | 0.037 | 0.146 | 1.000 |
| 93/94 | 0.047 | 0.553 | 1.000 |
| 94/95 | 0.036 | 0.086 | 1.000 |
| 95/96 | 0.040 | 0.390 | 1.000 |
| 96/97 | 0.087 | 0.077 | 1.000 |
| 97/98 | 0.057 | 0.449 | 1.000 |
| 98/99 | 0.010 | 0.089 | 1.000 |
| 99/00 | 0.071 | 0.099 | 1.000 |
| 00/01 | 0.009 | 0.190 | 1.000 |
| 01/02 | 0.033 | 0.071 | 1.000 |

Fit results for index = SEAMAP
Index Fitted to Beginning Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 1.3934 | 1.3934 | 1.0917 | 0.3017 | 1.1501 |
| 85/86 | 1.0520 | 1.0520 | 1.2873 | -0.2353 | -0.8968 |
| 86/87 | 0.7513 | 0.7513 | 0.8838 | -0.1325 | -0.5053 |
| 87/88 | 1.1911 | 1.1911 | 0.6636 | 0.5275 | 2.0109 |
| 88/89 | 0.8073 | 0.8073 | 0.7483 | 0.0590 | 0.2247 |
| 89/90 | 1.2523 | 1.2523 | 1.3075 | -0.0551 | -0.2102 |
| 90/91 | 1.0284 | 1.0284 | 1.5262 | -0.4979 | -1.8979 |
| 91/92 | 1.0668 | 1.0668 | 0.7921 | 0.2747 | 1.0473 |
| 92/93 | 1.2182 | 1.2182 | 1.0827 | 0.1355 | 0.5164 |
| 93/94 | 1.0941 | 1.0941 | 0.8369 | 0.2572 | 0.9805 |
| 94/95 | 0.7479 | 0.7479 | 1.0140 | -0.2661 | -1.0145 |
| 95/96 | 1.0950 | 1.0950 | 0.7543 | 0.3407 | 1.2988 |
| 96/97 | 0.5983 | 0.5983 | 0.7425 | -0.1442 | -0.5497 |
| 97/98 | 1.0420 | 1.0420 | 0.9117 | 0.1303 | 0.4969 |
| 98/99 | 0.6648 | 0.6648 | 0.7939 | -0.1291 | -0.4920 |
| 99/00 | 0.9972 | 0.9972 | 0.9415 | 0.0557 | 0.2125 |

Index ML estimate of the variance: 0.0688 (S.E.: 0.2623)
ML estimate of catchability: 0.74076E-07
Pearsons (parametric) correlation: 0.349 P= 0.0325
Kendalls (nonparametric) Tau: 0.183 P= 0.1140

Selectivities set to 1.0

| year | 0 |
|---|---|
| 84/85 | 1.000 |
| 85/86 | 1.000 |
| 86/87 | 1.000 |
| 87/88 | 1.000 |
| 88/89 | 1.000 |
| 89/90 | 1.000 |
| 90/91 | 1.000 |
| 91/92 | 1.000 |
| 92/93 | 1.000 |
| 93/94 | 1.000 |
| 94/95 | 1.000 |
| 95/96 | 1.000 |
| 96/97 | 1.000 |
| 97/98 | 1.000 |
| 98/99 | 1.000 |
| 99/00 | 1.000 |

Fit results for index = HeadBoat
Index Fitted to Mid-Year Stock Size in NUMBERS

| | Scaled | Obj.Function | Predicted | Residual | Scaled resid |
|---|---|---|---|---|---|
| 84/85 | 0.5673 | 0.5673 | 1.2247 | -0.6574 | -0.8865 |
| 85/86 | 0.2179 | 0.2179 | 1.2919 | -1.0740 | -1.4482 |
| 86/87 | 0.9351 | 0.9351 | 1.0442 | -0.1091 | -0.1472 |
| 87/88 | 1.7811 | 1.7811 | 0.6627 | 1.1184 | 1.5081 |
| 88/89 | 0.4715 | 0.4715 | 0.2088 | 0.2628 | 0.3543 |
| 89/90 | 1.1497 | 1.1497 | 1.3110 | -0.1613 | -0.2176 |
| 90/91 | 0.9310 | 0.9310 | 1.0992 | -0.1682 | -0.2268 |
| 91/92 | 3.0123 | 3.0123 | 0.6860 | 2.3262 | 3.1367 |
| 92/93 | 1.0975 | 1.0975 | 0.1474 | 0.9501 | 1.2812 |
| 93/94 | 0.6659 | 0.6659 | 0.5773 | 0.0886 | 0.1194 |
| 94/95 | 1.1478 | 1.1478 | 0.8606 | 0.2873 | 0.3873 |
| 95/96 | 1.0953 | 1.0953 | 0.6014 | 0.4939 | 0.6660 |
| 96/97 | 1.1483 | 1.1483 | 1.0265 | 0.1219 | 0.1643 |
| 97/98 | 0.7360 | 0.7360 | 0.5495 | 0.1865 | 0.2515 |
| 98/99 | 0.6486 | 0.6486 | 0.9711 | -0.3225 | -0.4348 |
| 99/00 | 0.8912 | 0.8912 | 1.0399 | -0.1487 | -0.2005 |
| 00/01 | 0.8675 | 0.8675 | 0.7424 | 0.1251 | 0.1687 |
| 01/02 | 0.6361 | 0.6361 | 0.9329 | -0.2968 | -0.4002 |

Index ML estimate of the variance: 0.5500 (S.E.: 0.7416)
ML estimate of catchability: 0.27788E-06
Pearsons (parametric) correlation: -0.166 P= 0.2327
Kendalls (nonparametric) Tau: -0.046 P= 0.5004

Selectivity at age from Partial Catches

| year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 84/85 | 0.264 | 1.000 | 0.254 | 0.282 | 0.057 | 0.345 |
| 85/86 | 0.224 | 1.000 | 0.174 | 0.020 | 0.001 | 0.157 |
| 86/87 | 0.222 | 0.280 | 0.401 | 0.750 | 0.580 | 1.000 |
| 87/88 | 0.109 | 0.220 | 0.293 | 0.640 | 1.000 | 0.974 |
| 88/89 | 0.037 | 0.126 | 0.096 | 0.137 | 0.262 | 1.000 |
| 89/90 | 0.498 | 0.606 | 0.921 | 1.000 | 0.779 | 0.682 |
| 90/91 | 0.245 | 0.402 | 0.621 | 1.000 | 0.928 | 0.662 |
| 91/92 | 0.072 | 0.269 | 0.432 | 0.620 | 0.964 | 1.000 |
| 92/93 | 0.016 | 0.042 | 0.095 | 0.221 | 0.247 | 1.000 |
| 93/94 | 0.082 | 0.294 | 0.292 | 0.452 | 0.309 | 1.000 |
| 94/95 | 0.193 | 0.213 | 0.927 | 0.544 | 0.485 | 1.000 |
| 95/96 | 0.053 | 0.308 | 0.254 | 0.736 | 0.347 | 1.000 |
| 96/97 | 0.179 | 0.263 | 1.000 | 0.250 | 0.802 | 0.277 |
| 97/98 | 0.048 | 0.145 | 0.216 | 1.000 | 0.124 | 0.360 |
| 98/99 | 0.091 | 0.250 | 1.000 | 0.481 | 0.375 | 0.082 |
| 99/00 | 0.203 | 0.189 | 1.000 | 0.850 | 0.084 | 0.282 |
| 00/01 | 0.036 | 0.331 | 0.409 | 1.000 | 0.052 | 0.020 |
| 01/02 | 0.022 | 0.480 | 1.000 | 0.169 | 0.260 | 0.102 |

Table 24. Maximum sustainable yield (MSY) and optimum yield (OY) related values from the Base model and the Full index model for Gulf Spanish mackerel 2003 stock evaluation. SS is spawning stock biomass in weight of mature females (million pounds), F values are associated with the fully selected age, and yields are given in millions of pounds. 80% confidence intervals generated from 500 bootstrap projections.

**MODEL BASE**

| | SS MSY | F MSY | MSY | SS OY | F OY | OY |
|---|---|---|---|---|---|---|
| Median | 16.486 | 0.629 | 7.063 | 22.070 | 0.412 | 5.948 |
| low 80% | 13.714 | 0.524 | 5.531 | 18.647 | 0.340 | 4.641 |
| upp 80% | 20.387 | 0.731 | 9.198 | 26.938 | 0.481 | 7.686 |
| Deterministic | 16.302 | 0.637 | 7.023 | 21.736 | 0.418 | 5.913 |

**MODEL Full Index**

| | SS MSY | F MSY | MSY | SS OY | F OY | OY |
|---|---|---|---|---|---|---|
| Median | 16.398 | 0.656 | 6.817 | 21.945 | 0.431 | 5.724 |
| low 80% | 13.759 | 0.527 | 5.311 | 18.691 | 0.344 | 4.375 |
| upp 80% | 19.495 | 0.778 | 8.790 | 25.696 | 0.511 | 7.399 |
| Deterministic | 16.503 | 0.678 | 7.021 | 22.004 | 0.449 | 5.913 |

Table 25. Estimated acceptable biological catch (ABC) in millions of pounds for the Gulf Spanish mackerel 2003/04 fishing year under a projected F of $F_{30\%SPR}$ or $F_{40\%SPR}$ from the Base and Full index models evaluated. Probability denotes the likelihood of exceeding the desired F mortality rates.

| | Base Model | | Full Index Model | |
|---|---|---|---|---|
| **Probability** | $F_{30\%SPR}$ | $F_{40\%SPR}$ | $F_{30\%SPR}$ | $F_{40\%SPR}$ |
| 50% Median | 8.982 | 6.307 | 8.334 | 5.851 |
| 10% lower CI | 4.803 | 3.306 | 4.028 | 2.736 |
| 90% upper CI | 17.094 | 12.262 | 16.315 | 11.620 |

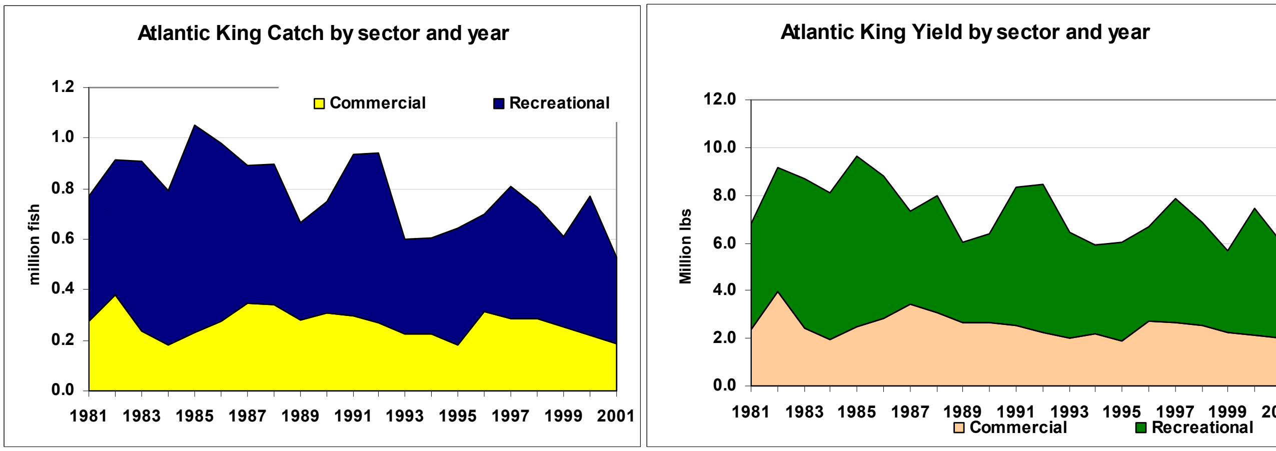



**Figure 1**. Atlantic king mackerel catch and yield by fishing year and sector from 1981 through 2001.

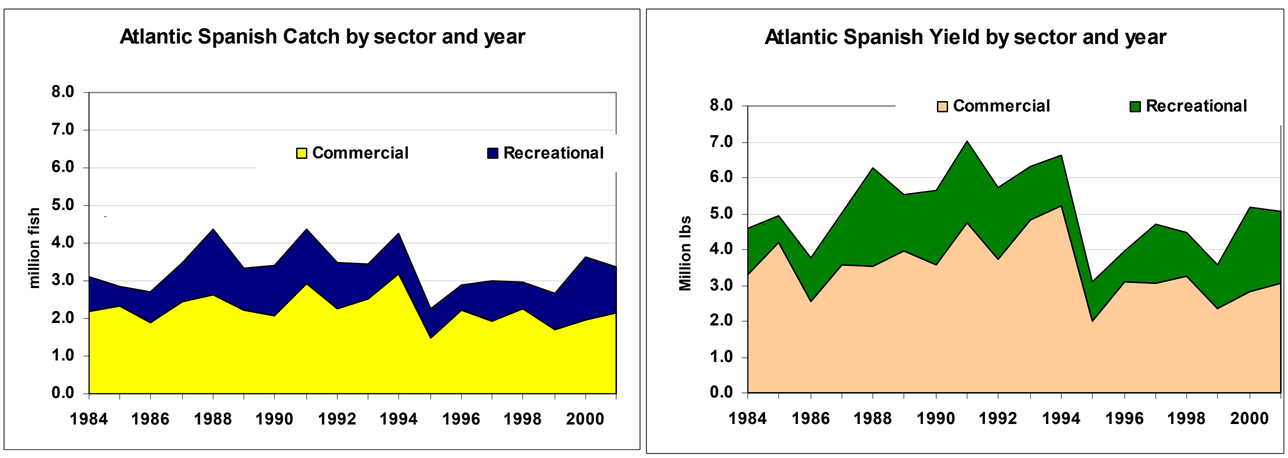



**Figure 2.** Atlantic Spanish mackerel catch and yield by fishing year and sector from 1984 through 2001

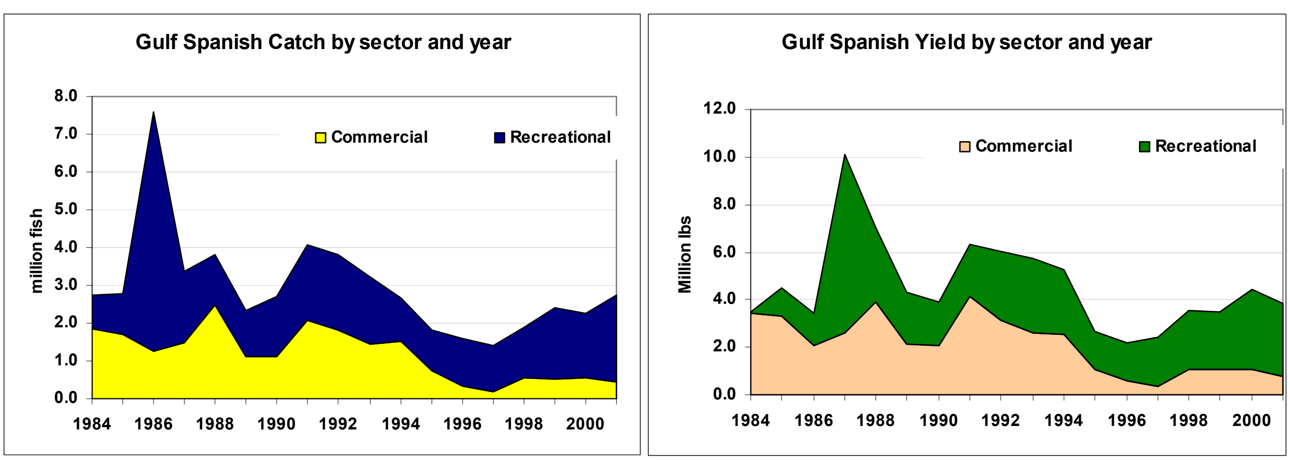



**Figure 3.** Gulf Spanish mackerel catch and yield by fishing year and sector from 1984 through 2001

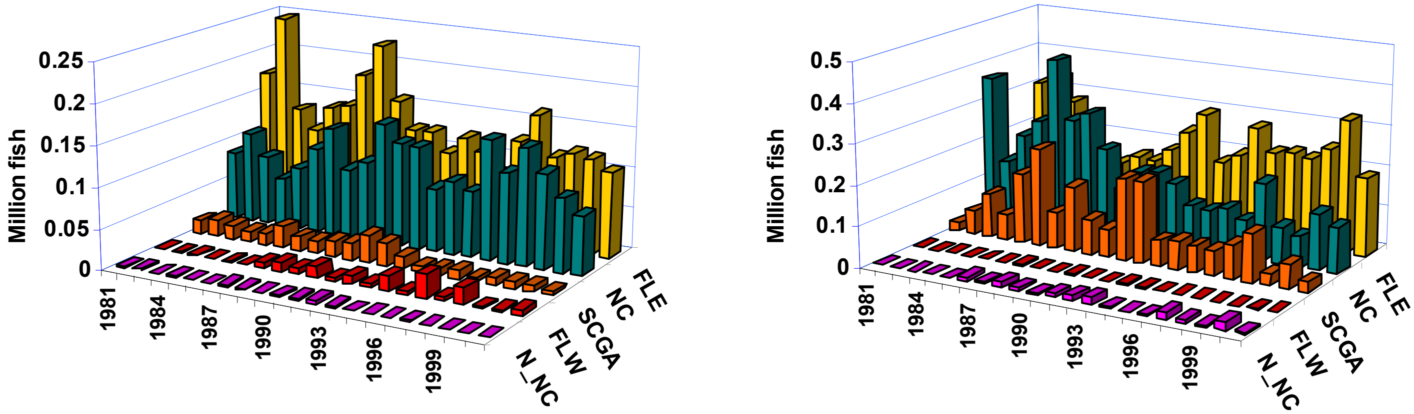



**Figure 4.** Atlantic king mackerel catch by state, fishing year and sector: commercial (left) and recreational (right) from 1981 through 2001.

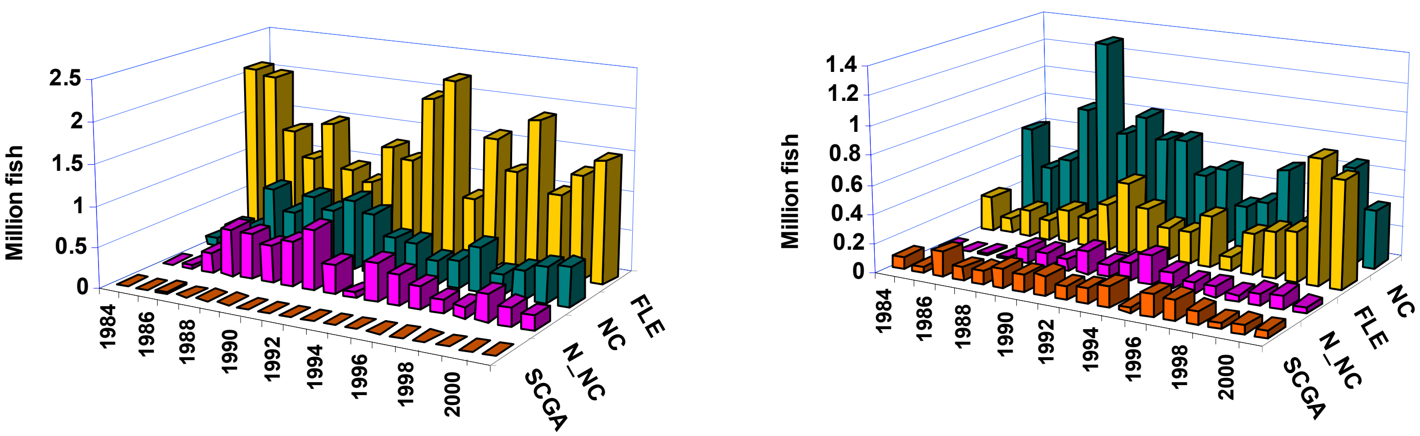



**Figure 5.** Atlantic Spanish mackerel catch by state, fishing year and sector: commercial (left) and recreational (right) from 1984 through 2001

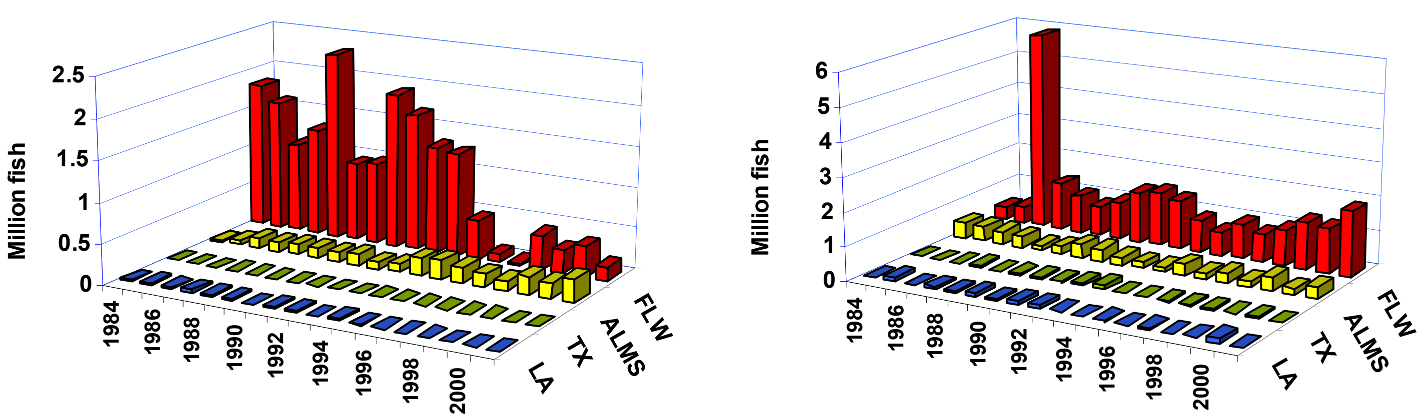



**Figure 6.** Gulf Spanish mackerel catch by state, fishing year and sector: commercial (left) and recreational (right) from 1984 through 2001

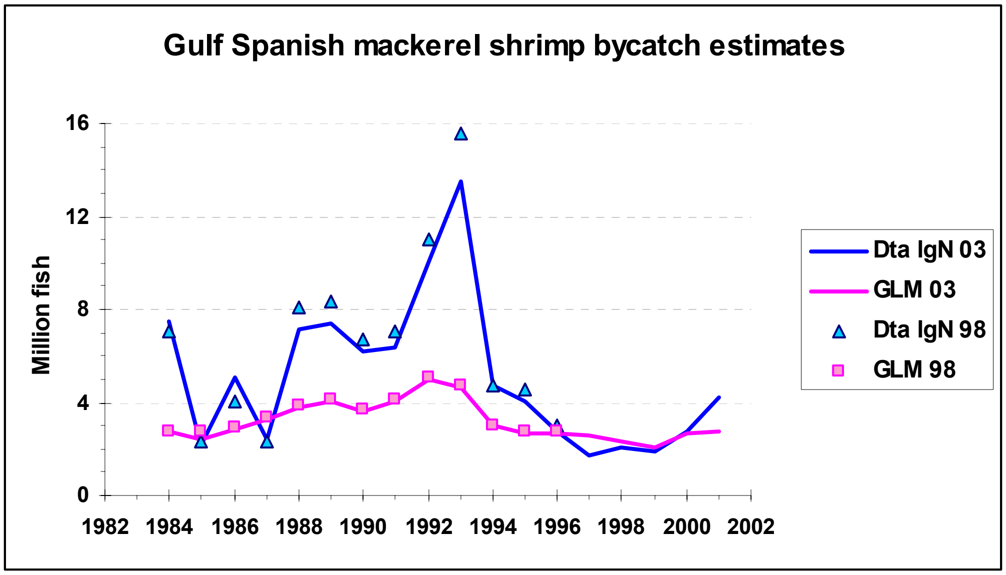



**Figure 7** Comparison of 1998 and 2003 estimates of Spanish mackerel bycatch in the shrimp trawl fishery of the US Gulf of Mexico. Estimates from the GLM (base) and delta lognormal models

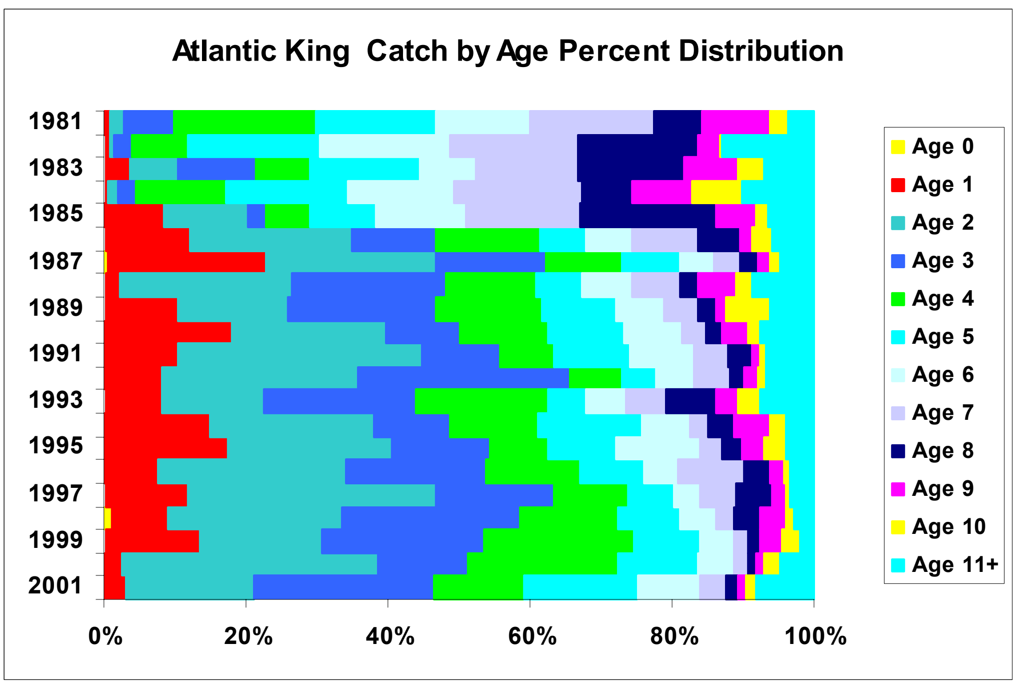



**Figure 8.** Proportion of total catch by age and year for Atlantic king mackerel from 1981 through 2001 fishing year.

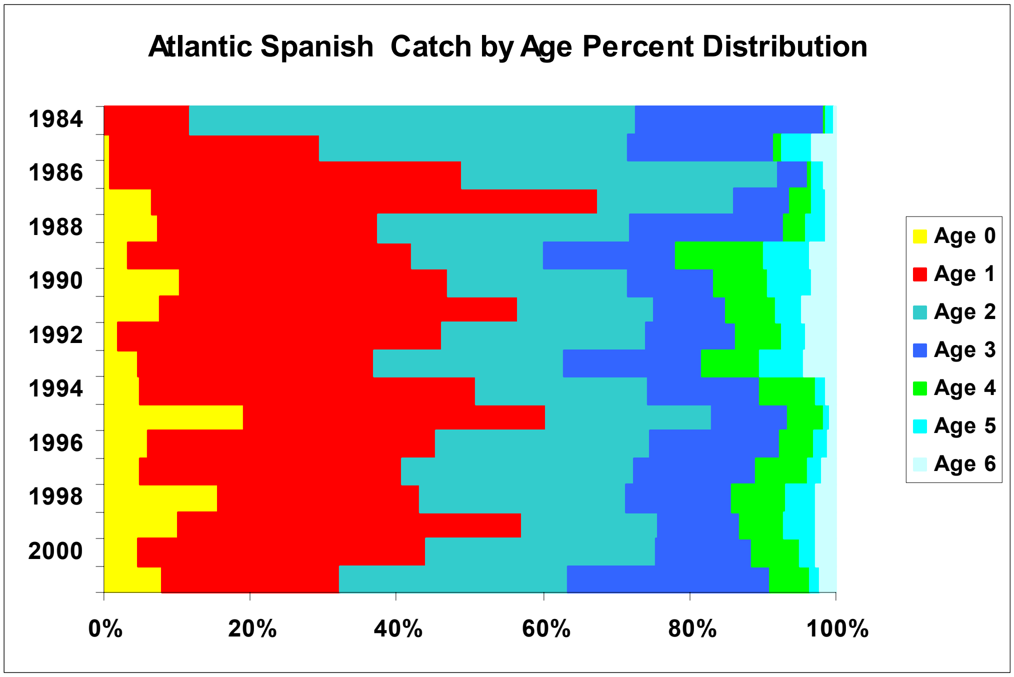



**Figure 9.** Proportion of total catch by age and year for Atlantic Spanish mackerel from 1984 through 2001 fishing year.

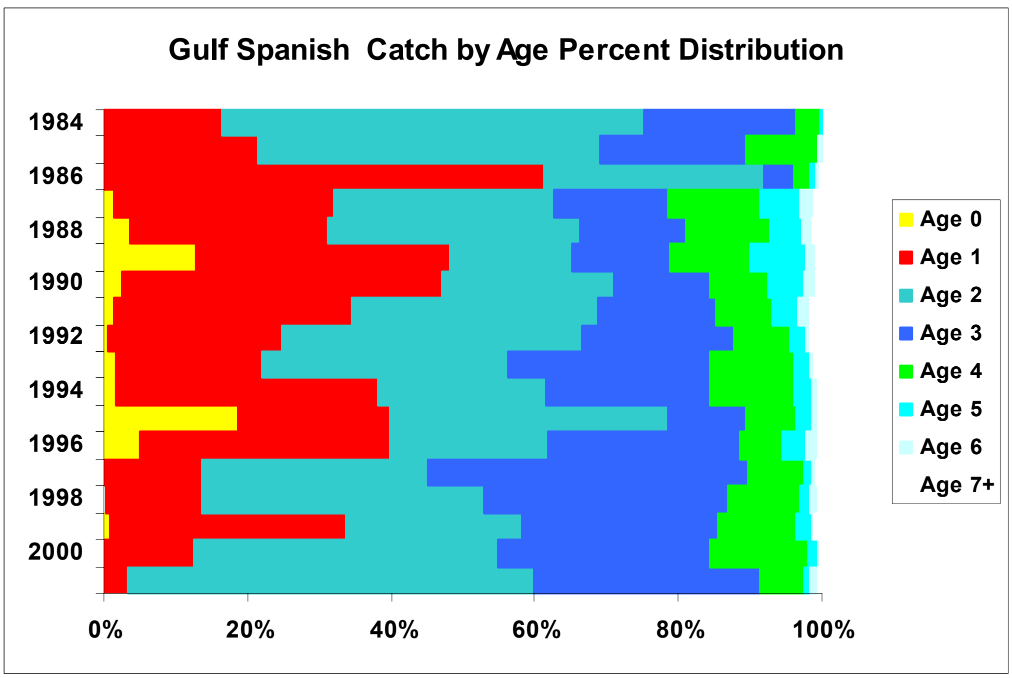



**Figure 10.** Proportion of total catch by age and year for Gulf Spanish mackerel from 1984 through 2001 fishing year.


**Figure 11.** Comparison of standardized indices of abundance for the Atlantic king mackerel used in 1998 stock assessments and correspondent ones available for 2003 analysis.

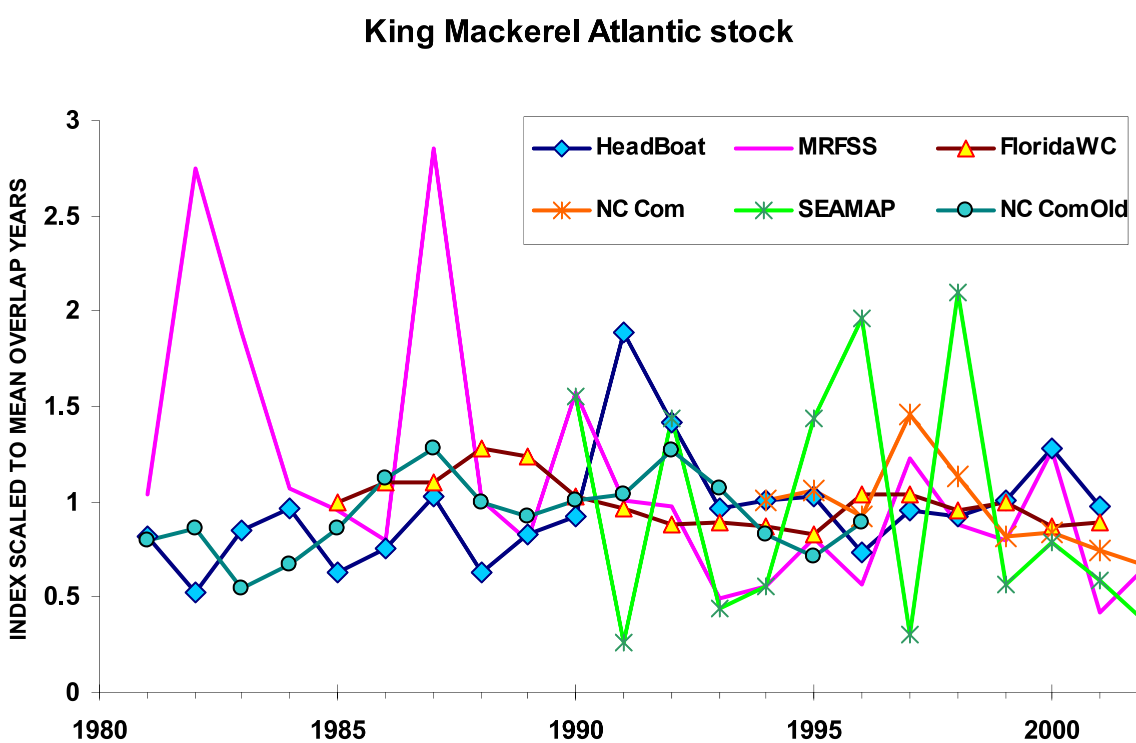



**Figure 12.** Standard indices of abundance of Atlantic king mackerel available for VPA tuning analysis in 2003. Indices are scaled to their mean for the overlapping years.

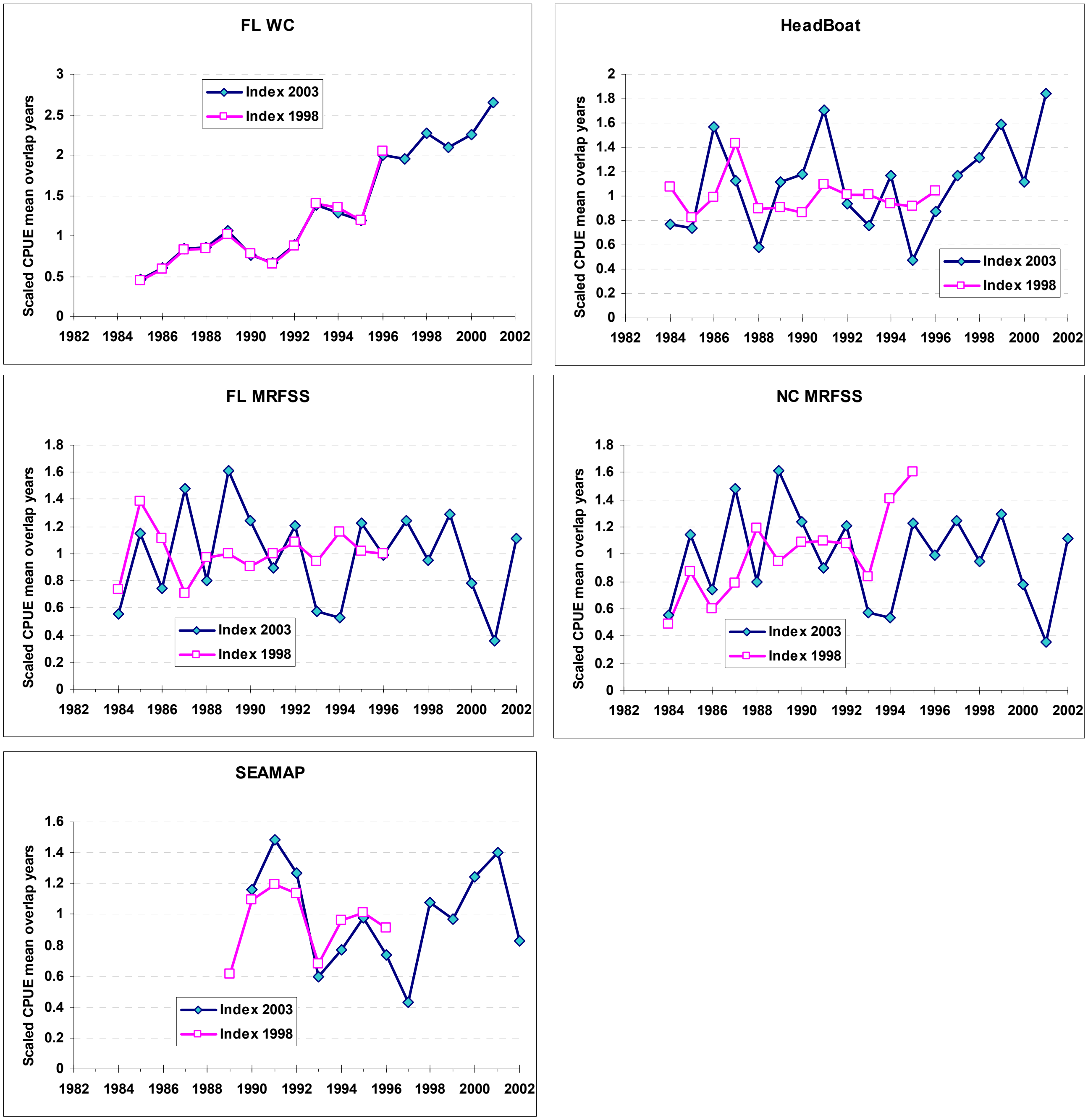



**Figure 13.** Comparison of standardized indices of abundance for the Atlantic Spanish mackerel used in 1998 stock assessments and correspondent ones available for 2003 analysis.

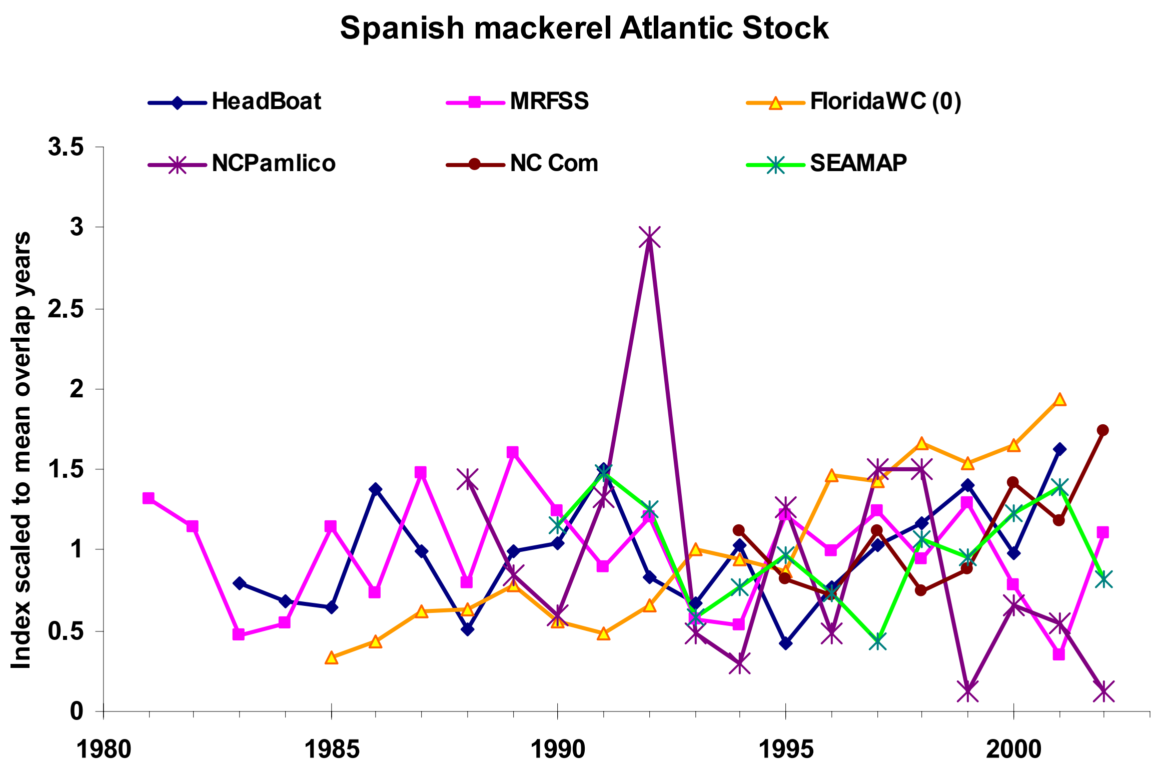
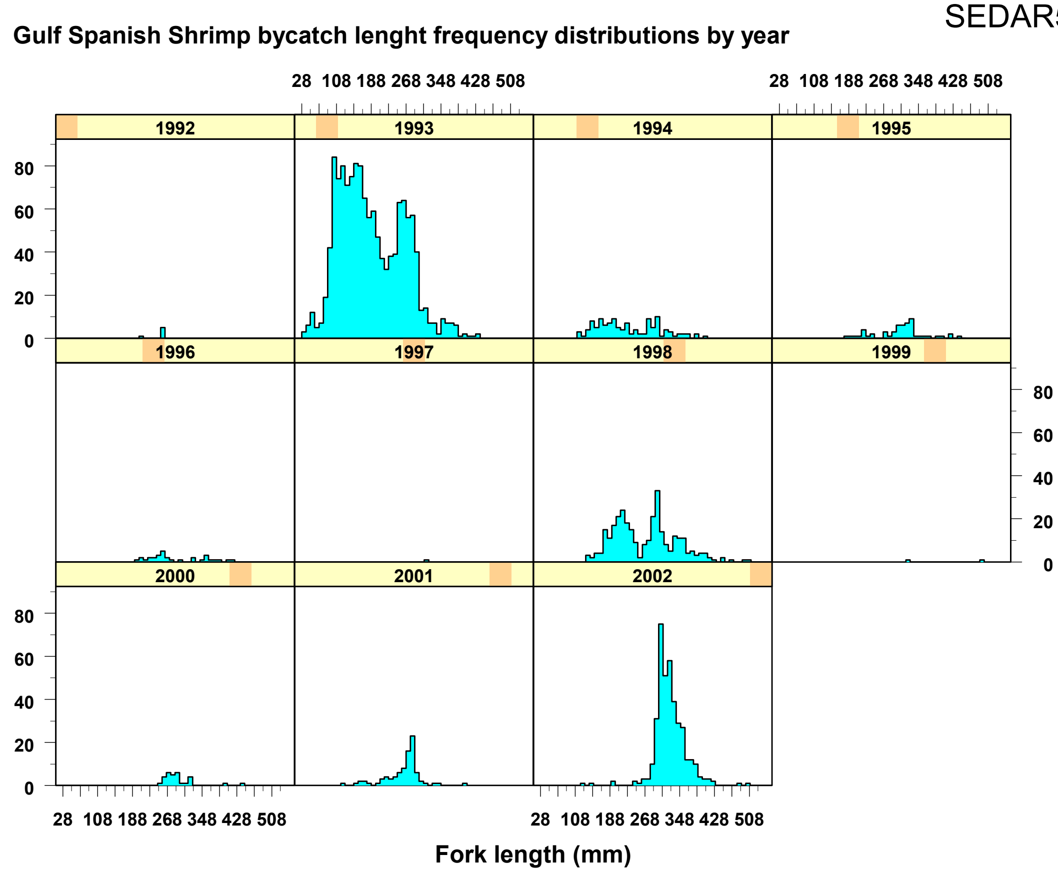



**Figure 14.** Standard indices of abundance of Atlantic Spanish mackerel available for VPA tuning analysis in 2003. Indices are scaled to their mean for the overlapping years.



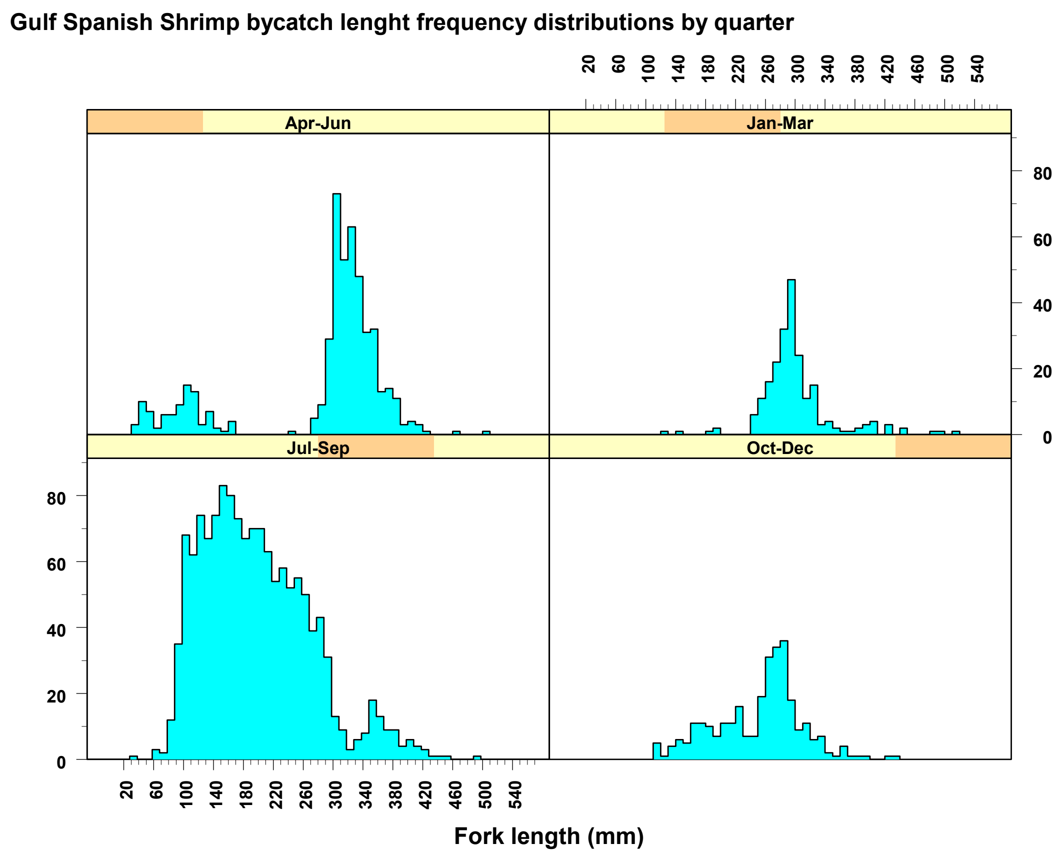




**Figure 15.** Size frequency distribution of Spanish mackerel bycatch from the US Gulf shrimp fishery by year and season (Data provided by NMFS SEFSC Galveston lab).

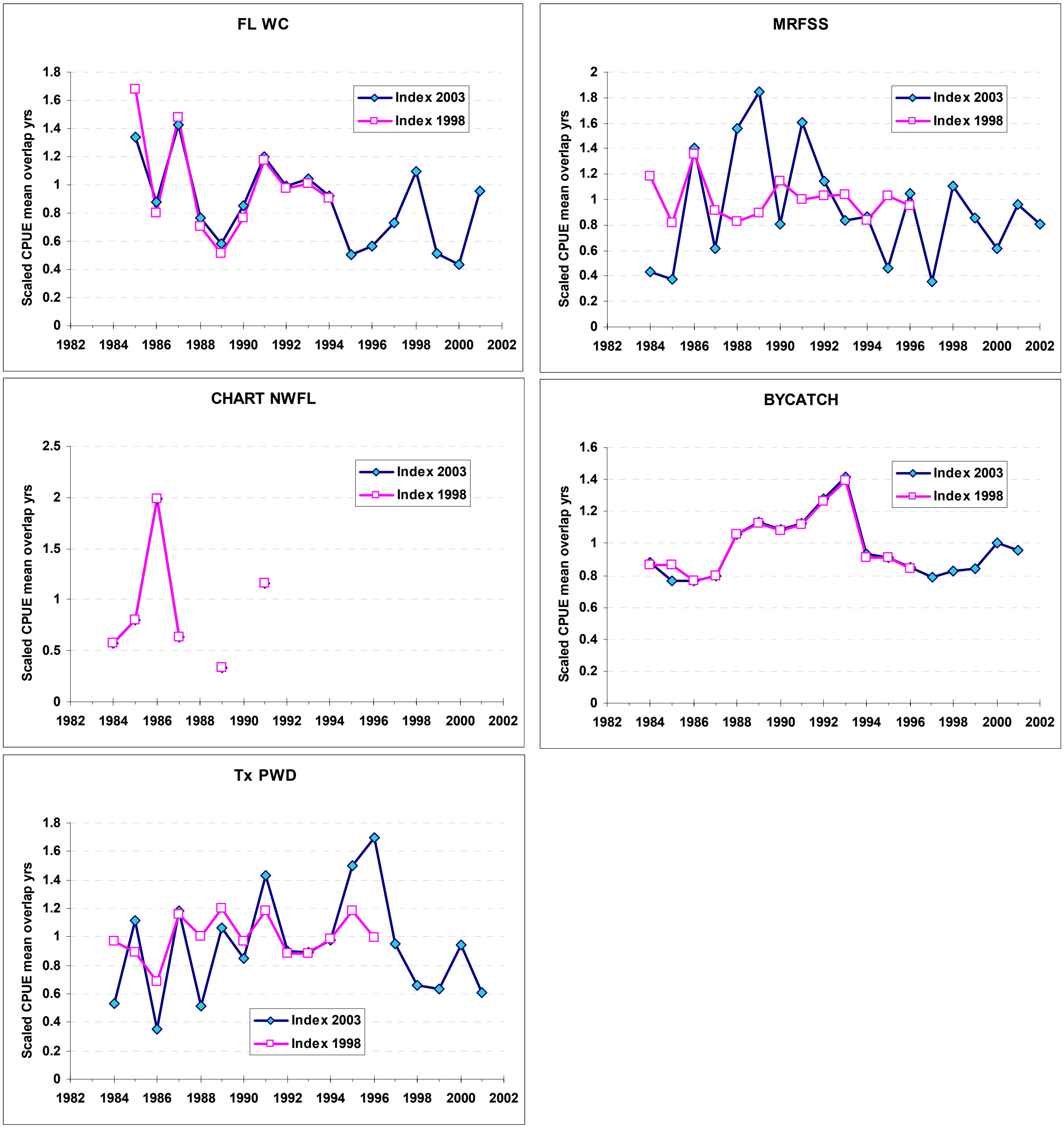



**Figure 15a.** Comparison of standardized indices of abundance for the Gulf Spanish mackerel used in 1998 stock assessments and correspondent ones available for 2003 analysis.

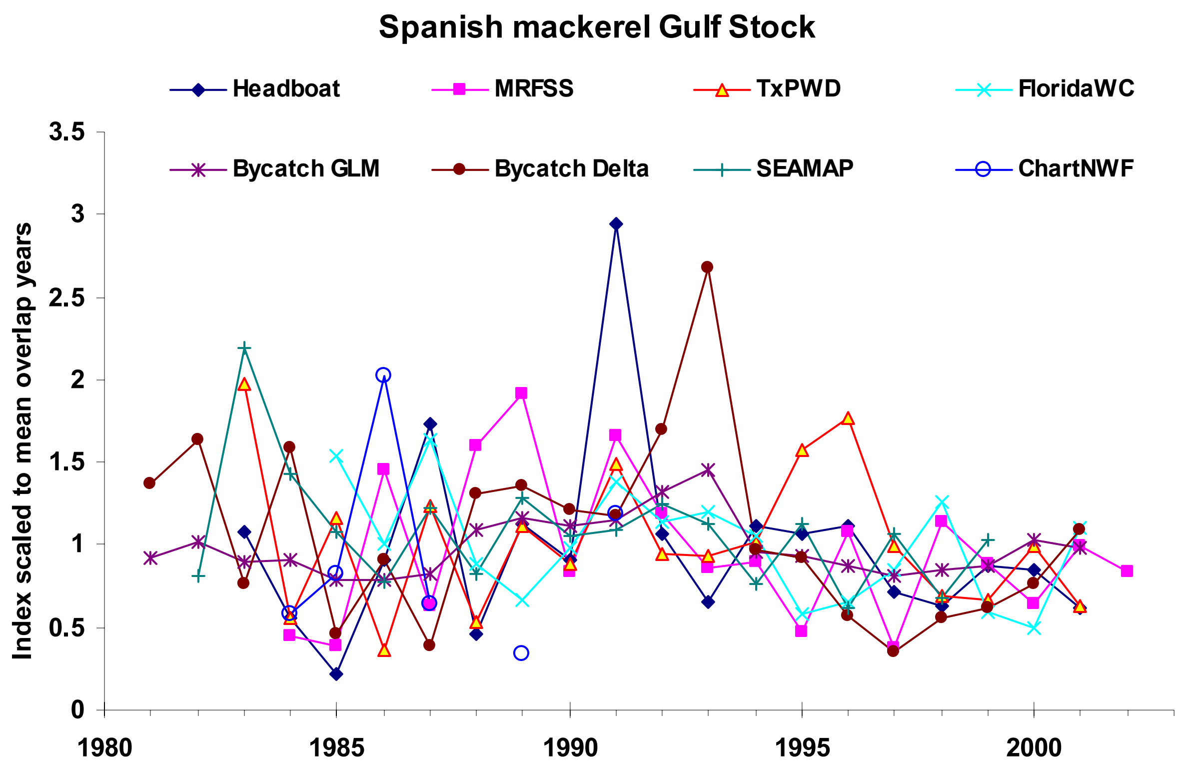



**Figure 16.** Standard indices of abundance of Gulf Spanish mackerel available for VPA tuning analysis in 2003. Indices are scaled to their mean for the overlapping years.

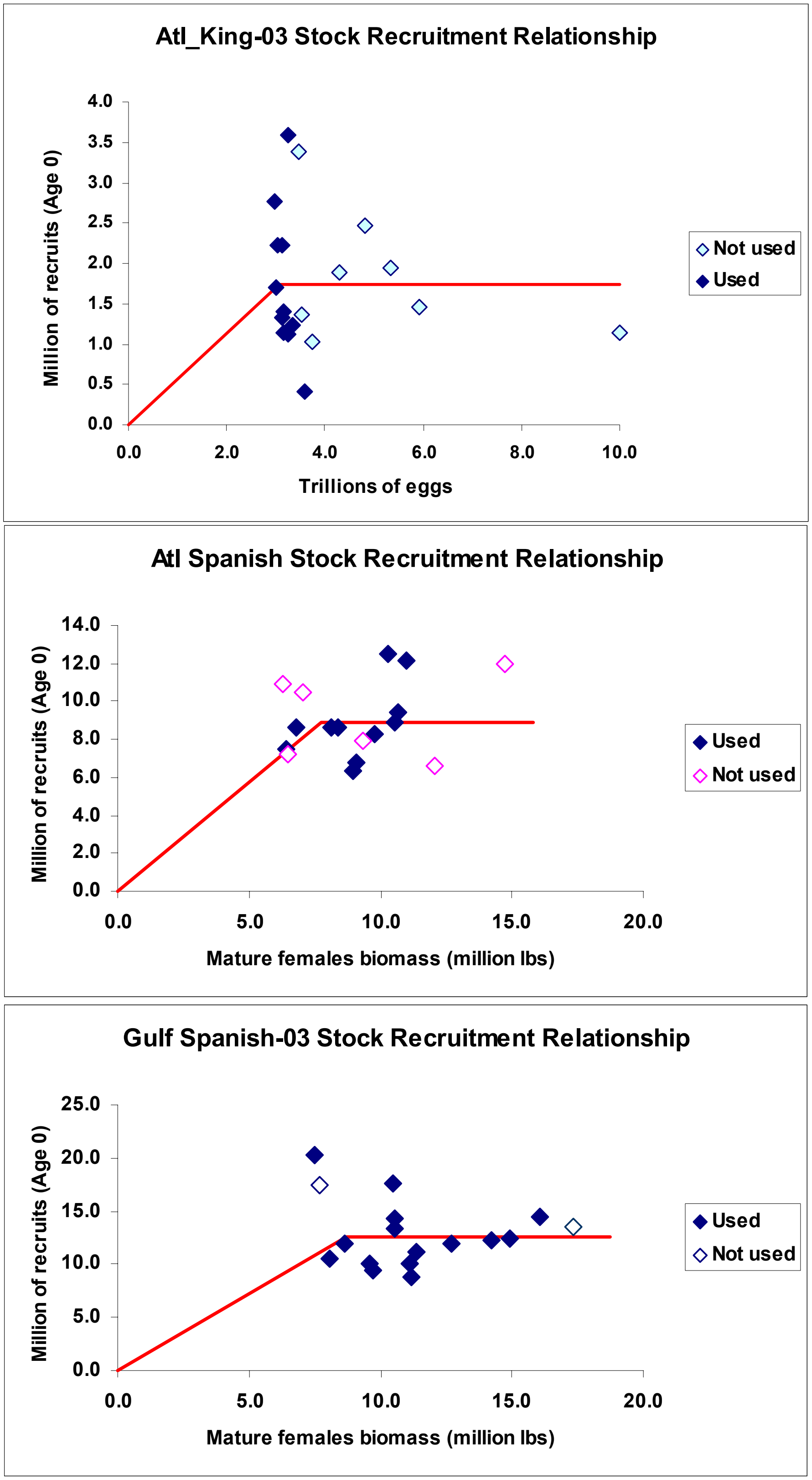



**Figure 17.** Deterministic stock recruitment relationship under the two line model for Atlantic king, Spanish king and Gulf king mackerel.

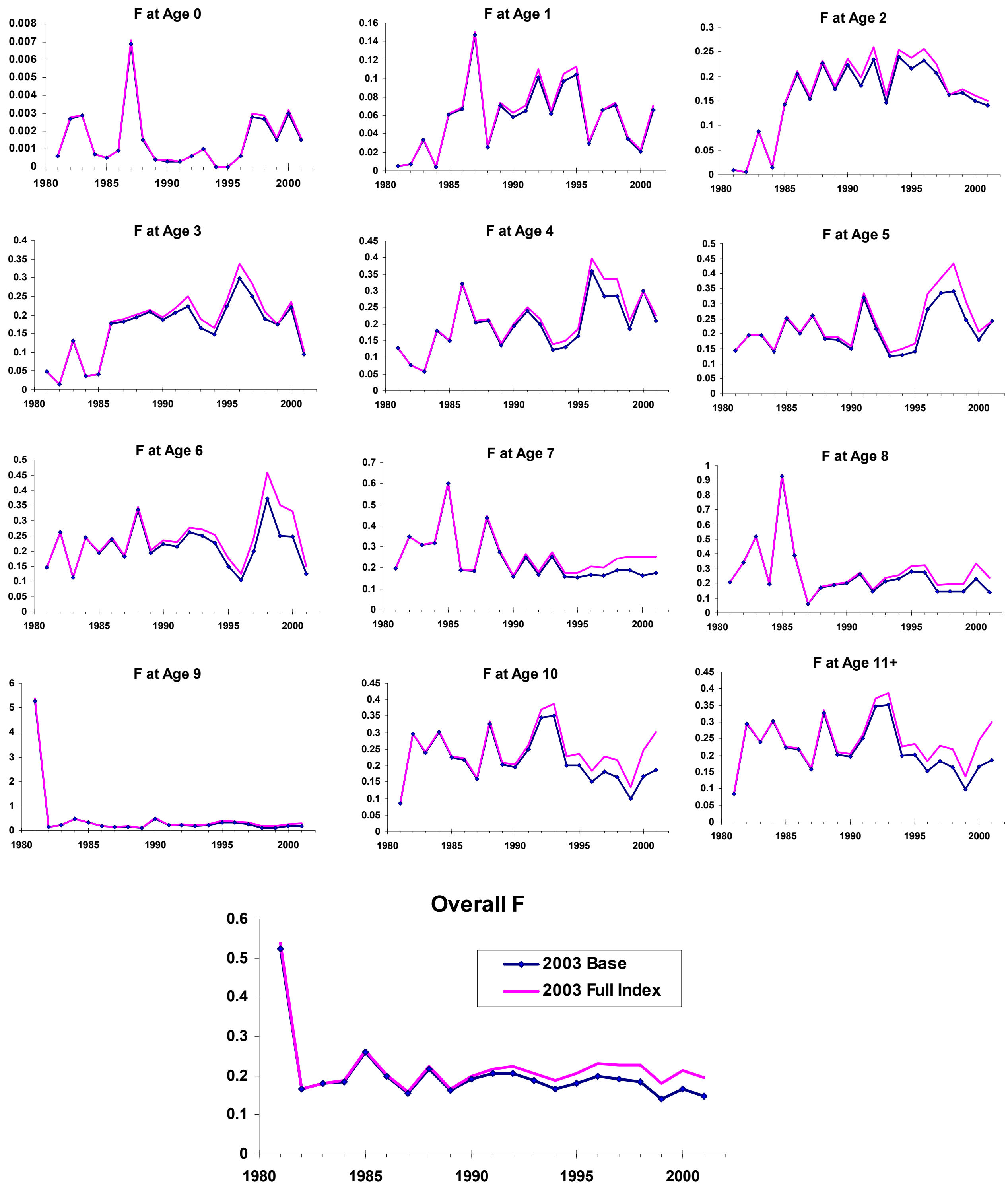



**Figure 18.** Atlantic king mackerel estimates of F mortality by age from the Base and Full index models.

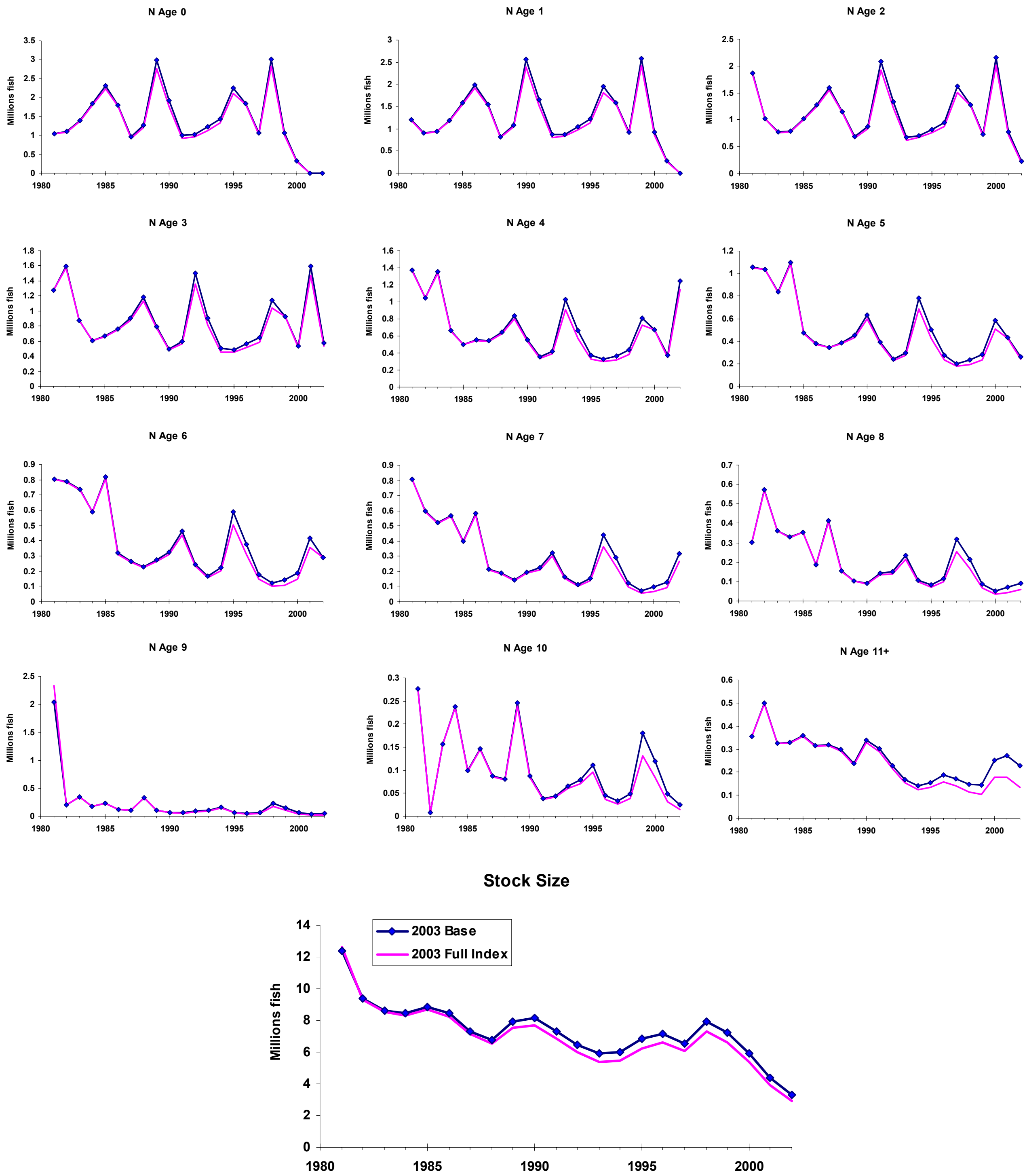



**Figure 19.** Atlantic king mackerel estimates of stock size by age from the Base and Full index models


**Figure 20.** Atlantic king mackerel predicted (solid lines) and standard index (diamonds) from the tuned VPA Base and Full index models.

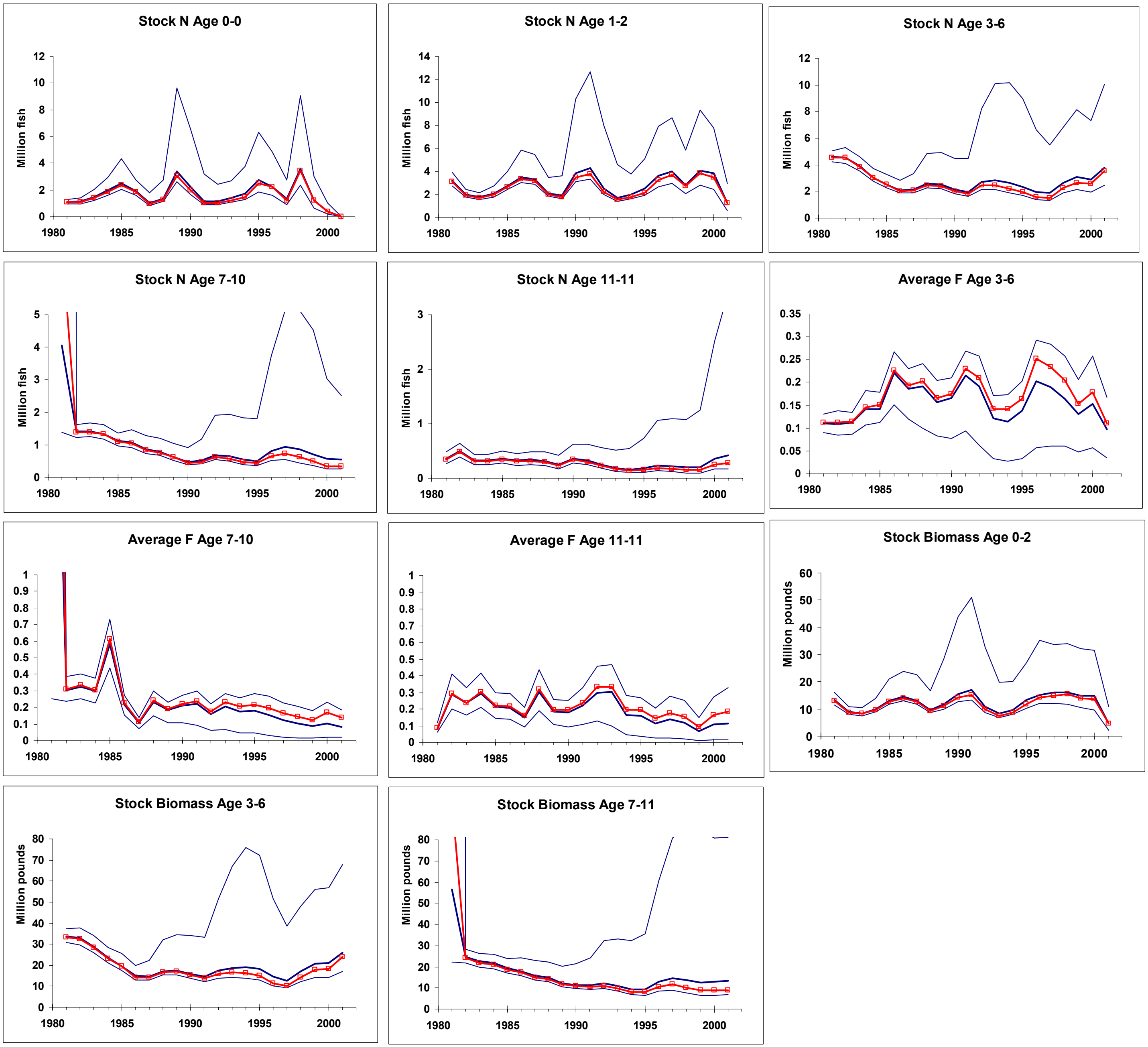



**Figure 21.** Comparison of Atlantic king mackerel population trends estimated by the Base model (solid lines) with 80% confidence intervals and the Full model index (open square line).

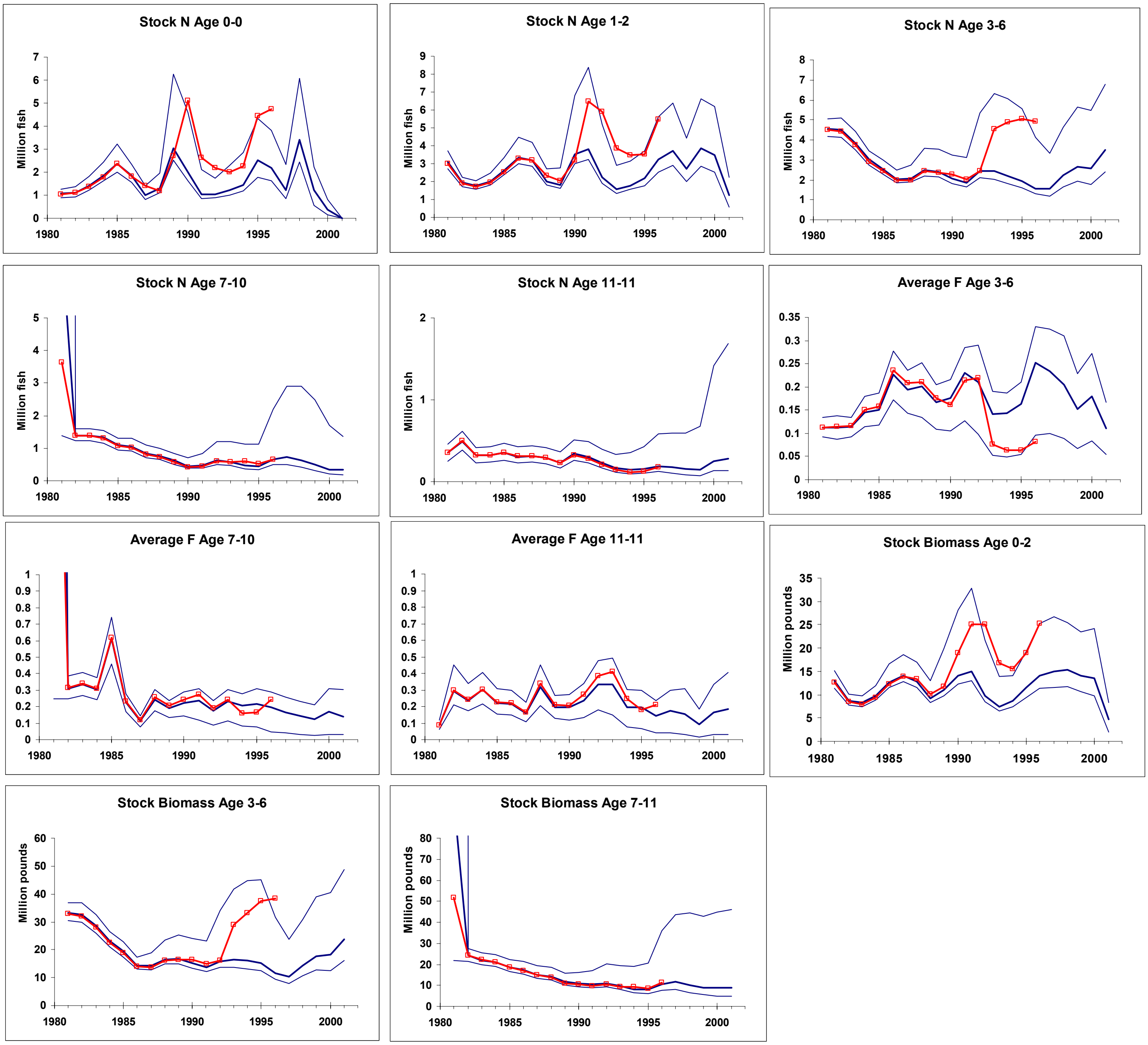



**Figure 22.** Atlantic king mackerel population trends with 80% confidence intervals from the Full Index model (solid lines). For comparison, results from the 1998 SA are also show (square marker line)

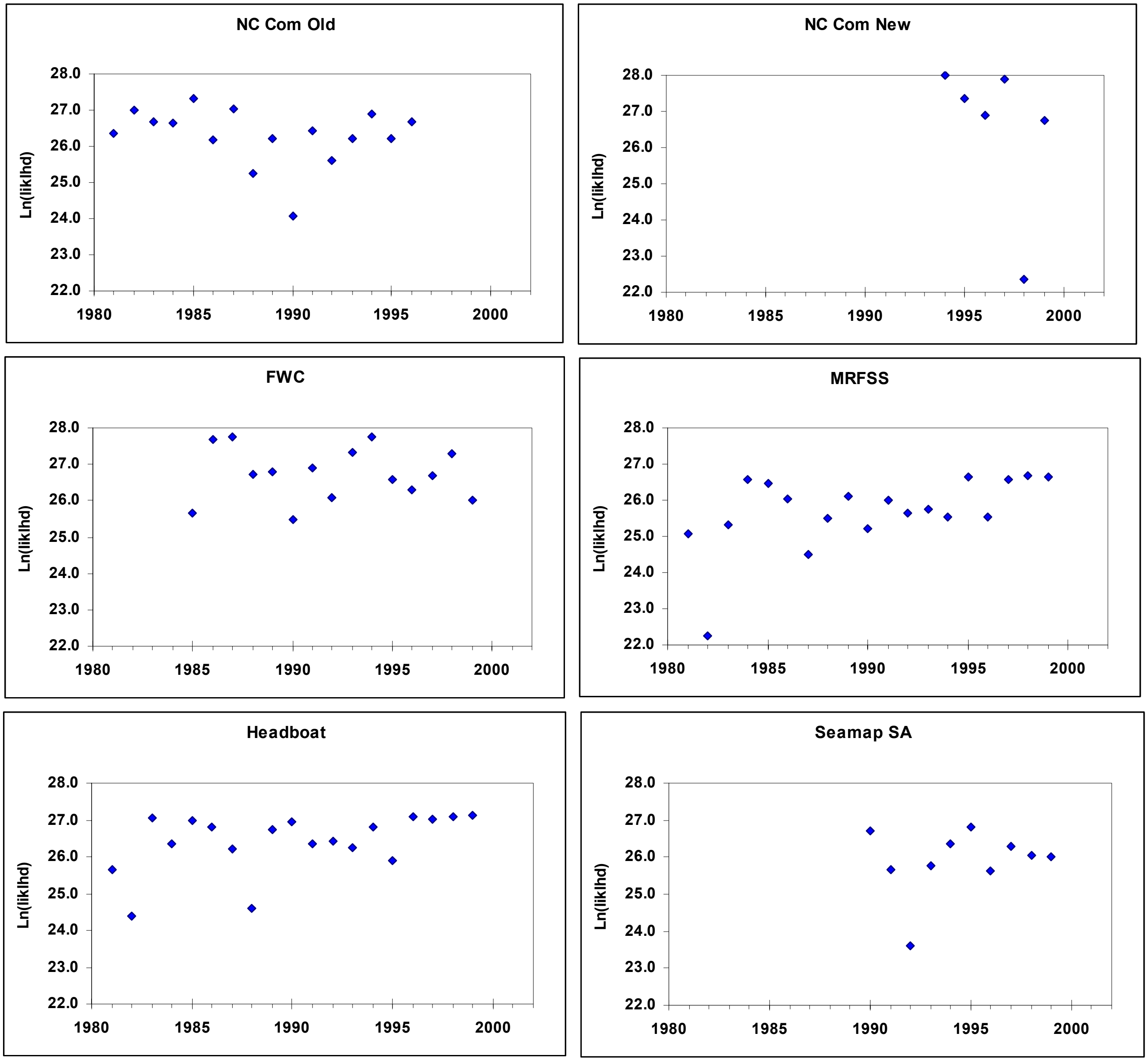



**Figure 23.** Jacknife estimates for tuned VPA Full index model fit Atlantic king mackerel.

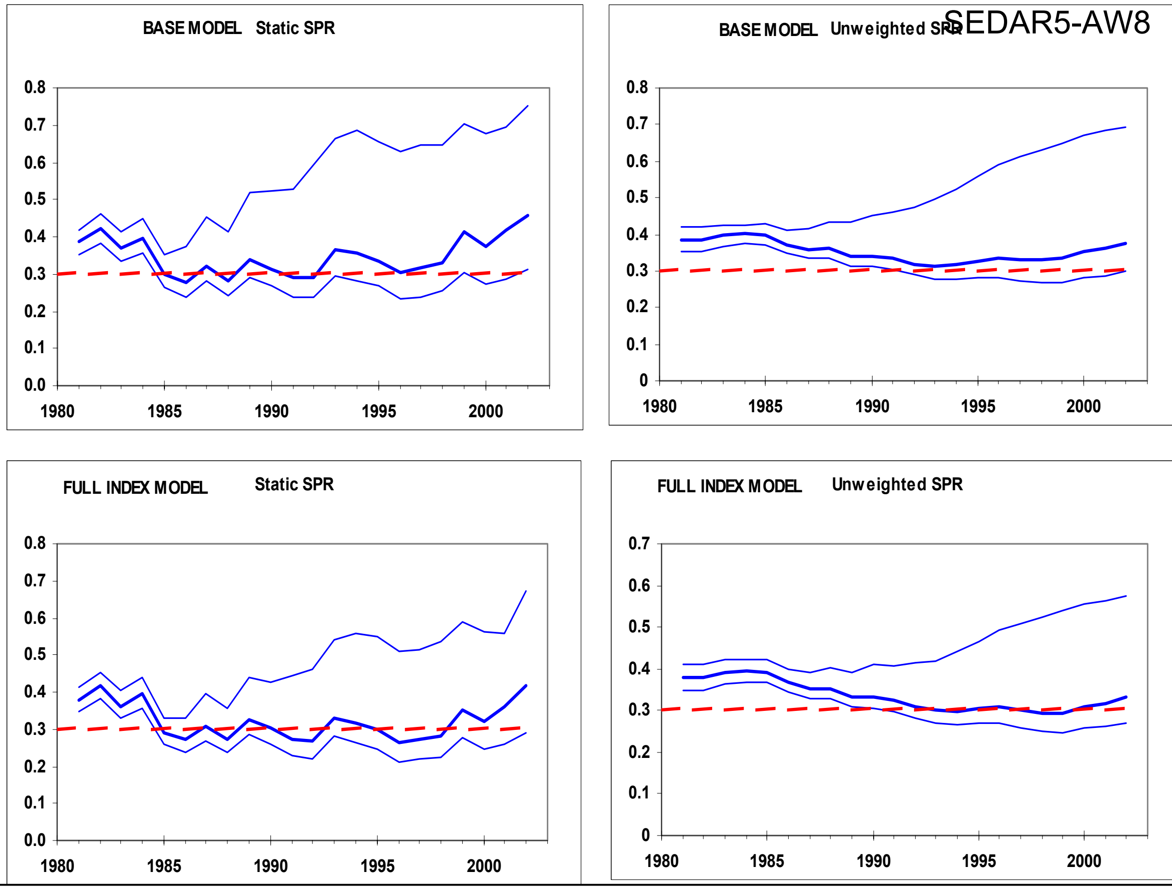



**Figure 24.** Comparison of static and transitional un-weighted SPR from the VPA Base model and the VPA Full index model for Atlantic king mackerel 2003 stock evaluation.

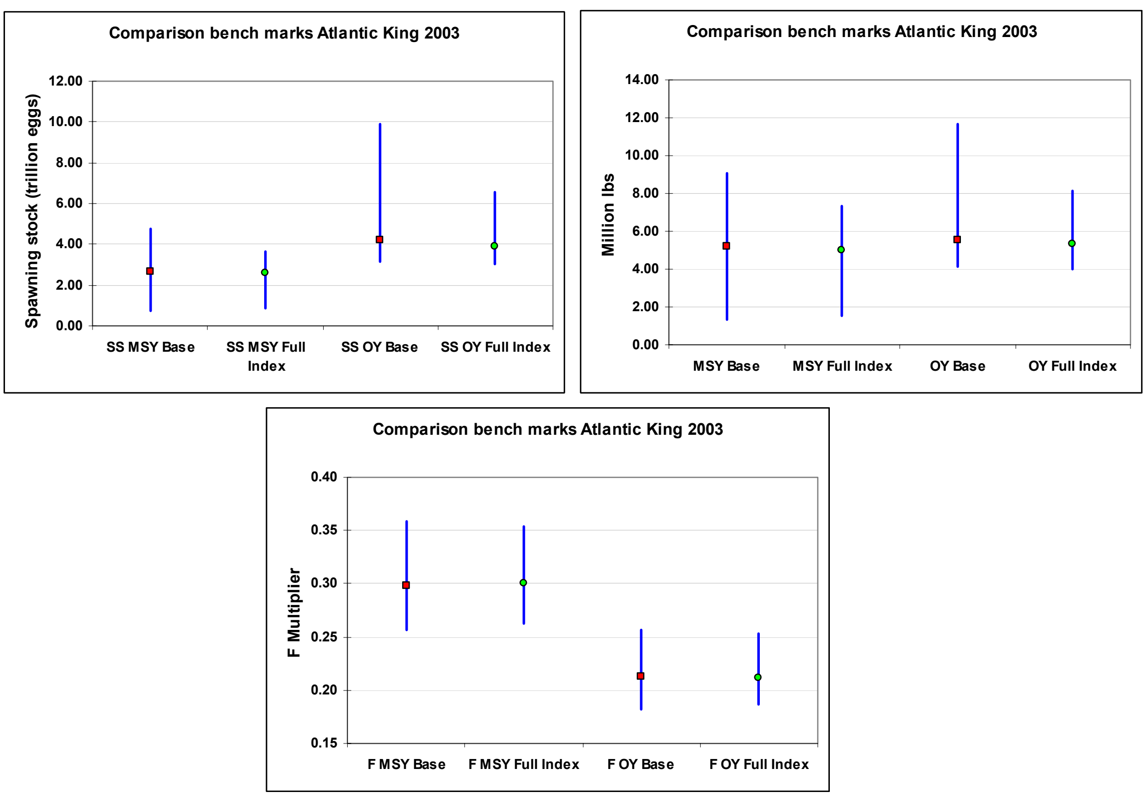



**Figure 25.** Atlantic king mackerel benchmarks 2003 assessment. Spawning stock (SS) biomass, MSY, OY, and correspondent fishing mortality rates from the two models.

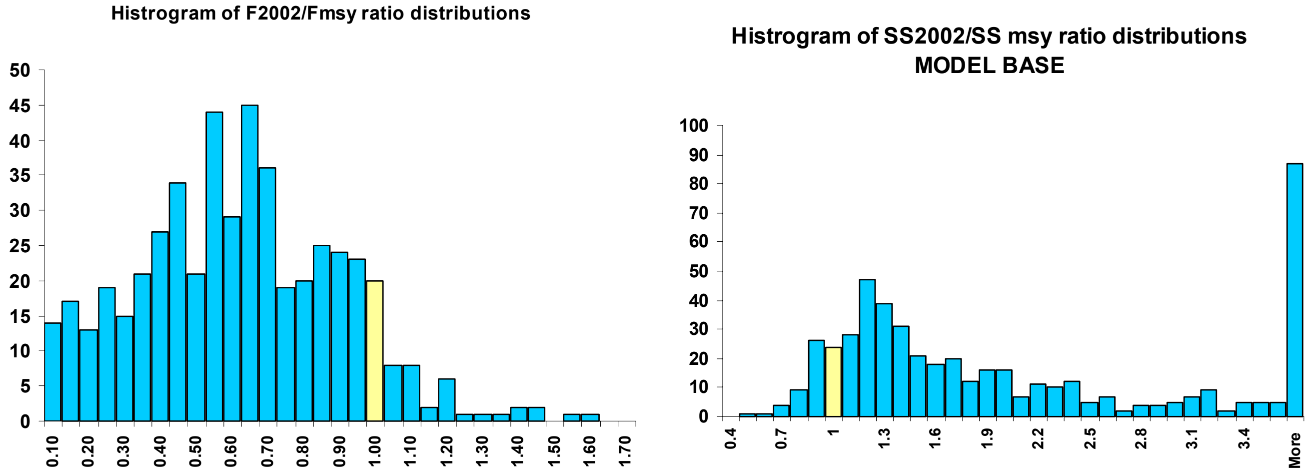



**Figure 26.** Frequency distribution of Atlantic king $F_{2002}/F_{MSY}$ and $SS_{2002}/SS_{MSY}$ ratios of 500 boostraps for the Base model.

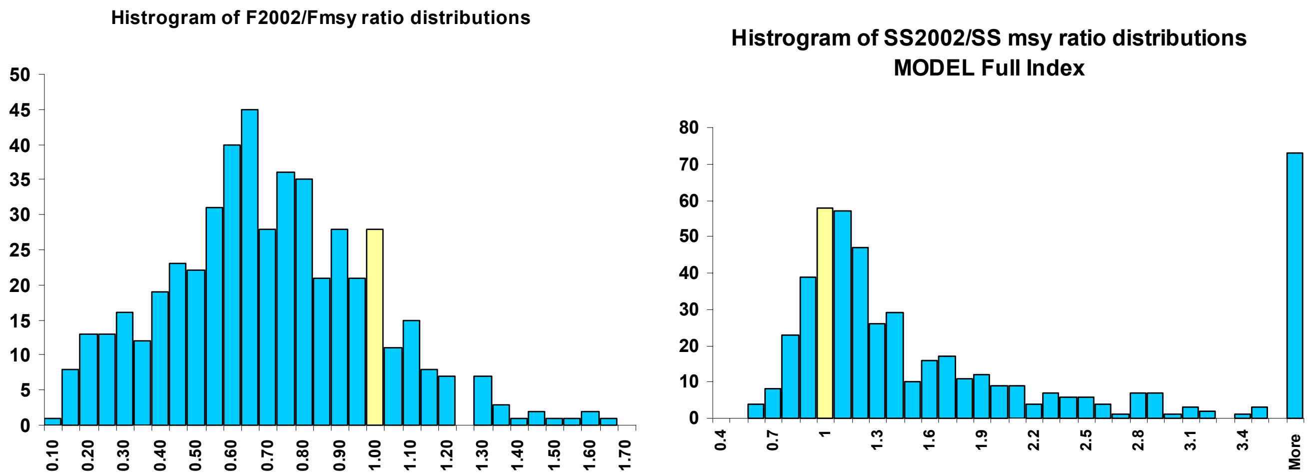



**Figure 27.** Frequency distribution of Atlantic king $F_{2002}/F_{MSY}$ and $SS_{2002}/SS_{MSY}$ ratios of 500 bootstraps for the Full Index model.

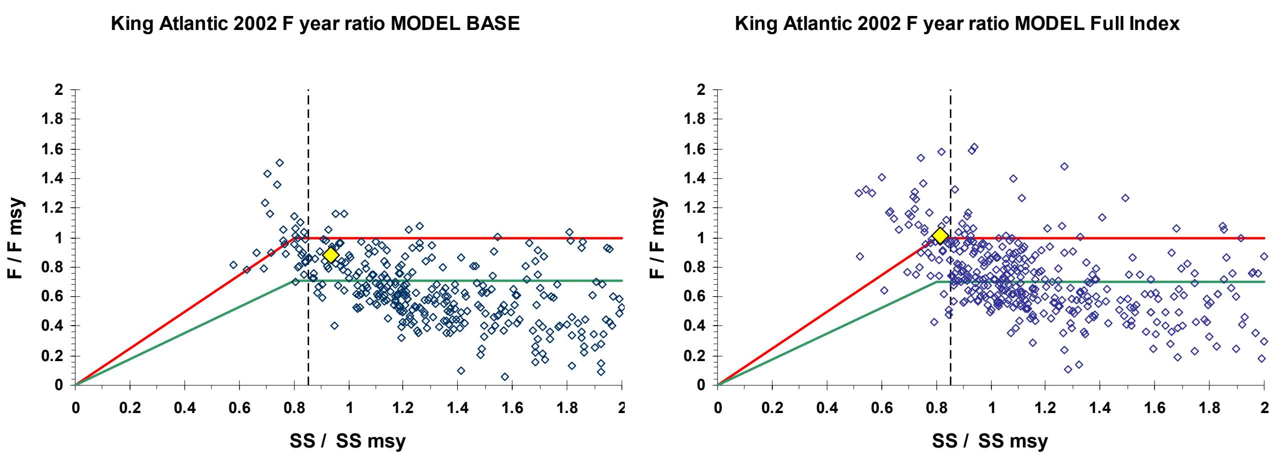
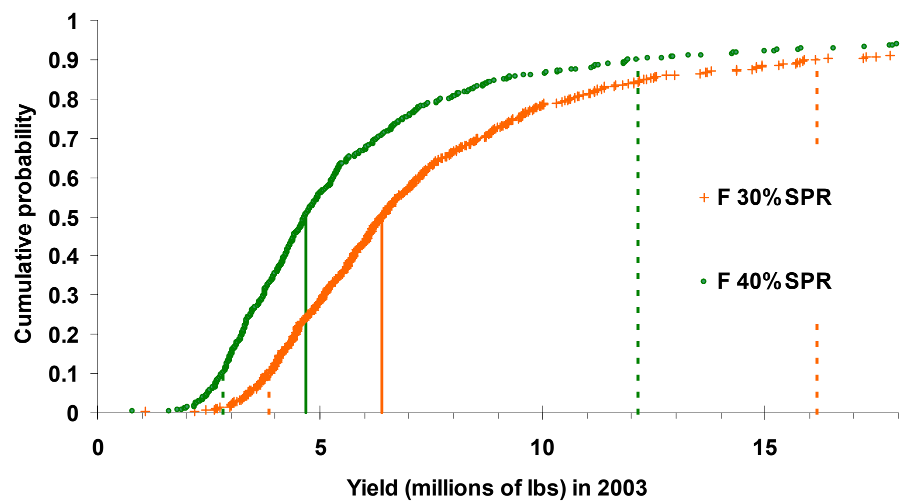



**Figure 28.** Phase plots of 500 bootstraps for the Base and Full index models. The upper solid line denotes the MFMT, the vertical dashed line denotes MSST, and the lower solid line denotes the OY control rule. The deterministic run corresponds to the larger diamond marker.

Atlantic King Group Base pdf of Yield in 2003




Atlantic King Group Full Index pdf of Yield in 2003

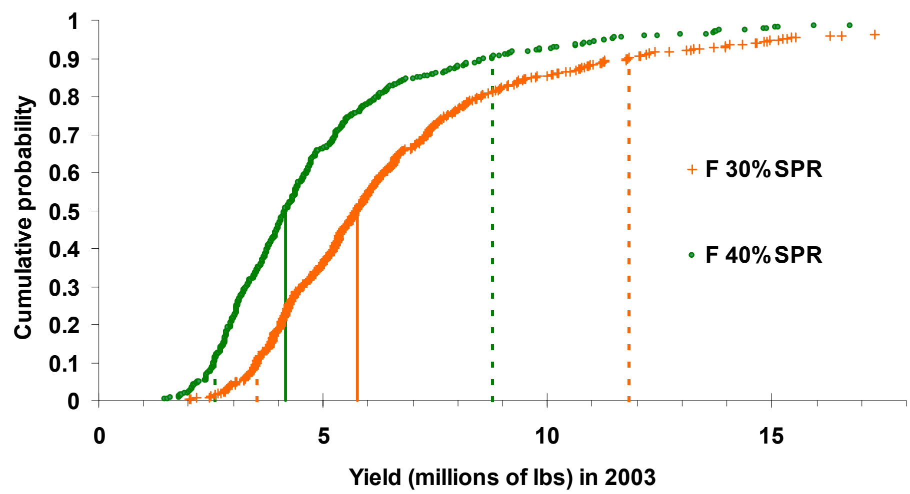



**Figure 29.** Frequency distribution of 500 bootstraps range of ABC based on probability of F exceeding F30%SPR and F40%SPR in the 2003/04 fishing year for Atlantic king mackerel under the two models. Vertical solid lines represent 0.5 percentile; dashed lines represent 0.1 and 0.9 percentiles of the cumulative distributions.

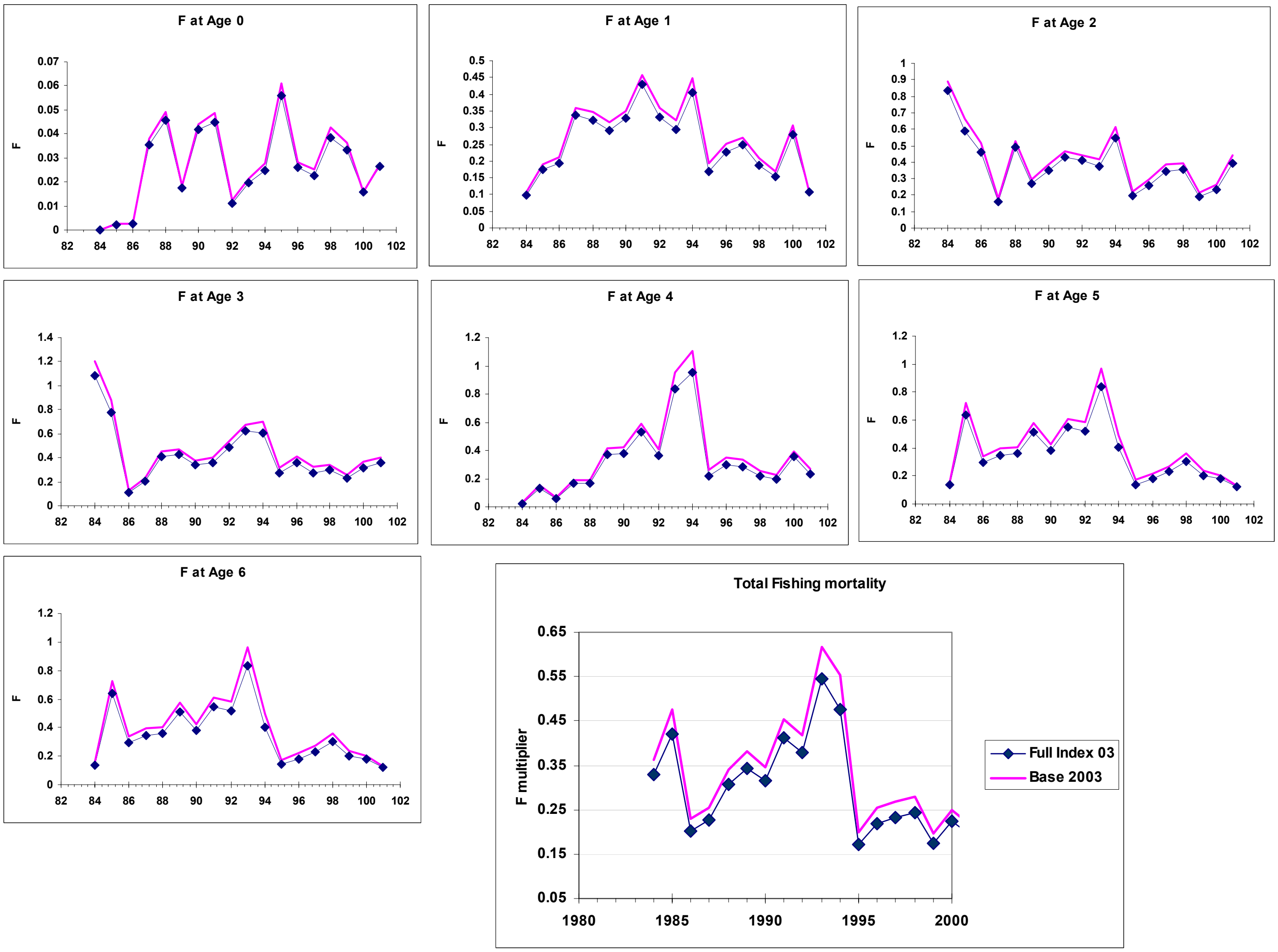



**Figure 30.** Atlantic Spanish mackerel estimates of F mortality by age from the Base and Full index models.


**Figure 31.** Atlantic Spanish mackerel estimates of stock size by age from the Base and Full index models.


**Figure 32.** Atlantic Spanish mackerel predicted (solid lines) and standard index (diamonds) from the tuned VPA Base and Full index models.

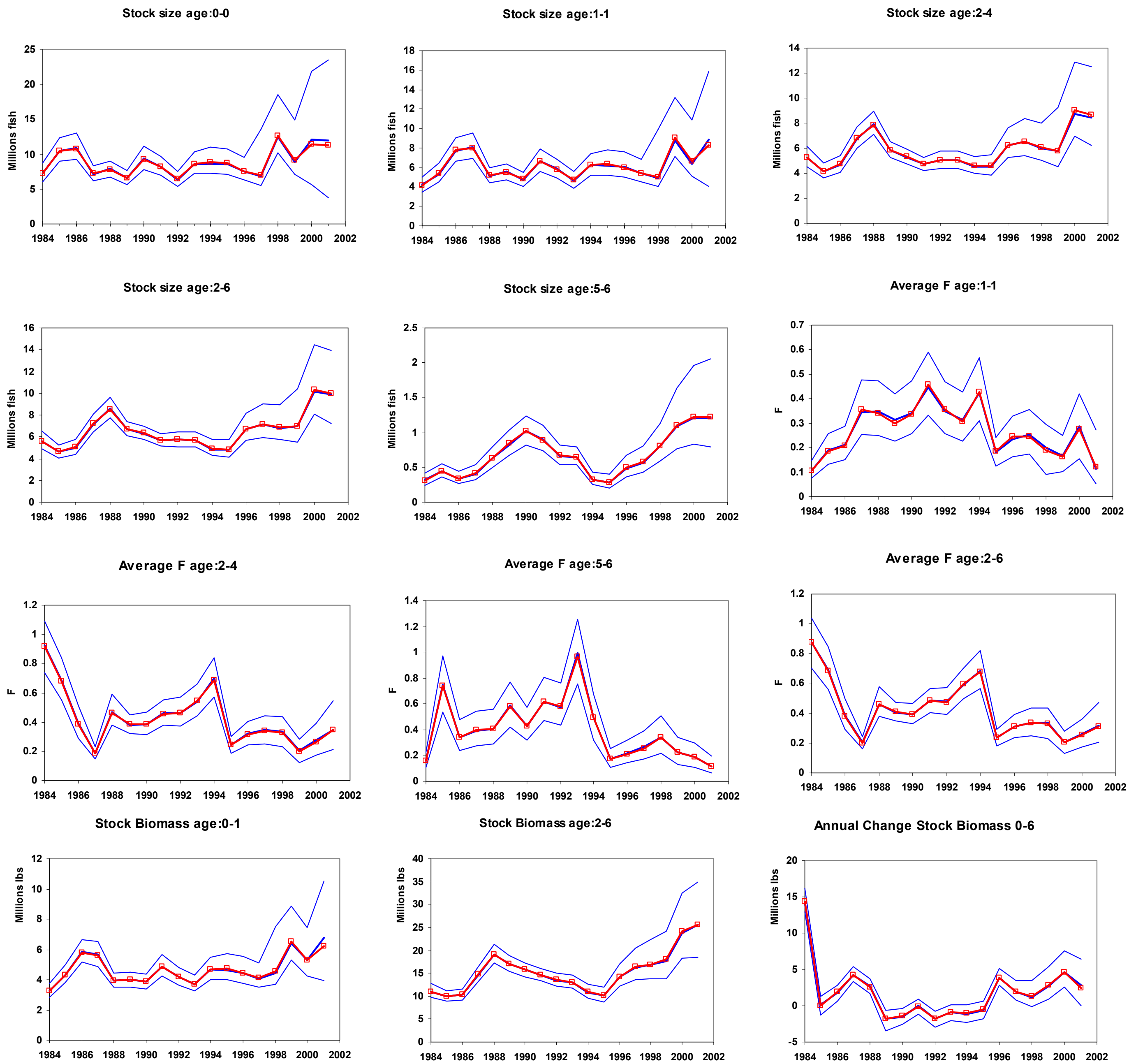



**Figure 33.** Comparison of Atlantic Spanish mackerel population trends estimated by the Base model (solid lines) with 80% confidence intervals and by the Full model index (open square line).

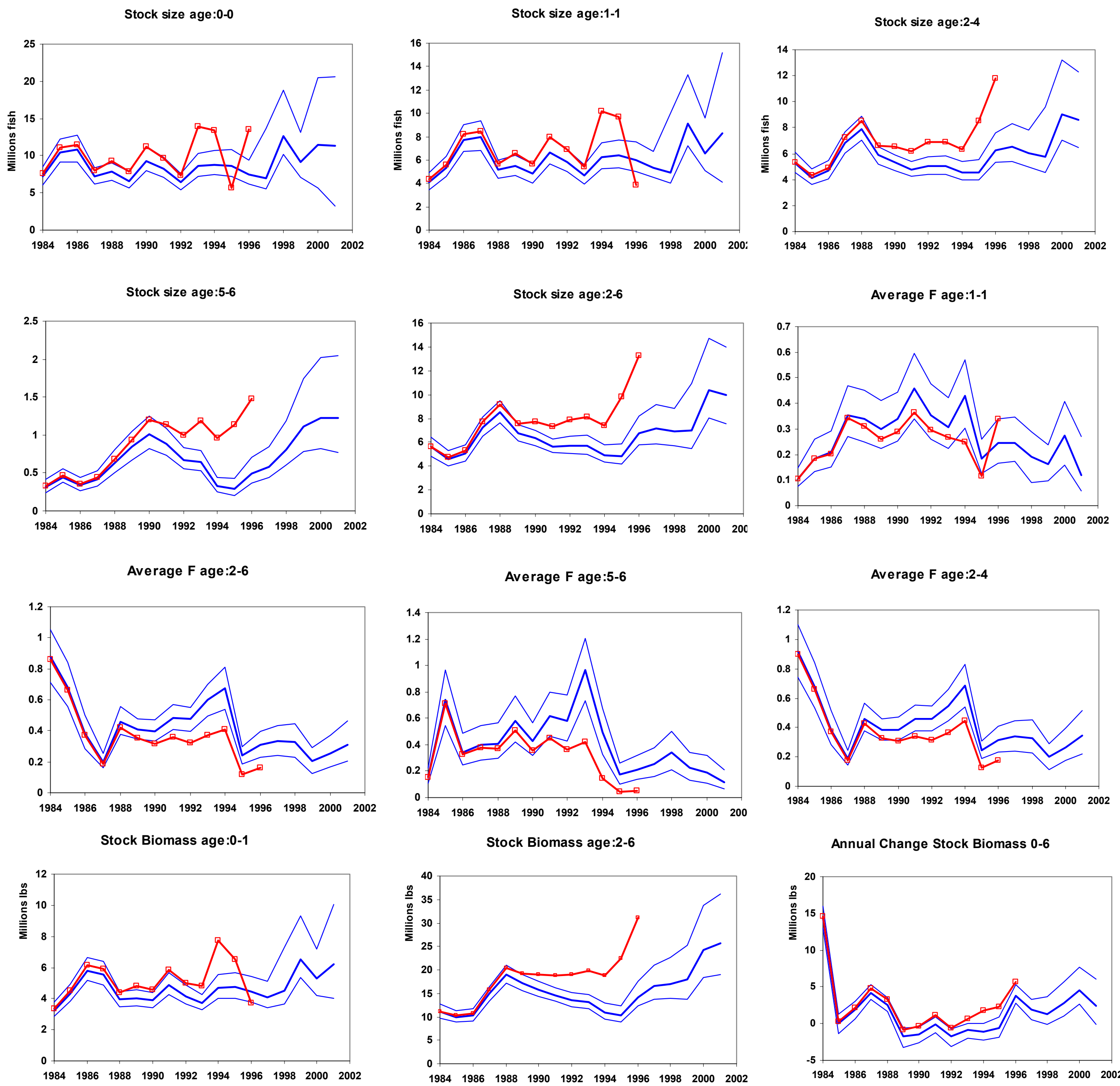



**Figure 34.** Atlantic Spanish mackerel population trends with 80% confidence intervals from the Full Index model (solid lines). For comparison, results from the 1998 SA are also shown (square marker line).

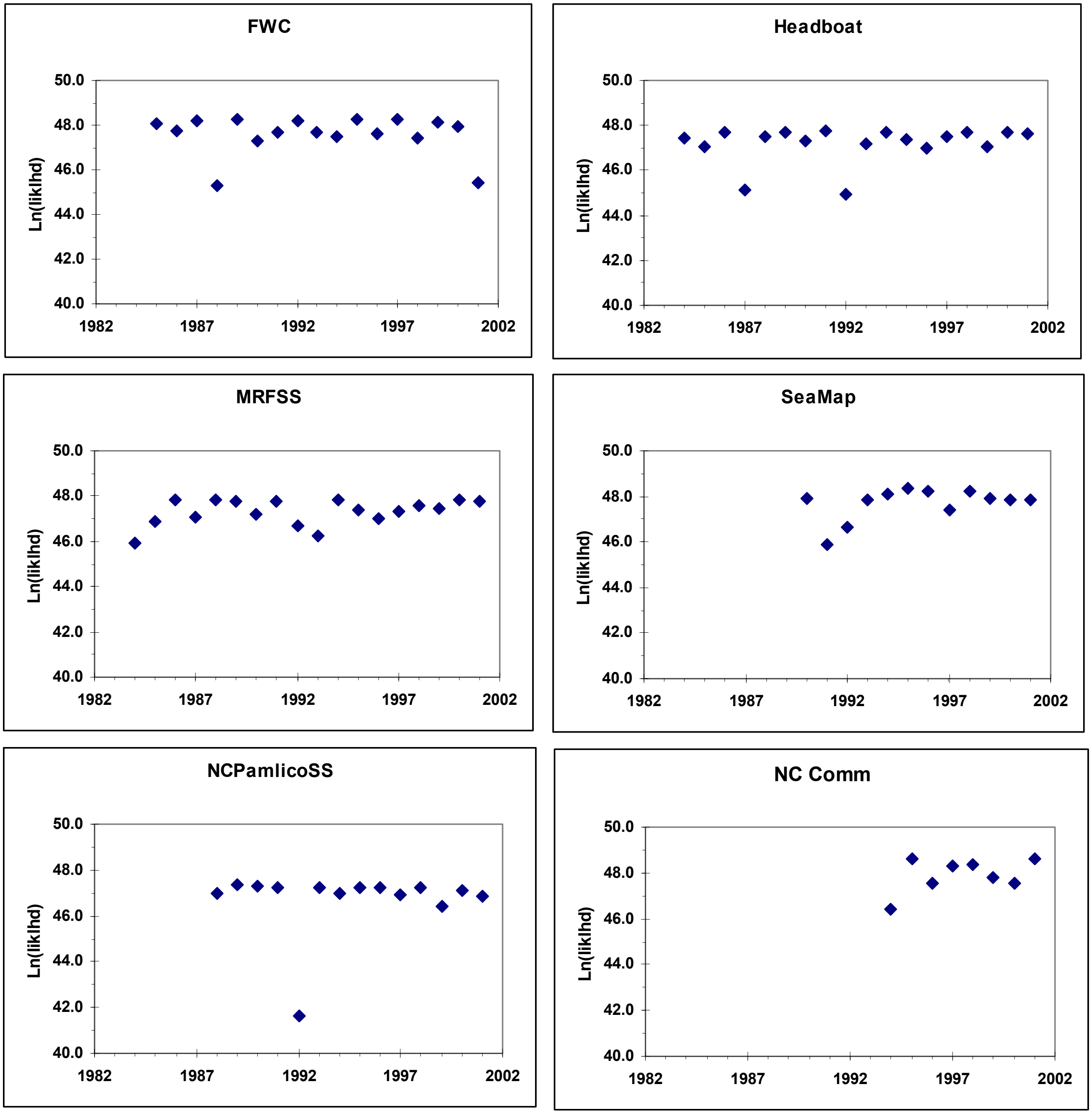



**Figure 35.** Jacknife estimates for tuned VPA Full index model fit Atlantic Spanish mackerel.

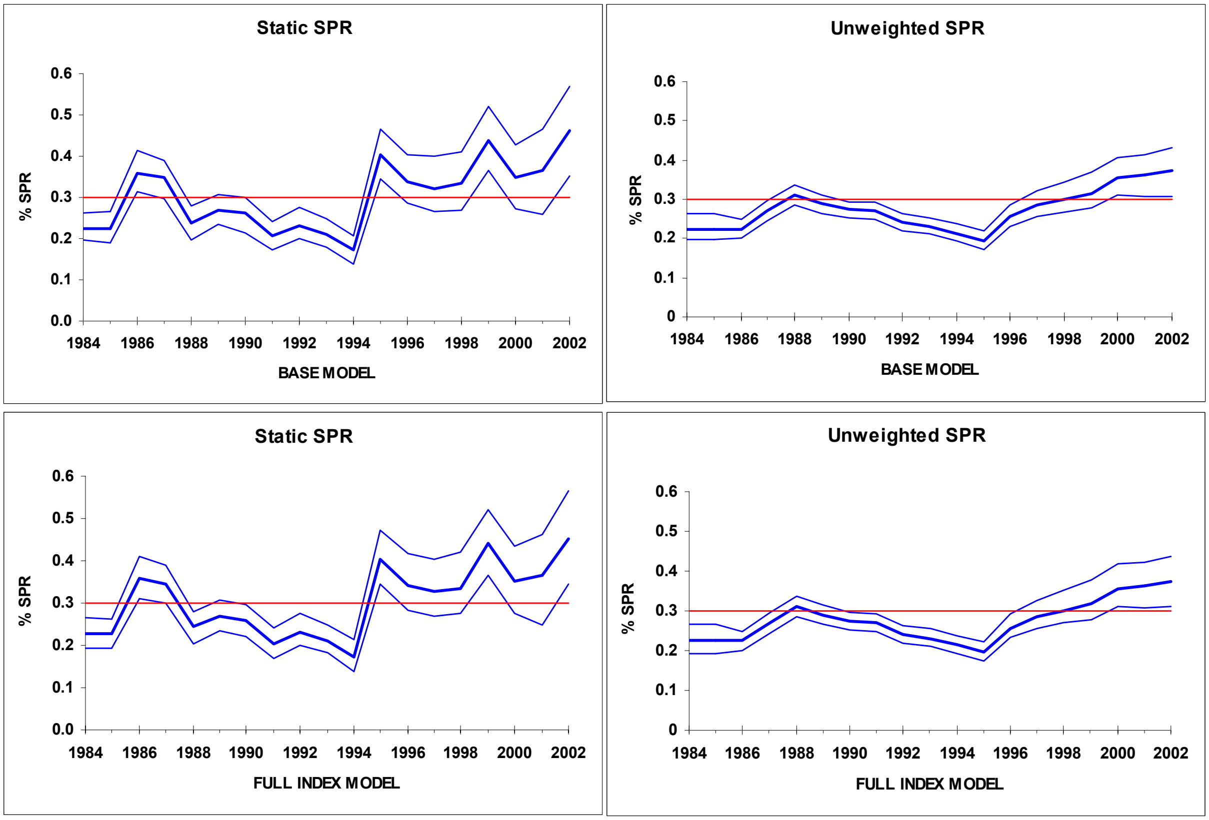



**Figure 36.** Comparison of static and transitional un-weighted SPR from the VPA Base model and the VPA Full index model for Atlantic Spanish mackerel 2003 stock evaluation.

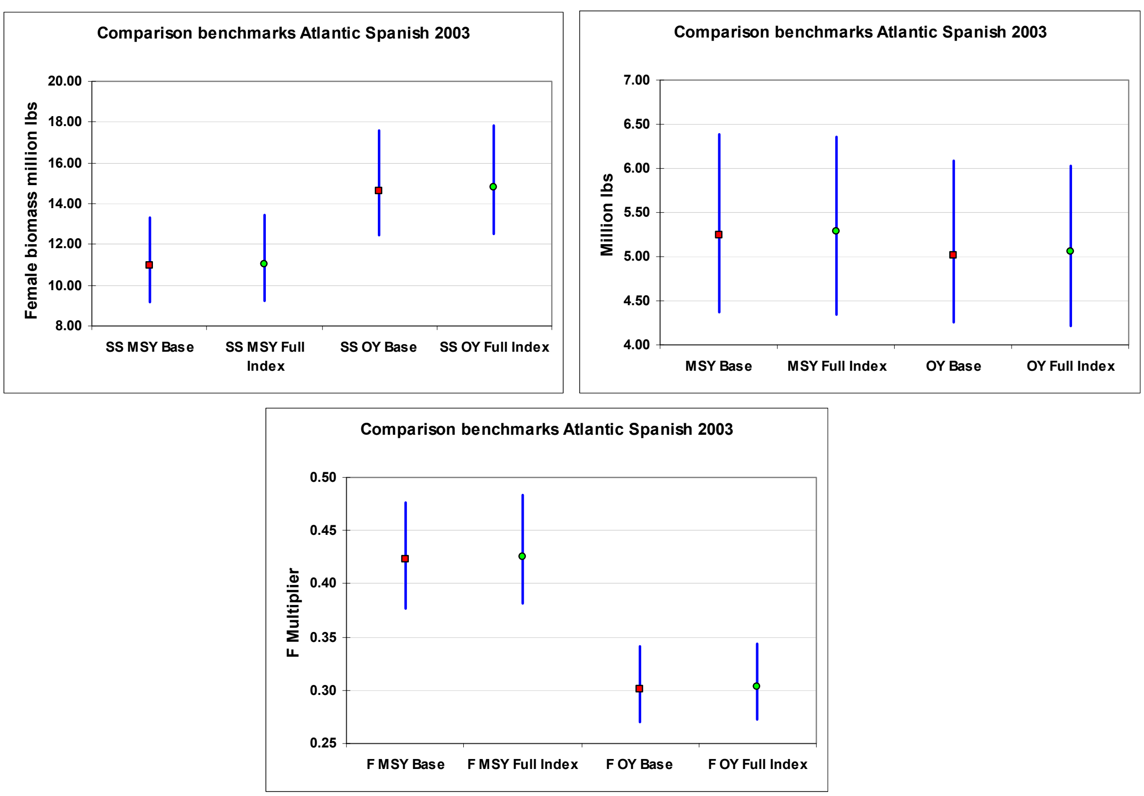



**Figure 37** Atlantic Spanish mackerel benchmarks 2003 assessment. Spawning stock (SS) biomass, MSY, OY, and correspondent fishing mortality rates from the two models evaluated.

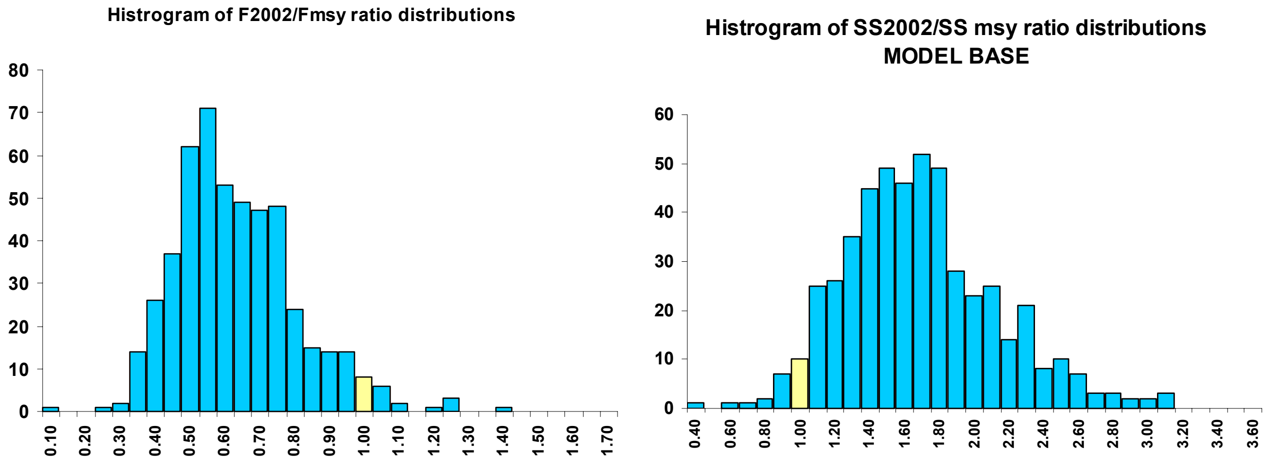



**Figure 38.** Frequency distribution of Atlantic Spanish $F_{2002}/F_{MSY}$ and $SS_{2002}/SS_{MSY}$ ratios of 500 bootstraps for the Base model.

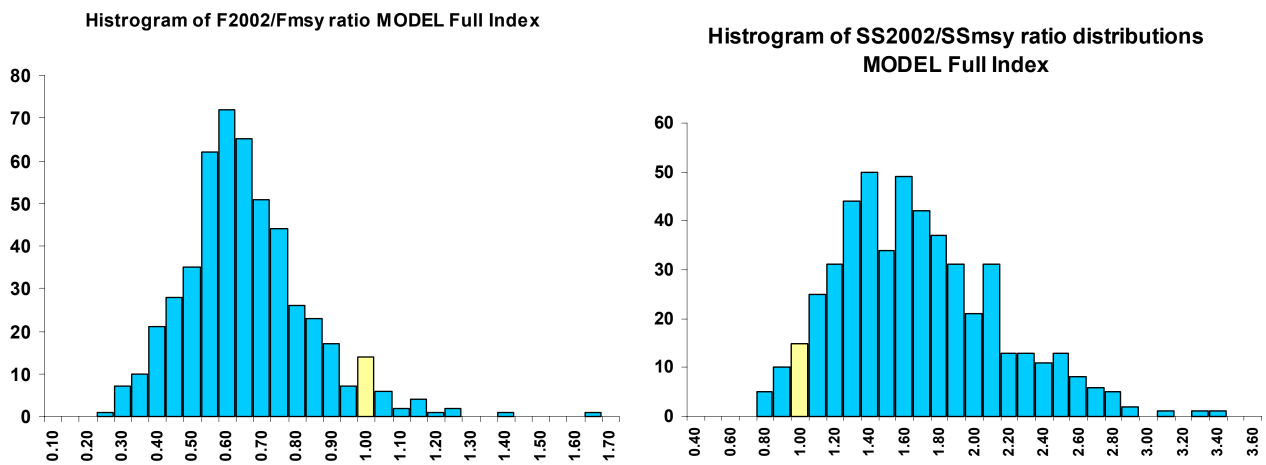



**Figure 39.** Frequency distribution of Atlantic Spanish $F_{2002}/F_{MSY}$ and $SS_{2002}/SS_{MSY}$ ratios of 500 bootstraps for the Full Index model.

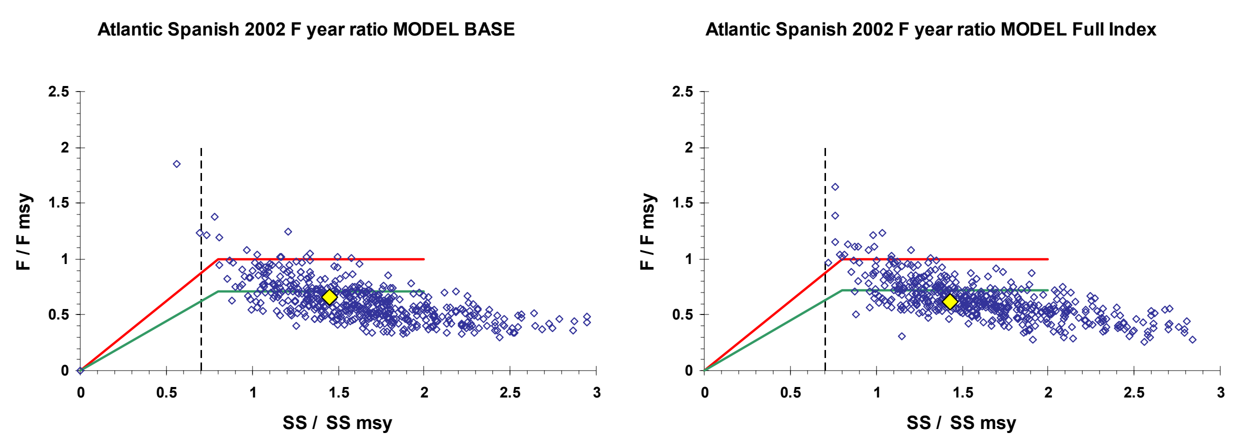
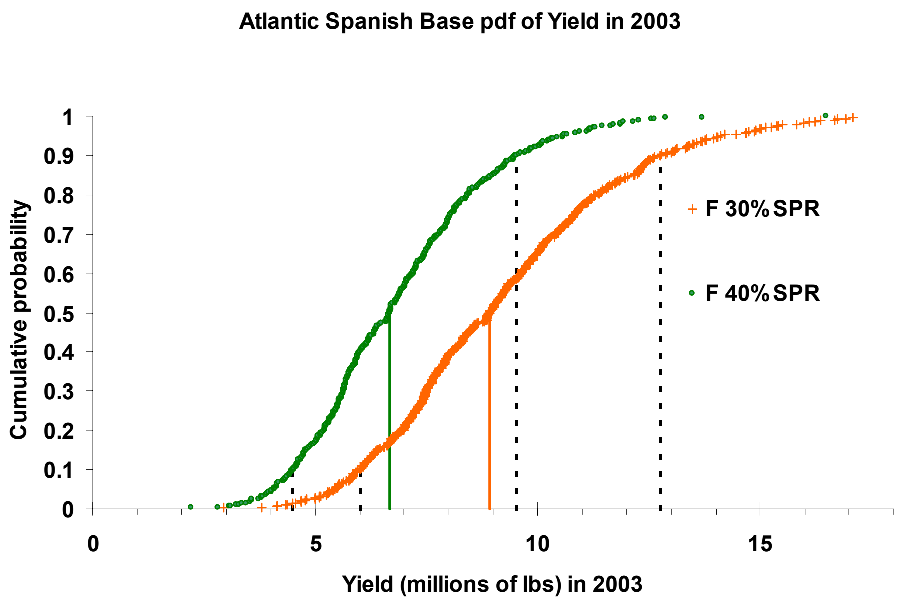



**Figure 40.** Phase plots of 500 bootstraps for the Base and Full index models. The upper solid line denotes the MFMT, the vertical dashed line denotes MSST, and the lower solid line denotes the OY control rule. The deterministic run corresponds to the larger diamond marker.



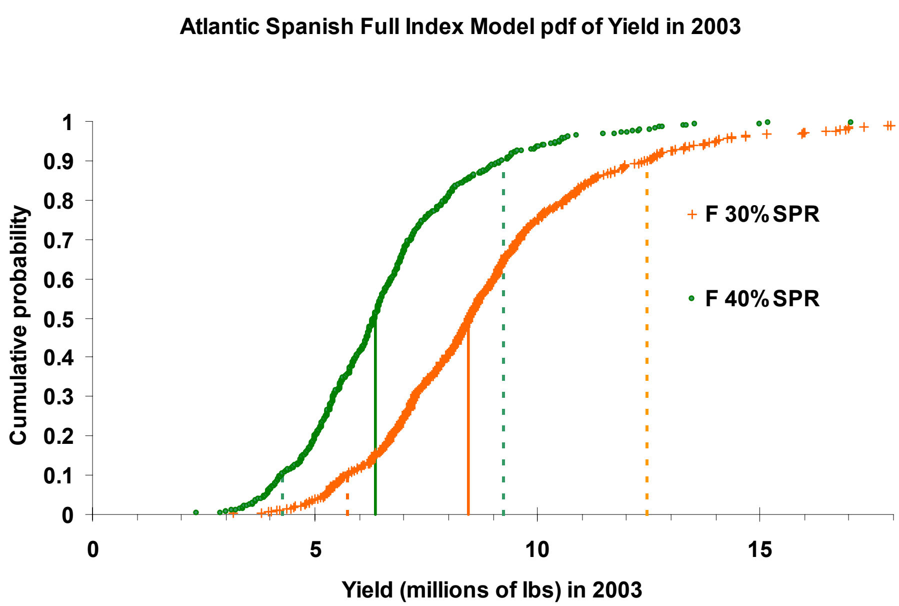




**Figure 41.** Frequency distribution of 500 bootstraps range of ABC based on probability of F exceeding $F_{30\%SPR}$ and $F_{40\%SPR}$ in the 2003/04 fishing year for Atlantic Spanish mackerel under the two models. Vertical solid lines represent 0.5 percentile; dashed lines represent 0.1 and 0.9 percentiles of the cumulative distributions.

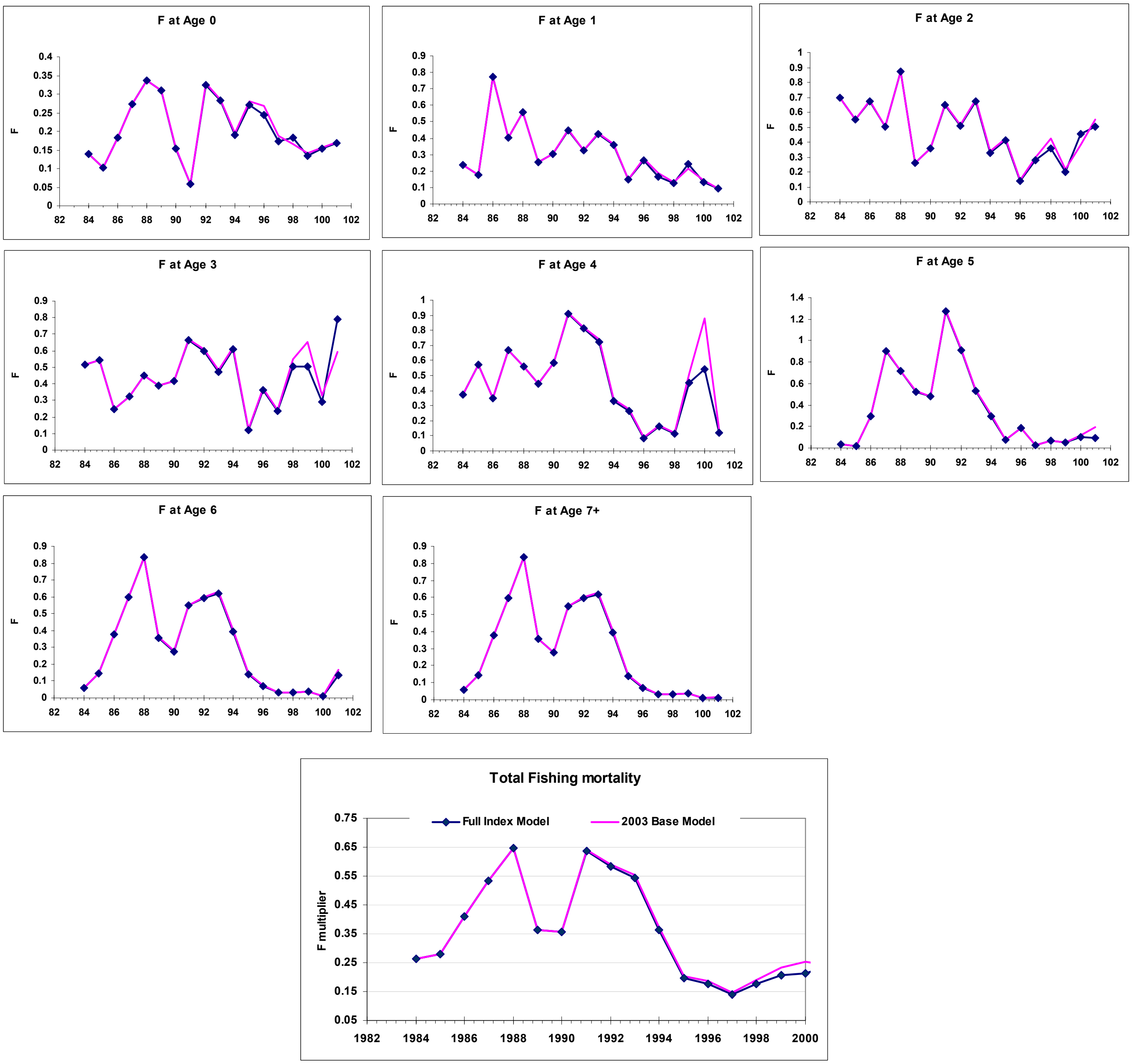



**Figure 42.** Gulf Spanish mackerel estimates of F mortality by age from the Base and Full index models.

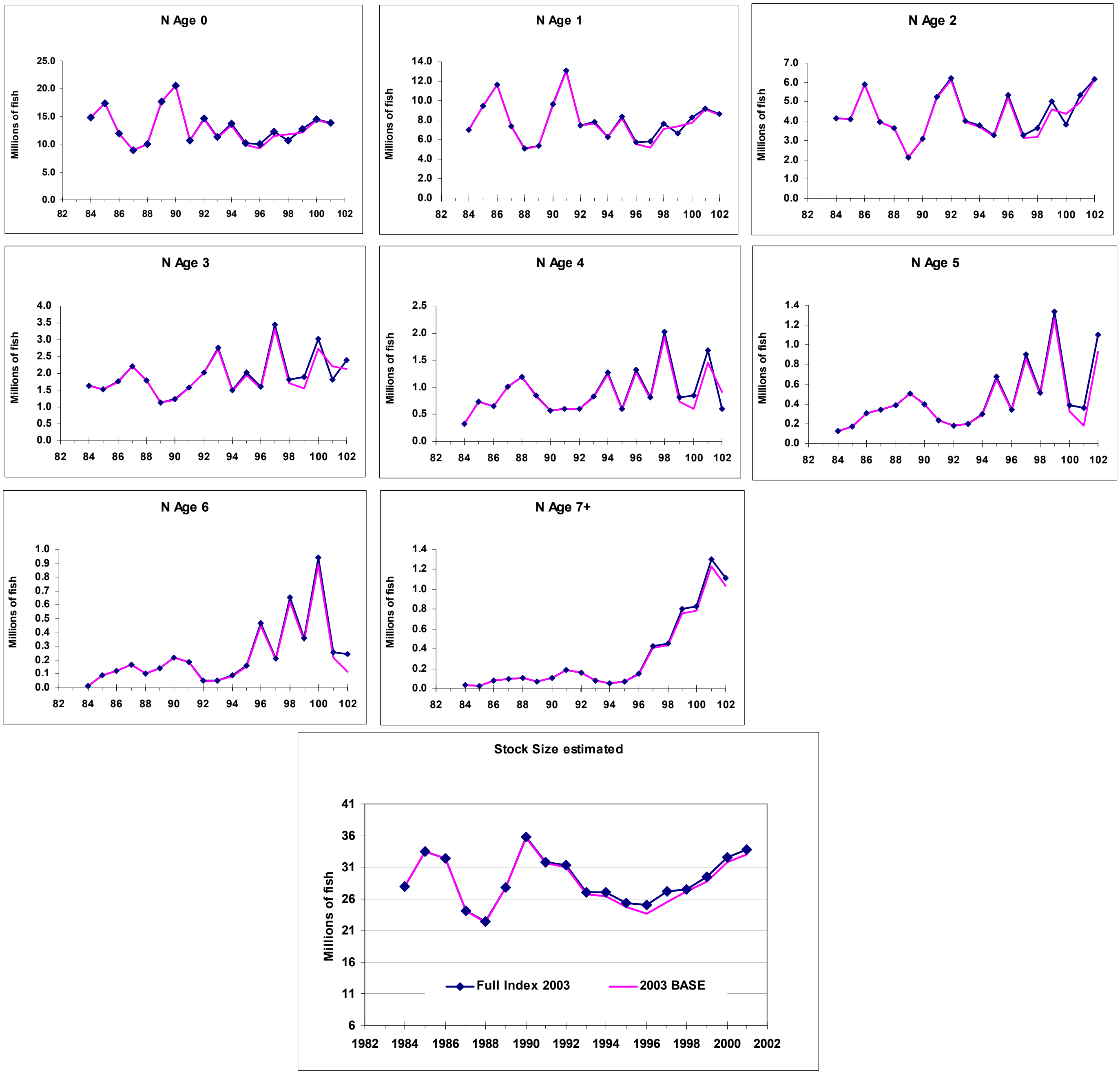
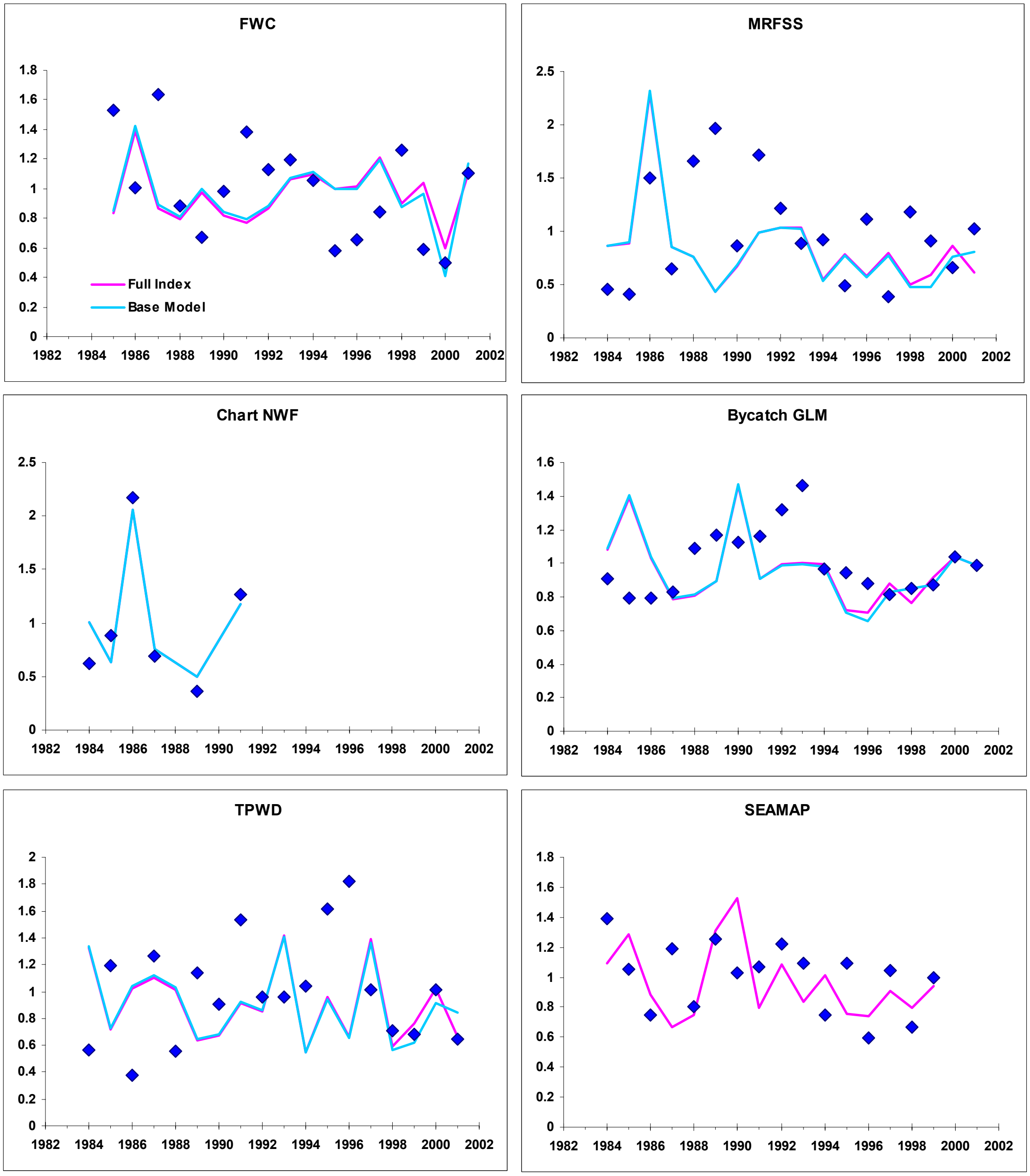



**Figure 43.** Gulf Spanish mackerel estimates of stock size by age from the Base and Full index models.



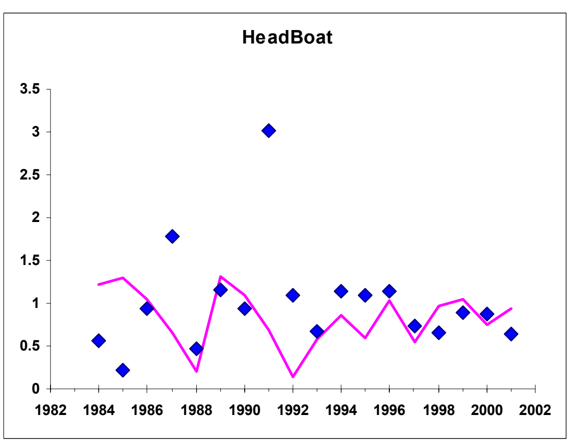




**Figure 44.** Gulf Spanish mackerel predicted (solid lines) and standard index (diamonds) form the tuned VPA Base and Full index models.

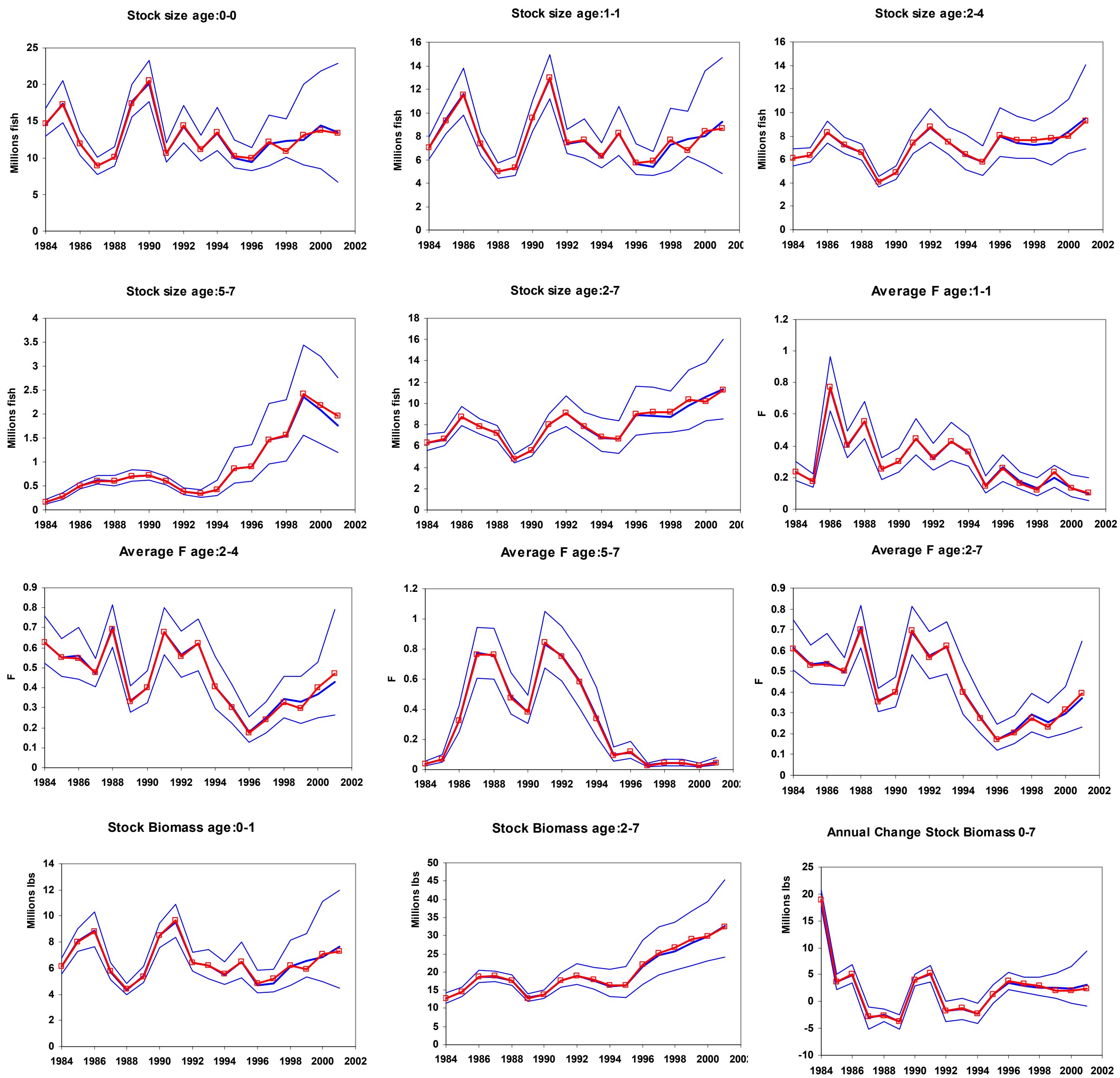



**Figure 45.** Comparison of Gulf Spanish mackerel population trends estimated by the Base model (solid lines) with 80% confidence intervals and the Full index model (open square line).

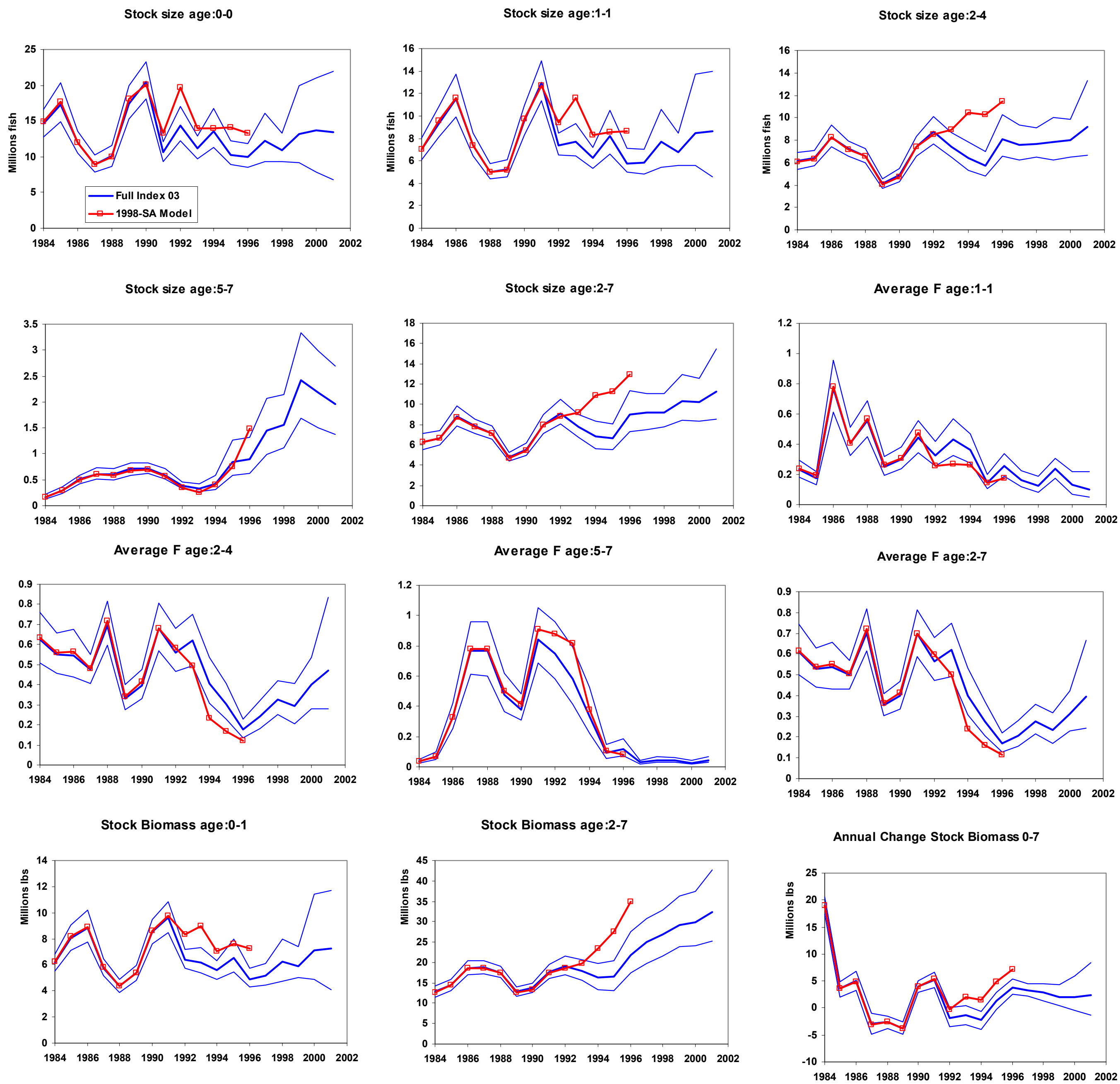
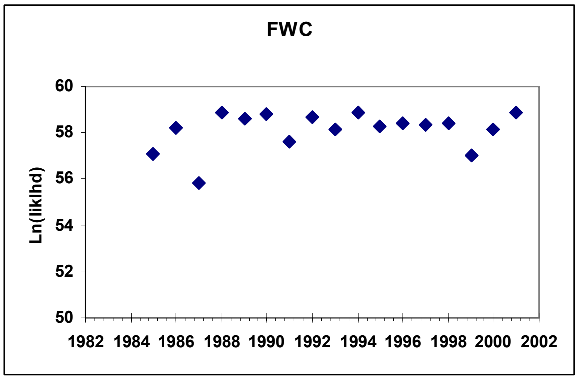
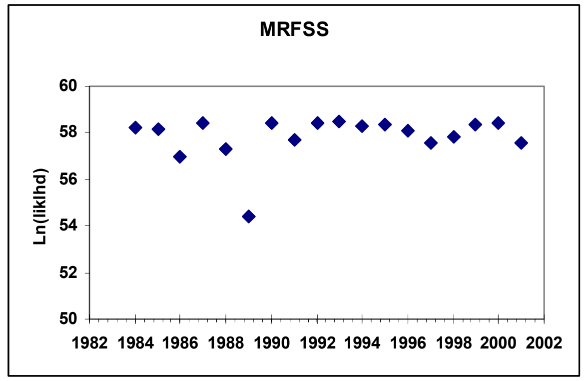
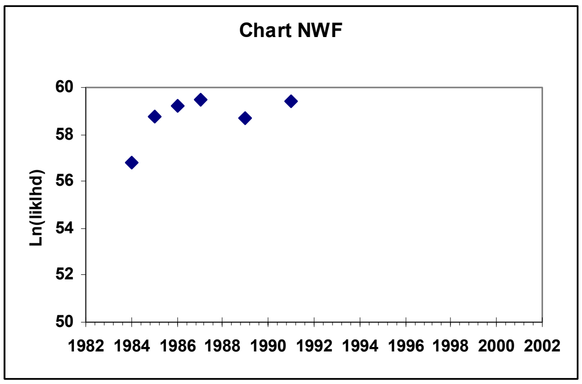
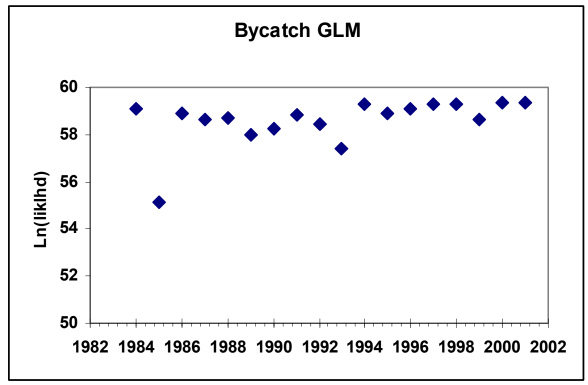


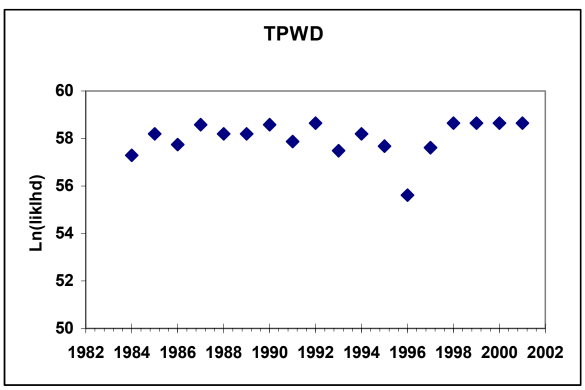

**Figure 46.** Gulf Spanish mackerel population trends with 80% confidence intervals from the Full Index model (solid lines). For comparison, results from the 1998 SA are also shown (square marker line).

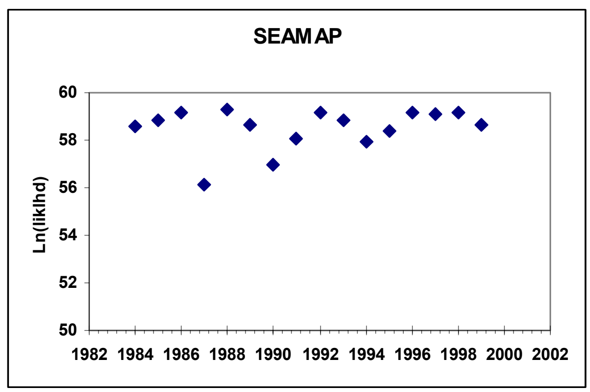


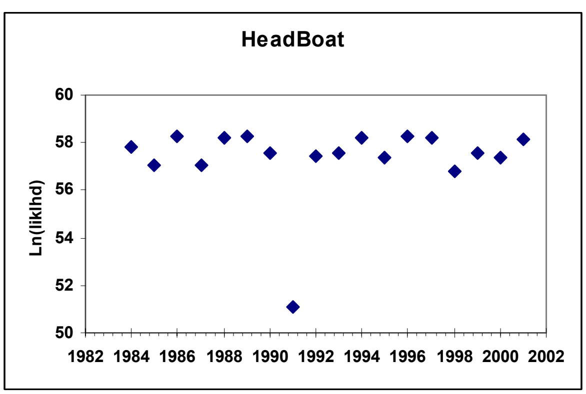




**Figure 47.** Jacknife estimates for tuned VPA Full index model fit Gulf Spanish mackerel.

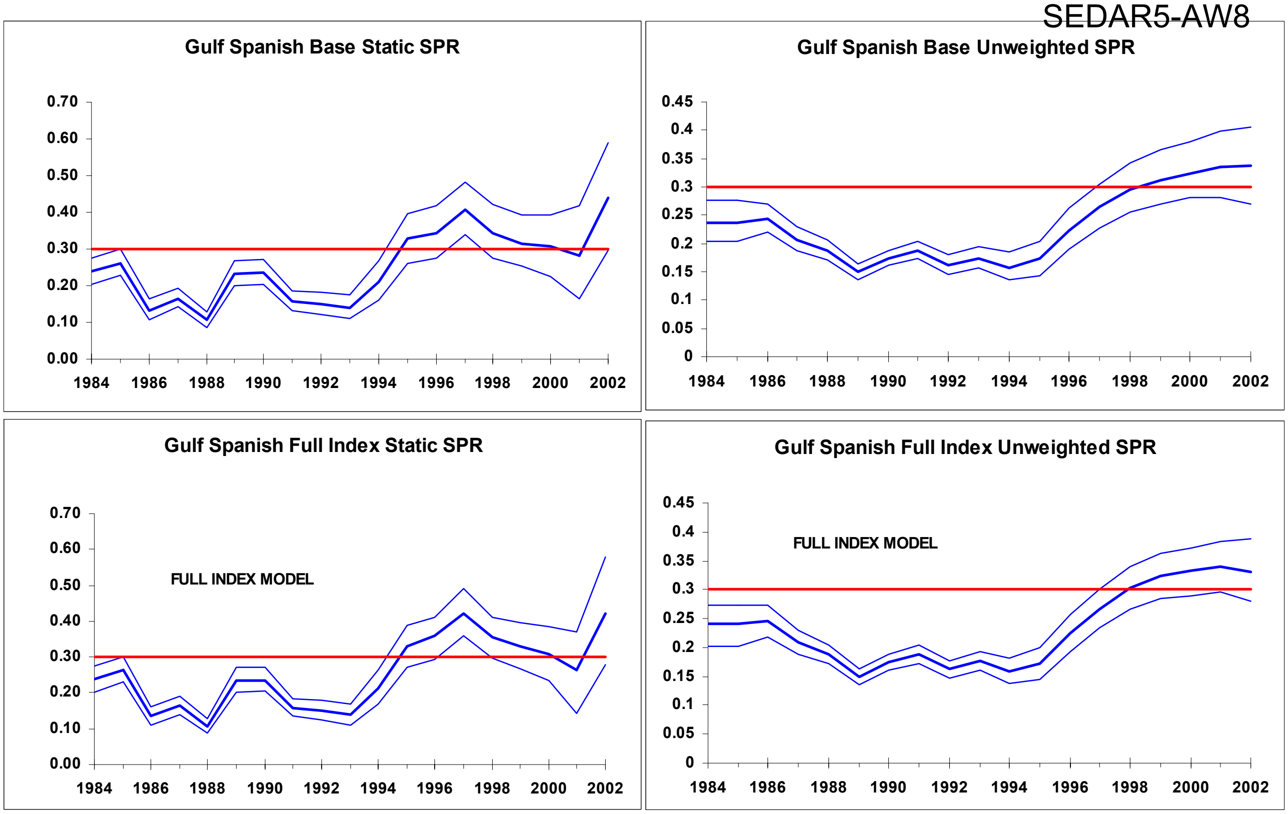



**Figure 48.** Comparison of static and transitional unweighted SPR from the VPA Base model and the VPA Full Index model for Gulf Spanish mackerel 2003 stock evaluation.

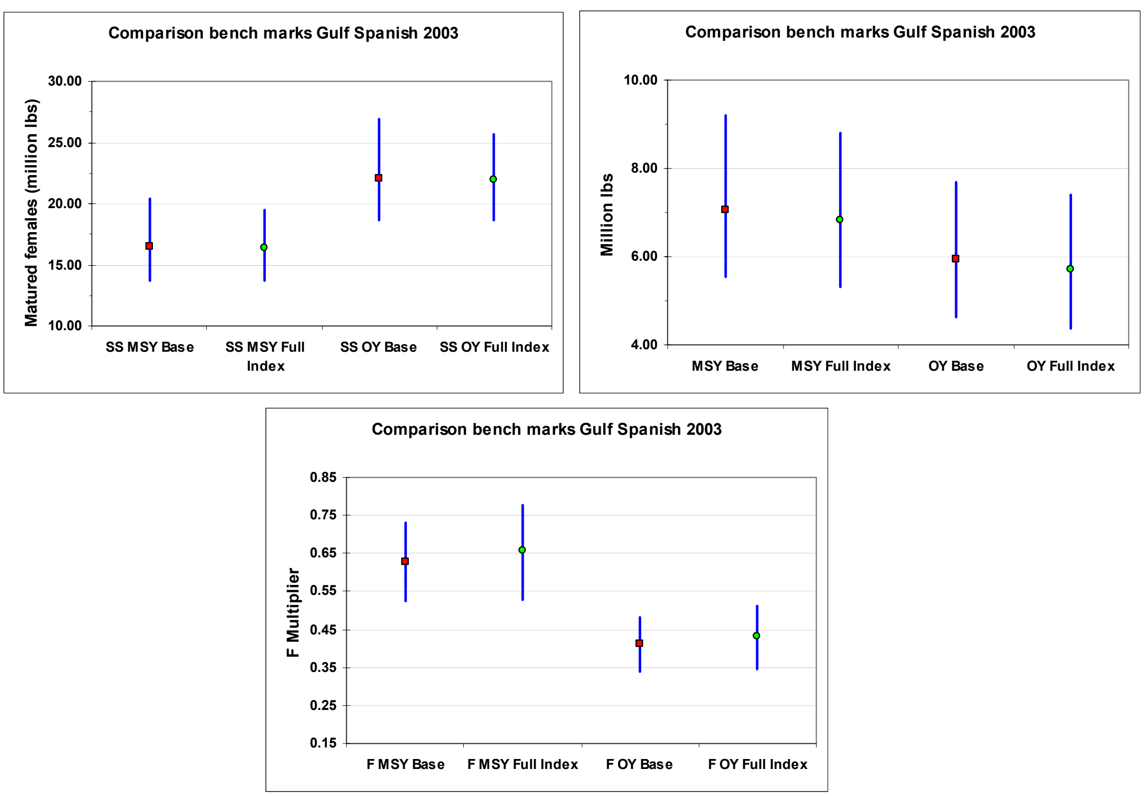



**Figure 49.** Gulf Spanish mackerel benchmarks 2003 assessment. Spawning stock (SS) biomass, MSY, OY, and correspondent fishing mortality rates from the two models.

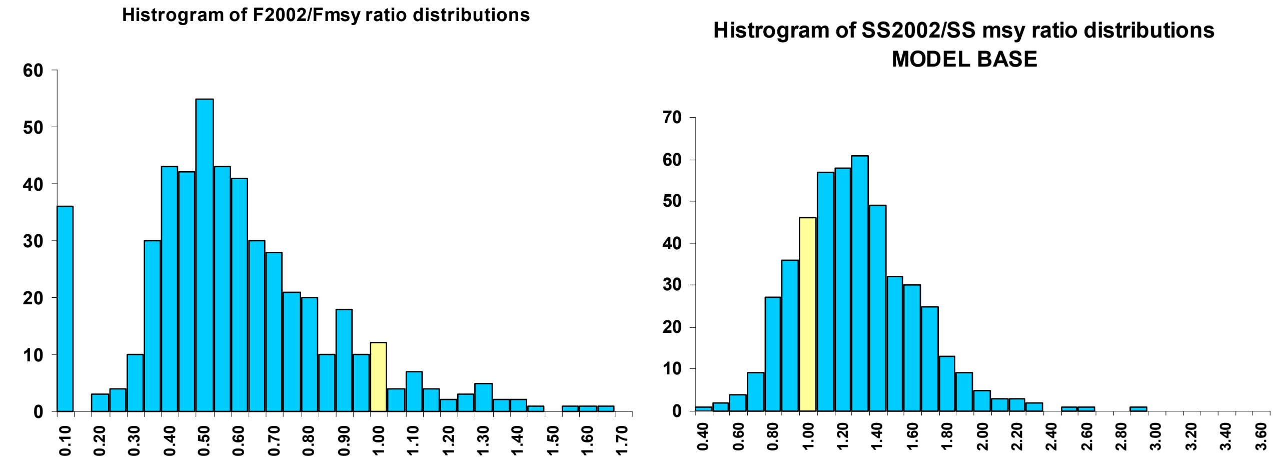



**Figure 50.** Frequency distribution of Gulf Spanish $F_{2002}/F_{MSY}$ and $SS_{2002}/SS_{MSY}$ ratios of 500 bootstraps for the Base model.

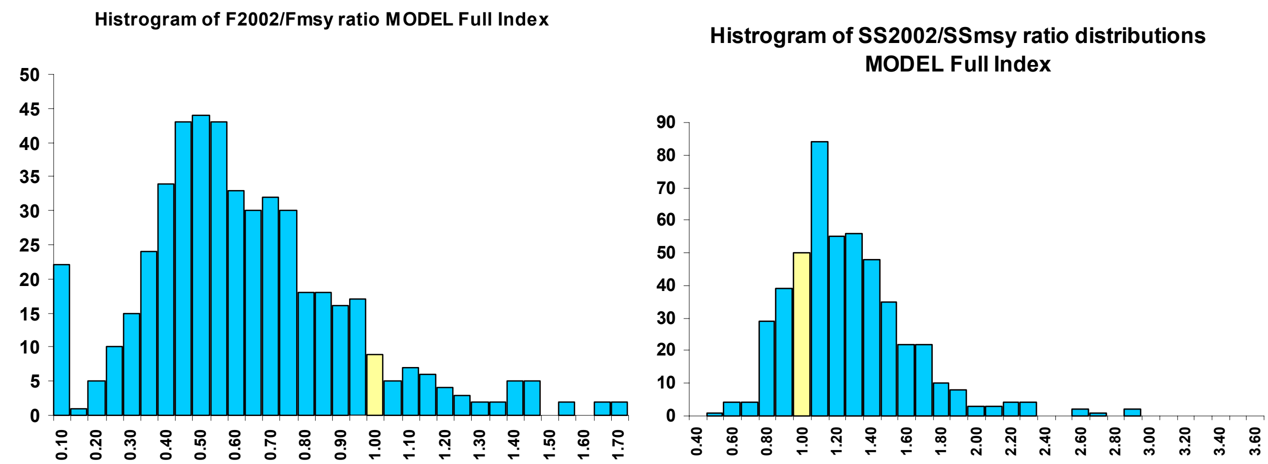



**Figure 51.** Frequency distribution of Gulf Spanish $F_{2002}/F_{MSY}$ and $SS_{2002}/SS_{MSY}$ ratios of 500 bootstraps for the Full Index model.

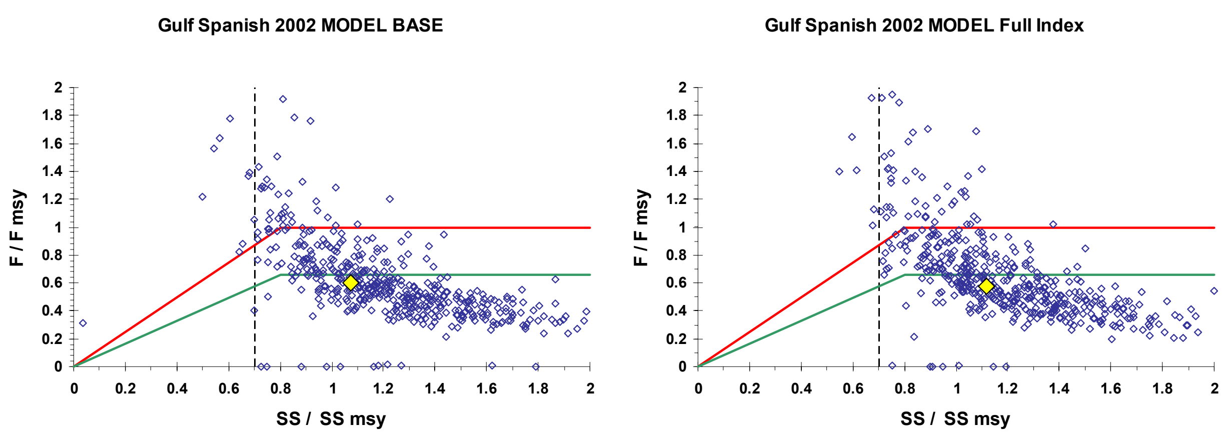
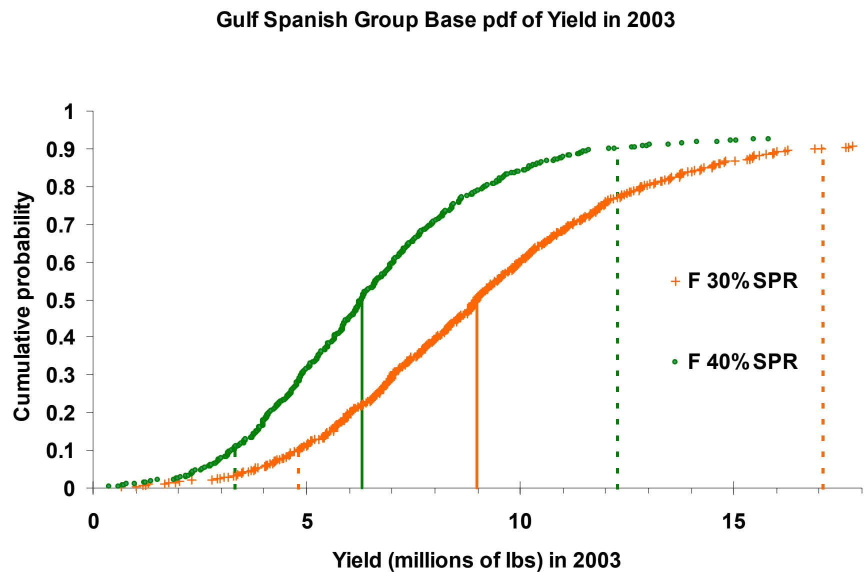



**Figure 52.** Phase plots of 500 bootstraps for the Base and Full Index models. The upper solid line denotes the MFMT, the vertical dashed line denotes MSST, and the lower solid line denotes the OY control rule. The deterministic run corresponds to the large diamond marker.



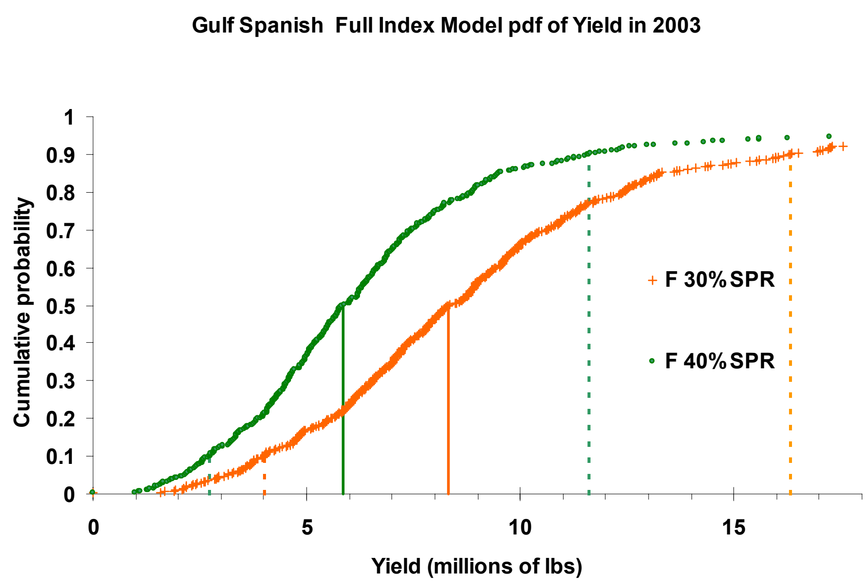




**Figure 53.** Frequency distribution of 500 bootstraps range of ABC based on probability of F exceeding F30%SPR and F40%SPR in the 2003/04 fishing year for Gulf Spanish mackerel under the two models. Vertical solid lines represent 0.5 percentile; dashed lines represent 0.1 and 0.9 percentiles of the cumulative distributions.

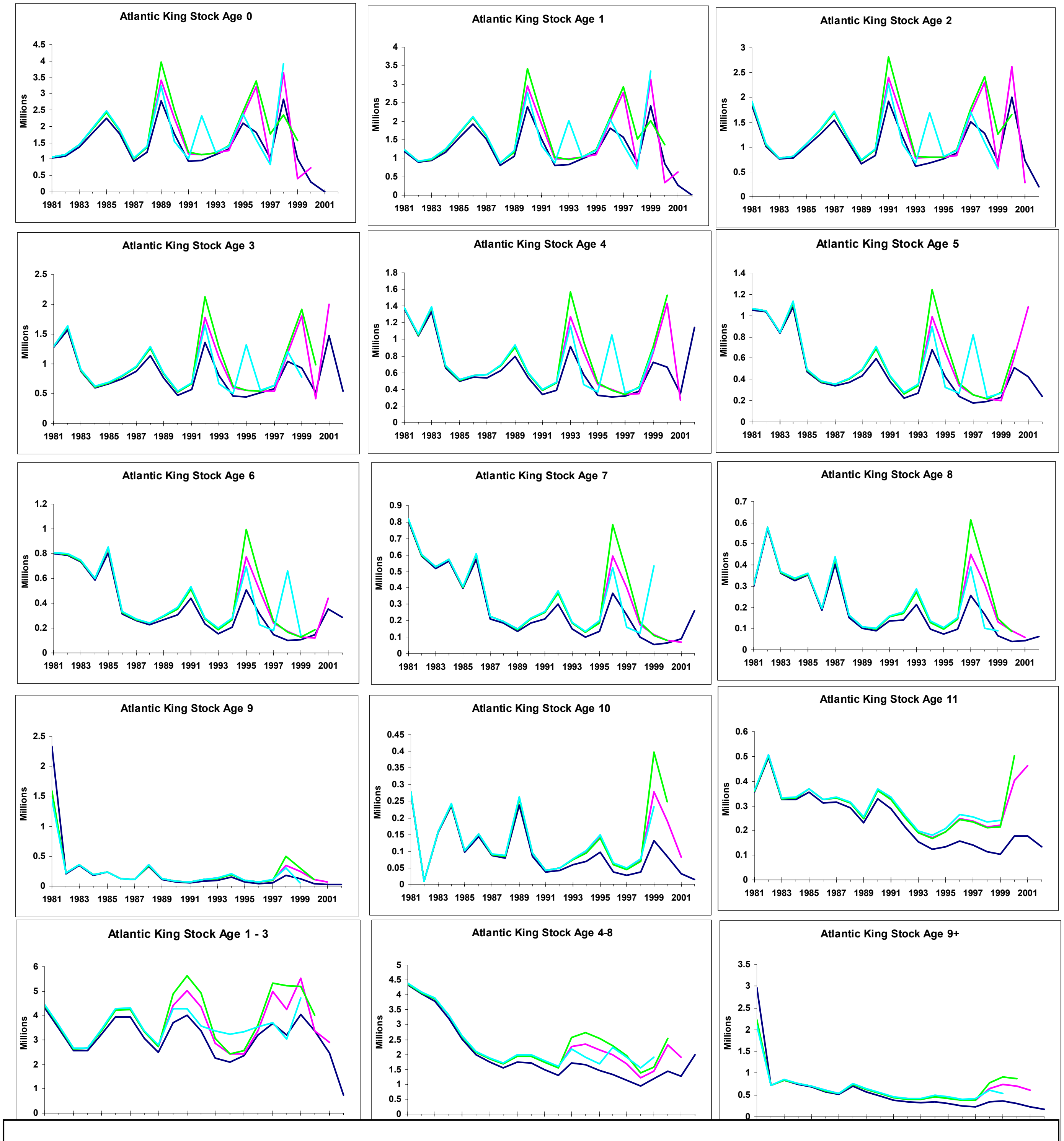



**Figure 54.** Atlantic king retrospective analysis stock size estimation.

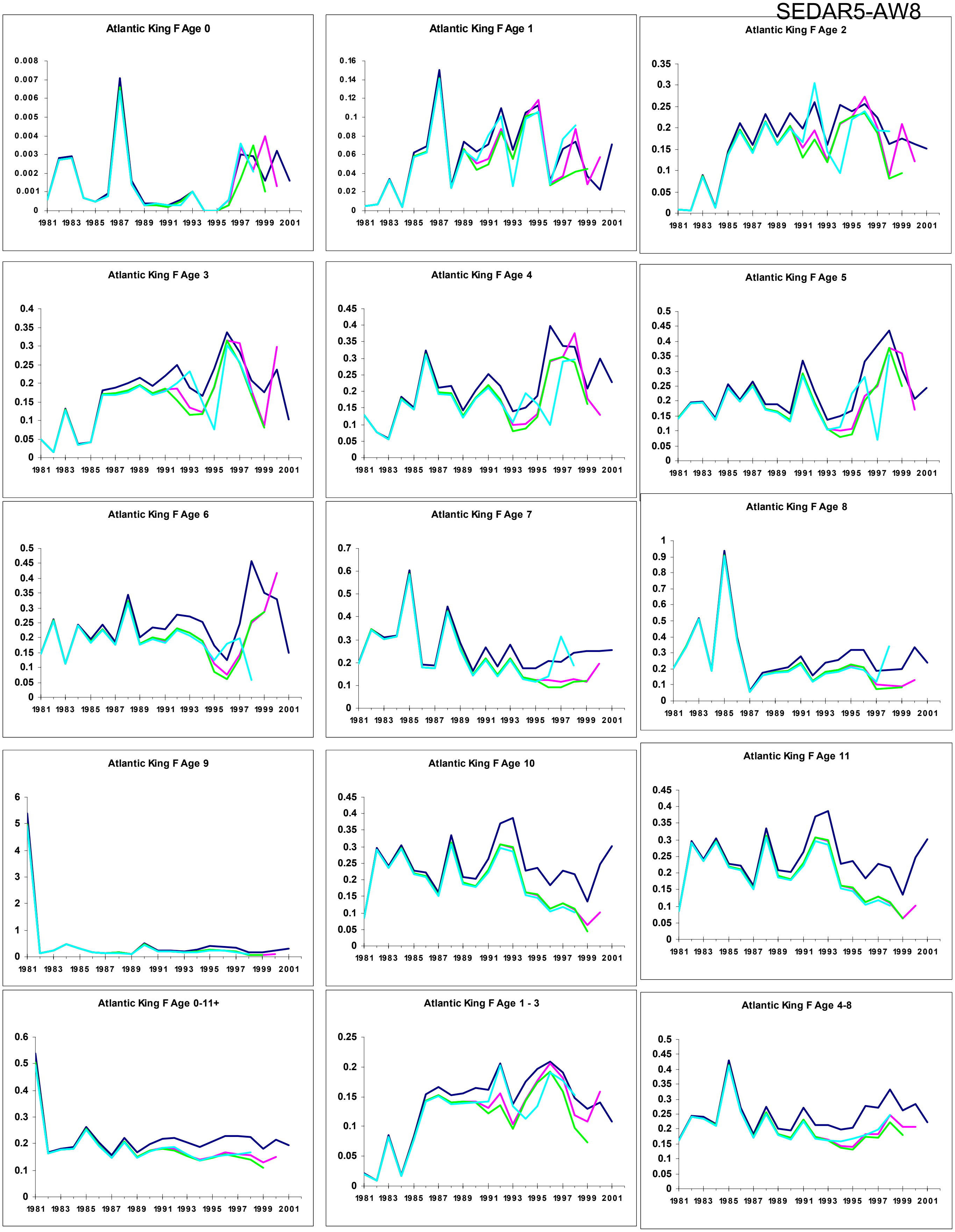



**Figure 55.** Atlantic king retrospective analysis F mortalities by age estimation.

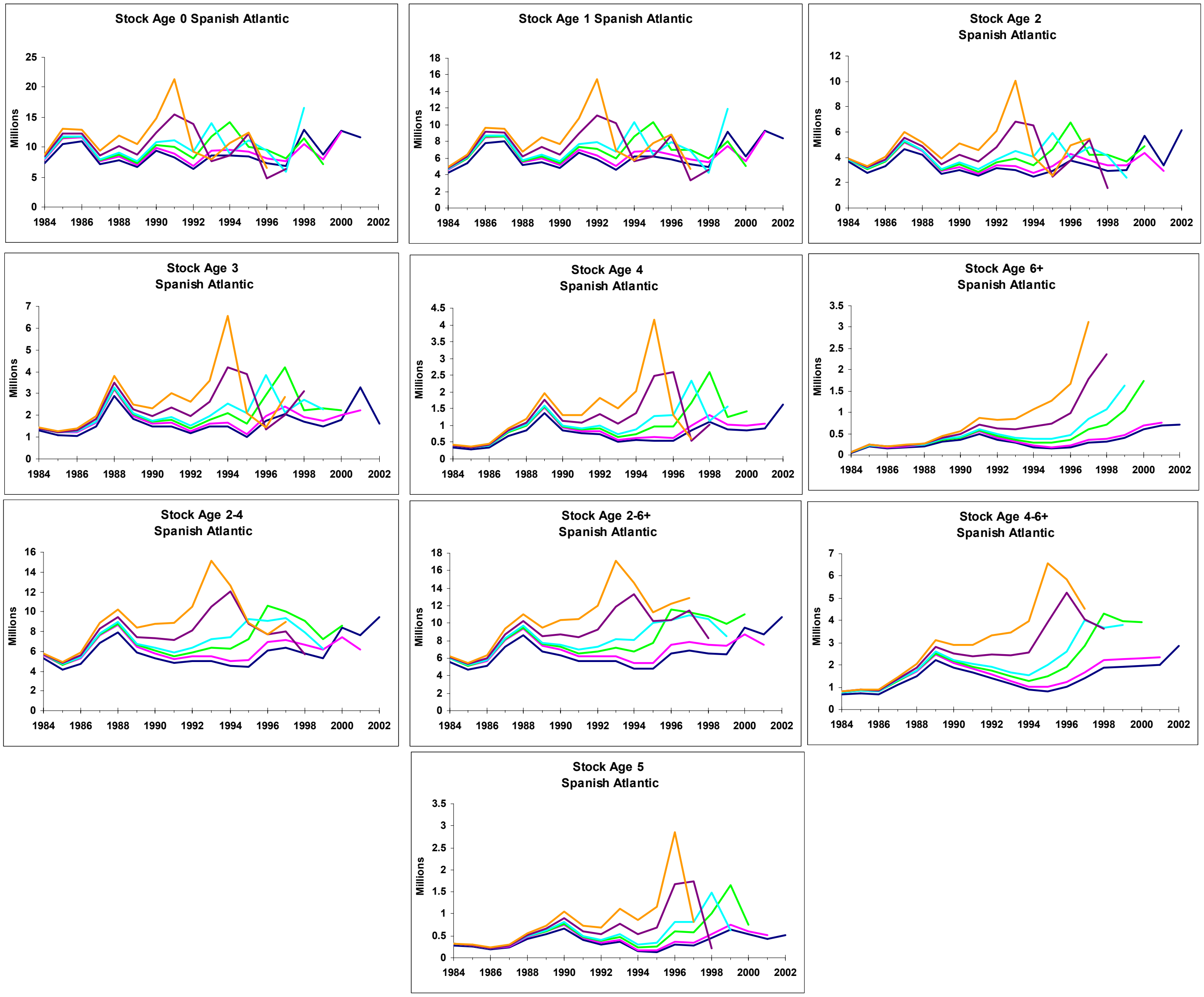



**Figure 56.** Atlantic Spanish retrospective analysis stock size estimation by sequentially removing the last year of data from the 1984-2001 catch at age and indices of abundance. The retrospective period covers 1996-2000 years.

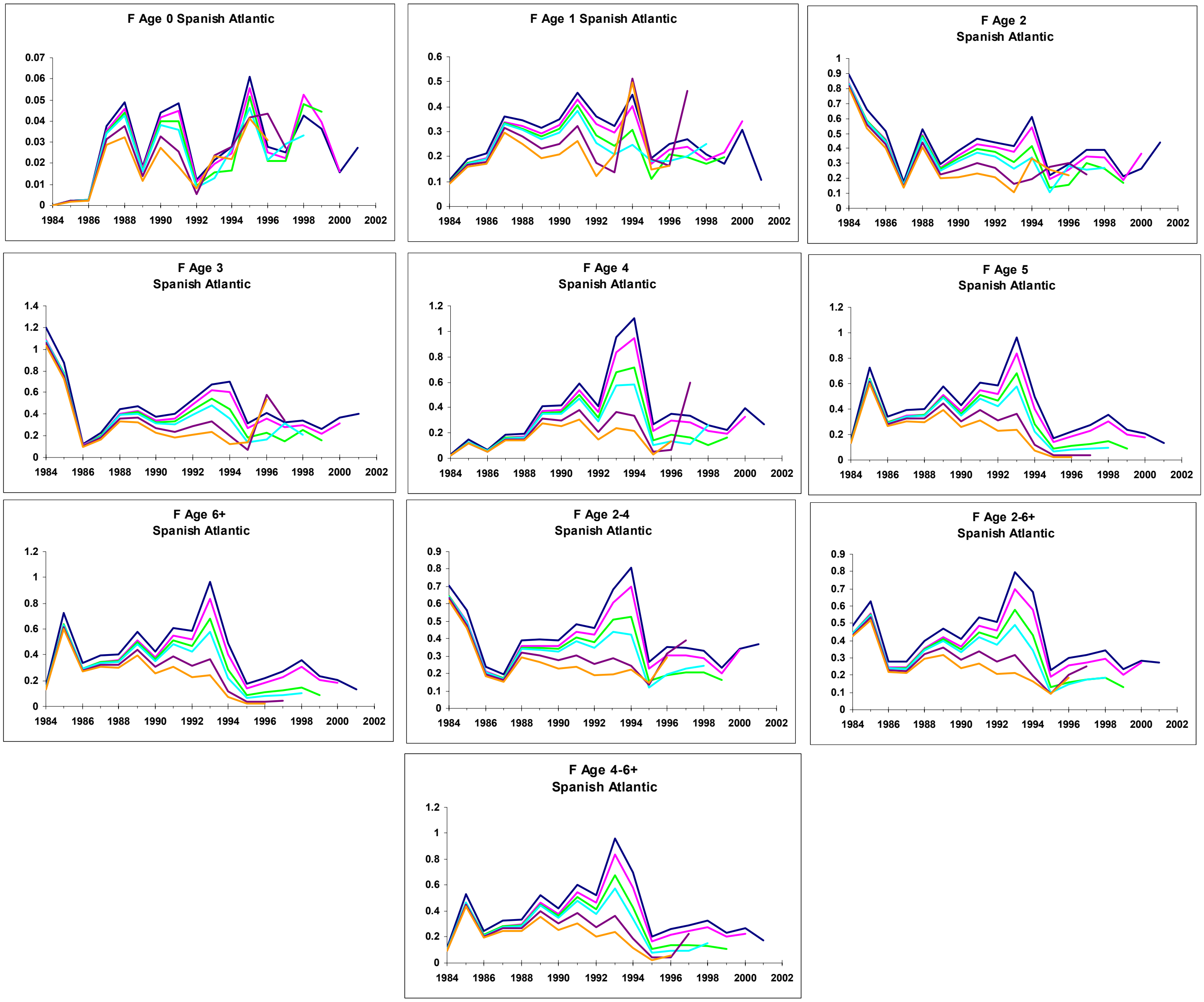



**Figure 57.** Atlantic Spanish retrospective analysis F mortality rates by age estimation.

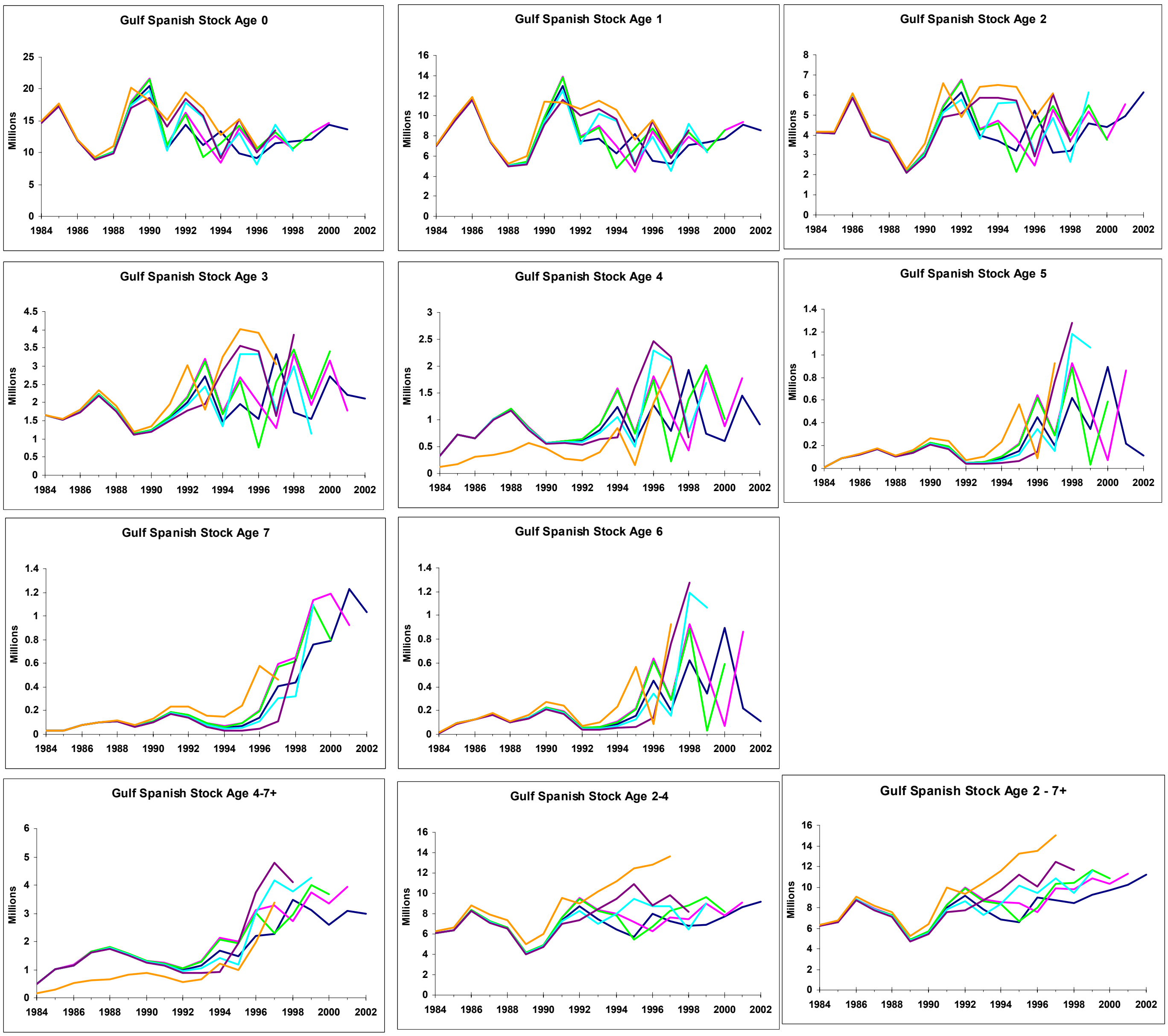



**Figure 58.** Gulf Spanish retrospective analysis stock size estimation.

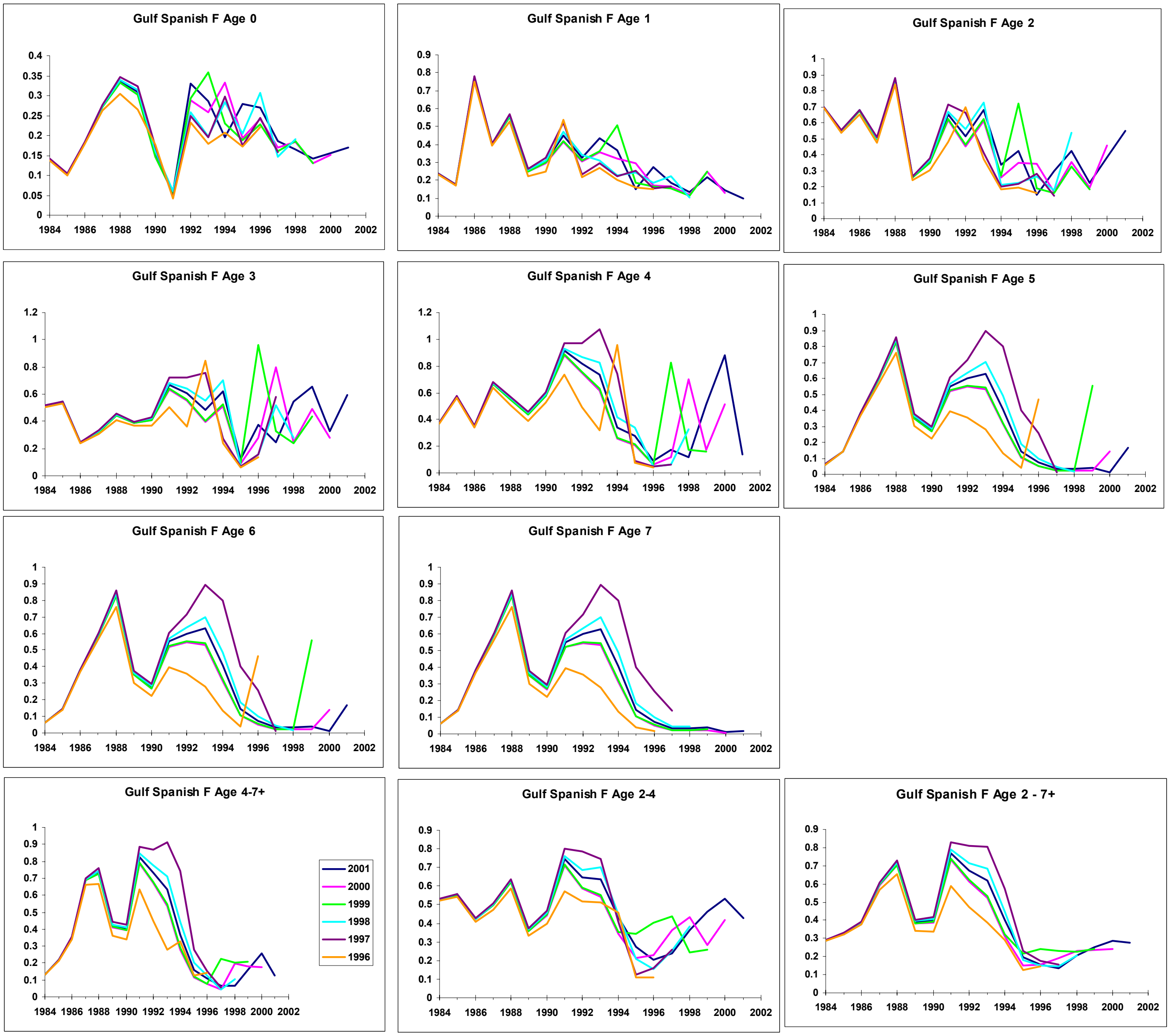



**Figure 59.** Gulf Spanish retrospective analysis F mortality rates by age estimation.

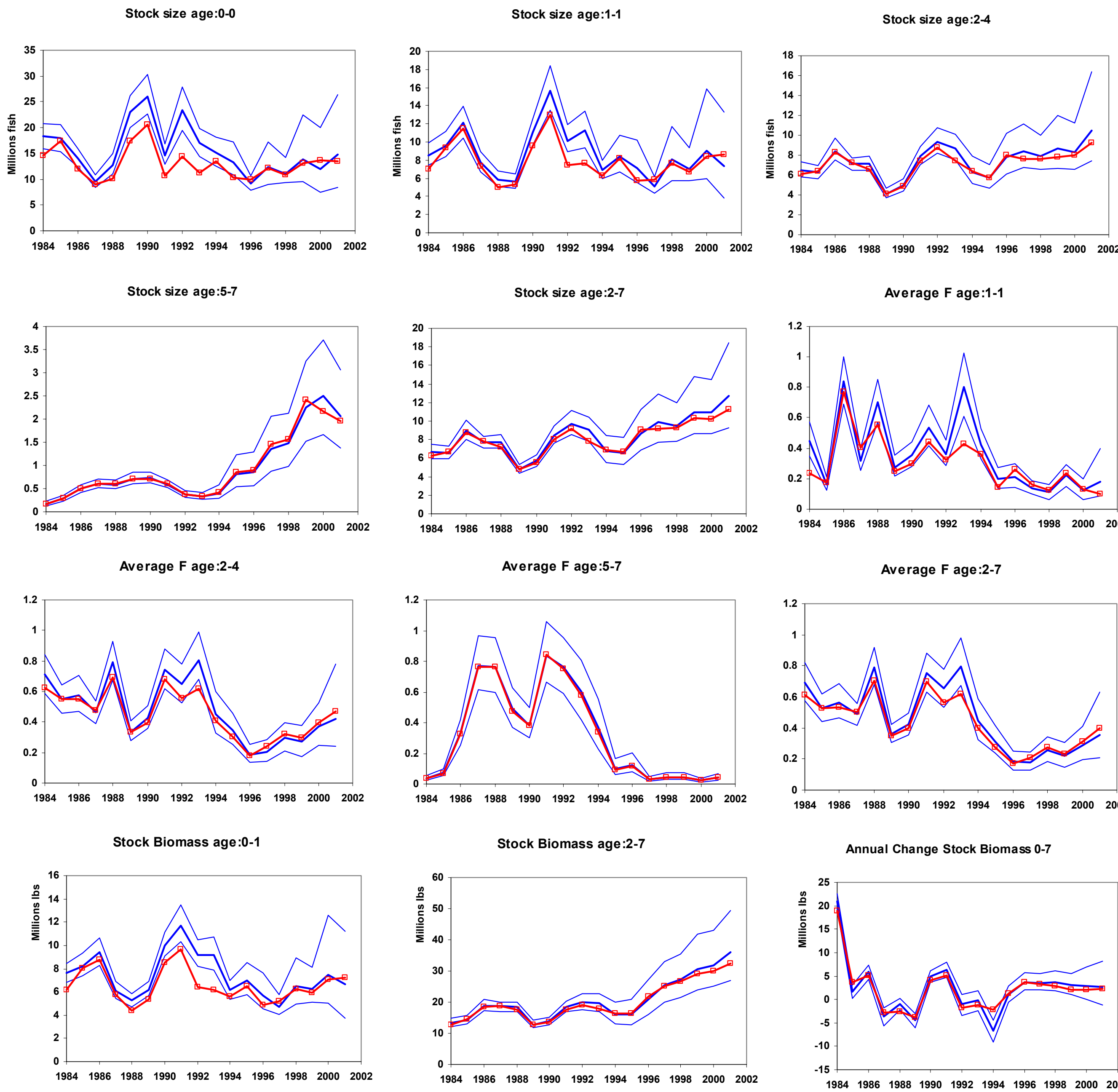



**Figure 60.** Gulf Spanish sensitivity analysis: Comparison of population trends estimated by the Bycatch Delta logN models (solid lines) with 80% confidence intervals and the Full index model (open square line).

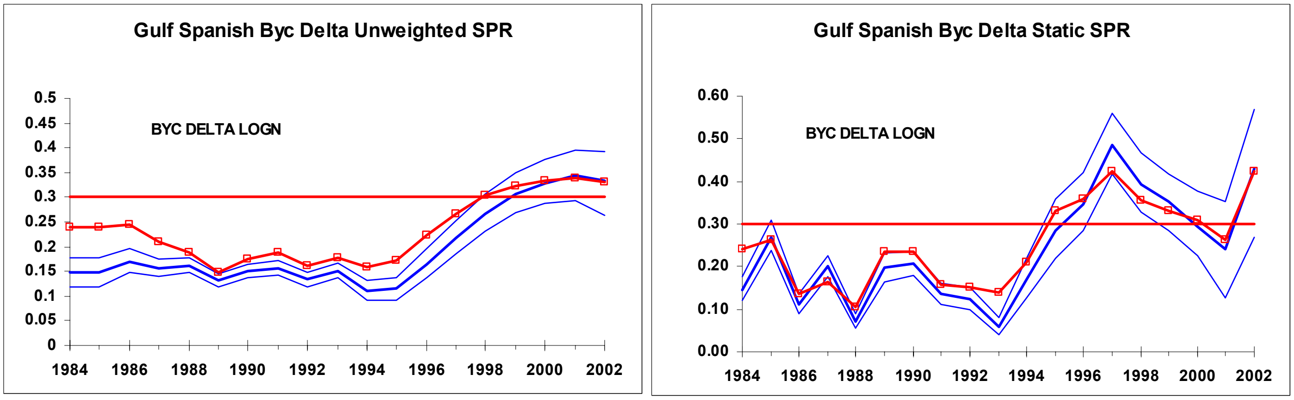



**Figure 61.** Static and transitional unweighted SPR from the VPA Bycatch Delta logN model for Gulf Spanish mackerel 2003 stock evaluation (solid lines). For comparison, equivalent values are plotted for the Full Index model (open square line).

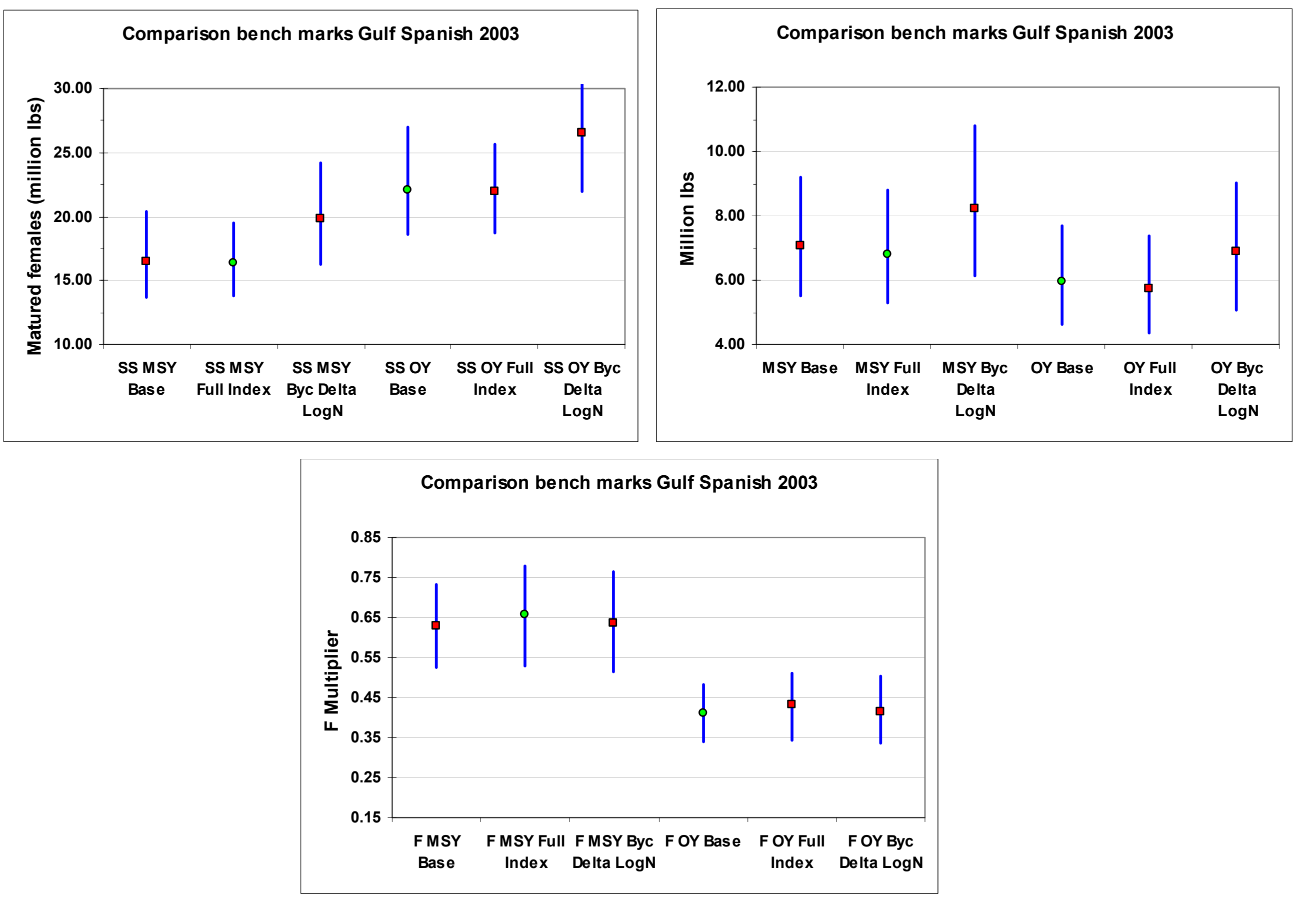



**Figure 62.** Gulf Spanish mackerel benchmarks 2003 SA. Comparison of estimates from the Base model, Full index model and the Bycatch Delta logN model reference points.

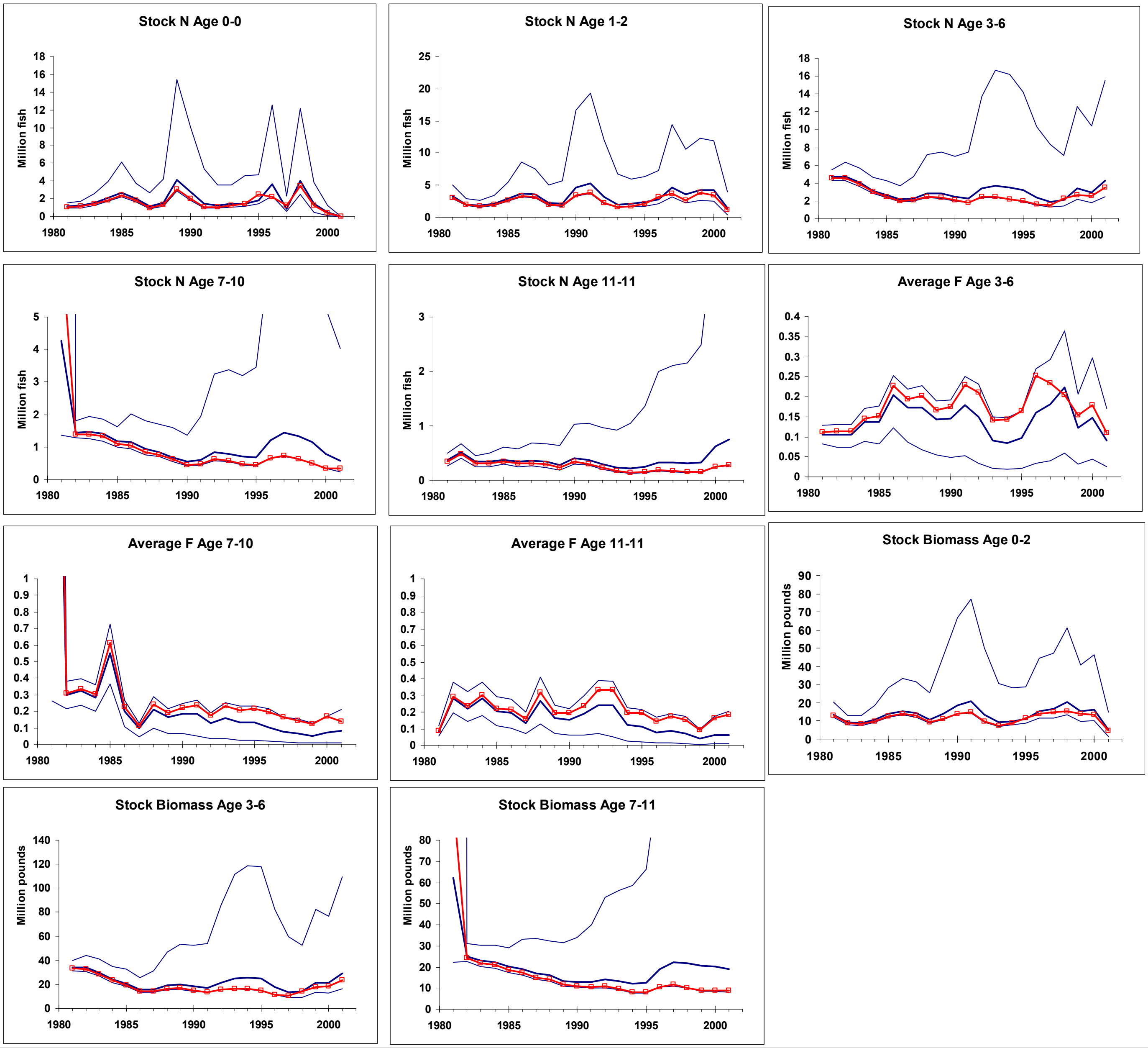



**Figure 63.** Sensitivity Analysis Atlantic king mackerel. Comparison of population trend estimates from the Full index model (open square line) and the model without the Florida FWC index of abundance (solid lines) with 80% confidence intervals.

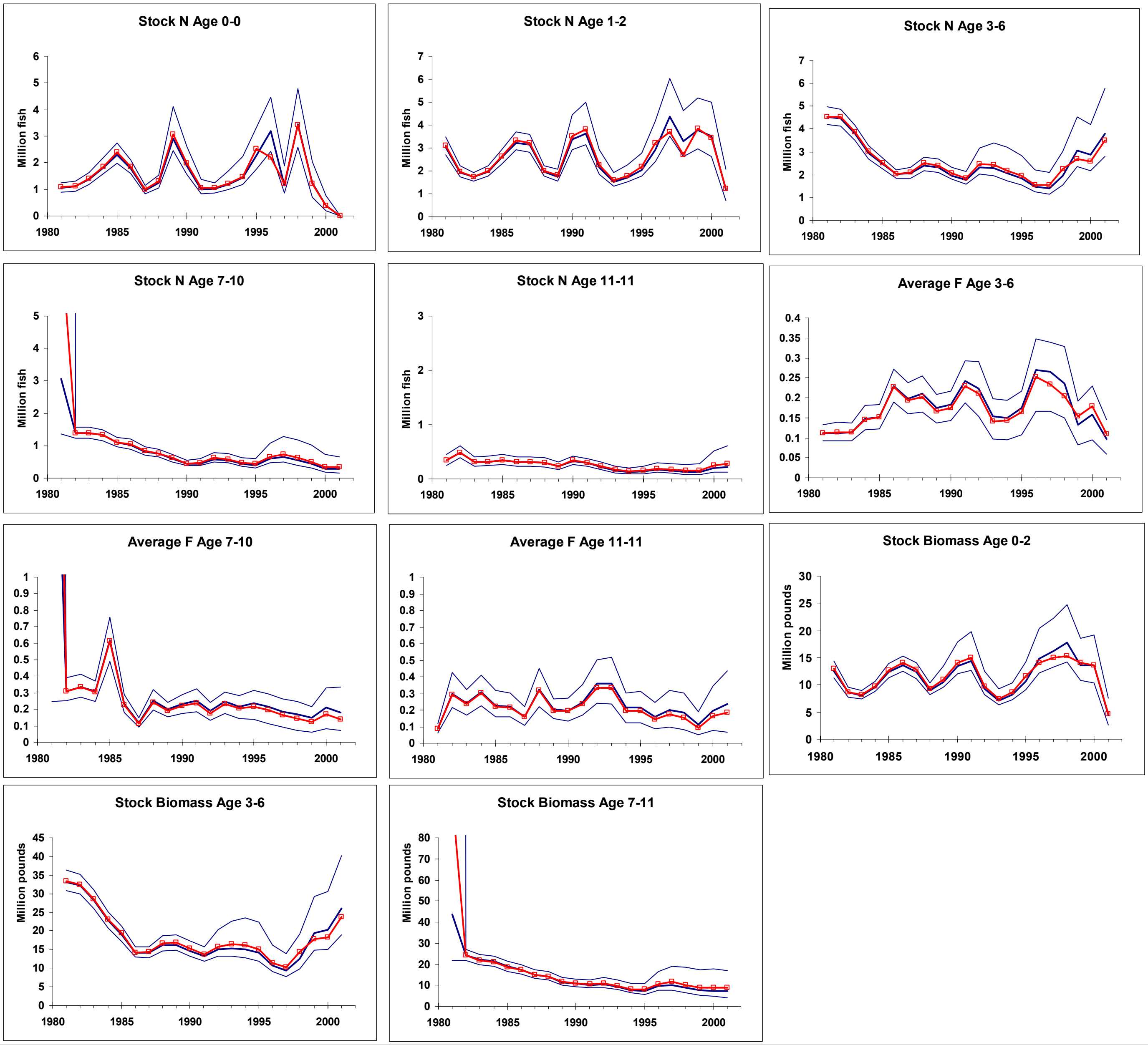



**Figure 64.** Sensitivity Analysis Atlantic king mackerel. Comparison of population trend estimates from the Full index model (open square line) and the model without the MRFSS index of abundance (solid lines) with 80% confidence intervals.

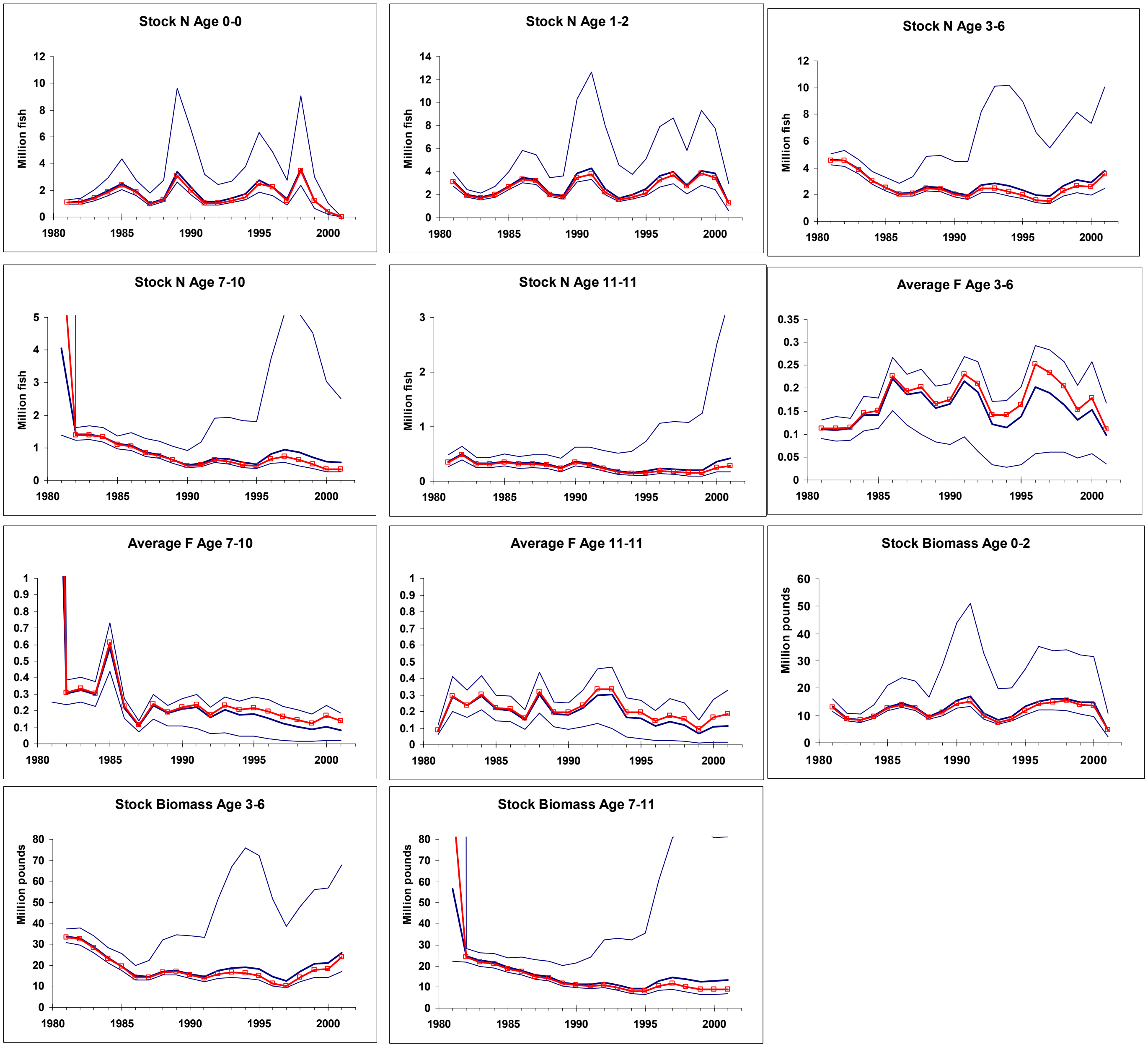



**Figure 65.** Sensitivity Analysis Atlantic king mackerel. Comparison of population trend estimates from the Full index model (open square line) and the model without the North Carolina Commercial (New) index of abundance (solid lines) with 80% confidence intervals.

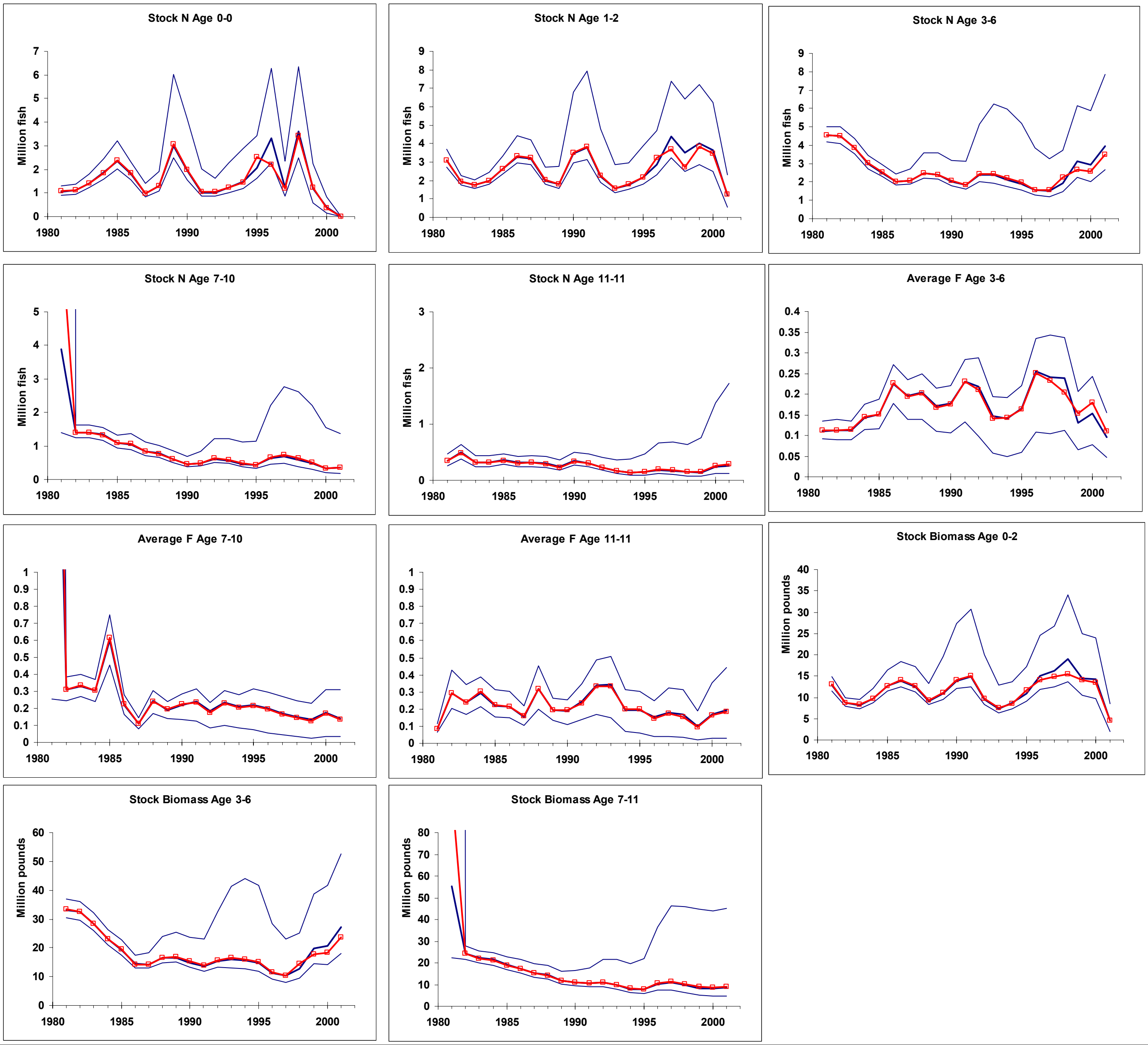



**Figure 66.** Sensitivity Analysis Atlantic king mackerel. Comparison of population trend estimates from the Full index model (open square line) and the model without the North Carolina Commercial (Old) index of abundance (solid lines) with 80% confidence intervals.

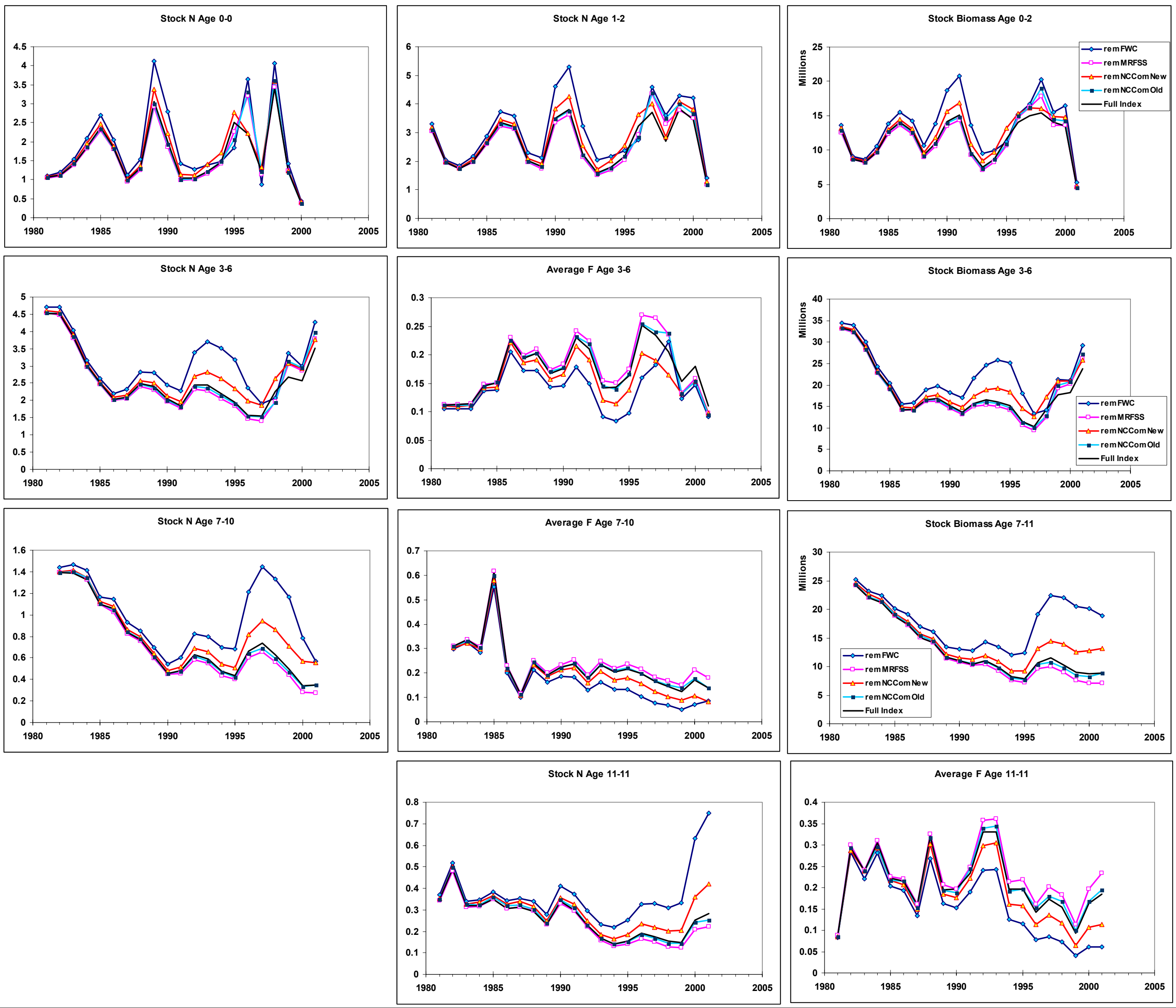



**Figure 67.** Sensitivity Atlantic king mackerel. Population trend estimators from the Full index model (solid line) and the models with the removal of a complete indices of abundance.

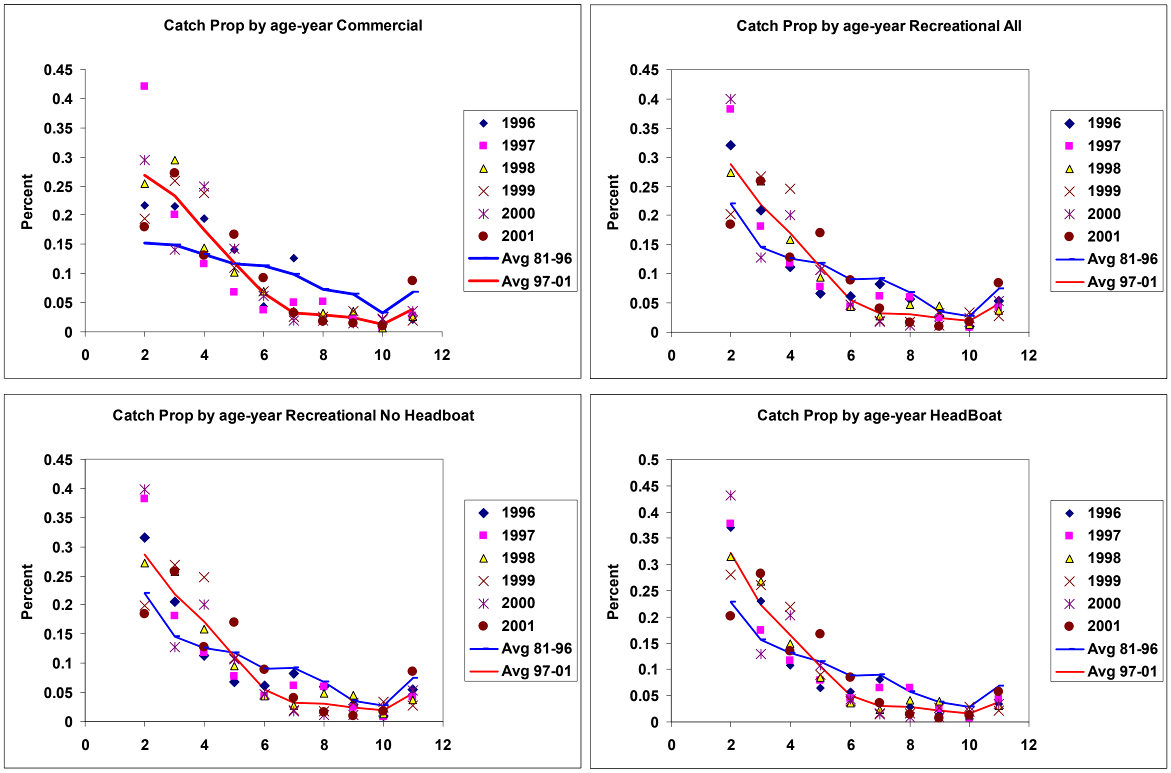



**Figure 68.** Atlantic King mackerel comparison of directed catch distribution by age and sector. Solid lines represent average of 1984-1996 years (blue) and average of 1997-2001 year (red).

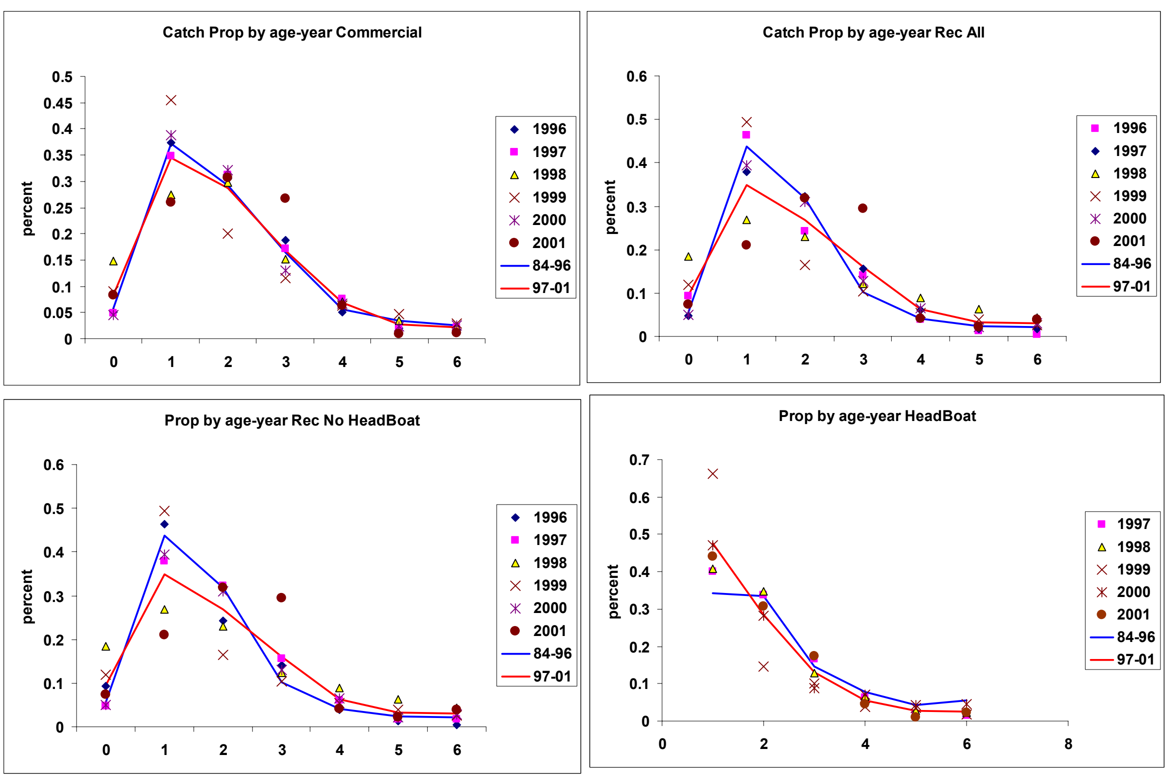



**Figure 69.** Atlantic Spanish mackerel comparison of directed catch distribution by age and sector. Solid lines represent average of 1984-1996 years (blue) and average of 1997-2001 year (red).

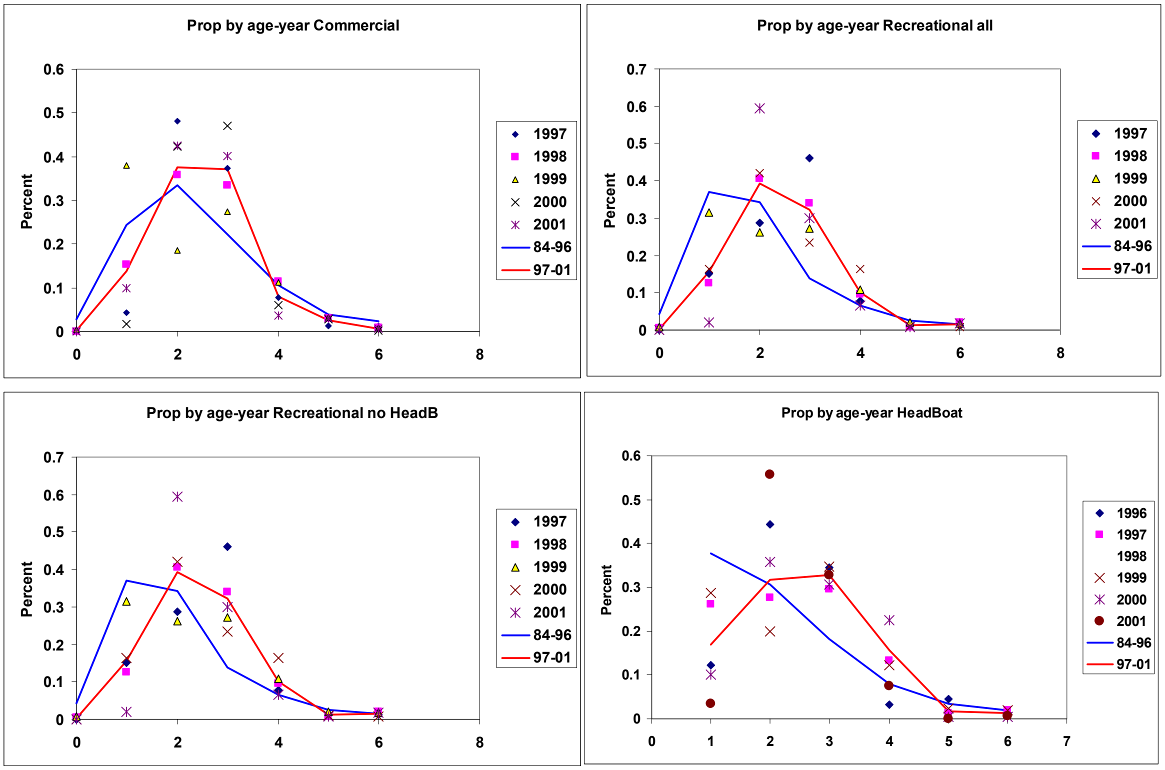



**Figure 70.** Gulf Spanish mackerel comparison of directed catch distribution by age and sector. Solid lines represent average of 1984-1996 years (blue) and average of 1997-2001 year (red).

# Appendix A.

## General Description of SEAMAP Plankton Surveys and Methods:

Ichthyoplankton samples have been collected annually since 1982 during Southeast Area Monitoring and Assessment Program (SEAMAP) surveys conducted by the National Marine Fisheries Service in cooperation with the states of Florida, Alabama, Mississippi, and Louisiana. Samples are taken during two, dedicated plankton surveys, one in the open Gulf in spring (mid April to early June) and the other over the continental shelf in late summer and early fall (late August to mid October). Plankton samples are also taken ('piggybacked') during summer and fall shrimp/groundfish surveys in June/July and October/November. In addition to the standard SEAMAP time series of plankton collections there have been collections taken during winter surveys of open Gulf waters; surveys conducted by individual states (Louisiana Seasonal Trawl survey); and special projects associated with specific habitats and species such as the Reef Fish and Squid/Butterfish surveys (Table 1 i.e. mackereleffort.xls).

Plankton samples are taken following standard SEAMAP collection procedures (see SEAMAP Field Methods Manual). The water column is sampled with oblique tows from near bottom (or a maximum depth of 200 m) to the surface using a 61-cm bongo net with 0.333 (0.335)[1] mm mesh nets. The upper 0.5 m of the water column is sampled with a 1X2 single or double neuston net frame with 0.947 (0.950)[1] mm mesh net(s) towed at the surface for 10 minutes. Non-standard gear has been used to collect plankton samples from smaller vessels operated by the states and are coded as such in the database. Most standard SEAMAP survey stations are located 30 nautical miles apart in a fixed grid and sampled at all times of day or night. Samples have been taken at stations that do not conform to the standard 30 mile grid and these are not as yet coded as such in the database. Catches of larvae from bongo nets are standardized to account for sampling effort and expressed as number of larvae under 10 $m^2$ of sea surface. This is accomplished by dividing the number of larvae of each taxon caught in a sample by the volume of water filtered during the tow; and than multiplying the resultant by the maximum depth (m) of the tow and the factor 10. Catches of larvae from neuston nets are standardized to account for sampling effort and expressed as number of larvae per 10 min tow.

## General description of king and Spanish mackerel datasets:

Annual mean abundance and occurrence of mackerel larvae are calculated only from the catches in 61-cm bongo net samples taken during the two sampling periods that encompass the king and Spanish mackerel spawning season in the Gulf of Mexico: June and July, and late-August to mid-October (Table 1). Samples used in annual estimates are collected on both state and federal cruises. Since 1982 the number of samples taken each year during SEAMAP summer shrimp/groundfish surveys has typically ranged from 30 to 76 samples. In 1998 only 10 samples were collected due to vessel breakdowns and severe weather. The summer survey area includes the continental shelf and coastal waters west of 88° W longitude; although in the earliest years of the time series (1982 to 1988) sampling was conducted further east off northwest Florida. Samples from late August to mid-October are taken during the SEAMAP fall plankton survey which only became a Gulfwide survey of continental shelf and coastal waters between Brownsville, Texas and south Florida in 1986. This survey has produced from 81 to 150 samples per year since 1986; however, 24 plankton samples taken during the Louisiana seasonal trawl survey in September 1985 are included in the estimate of mean abundance and occurrence for that year. In 1998 only 35 samples were collected during this timeframe due to vessel breakdowns and severe weather.

[1] Mesh size change in database does not represent an actual change in gear but only a change in the accuracy at which plankton mesh aperture size can be measured by the manufacturer.

# Appendix 2

Biological Program Documentation

Program 195 Pamlico Sound Survey

Masterfile: NER.NMA.NMA120-1.JUVENILE

Biologist: Tina Moore

# I. General Description

## A. Overview

Program 195 Narrative
Pamlico Sound Survey 2000
Prepared by: Tina Moore

The survey was initially designed to provide a long term fishery-independent database for the waters of the Pamlico Sound, eastern Albemarle Sound and the lower Neuse and Pamlico rivers. However, in 1990 the Albemarle Sound sampling in March and December was eliminated, and sampling occurs only in the Pamlico Sound and associated rivers and bays in June and September (Figure 1). The survey is now called the Pamlico Sound Survey.

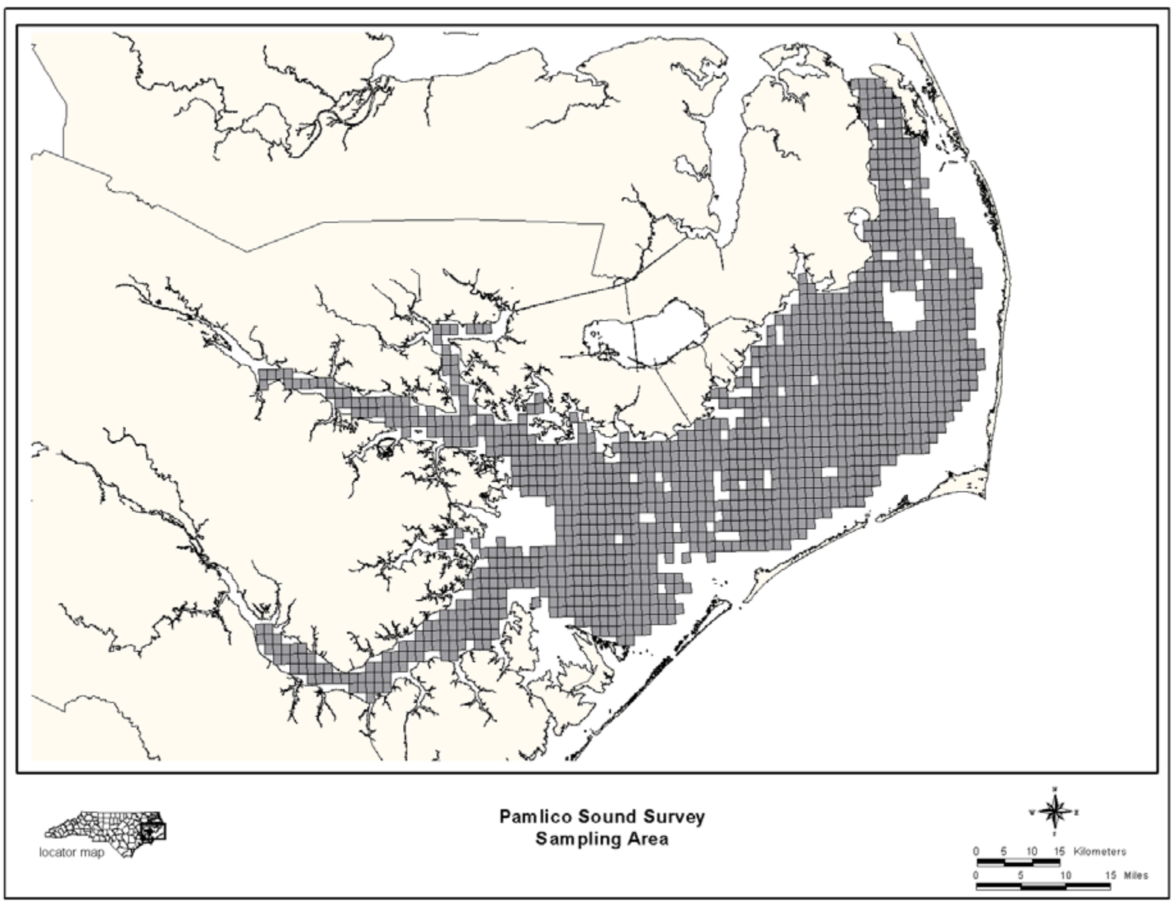


Figure 1. Location and grids of the Pamlico Sound Survey area of eastern North Carolina.

The original survey began in March 1987 and funding was provided by the Division of Marine Fisheries with additional funds provided by the SM-18 SEAMAP federal program. Since 1990, the funding has been provided from a federal F-42 grant to survey population parameters of marine recreational fishes in North Carolina. Data collected from the survey have provided juvenile abundance indices and long-term population parameters for interstate and statewide stock assessments of recreationally and commercially important fish stocks.

Sampling began in 1987 and was conducted over two weeks, quarterly during the months of March, June, September and December from 1987 to 1989. In 1990, sampling occurred over two weeks during the months of March, June, and September. From 1991 to the present the Pamlico Sound Survey has been conducted during the same two weeks in June and September. There were only two years in which the survey did not occur over the same time series, 1999 and 1988. In 1999, samples were collected during the month of July and the end of September and October because vessel repairs and hurricanes prevented following the normal schedule. In 1988, the December leg of the cruise was partially extended into January 1989 because of scheduling conflicts and adverse weather conditions.

Specific survey objectives are as follows:

1. To determine and monitor the distribution, relative abundance and size composition of fish, shrimp, and crabs in the survey area and how they vary temporally and spatially.

2. To provide data to ascertain fishery independent estimates of mortality and population size to compare to commercial fishery samples and landings data.

3. To determine which species utilize (and to what extent) the sound during their early life development and identify nursery areas for those species (e.g., *Cynoscion* spp., *Paralichthys dentatus*, etc.).

4. To determine if catch rates of various species are correlated with indices of juvenile abundance derived from the juvenile trawl survey (Program 120).

5. To determine if species distributions are correlated with each other or with some other measured parameter(s).

6. To monitor the movement of organisms out of the nursery area and into the open waters of the Pamlico Sound where they are available for commercial exploitation.

## B. Methods

From 1987-1989 the sample area covered all of Pamlico Sound and its bays, Croatan Sound, Roanoke Sound, Albemarle Sound east of a line from the mouth of Alligator River to the mouth of North River, the Pamlico River up to Bath Creek and the Neuse River up to Minnesott Beach. Gear 539 (Mongoose or Falcon Trawl) was used for comparison with SEAMAP data of inshore and offshore catches.

From 1990 to the present, fifty-two randomly selected stations (grids) are sampled over a two week period, usually the second and third week of the month in both June and September. The stations sampled are randomly selected from strata based upon depth and geographic location. The seven designated strata are: Neuse River; Pamlico River; Pungo River; Pamlico Sound east of Bluff Shoal, shallow and deep; and Pamlico Sound west of Bluff Shoal, shallow and deep. Shallow water is considered water depth between 6-12 feet and deep water is considered water greater than 12 feet depth.

Initially stations were allocated in proportion to the size of the strata. Beginning in March 1989, the randomly drawn stations are optimally allocated among the strata based upon all the previous sampling in order to provide the most accurate abundance estimates (PSE <20) for selected species. A minimum of three stations (replicates) are maintained in each strata. The number of stations per strata (Table 1) are determined by the following formula:

$$N_S = \frac{N_T}{F_T} F_S$$ (Cornus, 1984)

Where $N_S$ = number of hauls per stratum
$N_T$ = total number of hauls
$F_S$ = area of stratums
$F_T$ = total survey area

A minimum of 104 stations are trawled per year. This is done each year so that maximum coverage of area is achieved.

Tow duration is 20 minutes at 2.5 knots using the R/V Carolina Coast pulling double rigged demersal mongoose trawls (9.1 m headrope, 1.0 m X 0.6 m doors, 2.2 cm bar mesh body, 1.9 cm bar mesh cod end and a 100 mesh tailbag extension). All species are sorted and a total number and weight is recorded for each species. For target species, 30-60 individuals are measured and total weights are measured. Environmental data taken include temperature, salinity, wind speed, and direction.

The two catches from each tow are combined to form a single sample in an effort to reduce variability.

1) Finfish: Samples are sorted as follows: Incidentals and/or exotic species (present in low numbers) as well as shellfish are separated from the total catch. The remaining sample contains species present in large numbers (including target species) and the total weight of each species measured and discarded by baskets. One random basket is kept as a sample for species measured individually, a list of all species measured is indicated in Table 2. All individuals in the basket are separated by species and a total number and weight recorded as sample number and sample weight, respectively for each species (Record Type 3). From the species list, 30-60 individuals are measured and a total weight taken. Incidental and/or exotic species are enumerated and total weight of all individuals measured.

2) Shellfish: The total weight of all Penaeid shrimp and blue crabs is taken and a subsample of 30-60 individuals per species are measured and the total weight for that subsample measured. Other shellfish will have a total weight for each species group taken and are enumerated. Invertebrates are grouped together and a total weight taken.

A summary for sampling each station is included in the memorandum section to provide participants a checklist for the sampling protocol. An example of data sheet coding is included as well as Format A and Format B sheets. Tina Moore is the lead biologist for the program and DMF staff from various offices and individuals from separate agencies participate for each cruise on the R/V Carolina Coast. A list of all participants for the past surveys is included (Table 3).

Table 1. Number of stations trawled in each strata of the Pamlico Sound Survey.

| Timeframe | Year | Tows | AD | AS | PUR | NR | PR | PDE | PDW | PSE | PSW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| March 16-219, 25-26 | 1987 | 52 | 2 | 2 | 2 | 2 | | 21 | 9 | 9 | 5 |
| June 8-11,15-18 | 1987 | 52 | 2 | 2 | 2 | 2 | | 21 | 6 | 11 | 6 |
| September 16-18, 21-24 | 1987 | 52 | 3 | 1 | 2 | 2 | | 19 | 11 | 8 | 6 |
| December 7-11, 14-18 | 1987 | 49 | | 1 | 2 | 2 | | 19 | 10 | 12 | 3 |
| March 14-15, 21-25 | 1988 | 52 | 2 | 2 | 2 | 2 | | 19 | 12 | 8 | 5 |
| June 7-9, 13-17 | 1988 | 51 | 2 | 2 | 2 | 2 | | 16 | 11 | 6 | 10 |
| September 12-15, 20-22 | 1988 | 52 | 2 | 2 | 2 | 2 | | 18 | 11 | 7 | 8 |
| December 5-8, 1416/ January 9-11 | 1988 | 50 | | 2 | 2 | 2 | | 15 | 13 | 7 | 9 |
| March 13-16, 28-29 | 1989 | 56 | 3 | 3 | 3 | 3 | | 15 | 22 | 4 | 3 |
| June 5-8, 12-14 | 1989 | 50 | 3 | 3 | 3 | 3 | | 21 | 8 | 8 | 3 |
| September 11-14, 18-20 | 1989 | 52 | 3 | 3 | 3 | 3 | | 14 | 7 | 4 | 15 |
| December 4-7, 12-14 | 1989 | 50 | 3 | 3 | 3 | 3 | | 29 | 4 | 2 | 3 |
| March 5-8, 12-15 | 1990 | 54 | | | 3 | 5 | 5 | 12 | 12 | 14 | 3 |
| June 4-7, 11-15, 18-21 | 1990 | 54 | | | 3 | 5 | 5 | 22 | 9 | 6 | 4 |
| September 10-13, 18-20 | 1990 | 51 | | | 3 | 5 | 5 | 23 | 5 | 7 | 3 |
| June 10-14, 17-20, 24-27 | 1991 | 53 | | | 3 | 5 | 5 | 22 | 8 | 7 | 3 |
| September 9-12, 15-18 | 1991 | 53 | | | 3 | 5 | 5 | 22 | 6 | 8 | 4 |
| June 8-12, 15-19 | 1992 | 51 | | | 3 | 5 | 5 | 17 | 8 | 8 | 5 |
| September 14-18, 21-25 | 1992 | 52 | | | 3 | 5 | 5 | 20 | 8 | 8 | 3 |
| June 7-11, 14-18 | 1993 | 54 | | | 3 | 5 | 5 | 21 | 9 | 7 | 4 |
| September 12-16, 19-23 | 1993 | 52 | | | 3 | 5 | 5 | 21 | 8 | 7 | 3 |
| June 6-10, 13-17 | 1994 | 53 | | | 3 | 5 | 5 | 20 | 8 | 8 | 4 |
| September 12-16, 19-23 | 1994 | 52 | | | 3 | 5 | 5 | 19 | 7 | 6 | 4 |
| June 5-9, 19-23 | 1995 | 53 | | | 3 | 5 | 5 | 22 | 7 | 7 | 4 |
| September 11-15, 25-29 | 1995 | 52 | | | 3 | 5 | 5 | 21 | 8 | 7 | 3 |
| June 2-6, 9-13 | 1996 | 54 | | | 3 | 5 | 5 | 21 | 7 | 7 | 4 |
| September 9-13, 16-20 | 1996 | 53 | | | 3 | 5 | 5 | 21 | 8 | 7 | 4 |
| June 2-6, 9-13 | 1997 | 53 | | | 3 | 5 | 5 | 22 | 7 | 6 | 5 |
| September 8-12, 15-19 | 1997 | 53 | | | 3 | 5 | 5 | 18 | 12 | 7 | 3 |
| June 15-19, 22-26 | 1998 | 52 | | | 3 | 5 | 5 | 20 | 8 | 6 | 5 |
| September 14-18, 21-25 | 1998 | 54 | | | 3 | 5 | 5 | 18 | 12 | 8 | 3 |
| July 12-14,19-22 | 1999 | 54 | | | 3 | 5 | 5 | 19 | 10 | 7 | 5 |
| September 28-29/October 5, 13-14 | 1999 | 51 | | | 3 | 5 | 5 | 19 | 10 | 6 | 3 |
| June 5-8, 13-15 | 2000 | 53 | | | 3 | 5 | 5 | 19 | 9 | 7 | 5 |
| September 11-14, 18-120 | 2000 | 54 | | | | | | | | | |
| **TOTAL Tows by stratum** | | **1833** | **25** | **26** | **94** | **138** | **110** | **666** | **310** | **247** | **160** |

Table 2. List of species measured on the Pamlico Sound Survey

| Scientific name | Common name |
|---|---|
| *Anguilla rostrata* | American eel |
| *Alosa aestivalis* | blueback herring |
| *Alosa mediocris* | hickory shad |
| *Alosa pseudoharengus* | alewife |
| *Alosa sapidissima* | American shad |
| *Ictalurus natalis* | yellow bullhead |
| *Urophycis regius* | spotted hake |
| *Centropristis philadelphica* | rock sea bass |
| *Entropristis striata* | black sea bass |
| *Brevoortia tyrannus* | Atlantic menhaden |
| *Ictalurus catus* | white catfish |
| *Ictalurus punctatus* | channel catfish |
| *Morone americana* | white perch |
| *Epinephalus morio* | red grouper |
| *Mycteroperca microlepis* | gag |
| *Dorosoma cepedianum* | gizzard shad |
| *Ictalurus nebulosus* | brown bullhead |
| *Urophycis floridanus* | southern hake |
| *Morone saxatilis* | striped bass |
| *Mycteroperca bonaci* | black grouper |
| *Lepomis gibbosus* | pumpkinseed |
| *Lepomis machrochirus* | bluegill |
| *Perca flavescens* | yellow perch |
| *Caranx  hippos* | crevalle jack |
| *Lutjanus falcatus* | mutton snapper |
| *Micropterus salmoides* | largemouth bass |
| *Pomatomous saltatrix* | bluefish |
| *Trachinotus carolinus* | Florida pompano |
| *Lutjanus griseus* | gray snapper |
| *Pomoxis nigromaculatus* | black crappie |
| *Rachycentron canadum* | cobia |
| *Trachinotus falcatus* | permit |
| *Lutjanus synagris* | lane snapper |

| | |
|---|---|
| *Orthorpistis chrysoptera* | pigfish |
| *Archosargus probatocephalus* | sheepshead |
| *Cynoscion regalis* | weakfish |
| *Menticirrhus saxatilis* | Northern kingfish |
| *Pogonias cromis* | black drum |

Table 2. Continued.

| **Scientific name** | **Common name** |
|---|---|
| *Mugil cephalus* | striped mullet |
| *Peprilus alepidotus* | harvestfish |
| *Paralichthys lethostigma* | Southern flounder |
| *Bairdiella chrysoura* | silver perch |
| *Leiostomus xanthurus* | spot |
| *Micropogonias undulatus* | Atlantic croaker |
| *Chaetodipterus faber* | Atlantic spadefish |
| *Scomberomorus cavalla* | king mackerel |
| *Peprilus triacanthus* | butterfish |
| *Paralichthys albigutta* | Gulf flounder |
| *Cynoscion nebulosus* | spotted seatrout |
| *Menticirrhus americanus* | Southern kingfish |
| *Sciaenops ocellatus* | red drum |
| *Tautoga onitis* | tautog |
| *Scomberomorus maculatus* | Spanish mackerel |
| *Paralichthys dentatus* | summer flounder |
| *Sphoeroides maculatus* | Northern puffer |

Table 3. Participants for the North Carolina Pamlico Sound Survey, 1987-2000.

(*removed for briefness*)

## C. Data Analysis

Management actions proposed in fishery management plans are usually based on stock assessments, which evaluates whether or not a stock is overfished. Data necessary to prepare stock assessments include age-length keys, growth information, catch-at-age matrices, and indices of abundance. The Juvenile Abundance Index (JAI) is calculated from the Pamlico Sound Survey. The JAI is a critical component to any stock assessment because it provides an index of abundance that is independent of the commercial or recreational fisheries. The Sound Survey JAI for summer flounder is the most robust index used in the Atlantic Coast summer flounder stock assessment. The Sound Survey JAI for weakfish is also input into the Atlantic Coast weakfish stock assessment. Trends in the JAIs are also viewed as indicators of changes in the environment and of changes in the health of the critical nursery habitat.

The juvenile index is the annual geometric mean (weighted by strata) of the number of individuals per tow for young of the year (YOY). Quarterly length frequency distributions were examined to determine the size range for YOY of each species. YOY size ranges for each species were as follows: Atlantic croaker <120 mm TL in June and <200 TL mm in September; weakfish <140 mm FL in June and <200 mm FL in September; spot <110 mm FL in June and <130 FL mm in September; summer flounder <130 mm TL in June and <230 mm TL in September; and southern flounder <160 TL mm in June and <230 TL mm in September. The Pungo River stratum was excluded from the juvenile index calculations because it was not sampled throughout the entire time span of the survey.

Sound survey juvenile abundance indices were compared to YOY indices (individuals/tow) from the state nursery area survey. For the state survey, tows of one minute duration were made with a 2.3 m headrope two seam otter trawl (6.4 mm bar mesh body and 3.2 mm cod end) during May and June at a static set of 105 stations located in primary nursery areas from Roanoke Island through Cape Fear River. Data for weakfish were obtained from a subset of these stations sampled from May through June. Excluded from the nursery area analysis were individuals measuring >81 mm FL in May and >111 mm FL in June for spot and >70 mm FL in May and >100 mm FL in June for southern flounder (Phalen 1993). Arithmetic means were also computed for each survey.

The development of long-term databases is necessary for monitoring the status of fish stocks in North Carolina as well as along the Atlantic coast of the United States. Long-term juvenile abundance databases for various speciesallow DMF to monitor changes in mortality rates and recruitment rates of the stocks, and help determine whether or not overfishing is occurring. Continued monitoring is essential for evaluating and determining appropriate management strategies.

## D. Report Format

Reports are written after each survey to determine species composition, species distribution and relative abundance, environmental parameters, and provide the size composition of target species. Due to their economic importance, the target species are: weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), southern flounder (*Paralichthys lethostigma*), summer flounder (*Paralichthys dentatus*), bluefish (*Pomatomus saltatrix*), southern kingfish (*Menticirrhus americanus*), blue crab (*Callinectes sapidus*), and Penaeid shrimp. A list of current publications for these reports is:

Ross, J.L., D. Moye, and B. Burns. 1987. State of North Carolina R/V CAROLINA COAST, Pamlico-Albemarle sounds Survey, March 1987. North Carolina Dept. Resour. And Community Develop., Div. Mar. Fish., No. 167. 18 p.

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Stephan, C.D., D.W. Moye, and S.K. Strausser. 1988. State of North Carolina R/V CAROLINA COAST, Pamlico-Albemarle Sounds Survey, September 1987. North Carolina Dept. Resour. And Community Develop., Div. Mar. Fish., No. 180. 26 p.

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Moye, D.W., C.D. Stephan, and S.K. Strausser. 1988. State of North Carolina R/V CAROLINA COAST, Pamlico-Albemarle Sounds Survey, June 1988. North Carolina Dept. Resour. And Community Develop., Div. Mar. Fish., No. 196. 24 p.

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Moye, D.W., C.D. Stephan, and S.K. Strausser. 1990. Pamlico-Albemarle Sounds Survey June 1989 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 221. 21 p.

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Pulley, M.G. 1990. Pamlico-Albemarle Sounds Survey December 1989 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 233. 21 p.

Pulley, M.G. 1991. Pamlico Sound Survey March 1990 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 239. 23 p.

Pulley, M.G. 1992. Pamlico Sound Survey June 1990 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 244. 27 p.

Pulley, M.G. 1992. Pamlico Sound Survey September 1990 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 245. 33 p.

Pulley, M.G. 1992. Pamlico Sound Survey, June 1991 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 254. 29 p.

Pulley, M.G. 1992. Pamlico Sound Survey, September 1991 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 256. 32 p.

Pulley, M.G. 1993. Pamlico Sound Survey, June 1992 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 263. 27 p.

Pulley, M.G. 1993. Pamlico Sound Survey, September 1992 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 267. 33 p.

Pulley, Michael G. 1995. PAMLICO SOUND SURVEY June 1993 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 331. 29 p.

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Pulley, Michael G. 1996. Pamlico Sound Survey Sepetember 1994 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 310. 35 p.

Pulley, Michael G. 1996. PAMLICO SOUND SURVEY June 1995 Cruise Report. North Carolina Dept. Environ. and Nat. Resour., Div. Mar. Fish., No. 334. 21 p.

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Pulley, Michael G. 1997. PAMLICO SOUND SURVEY June 1996 Cruise Report. North Carolina Dept. Environ. and Nat. Resour., Div. Mar. Fish., No. 336. 24 p.

Pulley, Michael G. 1997. PAMLICO SOUND SURVEY September 1996 Cruise Report. North Carolina Dept. Environ. and Nat. Resour., Div. Mar. Fish., No. 337, 28 p.

The JAI information is included in an annual federal F-42 report for selected species. A list of current publications for these reports is:

North Carolina Division of Marine Fisheries. 1992. Survey of Population Parameters of Marine Recreational Fishes in North Carolina. Ann. Prog. Rep. Proj. F-42-1, North Carolina Dept. Nat. Resou., Div. Mar. Fish., No. 253 or 302, 29 p.

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North Carolina Division of Marine Fisheries. 1994. Survey of Population Parameters of Marine Recreational Fishes in North Carolina. Ann. Prog. Rep. Proj. F-42-3, North Carolina Dept. Environ., Health, Nat. Resour., Div. Mar. Fish., No. 294 or 302. 31 p.

Division of Marine Fisheries. 1995. Survey of Population Parameters of Marine Recreational Fishes in North Carolina. Ann. Prog. Rep. Proj. F-42-4 (Segments 1-4 are listed under #302, North Carolina Dept. Environ., Health, Nat. Resour., Div. Mar. Fish., No. 302. 34 p.

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North Carolina Division of Marine Fisheries. 1997. Survey of Population Parameters of Marine Recreational Fishes in North Carolina, Annual Progress Report, Grant F-42, January-December 1996, Segment 6, North Carolina Dept. Environ. & Nat. Resour., Div. Mar. Fish., No. 322. 41 p.

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North Carolina Division of Marine Fisheries. 1999. Survey of Population Parameters of Marine Recreational Fishes in North Carolina, Annual Progress Report, Grant F-42, January-December 1998, Segment 8, North Carolina Dept. Environ. & Nat. Resour., Div. Mar. Fish., No. 339. 35 p.

## E. Literature Reviewed

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*Serchuk and S. E. Wigley. 1985. Evaluation of USA and Canadian Research Vessel Surveys and Survey design in assessing abundance, size composition and recruitment of sea scallops on George□s Bank. NAFO Ser. Doc/ 85/88.

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*Used but not cited directly.

## F. Memorandums

MEMORANDUM

TO: Bio-Supervisors
FROM: David Moye
SUBJECT: Pamlico-Albemarle Sounds Survey
DATE: January 25, 1990

There has been some discussion recently about possible changes in the Pamlico-Albemarle Sounds Survey. Katy has asked me to write down my preference for a 1990 sampling plan (attached) and some relevant thoughts on some of the sampling concerns (see below). Given the time necessary for the logistics of setting up the March cruise you all may want to discuss this prior to the February biologist meeting.

**Item 1: Use the contents of only one tailbag for sample workup**

- still must pull both nets
- saw a lot of variability between sides; therefore, you could not divide the first 3 years worth of data by 2 to make the data comparable
- will not save enough time to pull more tows
- any sample over 1 basket can be subsampled already
- will cut down on incidentals

**Item 2: Clean out the nets**

- must make more of an effort to do this between tows when gilling is a problem and when crabs are numerous.
- it is easy to tell fish and crabs that have been dragged for hours
- problem is found mainly in Croatan and Albemarle Sounds

**Item 3: Expand up Pamlico and Neuse Rivers and include Pungo River**

- problems in the rivers make it imperative to get as much information as we can
- can add 2 more stations in each river and 3 in the Pungo River
- can add more grids in the Neuse and Pamlico Rivers and create grids for the Pungo River

**Item 4: Drop Albemarle or pick up all of Albemarle Sound**

- east end is not indicative of all Albemarle Sound
- need a 3rd week to do it all
- Elizabeth City and Manteo would be responsible for ship time; Mike Pulley would be responsible for all logistics and edit checks on data sheets
- by dropping Albemarle Sound we can add item 3 and not add any more time to the cruise

**Item 5: Drop all December and March cruises**

- set up for 5 years worth of winter cruises (P. Phalen suggestion for statistical validity)
- gives us an idea of what is available to the winter crab trawl fishery
- these months give us data on alosids
- the Pamlico District can staff these cruises since only 2 people are needed each week

NARRATIVE
DAVID MOYE
MARCH 26, 1990

An in-depth look at the Pamlico-Albemarle Sounds Survey resulted in responses to various concerns about the program (see attached memo). Some of these changes have been incorporated into the 1990 sampling plans. For 1990, the following changes are proposed:

1. Add the Pungo River
2. Expand more upstream in the Neuse and Pamlico Rivers
3. Drop Albemarle Sound
4. Drop the December cruise

Recent declines in the river fisheries as well as disease problems make it imperative to expand into the Pungo River as well as up the Pamlico and Neuse Rivers. This expansion will allow for total coverage of the Pamlico Estuary in water greater than 6 feet.

The decision to drop Albemarle Sound is based on two factors:

1. The east end is not indicative of all Albemarle Sound
2. Manpower restrictions preclude the addition of a third week which would be needed to sample all of Albemarle Sound

The March (1991 on) and December cruises will be dropped since three years of data has been obtained to show what species use the estuary during the winter months. This decision was also based on the fact that the time spent collecting this limited amount of data could be better used in other Division projects. The March cruise will be completed in 1990 in order to assess the effect of the winter freeze that occurred in late December of 1989.

The only change in methodology is that the nets will be cleaned out as much as feasible between tows.

The method to determine the number of stations per strata has changed since the program began. The number of stations per strata were originally selected based solely on the size of the strata. The rivers were originally set up with two stations in each but in order to get statistically meaningful data this was increased to three stations per river. Beginning with the March 1989 cruise, the number of stations are selected by using the data from previous years. This data is used to allocate the optimum number of stations per strata based on a proportional standard error (PSE) value of 20%. The DMFJCL member that runs this analysis is NCBDWM18.

MEMORANDUM

TO: Mike Tangedall
FROM: Mike Pulley
DATE: February 7, 1991
SUBJECT: Revision to Program 195, Pamlico Sound Survey Data Records

The above program started in March 1987 and used STATION field to describe each sampling site. STATION was composed of 4 digits followed by a letter (S - for Pamlico Sound, P - for Pamlico River, N - for Neuse River, and A - for Albemarle Sound). Starting with the March 1990 cruise the GRID field was used instead of STATION to describe sampling sites. GRID is composed of 1 or 2 letters and followed by 1 or 2 digits. There is a 1 to 1 correspondence between GRID and STATION for each sampling site (see enclosed table and diskette).

We are requesting that the blank GRID fields (data prior to 1990) on the <u>Master</u> file be filled in from the enclosed table i.e. if GRID = blank then utilize the value in STATION and the enclosed look up table to assign GRID a value.

MEMORANDUM

TO: Ray Mann
FROM: Mike Tangedal
DATE: 12 February 1991
SUBJECT: Mass changes to the Juvenile masterfile using a lookup table.

Enclosed please find a copy of a memo sent to me. From this memo, I am requesting that you make changes to the grid field in record type ones for program 195 before 1990. Record type is the first column in all masterfile records. The field program is located in columns 25-27 on record type one. The field year is located in column 28-29 in record type one. The list of records to be changed is all record type ones for program 195 before 1990 (in the Juvenile masterfile).

After obtaining this subset of records to be changed, the field grid (columns 49-52) needs to be entered based on the contents of two other fields. This is accomplished through a lookup list. I have uploaded this list into a data set under NERTSO.TEAM19.DATA(JV195GR). Columns 1-5 of this data set represent the field station, columns 30-39 represent the field location, grid is found in columns 61-64. If station and location from the lookup list match station (columns 34-38) and location (columns 39-48) in the masterfile subset, then the field grid on the masterfile should be changed to the value in the lookup table.

PAMLICO SOUND SURVEY
MIKE PULLEY
FEBRUARY 22, 1991

The following is a list of coding practice changes for program 195.

1. A coordinate system (letter and number), GRID field, replaced the sequential numbering system, STATION field, for distinguishing the sampling unit location. Grid field was first used in June of 1989, but it was used along with the station number. For coding purposes the station number was still used.

2. Beginning in March of 1990 the grid system was used exclusively. The station number field was left blank beginning in March and this will continue until the project is completed. In Feb. 1991 the master file was updated to include grid on all collections (prior to 1990) utilizing a station to grid look up table.

3. The quad field also began being used in March of 1990. The quad field is a number that refers to a specific strata. The quad numbers are used as follows:

   1 = Albemarle Deep (Dropped in 1990)
   2 = Albemarle Shallow (Dropped in 1990)
   3 = Neuse River
   4 = Pamlico Deep East
   5 = Pamlico Deep West
   6 = Pamlico River
   7 = Pamlico Shallow East
   8 = Pamlico Shallow West
   9 = Pungo River (Initiated in 1990)

4. Sampling in 1991 will be completed only in June and September - a total of 104 stations. An analysis of the CPUE indices (March-September vs. June-September) for the target species showed no significant differences in trends and maintains PSE values less than 20. This was also true for the Albemarle strata deletion. For comparison of CPUE values across years the minimum standard data must be used; i.e., June and September for the Pamlico Sound, Pamlico River, an Neuse River.

5. Wallo-Breaux may be source of funding in 1991 for the Pamlico Sound Survey. Mike Pulley took on project logistics and report writing responsibilities in June of 1990.

List of species to be measured for Pamlico Sound Survey

| | | |
|---|---|---|
| Anguilla rostrata (American eel) | Alosa aestivalis (blueback herring) | Alosa mediocris (hickory shad) |
| Alosa pseudoharengus (alewife) | Brevoortia tyrannus (Atlantic menhaden) | Dorosoma cepedianum (gizzard shad) |
| Alosa sapidissima (American shad) | Ictalurus catus (white catfish) | Ictalurus nebulosus (brown bullhead) |
| Ictalurus natalis (yellow bullhead) | Ictalurus punctatus (channel catfish) | Urophycis floridanus (southern hake) |
| Urophycis regius (spotted hake) | Morone americana (white perch) | Morone saxatilis (striped bass) |
| Centropristis philadelphica (rock sea bass) | Epinephalus morio (red grouper) | Mycteroperca bonaci (black grouper) |
| Centropristis striata (black sea bass) | Mycteroperca microlepis (gag) | Lepomis gibbosus (pumpkinseed) |
| Lepomis machrochirus (bluegill) | Micropterus salmoides (largemouth bass) | Pomoxis nigromaculatus (black crappie) |
| Perca flavescens (yellow perch) | Pomatomus saltatrix (bluefish) | Rachycentron canadum (cobia) |
| Caranx hippos (jack crevalle) | Trachinotus carolinus (Florida pompano) | Trachinotus falcatus (permit) |
| Lutjanus falcatus (mutton snapper) | Lutjanus griseus (gray snapper) | Lutjanus synagris (lane snapper) |
| ALL OTHER LUTJANIDA | | |
| Orthopristis chrysoptera (pigfish) | | |

| | | |
|---|---|---|
| Anguilla rostrata (American eel) | Alosa aestivalis (blueback herring) | Alosa mediocris (hickory shad) |
| ALL OTHER POMADASYIDAE | | |
| Archosargus probatocephalus (sheepshead) | Bairdiella chrysoura (silver perch) | Cynoscion nebulosus (spotted seatrout) |
| Cynoscion regalis (weakfish) | Leiostomus xanthurus (spot) | Menticirrhus americanus (southern kingfish) |
| Menticirrhus saxatilis (northern kingfish) | Micropogonias undulatus (Atlantic croaker) | Sciaenops ocellatus (red drum) |
| Pogonias cromis (black drum) | Chaetodipterus faber (Atlantic spadefish) | Tautoga onitis (tautog) |
| Mugil cephalus (striped mullet) | Scomberomorus cavalla (king mackerel) | Scomberomorus maculatus (Spanish mackerel) |
| Peprilus alepidotus (harvestfish) | Peprilus triacanthus (butterfish) | Paralichthys dentatus (summer flounder) |
| Paralichthys lethostigma (southern flounder) | Paralichthys albigutta (gulf flounder) | Sphoeroides maculatus (northern puffer) |

NARRATIVE

BY TINA MOORE
December, 2000

The following is a quick summary of the station work-up for the Pamlico Sound Survey, which is useful for participants to read before the cruise and have available onboard as a check list.

Pamlico Sound Survey Station Work-up

I. CALIBRATE SCALES

A. Make sure that all scales are calibrated to the particular bucket that you are going to use prior to or during the first tow each day (small “blue” buckets, 5-gallon buckets, and baskets) without accurate weights not much can be done with the data.

B. Make sure that all the buckets are the same, sometimes a slight difference in the buckets can be a big weight difference especially with light organisms.

C. Check them throughout the day. When reading the scales make sure to read the proper side of the scales. All weights should be in kgs.

II. ENVIRONMENTAL DATA

A. While hauling back to bring in the net, have some one get the environmental data for each station. Measure the surface temperature, surface salinity, surface D. O. and the same for the bottom.

B. Surface readings can be taken just prior to or during the beginning of the haul back, It is easier to obtain bottom readings when hoisting the tailbags (this is the period when the vessel has the slightest movement forward). That way it is easier to get the probe to the bottom.

III. SAMPLE WORK-UP (except blue crabs and incidentals)

A. Dump both tailbags into the tray.

B. Sort all of the catch to species (spot, blue crab, Atlantic croaker etc.)

C. There is a species list for all species that are measured. You must measure and get an aggregate weight of at least 30 individuals of the listed species (This is the subsample).

D. After measuring and weighing the subsample (the 30 individuals) the rest of each species should be weighed and counted. Each species should have a subsample weight and number, and an additional weight and number for the rest of the catch, by species. The subsample weight should be written in the approriate box on the data sheets, it is not necessary to fill in the subsample number. I will count them up when you return. At the bottom of each species column put the additional number of critters and the additional weight of those critters left over. Circle all additional weights and numbers so that they will not be confused with lengths. If you have 2 or 3 baskets of spot, croaker, or gray trout per tow., do not worry about counting all of them; count how many is in one kilogram and weigh the rest. Record this on the bottom of the column in the following manner: 56 per kg-10 kg total.

IV. BLUE CRAB WORKUP

A. It is necessary to workup all crabs in the sample.
B. Carapace length (mm), sex, maturity, and sponge color (O=Orange, B=Black, if present) must be coded for each crab. After obtaining the above information get the total weight of the blue crabs.
C. In some cases where you have an abnormally high number of crabs you may have to set them to the side and work them up at a later time. Make sure you place a tag or denote the station number on the basket so you will know what station they came from. Also it may helpful to make note on the cover sheet for that station.

V. INCIDENTALS

All other species should be counted and weighed. That included all jellyfish, grass, shell material etc. If you have live oysters try to get acount onthem. If you get into the wool grass around Hyde County try to get one of the bags into the tray and work it up. The other bag can be released overboard. Make sure you note on the data sheet that only half of the sample was worked up so the data can be doubled.

VI. MENHADEN

A. If you see menhaden with disease, they should be kept separate from the healthy menhaden.
B. The ones with disease should be put on a data sheet like the blue crabs (i.e. yellow sheets). Get a subsample weight for the 30 that you measure. Count and weigh the rest.
C. The healthy menhaden can be put on any sheet except the yellow “blue crab’ sheet. Work these up in the same manner as all other target species.

VII. MISCELLANEOUS INFORMATION

Make sure not to dump any of the samples overboard while towing to the next station. No one wants to catch anything extra. The tows will be big enough without adding to them.

Species to keep an eye on (Make sure to sort to species):
Shrimps: browns, pinks, whites (you will see all species)
Flounders: lethostigma, dentatus, albigutta, bay whiffs, fringed flounder, window panes
Crabs: Callinectes sapidus, Callinectes similis, portunid, and horseshoe
Sea robins: striped, big head, leopard, and northern

If you are not able to get to one of the stations for some reason you may pick an alternate station (red in Mike Guthrie's book) to pull. Make sure it is in the same strata (i.e. PDW, PSW etc.). Do not substitute a shallow station for a deep one.

## II. Data Elements Descriptions

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| I | 2-8 | Sequence Number | N/A | N/A | M | Assigned by Data Management. |
| | 25-27 | Fishery (Program) | N/A | N/A | M | 195 |
| | 28-33 | Date | N/A | N/A | M | Date sampled. |
| | 34-38 | County/Dealer | N/A | N/A | M | Station number. Mandatory prior to 1990. Last letter denotes:<br>S = Pamlico Sound (Dropped 1990)<br>N = Neuse River (Dropped 1990)<br>P = Pamlico River (Dropped 1990)<br>A = Albemarle Sound (Dropped 1990) |
| | 39-48 | Starting Location | N/A | N/A | M | Water body codes found in Appendix B in Manual. |
| | 49-52 | Area (Grid) | N/A | N/A | M | Sampling location grid coordinates began in 1990. |

Revised April 1990

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| I | 53 | Quad | N/A | 1-9 | M | 1 - Albemarle Sound<br>2 - Albemarle Shallow<br>3 - Neuse River<br>4 - Pamlico Deep East of Bluff Shoal<br>5 - Pamlico Deep West of Bluff Shoal<br>6 - Pamlico River<br>7 - Pamlico Shallow East of Bluff Shoal<br>8 - Pamlico Shallow West of Bluff Shoal<br>9 - Pungo River |
| | 54-57 | Time Gear Ended Fishing | N/A | 0-2400 | D | |
| | 58-61 | Soak Time | Minutes | N/A | M | Tow Time = 20 minutes. |
| | 62-64 | Gear #1 | N/A | N/A | M | 539 |
| | 65-68 | Gear Parameter #1 | lead length (ft.) | N/A | D | 30 ft. headrope. |

Revised April 1990

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| | 69-72 | Gear Parameter #2 | wing net mesh (bar-in.) | N/A | D | 1.875 wing |
| I | 73-76 | Gear Parameter #3 | tailbag mesh (bar-in.) | N/A | D | .75 tailbag |
| | 77 | Rig | N/A | N/A | M | 1 = single rigged<br>2 = double rigged, two barrel<br>3 = double rigged, four barrel |
| | 78 | Type of Tow | N/A | N/A | M | 3 = bottom |
| | 82-84 | Depth | Meters | N/A | M | Average depth of tow. |
| | 88-90 | Surface Temp. | °C | N/A | M | |
| | 91-93 | Bottom Temp. | °C | N/A | M | |
| | 94-96 | Surface Salinity | 0/00 | N/A | M | |

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| | 97-99 | Bottom Salinity | 0/00 | N/A | M | |
| I | 112 | Weather Element | N/A | N/A | D | 1 = clear skies<br>2 = one-quarter cover (25%)<br>3 = one-half cover (75%)<br>4 = three-quarter cover (75%)<br>5 = one hundred percent cover<br>6 = haze<br>7 = fog<br>8 = precipitation<br>9 = snow |

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| | 117 | Wind Direction | N/A | N/A | D | 1 = N<br>2 = NE<br>3 = E<br>4 = SE<br>5 = S<br>6 = SW<br>7 = W<br>8 = NW |
| | 121-122 | Gear Parameter #4 (Wind Speed) | Knots | N/A | D | Wind Speed |
| | 126-127 | No. of Replicates | N/A | N/A | M | Must correspond to the number of Record Type II's |

Revised April 1990

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| VIII | 27-32 | Variable Field #5 (Latitude) | N/A | N/A | M | Latitude in 6 spaces. (Right Justification.) |
| | 44-49 | Variable Field #3 (Longitude) | N/A | N/A | M | Longitude in 6 spaces. (Right Justification.) |

Revised April 1990

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| II | 9-10 | Replicate | N/A | N/A | M | Replicate 00 if disease data obtained; Replicate 01 contains all information for the tow. |
| | 25-30 | Collection Size | kilograms (to nearest .1) | N/A | M | Total weight of all species in the catch. |
| | 31-36 | Sample Size | kilograms (to nearest .01) | N/A | M | Total weight of species in sample (sum of Record Type III's sample weights). |
| | 37-38 | No. of Record Type III□s | N/A | N/A | M | Total number of Record Type III's associated with the replicate. |

Revised April 1990

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| III | 9-10 | Replicate | N/A | N/A | M | Corresponds to replicate number from Record Type II that sample came from (see manual). |
| | | Species | N/A | N/A | M | Scientific or common name. |
| | 11-20 | Species Code | N/A | N/A | M | See manual, Appendix G.2. |
| | 25-29 | Collection Number | N/A | N/A | M | Total number of particular species in the catch. |
| | 30-35 | Collection Weight | kg. (to nearest .1 kg) | N/A | M | Total weight of particular species. |
| | 36-40 | Sample Number | N/A | N/A | M | Number of particular species in sampling unit. |
| | 41-46 | Sample Weight | kg. (to nearest .01 kg.) | N/A | M | Sample weight in sampling unit. |
| | 47-51 | Subsample Number | N/A | N/A | M | Number of particular species measured in sampling unit. |

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| | 52-57 | Subsample Weight | kg. (to nearest .01 kg.) | N/A | M | Weight of measured individuals of particular species in sampling unit. |
| | 58 | Form of Record Type IV | N/A | N/A | M | See Manual. |

Revised April 1990

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| IV | 22-24 | Line Number | N/A | N/A | M | See Manual. |
| | 25-27 | Number | N/A | N/A | M | Frequency - See Manual. |
| | 28-31 | Length | Millimeters | N/A | M | |
| | 32-36 | Weight | kg. | .01 | M | Record weight if scales taken. |
| | 37 | Sex | N/A | 1-3 | M | Sex should always be recorded for blue crabs. |
| | 38 | Maturity | N/A | 1,3,7 | M | 1 immature<br>3 mature<br>7 sponge |
| | 43-46 | Parameter B | N/A | 1,2 | M | For sponge crabs only<br>1 sponge yellow to orange in color<br>2 sponge brown to black in color |
| | 47-50 | Parameter C | N/A | N/A | D | Lesion Type (if 2 lesions on same fish). |

FORMAT A

The following should be completed to reflect current activities. Please note in written descriptions any deviations from the current activities listed below.

| Rec. Type | Column # | Field Name | Units | Limits | Mandatory (M) vs. Desired (D) | Comments |
|---|---|---|---|---|---|---|
| | 51-54 | Parameter D | N/A | 1-6 | D | Lesion Type Code:<br>1 = skin ulcer<br>2 = fin erosion<br>3 = abnormal pigmentation<br>4 = tumors<br>5 = skeletal anomalies<br>6 = opercular damage |

## III. Maps

Available upon request.