

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:

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

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 through 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 mentioned, 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:

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

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:

$$F_{y,a,i} = F_{y,a} * \text{Catch}_{y,a,i} / \text{Catch}_{y,a}$$

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 ($F_{10}/F_9 = 1.0$, $F_{11+}/F_9 = 1.0$). 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 sector¹ and the 2002/03 total catch in numbers for the recreational sector² 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 MRFSS³), 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_{2-3}) 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_{5-6+} 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, FWC⁴, 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_{2-4}) 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_{5-7+} 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 used as starting 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 compared to those obtained in the Full index model, and 30%-50% for confidence intervals of F mortality rates. Only in the older age groups (Age 7-11+) 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, Seemap 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 Seemap 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.

LITERATURE CITED

- Collins, M.R. D.J. Schmidt, C.W. Waltz and J.L. Pickney. 1989. Age and growth of king mackerel, *Scomberomorus cavalla*, from the Atlantic coast of the United States. Fish. Bull. 87(1):49-61
- Cooke, J.G. and K. Lankester. 1996. Consideration of statistical models for catch-effort indices for use in tuning VPA's. ICCAT Col. Vol. Sci. Pap. 45(2):125-131.
- Fable, W.A Jr. A.G. Johnson and L.E. Barger. 1987. Age and growth of Spanish mackerel, *Scomberomorus maculatus*, from Florida and the Gulf of Mexico. Fish. Bull. 85(4):777-783.
- Finucane, J.H., L.A. Collins, H.A. Brusher, and C.H. Saloman. 1986. Reproductive biology of king mackerel, *Scomberomorus cavalla*, from the Southeastern United States. Fish. Bull. 84: 841-850.
- Gledhill, C.T. and J. Lyczkowski-Shultz. 2000. Indices of larval king mackerel (*Scomberomorus cavalla*) abundance in the Gulf of Mexico for use in population assessments. Fish. Bull. 98:684-691.
- Gulf of Mexico Fishery Management Council (GMFMC). 2003. A framework seasonal adjustment of harvest procedures, reference points, and status criteria under the Fishery Management Plan for coastal migratory pelagic resources in the Gulf of Mexico including environmental assessment, regulatory impact review, and initial regulatory flexibility analysis. GMFMC Tampa Florida.
- Harris, P.J. and J.M. Dean. The potential impact of juvenile king mackerel (*Scomberomorus cavalla*) and Spanish mackerel (*S. maculatus*) shrimp trawl bycatch mortality on southeast Atlantic adult populations. MSAP/98/01.
- Harris, P.J. and J.M. Dean. Characterization of the king mackerel and Spanish mackerel bycatch of South Carolina shrimp trawlers. MSAP/98/02.
- Legault, C.M. 1999. Updated projections for King and Spanish mackerel in the Gulf of Mexico and Atlantic Ocean. NMFS SEFSC Miami Sustainable Fisheries Division contribution SFD-98/99-49.
- Legault, C.M. and M. Ortiz. 1998. Delta lognormal estimates of bycatch for Gulf of Mexico king and Spanish mackerel and their impact on stock assessment and allowable biological catch. MSAP/98/12. NMFS Sustainable Fisheries Division Contribution SFD-97/98-11. Miami, FL.
- Legault, C.M., N. Cummings and P. Phares. 1998. Stock assessment analyses on Atlantic migratory group king mackerel, Gulf of Mexico migratory group king mackerel, Atlantic migratory group Spanish mackerel, and Gulf of Mexico migratory group Spanish mackerel. NMFS SEFSC Miami Sustainable Fisheries Division Contribution MIA-97/98-15.
- Legault, C.M., M. Ortiz, G.P. Scott, N. Cummings and P. Phares. 2000. Stock assessment analyses on Gulf of Mexico king mackerel. MSAP/00/02. NMFS SEFSC Miami Sustainable Fisheries Division Contribution 99/00-83.
- MSAP (Mackerel Stock Assessment Panel). 1999. 1999 Report of the Mackerel Stock Assessment Panel. Prepared at meeting held March 29 - April 1, 1999. Miami, FL. 25 p.
- MSAP (Mackerel Stock Assessment Panel). 1998. 1998 Report of the Mackerel Stock Assessment Panel. Prepared by the MSAP at the Panel Meeting held March 23 – 26, 1998. FL. Gulf of Mexico Fishery Management Council, Tampa FL, and South Atlantic Fishery Management Council, Charleston SC.
- MSAP (Mackerel Stock Assessment Panel). 2002. 2002 Report of the Mackerel Stock Assessment Panel. Prepared by the MSAP at the Panel Meeting held May 26- 28, 2002. FL. Gula of Mexico Fishery Management Council, Tampa FL., and South Atlantic Fishery Management Council, Charleston SC.
- Manooch, C.S. III, S.P. Naughton, C.B. Grimes, and L. Trent. 1987. Age and growth of king mackerel, *Scomberomorus cavalla*, from the U.S. Gulf of Mexico. Marine Fisheries Review. 49(2): 102-108.

- Nichols, S., A. Shah, G.J. Pellegrin Jr. and K. Mullin. 1987. Estimates of annual shrimp fleet bycatch for thirteen species in the offshore waters of the Gulf of Mexico. Report to the Gulf of Mexico Fishery Management Council.
- Ortiz, M. 2002. Even further projections for Gulf and Atlantic King and Spanish mackerel migratory groups. NMFS SEFSC Miami Sustainable Fisheries Division Contribution SFD-01/02-152.
- Ortiz, M. 2003. Standardized catch rates of king (*Scomberomorus cavalla*) and Spanish mackerel (*S. maculatus*) from U.S. Gulf of Mexico and South Atlantic recreational fisheries. NMFS SEFSC Miami Sustainable Fisheries Division Contribution SFD-02/03-006.
- Ortiz, M. 2002. Estimates of Gulf king mackerel bycatch from the U.S. Gulf of Mexico Shrimp Gulf trawl fishery. NMFS SEFSC Miami Sustainable Fisheries Division Contribution SFD-01/02/162.
- Ortiz, M. and C.M. Legault. 2001. Further projections for Gulf and Atlantic king and Spanish mackerel migratory groups. NMFS SEFSC Miami Sustainable Fisheries Division Contribution SFD-00/01-121.
- Ortiz, M., C.M. Legault and G. Scott. 2000. Variance component estimation for standardized catch rates for king mackerel (*Scomberomorus cavalla*) from U.S. Gulf of Mexico recreational fisheries useful for inverse variance weighting techniques. MSAP/00/03. NMFS Sustainable Fisheries Division Contribution SFD-99/00-86. Miami, FL.
- Ortiz, M., C.M. Legault and N.M. Ehrhardt. 2000. An alternative method for estimating bycatch from the U.S. shrimp trawl fishery in the Gulf of Mexico, 1972-1995. Fish. Bull. 98:538-599.
- Ortiz, M. and P. Phares. 2002. Standardized catch rates of king mackerel (*Scomberomorus cavalla*) from U.S. Gulf of Mexico and South Atlantic recreational fisheries. MSAP-02-#. NMFS SEFSC Miami Sustainable Fisheries Division Contribution 01/02-155.
- Ortiz, M., G.P. Scott, N. Cummings and P.L. Phares. 2002. Stock assessment analyses on Gulf of Mexico King Mackerel. NMFS SEFSC Miami Sustainable Fisheries Division Contribution SFD-01/02-161.
- Ortiz, M. and G.P. Scott. 2001. Standardized catch rates of king (*Scomberomorus cavalla*) and Spanish (*S. maculatus*) mackerel from U.S. Gulf of Mexico and South Atlantic recreational fisheries. MSAP-01-02. NMFS SEFSC Miami Sustainable Fisheries Division Contribution 00/01-125.
- Ortiz, M. and L. Sabo. 2003. Standardized catch rates of Spanish and king mackerel (*Scomberomorus maculatus* and *S. cavalla*) from the North Carolina Commercial Fisheries. NMFS SEFSC Miami Sustainable Fisheries Division Contribution SFD-02/03-005.
- Powers, J.E. and V.R. Restrepo. 1992. Additional options for age-sequenced analysis. ICCAT Coll. Vol. Sci. Pap. 39: 540-553.
- Punt, A.E., T.I. Walker, B.L. Taylor and F. Pribac. 2000. Standardization of catch and effort data in a spatially-structured shark fishery. Fisheries Research 45:129-145.
- Restrepo, V.R. 1996. FADAPT 3.0 A Guide. University of Miami, Cooperative Unit for Fisheries Research and Education (CUFER).
- Restrepo, V.R., G.G. Thompson, P.M. Mace, W.L. Gabriel, L.L. Low, A.D. MacCall, R.D. Methot, J.E. Powers, B.L. Taylor, P.R. Wade and J.F. Witzig. 1998. Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Technical Memorandum NMFS-F/SPO-#. 54 pp.
- Shepherd, J.G. 1985. Deconvolution of length compositions. ICES Methods Working Group. Working paper 7 pp.
- Vaughan, D.S. and J.M. Nance. 1998. Estimates of bycatch of mackerel and cobia in U.S. South Atlantic shrimp trawls. MSAP/98/04.

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	16698.9	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

Fishing Year	Commercial		Recreational		Total	
	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.

Fishing Year	Commercial					Recreational				
	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.

Fishing Year	Commercial		Recreational		Total	
	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.

Fishing Year	Commercial					Recreational				
	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.

Fishing Year	INDICES OF ABUNDANCE								Charter NW Florida
	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
Output 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
2	0.93422E-01	66.62022	0.15351E+06
3	0.33169E-01	34.85871	0.41365E+06
4	0.43622E-01	20.69346	0.45574E+06
5	0.45752E-01	18.97082	59568.
6	0.47051E-01	37.46921	62150.
7	0.45062E-01	25.50787	0.126663E+06
8	0.33243E-01	23.74243	25651.
9	0.89820E-01	48.08438	13487.
10	0.89820E-01	48.08438	13310.
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	0.87790E+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	0.028	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 0.343
 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	0.198	0.687	1.000	0.350	0.068	0.204
86/87	0.936	0.617	1.000	0.565	0.659					

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 = Seemap 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
Output 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)
0	0.10552E-02	64.88683	CV(N)
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	0.529	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

	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	1.078	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	0.744	0.925	1.000	0.576	0.406	0.682	0.682	
92/93	0.888	0.748	0.533	0.656	0.590	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	0.592	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	0.520	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	0.778	0.606	0.595				

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	0.699	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 = Seemap 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.

Probability	Base Model		Full Index Model	
	$F_{30\%SPR}$	$F_{40\%SPR}$	$F_{30\%SPR}$	$F_{40\%SPR}$
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
Output 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	0.553	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

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

<tbl

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
 Output 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	1.3106					
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

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	0.77					

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.

Probability	Base Model		Full Index Model	
	$F_{30\%SPR}$	$F_{40\%SPR}$	$F_{30\%SPR}$	$F_{40\%SPR}$
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
Output 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 51.18044 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

Pearson's (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	-1.5257
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

Pearson's (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		

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
Output 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		

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			

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.

Probability	Base Model		Full Index Model	
	$F_{30\%SPR}$	$F_{40\%SPR}$	$F_{30\%SPR}$	$F_{40\%SPR}$
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

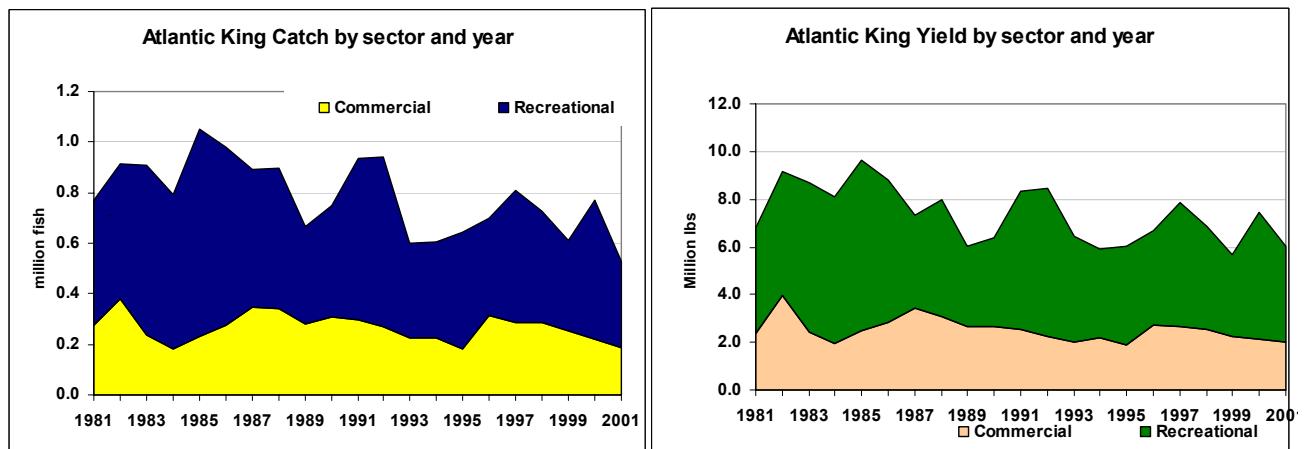


Figure 1. Atlantic king mackerel catch and yield by fishing year and sector from 1981 through 2001.

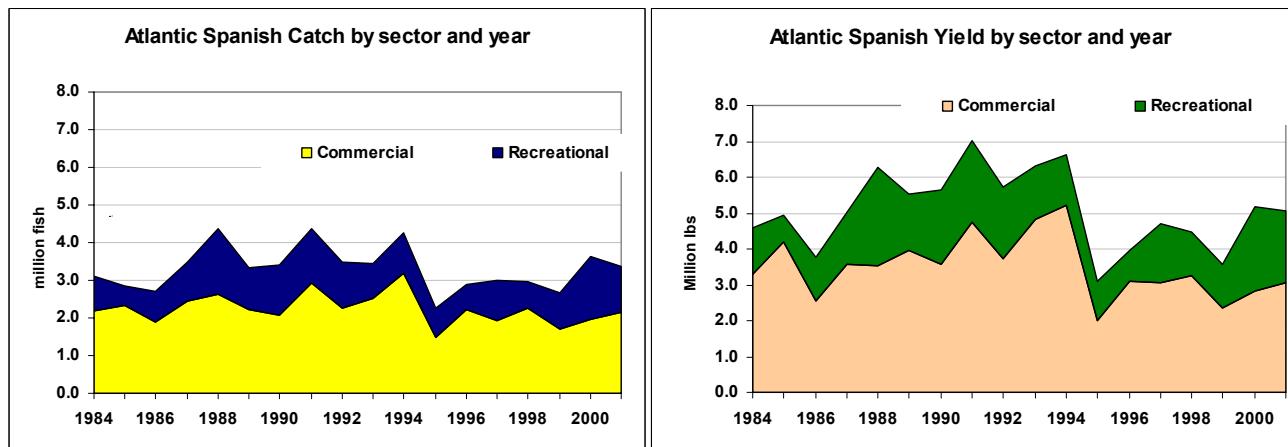


Figure 2. Atlantic Spanish mackerel catch and yield by fishing year and sector from 1984 through 2001

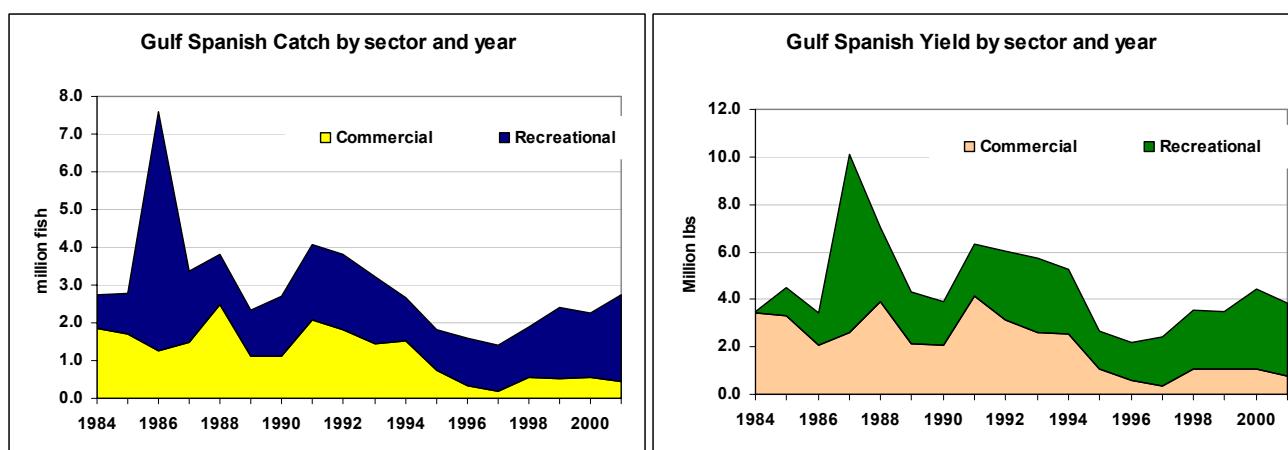


Figure 3. Gulf Spanish mackerel catch and yield by fishing year and sector from 1984 through 2001

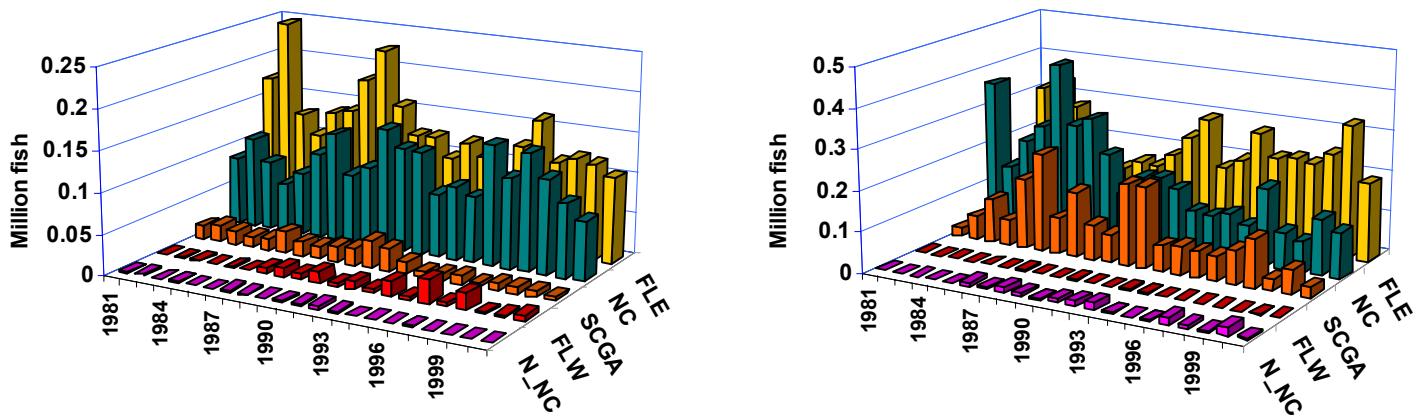


Figure 4. Atlantic king mackerel catch by state, fishing year and sector: commercial (left) and recreational (right) from 1981 through 2001.

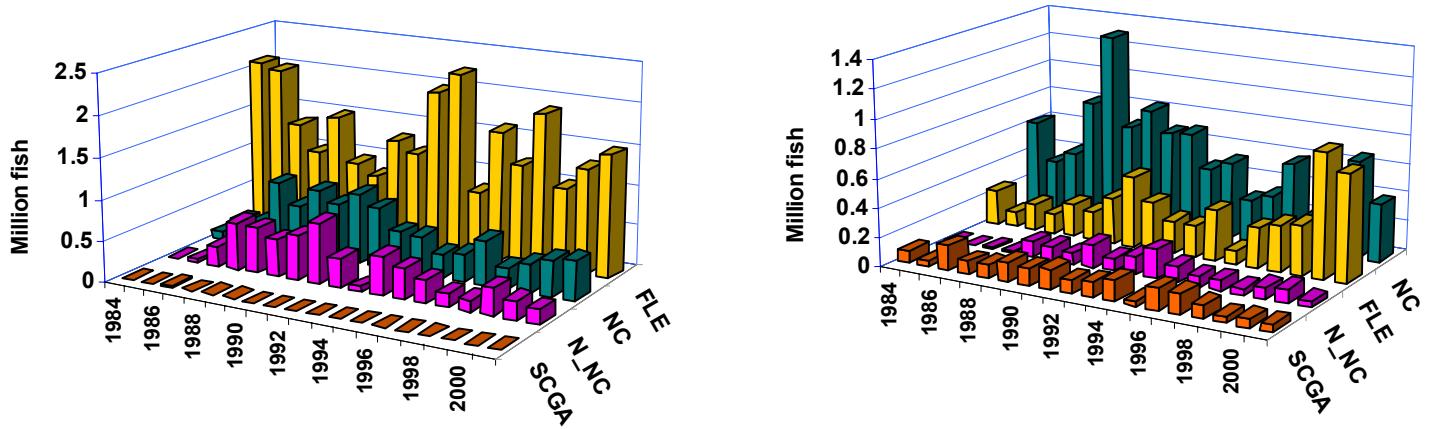


Figure 5. Atlantic Spanish mackerel catch by state, fishing year and sector: commercial (left) and recreational (right) from 1984 through 2001

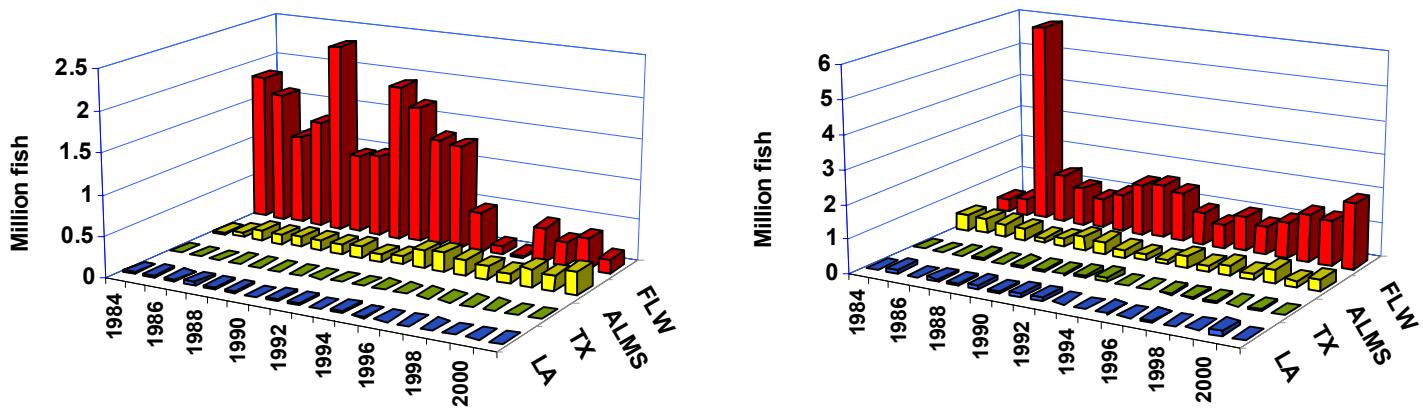


Figure 6. Gulf Spanish mackerel catch by state, fishing year and sector: commercial (left) and recreational (right) from 1984 through 2001

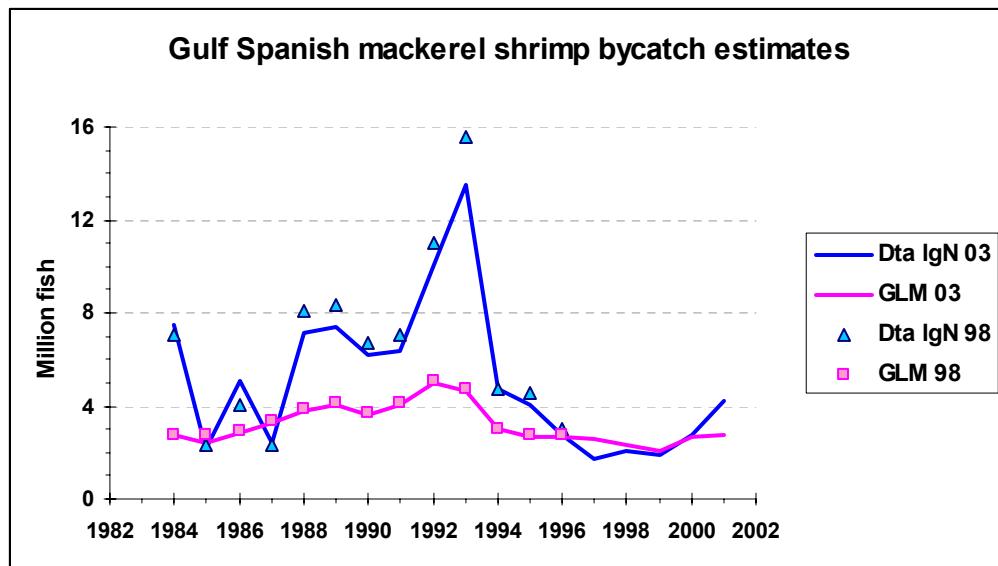


Figure 7 Comparison of 1998 and 2003 estimates of Spanish mackerel bycatch in the shrimp trawl fishery of the US Gulf of Mexico. Estimates from the GLM (base) and delta lognormal models

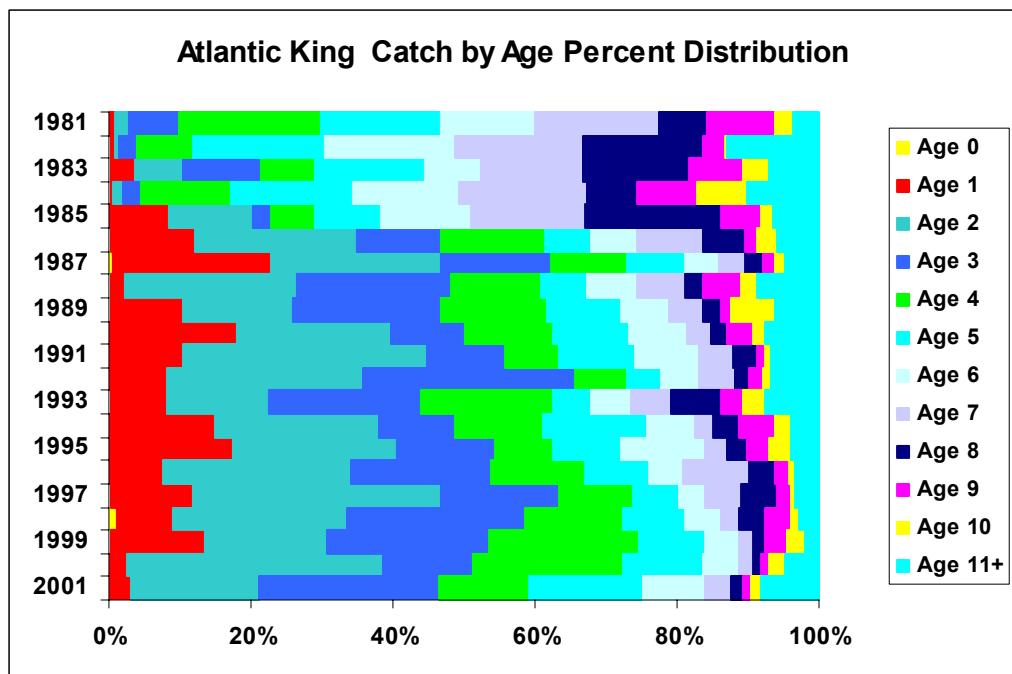


Figure 8. Proportion of total catch by age and year for Atlantic king mackerel from 1981 through 2001 fishing year.

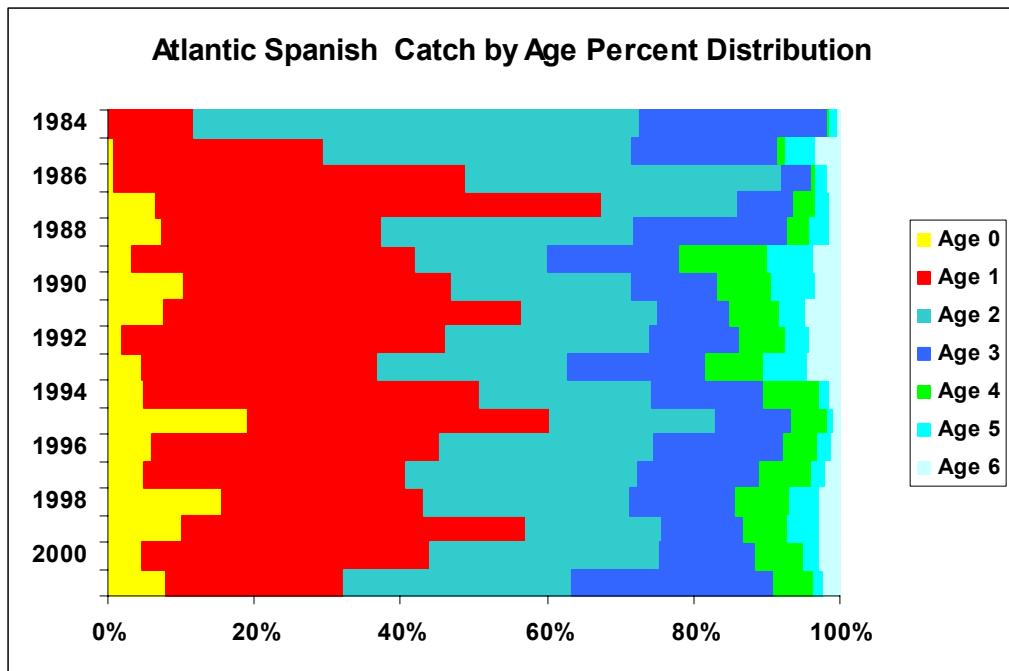


Figure 9. Proportion of total catch by age and year for Atlantic Spanish mackerel from 1984 through 2001 fishing year.

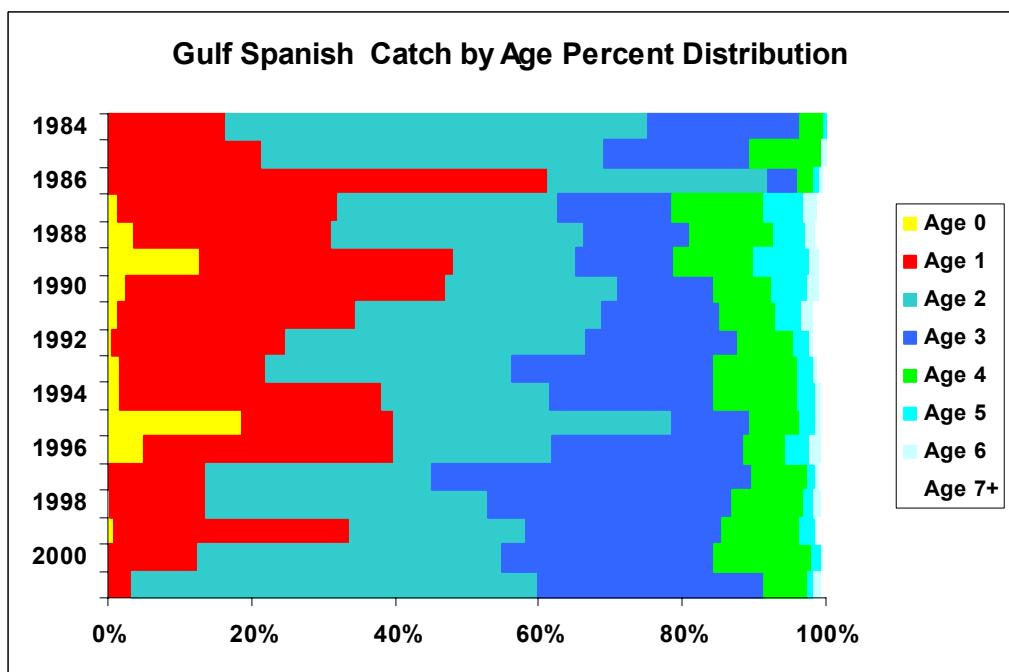


Figure 10. Proportion of total catch by age and year for Gulf Spanish mackerel from 1984 through 2001 fishing year.

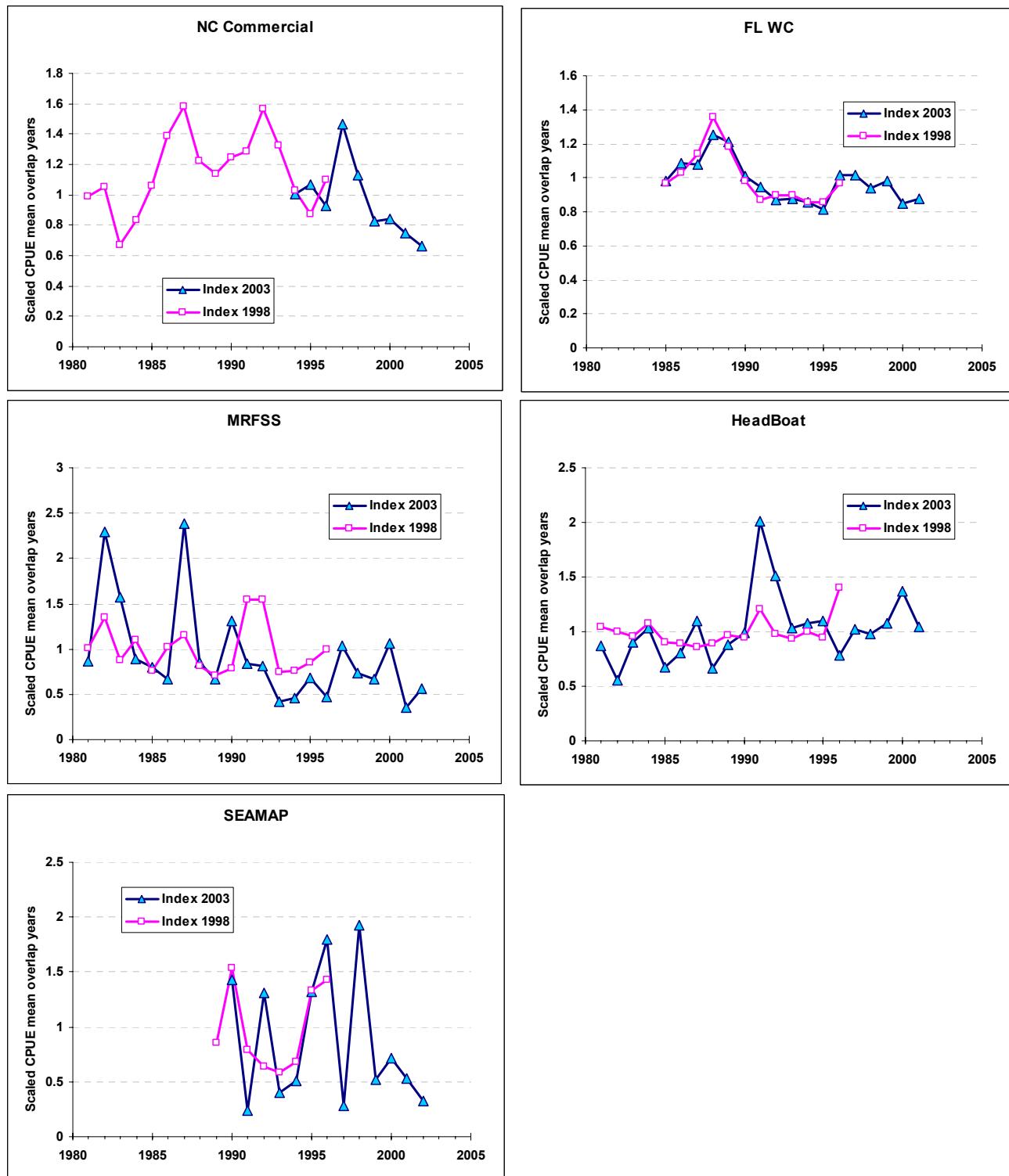


Figure 11. Comparison of standardized indices of abundance for the Atlantic king mackerel used in 1998 stock assessments and correspondent ones available for 2003 analysis.

King Mackerel Atlantic stock

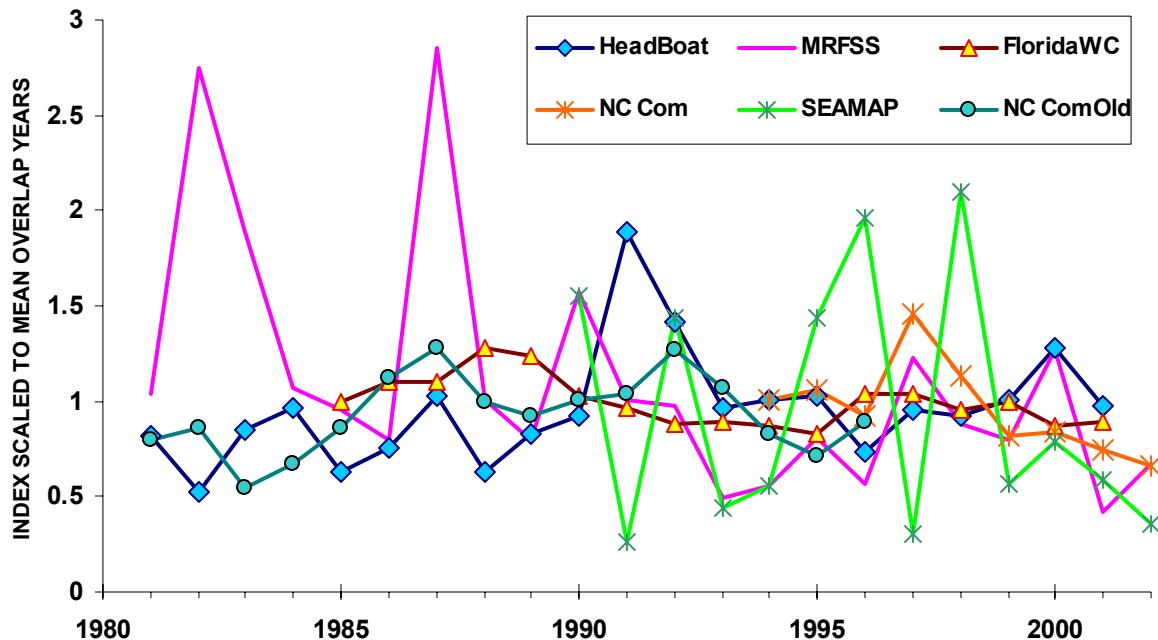


Figure 12. Standard indices of abundance of Atlantic king mackerel available for VPA tuning analysis in 2003.
Indices are scaled to their mean for the overlapping years.

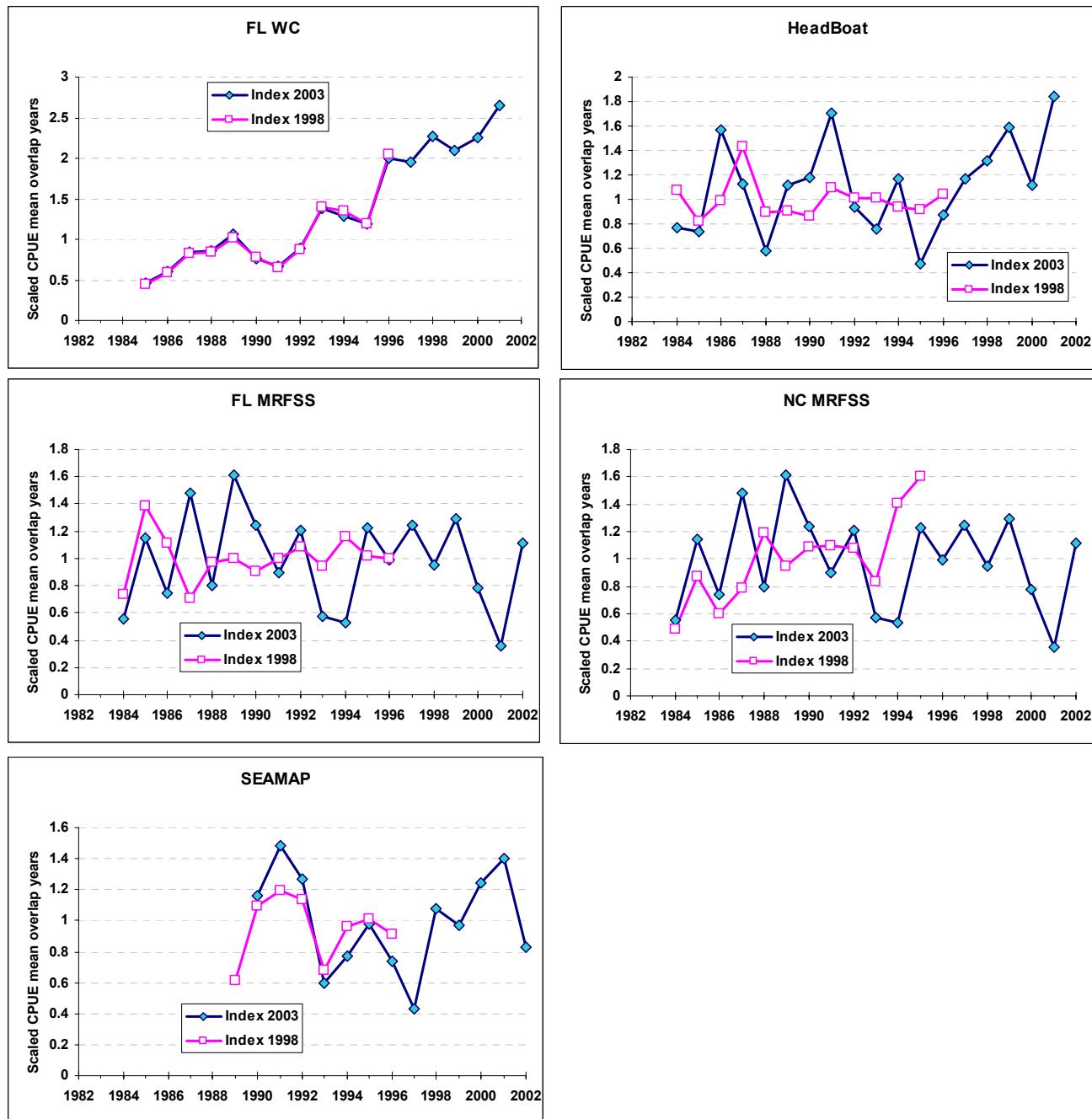


Figure 13. Comparison of standardized indices of abundance for the Atlantic Spanish mackerel used in 1998 stock assessments and correspondent ones available for 2003 analysis.

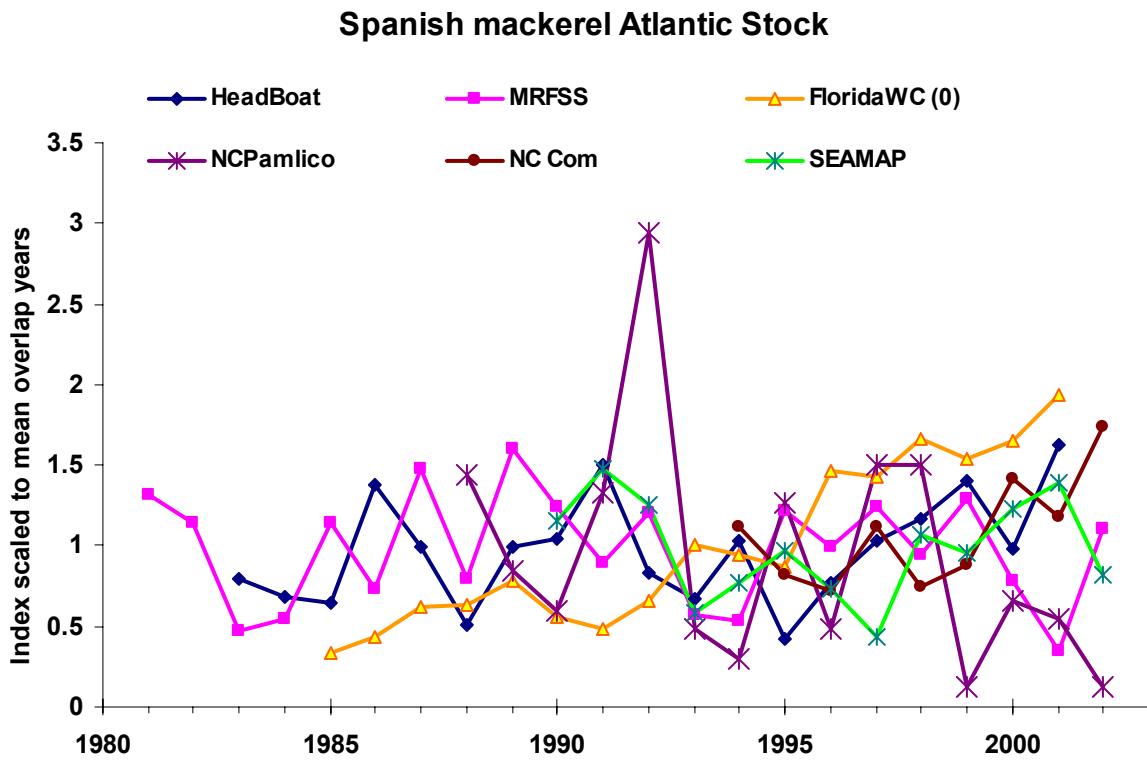
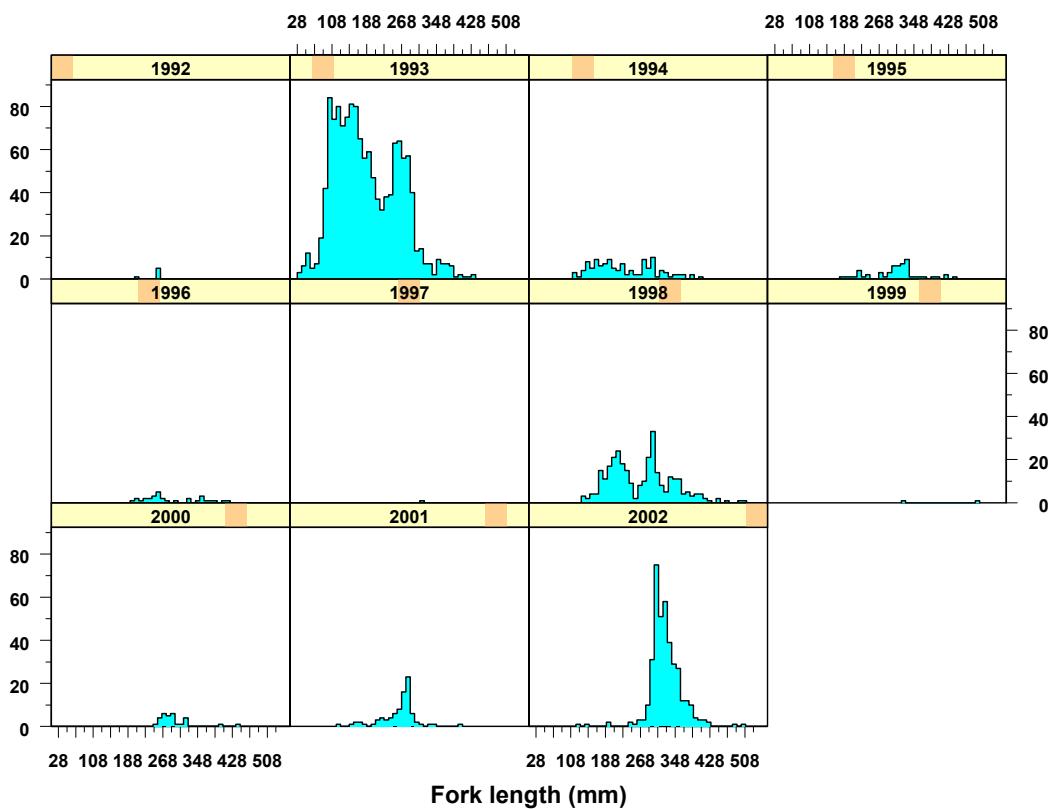


Figure 14. Standard indices of abundance of Atlantic Spanish mackerel available for VPA tuning analysis in 2003. Indices are scaled to their mean for the overlapping years.

Gulf Spanish Shrimp bycatch lenght frequency distributions by year



Gulf Spanish Shrimp bycatch lenght frequency distributions by quarter

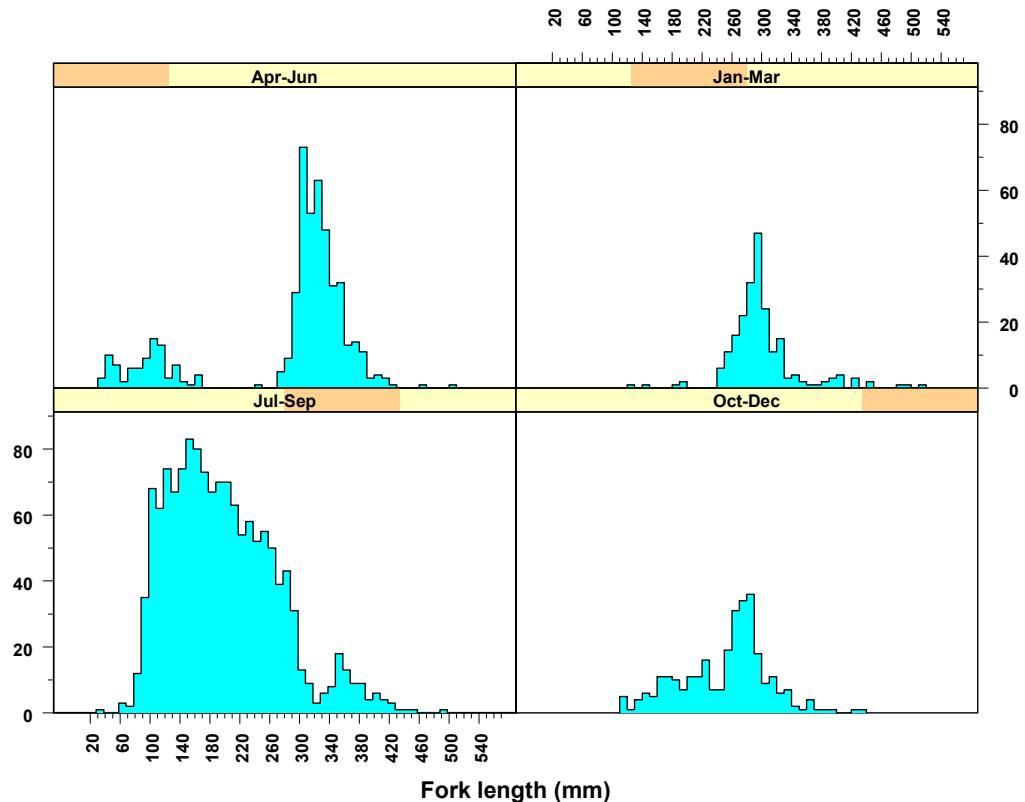


Figure 15. Size frequency distribution of Spanish mackerel bycatch from the US Gulf shrimp fishery by year and season (Data provided by NMFS SEFSC Galveston lab).

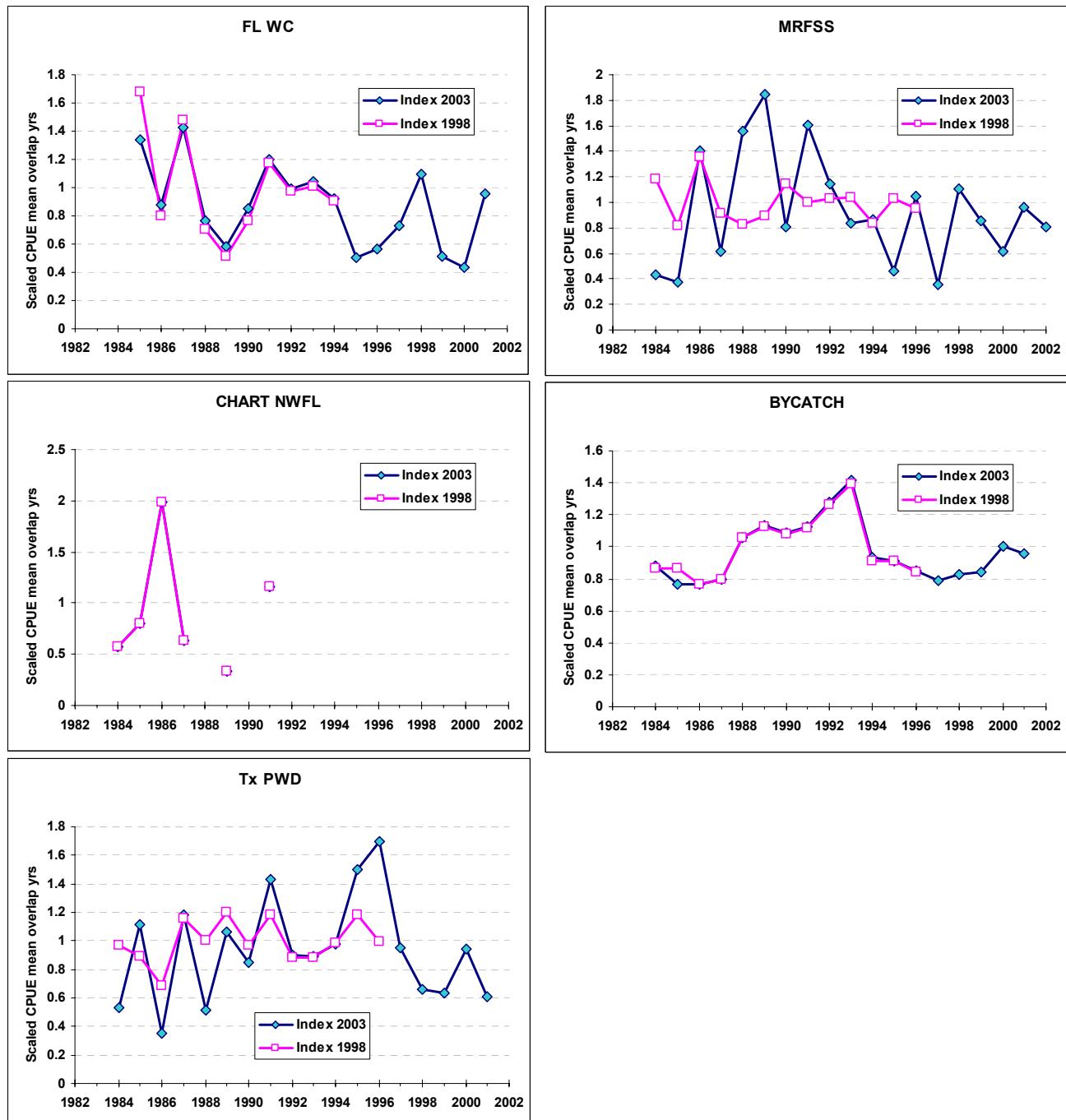


Figure 15a. Comparison of standardized indices of abundance for the Gulf Spanish mackerel used in 1998 stock assessments and correspondent ones available for 2003 analysis.

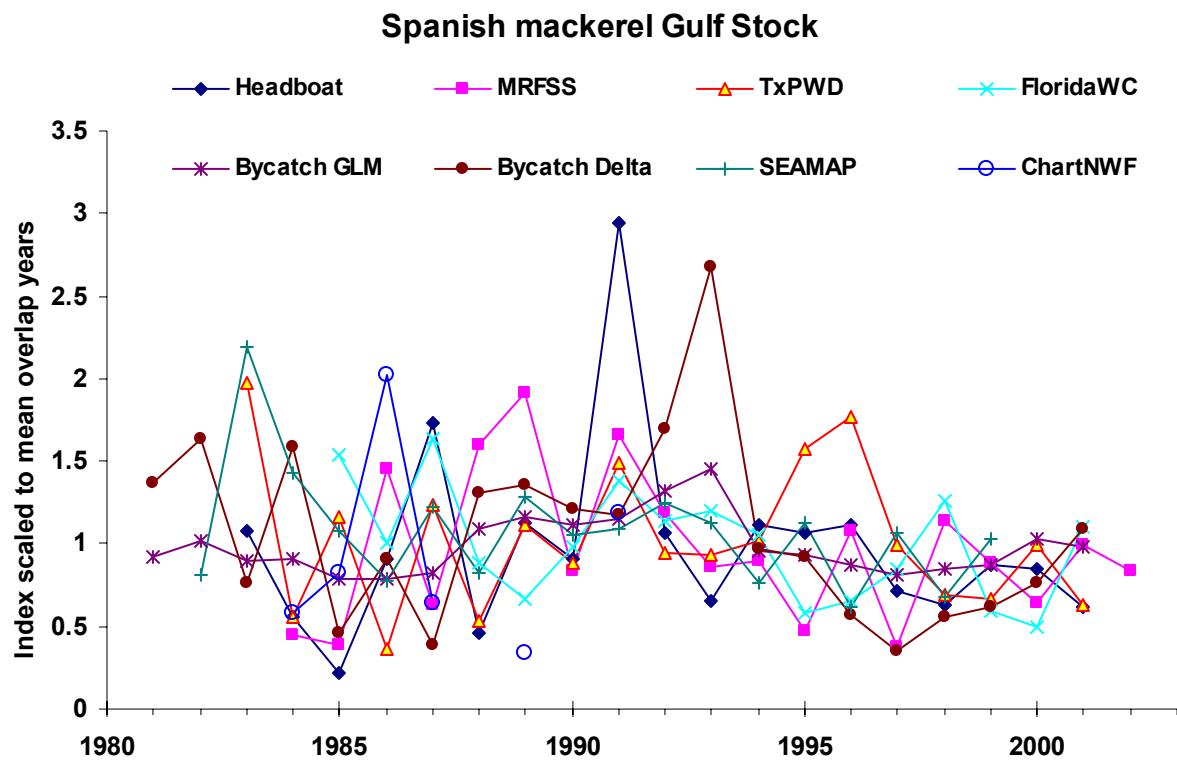


Figure 16. Standard indices of abundance of Gulf Spanish mackerel available for VPA tuning analysis in 2003. Indices are scaled to their mean for the overlapping years.

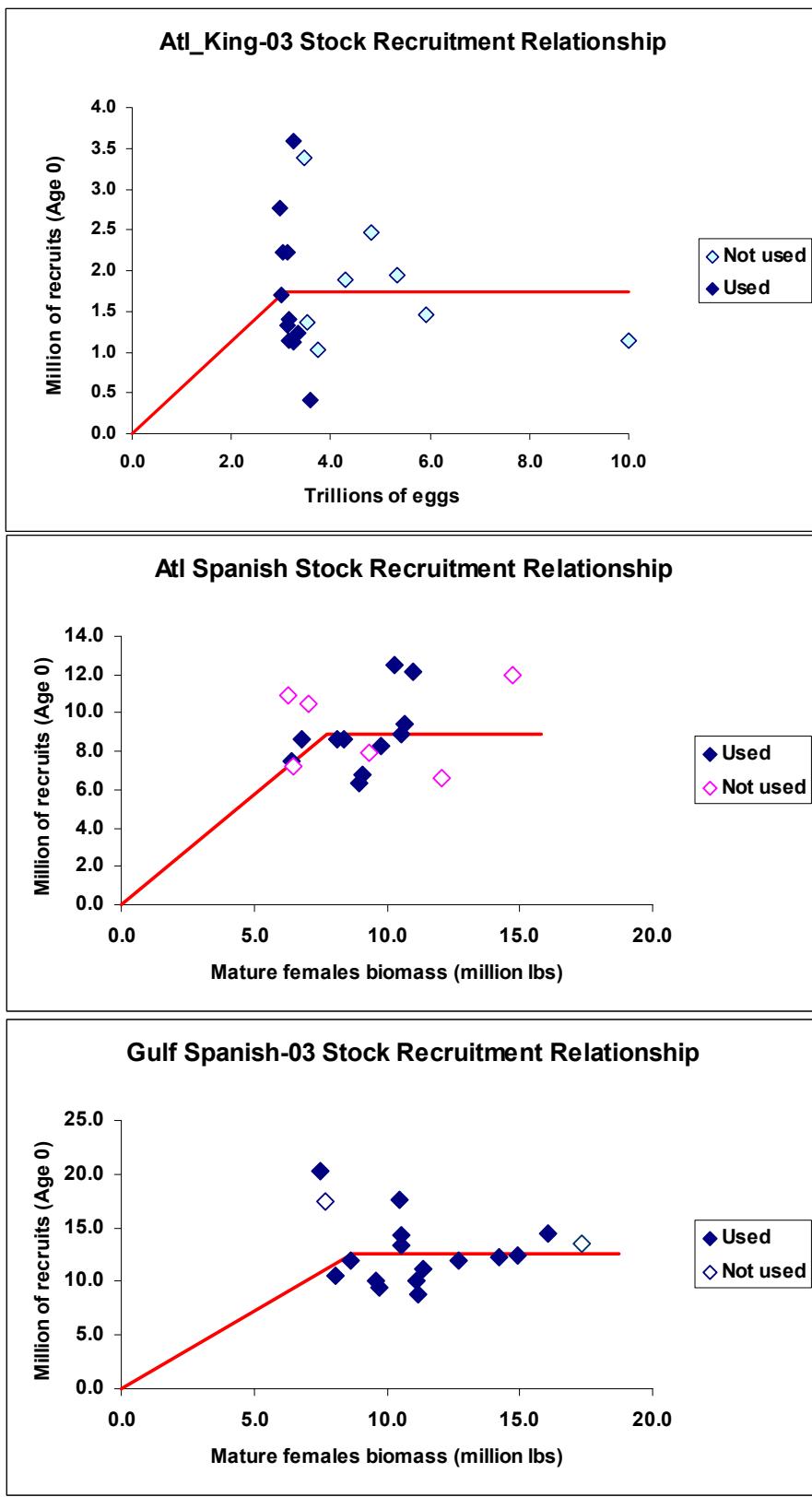


Figure 17. Deterministic stock recruitment relationship under the two line model for Atlantic king, Spanish king and Gulf king mackerel.

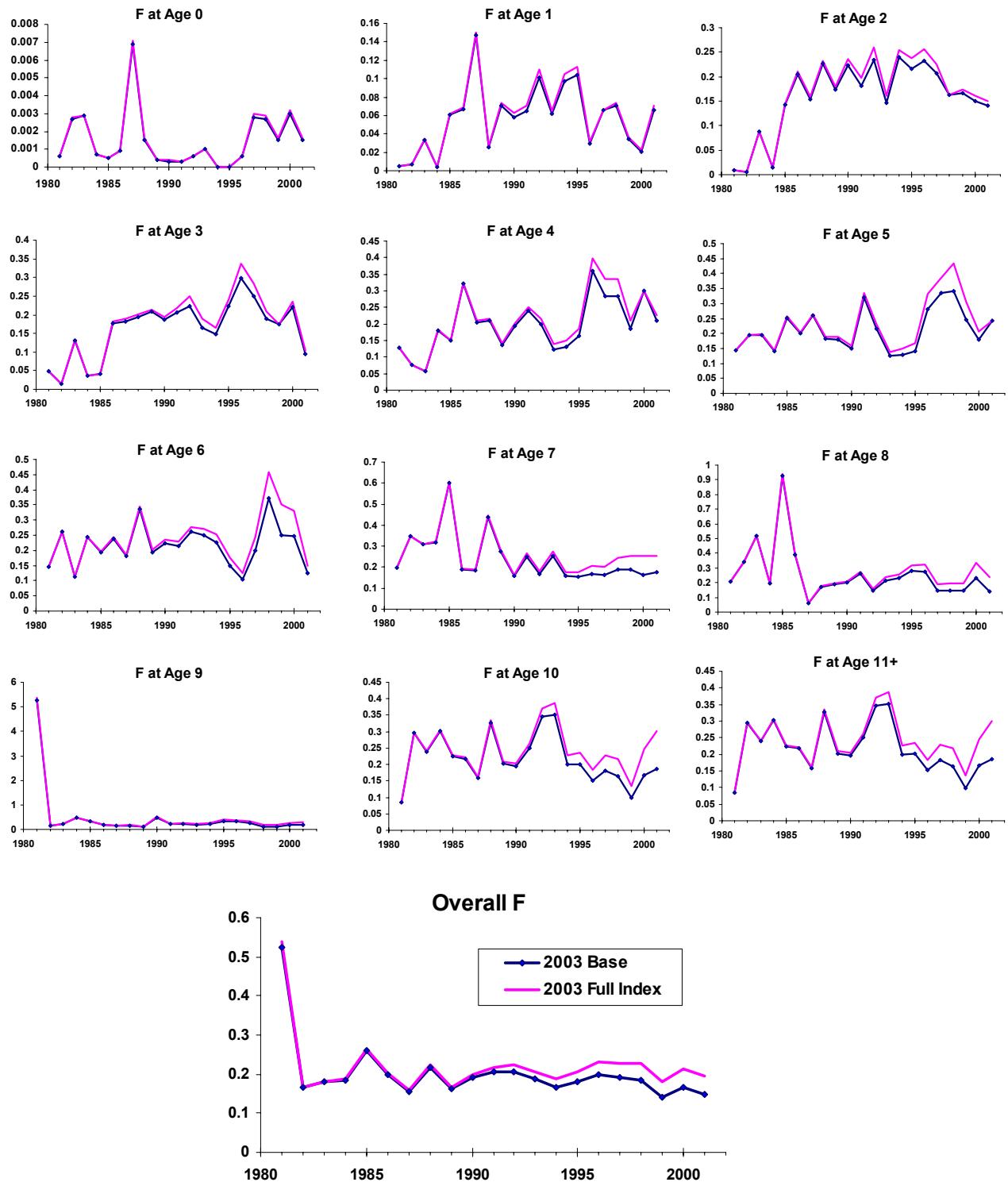


Figure 18. Atlantic king mackerel estimates of F mortality by age from the Base and Full index models.

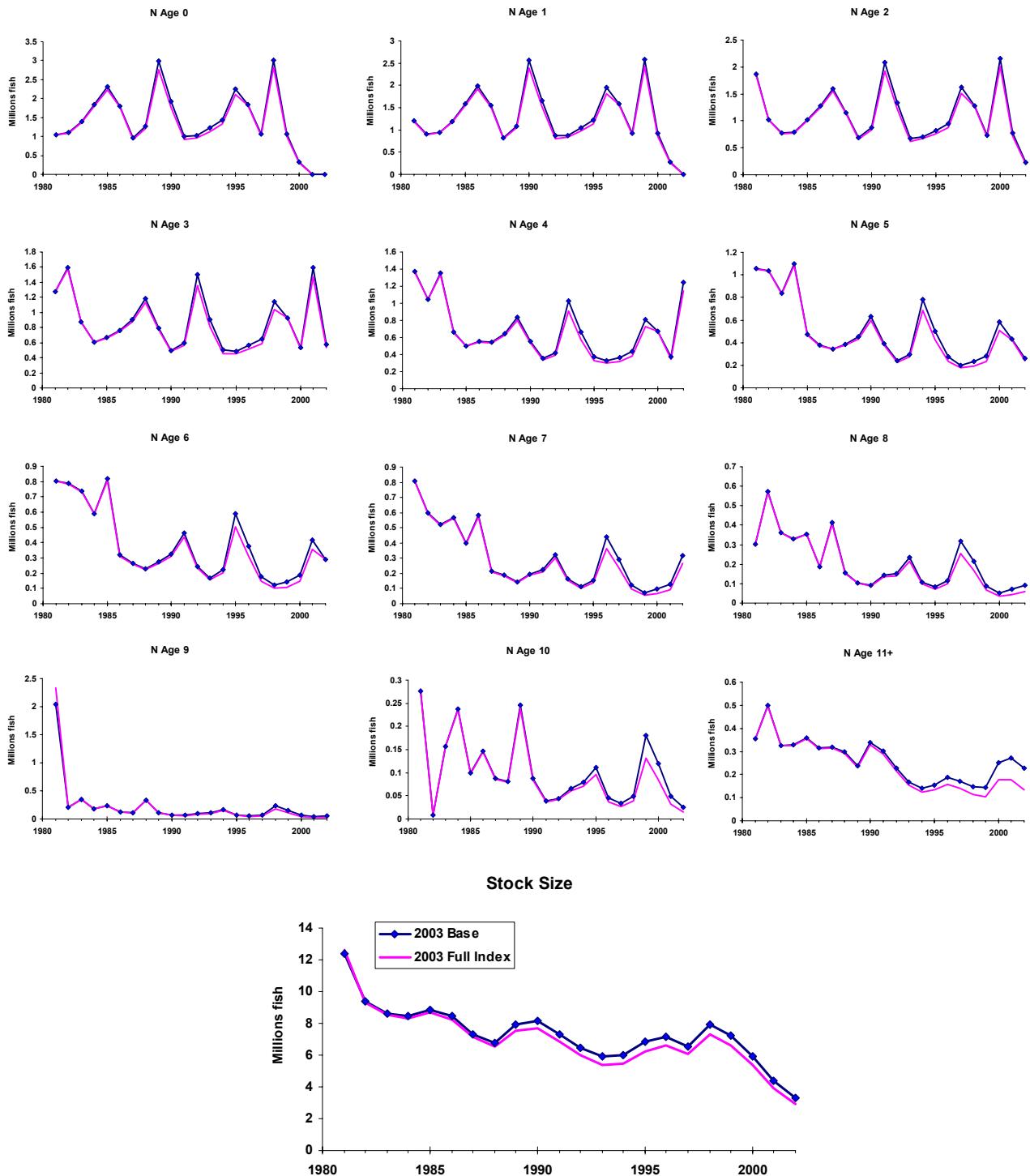


Figure 19. Atlantic king mackerel estimates of stock size by age from the Base and Full index models

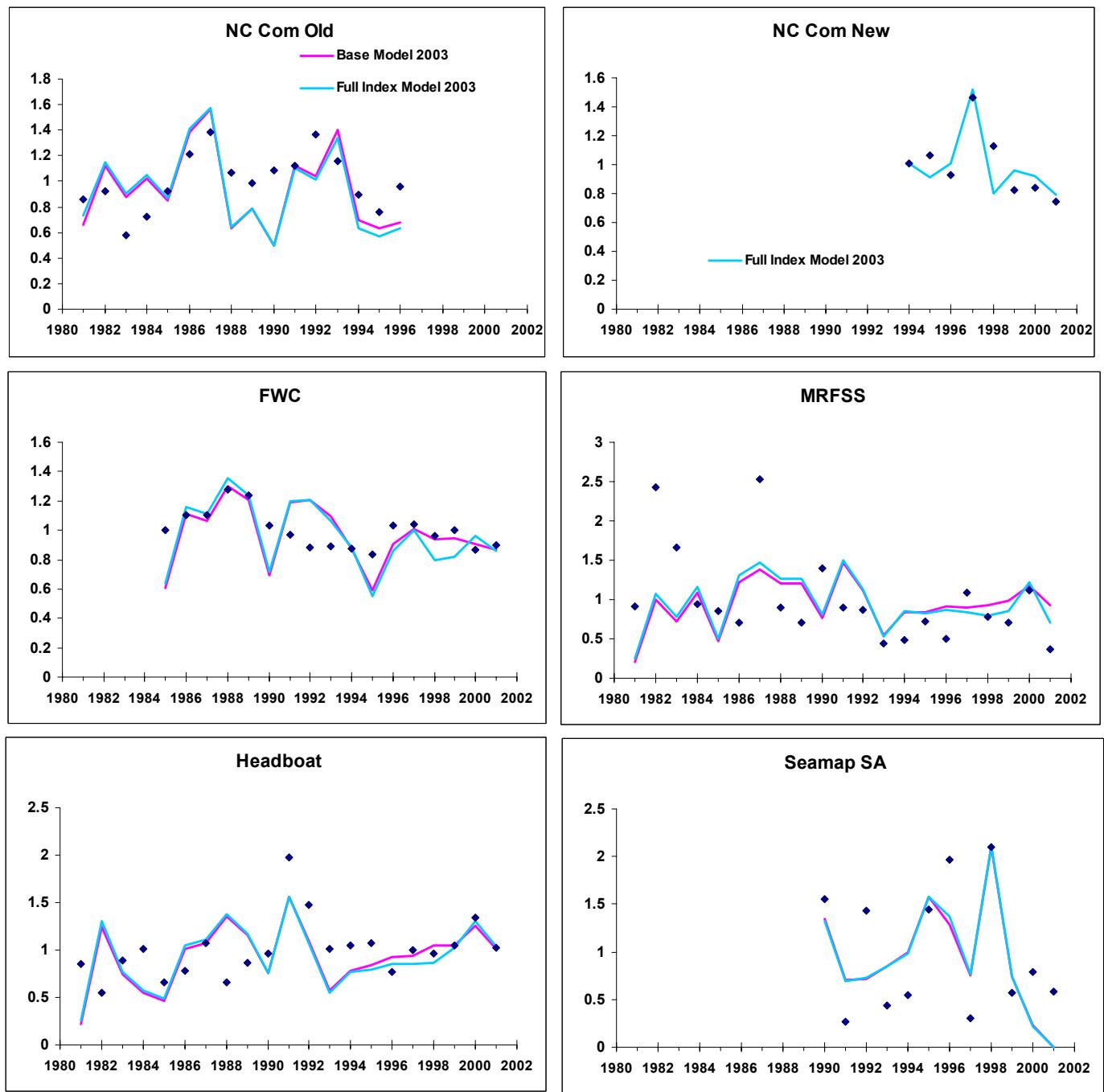


Figure 20. Atlantic king mackerel predicted (solid lines) and standard index (diamonds) from the tuned VPA Base and Full index models.

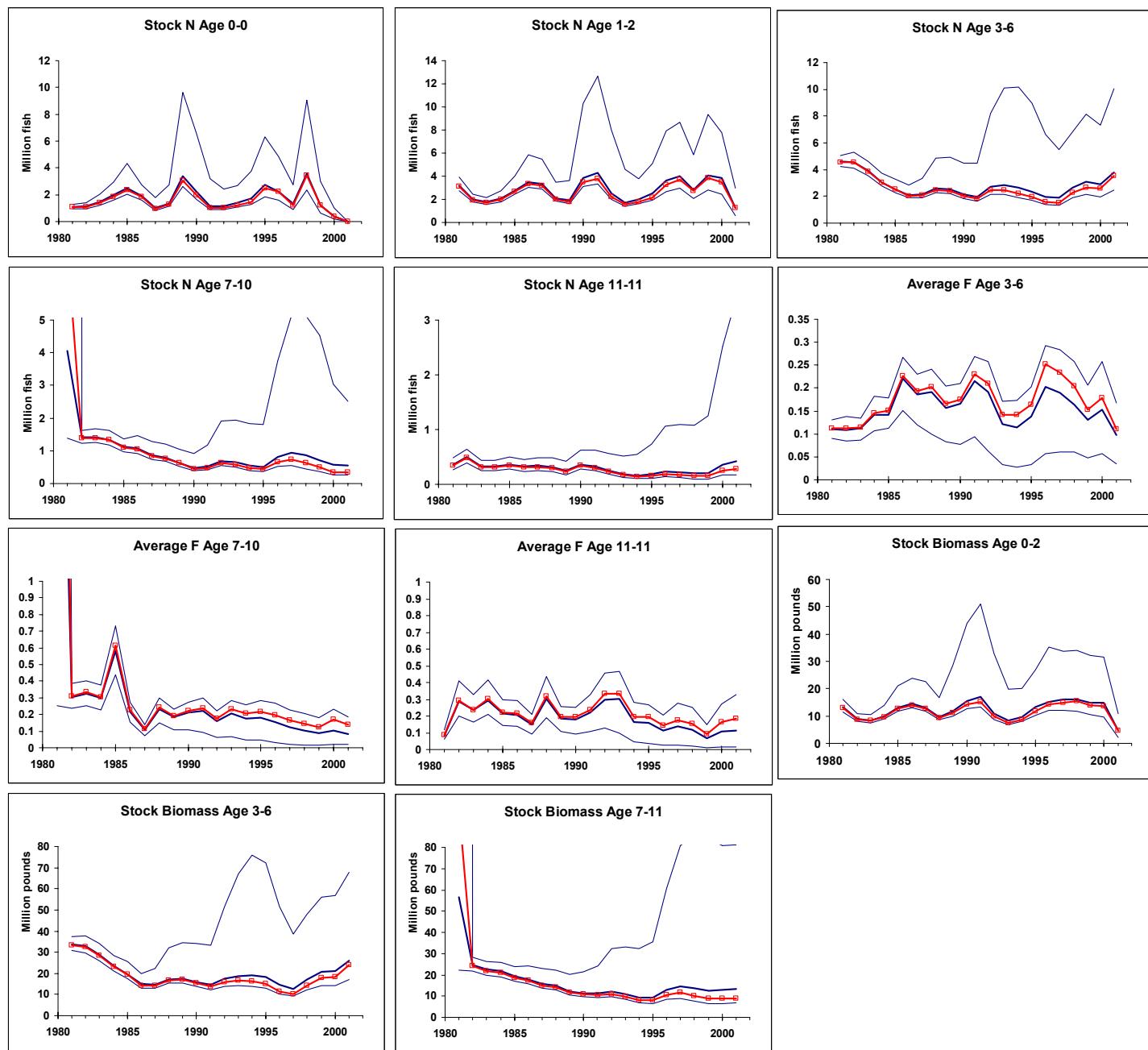


Figure 21. Comparison of Atlantic king mackerel population trends estimated by the Base model (solid lines) with 80% confidence intervals and the Full model index (open square line).

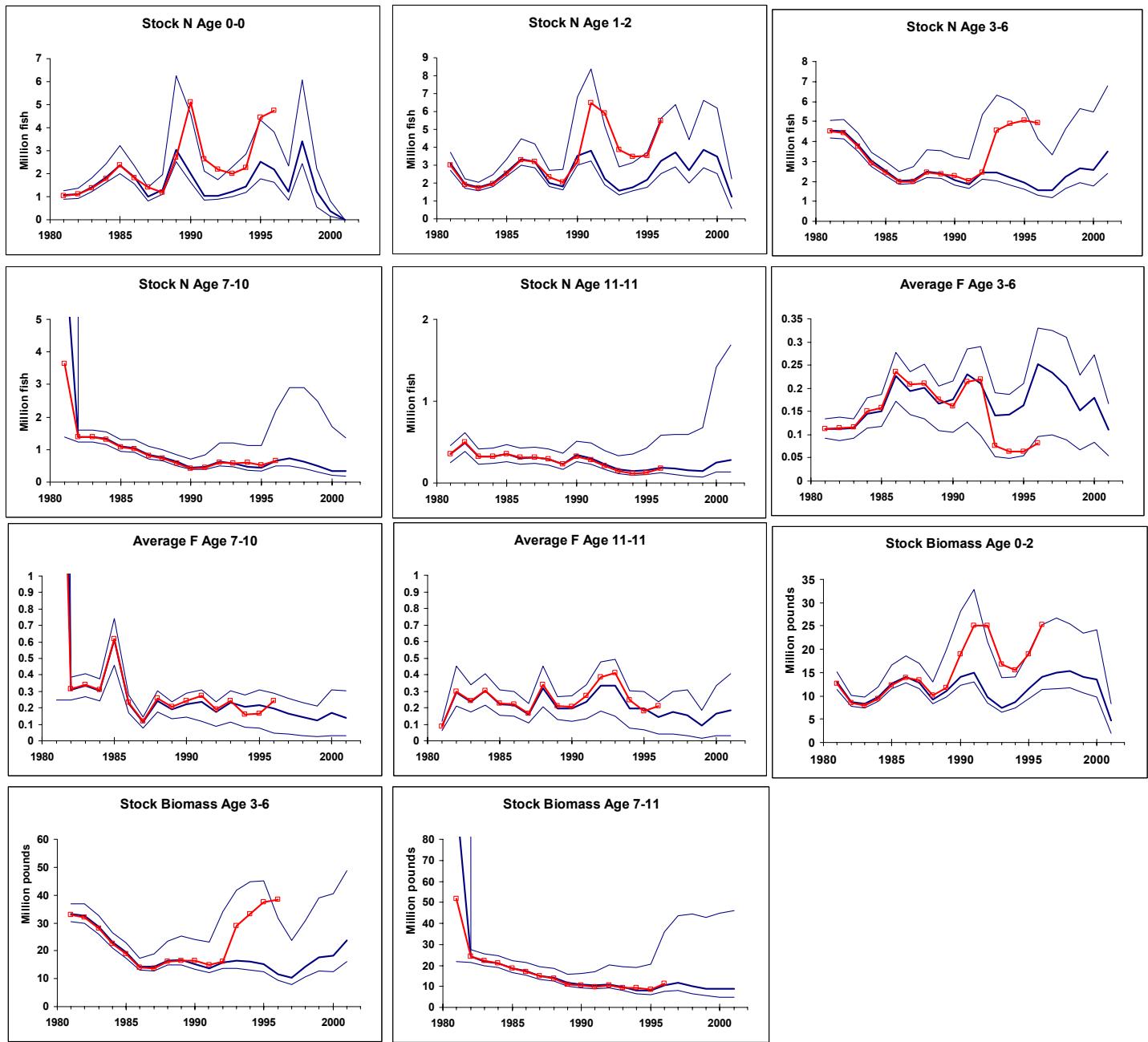


Figure 22. Atlantic king mackerel population trends with 80% confidence intervals from the Full Index model (solid lines). For comparison, results from the 1998 SA are also shown (square marker line)

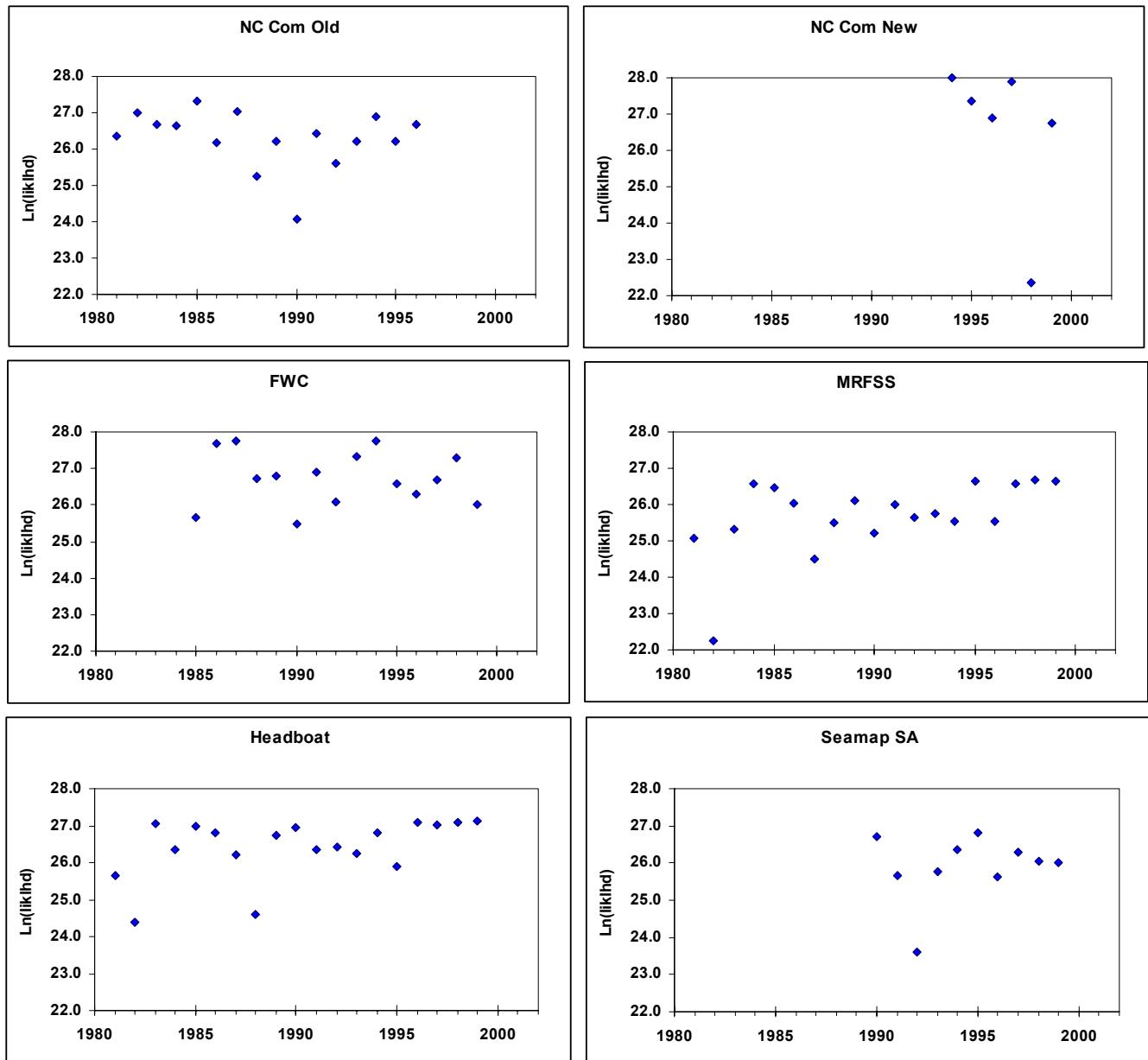


Figure 23. Jackknife estimates for tuned VPA Full index model fit Atlantic king mackerel.

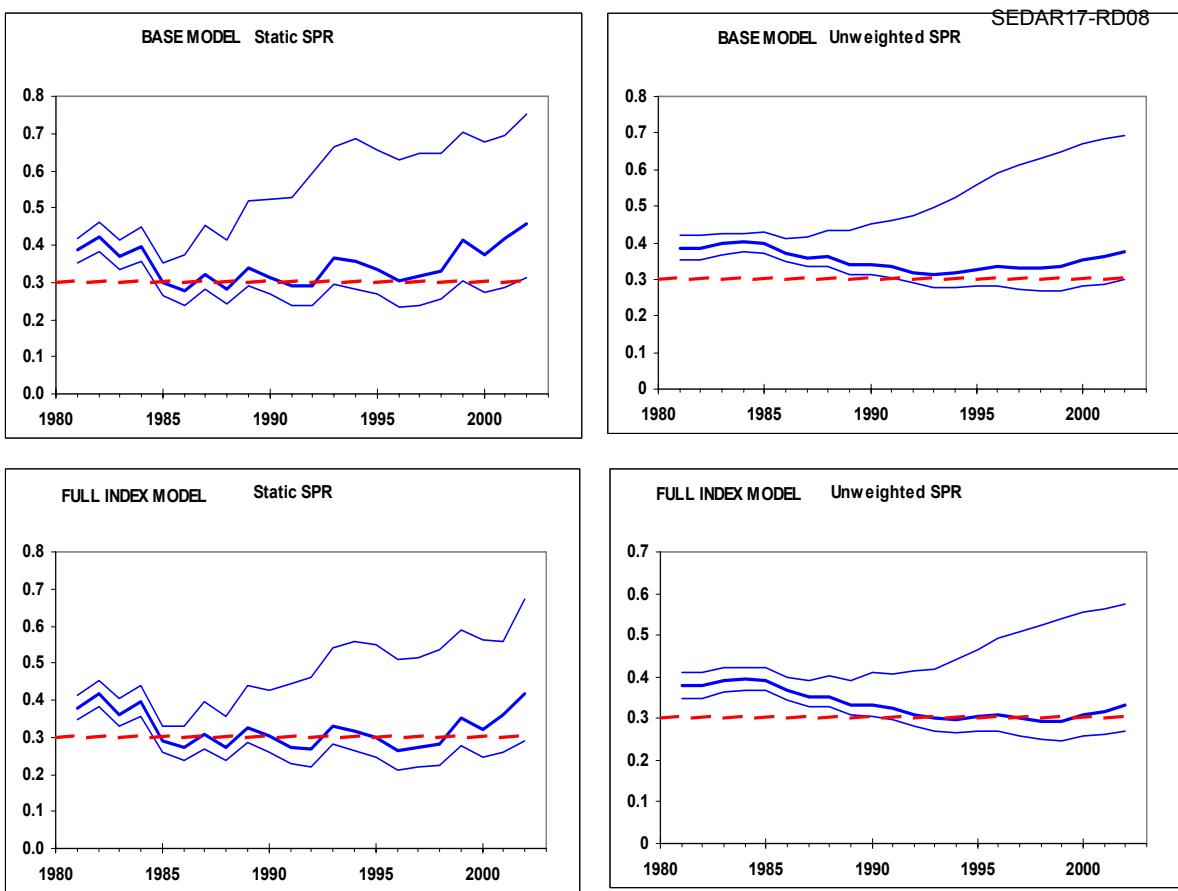


Figure 24. Comparison of static and transitional un-weighted SPR from the VPA Base model and the VPA Full index model for Atlantic king mackerel 2003 stock evaluation.

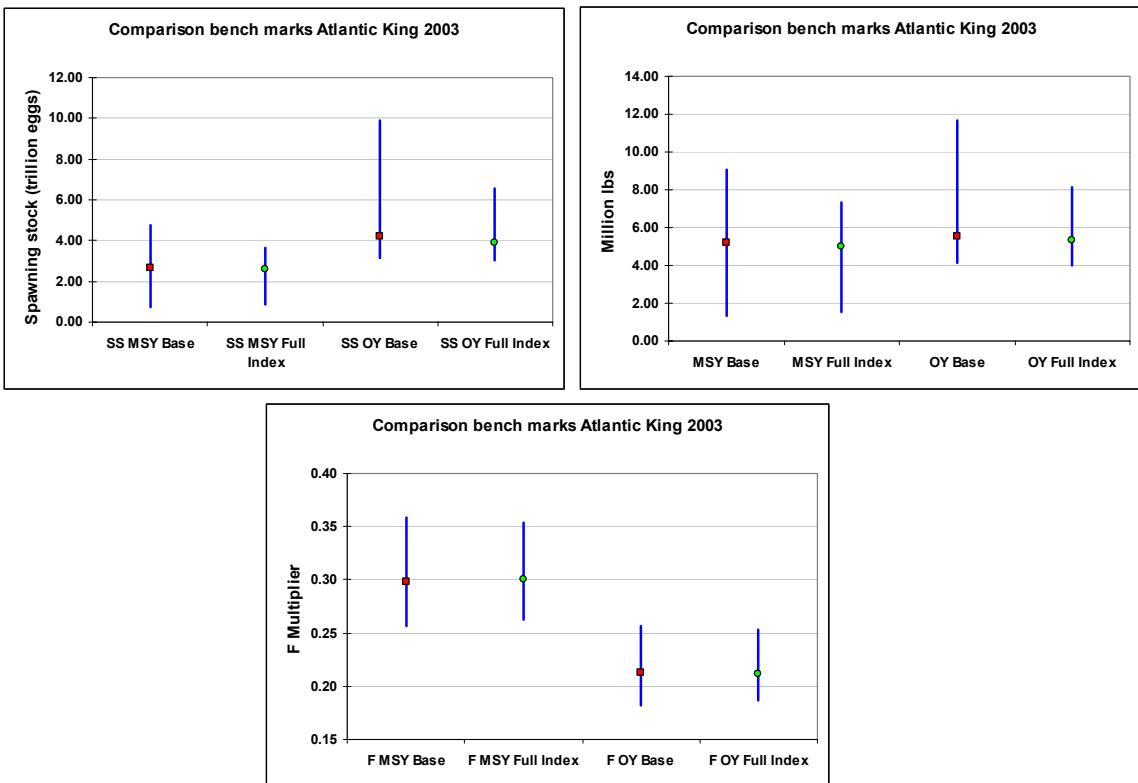


Figure 25. Atlantic king mackerel benchmarks 2003 assessment. Spawning stock (SS) biomass, MSY, OY, and correspondent fishing mortality rates from the two models.

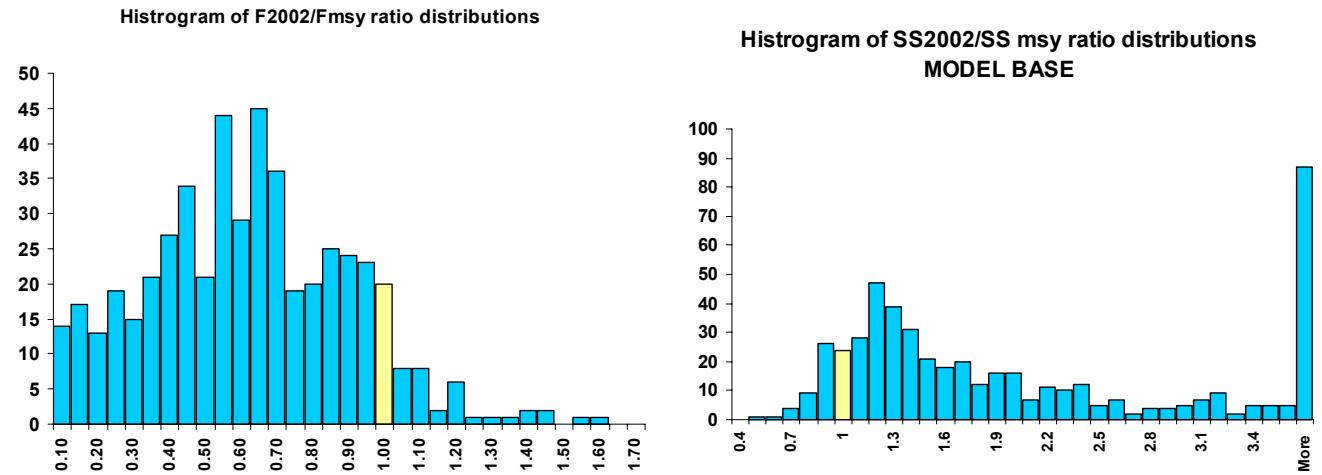


Figure 26. Frequency distribution of Atlantic king F_{2002}/F_{MSY} and SS_{2002}/SS_{MSY} ratios of 500 bootstraps for the Base model.

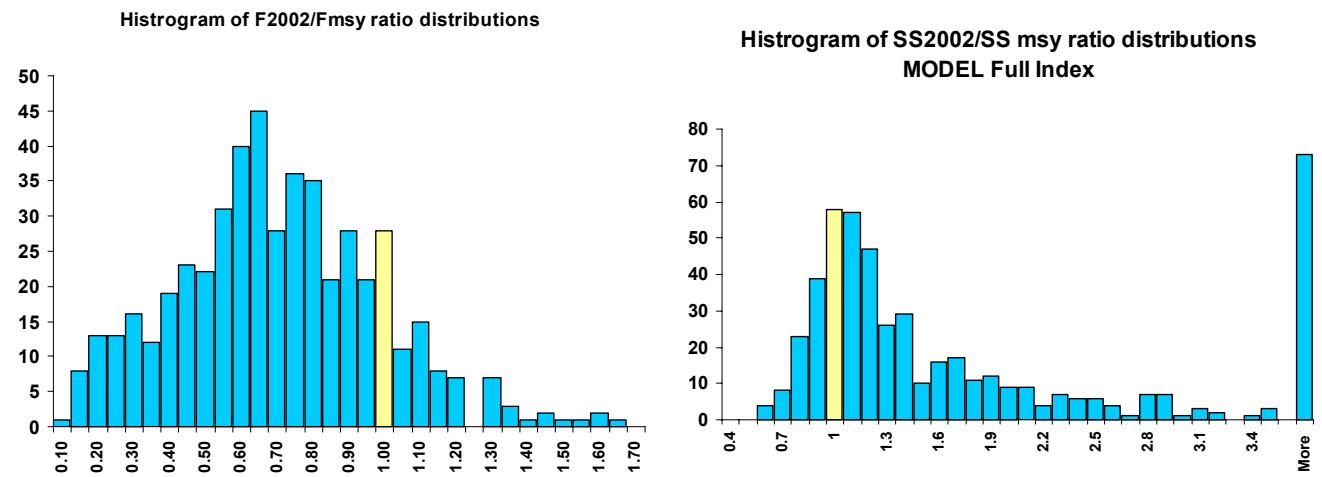


Figure 27. Frequency distribution of Atlantic king F_{2002}/F_{MSY} and SS_{2002}/SS_{MSY} ratios of 500 bootstraps for the Full Index model.

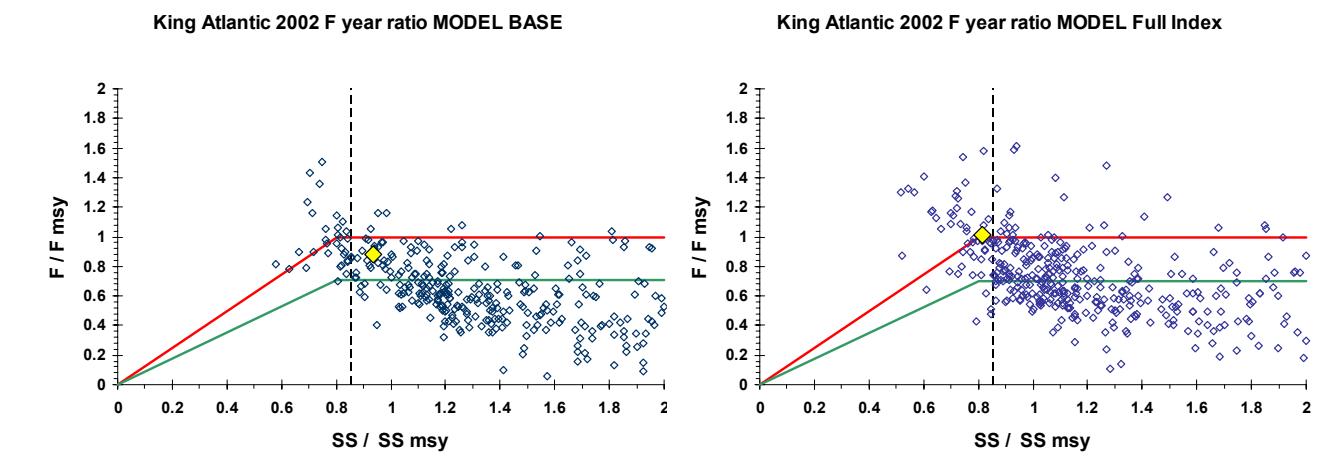


Figure 28. Phase plots of 500 bootstraps for the Base and Full index models. The upper solid line denotes the MFMT, the vertical dashed line denotes MSST, and the lower solid line denotes the OY control rule. The deterministic run corresponds to the larger diamond marker.

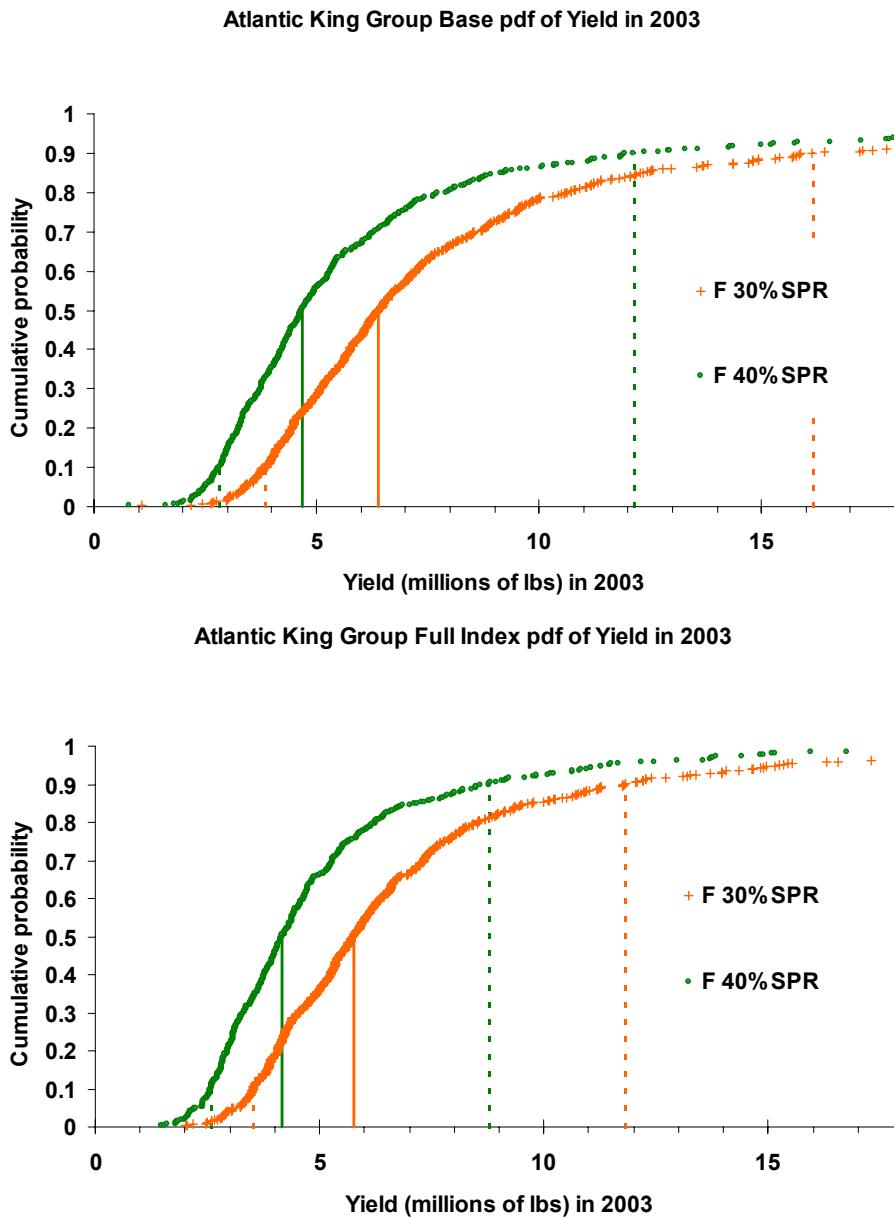


Figure 29. Frequency distribution of 500 bootstraps range of ABC based on probability of F exceeding F30%SPR and F40%SPR in the 2003/04 fishing year for Atlantic king mackerel under the two models. Vertical solid lines represent 0.5 percentile; dashed lines represent 0.1 and 0.9 percentiles of the cumulative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

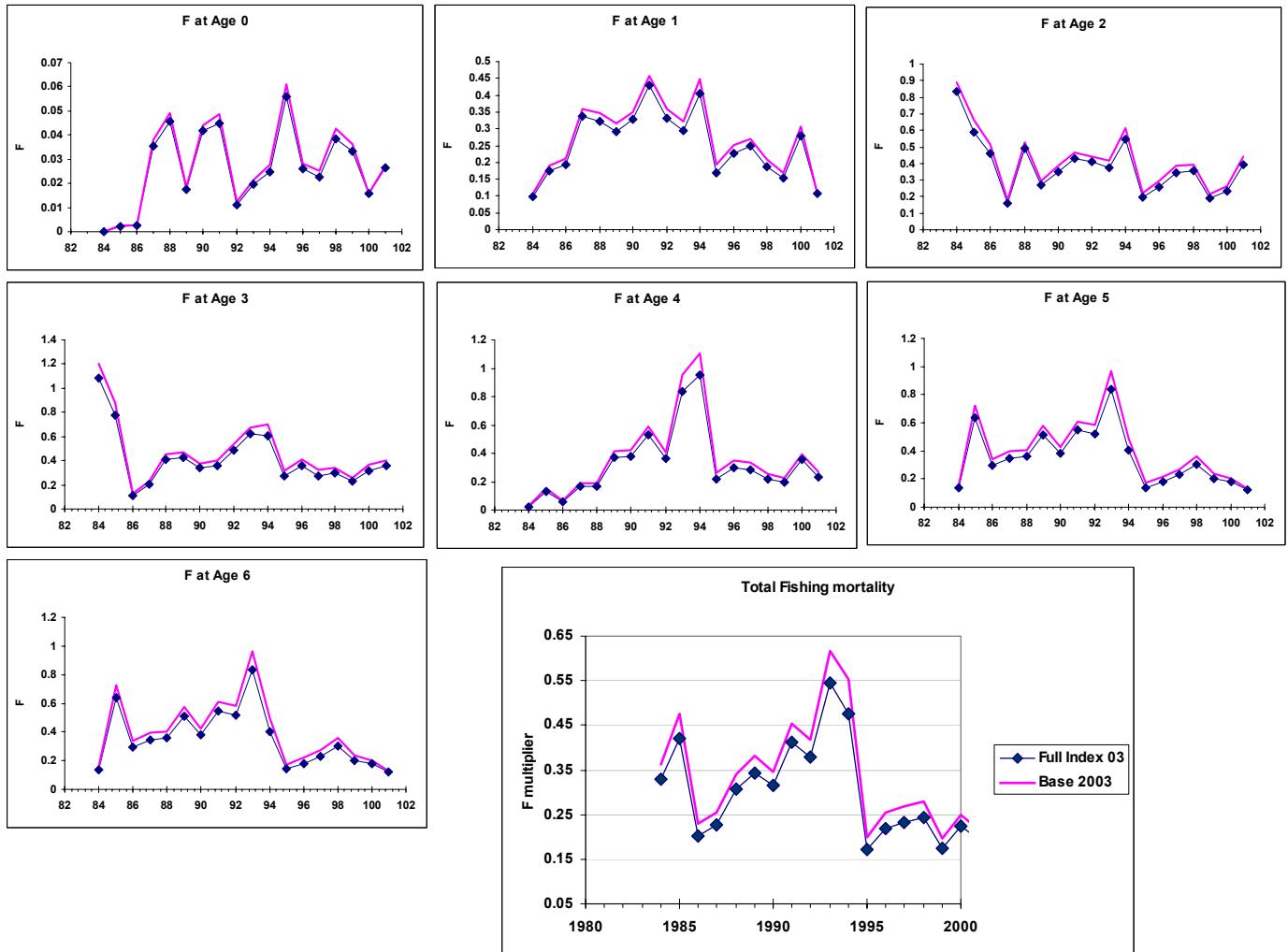


Figure 30. Atlantic Spanish mackerel estimates of F mortality by age from the Base and Full index models.

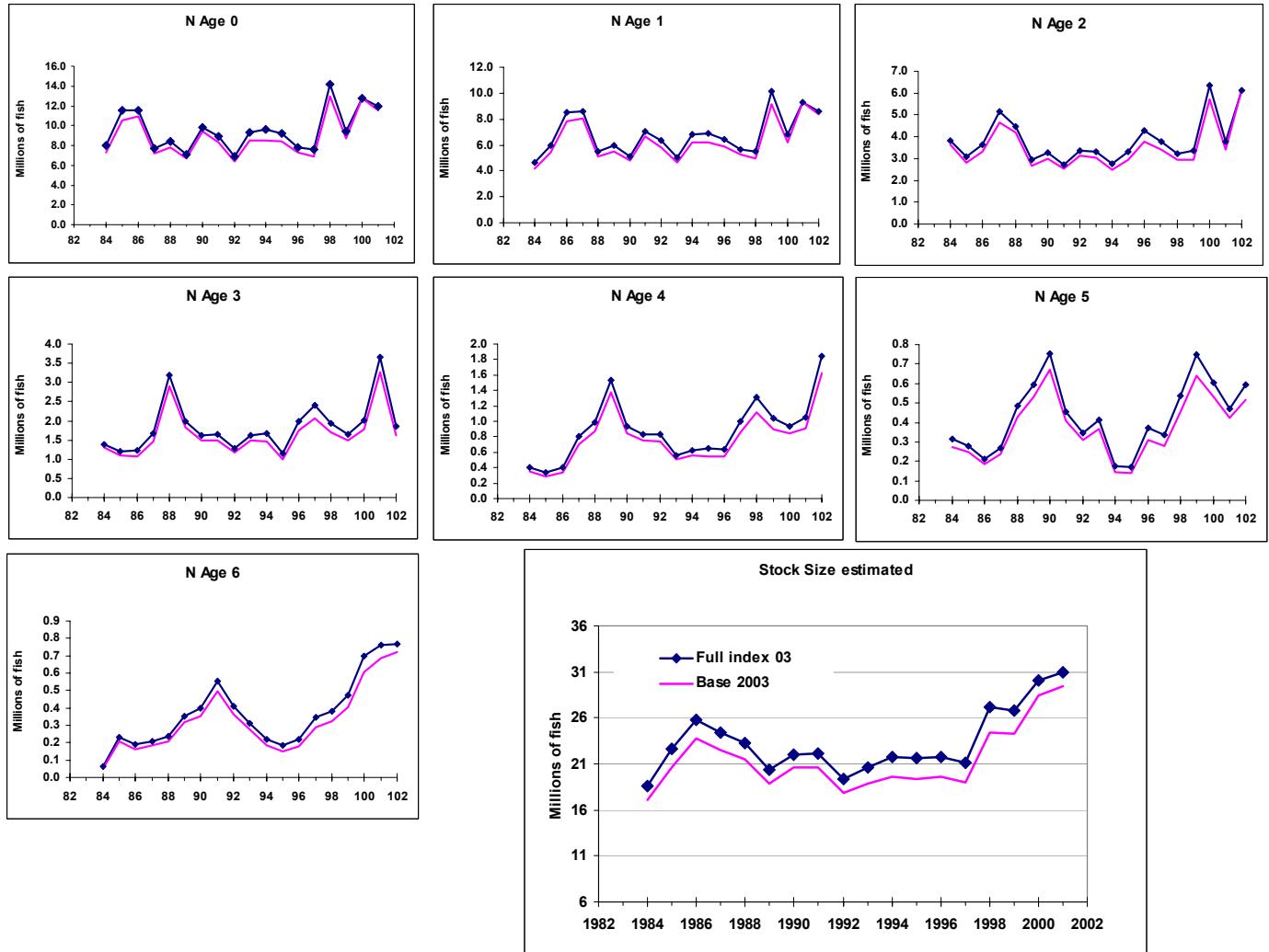


Figure 31. Atlantic Spanish mackerel estimates of stock size by age from the Base and Full index models.

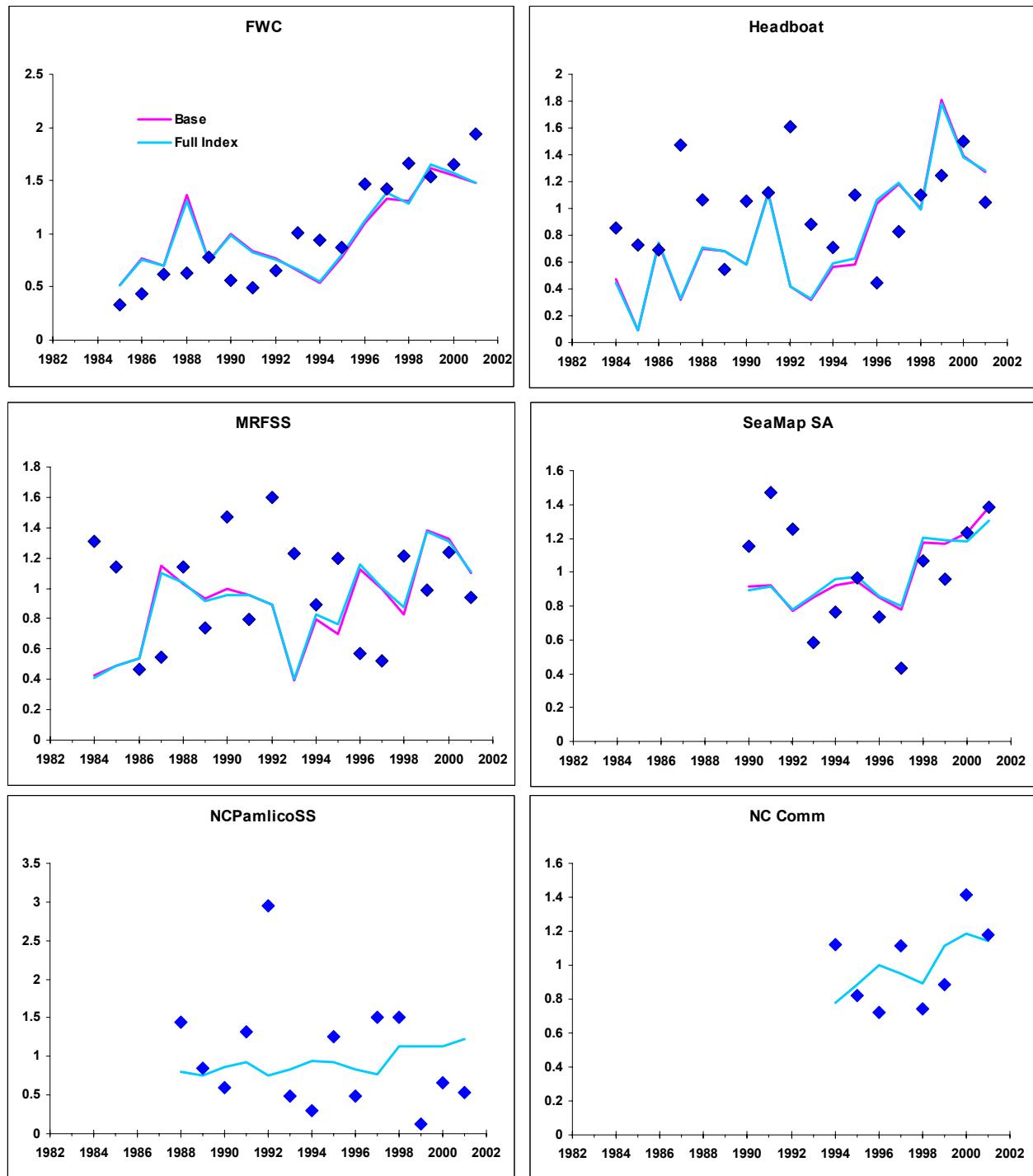


Figure 32. Atlantic Spanish mackerel predicted (solid lines) and standard index (diamonds) from the tuned VPA Base and Full index models.

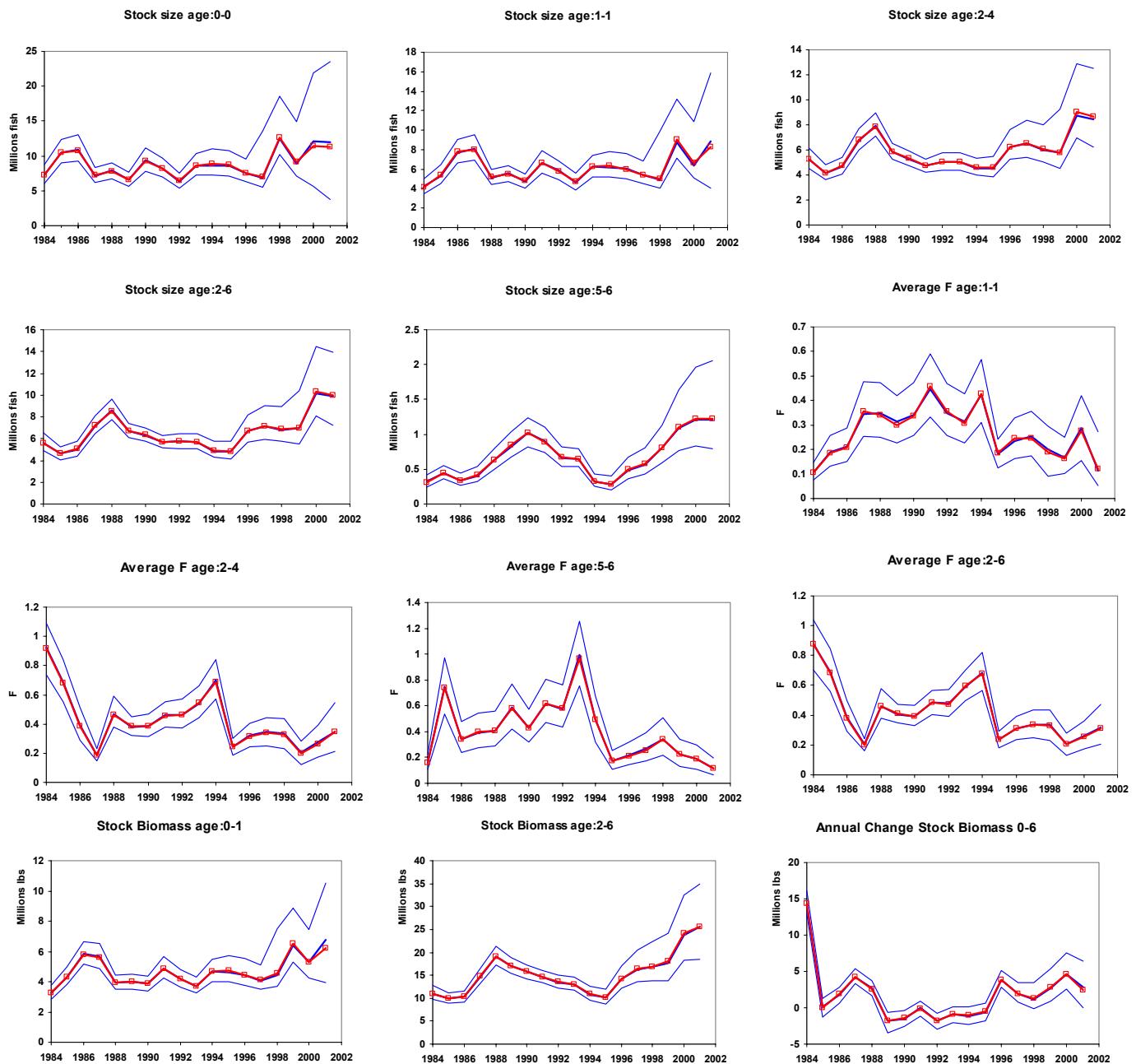


Figure 33. Comparison of Atlantic Spanish mackerel population trends estimated by the Base model (solid lines) with 80% confidence intervals and by the Full model index (open square line).

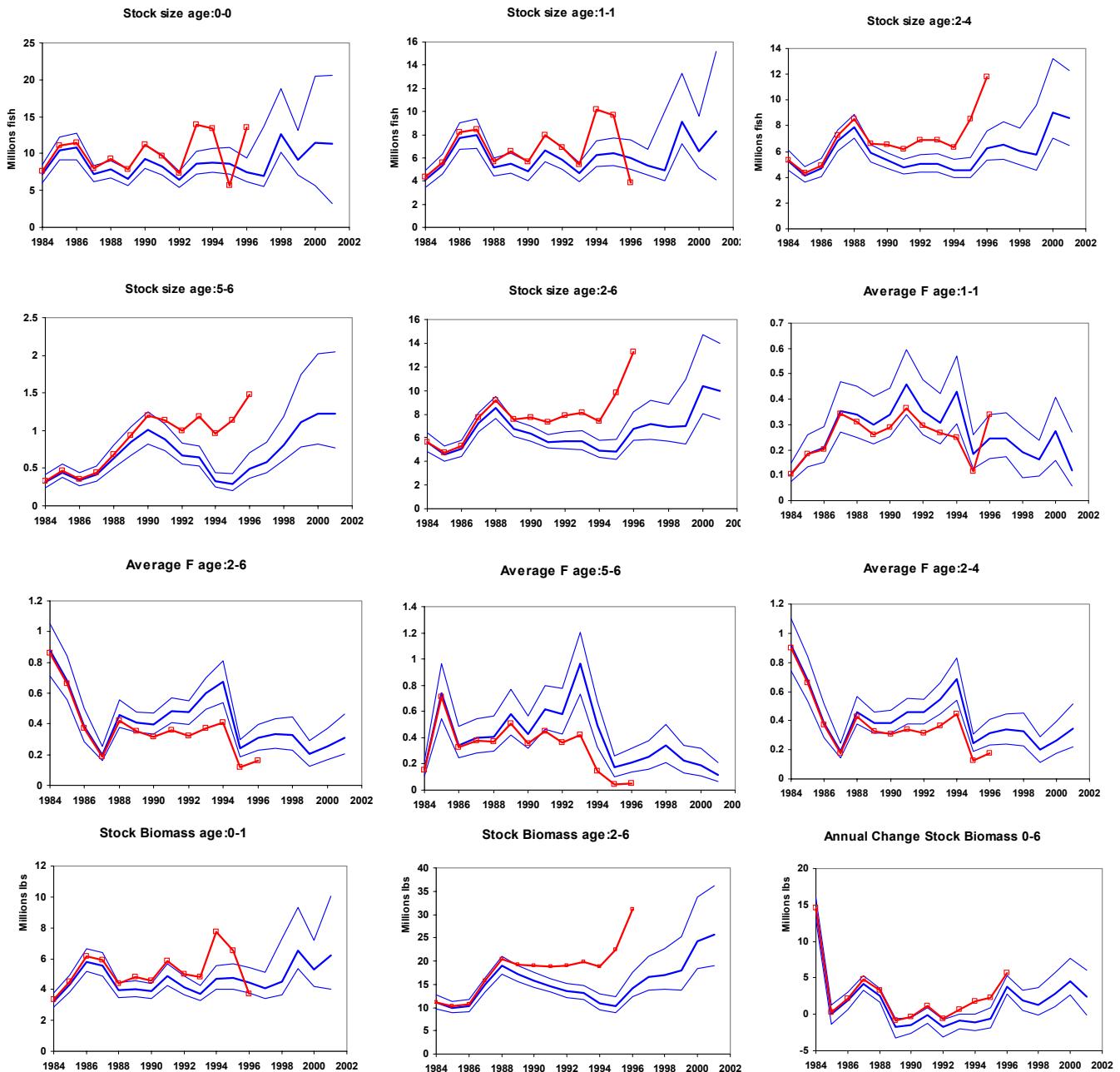


Figure 34. Atlantic Spanish mackerel population trends with 80% confidence intervals from the Full Index model (solid lines). For comparison, results from the 1998 SA are also shown (square marker line).

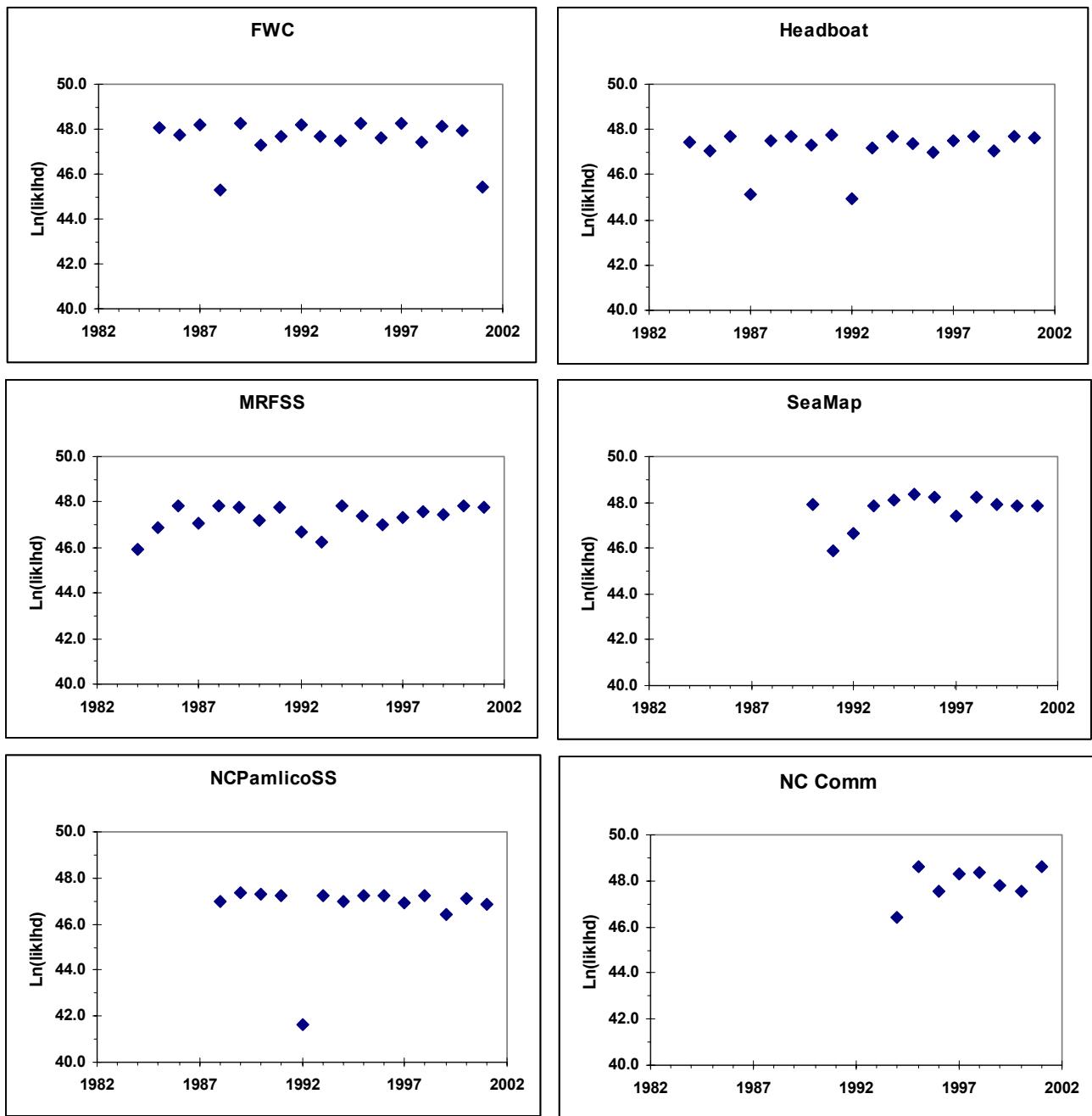


Figure 35. Jackknife estimates for tuned VPA Full index model fit Atlantic Spanish mackerel.

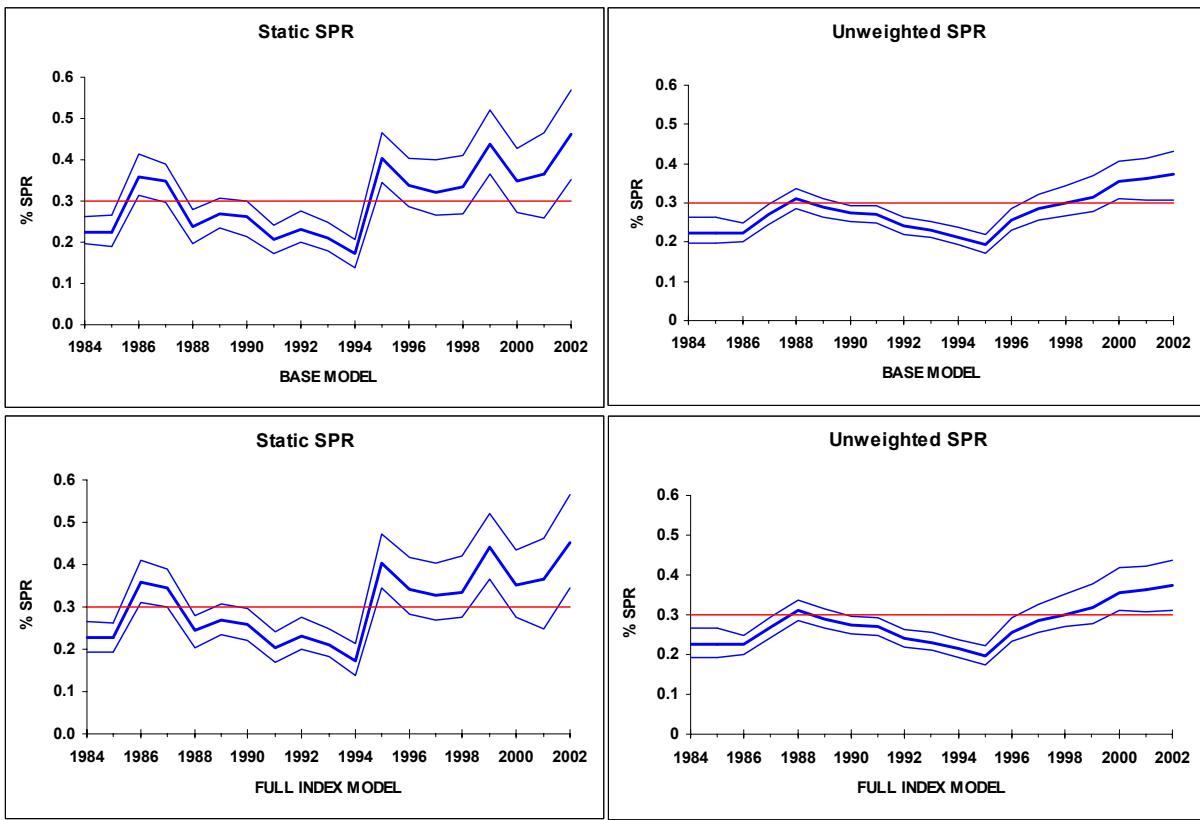


Figure 36. Comparison of static and transitional un-weighted SPR from the VPA Base model and the VPA Full index model for Atlantic Spanish mackerel 2003 stock evaluation.

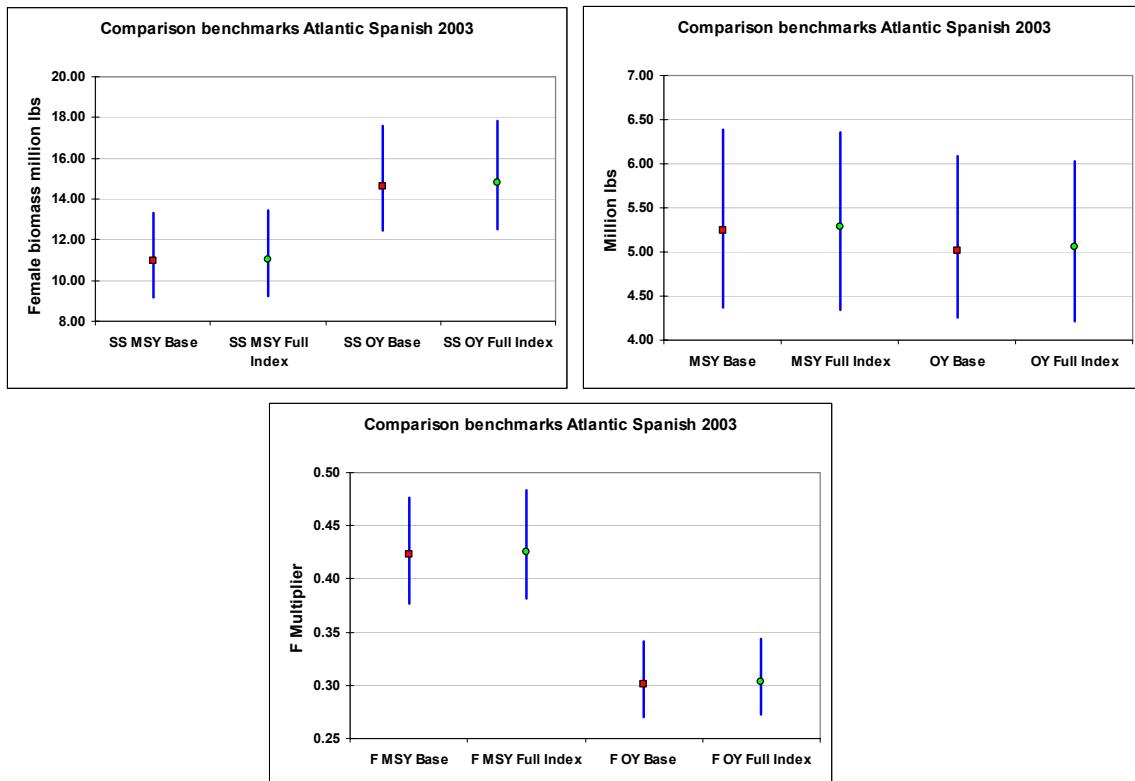


Figure 37 Atlantic Spanish mackerel benchmarks 2003 assessment. Spawning stock (SS) biomass, MSY, OY, and correspondent fishing mortality rates from the two models evaluated.

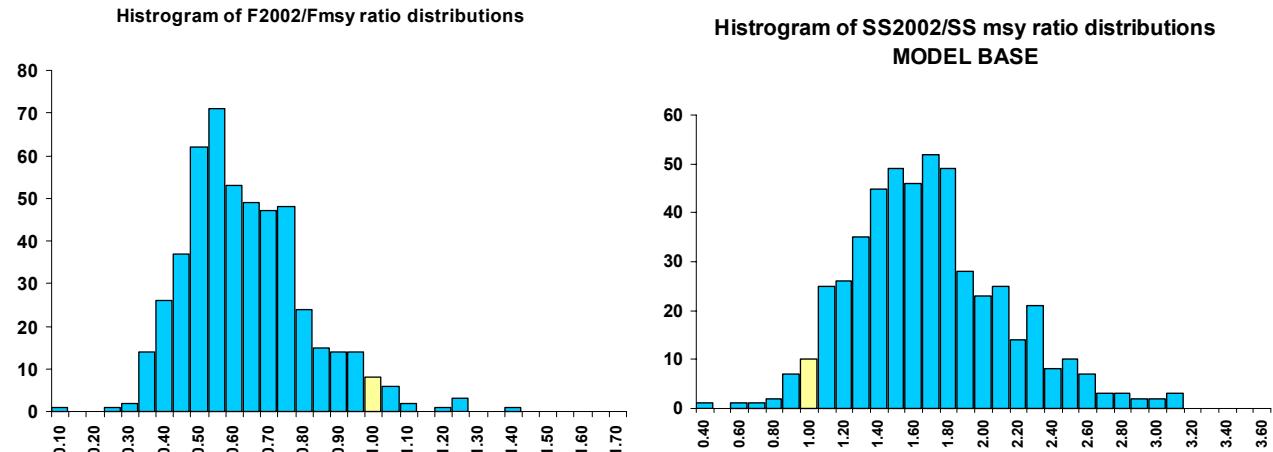


Figure 38. Frequency distribution of Atlantic Spanish F_{2002}/F_{MSY} and SS_{2002}/SS_{MSY} ratios of 500 bootstraps for the Base model.

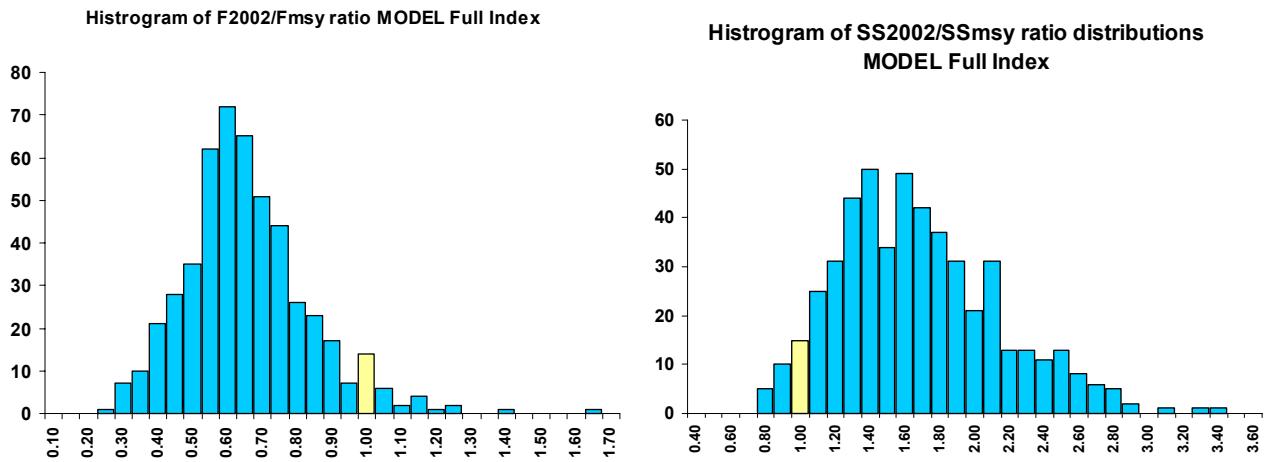


Figure 39. Frequency distribution of Atlantic Spanish F_{2002}/F_{MSY} and SS_{2002}/SS_{MSY} ratios of 500 bootstraps for the Full Index model.

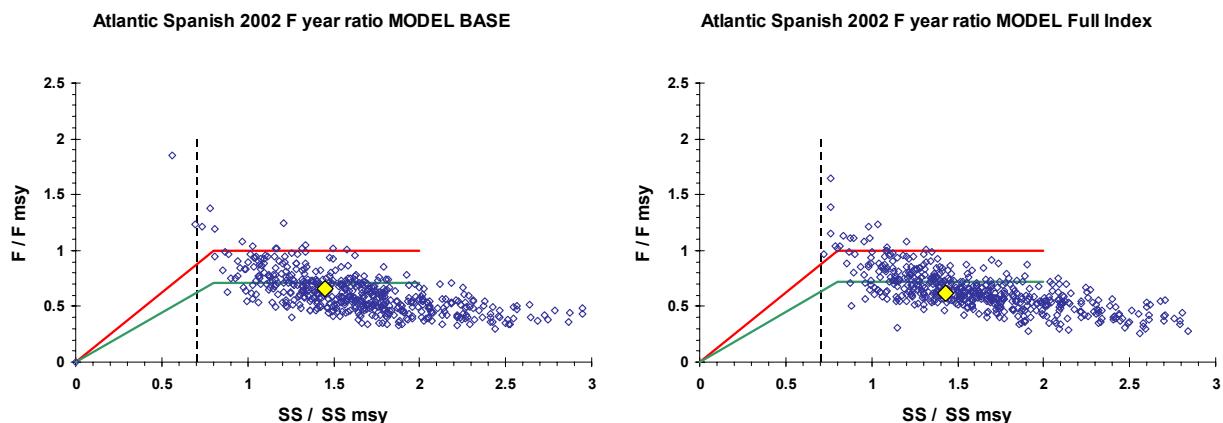
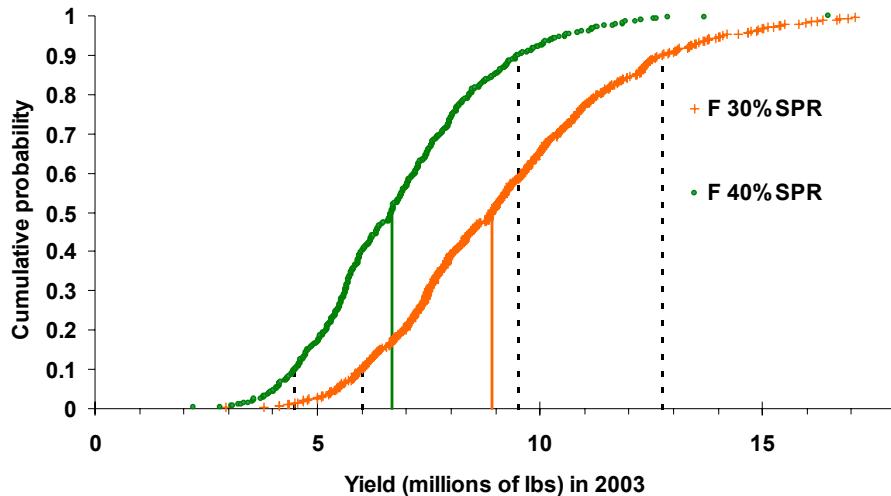


Figure 40. Phase plots of 500 bootstraps for the Base and Full index models. The upper solid line denotes the MFMT, the vertical dashed line denotes MSST, and the lower solid line denotes the OY control rule. The deterministic run corresponds to the larger diamond marker.

Atlantic Spanish Base pdf of Yield in 2003



Atlantic Spanish Full Index Model pdf of Yield in 2003

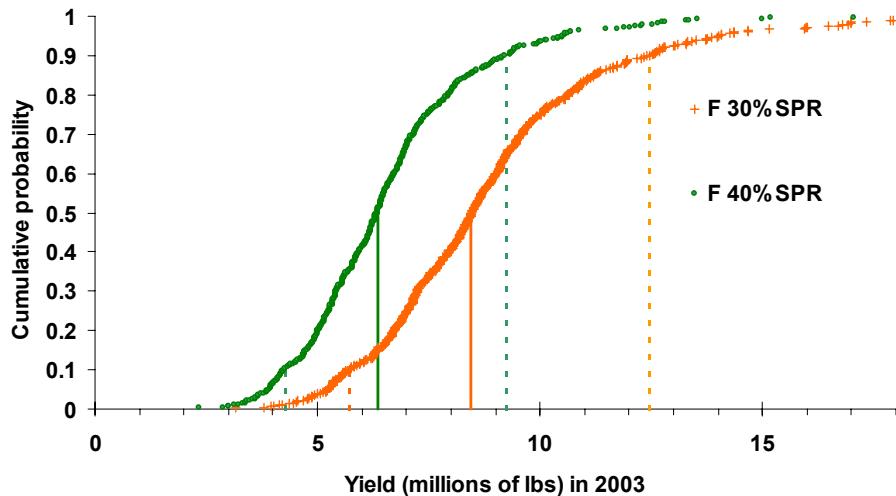


Figure 41. Frequency distribution of 500 bootstraps range of ABC based on probability of F exceeding $F_{30\%SPR}$ and $F_{40\%SPR}$ in the 2003/04 fishing year for Atlantic Spanish mackerel under the two models. Vertical solid lines represent 0.5 percentile; dashed lines represent 0.1 and 0.9 percentiles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

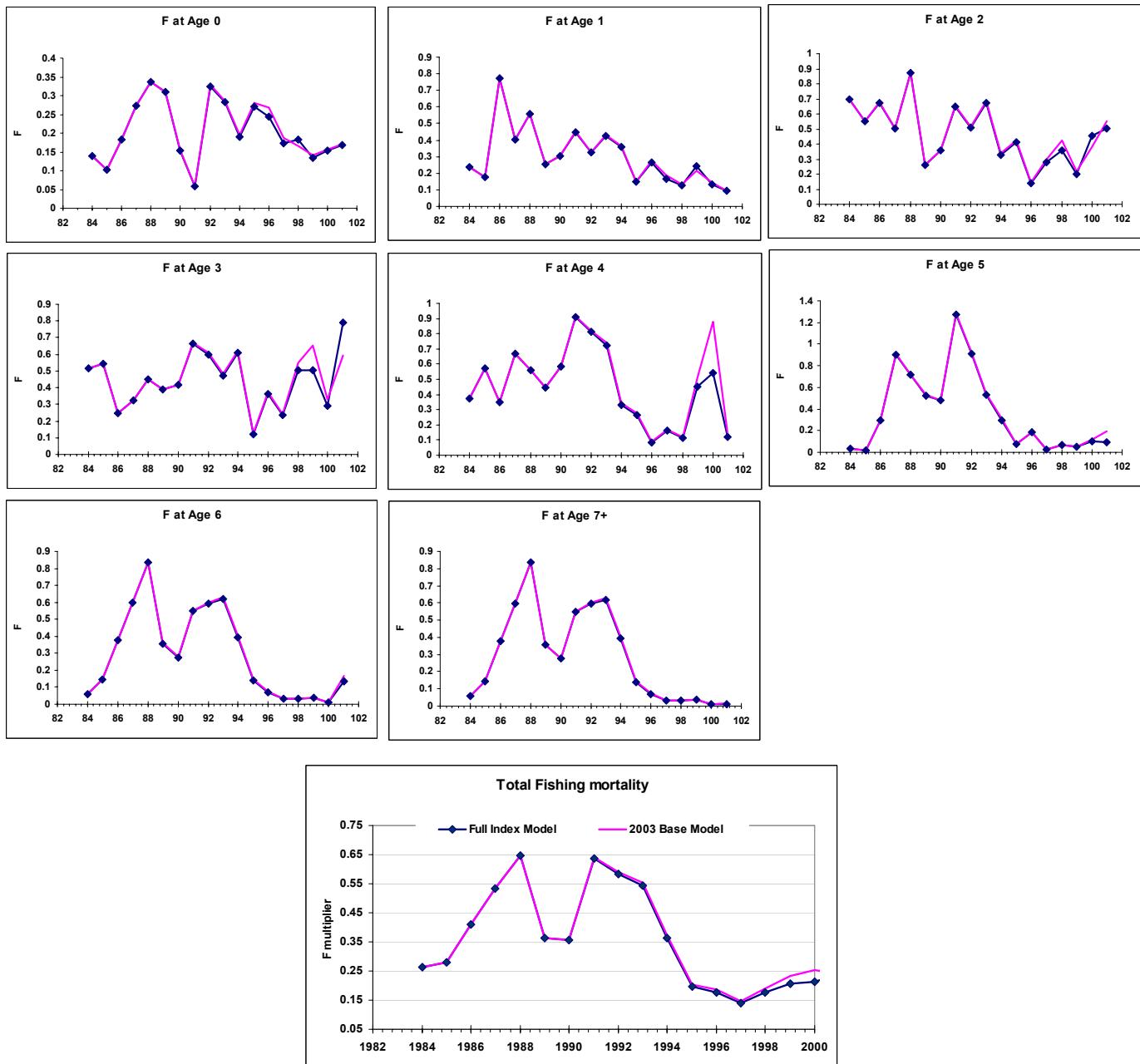


Figure 42. Gulf Spanish mackerel estimates of F mortality by age from the Base and Full index models.

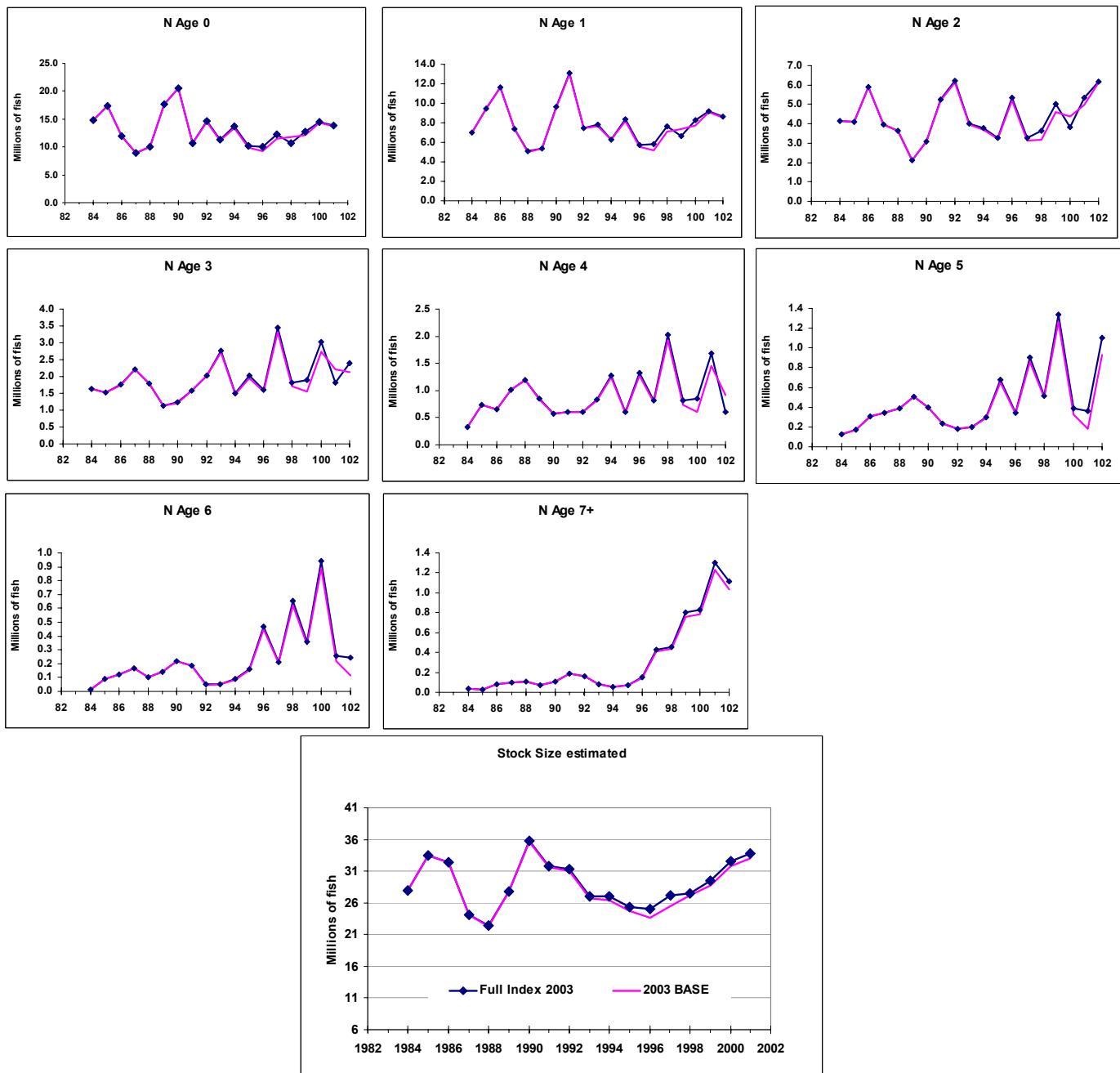


Figure 43. Gulf Spanish mackerel estimates of stock size by age from the Base and Full index models.

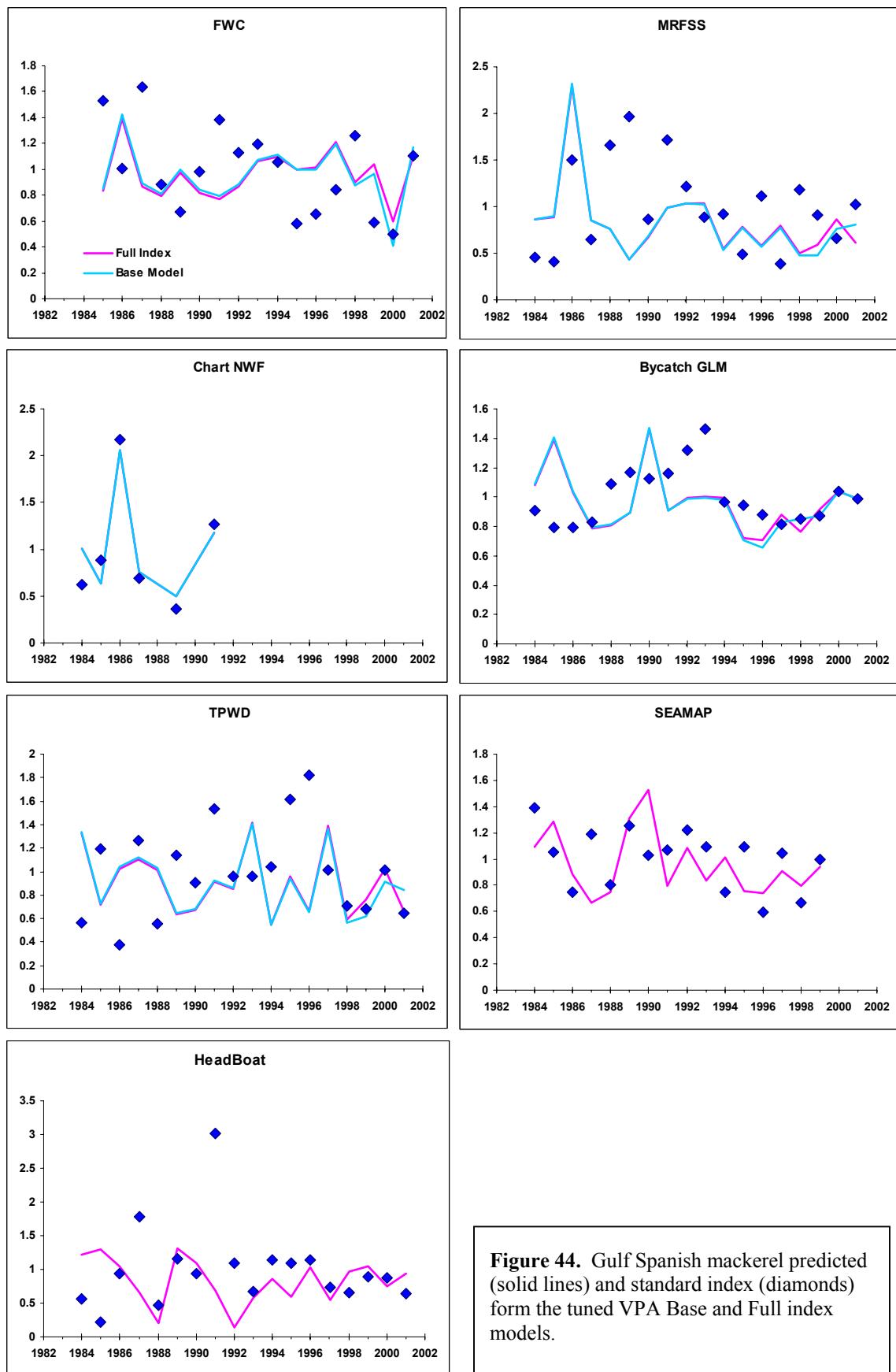


Figure 44. Gulf Spanish mackerel predicted (solid lines) and standard index (diamonds) from the tuned VPA Base and Full index models.

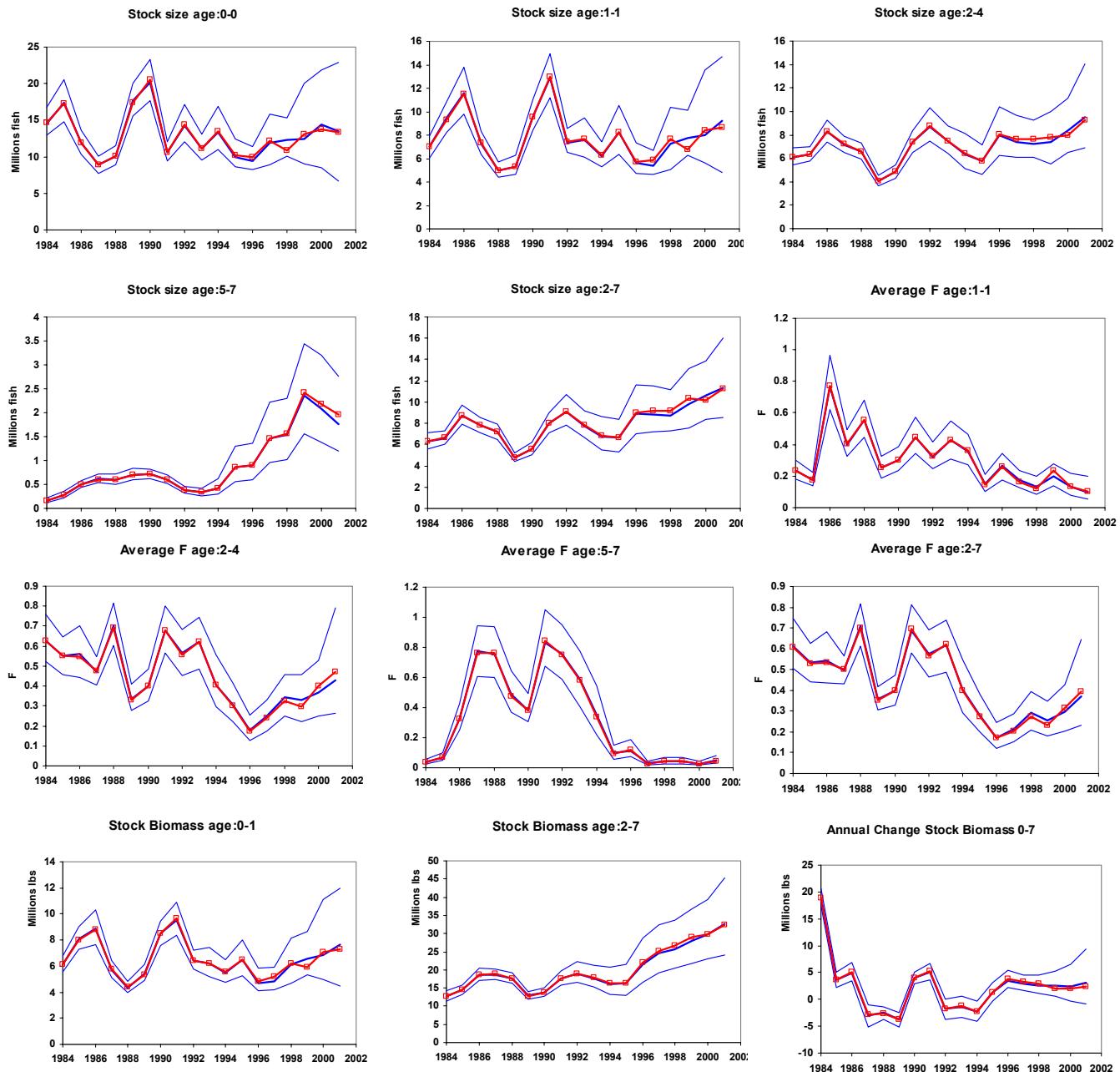


Figure 45. Comparison of Gulf Spanish mackerel population trends estimated by the Base model (solid lines) with 80% confidence intervals and the Full index model (open square line).

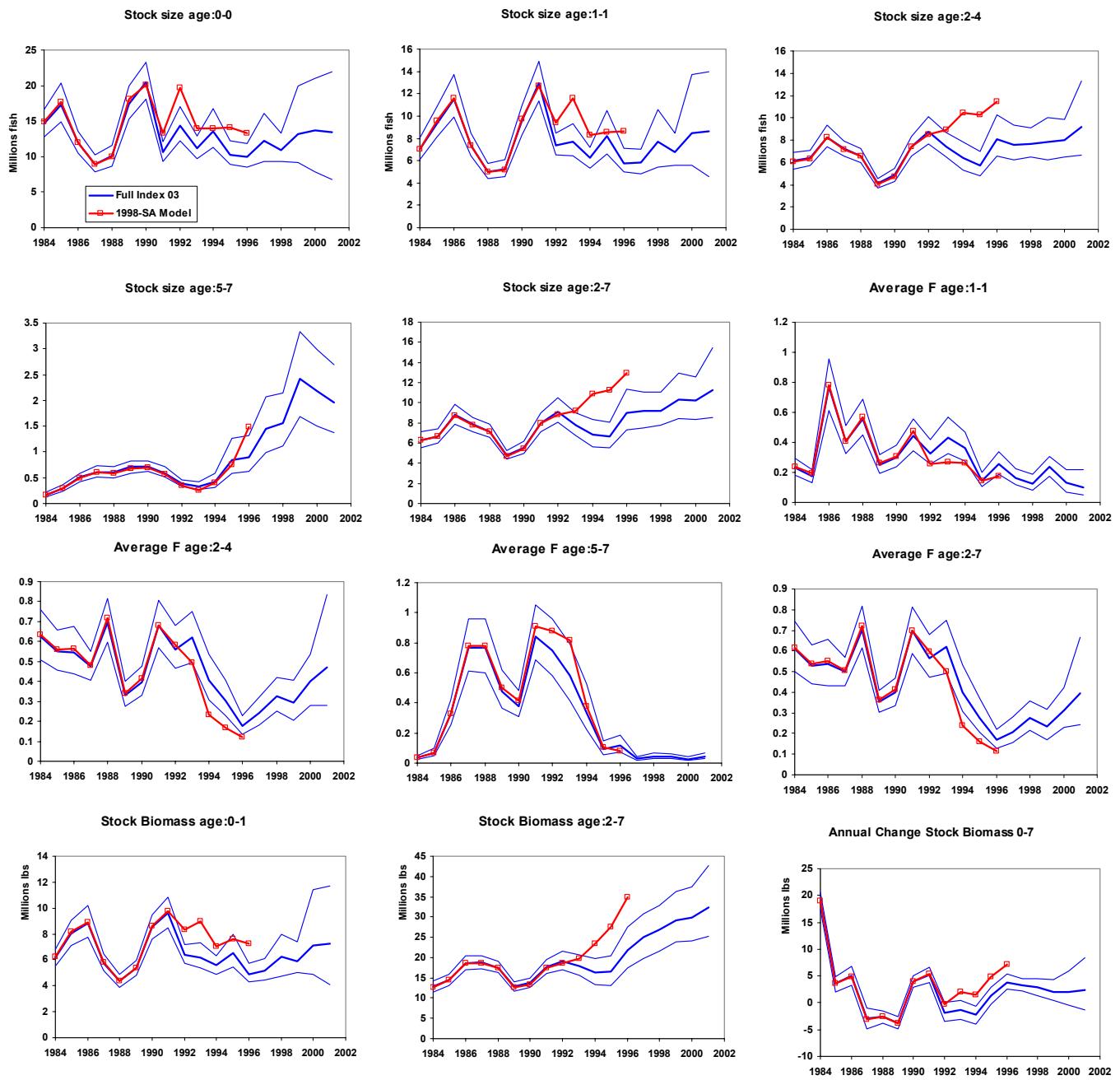


Figure 46. Gulf Spanish mackerel population trends with 80% confidence intervals from the Full Index model (solid lines). For comparison, results from the 1998 SA are also shown (square marker line).

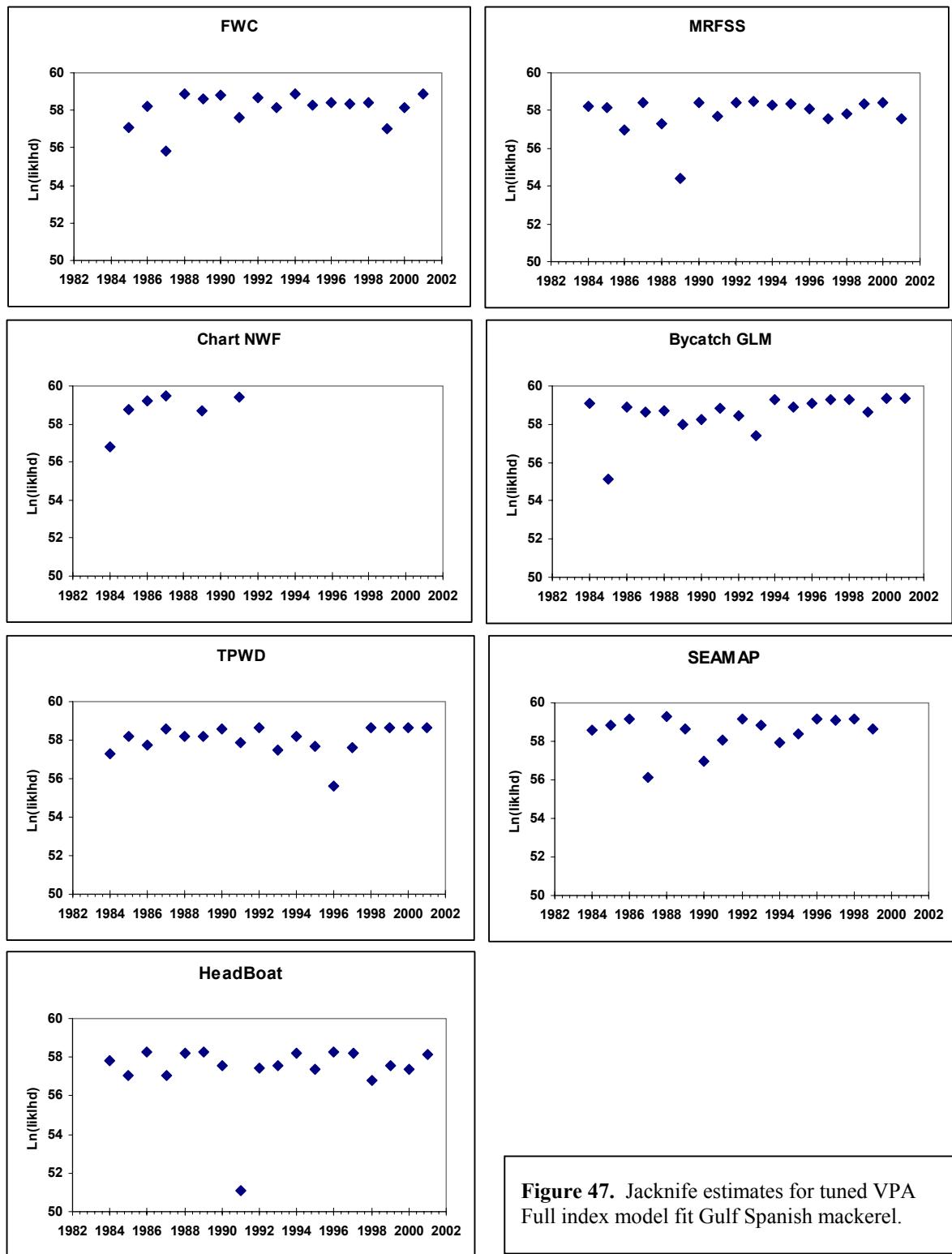


Figure 47. Jackknife estimates for tuned VPA Full index model fit Gulf Spanish mackerel.

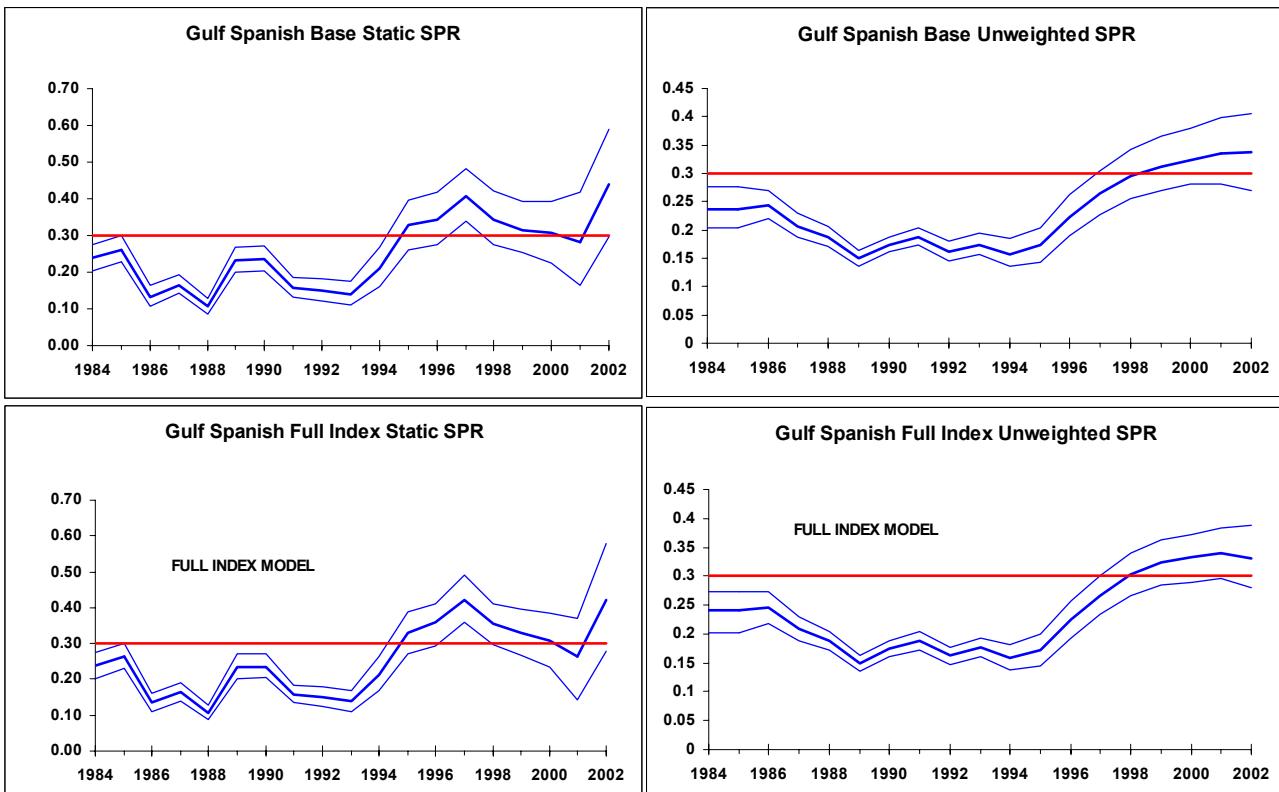


Figure 48. Comparison of static and transitional unweighted SPR from the VPA Base model and the VPA Full Index model for Gulf Spanish mackerel 2003 stock evaluation.

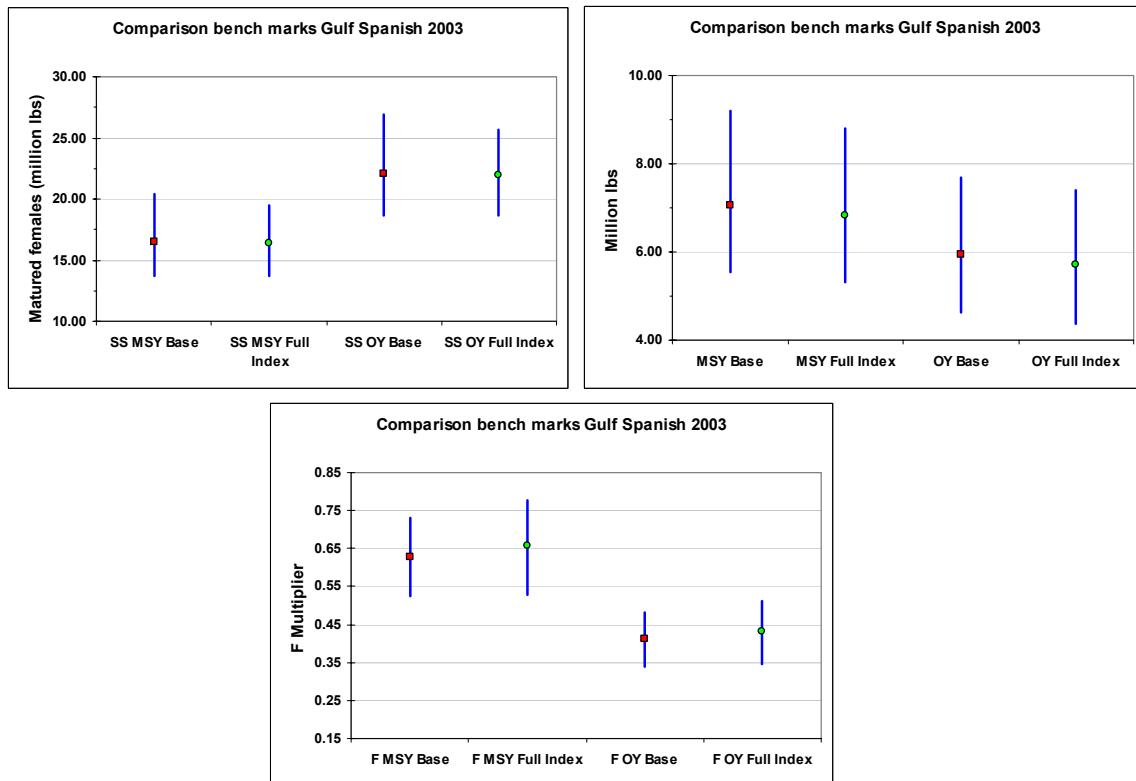


Figure 49. Gulf Spanish mackerel benchmarks 2003 assessment. Spawning stock (SS) biomass, MSY, OY, and correspondent fishing mortality rates from the two models.

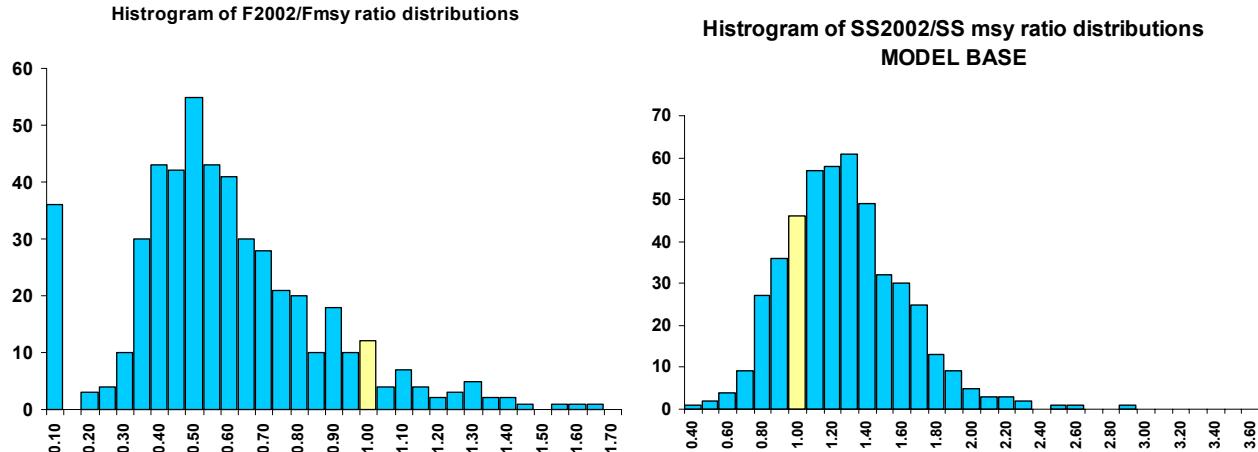


Figure 50. Frequency distribution of Gulf Spanish F_{2002}/F_{MSY} and SS_{2002}/SS_{MSY} ratios of 500 bootstraps for the Base model.

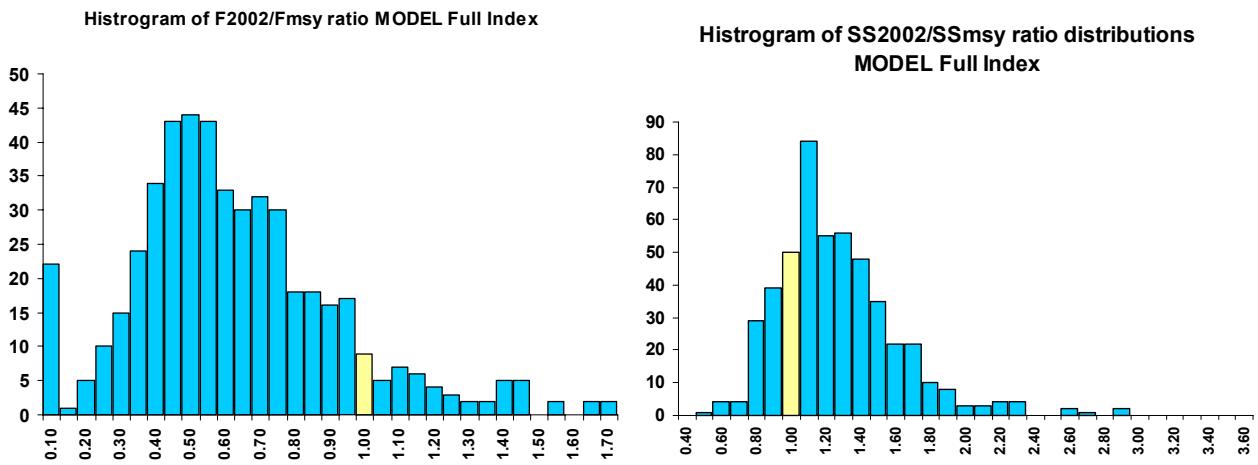


Figure 51. Frequency distribution of Gulf Spanish F_{2002}/F_{MSY} and SS_{2002}/SS_{MSY} ratios of 500 bootstraps for the Full Index model.

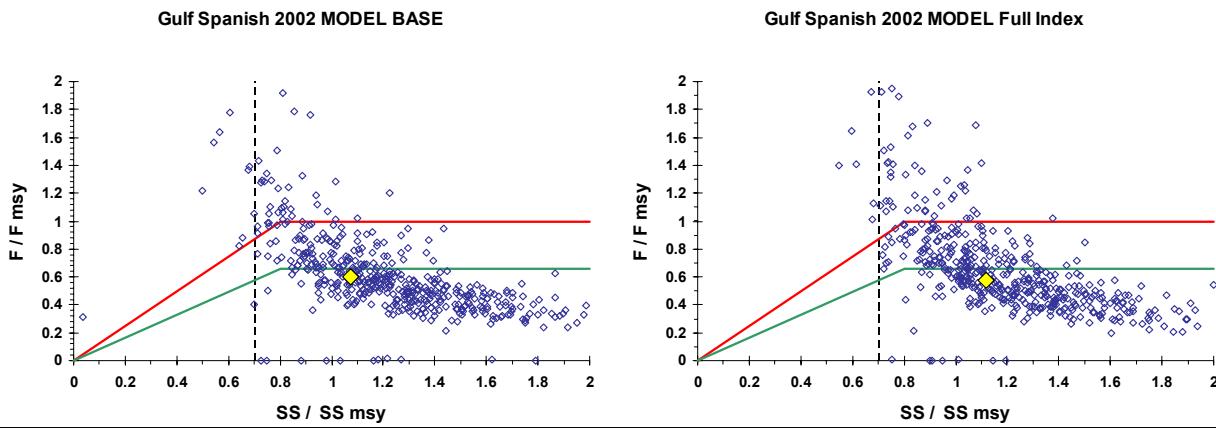
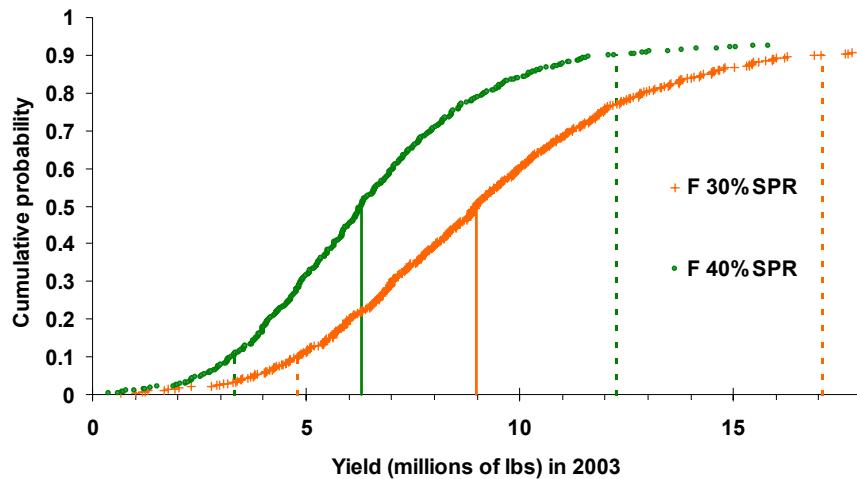


Figure 52. Phase plots of 500 bootstraps for the Base and Full Index models. The upper solid line denotes the MFMT, the vertical dashed line denotes MSST, and the lower solid line denotes the OY control rule. The deterministic run corresponds to the large diamond marker.

Gulf Spanish Group Base pdf of Yield in 2003



Gulf Spanish Full Index Model pdf of Yield in 2003

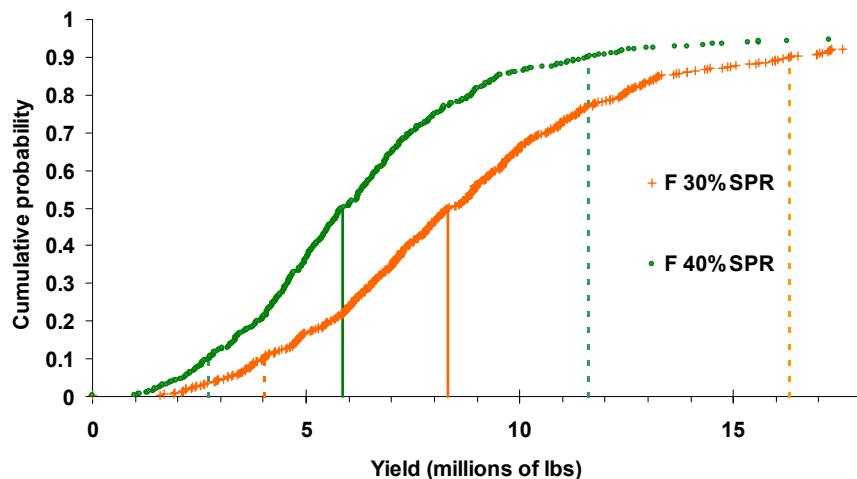


Figure 53. Frequency distribution of 500 bootstraps range of ABC based on probability of F exceeding F30%SPR and F40%SPR in the 2003/04 fishing year for Gulf Spanish mackerel under the two models. Vertical solid lines represent 0.5 percentile; dashed lines represent 0.1 and 0.9 percentiles of the cumulative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

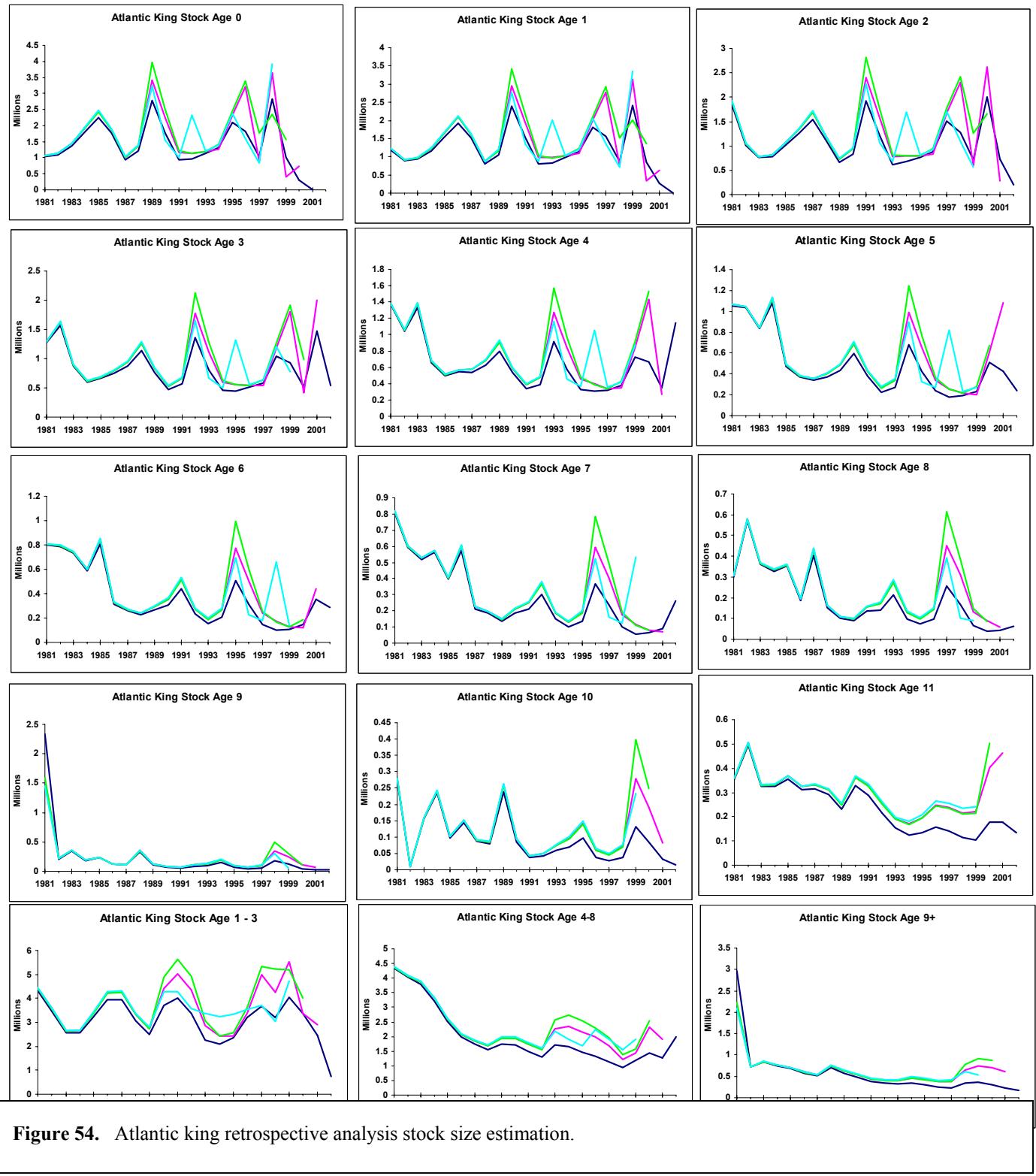


Figure 54. Atlantic king retrospective analysis stock size estimation.



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

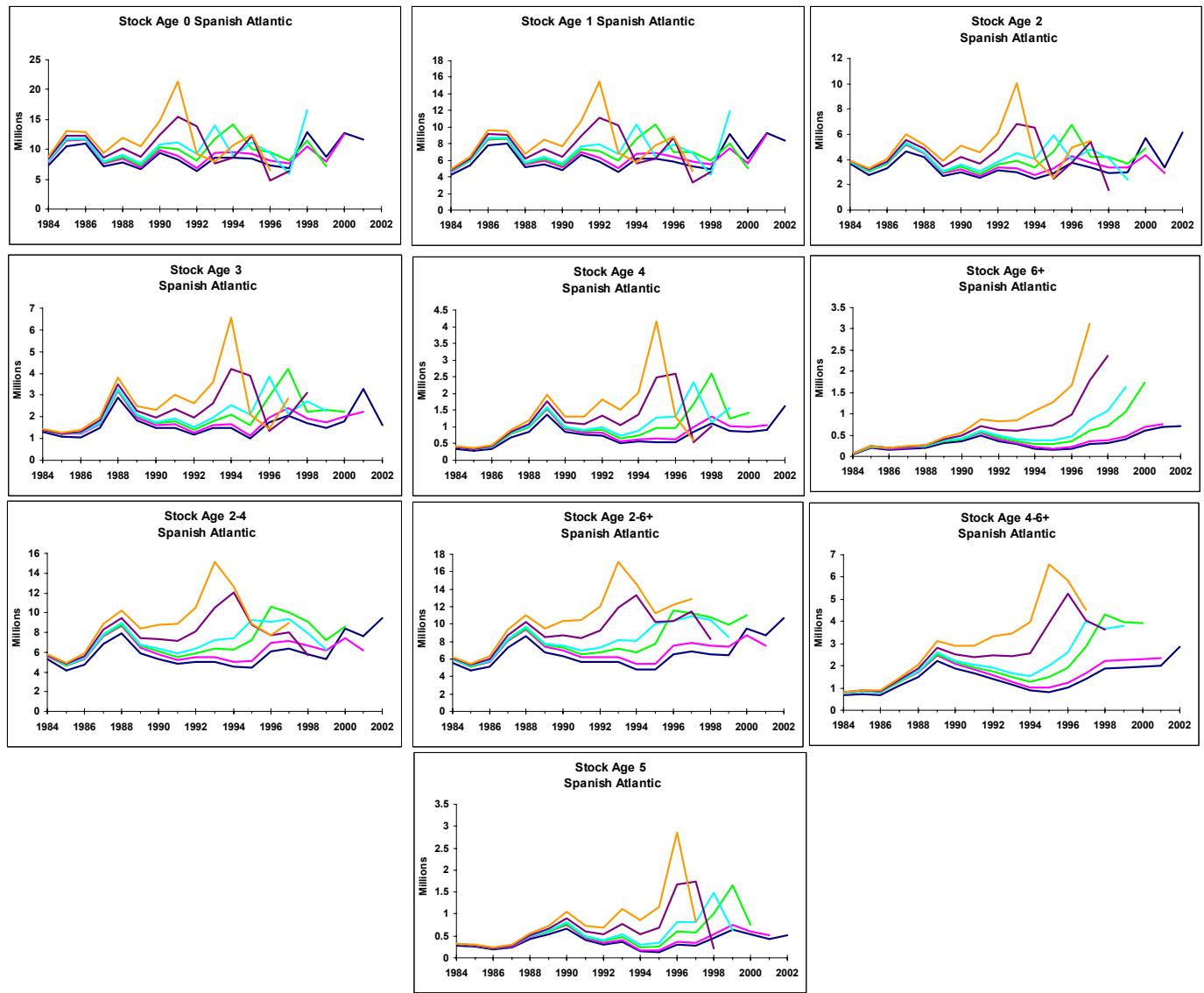


Figure 56. Atlantic Spanish retrospective analysis stock size estimation by sequentially removing the last year of data from the 1984-2001 catch at age and indices of abundance. The retrospective period covers 1996-2000 years.

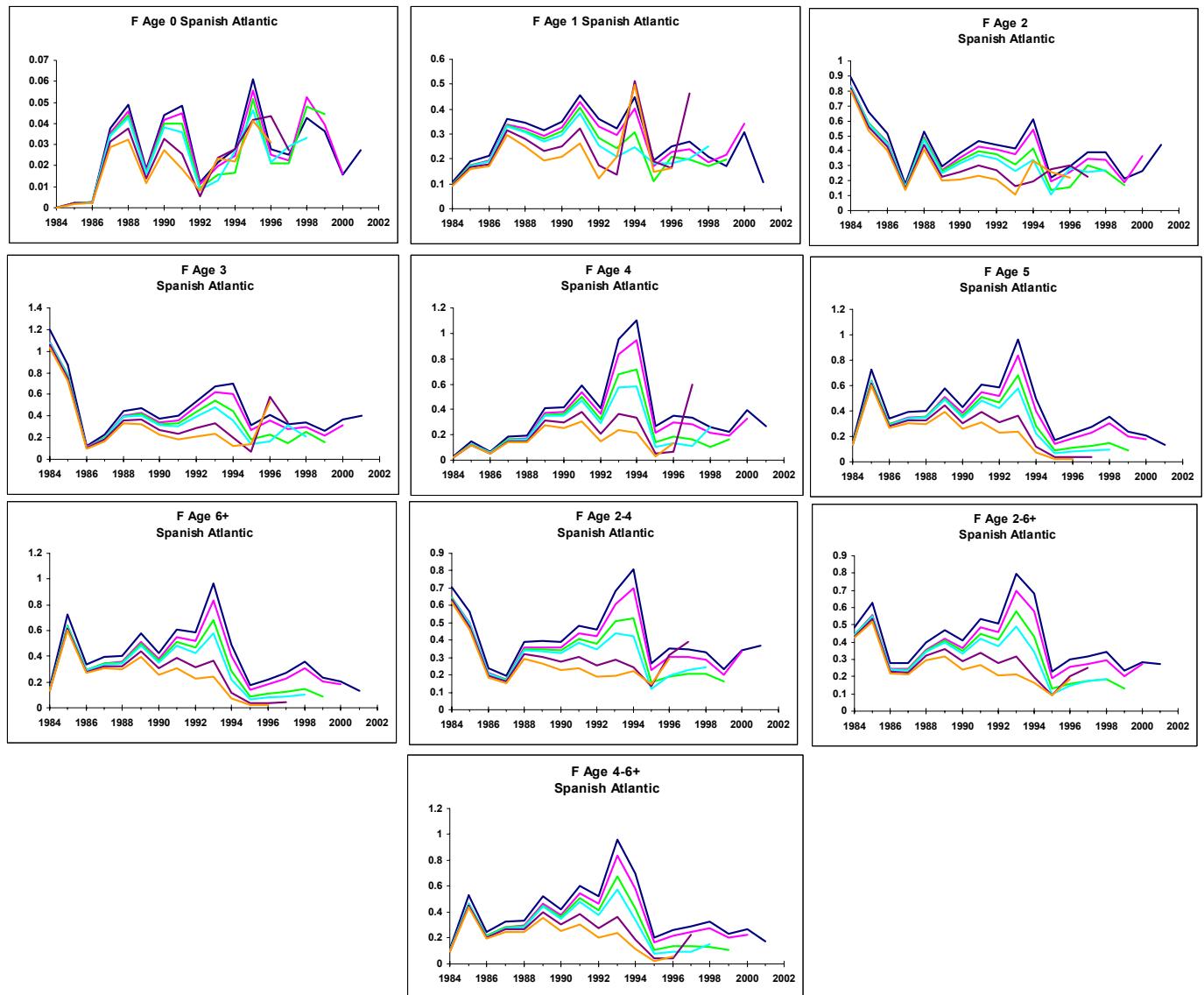


Figure 57. Atlantic Spanish retrospective analysis F mortality rates by age estimation.

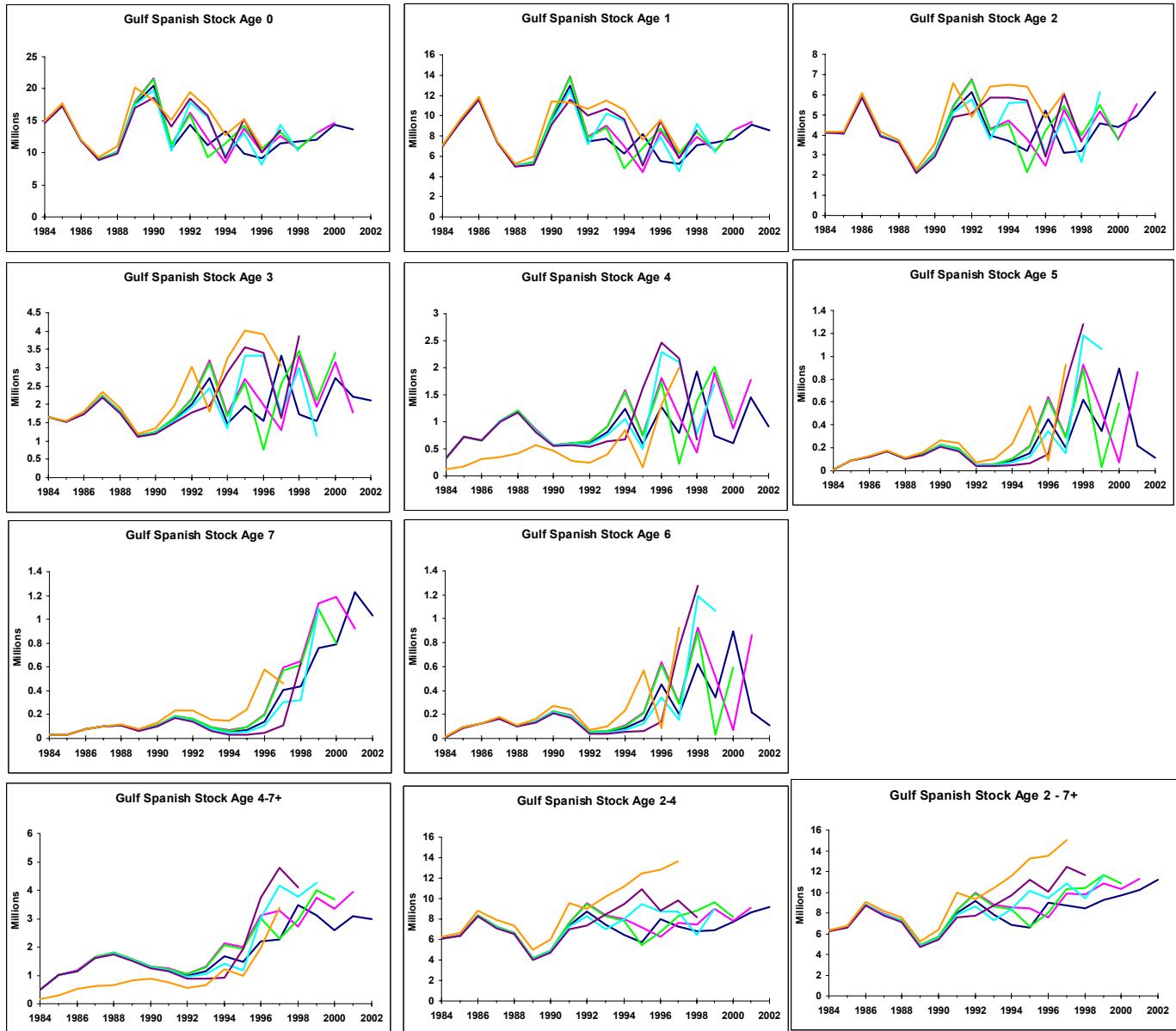


Figure 58. Gulf Spanish retrospective analysis stock size estimation.

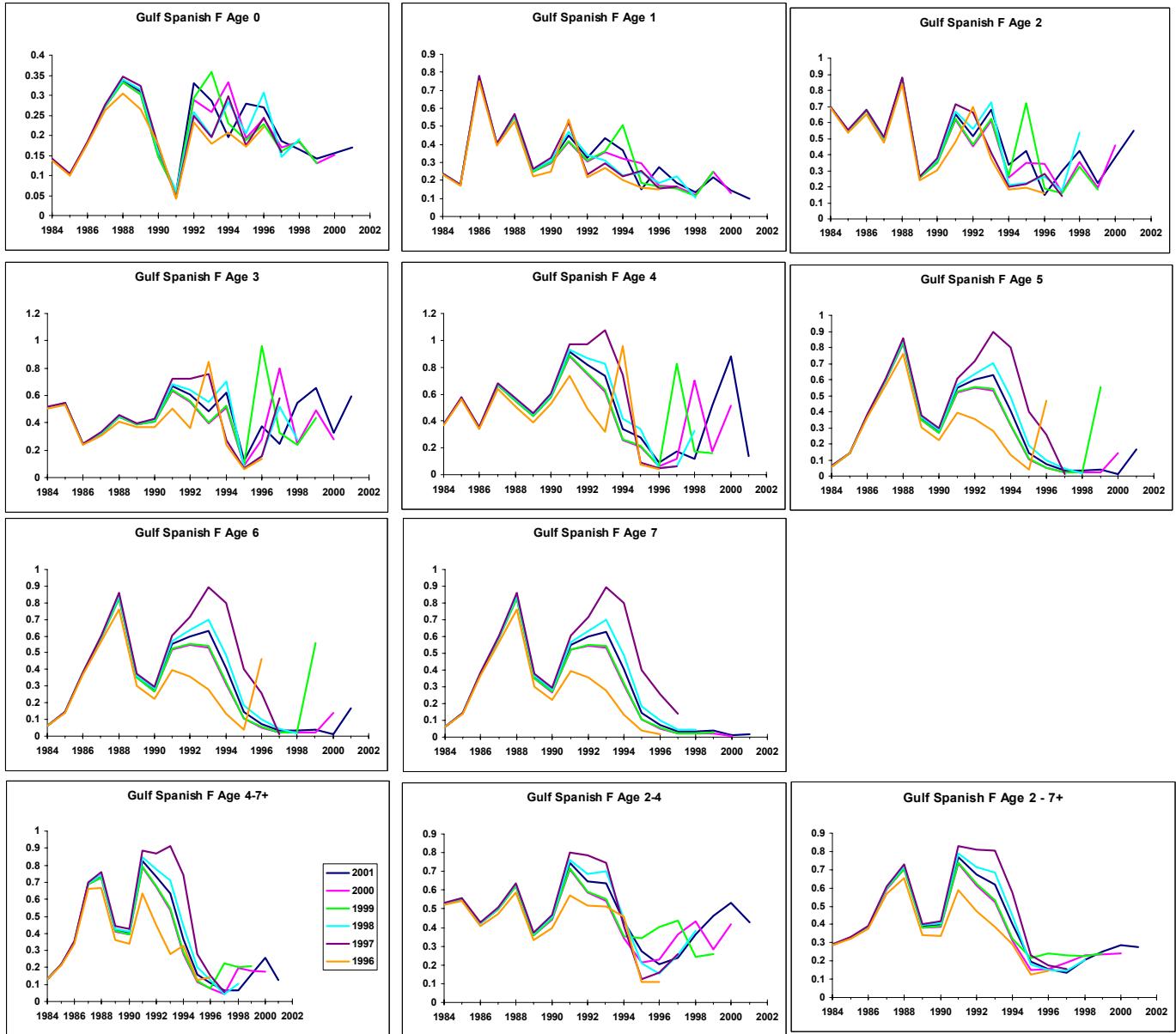


Figure 59. Gulf Spanish retrospective analysis F mortality rates by age estimation.

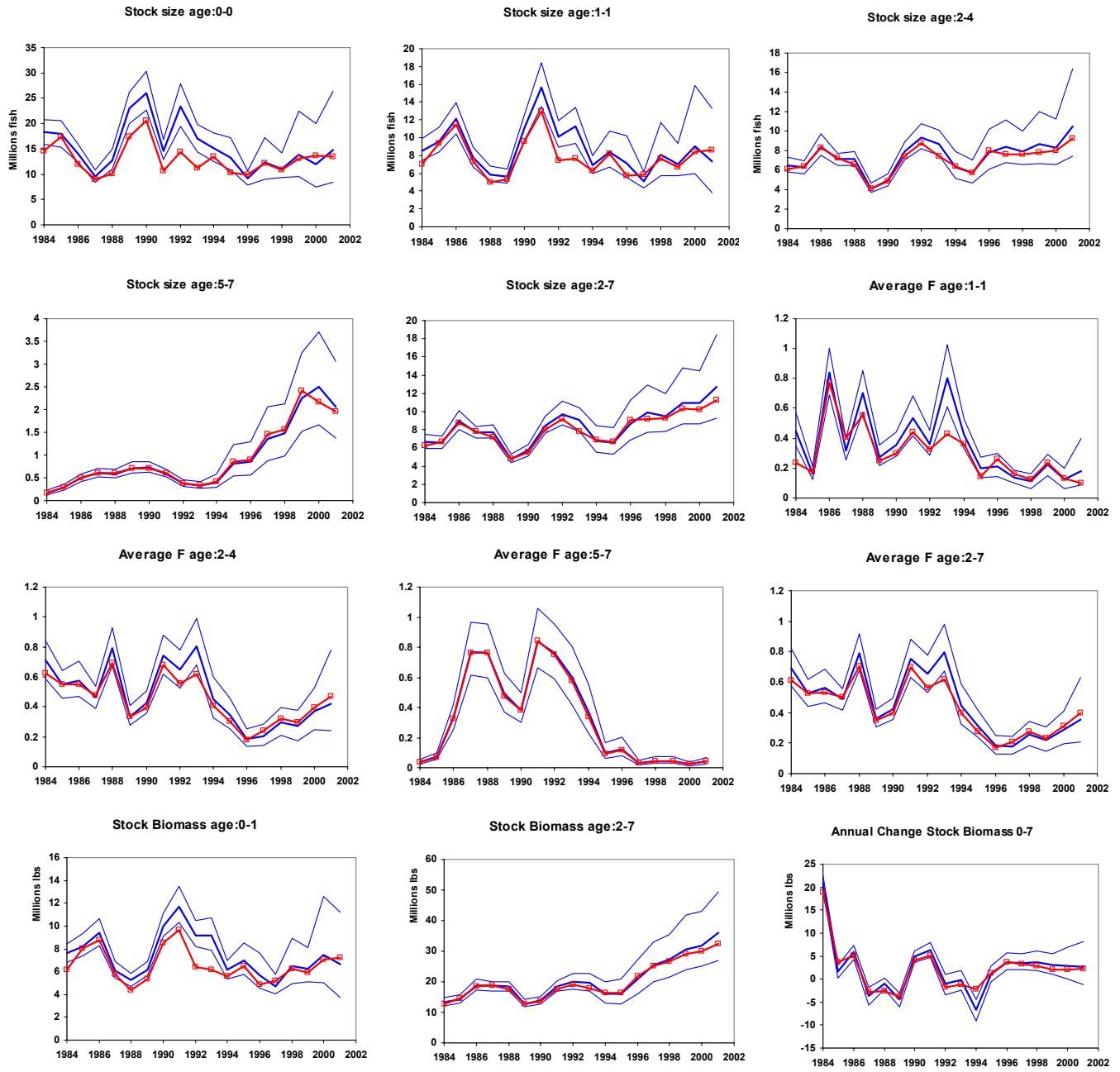


Figure 60. Gulf Spanish sensitivity analysis: Comparison of population trends estimated by the Bycatch Delta logN models (solid lines) with 80% confidence intervals and the Full index model (open square line).

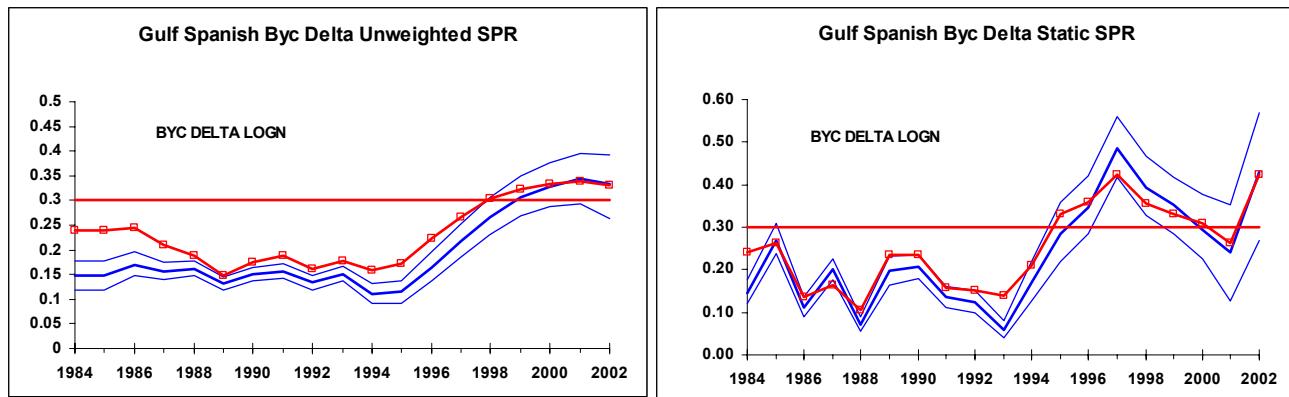


Figure 61. Static and transitional unweighted SPR from the VPA Bycatch Delta logN model for Gulf Spanish mackerel 2003 stock evaluation (solid lines). For comparison, equivalent values are plotted for the Full Index model (open square line).

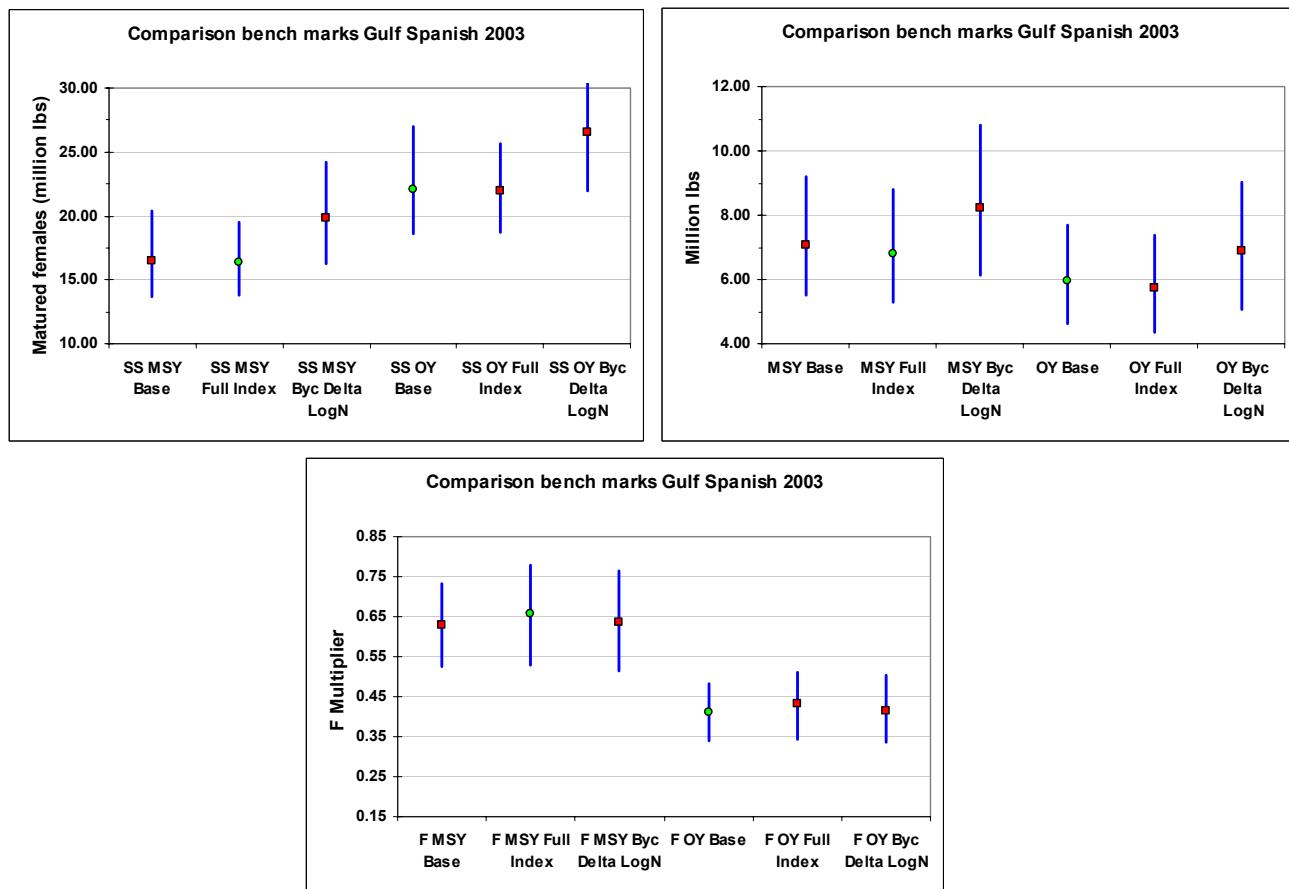


Figure 62. Gulf Spanish mackerel benchmarks 2003 SA. Comparison of estimates from the Base model, Full index model and the Bycatch Delta logN model reference points.

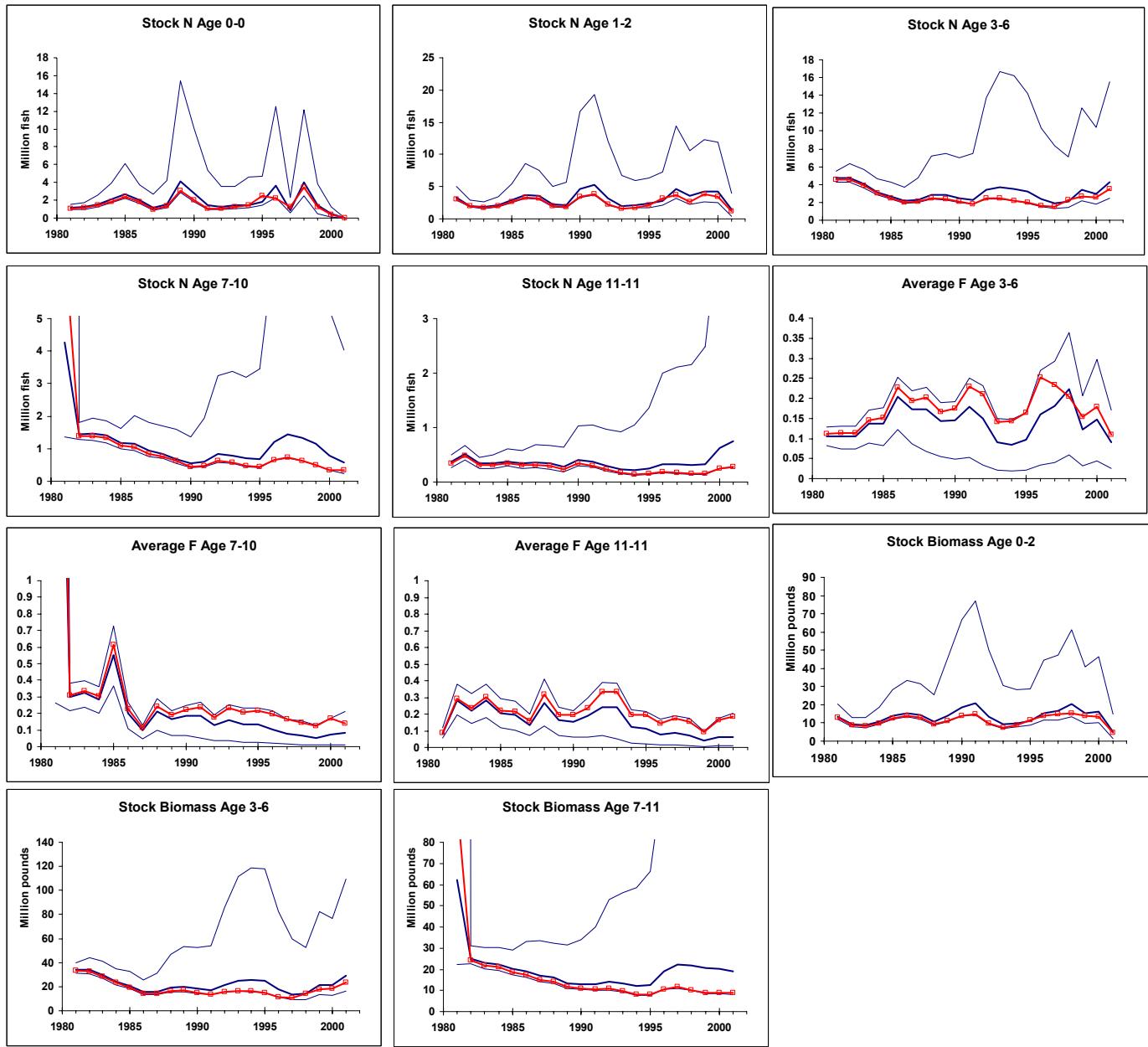


Figure 63. Sensitivity Analysis Atlantic king mackerel. Comparison of population trend estimates from the Full index model (open square line) and the model without the Florida FWC index of abundance (solid lines) with 80% confidence intervals.

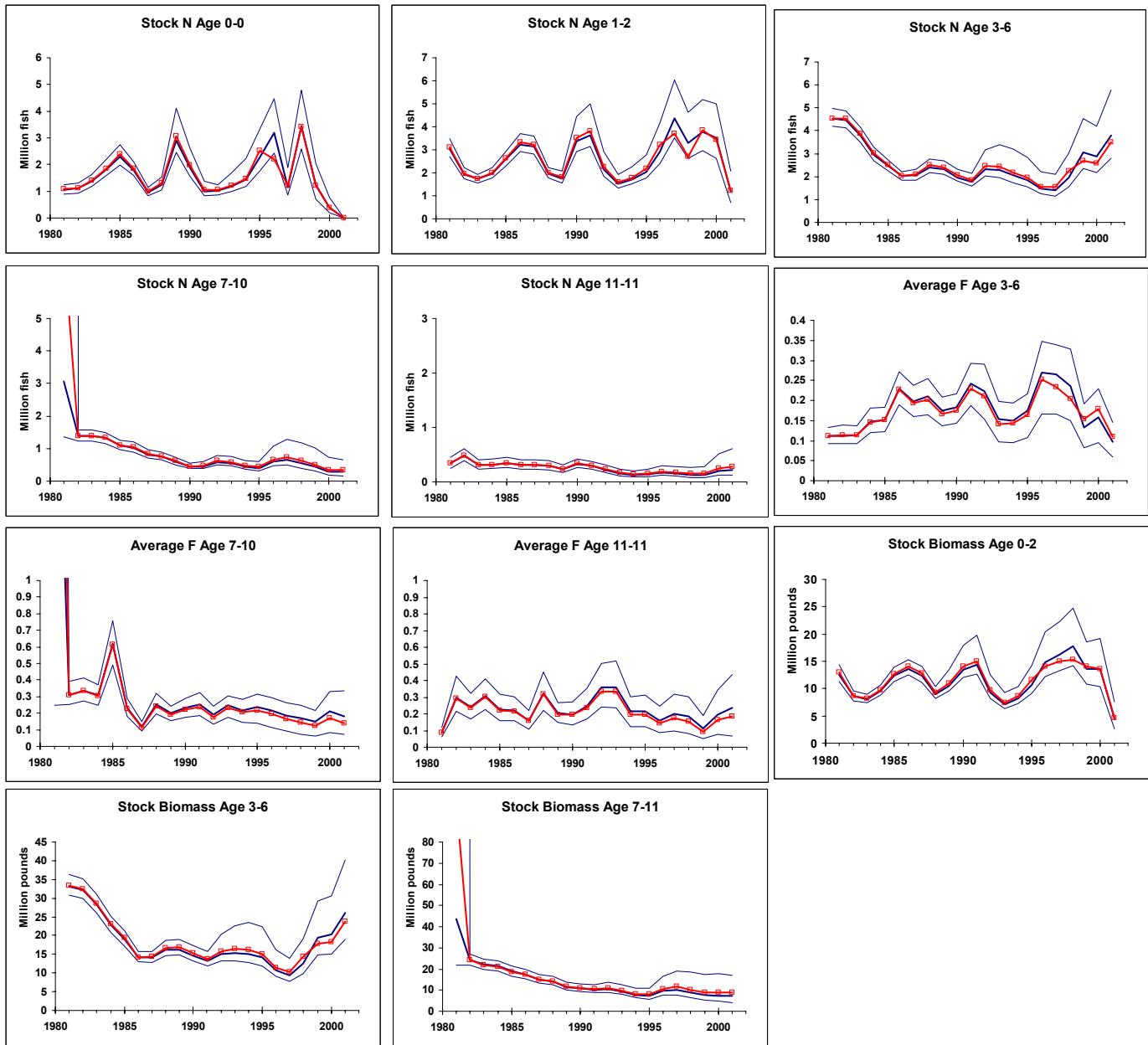


Figure 64. Sensitivity Analysis Atlantic king mackerel. Comparison of population trend estimates from the Full index model (open square line) and the model without the MRFSS index of abundance (solid lines) with 80% confidence intervals.

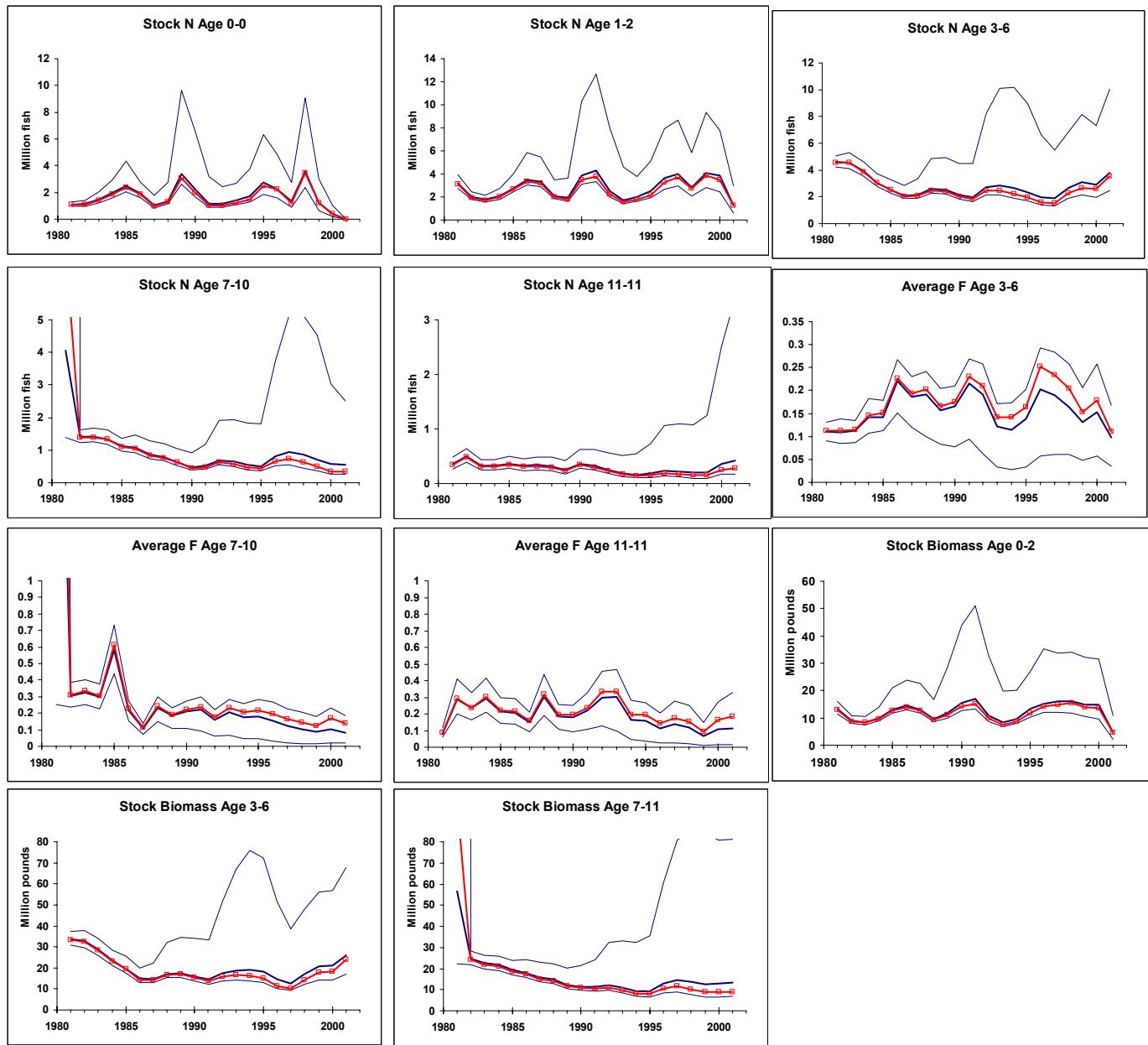


Figure 65. Sensitivity Analysis Atlantic king mackerel. Comparison of population trend estimates from the Full index model (open square line) and the model without the North Carolina Commercial (New) index of abundance (solid lines) with 80% confidence intervals.

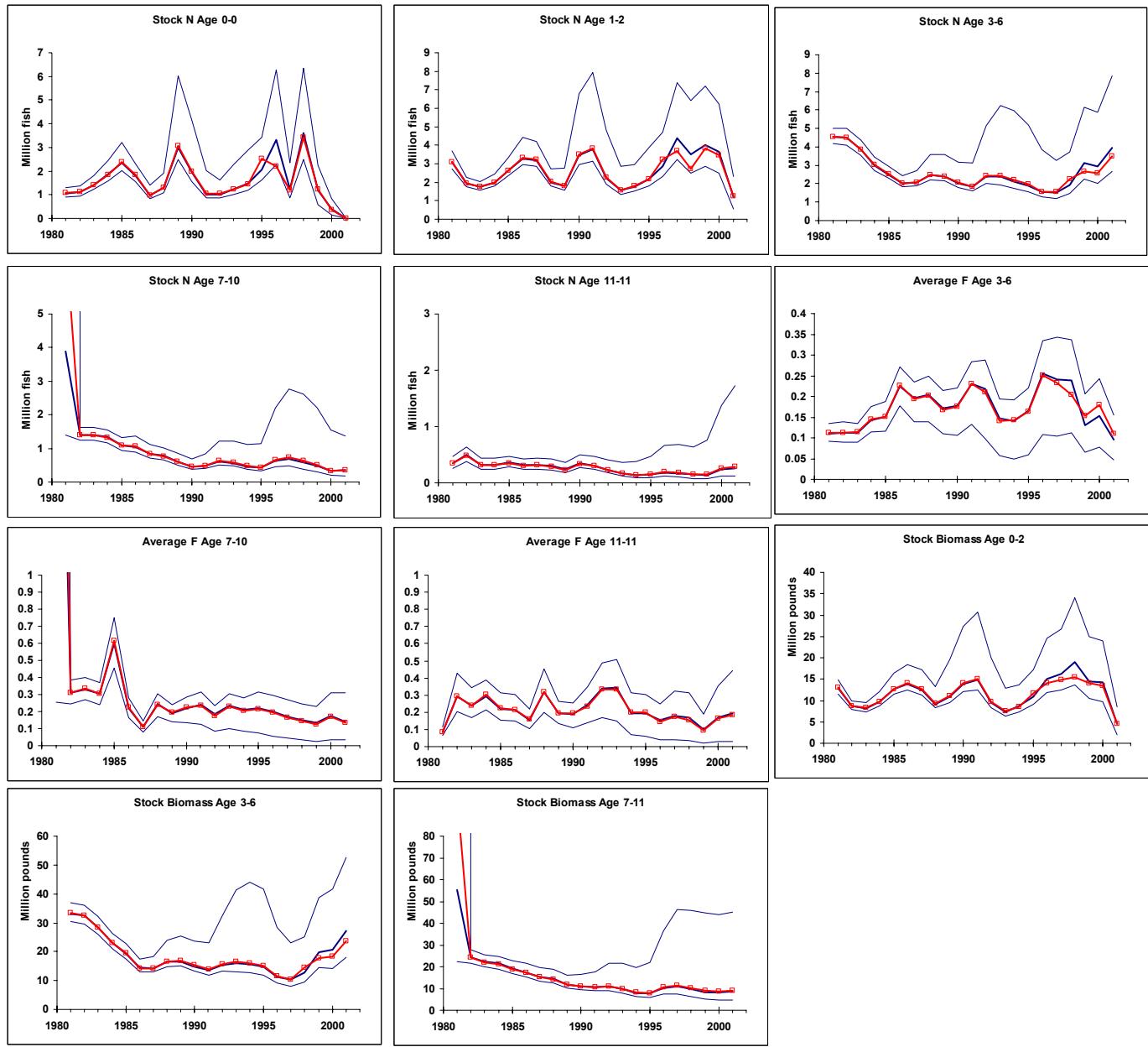


Figure 66. Sensitivity Analysis Atlantic king mackerel. Comparison of population trend estimates from the Full index model (open square line) and the model without the North Carolina Commercial (Old) index of abundance (solid lines) with 80% confidence intervals.

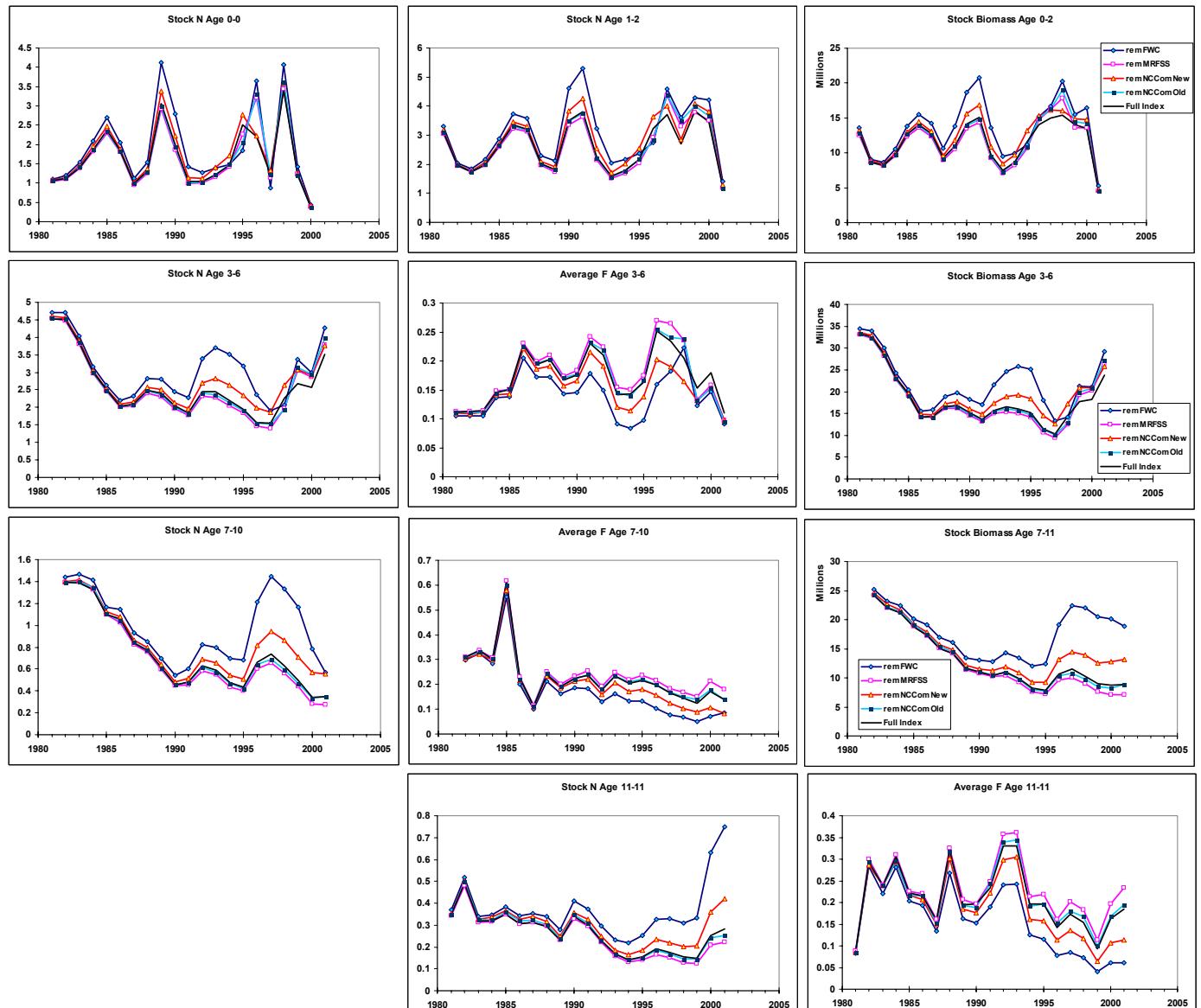


Figure 67. Sensitivity Atlantic king mackerel. Population trend estimators from the Full index model (solid line) and the models with the removal of a complete indices of abundance.

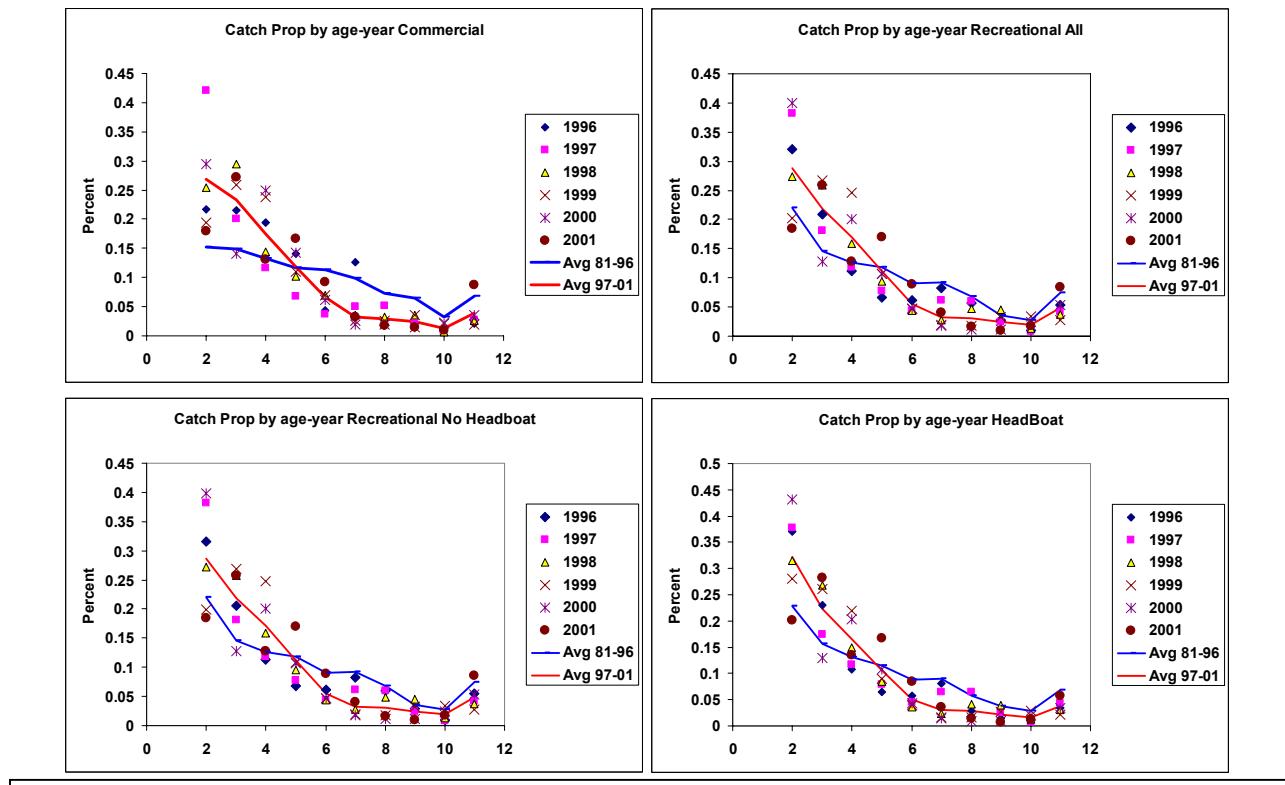


Figure 68. Atlantic King mackerel comparison of directed catch distribution by age and sector. Solid lines represent average of 1984-1996 years (blue) and average of 1997-2001 year (red).

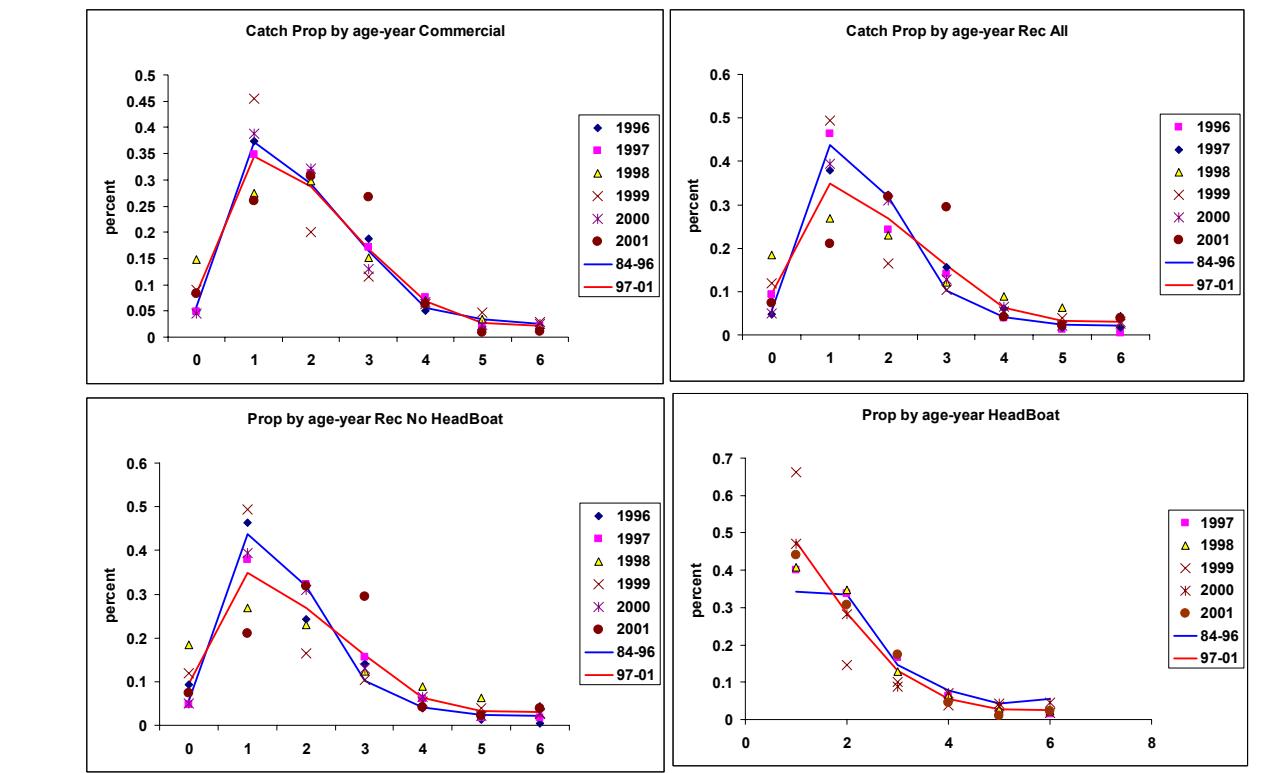


Figure 69. Atlantic Spanish mackerel comparison of directed catch distribution by age and sector. Solid lines represent average of 1984-1996 years (blue) and average of 1997-2001 year (red).

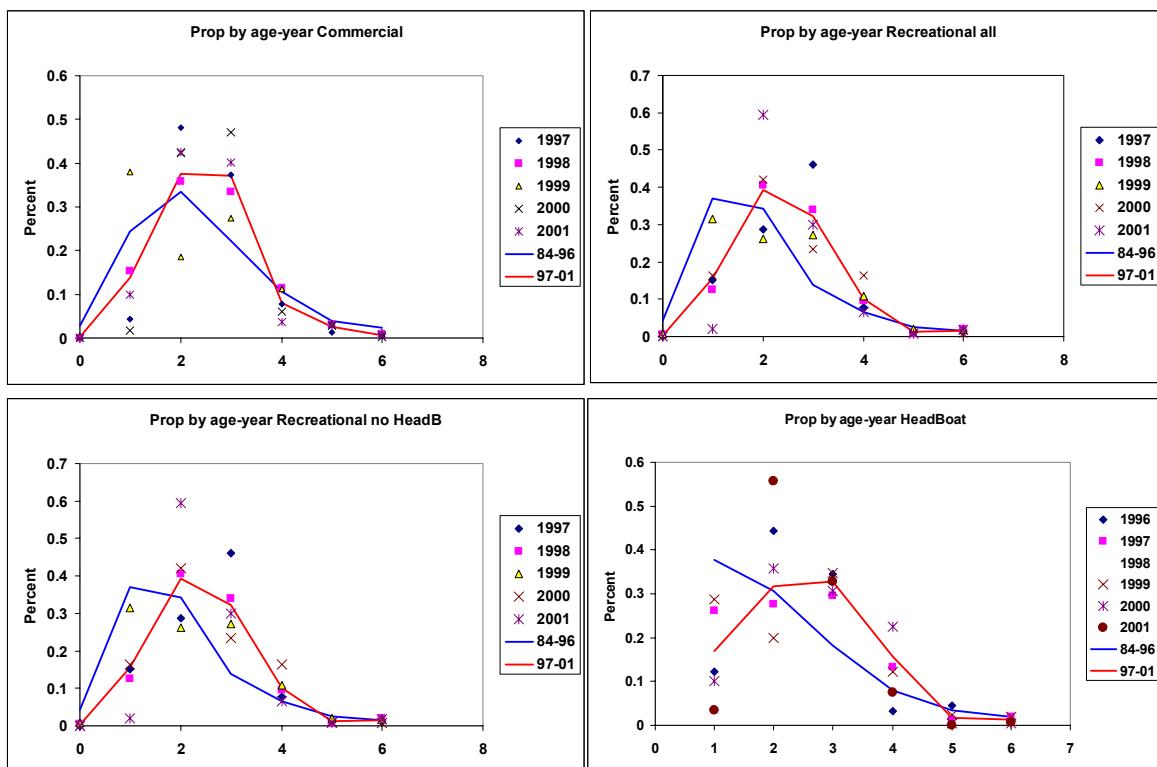


Figure 70. Gulf Spanish mackerel comparison of directed catch distribution by age and sector. Solid lines represent average of 1984-1996 years (blue) and average of 1997-2001 year (red).

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. mackereffort.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 m² 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.

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Appendix 2

Biological Program Documentation

Program 195 Pamlico Sound Survey

Masterfile: NER.NMA.NMA120-1.JUVENILE

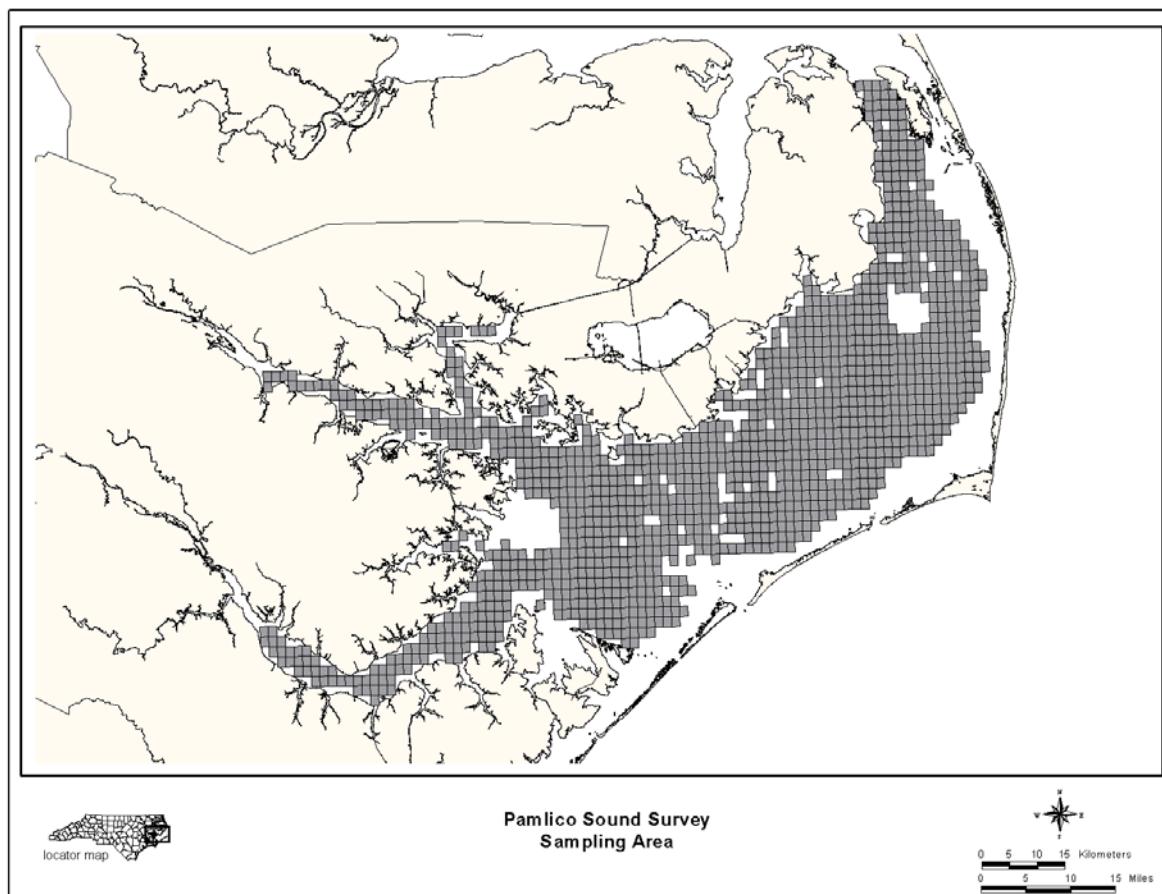
Biologist: Tina Moore

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.



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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).

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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 Minnesota 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:

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

Where N_S = number of hauls per stratum
 N_T = total number of hauls
 F_S = area of stratum
 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,

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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).

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

Orthopristis chrysoptera
Archosargus probatocephalus
Cynoscion regalis
Menticirrhus saxatilis
Pogonias cromis

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

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

(removed for brevity)

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

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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 species allow 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

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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.
- Moye, D.W., C.D. Stephan, and S.K. Strausser. 1987. State of North Carolina R/V CAROLINA COAST, Pamlico-Albemarle Sounds Survey, June 1987. North Carolina Dept. Resour. And Community Develop., Div. Mar. Fish., No. 177. 22 p.
- 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.
- Moye, D.W., C.D. Stephan, and S.K. Strausser. 1988. State of North Carolina R/V CAROLINA COAST, Pamlico-Albemarle Sounds Survey, December 1987. North Carolina Dept. Resour. And Community Develop., Div. Mar. Fish., No. 183. 22 p.
- Stephan, C.D., D.W. Moye, and S.K. Strausser. 1988. State of North Carolina R/V CAROLINA COAST, Pamlico-Albemarle Sounds Survey, March 1988. North Carolina Dept. Resour. And Community Develop., Div. Mar. Fish., No. 186. 19 p.
- 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.
- Stephan, C.D., D.W. Moye, and S.K. Strausser. 1989. State of North Carolina R/V CAROLINA COAST, Pamlico-Albemarle Sounds Survey, September 1988. North Carolina Dept. Resour. And Community Develop., Div. Mar. Fish., No. 200. 26 p.
- Moye, D.W., C.D. Stephan, and S.K. Strausser. 1989. State of North Carolina R/V CAROLINA COAST, Pamlico-Albemarle Sounds Survey, December 1988. North Carolina Dept. Resour. And Community Develop., Div. Mar. Fish., No. 210. 22 p.
- Stephan, C.D. and D.W. Moye. 1989. Pamlico-Albemarle Sounds Survey, March 1989. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 212. 16 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.
- Moye, D.W. and M.G. Pulley. 1990. Pamlico-Albemarle Sounds Survey September 1989 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 222. 24 p.
- 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.
- Pulley, Michael G. 1995. PAMLICO SOUND SURVEY September 1993 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 332. 24 p.
- Pulley, Michael G. 1995. PAMLICO SOUND SURVEY June 1994 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 333. 22 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.

Pulley, Michael G. 1996. PAMLICO SOUND SURVEY September 1995 Cruise Report. North Carolina Dept. Environ., Health, and Nat. Resour., Div. Mar. Fish., No. 335, 28 p.

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.

North Carolina Division of Marine Fisheries. 1993. Survey of Population Parameters of Marine Recreational Fishes in North Carolina. Ann. Prog. Rep. Proj. F-42, Seg. 2, North Carolina Dept. Environ., Health, Nat. Resour., Div. Mar. Fish., No. 274 or 302, 35 p.

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.

North Carolina Division of Marine Fisheries. 1996. Survey of Population Parameters of Marine Recreational Fishes in North Carolina, January-December 1995, Ann. Prog. Rep. Proj. F-42-5, North Carolina Dept. Environ., Health, Nat. Resour., Div. Mar. Fish., No. 315. 40 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.

North Carolina Division of Marine Fisheries. 1998. Survey of Population Parameters of Marine Recreational Fishes in North Carolina, Annual Progress Report, Grant F-42, January-December 1997, Segment 7, North Carolina Dept. Environ. & Nat. Resour., Div. Mar. Fish., No. 326.

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

Cornus, H.P. 1984. Development of a Bottom Trawl Survey off East Greenland from 1980 to 1984. Special session on biological surveys.

*Doubleday, W. G. (Ed) 1981. Manual on groundfish surveys in the Northwestern Atlantic. N.A.F.O. Sci. Coun. Studies, 2:55p.

Fogarty, M.J. 1985. Statistical considerations in the design of trawl surveys. FAO Fisheries Circular No. 786.

*Gavaris, S. and S. J. Smith. 1985. A comparison of survey stratification schemes based on depth and on historical spatial dispersion. NAFO SCR Doc. 85/93/

Grosslein, M.D. MS 1969. Groundfish Survey Methods U.S. Bur. Comm. Fish. Biol. Lab., Woods Hole, Massachusetts. Lab. Ref. #6912.

Phalen, P. S. 1993. Juvenile abundance indices for brown shrimp, blue crab, spot, Atlantic croaker, and southern flounder, 1979-1993. N.C. Dept. Environ., Health, Nat. Resour., Div. Mar. Fish., 9 p.

*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.

NMFS SEFSC Miami SFD/2003-008 Appendix

- *Ultang, O. 1977. Methods of measuring stock abundance other than by the use of commercial catch and effort data. FAO Fish. Tech. Pap. No. 176.

- Yoshiyama, R.M., et al. 1982. Abundance and distribution Patterns of Demersal fishes on the South Texas Outer Continental Shelf: A Statistical Description.

*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

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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

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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

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per strata based on a proportional standard error (PSE) value of 20%. The DMFJCL member that runs this analysis is NCBDWM18.

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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 Master 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.

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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.

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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.

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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)
Centropristes philadelphica (rock sea bass)	Epinephalus morio (red grouper)	Mycteroperca bonaci (black grouper)
Centropristes 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)		

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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

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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 appropriate 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

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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 account on them. 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.

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Species to keep an eye on (Make sure to sort to species):

Shrimps: browns, pinks, whites (you will see all species)

Flounders: lethostigma, dentatus, alboguttata, 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

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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.

<u>Rec. Type</u>	<u>Column #</u>	<u>Field Name</u>	<u>Units</u>	<u>Limits</u>	<u>Mandatory (M) vs. Desired (D)</u>	<u>Comments</u>
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: S = Pamlico Sound (Dropped 1990) N = Neuse River (Dropped 1990) P = Pamlico River (Dropped 1990) 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.

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1990

FORMAT A

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<u>Rec. Type</u>	<u>Column #</u>	<u>Field Name</u>	<u>Units</u>	<u>Limits</u>	<u>Mandatory (M) vs. Desired (D)</u>	<u>Comments</u>
I	53	Quad	N/A	1-9	M	1 - Albemarle Sound 2 - Albemarle Shallow 3 - Neuse River 4 - Pamlico Deep East of Bluff Shoal 5 - Pamlico Deep West of Bluff Shoal 6 - Pamlico River 7 - Pamlico Shallow East of Bluff Shoal 8 - Pamlico Shallow West of Bluff Shoal 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.

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1990

FORMAT A

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<u>Rec. Type</u>	<u>Column #</u>	<u>Field Name</u>	<u>Units</u>	<u>Limits</u>	<u>Mandatory (M) vs. Desired (D)</u>	<u>Comments</u>
	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 2 = double rigged, two barrel 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	

Revised April
1990

FORMAT A

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

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.

<u>Rec. Type</u>	<u>Column #</u>	<u>Field Name</u>	<u>Units</u>	<u>Limits</u>	<u>Mandatory (M) vs. Desired (D)</u>	<u>Comments</u>
	117	Wind Direction	N/A	N/A	D	1 = N 2 = NE 3 = E 4 = SE 5 = S 6 = SW 7 = W 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

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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.

<u>Rec. Type</u>	<u>Column #</u>	<u>Field Name</u>	<u>Units</u>	<u>Limits</u>	<u>Mandatory (M) vs. Desired (D)</u>	<u>Comments</u>
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.

<u>Rec. Type</u>	<u>Column #</u>	<u>Field Name</u>	<u>Units</u>	<u>Limits</u>	<u>Mandatory (M) vs. Desired (D)</u>	<u>Comments</u>
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.

<u>Rec. Type</u>	<u>Column #</u>	<u>Field Name</u>	<u>Units</u>	<u>Limits</u>	<u>Mandatory (M) vs. Desired (D)</u>	<u>Comments</u>
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.

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.

<u>Rec. Type</u>	<u>Column #</u>	<u>Field Name</u>	<u>Units</u>	<u>Limits</u>	<u>Mandatory (M) vs. Desired (D)</u>	<u>Comments</u>
	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.

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FORMAT A

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<u>Rec. Type</u>	<u>Column #</u>	<u>Field Name</u>	<u>Units</u>	<u>Limits</u>	<u>Mandatory (M) vs. Desired (D)</u>	<u>Comments</u>
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 3 mature 7 sponge
	43-46	Parameter B	N/A	1,2	M	For sponge crabs only 1 sponge yellow to orange in color 2 sponge brown to black in color
	47-50	Parameter C	N/A	N/A	D	Lesion Type (if 2 lesions on same fish).

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FORMAT A

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

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

III. Maps

Available upon request.