Stock Assessment Analyses on Gulf of Mexico King Mackerel

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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 assessment of the Gulf king mackerel migratory group was on April 2000 (Legault *et al.* 2000). This document provides: updated baseline analyses considering catch and effort through 2001, comparison of evaluation results with the prior assessment, and measures of uncertainty in the results for the MSAP to use in advising the Gulf Council of resource risk for the Gulf of Mexico king mackerel migratory group under different levels of catch for the 2002 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 in data and methodology from those used in year 2000. Comparison of the 2000 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 and 2001* are updated in this assessment. Estimates through the 2000/2001 fishing year (July to June) 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 (Fig 1).

Shrimp Trawl Bycatch

Estimates of annual bycatch of king mackerel in the Gulf of Mexico shrimp trawl fishery were updated using the same general linear model (GLM) as in year 2000. 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 are nearly identical to those from the previous assessment (Fig 2, Table 2). The model takes into account the use of bycatch reduction devices (BRDs) in the Gulf of Mexico. This was accomplished by adding another level to the dataset factor in 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 and 2000, the area season distribution of BRDs was assumed similar as in 1998.

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). This year only bycatch estimates from the delta model are presented; no further evaluation was performed.

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. In the event that there are insufficient size frequency observations (<100 per analytical stratum), unless the catch is very small, additional composite samples are added from neighboring strata until sufficient sample sizes (of 100) are obtained to size the catch. Strata used historically in assigning samples to catches have been year, month, area, sector, and gear. Each match is assigned a code so that calculations can be made of the amount of catch that is sized with exact matches (approximately 80%) and the amount requiring substitution samples (MSAP Supplemental 1997). The numbers of fish at length are assigned sex based upon length, migratory group, season, and year (Restrepo 1996).

The catches by migratory group, length, sex, year, quarter of the year, sector, and gear were assigned ages with one of two approaches: either using an age-length-key which is specific to year, quarter, migratory group or by applying a stochastic ageing procedure that utilizes a growth model which accounts for monthly variation in the length at age (see Cummings 1989). The variability in length at age was determined using previously published growth models for king mackerel and this method was

* Data for year 2001 are provisional NMFS SEFSC Miami

adopted by MSAP 1989 and since reviewed (MSAP 1997). 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.

For this assessment king mackerel otolith observations from all calendar years were reviewed for accuracy and coding consistencies. All otolith observations and resulting age determinations incorporated into this analysis were collected by NMFS, SEFSC, Panama City Laboratory and/or cooperators (Virginia Division of Marine Resources, North Carolina Division of Marine Resources) using protocol defined by the MSAP for mackerels (see MSAP 1989). For this full assessment as in previous complete year's assessment (as opposed years when only an update was conducted), mackerel stock assessments catches and size samples were both revised (1998, 1999) and calendar years 2000 and 2001 were added as new data thus revised catch at age derivations were made for fishing years 1997, 1998, 1999 and new estimates generated for fishing years 2000. An additional review of the complete ageing dataset revealed several different area codes for the same region for some ageing observations collected during 1995, 1996, and 1997 which were not identified during the age length key constructions in the previous assessment carried out in 2000. The result was the addition of more fish into the age length key database for calendar years 1995-1997 which had been excluded in the previous assessment. Thus, in this assessment age length keys were revised for calendar years 1995-1997 as well as revisiting 1998, and new age length keys built for 1999, 2000 and 2001. The overall change to the database added additional fish to several areas (southeast Florida, South Florida, west Florida, and northwest Florida resulting in a total addition of 108 fish in 1995, 144 fish in 1996, and 37 fish in 1997. As in previous assessments the otolith database was then used to assign age length keys on a calendar year and migratory group basis. King mackerel otolith samples were considered sufficient (in terms of temporal coverage) to assign sex specific age length keys for quarters 2-4 (1995), quarters 1-4 (1996,1997,2000), quarters 1-3 (1998), quarters 3-4 (1999), and quarter one (2001). For catches where age length keys did not exist the stochastic ageing procedure based on the Shepherd (1985) method adopted previously by the MSAP in 1998 (see Cummings 1989) was used. Catch at age by sector (commercial, recreational and bycatch) for Gulf king mackerel are given in Tables 2-5.

BIOLOGICAL CHARACTERISTICS

Natural Mortality

The natural mortality rate (M) used for the Gulf king mackerel analyses in this report is the same as used in previous assessments, 0.2. The stochastic analyses allowed the value of M to vary over both years and ages using a random draw from a uniform distribution of 0.15 to 0.25 such that the mean of the distribution matches the point estimate. The point estimate has 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 vector is the same as used in previous assessments. The age specific fecundity values correspond to millions of eggs. The derivation of the egg values comes from an age-length relationship (Manooch *et al*. 1987), 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.

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:

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

where a and the b_i are parameters, the I_i are categorical variables and e is the error term assumed to be normally distributed with mean 0 and variance v^2. The categorical variables include year and other factors which contribute to the variation in log(CPUE) independently of abundance. However, this model requires modifying values of zero catch (to make the logarithmic transformation). Traditionally a value of 1 or other constant positive value was added to all observations prior to the standardization procedure. In cases where the proportion of zero catch values to the total observations is relatively high, the standardized catch rates may dependent largely on the selection of such 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 king mackerel using the delta model have previously presented to the MSAP working group (Ortiz and Scott 2001, Ortiz *et al.* 2000).

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, assumed directly proportional to abundance. The annual trends in CPUE are 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. In addition, all tuning indices used in the VPA analyses are listed in Table 6, along with the time of the year when the index related to abundance, whether the index was compared to estimated numbers or biomass, and the age range used for tuning.

A. Florida Department of Environmental Protection (FDEP) Marine Fisheries Trip Ticket Program

The FDEP commercial trip ticket data were used to develop two indices, the Panhandle index (NW) and the South Florida index (SW), for fish sold in Florida. The Panhandle index included only observations between the months July and October and landings from the counties of Taylor through Escambia and was applied to ages three through six. The South area index, applied to fish ages three through eight, included observations from November and December in Monroe or Collier counties and included a maximum catch limit of 3,500 pounds. These selections were made to account for concern expressed by the 1996 and 1998 MSAP of potential biases in indices from trip limits put into place during specific months. Index calculations were provided by Dr. Robert Muller of the Florida Marine Research Institute, St. Petersburg, FL (March 2002, pers. comm.). Both indices were modeled as the standardized pounds per day fished adjusted for month and county (Table 6). The results of the most recent index standardizations compared to the available index values, scaled to their respective means are shown in Figure 3.

B. Marine Recreational Fishing Statistical Survey (MRFSS) - Florida

Observations of private or charter boat anglers in Florida successfully catching king mackerel and/or indicating they were targeting king mackerel were used to index abundance using the protocol recommended by the MSAP in the 1996 and 1998 Reviews. Observations from July through December were used in the index to minimize the impact of bag limits and the analysis was constrained to data collected since 1985. The index developed was the standardized number of fish per angler hour adjusted for month, county of interview, and fishing mode and included the annual standardized probability of having a successful trip, also adjusted by month, county, and mode. This index was applied to fish of ages two through eight (Table 6). A detailed report of the standardization procedure is presented in Ortiz and Phares (MSAP-02-03). A comparison of the pattern in the data available for the previous assessment and the current one are shown in Figure 4.

C. Texas Parks and Wildlife Department (TPWD) Recreational Angler Creel Survey

Successful recreational anglers in Texas that caught king mackerel were also used to index CPUE. The data used included observations between the months of May and September from the private and charter boat fisheries. As recommended in the 1996 and 1998 Reviews, auxiliary data on bay vs. inshore was not used in the model. The index was the standardized number of fish caught per 100 angler hours of fishing, adjusted for month and fishing mode and was used to index ages two through eight (Table 6). A detailed report of the standardization procedure is presented in Ortiz and Phares (MSAP-02-03). A comparison of the pattern in the data available for the previous assessment and the current one are shown in Figure 5.

D. NMFS Beaufort Laboratory Headboat (Southeast Florida)

CPUE data from this source represents successful recreational anglers fishing from headboats. Historically, data from southeast Florida; headboat areas from Daytona through the Florida Keys during the months of November through March, have been used as an index of abundance of the eastern group of king mackerel. The index is the standardized numbers of fish caught per trip divided by the number of anglers reported on a trip, adjusted for individual month and vessel terms. Headboat catch and effort data was available only until calendar year 1999. A detailed report of the standardization procedure is presented in Ortiz and Scott (2001). This index was applied against the size of fish ages two through six (Table 6). A comparison of the pattern in the data available for the previous assessment and the current one are shown in Figure 6.

E. Bycatch Indices from GLM and Delta Lognormal Approaches

Tuning indices from the bycatch analyses were computed using the traditional method, dividing the total estimated bycatch in a year by the total shrimp effort in that year. When estimating the total bycatch for use in this tuning index, areas that used BRDs are instead assigned the commercial catch rate in order to have a consistent time series (i.e. removing the observations from BRD tows). The bycatch index used for the base case analyses comes from the GLM estimates of bycatch and the traditional method (Table 6). A comparison of the GLM and delta bycatch estimates used to create tuning indices is presented in Figure 7.

F. Other indices

In prior assessments two other indices of abundance for Gulf king mackerel has also been used; the Florida Charter index which is split between the Northwest Florida Panhandle area and the Southwest Florida (Fig 8). These indices cover from 1985 to 1994/95 years. The other index is the SEAMAP survey of larval abundance in the Gulf of Mexico (Gledhill and Lyczkowski-Shultz 2000). This index is a fishery independent sampling in the Gulf, as in the last assessment the index used is the estimated percentage of occurrence of king mackerel, rather than the estimates of density (Fig 9).

METHODS

Virtual Population Analysis

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

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

where X_{it} is the index i in year t, N_{ijt} is the abundance in year t of the j ages represented in index i and the b_{ijt} are appropriate conversion factors for that index and age (for example conversion from numbers to weight, conversion of the abundance from the beginning of the year to mid-year, or conversion of selectivity by age within the age group). For the indices 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 to evaluate 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). Thus, in the present analysis each index was given equal weight in the minimization process.

The scaling parameters q_i are computed by maximum likelihood during the minimization process in both situations, they are not estimated directly. Since all indices are scaled to their own mean prior to fitting in the VPA, the absolute values of the q_i are not meaningful relative to the original data used to create the index. In each analysis, the fishing mortality rates at age in the 2000/2001 fishing year (terminal year) are the parameters estimated. Note that this is analytically equivalent to estimating the population abundance in the next year at the next age. An additional assumption made in each analysis is that the fishing mortality rate was the same in the plus group (Age 11+) and the previous age (age 10) for all years. The upper right corner of a VPA matrix (recent years and young ages) is difficult to estimate. For this reason, a separable VPA was run over a range of fixed selectivity ages and terminal year F values in order to estimate the appropriate relative selectivity pattern of the youngest ages in the terminal year. The results from the SVPA runs between the Stock Assessment in year 2000 and the present varied, significantly. Figure 10 shows the results of the SPVA in year 2000 and 2002 respectively. The main difference is the increase of selectivity for the younger ages, particularly Age 2 through 7. In the present Assessment, the average of mean selectivity for age 0 relative to age 2 was 1.2 (compare to 3.1 in SA 2000), while the average of mean selectivity for age 1 relative to age 2 was 0.26, similar as in SA 2000 [further discussion about the changes of F at age ratios will be presented in the results section]. The F value for ages 2-10 in the terminal year are estimated within Fadapt, with the F for the plus group in the terminal year set equal to the F at age 10.

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

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

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

Characterization of Uncertainty

The uncertainty in the assessment estimation is 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 are accumulated and sorted to provide probability statements of relevant statistics. Projections are 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 are used to construct 80% pseudo-confidence intervals (removing the 10% lowest and highest observations).

The stochastic simulations estimate the same number of parameters as the deterministic case. The final estimates from the deterministic case are used as initial guesses for the terminal year fishing mortality rates at age. Thus, the potential exists for highly different VPA estimates in each simulation, especially given that all the random selections described above are 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 (2000/01 fishing year) are projected into the 2001/02 fishing year according to the estimated F and M at age values in the terminal year. Recruitment in the projection years comes 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 in which both the stock and recruitment values have tuning information present are used to create the relationship. In the case of Gulf king mackerel, this means that only years 1987-2000 are used. The maximum recruitment is 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" is determined by the average of the five lowest spawning stock sizes within the years 1987-2000 (Fig 11).

The bycatch fishing mortality rate for the projection years is 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 is not included in this average because BRDs were partially implemented then. The bycatch reduction due to BRDs implementation was estimated as 50% for king 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 (1996/97-2000/01) and the year multipliers specific to each sector. For the 2001/2002 fishing year, the two fishing mortality rate multipliers were estimated simultaneously such that the observed total catch in weight for the commercial sector[1] and the 2001/02 total allowable catch (TAC) in weight for the recreational sector[2] was achieved. The total fishing mortality rate at age was computed as the sum of the bycatch F at age, the product of the commercial multiplier and selectivity at age, and the product of the recreational multiplier and selectivity at age. The two multipliers are unique values assuming both catches are smaller than the estimated population.

The population abundances were then projected into the 2002/2003 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 2002/2003 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 are again unique assuming the SPR can be achieved in that year. The yield resulting from application of the directed fishing mortality rates on the estimated population abundance generates the ABC value. This approach of treating separately the commercial and recreational sectors was used in the two previous 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 at the last MSAP meeting, the recommended proxy for Fmsy is F30%SPR and the proxy for Bmsy is the spawning stock that results in equilibrium under the Fmsy proxy

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1 The commercial catch for Gulf king mackerel fishing year 2001/02 was set to 2,856,562 lbs. From the Preliminary Landings, Status of Quotas, and daily vessel trip/landing limit report on April 12, 2002.
2 The recreational catch for Gulf king mackerel fishing year 2001/02 was set to 6,940,000 lbs. Corresponding recreational fraction of the TAC for year 2001. Southeast Fishery Bulletin. NMFS Southeast Regional office. St. Petersburg FL.

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)*Bmsy and the maximum fishing mortality threshold (MFMT) to Fmsy 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 two year constant catch projections.

RESULTS AND DISCUSSION

This stock assessment used the base model from the last Mackerel Stock Assessment Panel 2000 as the starting point for the analyses. In this case, the MSAP 2000 adopted the 'equal' weighting option with normal error assumption for all 9 indices of abundance available, with the same age coverage and time of year application as presented in the indices section. The VPA's model estimated nine fishing mortality rates in the last year, corresponding to the age classes 2 through 10, with fixed F ratios for ages 0, 1 and 11+. F ratios where defined as: F Age 0 = 3.1 of F age 2, F Age 1 = 0.26 of F age 2, and F age 11+ = 1.0 F age 10.

For this stock assessment, updated data was available in comparison with the year 2000 SA: Commercial and recreational catch for calendar years 1999, 2000, and 2001 was available. Thus, the Catch at Age (CAA) was update for the fishing years 1999/00 and 2000/01. Overall the 2002 SA CAA match the total numbers of the 2000 SA CAA (see Table 1 for total). However, there were noticeable changes in the distribution of numbers of fish per age classes. Figure 12 and table 7 summaries the difference in numbers between the 2002SA CAA and the corresponding 2000SA CAA for all commercial and all recreational sectors (the plots only covers 1994-1998 fishing year). In general, the trend of changes was the reallocation of fish from older towards younger ages in the 2002 SA CAA and only for the fishing year 1994 through 1998. As such, age classes 0, 1 and 2 for fishing years 1994-98 increase in proportion between 50% and 13 % for the commercial sector, and between 28% and 10% for the recreational sector in the 2002SA CAA. As overall total numbers of catch did not change, the increases of these age classes were matched by correspondent decreases in older age classes, particularly in age class 3, 4, 5 and 6 in the commercial sector and 3 to 5 in the recreational sector. Some additional changes in older age classes were observed although of smaller percentage and at different levels between sectors (Table 7). The difference between 2002SA CAA and 2000SA CAA also translates into changes in the different Partial CAA tables that are input in the VPA model associated with particular indices. Figure 13 shows absolute difference in numbers for different sectors, gears and areas that are used to create the Partial CAA tables. Another result of the CAA modification, and particularly associated with projection analyses is the changes in the proportion of directed catch by age for both the commercial and recreational sectors. The 2000SA projections used the average of proportions of catch by age of fishing years 1994-98, in the present evaluation, the average proportion of catch by age was extended from 1994 to 2000. Figure 14 shows the changes in this average proportions for the commercial and recreational sectors that are used for projection evaluations.

As mentioned before, this change in the CAA distribution resulted in a difference in the estimated selectivity patterns as indicated by the SPVA runs (Fig 10). Thus, the F ratios in particular for age 0 class with respect to age 2 varied from 3.1 in the 2000SA to 1.2 in the present evaluation. If the SPVA is restricted to the last four years (1996-2000), the selectivity patterns show greater difference (Plot c in Fig 10), with respect to the 1995-98 2000 SA.

Following the base model of 2000 SA evaluation, the Gulf of Mexico king mackerel virtual population tuning results are given in Table 8, including parameter standard errors and coefficients of variation, index fits, index selectivity, residual analyses, diagnostics, abundance at age and fishing mortality at age estimates (for comparison purposes this run was labeled BASE 9 model). Figure 15 shows a comparison of the 2002 SA estimates of stock size, fishing mortality rates and stock biomass with the correspondent estimates from the 2000 SA (square symbols). In general, the 2002 SA Base 9 model estimated somewhat smaller stock sizes, particularly for ages 3 and older, with larger differences towards the later years. Consequently, the 2002 SA Base 9 model also estimated higher fishing mortality rates, particularly for ages 3 and older in the later years. This translates into a lower stock biomass estimates for Gulf king mackerel stock (Age 3-11+) with a difference of about 12.6 million lbs in the year 1998. Figure 16 shows the VPA fitting and residuals of the nine index series.

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 point for tuning index according to the jackknife analysis is the 1992 FDEP SW point (Table 9), as was the case in the 2000 SA evaluation. However, overall the early years of the TPWD index show a systematic departure in the fit, where the VPA model consistently predicts a lower abundance for the years prior to 1985 (Fig 16). A further review of the TPWD index shows that the selectivity pattern associated with this index changed considerably in 1985 (Fig 17). From 1981 to 1985 the fishery landed king mackerels ages 4, 5 and 6-7 primarily, then from 1986 until 2000, the fishery shifted towards ages 2 and 3. Based on this observation, we decided to split the index into two time series, the early TPWD index from 1981-1985 and the late TPWD index from 1986-2000. Due to time constraints, the index was simple split without further standardization analysis of each period independently. The new VPA model (denoted BASE 10), now with 10 indices of abundance resulted, as expected in a better model fit to the data, as indicated by the lower sum or squared residuals and higher R-squared value (Table 10). Given the index fitting and diagnostic indicators, we decided to use BASE 10 model as the base case scenario for this 2002 stock assessment. Figure 18 shows a comparison of the Base 10 model and the 2000 SA estimates of stock size, fishing mortality rates and stock biomass. Figure 19 shows the VPA predicted and residual fits to the 10 index series. Figures 20 and 21 present in more detailed the comparison of estimates between year 2000 (diamond symbols) and year 2002 Gulf king mackerel stock assessment. In terms of stock size, the 2002 SA predicted lower numbers at ages 7 through 11 consistently in all common years, compared to 2000 SA (Fig 20). The largest percent decrease is in the plus group (Age 11+). Instead, for ages 0 to 3 both evaluations tend to converge to similar stock size in the early years while the 2002 SA estimates in general, result in lower stock sizes for these ages in the most recent years. The fishing mortality rates for ages 0 through 5 are similar between 2000 SA and 2002 SA, in the early years, but diverge in the latest years. More pronounce are the difference in ages 8, 10 and 11+, for which the 2002 SA estimated overall higher mortality rates (Fig 21).

These results are consistent with the observed change in the 2002 CAA matrix with respect to 2000 evaluation. As the total number of fish by year, summed over all ages did not change, but the distribution of fish by age did vary, moving fish towards younger ages classes, the 2002 VPA results show somewhat higher fishing mortality rates for the older age classes.

The impact of the different index scenarios can also be seen in the spawning potential ratios (SPR). The Base 10 model estimates marginally higher SPR values due to lower estimated F on the plus group relative to the Base 9 scenario (Fig 22). Again, the trends from the two index scenarios are similar, but the Base 9 SPR estimates are lower than the Base 10 ones. In both index scenarios, the transitional SPR trends show an increase since 1995, with a slight decrease in 1999, but increases in 2000 and 2001 fishing years. The static SPR trends show an overall increase since 1994, with a peak in 1999 and decline in 2000 and 2001. The median 2002 static SPR estimates are both just below 30% (29.7%).

For both index scenarios, under the old status determination criteria[3] Gulf of Mexico king mackerel would be classified as overfished because the median unweighted transitional SPR estimate is below 30% and classified as undergoing overfishing in 1999 because the median static SPR estimate is below 30%.

As stated in the last Gulf king mackerel evaluation report (Legault *et al.* 2000), in order to determine the stock status under the new definitions, the maximum sustainable yield fishing mortality rate and associated spawning stock proxies must first be calculated. These proxies are based upon F30%SPR and the two-line model of stock recruitment relationship described above. These proxies are computed by projecting each bootstrap to the year 2050 under constant recruitment and F30%SPR, both specific to that bootstrap. The same proxies for optimum yield (OY) are computed using F40%SPR. The median and 80% confidence intervals for these MSY and OY related benchmarks are given in Table 11. The Base 9 model scenario produces slightly lower estimates for all of these benchmarks compared to the Base 10 model scenario, but the confidence bounds clearly overlap for both models (Fig 23). However, these 2002 SA benchmarks estimates are lower than those estimated in the 2000 SA. This result is partly due to the change in selectivity patterns, with the current fisheries targeting younger ages, and partly due to lower estimated spawning stock abundance producing essentially the same historical level of recruitment as estimated in the 2000 SA.

Using the bootstrap specific estimates of MFMT and MSST, the probability of being classified as undergoing overfishing or being overfished in fishing year 2001 can be calculated. For the Base 10 case, 301 of the 500 bootstraps (60%) produced F>MFMT, while 398 of the 500 bootstraps (80%) produced SS<MSST (Fig 24). For the base 9 case, 359 of the 500 bootstraps (72%) produced F>MFMT, while 434 of the 500 bootstraps (87%) produced SS<MSST (Fig 25). Additionally, the base 10 and base 9 cases produced F>Foy for 486 (97%) and 489 (98%) out of 500 bootstraps, respectively. 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 Gulf king mackerel stock status in fishing year 2001/2002 are shown for both index scenarios in Figure 26.

The fishing year 2002/2003 acceptable biological catch (ABC) for the two index model scenarios have different median values and estimated 80% pseudo confidence interval (Table 12 and Figure 27). Both however, imply a lower ABC that the current TAC allocated for 2001/2002 fishing year.

Two main groups of sensitivity runs were conducted with specific objectives in terms of evaluation of the VPA model fitting.

Sensitivity 1 evaluates the influence of the changes in the 2002 CAA matrix with regards to the 2000 SA evaluation (this run was label CAA00 for identification). In this case the following settings were done:

a) The 2000 CAA was update only for the fishing years 1999 and 2000 (as total number per year did not vary). This was done to recreate the CAA as it existed in 2000, with updates for the most recent years.

b) The partial CAA of 2000 SA for each of the 9 indices were used, for the years 1999 and 2000 the same partial CAA as 1998 was used.

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3 This definition was included in the 2000 MSAP report, here is just repeated. ??????????

c) Nine indices of abundance were used (no split of TPWD index), with the updated as of 2002 standardized values.

d) Equal weighting for indices, and

e) The F ratios for ages 0, 1 to age 2 and 11+ to age 10 were the same as in 2000 SA [3.1, 0.26, 1.0].

Sensitivity 2 evaluates the influence of particular indices in the overall VPA results. In this case, the base-10 model was use a base case, from which 10 runs were attempted each one removing one index at the time. In some cases, the model failed to converge under the base run specifications, in those cases, the model was modified by reducing the number of parameter estimates, specifically terminal F for ages 9 and 10 were no longer considered estimable. Thus for these age classes (and the age 11+) the F ratios were setup equal to 1.0 with respect to F age 7. Only in one case the VPA did no converge, when the bycatch GLM index was remove. For those cases where estimated parameter vary significantly, further bootstrap evaluations were done, as well projections under targets of 30% SPR and 40%SPR.

Results of Sensitivity Analyses

Sensitivity 1. Figure 28 shows a comparison of the sensitivity run CAA00 estimates of stock size, fishing mortality rates and stock biomass with 80% confidence range. In general, estimates of stock biomass were similar to the base 10 scenario, as well fishing mortality rates and stock biomass. Comparison of these estimates with 2000 assessment results were similar to the comparison between Base 10 and the 2000 SA: the CAA00 predicted lower stock sizes and high F's (Fig 28).

The estimates of weighted spawning potential ratios (SPR) show higher values for the CAA00 run compare with the Base 10 scenario for recent fishing years; but static SPR was similar in both cases. With the CAA00 run, the probabilities of the Gulf king mackerel stock being overfished and undergoing overfishing were evaluated. For CAA00, 200 of the 500 bootstraps (40%) produced F > MFMT, while 385 of the 500 bootstraps (77%) produced SS < MSST (Fig 29), and 459 of the 500 bootstraps (92%) produce $F > F_{OY}$. The deterministic run in the CAA00 scenario indicates that at fishing year 2001/02 the Gulf king mackerel stock is above the MSST (i.e. no overfished), and below the MFMT but above the fishing mortality rate F_{OY}.

Sensitivity 2. Figures 30 and 31 summarize the results of sensitivity runs 2 where indices of abundance were removed one at the time from the Base 10 model. The labels 1 through 9 in the plots indicate which index was omitted from that particular run. For runs 1 FEDP NW* and 6 Chart NWF**, we reduced the number of parameter estimates in the model from 9 to 7 (see above for details) to obtained a proper convergence of the model. The model without the Bycatch GLM index did not converge at all. Stock size estimates for younger age(s) groups 0, and 1-2 did not vary greatly between runs or from correspondent estimates of the 2000 assessment (thick line through 1998 in plots). The largest departure was observed in these age groups when the HeadBoat index was not present. For age 3-6, and 7–10 groups overall the sensitivity runs predicted similar stock size with the exception for the case when the Headboat index was not present. The largest difference were observer in 1991-94 for age 3-6, and in 1990-2000 for ages 7-10. In addition, by removing the HeadBoat index the VPA model predicted larger stock sizes than the 2000 assessment. In the case when the TPWD late (1986-00) index was removed, the age group 7-10 estimates were larger compare to the base model, in particular for the latest years 1994 and up. For the plus group (age 11+), again large difference were observed when the HeadBoat index was removed, also the removal of TPWD late index, show departure from the base model in the latest years.

Estimates of stock biomass (ages 3-11+) mirror the results of estimated numbers of Gulf king mackerel. Removing the HeadBoat index had the largest impact, follow by the TPWD late index in total estimated biomass. However, with the exception of the Headboat removal, all predicted stock biomass were below the results predicted in the 2000 assessment.

Estimates of acceptable biological catch (ABC) for the fishing year 2002/2003 from the selected sensitivity runs are presented in Table 15 and Figure 36.

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Table 1. King mackerel Gulf Stock catch summary for number in thousands (July – June fishing year).

	East Gulf			West Gulf			Gulf Mexico		
Fishing Year	**Com**	**Rec**	**Total**	**Com**	**Rec**	**Total**	**Com**	**Rec**	**Total**
1981/82	654	172	827	0	126	126	654	299	953
1982/83	406	435	841	42	388	430	449	823	1271
1983/84	360	270	630	29	72	101	389	342	731
1984/85	282	317	599	44	81	125	326	398	724
1985/86	335	116	451	42	68	110	377	184	561
1986/87	153	384	538	19	58	77	172	442	615
1987/88	107	257	364	12	46	58	119	303	422
1988/89	103	463	566	19	62	81	122	526	647
1989/90	156	469	625	27	45	73	184	514	698
1990/91	180	436	616	37	66	103	217	502	719
1991/92	195	648	843	28	90	118	223	738	961
1992/93	340	540	881	70	92	162	410	632	1042
1993/94	215	560	775	52	125	177	267	685	952
1994/95	276	710	986	55	82	136	330	792	1122
1995/96	241	569	811	49	65	114	290	634	925
1996/97	320	591	911	49	72	121	369	663	1032
1997/98	336	604	940	63	110	173	399	714	1112
1998/99	377	475	852	64	86	150	441	561	1002
1999/00	262	387	649	72	75	147	334	462	796
2000/01	271	474	745	51	98	149	322	572	894

Table 1. (cont.) King mackerel Gulf stock catch summary for weight in thousands of pounds (July – June fishing year).

	East Gulf			West Gulf			Gulf Mexico		
Fishing Year	**Com**	**Rec**	**Total**	**Com**	**Rec**	**Total**	**Com**	**Rec**	**Total**
1981/82	5646	1425	7071	0	1476	1476	5646	2901	8548
1982/83	3802	3735	7538	837	3958	4795	4640	7693	12333
1983/84	2624	1626	4250	348	812	1161	2972	2439	5411
1984/85	2601	2358	4959	603	751	1354	3205	3109	6313
1985/86	2976	979	3956	574	852	1426	3550	1832	5382
1986/87	1165	2618	3784	308	650	958	1473	3269	4742
1987/88	690	1655	2345	178	490	668	868	2145	3013
1988/89	1103	4515	5618	303	761	1063	1405	5276	6681
1989/90	1521	2856	4377	432	504	937	1954	3360	5314
1990/91	1395	3288	4683	421	664	1084	1816	3951	5767
1991/92	1731	3966	5697	386	808	1194	2117	4773	6890
1992/93	2839	5458	8297	760	800	1560	3599	6258	9857
1993/94	1954	4923	6877	618	1224	1841	2572	6146	8718
1994/95	2288	7297	9585	613	651	1265	2901	7948	10849
1995/96	2101	5663	7764	544	602	1146	2645	6265	8910
1996/97	2339	6273	8612	525	659	1185	2864	6933	9797
1997/98	2676	5475	8150	769	1159	1928	3445	6634	10078
1998/99	3209	4360	7569	686	875	1561	3895	5235	9130
1999/00	2189	3222	5411	785	772	1557	2974	3994	6968
2000/01	2375	4072	6446	703	879	1582	3077	4951	8028

Table 2. Gulf of Mexico king mackerel bycatch (Age 0) estimates from two methods, GLM and Delta lognormal models. Note the Delta model did not estimate a value for 1983/84 due to lack of data and so the average of adjacent years was used.

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92
GLM	367439	364263	339505	512626	485458	378920	857273	642341	1309887	874315	1094890
Delta	610384	325065	1054963	1784860	730905	531441	1538399	1224248	2526706	1688042	1877098

	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
GLM	593257	1042106	951220	1118991	619079	740053	405192	258315	442066
Delta	869289	2028434	2180036	2545294	1034516	1026683	168029	111859	128055

Table 3. Gulf of Mexico king mackerel commercial catch at age (CAA) matrix.

Fishing 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	33	269	2143	24979	431877	145049	13810	15813	12361	1683	3426	2825
1982/83	167	941	2370	23797	147982	184071	10241	23576	24523	8721	7696	14666
1983/84	23	72	25528	123668	139142	27218	45800	17099	7077	369	1004	1985
1984/85	12	81	443	7621	144625	96361	42931	24351	6517	730	817	1731
1985/86	227	1345	3110	25053	152975	108375	72874	3489	1225	2448	2957	3336
1986/87	81	13881	10049	25673	71047	19617	11223	8986	1423	4345	78	6003
1987/88	166	14301	43845	23042	15404	7146	5858	6429	595	261	632	1060
1988/89	9	837	4252	3923	54150	33578	9090	5719	2893	1710	543	5114
1989/90	198	24659	35197	31815	33426	20107	7512	9363	6476	2875	4665	7432
1990/91	431	8907	47733	78061	43954	13527	11727	4005	4469	1977	412	1790
1991/92	279	14610	53702	60739	43980	10694	16513	5136	1687	7395	2373	5883
1992/93	69	19588	86658	142777	62525	48482	23474	8588	6225	2529	4465	4946
1993/94	342	30698	61072	62024	48268	22299	8482	10164	6979	3225	1278	12115
1994/95	41	18433	32831	68164	112258	49270	26901	3890	6994	4265	1869	5299
1995/96	411	37434	97105	60646	33082	20527	20318	9059	2907	2637	3362	2888
1996/97	0	50250	176639	71101	28531	12969	12868	8127	3529	987	1018	3381
1997/98	0	34723	133378	115871	49825	25435	8805	9110	8450	6721	2158	4213
1998/99	14	810	19890	98524	115002	159974	18866	10659	8553	4512	1464	2431
1999/00	0	51629	86146	59065	56693	36436	13739	8345	6364	6722	1711	6952
2000/01	662	14972	75169	106336	51791	32486	12681	11773	4014	3808	3013	5430

Table 4. Gulf of Mexico king mackerel recreational catch at age (CAA) matrix.

Fishing 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	32	1177	5098	40397	140234	42485	34317	16406	3130	5775	682	8799
1982/83	9274	21581	180902	112149	176993	102985	81494	41057	13780	64545	12181	5673
1983/84	59	296	103817	134897	26966	22185	23301	11728	8765	5450	1093	3249
1984/85	25	6588	9943	176234	142261	31149	10876	11034	5111	1185	1129	2296
1985/86	270	9300	38517	14012	37855	41969	7695	14471	7564	3877	1743	6353
1986/87	3496	63784	168798	74851	61502	18761	22368	11232	8728	1858	1229	5565
1987/88	1201	50435	123855	55792	28191	19839	9948	4198	3234	1584	1048	3479
1988/89	762	38536	118929	77730	136566	33767	52906	23654	9314	8247	6986	18116
1989/90	2093	195900	155905	65618	38590	17494	7719	11651	6354	3329	2161	7216
1990/91	6574	69623	151680	145433	34576	26169	22922	10596	7585	12734	2517	11349
1991/92	1939	200932	254057	127793	80867	22587	17819	8345	3958	6455	3433	9819
1992/93	2169	69519	160888	174006	60810	42648	23096	20231	26627	13000	7023	31874
1993/94	5426	137406	151431	128748	114376	55724	21943	18197	18467	12551	3202	17675
1994/95	3348	152040	106663	80631	90282	179441	69334	10978	40596	30040	10526	18100
1995/96	3310	89014	201889	116818	66046	45869	49509	26614	11328	5022	6951	12018
1996/97	649	89294	220282	115928	70582	40939	31576	26639	27486	15148	1403	22828
1997/98	161	43310	230130	202417	95252	53551	21066	17176	20280	16253	4567	9630
1998/99	22	19163	51107	107820	181773	95169	56987	13935	13960	6470	7334	7546
1999/00	163	122318	92592	71118	71666	44802	17259	12992	7826	8672	3181	9631
2000/01	332	60436	157542	136291	97238	47635	24659	19305	6406	11559	3365	6915

Table 5. Gulf of Mexico king mackerel total directed catch at age matrix.

Fishing 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	65	1446	7242	65376	572111	187534	48128	32219	15491	7458	4108	11624
1982/83	9441	22522	183273	135947	324974	287056	91735	64634	38302	73266	19877	20338
1983/84	82	368	129346	258565	166109	49403	69101	28827	15842	5819	2097	5233
1984/85	38	6669	10386	183855	286885	127509	53807	35385	11628	1915	1946	4027
1985/86	497	10645	41627	39065	190830	150344	80569	17960	8789	6325	4700	9689
1986/87	3577	77665	178847	100524	132548	38378	33590	20219	10150	6203	1307	11567
1987/88	1367	64736	167700	78833	43595	26985	15806	10627	3828	1844	1680	4539
1988/89	771	39373	123181	81653	190716	67345	61996	29372	12207	9957	7529	23230
1989/90	2292	220559	191102	97434	72016	37602	15230	21013	12830	6204	6826	14648
1990/91	7005	78530	199413	223494	78530	39696	34648	14600	12055	14711	2929	13139
1991/92	2218	215542	307759	188532	124847	33281	34331	13481	5645	13850	5807	15702
1992/93	2239	89108	247546	316783	123335	91130	46570	28818	32853	15529	11488	36820
1993/94	5768	168104	212503	190773	162643	78023	30426	28361	25445	15776	4481	29790
1994/95	3389	170473	139494	148795	202540	228711	96235	14868	47589	34305	12395	23399
1995/96	3722	126449	298994	177464	99129	66396	69827	35673	14235	7660	10313	14906
1996/97	649	139544	396921	187029	99113	53908	44443	34766	31014	16136	2421	26210
1997/98	161	78033	363508	318288	145077	78987	29871	26286	28730	22974	6725	13843
1998/99	36	19973	70997	206344	296774	255143	75853	24594	22513	10982	8798	9977
1999/00	163	173947	178738	130183	128359	81238	30997	21337	14190	15394	4893	16583
2000/01	994	75407	232711	242627	149029	80121	37341	31078	10420	15367	6378	12345

Table 6. Tuning indices for base case[1] runs of Gulf of Mexico king mackerel. 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, numbers or eggs.

	INDICES OF ABUNDANCE								
Fishing Year	**Florida DEP Northwest**	**Florida DEP Southwest**	**MRFSS**	**Texas PWD[4]**	**HeadBoat**	**Charter Northwest Florida**	**Charter Southwest Florida**	**Bycatch Shrimp fishery**	**SEAMAP occurrence**
1981				1.0210	0.7001			2.1547	
1982				0.8744	0.3852			2.0945	
1983				1.2778	0.8893			1.9198	
1984				1.2597	0.3102			2.6963	
1985	17.753	36.787		1.0567	0.2934			2.5305	
1986	21.755	35.696	0.1632	0.4729	0.3851			1.6932	0.1030
1987	22.838	48.300	0.5943	0.8995	0.1769			3.4250	0.1160
1988	18.690	69.571	0.4652	0.7193	0.2563	0.4480	0.4160	2.9394	0.1030
1989	19.880	65.726	0.3460	0.7746	0.5085	0.4425	0.5500	6.0170	0.1940
1990	26.707	84.943	0.9172	0.6212	0.4008	0.4417	0.4700	4.2740	0.1630
1991	29.515	82.456	1.0000	1.5183	0.5943	0.4772	0.3850	4.9805	0.1660
1992	38.750	167.154	0.7519	1.0878	0.6855	0.5012	0.4960	2.4888	0.2630
1993	32.521	103.767	0.5080	0.9896	0.7421	0.4669	0.5600	5.1361	0.2820
1994	39.116	56.904	0.5030	1.0046	0.7353	0.6025	0.8030	4.8192	0.2610
1995	34.617	83.851	0.3943	1.0717	0.6587	0.6341		6.3063	0.3200
1996	55.880	109.332	0.7064	1.2325	0.9318			3.1842	0.2400
1997	75.432	85.442	0.9021	0.8769	1.0000			3.7494	0.3033
1998	46.696	104.764	0.5564	1.1371	0.6645			3.9712	
1999	64.776	57.090	0.5963	0.9398	0.8010			3.9894	
2000	57.088	96.376	0.7207	0.7206				4.9200	
Time	BEG	MID	BEG	BEG	MID	BEG	MID	BEG	BEG
Stock	Biomass	Biomass	Number	Number	Number	Number	Number	Number	Eggs
Ages	3 - 6	3 - 8	2 - 8	2 - 8	2 - 6	2 - 6	3 - 8	0	1 -11+

Table 7. Difference in numbers of the Catch at Age 2002 and Catch at Age 2000 matrix distribution by age and year of Gulf king mackerel. Positive values means that the numbers at age-year in 2002 CAA is larger than the corresponding value in 2000 CAA.

Fishing 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+**
Recreational												
1994/95	629.29	635.18	-331.43	498.34	1285.83	219.83	-1198.91	-193.8	-260.64	-587.13	25.38	-722.08
1995/96	2070.59	10636.29	20809.95	-16405	19011.24	-26543.8	7938.7	-18738.1	174.47	-760.72	2152.93	-346.06
1996/97	-12.38	38651.73	-1271.64	-6515.97	-14692.5	-19038.7	6533.35	-4996.37	-299.27	1875.94	232.89	-467.27
1997/98	-168.77	16074.42	66980.11	-16035.5	-56104.7	1038.39	-10257.7	-4511.08	1048.22	2330.88	-66.94	-325.72
1998/99	-418.91	440.95	-1136.48	-3.67	-444.25	-294.66	107.17	-290.05	-622.05	386.98	-38.39	36.84
Commercial												
1994/95	1.56	1.71	4.44	2.95	11.54	1.4	-8.86	-0.96	-1.61	-4.62	-3.21	-4.31
1995/96	236.39	6701.68	7038.12	-5518.71	6476.74	-11634.1	-4414.75	1053.07	-175.46	-286.84	678.52	-154.47
1996/97	-5.13	27951.01	19225.84	-38641.5	-2594.19	-7797.22	836.14	495.51	-64.54	110.76	86.29	397.23
1997/98	-1.35	12832.65	29331.4	-2734.64	-39734.6	-1434.8	-2456.9	825.32	192.9	391.94	104.79	99.48
1998/99	1	-438.76	3042.11	-1484.73	944.22	1827.45	-1716.95	-1605.09	-685.67	105.56	69.72	-215.36

4 Texas PWD index was split into two series, from 1981-1985 (early TPWD) and from 1986-2000 (late TPWD). See text for further details.

Table 8. Gulf king mackerel tuned VPA results for model BASE 9 (*see text for model setting definitions*).

Stock At Age at beginning of year.

Age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	2441351	1806906	1381385	2514733	2543813	1885361	3007595	3647072	4656750	3647016	2930641
1	2097505	1667830	1143234	825820	1597731	1645436	1199526	1691589	2407104	2634537	2193865
2	1442663	1715986	1345164	935668	670101	1298497	1277074	923671	1349405	1771885	2086078
3	1023784	1174612	1239719	984702	756680	511074	902002	894484	645258	932657	1270957
4	1445439	779219	839164	782434	640757	584263	327992	667404	658712	440543	562726
5	475659	671436	347343	537608	383639	353350	359188	229260	375216	474392	290004
6	361273	221602	293095	239879	325549	179536	254704	269737	127258	273299	352598
7	229109	252425	99385	177854	148018	194138	116765	194273	165109	192538	192538
8	196572	158555	148601	55494	113781	105002	140720	86016	132605	116246	60920
9	136085	146967	95391	107383	34976	85229	76817	111755	59428	97000	84306
10	38686	104687	54989	72849	86188	22943	64184	61227	82518	43063	66168
11+	109466	107115	137222	150752	177677	203050	173411	188911	177077	193172	178916

Age	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
0	2979198	4818302	4643145	5808448	2357754	3404716	4212299	3745734	3797141	0
1	1416948	1903443	3002597	2942818	3745390	1373698	2121911	3083365	2833564	2709520
2	1601850	1079701	1406812	2304491	2295242	2940500	1054275	1719235	2367482	2251842
3	1430745	1088559	692800	1026034	1617358	1521889	2079908	799116	1246457	1728516
4	870769	886557	719518	433405	680298	1155614	959743	1516846	537048	802215
5	348465	601826	579480	407248	265725	467708	815408	519518	1126126	305883
6	207439	203439	422433	269754	273645	169064	311819	438719	352190	849717
7	257729	127966	139159	259342	158128	184026	111531	187128	331230	254687
8	145475	185036	79269	100531	180194	98203	126990	69200	133976	243165
9	44787	89568	128572	22641	69485	119612	54615	83707	43892	100292
10	56554	22751	59132	74454	11670	42385	77259	34836	54680	22165
11+	181261	151251	111628	107613	126346	87246	87612	118062	105837	114545

F at Age during year.

Age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.181	0.2578	0.3145	0.2536	0.2357	0.2522	0.3755	0.2155	0.3696	0.3082	0.5267
1	0.0008	0.015	0.0004	0.0089	0.0074	0.0534	0.0613	0.026	0.1064	0.0334	0.1145
2	0.0056	0.1251	0.1119	0.0123	0.0709	0.1643	0.1561	0.1587	0.1694	0.1323	0.1771
3	0.073	0.1363	0.2602	0.2297	0.0586	0.2435	0.1012	0.106	0.1816	0.3052	0.1781
4	0.5667	0.608	0.2453	0.5127	0.3952	0.2865	0.1581	0.3759	0.1283	0.2181	0.2793
5	0.5638	0.6289	0.1702	0.3016	0.5593	0.1274	0.0864	0.3886	0.1169	0.0967	0.1351
6	0.1585	0.6019	0.2995	0.2828	0.3169	0.2302	0.0708	0.2908	0.1413	0.1503	0.1134
7	0.1681	0.3299	0.3827	0.2467	0.1434	0.1218	0.1056	0.1819	0.1509	0.1954	0.0803
8	0.0908	0.3081	0.1249	0.2616	0.0889	0.1126	0.0305	0.1698	0.1127	0.1213	0.1076
9	0.0623	0.7831	0.0696	0.0199	0.2216	0.0836	0.0268	0.1033	0.1221	0.1825	0.1993
10	0.1243	0.234	0.043	0.0299	0.062	0.0648	0.0293	0.1454	0.0955	0.0779	0.1017
11+	0.1243	0.234	0.043	0.0299	0.062	0.0648	0.0293	0.1454	0.0955	0.0779	0.1017

Age	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01
0	0.248	0.2729	0.256	0.2388	0.3402	0.2728	0.112	0.0791	0.1375
1	0.0718	0.1023	0.0646	0.0485	0.0419	0.0647	0.0104	0.0642	0.0298
2	0.1863	0.2437	0.1156	0.1541	0.2109	0.1463	0.0771	0.1216	0.1146
3	0.2786	0.214	0.2691	0.2109	0.1362	0.261	0.1157	0.1974	0.2407
4	0.1694	0.2252	0.3692	0.2892	0.1747	0.1487	0.4138	0.0978	0.3629
5	0.3382	0.1539	0.5646	0.1976	0.2522	0.2054	0.4198	0.1887	0.0816
6	0.2831	0.1797	0.2879	0.3341	0.1968	0.216	0.3106	0.081	0.1241
7	0.1314	0.2789	0.1252	0.1641	0.2764	0.171	0.2773	0.1341	0.1091
8	0.285	0.1641	1.0531	0.1694	0.2098	0.3867	0.2168	0.2553	0.0896
9	0.4773	0.2152	0.3463	0.4627	0.2943	0.2371	0.2497	0.2258	0.4832
10	0.2526	0.2439	0.2617	0.1654	0.2586	0.1918	0.1339	0.1679	0.1374
11+	0.2526	0.2439	0.2617	0.1654	0.2586	0.1918	0.1339	0.1679	0.1374

Parameter Estimates

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

```
   Input DATA file: gk1a.inp
   Input CONTROL file: gk2a.inp
   Output Stock Size file: gk1eqnor.naa
   Output Fishing Mortality file: gk1eqnor.faa
   Ouput Fitted Indices file: gk1eqnor.ind
   Output Diagnostics (this) file: gk1eqnor.par

   Run name: Gulf King Mackerel 81/82-00/01
   No. index values: 133  Parameters:  9
   Mean Squared Error (rss/df) =   .11765E+00
   Rsquared =   .1404
   Loglikelihood =  -.41749E+02


res from indices   =      178.238143814975900
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 2	.1146	.02445	21.34
F age 3	.2407	.13614	56.56
F age 4	.3629	.05641	15.55
F age 5	.0816	.03421	41.91
F age 6	.1241	.02324	18.73
F age 7	.1091	.05061	46.40
F age 8	.0896	.06291	70.23
F age 9	.4832	.14617	30.25
F age 10	.1374	.03789	27.57

Variances of terminal yr F and survivors

Age,	SE(F,100)	CV(F)	SE(N,101)	CV(N)
0	.29339E-01	21.34091		
1	.63567E-02	21.34091	.62021E+06	22.89020
2	.24449E-01	21.34091	.48799E+06	21.67091
3	.13614	56.56219	.39112E+06	22.62734
4	.56414E-01	15.54609	.51235E+06	63.86732
5	.34213E-01	41.90976	56986.	18.63005
6	.23245E-01	18.72546	.37133E+06	43.70062
7	.50614E-01	46.40487	50811.	19.95038
8	.62911E-01	70.22925	.11931E+06	49.06574
9	.14617	30.24780	73741.	73.52638
10	.37892E-01	27.57275	8507.2	38.38189
11	.37892E-01	27.57275	25141.	21.94808

Obs. and pred. indices in objective function

.47184E+00	.72844E+00
.57818E+00	.86706E+00
.60698E+00	.58945E+00
.49673E+00	.72930E+00
.52836E+00	.53622E+00
.70981E+00	.76902E+00
.78444E+00	.65045E+00
.10299E+01	.11013E+01
.86433E+00	.12075E+01
.10396E+01	.13161E+01
.92004E+00	.91764E+00
.14852E+01	.14107E+01
.20048E+01	.16387E+01
.12411E+01	.12896E+01
.17216E+01	.15603E+01
.15172E+01	.99390E+00
.45692E+00	.33804E+00
.44337E+00	.61875E+00
.59993E+00	.64311E+00
.86413E+00	.50361E+00
.81637E+00	.10823E+01
.10551E+01	.77393E+00
.10242E+01	.62666E+00
.20762E+01	.81190E+00
.12889E+01	.13101E+01
.70679E+00	.95618E+00
.10415E+01	.98829E+00
.13580E+01	.14465E+01
.10613E+01	.15364E+01
.13013E+01	.13155E+01
.70911E+00	.10755E+01
.11971E+01	.10043E+01
.26833E+00	.58390E+00
.97698E+00	.87594E+00
.76466E+00	.74314E+00
.56882E+00	.10520E+01
.15078E+01	.74030E+00
.16438E+01	.12867E+01
.12360E+01	.85038E+00
.83512E+00	.11518E+01
.82687E+00	.46964E+00
.64808E+00	.86446E+00
.11611E+01	.12789E+01
.14829E+01	.14978E+01
.91467E+00	.10239E+01
.98015E+00	.91708E+00
.11847E+01	.13046E+01
.10442E+01	.71706E+00
.89426E+00	.80820E+00
.13068E+01	.29347E+00
.12883E+01	.56939E+00
.10807E+01	.34493E+00
.48362E+00	.88590E+00
.91998E+00	.71546E+00
.73567E+00	.76603E+00
.79218E+00	.66328E+00
.63532E+00	.77276E+00
.15528E+01	.10861E+01
.11125E+01	.12239E+01
.10120E+01	.86215E+00
.10274E+01	.10560E+01
.10960E+01	.13835E+01
.12605E+01	.16005E+01
.89678E+00	.87083E+00
.11629E+01	.13675E+01
.96115E+00	.74425E+00
.73702E+00	.11289E+01
.11964E+01	.63773E+00
.65823E+00	.11335E+01
.15196E+01	.84644E+00
.53000E+00	.51150E+00
.50133E+00	.60542E+00
.65800E+00	.39657E+00
.30225E+00	.89639E+00
.43792E+00	.46151E+00
.86892E+00	.94609E+00
.68487E+00	.76525E+00
.10155E+01	.14670E+01
.11714E+01	.93024E+00
.12682E+01	.12941E+01
.12565E+01	.50790E+00
.11255E+01	.92029E+00
.15922E+01	.12116E+01
.17088E+01	.18421E+01
.11356E+01	.10112E+01
.13687E+01	.15010E+01
.89285E+00	.74811E+00
.88189E+00	.86033E+00
.88030E+00	.10353E+01
.95105E+00	.10554E+01
.99888E+00	.10040E+01
.93052E+00	.92707E+00
.12008E+01	.10109E+01
.12637E+01	.12994E+01
.79130E+00	.56171E+00
.10462E+01	.76396E+00
.89402E+00	.43457E+00
.73234E+00	.11661E+01
.94348E+00	.78704E+00
.10652E+01	.14642E+01
.15274E+01	.36288E+00
.58800E+00	.73441E+00
.57158E+00	.54356E+00
.52390E+00	.41555E+00
.73580E+00	.75649E+00
.69056E+00	.76524E+00
.46205E+00	.56716E+00
.93465E+00	.90475E+00
.80214E+00	.10971E+01
.16420E+01	.14009E+01
.11663E+01	.10971E+01
.13591E+01	.88160E+00
.67918E+00	.89621E+00
.14016E+01	.14495E+01
.13151E+01	.13968E+01
.17209E+01	.17473E+01
.86892E+00	.70927E+00
.10232E+01	.10242E+01
.10837E+01	.12672E+01
.10887E+01	.11268E+01
.13426E+01	.11423E+01
.49159E+00	.91598E+00
.55363E+00	.91492E+00
.49159E+00	.98211E+00
.92590E+00	.93930E+00
.77795E+00	.99687E+00
.79227E+00	.10511E+01
.12552E+01	.11137E+01
.13459E+01	.10698E+01
.12457E+01	.10597E+01
.15273E+01	.95430E+00
.11454E+01	.10157E+01
.14476E+01	.11092E+01

INDEX RESULTS

Equal weighting for indices
ML estimate of variance (all indices): .1097

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	.4718	.4718	.7284	-.2566	-.7748
86/87	.5782	.5782	.8671	-.2889	-.8722
87/88	.6070	.6070	.5894	.0175	.0529
88/89	.4967	.4967	.7293	-.2326	-.7022
89/90	.5284	.5284	.5362	-.0079	-.0237
90/91	.7098	.7098	.7690	-.0592	-.1788
91/92	.7844	.7844	.6505	.1340	.4046
92/93	1.0299	1.0299	1.1013	-.0715	-.2158
93/94	.8643	.8643	1.2075	-.3432	-1.0362
94/95	1.0396	1.0396	1.3161	-.2765	-.8348
95/96	.9200	.9200	.9176	.0024	.0072
96/97	1.4852	1.4852	1.4107	.0744	.2247
97/98	2.0048	2.0048	1.6387	.3661	1.1052
98/99	1.2411	1.2411	1.2896	-.0485	-.1465
99/00	1.7216	1.7216	1.5603	.1613	.4870
00/01	1.5172	1.5172	.9939	.5233	1.5802

ML estimate of catchability: .72509E-07
Pearsons (parametric) correlation: .871 P= .0000
Kendalls (nonparametric) Tau: .700 P= .0000

Selectivity at age from Partial Catches

year	3	4	5	6
85/86	.034	1.000	.639	.257
86/87	.503	.988	1.000	.342
87/88	.361	1.000	.585	.145
88/89	.296	1.000	.141	.479
89/90	1.000	.347	.179	.117
90/91	1.000	.183	.088	.819
91/92	.276	1.000	.292	.100
92/93	1.000	.118	.841	.436
93/94	1.000	.689	.368	.426
94/95	.720	1.000	.838	.438
95/96	.321	.908	.650	1.000
96/97	.869	.625	.755	1.000
97/98	1.000	.699	.602	.743
98/99	.444	1.000	.133	.361
99/00	.979	.532	1.000	.468
00/01	.364	1.000	.340	.265

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	.4569	.4569	.3380	.1189	.3589
86/87	.4434	.4434	.6187	-.1754	-.5295
87/88	.5999	.5999	.6431	-.0432	-.1304
88/89	.8641	.8641	.5036	.3605	1.0885
89/90	.8164	.8164	1.0823	-.2659	-.8030
90/91	1.0551	1.0551	.7739	.2811	.8488
91/92	1.0242	1.0242	.6267	.3975	1.2002
92/93	2.0762	2.0762	.8119	1.2643	3.8173
93/94	1.2889	1.2889	1.3101	-.0212	-.0640
94/95	.7068	.7068	.9562	-.2494	-.7530
95/96	1.0415	1.0415	.9883	.0532	.1607
96/97	1.3580	1.3580	1.4465	-.0885	-.2671
97/98	1.0613	1.0613	1.5364	-.4751	-1.4346
98/99	1.3013	1.3013	1.3155	-.0143	-.0431
99/00	.7091	.7091	1.0755	-.3664	-1.1062
00/01	1.1971	1.1971	1.0043	.1928	.5821

ML estimate of catchability: .80818E-07
Pearsons (parametric) correlation: .427 P= .0087
Kendalls (nonparametric) Tau: .483 P= .0002

Selectivity at age from Partial Catches

year	3	4	5	6	7	8
85/86	.002	.000	1.000	.279	.005	.026
86/87	.319	1.000	.649	.095	.020	.018
87/88	.361	.861	.213	1.000	.000	.000
88/89	.013	1.000	.702	.008	.002	.067
89/90	.906	.898	.584	.328	1.000	.276
90/91	.986	1.000	.013	.314	.307	.000
91/92	.264	1.000	.097	.203	.201	.111
92/93	.807	.012	1.000	.077	.002	.241
93/94	.947	.740	.399	.404	1.000	.249
94/95	.865	.933	.466	.176	.055	1.000
95/96	.597	1.000	.570	.675	.301	.298
96/97	1.000	.605	.559	.773	.559	.213
97/98	1.000	.602	.448	.569	.585	.667
98/99	.493	1.000	.194	.553	.095	.228
99/00	.547	.322	.651	.357	.328	1.000
00/01	.516	1.000	.244	.183	.276	.168

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	.2683	.2683	.5839	-.3156	-.9528
87/88	.9770	.9770	.8759	.1010	.3051
88/89	.7647	.7647	.7431	.0215	.0650
89/90	.5688	.5688	1.0520	-.4831	-1.4588
90/91	1.5078	1.5078	.7403	.7675	2.3173
91/92	1.6438	1.6438	1.2867	.3571	1.0782
92/93	1.2360	1.2360	.8504	.3856	1.1642
93/94	.8351	.8351	1.1518	-.3167	-.9562
94/95	.8269	.8269	.4696	.3572	1.0786
95/96	.6481	.6481	.8645	-.2164	-.6533
96/97	1.1611	1.1611	1.2789	-.1178	-.3556
97/98	1.4829	1.4829	1.4978	-.0149	-.0451
98/99	.9147	.9147	1.0239	-.1093	-.3299
99/00	.9801	.9801	.9171	.0631	.1904
00/01	1.1847	1.1847	1.3046	-.1199	-.3620

ML estimate of catchability: .39197E-06
Pearsons (parametric) correlation: .537 P= .0011
Kendalls (nonparametric) Tau: .314 P= .0148

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8
86/87	.409	1.000	.522	.172	.286	.120	.066
87/88	1.000	.548	.637	.428	.244	.221	.092
88/89	.533	.320	1.000	.573	.759	.414	.383
89/90	1.000	.938	.584	.351	.385	.808	.228
90/91	.374	1.000	.247	.122	.211	.525	.187
91/92	.866	.568	1.000	.298	.194	.146	.146
92/93	.413	.597	.181	.552	.477	.225	1.000
93/94	.898	.786	.621	.380	.517	1.000	.546
94/95	.200	.300	.338	.481	.232	.066	1.000
95/96	.310	.398	.851	.649	1.000	.518	.465
96/97	.626	.430	.530	.976	.846	1.000	.674
97/98	.571	.707	.449	.516	.616	.554	1.000
98/99	.305	.229	1.000	.637	.695	.508	.484
99/00	.338	.696	.365	.667	.323	.478	1.000
00/01	.627	.666	1.000	.243	.233	.304	.146

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.0442	1.0442	.7171	.3271	.9876
82/83	.8943	.8943	.8082	.0861	.2599
83/84	1.3068	1.3068	.2935	1.0133	3.0596
84/85	1.2883	1.2883	.5694	.7189	2.1705
85/86	1.0807	1.0807	.3449	.7358	2.2215
86/87	.4836	.4836	.8859	-.4023	-1.2146
87/88	.9200	.9200	.7155	.2045	.6175
88/89	.7357	.7357	.7660	-.0304	-.0917
89/90	.7922	.7922	.6633	.1289	.3892
90/91	.6353	.6353	.7728	-.1374	-.4150
91/92	1.5528	1.5528	1.0861	.4666	1.4089
92/93	1.1125	1.1125	1.2239	-.1113	-.3362
93/94	1.0120	1.0120	.8621	.1499	.4526
94/95	1.0274	1.0274	1.0560	-.0285	-.0862
95/96	1.0960	1.0960	1.3835	-.2875	-.8680
96/97	1.2605	1.2605	1.6005	-.3401	-1.0268
97/98	.8968	.8968	.8708	.0259	.0783
98/99	1.1629	1.1629	1.3675	-.2046	-.6179
99/00	.9612	.9612	.7442	.2169	.6549
00/01	.7370	.7370	1.1289	-.3919	-1.1832

ML estimate of catchability: .55129E-06
Pearsons (parametric) correlation: .140 P= .2729
Kendalls (nonparametric) Tau: .063 P= .4115

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8
81/82	.001	.058	.329	1.000	.528	.418	.013
82/83	.022	.009	.554	1.000	.348	.689	.401
83/84	.004	.016	.160	.289	.576	1.000	.030
84/85	.001	.090	.366	.847	.250	.488	1.000
85/86	.018	.020	.216	.629	.204	1.000	.036
86/87	.119	.581	.738	.813	1.000	.884	.819
87/88	.196	.421	1.000	.373	.399	.391	.418
88/89	.199	.338	.554	1.000	.613	.518	.445
89/90	.111	.421	.395	.620	1.000	.605	.462
90/91	.124	.263	.698	.598	.664	1.000	.636
91/92	.197	.543	.599	.725	.454	.525	1.000
92/93	.207	.527	.428	.845	1.000	.538	.824
93/94	.361	.299	.468	.349	.261	1.000	.234
94/95	.340	1.000	.245	.571	.353	.455	.318
95/96	.360	.580	1.000	.637	.922	.407	.374
96/97	.432	.481	.613	.914	.875	1.000	.425
97/98	.114	.328	.261	.400	.463	.432	1.000
98/99	.240	.420	.560	.598	.461	.535	1.000
99/00	.110	.394	.239	.486	.258	.265	1.000
00/01	.206	.364	1.000	.294	.228	.409	.165

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.1964	1.1964	.6377	.5586	1.6867
82/83	.6582	.6582	1.1335	-.4753	-1.4351
83/84	1.5196	1.5196	.8464	.6732	2.0327
84/85	.5300	.5300	.5115	.0185	.0559
85/86	.5013	.5013	.6054	-.1041	-.3143
86/87	.6580	.6580	.3966	.2614	.7894
87/88	.3023	.3023	.8964	-.5941	-1.7939
88/89	.4379	.4379	.4615	-.0236	-.0712
89/90	.8689	.8689	.9461	-.0772	-.2330
90/91	.6849	.6849	.7652	-.0804	-.2427
91/92	1.0155	1.0155	1.4670	-.4515	-1.3631
92/93	1.1714	1.1714	.9302	.2412	.7281
93/94	1.2682	1.2682	1.2941	-.0259	-.0782
94/95	1.2565	1.2565	.5079	.7486	2.2602
95/96	1.1255	1.1255	.9203	.2052	.6197
96/97	1.5922	1.5922	1.2116	.3807	1.1494
97/98	1.7088	1.7088	1.8421	-.1333	-.4024
98/99	1.1356	1.1356	1.0112	.1244	.3756
99/00	1.3687	1.3687	1.5010	-.1323	-.3994

ML estimate of catchability: .53735E-06
Pearsons (parametric) correlation: .589 P= .0000
Kendalls (nonparametric) Tau: .392 P= .0006

Selectivity at age from Partial Catches

year	2	3	4	5	6
81/82	.032	.120	1.000	.001	.091
82/83	.370	1.000	.763	.287	.202
83/84	.026	1.000	.472	.695	.129
84/85	.038	.148	1.000	.361	.471
85/86	1.000	.109	.578	.655	.046
86/87	.076	1.000	.384	.084	.273
87/88	.660	.650	1.000	.318	.349
88/89	.083	.264	.714	1.000	.261

89/90	1.000	.619	.306	.258	.425
90/91	.360	1.000	.175	.092	.209
91/92	.630	1.000	.761	.362	.490
92/93	.277	.653	.365	1.000	.520
93/94	.855	.625	.807	.698	1.000
94/95	.108	.212	.238	1.000	.484
95/96	.331	.482	.755	.585	1.000
96/97	.551	.381	.574	1.000	.687
97/98	.493	1.000	.557	.830	.882
98/99	.245	.120	1.000	.864	.818
99/00	.622	1.000	.512	.914	.401

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
88/89	.8929	.8929	.7481	.1447	.4370
89/90	.8819	.8819	.8603	.0216	.0651
90/91	.8803	.8803	1.0353	-.1550	-.4679
91/92	.9510	.9510	1.0554	-.1043	-.3150
92/93	.9989	.9989	1.0040	-.0051	-.0155
93/94	.9305	.9305	.9271	.0034	.0104
94/95	1.2008	1.2008	1.0109	.1899	.5734
95/96	1.2637	1.2637	1.2994	-.0356	-.1075

ML estimate of catchability: .34708E-06
Pearsons (parametric) correlation: .727 P= .0004
Kendalls (nonparametric) Tau: .429 P= .0253

Selectivity at age from Partial Catches

year	2	3	4	5	6
88/89	.778	.473	.990	.360	1.000
89/90	.942	1.000	.605	.334	.297
90/91	.889	1.000	.567	.286	.327
91/92	.899	.393	1.000	.254	.086
92/93	1.000	.668	.209	.248	.322
93/94	1.000	.822	.544	.251	.315
94/95	.735	.905	1.000	.673	.336
95/96	.924	1.000	.700	.372	.491

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
88/89	.7913	.7913	.5617	.2296	.6932
89/90	1.0462	1.0462	.7640	.2822	.8522
90/91	.8940	.8940	.4346	.4595	1.3873
91/92	.7323	.7323	1.1661	-.4337	-1.3096
92/93	.9435	.9435	.7870	.1564	.4723
93/94	1.0652	1.0652	1.4642	-.3990	-1.2047
94/95	1.5274	1.5274	.3629	1.1646	3.5162

ML estimate of catchability: .69448E-06
Pearsons (parametric) correlation: -.314 P= .1841
Kendalls (nonparametric) Tau: -.143 P= .3705

Selectivity at age from Partial Catches

year	3	4	5	6	7	8
88/89	.104	1.000	.623	.425	.115	.065
89/90	1.000	.505	.408	.661	.323	.286
90/91	.316	.350	.236	.392	1.000	.065
91/92	.855	.652	.451	.668	.698	1.000
92/93	.441	.281	.551	.460	.399	1.000
93/94	.716	1.000	.751	.939	.702	.883
94/95	.089	.128	.620	.291	.083	1.000

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	.5880	.5880	.7344	-.1464	-.4421
82/83	.5716	.5716	.5436	.0280	.0846
83/84	.5239	.5239	.4156	.1083	.3271
84/85	.7358	.7358	.7565	-.0207	-.0625
85/86	.6906	.6906	.7652	-.0747	-.2255
86/87	.4620	.4620	.5672	-.1051	-.3174
87/88	.9346	.9346	.9048	.0299	.0903
88/89	.8021	.8021	1.0971	-.2950	-.8906
89/90	1.6420	1.6420	1.4009	.2411	.7280
90/91	1.1663	1.1663	1.0971	.0692	.2090
91/92	1.3591	1.3591	.8816	.4775	1.4418
92/93	.6792	.6792	.8962	-.2170	-.6553
93/94	1.4016	1.4016	1.4495	-.0479	-.1445
94/95	1.3151	1.3151	1.3968	-.0816	-.2465
95/96	1.7209	1.7209	1.7473	-.0264	-.0797
96/97	.8689	.8689	.7093	.1597	.4821
97/98	1.0232	1.0232	1.0242	-.0010	-.0032
98/99	1.0837	1.0837	1.2672	-.1835	-.5539
99/00	1.0887	1.0887	1.1268	-.0381	-.1151
00/01	1.3426	1.3426	1.1423	.2004	.6050

ML estimate of catchability: .30082E-06
Pearsons (parametric) correlation: .884 P= .0000
Kendalls (nonparametric) Tau: .705 P= .0000

Selectivities set to 1.0

year	0
81/82	1.000
82/83	1.000
83/84	1.000
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
00/01	1.000

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	.4916	.4916	.9160	-.4244	-1.2814
87/88	.5536	.5536	.9149	-.3613	-1.0909
88/89	.4916	.4916	.9821	-.4905	-1.4811
89/90	.9259	.9259	.9393	-.0134	-.0404
90/91	.7780	.7780	.9969	-.2189	-.6610
91/92	.7923	.7923	1.0511	-.2588	-.7814
92/93	1.2552	1.2552	1.1137	.1415	.4273
93/94	1.3459	1.3459	1.0698	.2761	.8336
94/95	1.2457	1.2457	1.0597	.1860	.5615
95/96	1.5273	1.5273	.9543	.5730	1.7300
96/97	1.1454	1.1454	1.0157	.1297	.3916
97/98	1.4476	1.4476	1.1092	.3383	1.0216

ML estimate of catchability: .30631E-06
Pearsons (parametric) correlation: .611 P= .0006
Kendalls (nonparametric) Tau: .504 P= .0009

Selectivities input

year	1	2	3	4	5	6	7	8	9	10	11
86/87	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
87/88	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
88/89	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
89/90	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
90/91	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
91/92	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
92/93	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
93/94	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
94/95	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
95/96	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
96/97	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
97/98	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853

Table 9 Jacknife estimates for tuned VPA model fit Base 9.

MODEL BASE 9

INDEX	Year	Flag	Ln(liklhd)	MSE	Values								
Initial estimates			45.549	0.125	0.1126	0.405	0.2433	0.0871	0.1406	0.2905	0.0671	0.5366	0.1638
FDEP SW	92	*0*	38.235	0.112	0.1124	0.3908	0.2426	0.0871	0.1374	0.2868	0.0661	0.5081	0.1754
Chart SWF	94	*0*	39.447	0.114	0.1127	0.4059	0.2437	0.0873	0.141	0.2917	0.0669	0.5392	0.1661
TPWD	83	*0*	41.209	0.117	0.1123	0.4018	0.2418	0.0868	0.1392	0.2818	0.0683	0.5214	0.1569
Bycatch GLM	100	*0*	42.451	0.12	0.1332	0.4059	0.2433	0.0871	0.1406	0.2911	0.0669	0.5367	0.1637
Bycatch GLM	92	*0*	42.802	0.12	0.1176	0.4156	0.251	0.101	0.146	0.3106	0.0079	0.5716	0.1844
TPWD	100	*0*	43.042	0.121	0.1097	0.3883	0.2345	0.0832	0.1302	0.1102	0.0914	0.4984	0.1434
MRFSS	90	*0*	43.179	0.121	0.1123	0.3931	0.2415	0.0869	0.139	0.2824	0.0685	0.5185	0.1562
Headboat	94	*0*	43.26	0.121	0.1125	0.4048	0.2428	0.0871	0.1385	0.2898	0.0668	0.5338	0.1656
TPWD	85	*0*	43.38	0.121	0.1124	0.4027	0.2423	0.0869	0.1396	0.2838	0.0681	0.5249	0.1591
TPWD	84	*0*	43.492	0.121	0.1123	0.4009	0.2415	0.0867	0.1389	0.2791	0.0688	0.5169	0.1554
Headboat	83	*0*	43.737	0.122	0.1108	0.3908	0.2356	0.0846	0.1343	0.2778	0.0703	0.5166	0.1289
Headboat	87	*0*	43.938	0.122	0.113	0.4083	0.2457	0.0878	0.1457	0.2947	0.0671	0.5499	0.1686
SEAMAP Occurrence	95	*0*	44.029	0.122	0.1136	0.4077	0.2446	0.088	0.1417	0.2949	0.0913	0.5468	0.1699
MRFSS	89	*0*	44.42	0.123	0.1129	0.4185	0.2452	0.0874	0.1422	0.2996	0.0656	0.5573	0.1726
Headboat	81	*0*	44.426	0.123	0.1123	0.4021	0.2414	0.0866	0.1373	0.2864	0.0672	0.5263	0.1585
Headboat	82	*0*	44.46	0.123	0.1131	0.4092	0.2462	0.0879	0.1464	0.2959	0.067	0.5529	0.1707
FDEP SW	97	*0*	44.484	0.123	0.1125	0.4185	0.2421	0.0869	0.1358	0.2821	0.0667	0.5675	0.1661
SEAMAP Occurrence	88	*0*	44.509	0.123	0.113	0.4061	0.2439	0.088	0.1411	0.2923	0.0744	0.5404	0.1661
Chart SWF	93	*0*	44.551	0.123	0.1126	0.4053	0.2434	0.0872	0.1407	0.2908	0.067	0.5373	0.1644
Headboat	91	*0*	44.552	0.123	0.1139	0.3999	0.2419	0.089	0.1427	0.3024	0.182	0.5539	0.1364
Chart SWF	91	*0*	44.63	0.124	0.1125	0.4046	0.2431	0.0871	0.1404	0.2898	0.0671	0.5353	0.1626
FDEP SW	99	*0*	44.666	0.124	0.1139	0.4035	0.2421	0.0881	0.1387	0.2861	0.1824	0.3173	0.1623
Bycatch GLM	95	*0*	44.707	0.124	0.1151	0.4066	0.2422	0.0098	0.14	0.2944	0.1737	0.5462	0.1661
Headboat	98	*0*	44.717	0.124	0.1128	0.4071	0.2449	0.0877	0.1434	0.3044	0.0674	0.5394	0.1647
TPWD	91	*0*	44.76	0.124	0.1123	0.4012	0.2417	0.0868	0.1391	0.278	0.0691	0.5156	0.1567
Bycatch GLM	91	*0*	44.76	0.124	0.1082	0.4035	0.2411	0.0814	0.1398	0.2888	0.0593	0.5458	0.1621
Chart SWF	90	*0*	44.765	0.124	0.1126	0.405	0.2433	0.0871	0.1405	0.2904	0.0671	0.5364	0.1636
SEAMAP Occurrence	97	*0*	44.796	0.124	0.1151	0.4085	0.2453	0.0942	0.141	0.2973	0.1744	0.5492	0.1698
FDEP NW	97	*0*	44.808	0.124	0.1117	0.3976	0.23	0.0862	0.1426	0.2963	0.0656	0.5181	0.1395
SEAMAP Occurrence	86	*0*	44.81	0.124	0.113	0.4061	0.2439	0.0879	0.1411	0.2923	0.0727	0.5403	0.1661
TPWD	96	*0*	44.858	0.124	0.1107	0.3887	0.2345	0.0841	0.1375	0.2869	0.0731	0.5285	0.1174
TPWD	86	*0*	44.886	0.124	0.1128	0.4079	0.2446	0.0874	0.1418	0.2998	0.0655	0.5541	0.1696
Headboat	96	*0*	44.975	0.124	0.1125	0.4065	0.2424	0.0868	0.1383	0.2895	0.0669	0.6071	0.1621
SEAMAP Occurrence	87	*0*	45.056	0.124	0.1129	0.4058	0.2439	0.0878	0.1411	0.292	0.0718	0.54	0.1661
FDEP SW	91	*0*	45.065	0.124	0.1125	0.4011	0.2428	0.0871	0.1393	0.2896	0.0669	0.5278	0.1651
MRFSS	93	*0*	45.073	0.124	0.1128	0.4158	0.2449	0.0874	0.142	0.298	0.0658	0.5547	0.1713
MRFSS	92	*0*	45.084	0.124	0.1126	0.3994	0.2429	0.0872	0.1402	0.2876	0.0677	0.5296	0.1626
FDEP NW	93	*0*	45.179	0.125	0.1126	0.4046	0.2498	0.087	0.1429	0.2904	0.0667	0.535	0.1603
MRFSS	91	*0*	45.182	0.125	0.1125	0.3961	0.2424	0.0871	0.1398	0.2852	0.0681	0.5245	0.1601
MRFSS	94	*0*	45.183	0.125	0.1125	0.4018	0.2429	0.0871	0.1402	0.2885	0.0668	0.5318	0.1622
TPWD	95	*0*	45.184	0.125	0.1132	0.4065	0.2442	0.0872	0.142	0.3004	0.0697	0.508	0.1731
MRFSS	86	*0*	45.19	0.125	0.1127	0.4095	0.2439	0.0872	0.1411	0.2935	0.0665	0.5435	0.1667
FDEP SW	88	*0*	45.195	0.125	0.1125	0.4016	0.2427	0.087	0.1394	0.289	0.067	0.5287	0.1633
FDEP NW	99	*0*	45.199	0.125	0.1125	0.4037	0.2365	0.0863	0.152	0.3042	0.0696	0.5347	0.1484
Bycatch GLM	98	*0*	45.218	0.125	0.0944	0.3986	0.2405	0.0867	0.1398	0.2938	0.069	0.522	0.1456
Bycatch GLM	88	*0*	45.238	0.125	0.1164	0.4055	0.2446	0.0923	0.1408	0.2903	0.0756	0.535	0.1612
TPWD	81	*0*	45.252	0.125	0.1117	0.396	0.2394	0.086	0.1378	0.288	0.0694	0.5089	0.14
FDEP SW	89	*0*	45.26	0.125	0.1128	0.4121	0.2444	0.0874	0.143	0.2931	0.0672	0.5532	0.1641
FDEP NW	96	*0*	45.293	0.125	0.1124	0.4042	0.2376	0.087	0.1402	0.295	0.0656	0.534	0.1606
FDEP NW	94	*0*	45.301	0.125	0.1116	0.3952	0.2438	0.0856	0.139	0.2914	0.0689	0.5293	0.131
FDEP NW	86	*0*	45.305	0.125	0.1128	0.4064	0.2481	0.0873	0.1427	0.2928	0.0666	0.5403	0.1658
SEAMAP Occurrence	93	*0*	45.339	0.125	0.1125	0.4056	0.2435	0.0869	0.1408	0.2912	0.0642	0.5385	0.1656
FDEP SW	96	*0*	45.347	0.125	0.1125	0.3998	0.243	0.087	0.1404	0.2956	0.0671	0.5246	0.1621
Chart SWF	89	*0*	45.347	0.125	0.1125	0.4041	0.2428	0.087	0.1402	0.2891	0.0672	0.5339	0.1613
FDEP SW	94	*0*	45.351	0.125	0.1127	0.4097	0.2438	0.0872	0.1421	0.2914	0.0673	0.547	0.1619
SEAMAP Occurrence	91	*0*	45.371	0.125	0.1128	0.4052	0.2434	0.0875	0.1407	0.2909	0.071	0.5376	0.164
FDEP NW	85	*0*	45.388	0.125	0.1128	0.4063	0.247	0.0873	0.1423	0.2925	0.0667	0.5401	0.166
TPWD	99	*0*	45.407	0.125	0.1127	0.4076	0.2435	0.087	0.1414	0.2901	0.0672	0.5982	0.1643
Headboat	86	*0*	45.436	0.125	0.1125	0.4043	0.2428	0.087	0.1397	0.2895	0.0671	0.534	0.1625
FDEP SW	90	*0*	45.437	0.125	0.1124	0.4005	0.2423	0.0869	0.139	0.288	0.0671	0.5259	0.1617
Headboat	92	*0*	45.444	0.125	0.1126	0.4053	0.2431	0.0872	0.1393	0.2911	0.0669	0.5361	0.1661
FDEP NW	88	*0*	45.452	0.125	0.1127	0.4059	0.2464	0.0873	0.142	0.2918	0.0668	0.5388	0.1649
SEAMAP Occurrence	90	*0*	45.463	0.125	0.1128	0.4054	0.2435	0.0875	0.1407	0.2911	0.0702	0.5379	0.1644
Chart SWF	88	*0*	45.468	0.125	0.1126	0.4049	0.2432	0.0871	0.1405	0.2903	0.0671	0.5363	0.1635
MRFSS	95	*0*	45.47	0.125	0.1126	0.4079	0.2432	0.087	0.1405	0.2915	0.0681	0.5395	0.1626
Bycatch GLM	97	*0*	45.48	0.125	0.1108	0.4181	0.2431	0.0848	0.1407	0.2912	0.0635	0.5394	0.1644
Bycatch GLM	89	*0*	45.496	0.125	0.1091	0.4036	0.2416	0.0826	0.1399	0.2891	0.0608	0.5351	0.1633

Headboat	95	*0*	45.502	0.125	0.1126	0.4054	0.2432	0.0872	0.1396	0.2912	0.0669	0.5366	0.1661
FDEP SW	86	*0*	45.521	0.125	0.1127	0.4079	0.2439	0.0873	0.1416	0.2919	0.0671	0.5435	0.1648
Chart NWF	90	*0*	45.522	0.125	0.1126	0.4053	0.2434	0.0871	0.1406	0.2919	0.0666	0.5386	0.164
Headboat	99	*0*	45.527	0.125	0.1121	0.4016	0.2404	0.0864	0.1343	0.2778	0.0669	0.5295	0.1611
SEAMAP Occurrence	94	*0*	45.534	0.125	0.1127	0.4057	0.2436	0.0872	0.1408	0.2913	0.0684	0.539	0.1655
Chart NWF	94	*0*	45.538	0.125	0.1126	0.4057	0.2437	0.0872	0.1409	0.2906	0.0662	0.5372	0.1661
TPWD	87	*0*	45.553	0.125	0.1125	0.4036	0.2426	0.087	0.14	0.2865	0.0676	0.5296	0.1606
TPWD	98	*0*	45.557	0.125	0.112	0.3986	0.24	0.0866	0.1379	0.2873	0.0686	0.525	0.1465
SEAMAP Occurrence	96	*0*	45.566	0.125	0.1132	0.4062	0.2439	0.088	0.1412	0.2926	0.0788	0.5411	0.1661
Chart SWF	92	*0*	45.57	0.125	0.1126	0.4056	0.2436	0.0872	0.1408	0.2913	0.067	0.5383	0.1653
Bycatch GLM	81	*0*	45.578	0.125	0.1139	0.4057	0.244	0.089	0.1409	0.2911	0.0697	0.5375	0.1642
Bycatch GLM	93	*0*	45.593	0.125	0.1105	0.4045	0.2424	0.0843	0.1403	0.2945	0.063	0.5366	0.1634
TPWD	92	*0*	45.599	0.125	0.1127	0.4065	0.2439	0.0873	0.1411	0.2954	0.0663	0.5454	0.1667
TPWD	90	*0*	45.6	0.125	0.1127	0.406	0.2437	0.0872	0.1409	0.2936	0.0666	0.5421	0.1658
Chart NWF	95	*0*	45.6	0.125	0.1125	0.4049	0.2432	0.087	0.1405	0.2957	0.0658	0.535	0.1625
SEAMAP Occurrence	92	*0*	45.614	0.125	0.1125	0.4051	0.2433	0.0869	0.1406	0.2904	0.0651	0.5366	0.164
Chart NWF	91	*0*	45.615	0.125	0.1126	0.4048	0.2432	0.0871	0.1405	0.2909	0.0668	0.537	0.1629
FDEP NW	91	*0*	45.624	0.125	0.1126	0.4049	0.2419	0.0871	0.14	0.2902	0.0672	0.5363	0.1639
TPWD	93	*0*	45.63	0.125	0.1125	0.4039	0.2428	0.087	0.1401	0.2872	0.0675	0.5307	0.1614
Bycatch GLM	99	*0*	45.63	0.125	0.1042	0.4046	0.2432	0.0869	0.1405	0.2901	0.0668	0.5364	0.1637
Headboat	85	*0*	45.637	0.125	0.1127	0.4056	0.2437	0.0872	0.1413	0.2912	0.067	0.5387	0.1648
Bycatch GLM	86	*0*	45.638	0.125	0.1133	0.4054	0.2437	0.0882	0.1407	0.2909	0.0685	0.5372	0.1641
MRFSS	96	*0*	45.641	0.125	0.1125	0.4065	0.2428	0.0869	0.1402	0.29	0.0675	0.5363	0.1606
Chart NWF	88	*0*	45.643	0.125	0.1126	0.4048	0.2432	0.0871	0.1405	0.2897	0.0673	0.5355	0.1634
Headboat	97	*0*	45.645	0.125	0.1126	0.4051	0.2429	0.0871	0.1388	0.2909	0.0669	0.5383	0.1651
TPWD	89	*0*	45.647	0.125	0.1125	0.4043	0.243	0.0871	0.1403	0.2884	0.0674	0.533	0.1624
FDEP SW	85	*0*	45.658	0.125	0.1126	0.4042	0.2431	0.0871	0.1403	0.2901	0.0671	0.5348	0.1635
Headboat	89	*0*	45.66	0.126	0.1126	0.4055	0.2436	0.0872	0.1414	0.291	0.0671	0.5385	0.1643
Bycatch GLM	94	*0*	45.663	0.126	0.1141	0.4053	0.2436	0.0891	0.1397	0.2907	0.0701	0.5363	0.1639
Headboat	90	*0*	45.665	0.126	0.1126	0.4053	0.2435	0.0872	0.1411	0.2907	0.0671	0.5378	0.1639
Bycatch GLM	83	*0*	45.665	0.126	0.1122	0.4048	0.2431	0.0866	0.1405	0.2902	0.0663	0.5363	0.1636
MRFSS	99	*0*	45.667	0.126	0.1126	0.4049	0.2434	0.0871	0.141	0.2913	0.067	0.566	0.1642
Bycatch GLM	85	*0*	45.667	0.126	0.1133	0.4052	0.2436	0.0881	0.1406	0.2906	0.0686	0.5366	0.1635
FDEP NW	92	*0*	45.672	0.126	0.1127	0.4056	0.2451	0.0872	0.1414	0.2913	0.0669	0.538	0.1646
FDEP SW	93	*0*	45.675	0.126	0.1127	0.4075	0.2438	0.0873	0.1414	0.2916	0.0671	0.5424	0.1644
MRFSS	100	*0*	45.679	0.126	0.1126	0.3886	0.243	0.087	0.1403	0.2906	0.0667	0.5359	0.1647
MRFSS	87	*0*	45.68	0.126	0.1126	0.4036	0.2431	0.0871	0.1404	0.2895	0.0672	0.5344	0.1628
FDEP SW	87	*0*	45.683	0.126	0.1126	0.406	0.2435	0.0872	0.1409	0.2909	0.0671	0.5388	0.164
FDEP NW	90	*0*	45.687	0.126	0.1126	0.4052	0.2441	0.0872	0.1409	0.2908	0.067	0.5371	0.1639
TPWD	82	*0*	45.688	0.126	0.1125	0.4044	0.243	0.0871	0.1403	0.2889	0.0673	0.5338	0.1624
TPWD	97	*0*	45.688	0.126	0.1126	0.4057	0.2437	0.0872	0.1409	0.2907	0.0668	0.5374	0.1659
MRFSS	98	*0*	45.693	0.126	0.1126	0.4057	0.2433	0.0872	0.1407	0.2862	0.0673	0.5372	0.1642
TPWD	88	*0*	45.693	0.126	0.1126	0.4054	0.2435	0.0872	0.1407	0.2916	0.0669	0.5387	0.1647
TPWD	94	*0*	45.693	0.126	0.1126	0.4054	0.2435	0.0872	0.1407	0.292	0.0671	0.5353	0.1652
Bycatch GLM	90	*0*	45.693	0.126	0.112	0.4049	0.2431	0.0863	0.1405	0.2905	0.0658	0.5368	0.1641
Bycatch GLM	84	*0*	45.697	0.126	0.1129	0.4052	0.2434	0.0876	0.1406	0.2906	0.0677	0.5367	0.1638
FDEP SW	100	*0*	45.698	0.126	0.1125	0.3959	0.243	0.087	0.1407	0.2899	0.067	0.5368	0.1633
Headboat	88	*0*	45.699	0.126	0.1126	0.4051	0.2434	0.0872	0.1407	0.2906	0.0671	0.537	0.1639
Chart NWF	92	*0*	45.699	0.126	0.1126	0.405	0.2433	0.0871	0.1405	0.2905	0.067	0.5367	0.1636
Chart NWF	93	*0*	45.699	0.126	0.1126	0.4051	0.2434	0.0872	0.1406	0.2908	0.067	0.5352	0.1642
MRFSS	97	*0*	45.7	0.126	0.1126	0.405	0.2437	0.0871	0.1409	0.2913	0.0668	0.5381	0.1661
FDEP SW	95	*0*	45.702	0.126	0.1126	0.4047	0.2432	0.0871	0.1404	0.2903	0.0671	0.5381	0.1637
Chart NWF	89	*0*	45.702	0.126	0.1126	0.4051	0.2433	0.0872	0.1406	0.2907	0.067	0.537	0.164
SEAMAP Occurrence	89	*0*	45.702	0.126	0.1126	0.4051	0.2433	0.0872	0.1406	0.2905	0.0673	0.5368	0.1639
FDEP NW	89	*0*	45.703	0.126	0.1126	0.4051	0.2435	0.0871	0.1406	0.2906	0.067	0.5368	0.1639
FDEP NW	95	*0*	45.703	0.126	0.1126	0.4051	0.243	0.0871	0.1405	0.2905	0.067	0.5368	0.1641
FDEP SW	98	*0*	45.703	0.126	0.1126	0.4048	0.2434	0.0872	0.1409	0.2904	0.0671	0.5361	0.1638
Headboat	93	*0*	45.703	0.126	0.1126	0.4049	0.2433	0.0871	0.1406	0.2903	0.0671	0.5364	0.1634
Bycatch GLM	96	*0*	45.703	0.126	0.1128	0.405	0.2421	0.0873	0.1405	0.2904	0.0674	0.5365	0.1637
FDEP NW	87	*0*	45.704	0.126	0.1126	0.405	0.2432	0.0871	0.1405	0.2904	0.0671	0.5365	0.1637
FDEP NW	98	*0*	45.704	0.126	0.1126	0.405	0.2433	0.0871	0.1406	0.2905	0.0671	0.5366	0.1638
FDEP NW	100	*0*	45.704	0.126	0.1126	0.4051	0.2465	0.0872	0.1406	0.2906	0.0672	0.5367	0.1638
MRFSS	88	*0*	45.704	0.126	0.1126	0.4051	0.2433	0.0871	0.1406	0.2905	0.0671	0.5367	0.1638
Headboat	84	*0*	45.704	0.126	0.1126	0.405	0.2433	0.0871	0.1406	0.2905	0.0671	0.5366	0.1638
Bycatch GLM	82	*0*	45.704	0.126	0.1125	0.405	0.2433	0.087	0.1406	0.2904	0.0669	0.5366	0.1638
Bycatch GLM	87	*0*	45.704	0.126	0.1125	0.405	0.2433	0.087	0.1406	0.2904	0.0669	0.5366	0.1638
AVERAGE					0.1126	0.4044	0.243	0.0866	0.1405	0.2895	0.0707	0.5356	0.1623

Table 10. Gulf king mackerel tuned VPA results for model BASE 10 (*see text for model setting definitions*).

Stock At Age at beginning of year.

Age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93
0	2458608	1823222	1389869	2542745	2589498	1893996	3047482	3734741	4702401	3731076	2953230	3008457
1	2106070	1681951	1156578	832755	1620641	1682806	1206588	1724171	2478828	2671829	2262581	1435359
2	1454784	1722998	1356725	946593	675779	1317254	1307668	929452	1376080	1830597	2116609	1658098
3	1030176	1184535	1245458	994166	765625	515722	917353	919523	649989	954486	1319012	1455729
4	1450799	784452	847286	787128	648498	591586	331794	679970	679208	444415	580572	910093
5	477131	675801	351601	544251	387465	359672	365175	232371	385480	491168	293172	363058
6	365473	222801	296646	243364	330980	182653	259879	274638	129799	281702	366332	210032
7	231928	255861	100360	180757	150868	198577	119314	198509	169116	92544	199415	268971
8	198254	160863	151409	56290	116156	107334	144353	88103	136071	119525	62622	151105
9	138142	148344	97277	109682	35628	87172	78726	114730	61136	99837	86991	46180
10	39236	106371	56105	74393	88071	23476	65775	62790	84954	44461	68490	58751
11+	111021	108838	140009	153948	181557	207768	177709	193733	182303	199443	185195	188302

Age	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
0	4889860	4717352	5893108	2423513	3446781	4267427	3802027	3855729	0
1	1927375	3061113	3003509	3814639	1427437	2156310	3128491	2879647	2757474
2	1094774	1426402	2352396	2344930	2997194	1098270	1747398	2404425	2289572
3	1134586	705128	1042069	1656565	1562541	2126309	835132	1269509	1758756
4	906986	757174	443487	693417	1187704	992989	1554828	566518	821071
5	634008	596192	438013	273968	478444	841672	546663	1157219	329961
6	215365	448772	283368	298818	175806	320603	460162	374403	875170
7	130086	148918	280878	169254	204624	117047	194308	348784	272869
8	194237	81002	108519	197820	107302	143847	73710	139853	257535
9	94171	136102	24035	76023	134033	62048	97499	47581	105103
10	23888	62898	80608	12808	47730	89056	40916	65964	25174
11+	158806	118738	116508	138661	98249	100990	138669	127677	141658

F at Age during year.

Age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.1796	0.2551	0.3122	0.2504	0.231	0.2509	0.3696	0.2099	0.3653	0.3002	0.5215
1	0.0008	0.0149	0.0004	0.0089	0.0073	0.0522	0.061	0.0255	0.1031	0.0329	0.1108
2	0.0055	0.1246	0.1109	0.0122	0.0703	0.1618	0.1521	0.1576	0.1658	0.1278	0.1743
3	0.0725	0.1351	0.2589	0.2272	0.0579	0.2411	0.0994	0.1029	0.1802	0.2972	0.1711
4	0.564	0.6025	0.2426	0.5088	0.3895	0.2824	0.1562	0.3676	0.1241	0.216	0.2695
5	0.5615	0.6234	0.1679	0.2974	0.552	0.125	0.0849	0.3823	0.1136	0.0932	0.1335
6	0.1566	0.5975	0.2954	0.2782	0.3109	0.2258	0.0694	0.2849	0.1383	0.1455	0.1089
7	0.1659	0.3246	0.3782	0.2422	0.1405	0.1189	0.1033	0.1777	0.1471	0.1906	0.0774
8	0.09	0.303	0.1224	0.2574	0.087	0.11	0.0297	0.1654	0.1096	0.1177	0.1046
9	0.0613	0.7723	0.0682	0.0194	0.2171	0.0816	0.0262	0.1005	0.1185	0.1769	0.1925
10	0.1225	0.2299	0.0421	0.0293	0.0606	0.0633	0.0286	0.1415	0.0927	0.0754	0.098
11+	0.1225	0.2299	0.0421	0.0293	0.0606	0.0633	0.0286	0.1415	0.0927	0.0754	0.098

Age	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01
0	0.2453	0.2684	0.2515	0.2349	0.3293	0.269	0.1105	0.0779	0.1352
1	0.0709	0.101	0.0633	0.0475	0.0412	0.0621	0.0103	0.0632	0.0293
2	0.1794	0.2399	0.1139	0.1507	0.2059	0.1433	0.0739	0.1195	0.1127
3	0.2731	0.2044	0.2637	0.2073	0.1327	0.2533	0.113	0.1881	0.2358
4	0.1615	0.2196	0.3473	0.2817	0.1711	0.1444	0.3969	0.0953	0.3405
5	0.3222	0.1455	0.5438	0.1824	0.2436	0.2003	0.4038	0.1785	0.0794
6	0.2791	0.1689	0.2686	0.3153	0.1787	0.2068	0.3008	0.0771	0.1163
7	0.1255	0.2737	0.1165	0.1506	0.2558	0.1524	0.2624	0.1289	0.1033
8	0.2729	0.1557	1.0149	0.1559	0.1893	0.3477	0.1889	0.2377	0.0857
9	0.4592	0.2036	0.3238	0.4295	0.2655	0.2088	0.2164	0.1907	0.4366
10	0.2419	0.2309	0.244	0.1518	0.2329	0.1684	0.1152	0.1411	0.1126
11+	0.2419	0.2309	0.244	0.1518	0.2329	0.1684	0.1152	0.1411	0.1126

PARAMETER ESTIMATES

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

Input DATA file: gk1c.inp
Input CONTROL file: gk2a.inp
Output Stock Size file: gk1eqnor.naa
Output Fishing Mortality file: gk1eqnor.faa
Ouput Fitted Indices file: gk1eqnor.ind
Output Diagnostics (this) file: gk1eqnor.par

Run name: Gulf King Mackerel 81/82-00/01
No. index values: 133 Parameters: 9
Mean Squared Error (rss/df) =   .10734E+00
Rsquared =   .2140
Loglikelihood = -.35646E+02

res from indices   =   172.135504917566400
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 2	.1127	.02297	20.38
F age 3	.2358	.12702	53.87
F age 4	.3405	.05109	15.00
F age 5	.0794	.03131	39.46
F age 6	.1163	.02083	17.90
F age 7	.1033	.04500	43.57
F age 8	.0857	.05661	66.10
F age 9	.4366	.11936	27.34
F age 10	.1126	.02796	24.83

Variances of terminal yr F and survivors

Age,	SE(F,100)	CV(F)	SE(N,101)	CV(N)
0	.27570E-01	20.38497		
1	.59734E-02	20.38497	.60224E+06	21.84033
2	.22975E-01	20.38497	.47383E+06	20.69504
3	.12702	53.87205	.37978E+06	21.59347
4	.51086E-01	15.00173	.49825E+06	60.68273
5	.31310E-01	39.45514	58684.	17.78501
6	.20827E-01	17.90185	.35964E+06	41.09344
7	.45004E-01	43.56726	51840.	18.99802
8	.56614E-01	66.09631	.11829E+06	45.93105
9	.11936	27.33874	72586.	69.06161
10	.27959E-01	24.83287	8543.2	33.93576
11	.27959E-01	24.83287	27653.	19.52111

Obs. and pred. indices in objective function

.47184E+00	.70673E+00
.57818E+00	.84585E+00
.60698E+00	.57175E+00
.49673E+00	.71284E+00
.52836E+00	.51764E+00
.70981E+00	.75511E+00
.78444E+00	.64397E+00
.10299E+01	.10732E+01
.86433E+00	.12075E+01
.10396E+01	.13302E+01
.92004E+00	.92699E+00
.14852E+01	.14847E+01
.20048E+01	.16141E+01
.12411E+01	.12825E+01
.17216E+01	.15768E+01
.15172E+01	.10106E+01
.45692E+00	.33114E+00
.44337E+00	.60685E+00
.59993E+00	.63484E+00
.86413E+00	.49794E+00
.81637E+00	.10737E+01
.10551E+01	.75556E+00
.10242E+01	.62791E+00
.20762E+01	.82379E+00
.12889E+01	.12906E+01
.70679E+00	.95916E+00
.10415E+01	.98112E+00
.13580E+01	.14347E+01
.10613E+01	.15305E+01
.13013E+01	.13260E+01
.70911E+00	.11166E+01
.11971E+01	.10347E+01
.26833E+00	.56086E+00
.97698E+00	.85430E+00
.76466E+00	.72192E+00
.56882E+00	.10215E+01
.15078E+01	.72195E+00
.16438E+01	.12667E+01
.12360E+01	.84278E+00
.83512E+00	.11140E+01
.82687E+00	.46092E+00
.64808E+00	.86867E+00
.11611E+01	.12876E+01
.14829E+01	.15814E+01
.91467E+00	.10108E+01
.98015E+00	.93508E+00
.11847E+01	.13198E+01
.92993E+00	.11108E+01
.79643E+00	.12564E+01
.11638E+01	.45790E+00
.11473E+01	.89206E+00
.96246E+00	.54237E+00
.50427E+00	.82264E+00
.95925E+00	.66016E+00
.76708E+00	.70860E+00
.82600E+00	.61711E+00
.66245E+00	.72128E+00
.16190E+01	.10173E+01
.11600E+01	.11284E+01
.10553E+01	.79896E+00
.10713E+01	.97833E+00
.11428E+01	.12914E+01
.13143E+01	.15726E+01
.93507E+00	.88009E+00
.12125E+01	.14248E+01
.10022E+01	.72687E+00
.76848E+00	.10931E+01
.11964E+01	.61924E+00
.65823E+00	.11052E+01
.15196E+01	.82217E+00
.53000E+00	.49806E+00
.50133E+00	.59011E+00
.65800E+00	.38711E+00
.30225E+00	.87698E+00
.43792E+00	.45327E+00
.86892E+00	.93379E+00
.68487E+00	.75953E+00
.10155E+01	.14759E+01
.11714E+01	.94331E+00
.12682E+01	.13304E+01
.12565E+01	.50953E+00
.11255E+01	.94214E+00
.15922E+01	.12118E+01
.17088E+01	.18340E+01
.11356E+01	.10186E+01
.13687E+01	.15223E+01
.89285E+00	.74309E+00
.88189E+00	.84424E+00
.88030E+00	.10342E+01
.95105E+00	.10640E+01
.99888E+00	.10133E+01
.93052E+00	.91525E+00
.12008E+01	.10423E+01
.12637E+01	.12858E+01
.79130E+00	.55941E+00
.10462E+01	.74992E+00
.89402E+00	.43390E+00
.73234E+00	.11690E+01
.94348E+00	.80056E+00
.10652E+01	.14626E+01
.15274E+01	.36665E+00
.58800E+00	.72890E+00
.57158E+00	.54053E+00
.52390E+00	.41205E+00
.73580E+00	.75384E+00
.69056E+00	.76770E+00
.46205E+00	.56151E+00
.93465E+00	.90348E+00
.80214E+00	.11072E+01
.16420E+01	.13941E+01
.11663E+01	.11061E+01
.13591E+01	.87554E+00
.67918E+00	.89191E+00
.14016E+01	.14497E+01
.13151E+01	.13985E+01
.17209E+01	.17471E+01
.86892E+00	.71849E+00
.10232E+01	.10219E+01
.10837E+01	.12652E+01
.10887E+01	.11272E+01
.13426E+01	.11431E+01
.49159E+00	.90222E+00
.55363E+00	.90289E+00
.49159E+00	.96980E+00
.92590E+00	.93120E+00
.77795E+00	.99080E+00
.79227E+00	.10476E+01
.12552E+01	.11141E+01
.13459E+01	.10777E+01
.12457E+01	.10730E+01
.15273E+01	.97632E+00
.11454E+01	.10406E+01
.14476E+01	.11357E+01

INDEX RESULTS

Equal weighting for indices
ML estimate of variance (all indices): .1001

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	.4718	.4718	.7067	-.2349	-.7425
86/87	.5782	.5782	.8458	-.2677	-.8461
87/88	.6070	.6070	.5718	.0352	.1114
88/89	.4967	.4967	.7128	-.2161	-.6832
89/90	.5284	.5284	.5176	.0107	.0339
90/91	.7098	.7098	.7551	-.0453	-.1432
91/92	.7844	.7844	.6440	.1405	.4441
92/93	1.0299	1.0299	1.0732	-.0433	-.1370
93/94	.8643	.8643	1.2075	-.3431	-1.0847
94/95	1.0396	1.0396	1.3302	-.2906	-.9187
95/96	.9200	.9200	.9270	-.0070	-.0220
96/97	1.4852	1.4852	1.4847	.0005	.0015
97/98	2.0048	2.0048	1.6141	.3907	1.2349
98/99	1.2411	1.2411	1.2825	-.0414	-.1309
99/00	1.7216	1.7216	1.5768	.1447	.4575
00/01	1.5172	1.5172	1.0106	.5067	1.6016

ML estimate of catchability: .69519E-07
Pearsons (parametric) correlation: .873 P= .0000
Kendalls (nonparametric) Tau: .700 P= .0000

Selectivity at age from Partial Catches

year	3	4	5	6
85/86	.034	1.000	.640	.256
86/87	.507	.993	1.000	.342
87/88	.359	1.000	.582	.144
88/89	.294	1.000	.142	.480
89/90	1.000	.338	.175	.116
90/91	1.000	.187	.087	.815
91/92	.275	1.000	.299	.100
92/93	1.000	.115	.818	.439
93/94	1.000	.703	.364	.419
94/95	.750	1.000	.858	.435
95/96	.334	.936	.636	1.000
96/97	.932	.674	.804	1.000
97/98	1.000	.699	.605	.733
98/99	.452	1.000	.133	.364
99/00	.986	.548	1.000	.471
00/01	.380	1.000	.353	.265

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	.4569	.4569	.3311	.1258	.3976
86/87	.4434	.4434	.6068	-.1635	-.5168
87/88	.5999	.5999	.6348	-.0349	-.1104
88/89	.8641	.8641	.4979	.3662	1.1576
89/90	.8164	.8164	1.0737	-.2574	-.8136
90/91	1.0551	1.0551	.7556	.2995	.9468
91/92	1.0242	1.0242	.6279	.3963	1.2526
92/93	2.0762	2.0762	.8238	1.2524	3.9590
93/94	1.2889	1.2889	1.2906	-.0018	-.0056
94/95	.7068	.7068	.9592	-.2524	-.7978
95/96	1.0415	1.0415	.9811	.0604	.1909
96/97	1.3580	1.3580	1.4347	-.0767	-.2425
97/98	1.0613	1.0613	1.5305	-.4693	-1.4834
98/99	1.3013	1.3013	1.3260	-.0247	-.0781
99/00	.7091	.7091	1.1166	-.4075	-1.2882
00/01	1.1971	1.1971	1.0347	.1624	.5133

ML estimate of catchability: .78136E-07
Pearsons (parametric) correlation: .432 P= .0081
Kendalls (nonparametric) Tau: .467 P= .0003

Selectivity at age from Partial Catches

year	3	4	5	6	7	8
85/86	.002	.000	1.000	.278	.005	.026
86/87	.321	1.000	.646	.095	.019	.017
87/88	.363	.868	.214	1.000	.000	.000
88/89	.013	1.000	.706	.008	.002	.066
89/90	.923	.892	.583	.329	1.000	.275
90/91	.970	1.000	.013	.307	.302	.000
91/92	.263	1.000	.100	.202	.201	.112
92/93	.830	.012	1.000	.079	.002	.242
93/94	.922	.735	.385	.387	1.000	.241
94/95	.880	.911	.465	.171	.053	1.000
95/96	.603	1.000	.541	.654	.284	.281
96/97	1.000	.608	.554	.720	.531	.197
97/98	1.000	.602	.450	.561	.537	.618
98/99	.502	1.000	.195	.558	.093	.207
99/00	.560	.336	.661	.365	.338	1.000
00/01	.538	1.000	.252	.183	.279	.172

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	.2683	.2683	.5609	-.2925	-.9247
87/88	.9770	.9770	.8543	.1227	.3878
88/89	.7647	.7647	.7219	.0427	.1351
89/90	.5688	.5688	1.0215	-.4527	-1.4311
90/91	1.5078	1.5078	.7219	.7858	2.4841
91/92	1.6438	1.6438	1.2667	.3771	1.1921
92/93	1.2360	1.2360	.8428	.3932	1.2430
93/94	.8351	.8351	1.1140	-.2789	-.8816
94/95	.8269	.8269	.4609	.3660	1.1568
95/96	.6481	.6481	.8687	-.2206	-.6973
96/97	1.1611	1.1611	1.2876	-.1264	-.3996
97/98	1.4829	1.4829	1.5814	-.0985	-.3115
98/99	.9147	.9147	1.0108	-.0961	-.3038
99/00	.9801	.9801	.9351	.0451	.1425
00/01	1.1847	1.1847	1.3198	-.1351	-.4271

ML estimate of catchability: .37319E-06
Pearsons (parametric) correlation: .548 P= .0008
Kendalls (nonparametric) Tau: .295 P= .0212

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8
86/87	.407	1.000	.520	.171	.284	.119	.065
87/88	1.000	.552	.646	.431	.245	.221	.092
88/89	.542	.318	1.000	.576	.760	.413	.382
89/90	1.000	.950	.578	.349	.385	.805	.227
90/91	.371	1.000	.251	.121	.210	.526	.186
91/92	.883	.565	1.000	.305	.193	.146	.147
92/93	.416	.612	.181	.549	.492	.225	1.000
93/94	.901	.765	.617	.366	.495	1.000	.528
94/95	.205	.305	.330	.481	.224	.064	1.000
95/96	.321	.414	.878	.635	1.000	.504	.454
96/97	.648	.445	.551	1.000	.815	.982	.646
97/98	.622	.764	.485	.560	.656	.549	1.000
98/99	.305	.233	1.000	.639	.701	.501	.440
99/00	.357	.713	.382	.678	.331	.494	1.000
00/01	.658	.695	1.000	.252	.232	.307	.149

Fit results for index = TPWD 81-85
Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	.9299	.9299	1.1108	-.1809	-.5717
82/83	.7964	.7964	1.2564	-.4600	-1.4540
83/84	1.1638	1.1638	.4579	.7059	2.2315
84/85	1.1473	1.1473	.8921	.2553	.8069
85/86	.9625	.9625	.5424	.4201	1.3279

ML estimate of catchability: .85139E-06
Pearsons (parametric) correlation: -.684 P= .0128
Kendalls (nonparametric) Tau: -.800 P= .0039

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8
81/82	.001	.057	.328	1.000	.524	.414	.012
82/83	.022	.009	.554	1.000	.349	.684	.398
83/84	.004	.016	.160	.288	.575	1.000	.029
84/85	.001	.091	.369	.848	.250	.487	1.000
85/86	.018	.020	.218	.634	.204	1.000	.036

Fit results for index = TPWD 86-00
Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	.5043	.5043	.8226	-.3184	-1.0064
87/88	.9593	.9593	.6602	.2991	.9455
88/89	.7671	.7671	.7086	.0585	.1848
89/90	.8260	.8260	.6171	.2089	.6603
90/91	.6624	.6624	.7213	-.0588	-.1860
91/92	1.6190	1.6190	1.0173	.6017	1.9021
92/93	1.1600	1.1600	1.1284	.0316	.0998
93/94	1.0553	1.0553	.7990	.2563	.8102
94/95	1.0713	1.0713	.9783	.0930	.2938
95/96	1.1428	1.1428	1.2914	-.1486	-.4698
96/97	1.3143	1.3143	1.5726	-.2583	-.8165
97/98	.9351	.9351	.8801	.0550	.1738
98/99	1.2125	1.2125	1.4248	-.2123	-.6710
99/00	1.0022	1.0022	.7269	.2753	.8703
00/01	.7685	.7685	1.0931	-.3247	-1.0263

ML estimate of catchability: .50290E-06
Pearsons (parametric) correlation: .570 P= .0004
Kendalls (nonparametric) Tau: .505 P= .0001

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8
86/87	.119	.586	.742	.814	1.000	.880	.816
87/88	.193	.418	1.000	.371	.396	.387	.412
88/89	.201	.334	.551	1.000	.610	.514	.441
89/90	.111	.426	.391	.615	1.000	.602	.459
90/91	.123	.262	.708	.591	.659	1.000	.633
91/92	.200	.537	.595	.737	.449	.521	1.000
92/93	.202	.524	.414	.817	1.000	.521	.800
93/94	.362	.291	.465	.336	.250	1.000	.226
94/95	.342	1.000	.235	.561	.336	.432	.313
95/96	.361	.586	1.000	.604	.894	.384	.354
96/97	.456	.506	.648	.954	.859	1.000	.415
97/98	.124	.354	.282	.434	.493	.429	1.000
98/99	.264	.470	.616	.660	.512	.582	1.000
99/00	.116	.404	.250	.493	.263	.273	1.000
00/01	.216	.380	1.000	.305	.228	.413	.168

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.1964	1.1964	.6192	.5771	1.8244
82/83	.6582	.6582	1.1052	-.4469	-1.4128
83/84	1.5196	1.5196	.8222	.6975	2.2048
84/85	.5300	.5300	.4981	.0319	.1010
85/86	.5013	.5013	.5901	-.0888	-.2806
86/87	.6580	.6580	.3871	.2709	.8563
87/88	.3023	.3023	.8770	-.5747	-1.8168
88/89	.4379	.4379	.4533	-.0153	-.0485
89/90	.8689	.8689	.9338	-.0649	-.2050
90/91	.6849	.6849	.7595	-.0747	-.2360
91/92	1.0155	1.0155	1.4759	-.4604	-1.4554
92/93	1.1714	1.1714	.9433	.2281	.7210
93/94	1.2682	1.2682	1.3304	-.0622	-.1968
94/95	1.2565	1.2565	.5095	.7470	2.3612
95/96	1.1255	1.1255	.9421	.1834	.5797
96/97	1.5922	1.5922	1.2118	.3805	1.2027
97/98	1.7088	1.7088	1.8340	-.1252	-.3956
98/99	1.1356	1.1356	1.0186	.1170	.3698
99/00	1.3687	1.3687	1.5223	-.1536	-.4856

ML estimate of catchability: .51921E-06

Pearsons (parametric) correlation: .596 P= .0000
Kendalls (nonparametric) Tau: .427 P= .0002

Selectivity at age from Partial Catches

year	2	3	4	5	6
81/82	.032	.119	1.000	.001	.090
82/83	.372	1.000	.763	.287	.202
83/84	.026	1.000	.469	.689	.128
84/85	.037	.147	1.000	.359	.467
85/86	1.000	.109	.575	.652	.045
86/87	.075	1.000	.383	.083	.270
87/88	.651	.646	1.000	.317	.346
88/89	.084	.261	.709	1.000	.260
89/90	1.000	.627	.302	.256	.425
90/91	.358	1.000	.178	.091	.208
91/92	.645	1.000	.765	.372	.490
92/93	.280	.672	.366	1.000	.538
93/94	.896	.635	.837	.702	1.000
94/95	.111	.216	.232	1.000	.469
95/96	.343	.502	.779	.572	1.000
96/97	.557	.384	.582	1.000	.646
97/98	.497	1.000	.557	.834	.871
98/99	.245	.122	1.000	.867	.826
99/00	.642	1.000	.524	.907	.401

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
88/89	.8929	.8929	.7431	.1498	.4734
89/90	.8819	.8819	.8442	.0377	.1190
90/91	.8803	.8803	1.0342	-.1539	-.4864
91/92	.9510	.9510	1.0640	-.1129	-.3569
92/93	.9989	.9989	1.0133	-.0144	-.0456
93/94	.9305	.9305	.9153	.0153	.0483
94/95	1.2008	1.2008	1.0423	.1585	.5011
95/96	1.2637	1.2637	1.2858	-.0221	-.0698

ML estimate of catchability: .33837E-06
Pearsons (parametric) correlation: .752 P= .0002
Kendalls (nonparametric) Tau: .500 P= .0101

Selectivity at age from Partial Catches

year	2	3	4	5	6
88/89	.789	.469	.989	.362	1.000
89/90	.930	1.000	.590	.328	.294
90/91	.882	1.000	.577	.283	.325
91/92	.917	.391	1.000	.260	.085
92/93	1.000	.680	.207	.245	.329
93/94	1.000	.797	.538	.241	.301
94/95	.770	.942	1.000	.689	.333
95/96	.920	1.000	.693	.350	.472

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
88/89	.7913	.7913	.5594	.2319	.7330
89/90	1.0462	1.0462	.7499	.2963	.9365
90/91	.8940	.8940	.4339	.4601	1.4545
91/92	.7323	.7323	1.1690	-.4366	-1.3802
92/93	.9435	.9435	.8006	.1429	.4518
93/94	1.0652	1.0652	1.4626	-.3974	-1.2561
94/95	1.5274	1.5274	.3667	1.1608	3.6694

ML estimate of catchability: .67630E-06
Pearsons (parametric) correlation: -.314 P= .1845
Kendalls (nonparametric) Tau: -.143 P= .3705

Selectivity at age from Partial Catches

year	3	4	5	6	7	8
88/89	.103	1.000	.626	.425	.115	.065
89/90	1.000	.493	.400	.652	.317	.281
90/91	.316	.356	.233	.389	1.000	.064
91/92	.845	.648	.459	.660	.693	1.000
92/93	.452	.280	.548	.474	.398	1.000
93/94	.702	1.000	.729	.905	.707	.859
94/95	.090	.125	.620	.281	.080	1.000

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	.5880	.5880	.7289	-.1409	-.4454
82/83	.5716	.5716	.5405	.0311	.0982
83/84	.5239	.5239	.4121	.1118	.3536
84/85	.7358	.7358	.7538	-.0180	-.0570
85/86	.6906	.6906	.7677	-.0771	-.2439
86/87	.4620	.4620	.5615	-.0995	-.3144
87/88	.9346	.9346	.9035	.0312	.0985
88/89	.8021	.8021	1.1072	-.3051	-.9644
89/90	1.6420	1.6420	1.3941	.2479	.7835
90/91	1.1663	1.1663	1.1061	.0602	.1902
91/92	1.3591	1.3591	.8755	.4836	1.5286
92/93	.6792	.6792	.8919	-.2127	-.6725
93/94	1.4016	1.4016	1.4497	-.0481	-.1520
94/95	1.3151	1.3151	1.3985	-.0834	-.2637
95/96	1.7209	1.7209	1.7471	-.0262	-.0828
96/97	.8689	.8689	.7185	.1504	.4755
97/98	1.0232	1.0232	1.0219	.0013	.0041
98/99	1.0837	1.0837	1.2652	-.1815	-.5736
99/00	1.0887	1.0887	1.1272	-.0385	-.1217
00/01	1.3426	1.3426	1.1431	.1995	.6307

ML estimate of catchability: .29647E-06
Pearsons (parametric) correlation: .883 P= .0000
Kendalls (nonparametric) Tau: .695 P= .0000

Selectivities set to 1.0

year	0
81/82	1.000
82/83	1.000
83/84	1.000
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
00/01	1.000

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

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	.4916	.4916	.9022	-.4106	-1.2981
87/88	.5536	.5536	.9029	-.3493	-1.1040
88/89	.4916	.4916	.9698	-.4782	-1.5117
89/90	.9259	.9259	.9312	-.0053	-.0167
90/91	.7780	.7780	.9908	-.2128	-.6728
91/92	.7923	.7923	1.0476	-.2553	-.8070
92/93	1.2552	1.2552	1.1141	.1411	.4461
93/94	1.3459	1.3459	1.0777	.2682	.8480
94/95	1.2457	1.2457	1.0730	.1727	.5460
95/96	1.5273	1.5273	.9763	.5509	1.7416
96/97	1.1454	1.1454	1.0406	.1049	.3315
97/98	1.4476	1.4476	1.1357	.3119	.9859

ML estimate of catchability: .29596E-06
Pearsons (parametric) correlation: .709 P= .0000
Kendalls (nonparametric) Tau: .595 P= .0001

Selectivities input

year	1	2	3	4	5	6	7	8	9	10	11
86/87	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
87/88	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
88/89	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
89/90	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
90/91	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
91/92	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
92/93	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
93/94	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
94/95	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
95/96	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
96/97	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
97/98	.015	.121	.308	.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853

Table 11. Maximum sustainable yield (MSY) and optimum yield (OY) related values for two sets of tuning indices scenarios. SS is spawning stock biomass in trillions of eggs, F values are associated with the fully selected age, and yields are given in millions of pounds.

MODEL **Base 9**

	SS MSY	F MSY	MSY	SS OY	F OY	OY
Median	5.68	0.258	9.86	7.58	0.179	8.77
low 80%	4.97	0.219	8.38	6.69	0.153	7.52
upp 80%	6.29	0.302	11.06	8.37	0.209	9.87

MODEL **Base 10**

	SS MSY	F MSY	MSY	SS OY	F OY	OY
Median	5.78	0.249	9.93	7.73	0.174	8.88
low 80%	5.12	0.221	8.62	6.87	0.155	7.74
upp 80%	6.41	0.284	11.26	8.54	0.197	9.98

Table 12. Fishing year 2002/2003 acceptable biological catch (ABC) in millions of pounds for the two tuning index scenarios: Base 10 and Base 9 models under two levels of F mortality. Probability denotes likelihood of exceeding the desired F mortality rate.

		Base 9 Model		Base 10 Model	
Probability		*F 30%SPR*	*F 40%SPR*	*F 30%SPR*	*F 40%SPR*
50%	Median	8.942	6.358	9.459	6.790
10 %	Lower CI	6.698	4.717	7.235	5.150
90%	Upper CI	12.341	8.869	12.861	9.301

Table 13. Sensitivity Analyses. Catch at Age 2000 run. Maximum sustainable yield (MSY) and optimum yield (OY) related values for the CAA00 sensitivity run (see text for details). SS is spawning stock biomass in trillions of eggs, F values are associated with the fully selected age, and yields are given in millions of pounds.

MODEL CAA00

	SS MSY	F MSY	MSY	SS OY	F OY	OY
Median	6.16	0.243	11.00	8.20	0.170	9.80
low 80%	5.73	0.216	10.12	7.63	0.151	9.01
upp 80%	6.54	0.266	11.74	8.64	0.185	10.41

Table 14. Sensitivity Analyses. Index Removal. Maximum sustainable yield (MSY) and optimum yield (OY) related values for two selected runs of the index removal analyses; case without the HeadBoat index, and case without the TPWD late (1986-00) index (see text for details). SS is spawning stock biomass in trillions of eggs, F values are associated with the fully selected age, and yields are given in millions of pounds.

MODEL Base 10 without HEADBOAT index

	SS MSY	F MSY	MSY	SS OY	F OY	OY
Median	6.17	0.262	10.35	8.25	0.185	9.11
low 80%	5.40	0.233	9.01	7.20	0.164	7.97
upp 80%	6.82	0.289	11.84	9.05	0.205	10.40

MODEL Base 10 without TPWD late (86-00) index

	SS MSY	F MSY	MSY	SS OY	F OY	OY
Median	5.92	0.244	10.12	7.90	0.171	8.98
low 80%	5.22	0.215	8.80	7.01	0.151	7.82
upp 80%	6.50	0.280	11.37	8.67	0.195	10.05

Table 14. Sensitivity Analysis. Fishing year 2002/2003 acceptable biological catch (ABC) in millions of pounds for three sensitivity scenarios: CAA00 and index removal; no Headboat index, and no TPWD late index under two levels of F mortality. Probability denotes likelihood of exceeding the desired F mortality rate.

		CAA00		*Base 10 no HeadBoat*		*Base 10 no TPWD late*	
Probability		*$F_{30\%}$SPR*	*$F_{40\%}$SPR*	*$F_{30\%}$SPR*	*$F_{40\%}$SPR*	*$F_{30\%}$SPR*	*$F_{40\%}$SPR*
50%	Median	10.19	7.28	10.50	7.59	9.93	7.15
10 %	Lower CI	7.75	5.50	7.87	5.64	7.12	5.10
90%	Upper CI	13.42	9.81	14.40	10.49	13.32	9.66

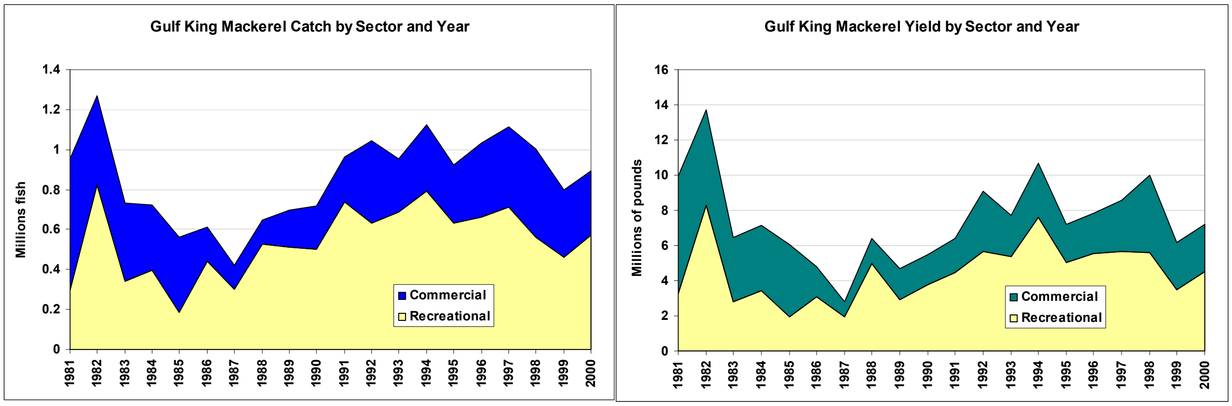


Figure 1. Gulf king mackerel catch and yield by year and sector from 1981 through 2001 fishing year (July-June).

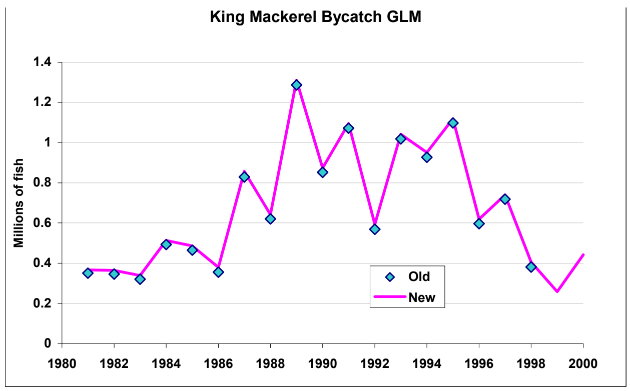


Figure 2. Comparison of 2000 (old) and 2002 (new) estimates of king mackerel bycatch in the shrimp trawl fishery of the US Gulf of Mexico. Estimates generated by the GLM model.

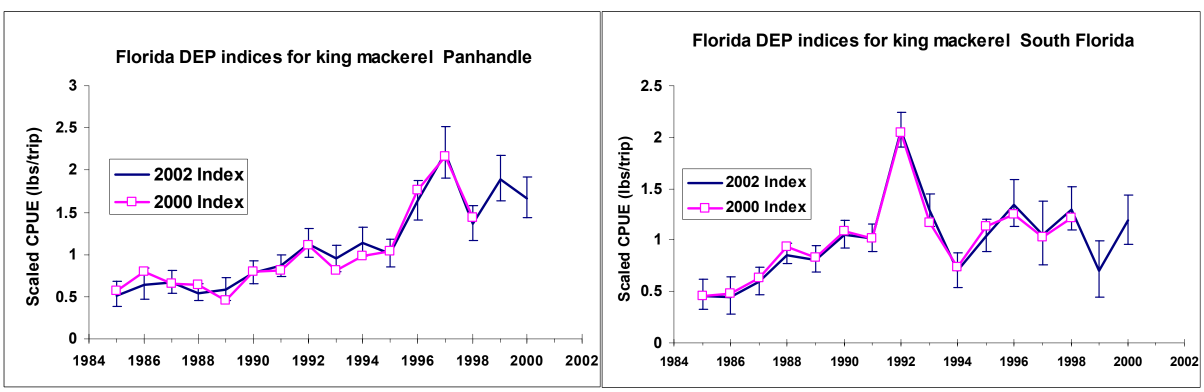
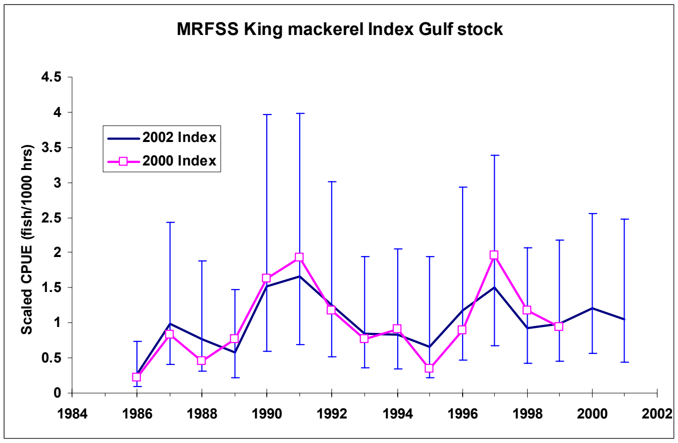


Figure 3. Comparison of the standardized CPUE patterns estimated from the FDEP trip ticket data for the Gulf of Mexico king mackerel used in the 2000 assessment and available for this assessment. Error bars indicate approximate 95% confidence range for the most recent time series.



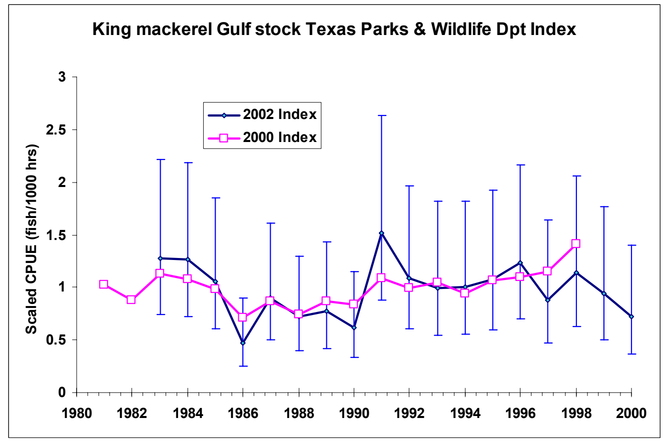
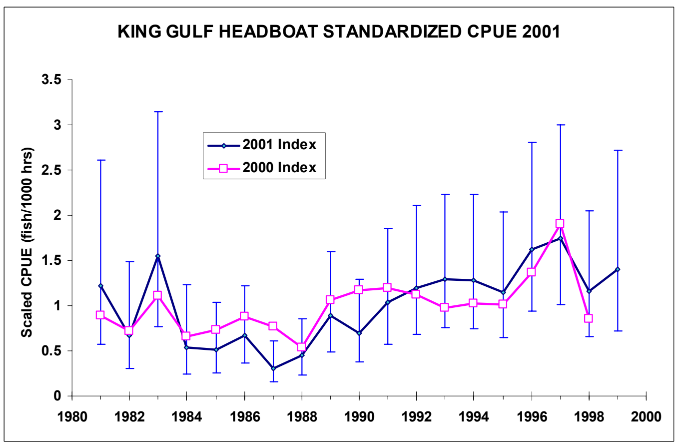


Figure 4 Comparison of 2000 and 2002 standardized CPUE index for the MRFSS data set. Error bars represent 95% confidence range.

Figure 5. Comparison of 2000 and 2002 standardized CPUE index for the TPWD data set. Error bars represents 95% confidence range.



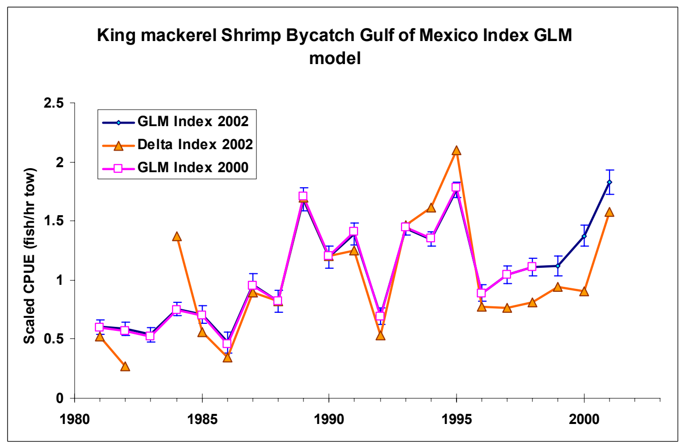
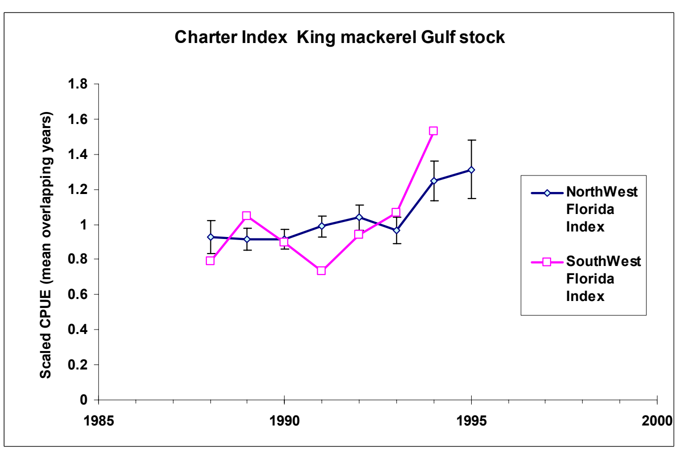


Figure 6. Comparison of 2000 and 2002 standardized CPUE index for the Headboat data set. Error bars represents 95% confidence range.

Figure 7. Comparison of king mackerel bycatch standardized CPUE indices from the Delta and GLM models.



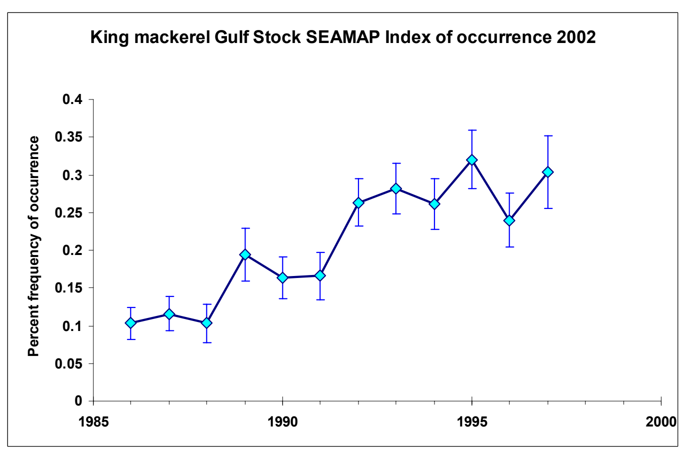


Figure 8. Standardized CPUE index series from the Florida Charter data set.

Figure 9. Percentage of occurrence for king mackerel in the Gulf of Mexico SEAMAP survey.

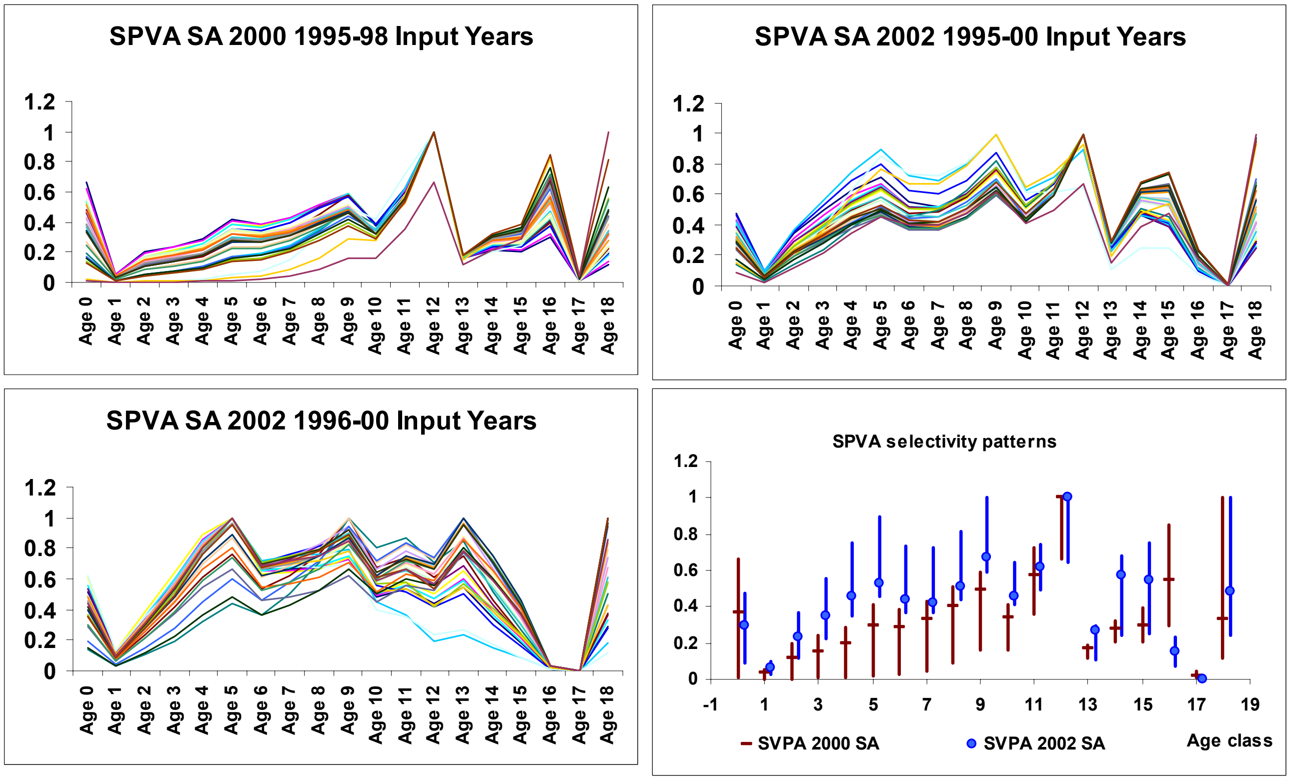


Figure 10. Selectivity pattern results from a SPVA model with a range of fixed F ratios for catch at age of Gulf king mackerel. Top-left results of 2000 assessment, the rest are for 2002 assessment. Bottom-right panel compares the results of 2000 and 2002 runs with markers representing the mean value and the bars the minimum and maximum values per age class.

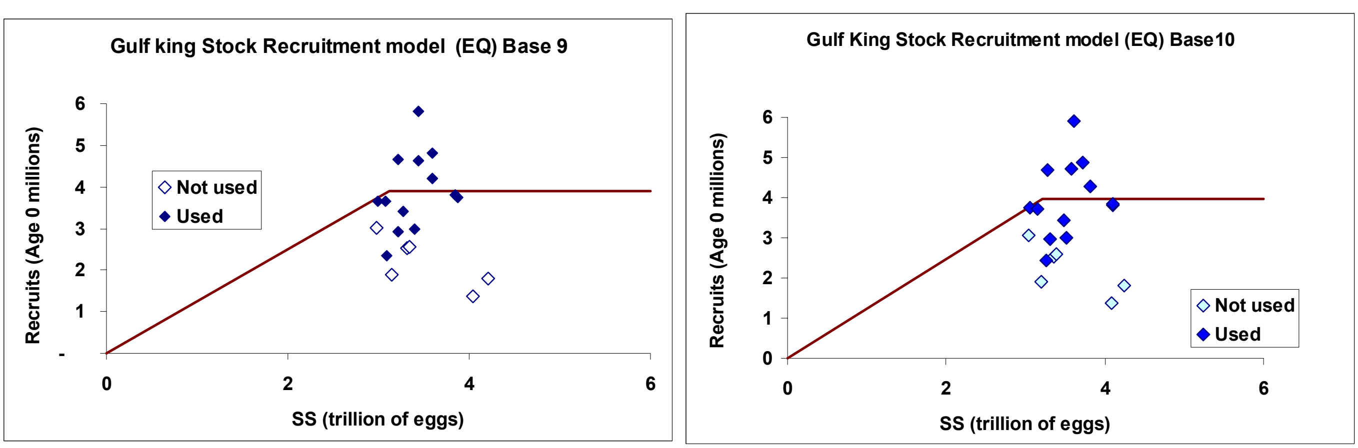


Figure 11. Deterministic stock recruitment relationship under the two line model for the two index scenarios; base 9 model (left) and base 10 model (right).

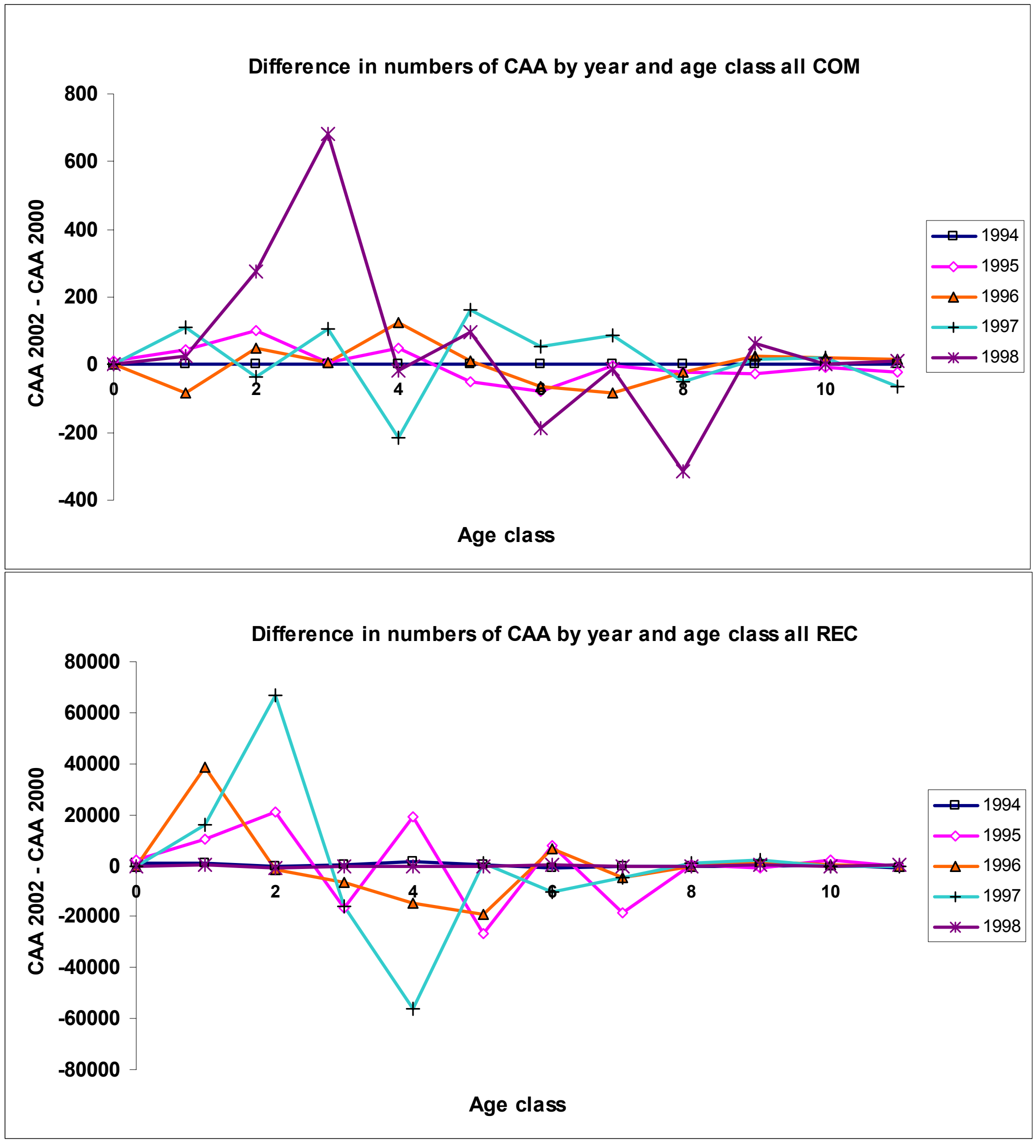


Figure 12. Comparison of catch at age (CAA) matrices from 2002 minus 2000 assessments for the commercial (top) and recreational (bottom) sectors.

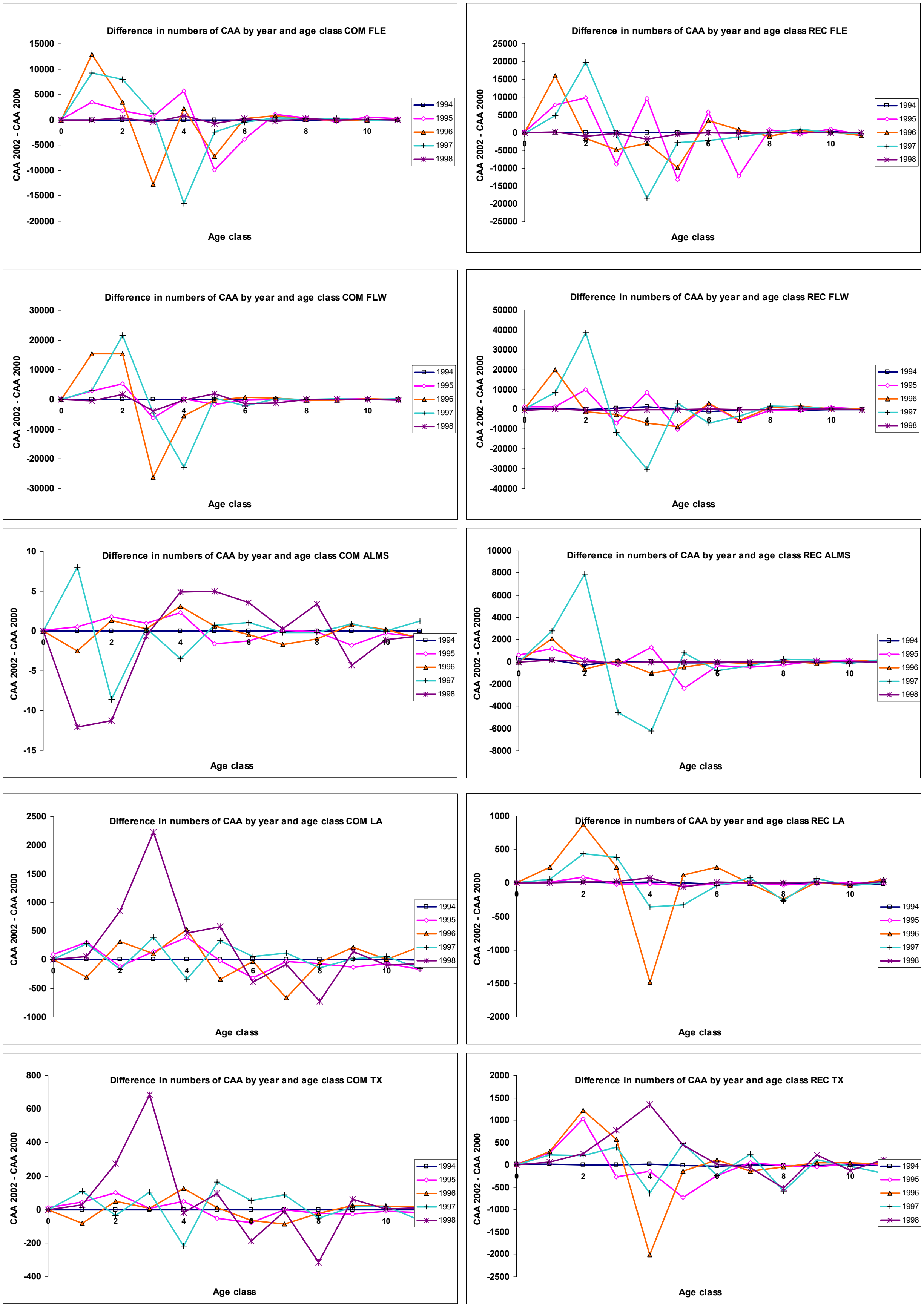


Figure 13. Comparison of CAA matrices from 2002 minus 2000 assessments by sectors, gears, and area.

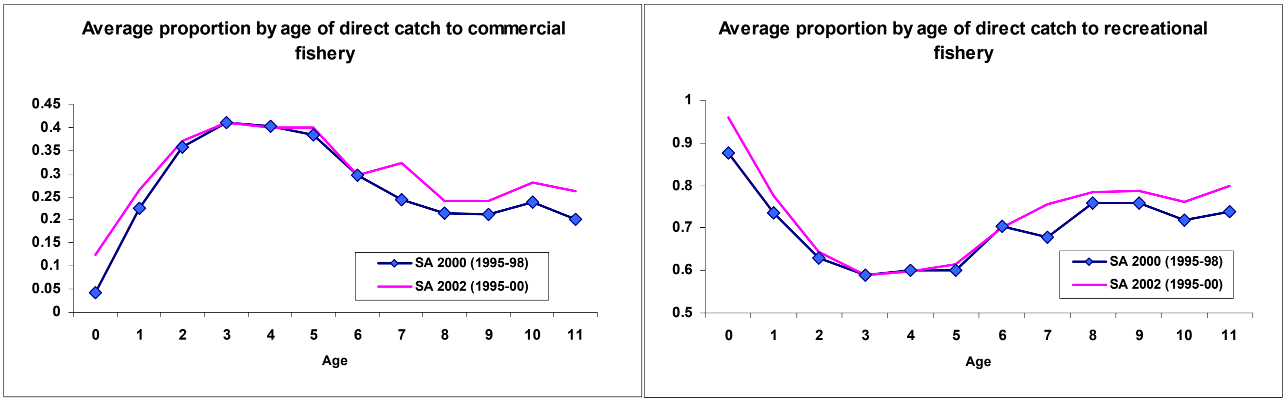


Figure 14. Estimated proportion of catch at age for Gulf king mackerel used in projection analyses. The 2000 assessment proportion is the average of years 1995 to 1998. For the 2002 assessment proportion the average includes the 1995 to 2000 fishing years.

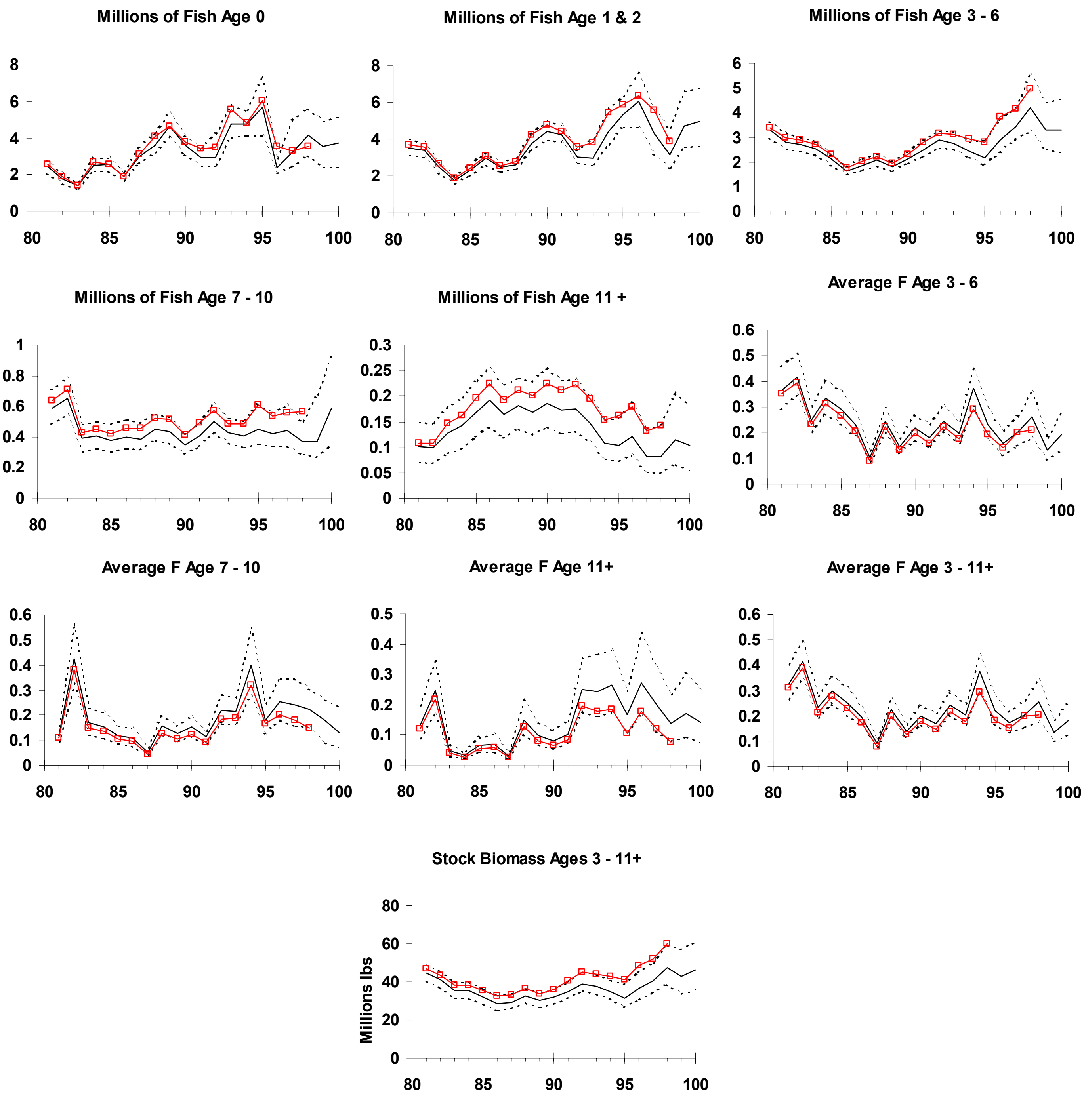


Figure 15 Gulf of Mexico king mackerel population trends with 80% confidence intervals from the base 9 model (solid and broken lines). For comparison, results from the 2000 assessment are shown (square markers line).

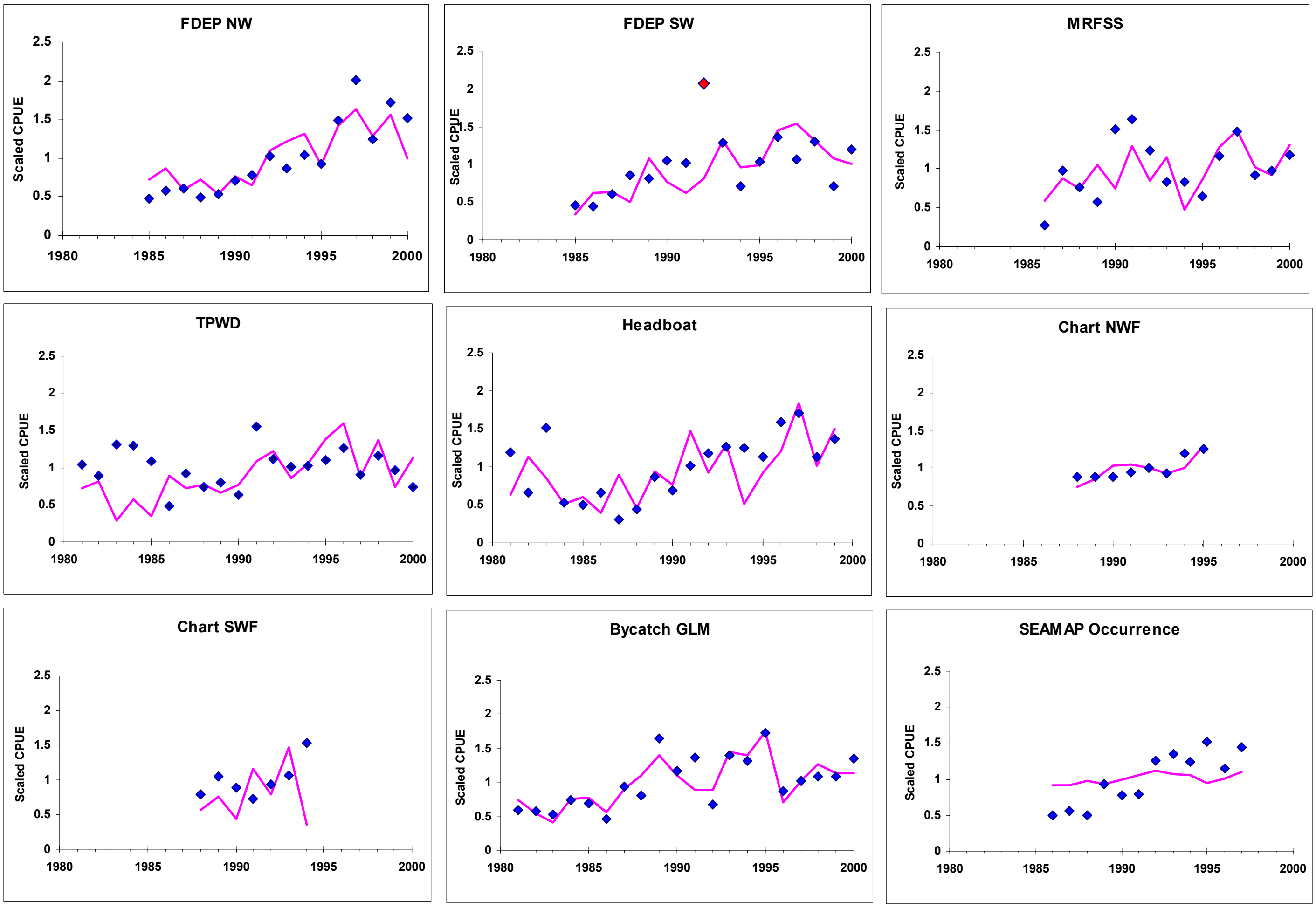
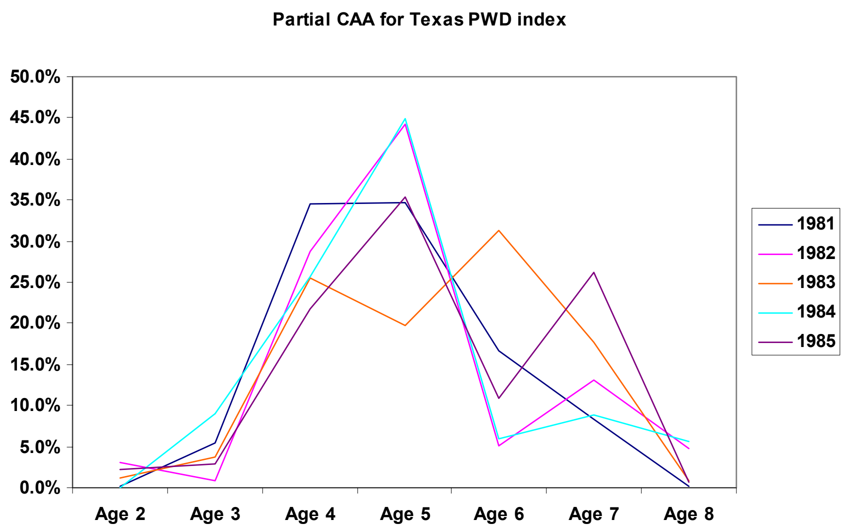


Figure 16. Gulf of Mexico king mackerel predicted (solid line) and standardized index (diamonds) from the tuned VPA model Base 9.



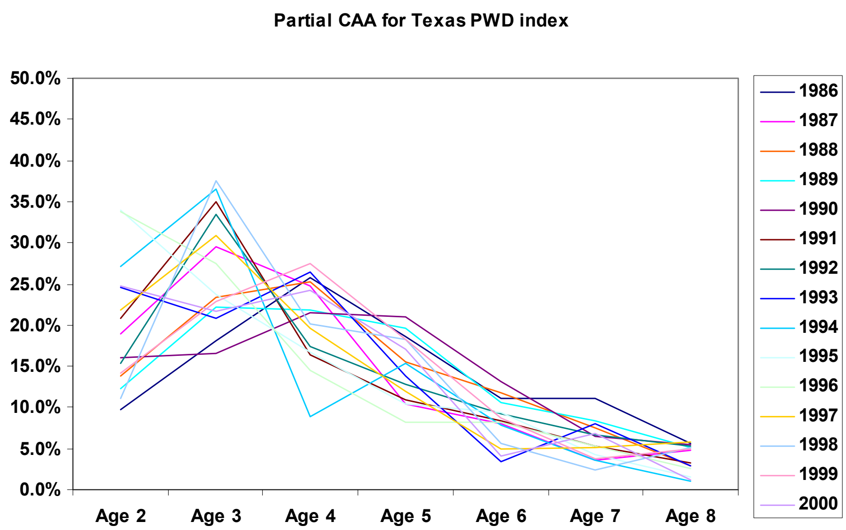


Figure 17. Comparison of the Texas PWD partial selectivity at age for the early (1981-1985) series (top) and the late (1986-2000) series (bottom).

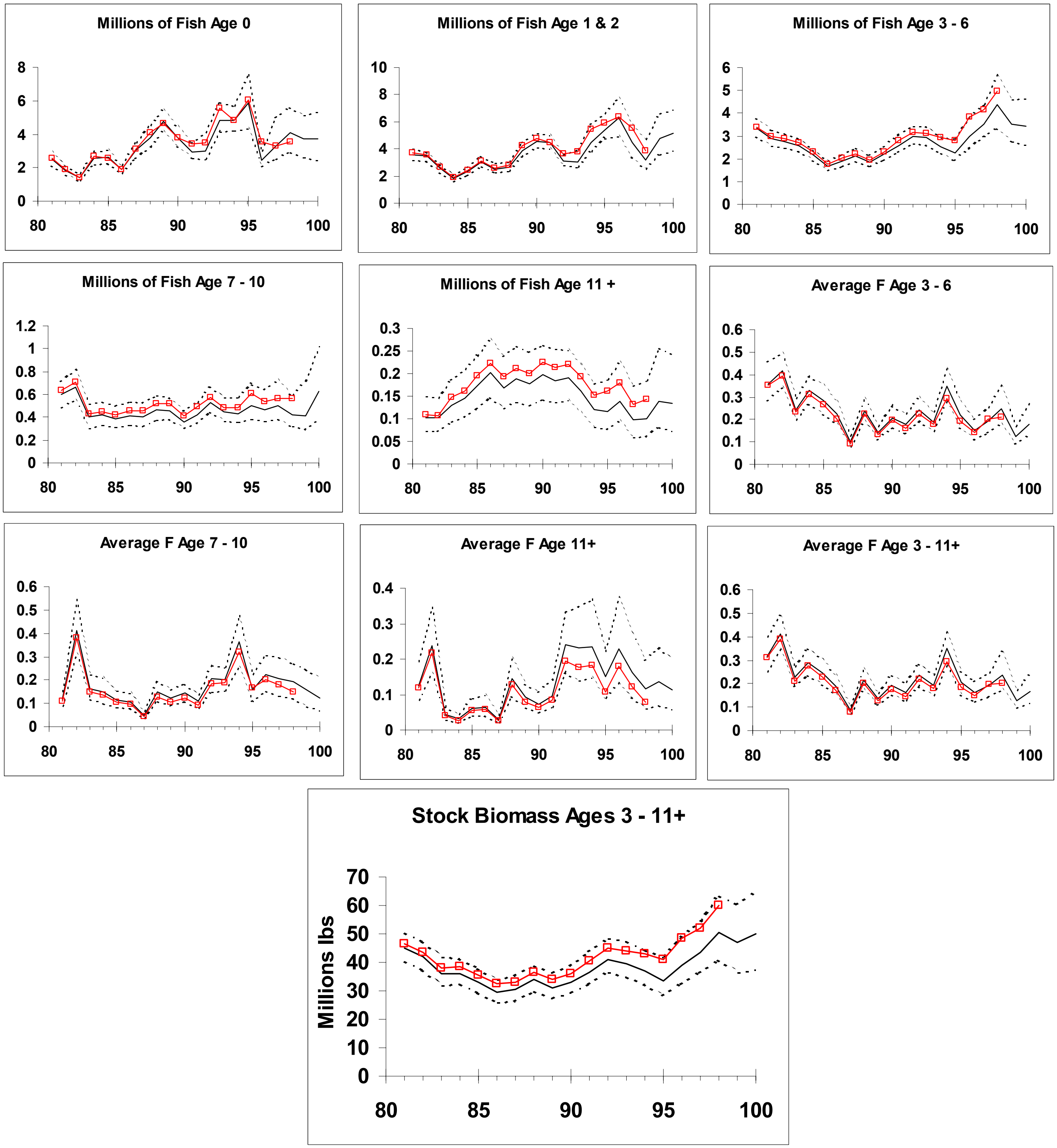


Figure 18. Gulf of Mexico king mackerel population trends with 80% confidence intervals from the base 10 model (solid and broken lines). For comparison, results from the 2000 assessment are shown (square markers line).

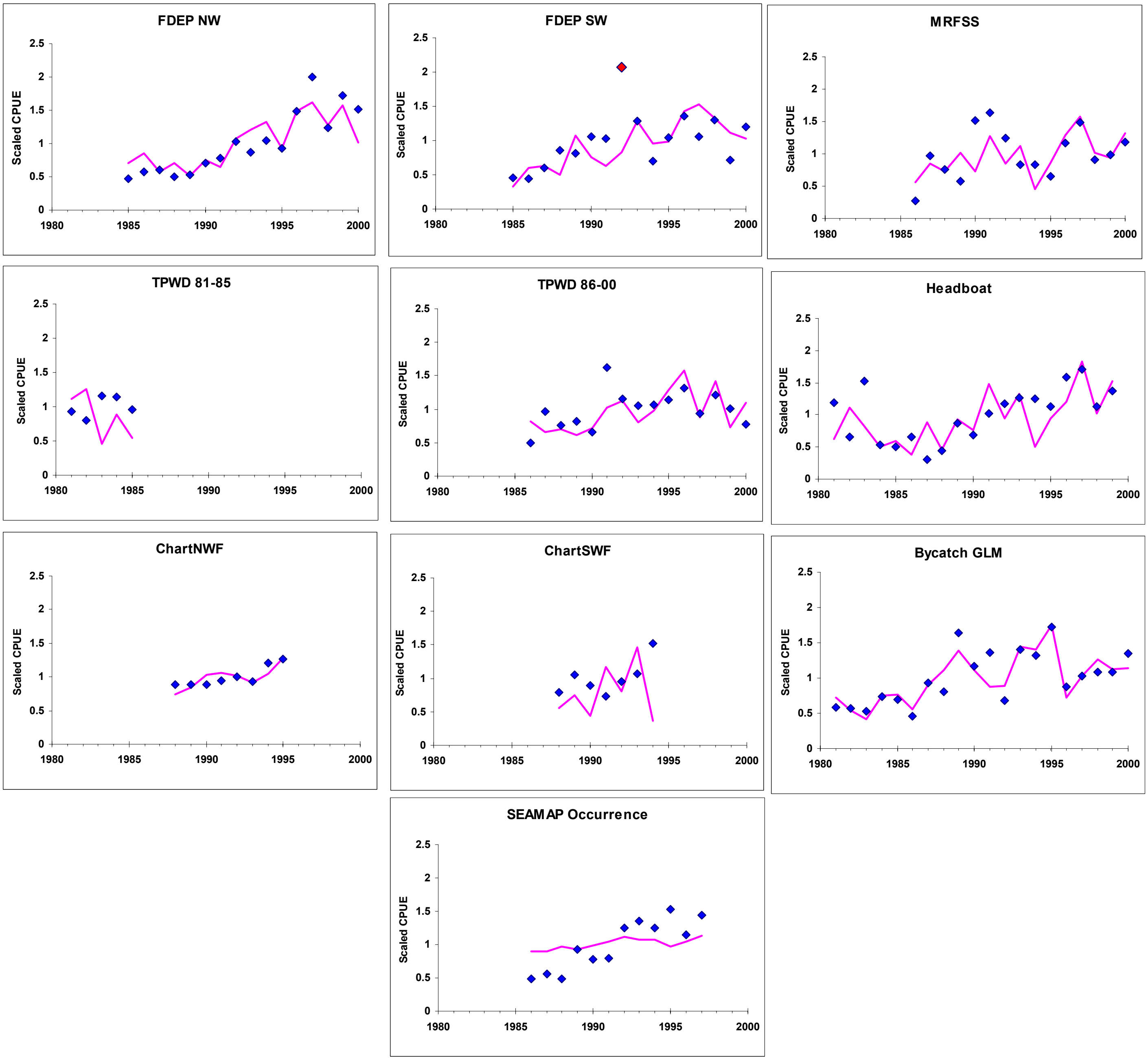


Figure 19. Gulf of Mexico king mackerel predicted (solid line) and standardized index (diamonds) from the tuned VPA model Base 10.

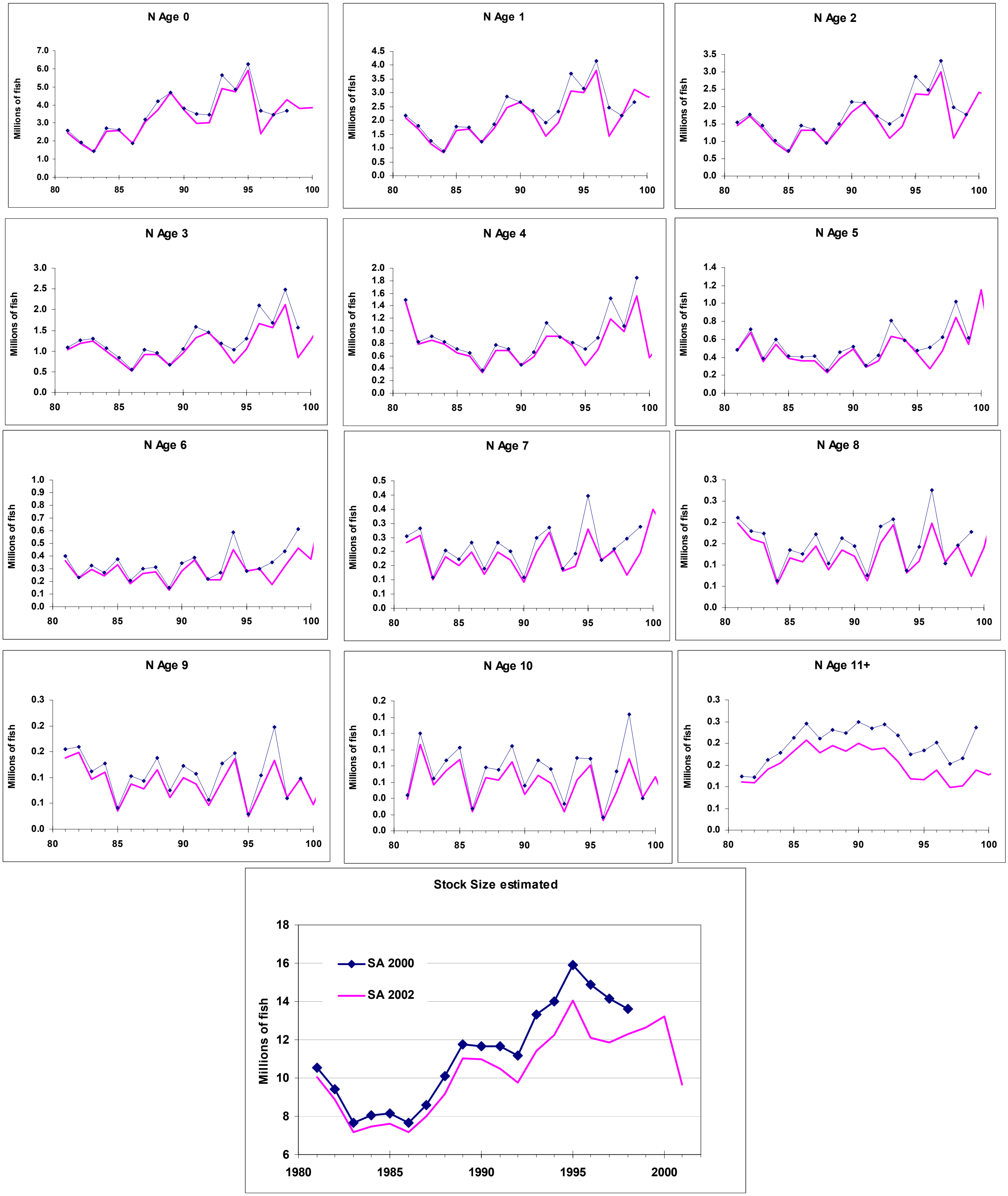


Figure 20. Estimated stock size by age from the tuned VPA results from BASE 10 model (solid line) and corresponding estimates from the 2000 assessment (diamonds line).

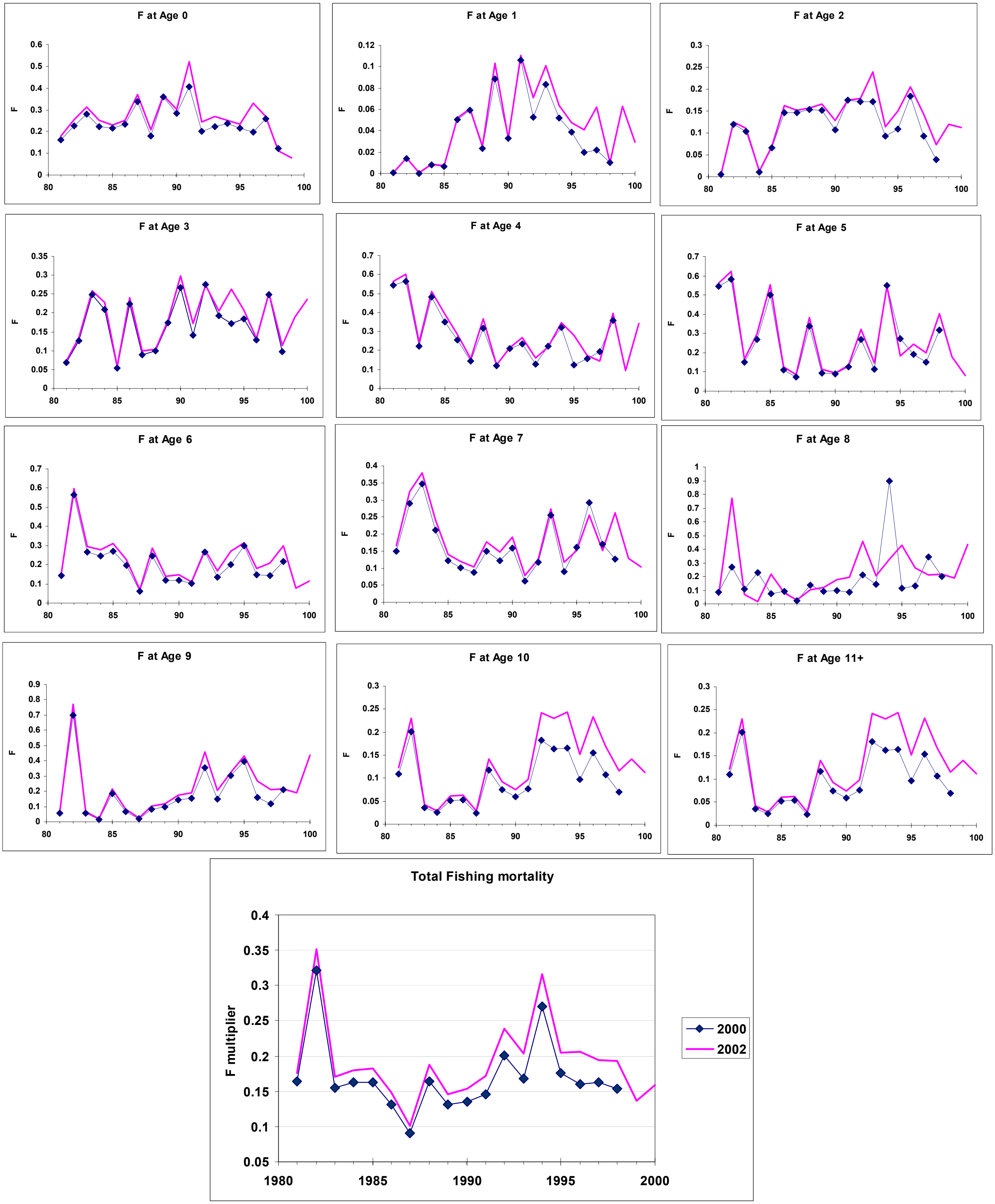


Figure 21 Estimated fishing mortality rates (F) by age from the tuned VPA results from BASE 10 model (solid line) and corresponding estimates from the 2000 assessment (diamonds line).

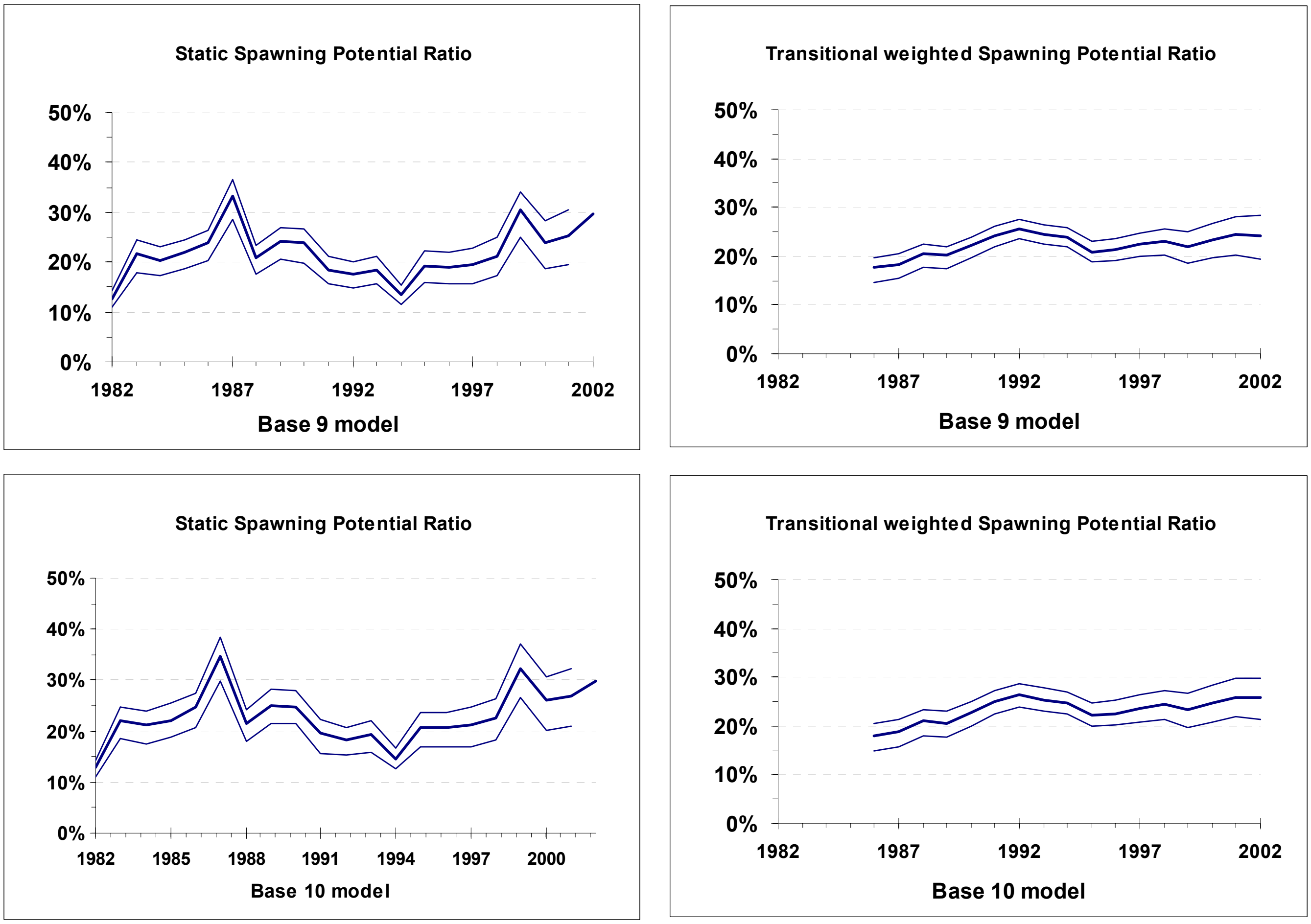


Figure 22. Comparison of static and weighted SPRs from the two index scenarios; base 9 model (top row) and base 10 model (bottom row).

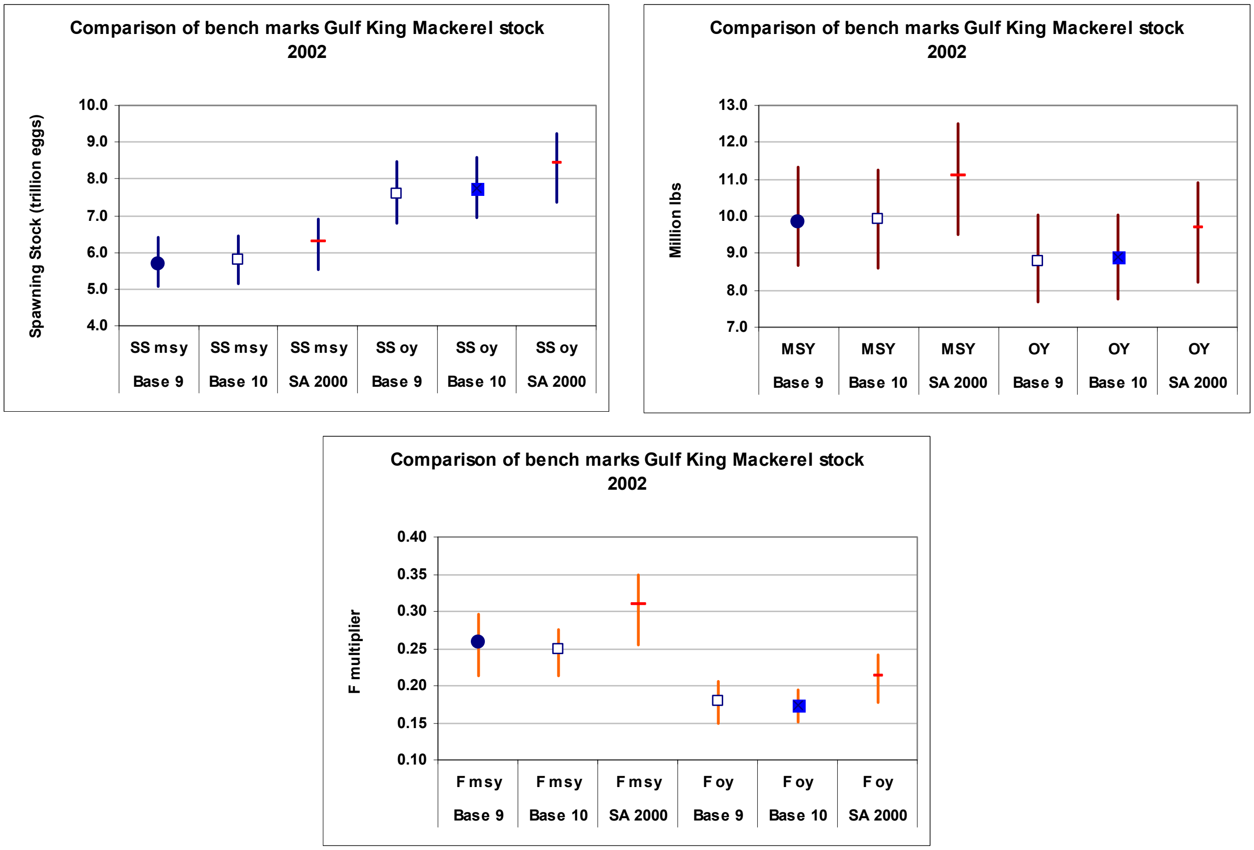


Figure 23. Gulf king mackerel benchmarks 2002 assessment. Spawning stock (SS) biomass (trillion eggs), maximum sustainable yield (MSY), optimum yield (OY), in millions of pounds, and corresponding fishing mortality rates (F_{ref}) from the two index scenarios Base 9 model and Base 10 model. For comparison, equivalent values are plotted from the 2000 assessment.

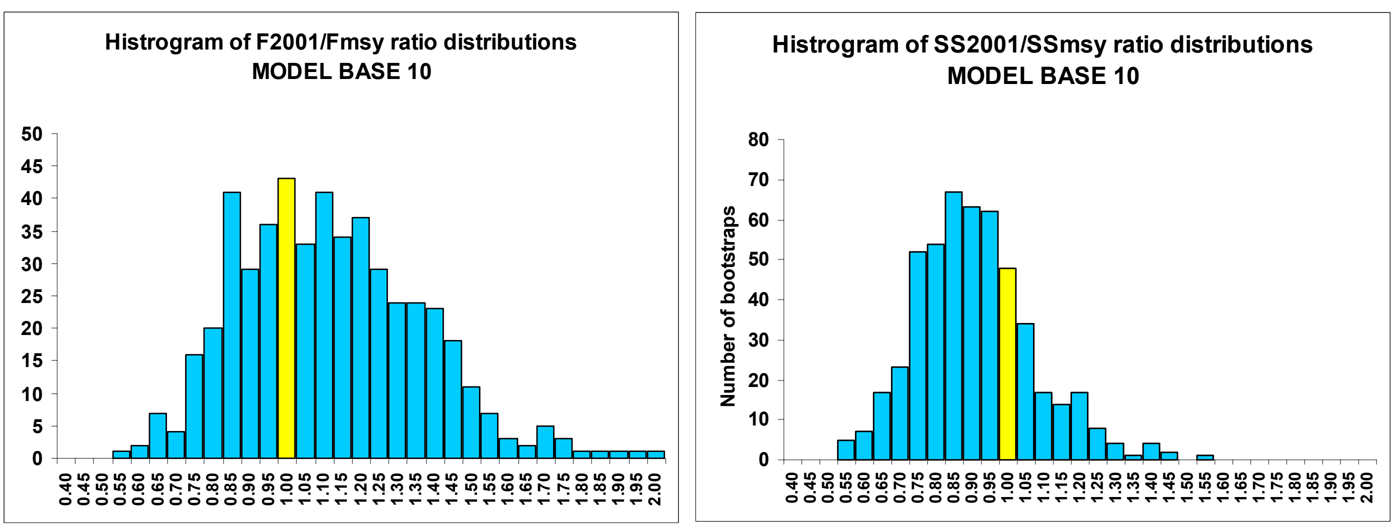


Figure 24. Distribution of Gulf king mackerel F_{2001}/F_{MSY} (left) and SS_{2001}/SS_{MSY} (right) ratios from 500 bootstraps for the Base 10 index model scenario.

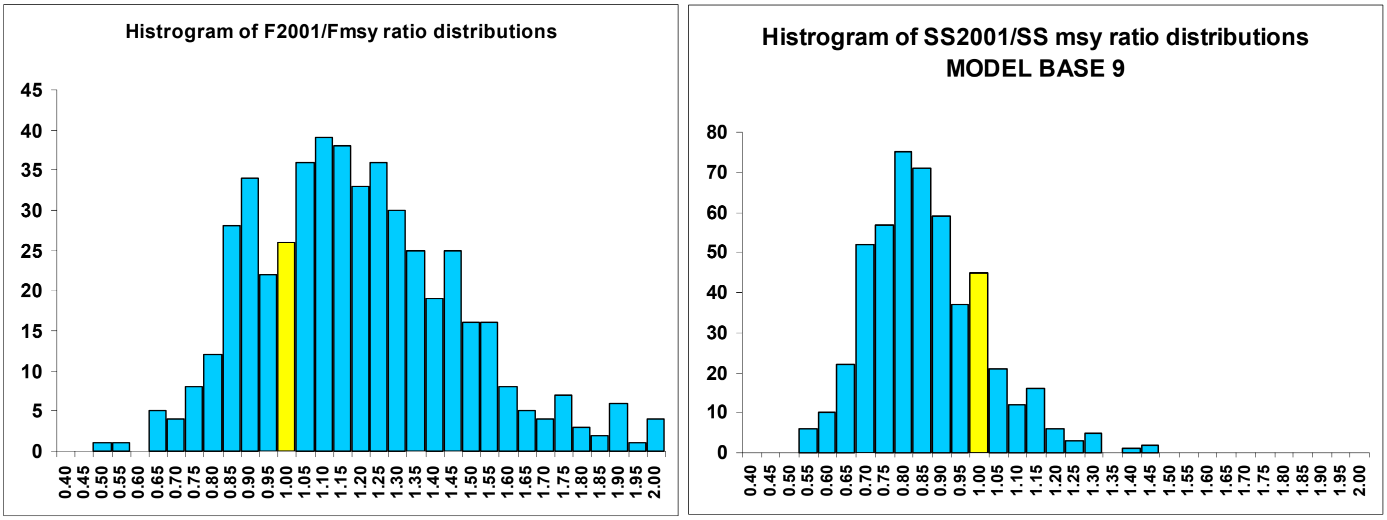


Figure 25. Distribution of Gulf king mackerel F_{2001}/F_{MSY} (left) and SS_{2001}/SS_{MSY} (right) ratios from 500 bootstraps for the Base 9 index model scenario.

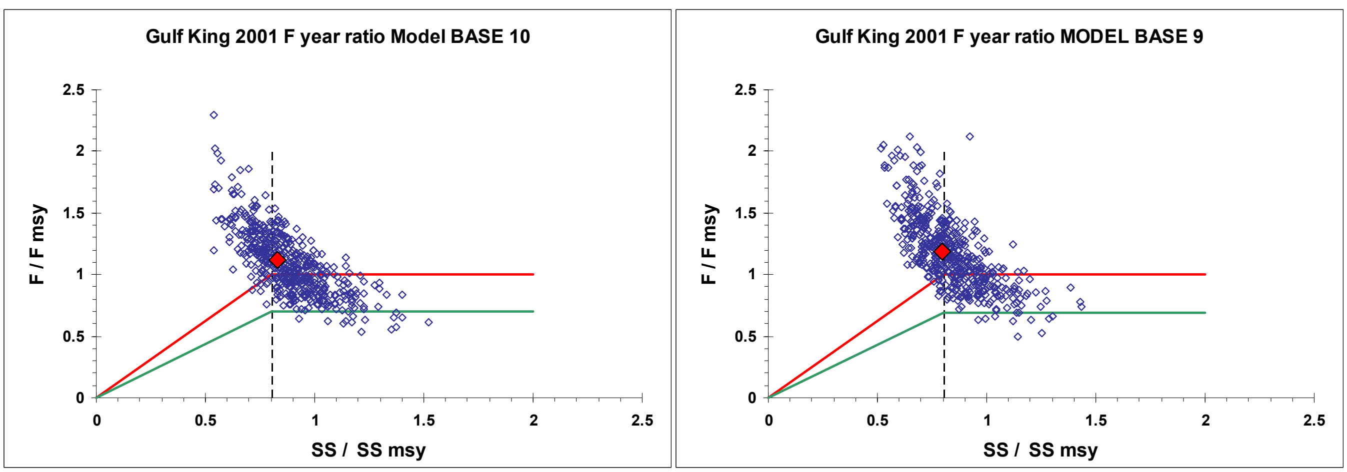
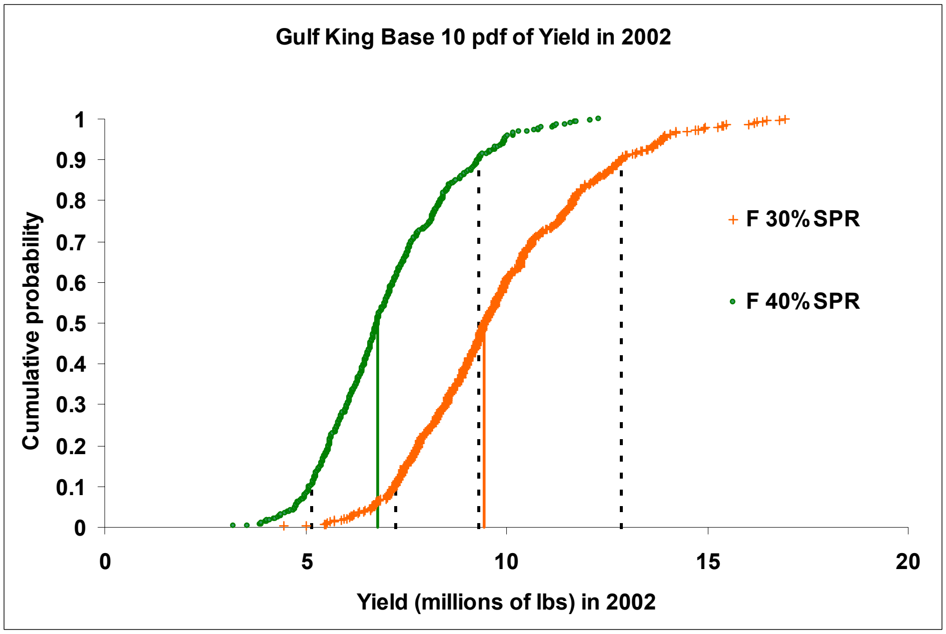


Figure 26. Phase plots of 500 bootstraps for the index scenarios. The bent solid line denotes the MFMT, the vertical dashed line denotes MSST, and the lower solid line denotes the OY control rule. The deterministic run corresponds to the larger diamond marker.



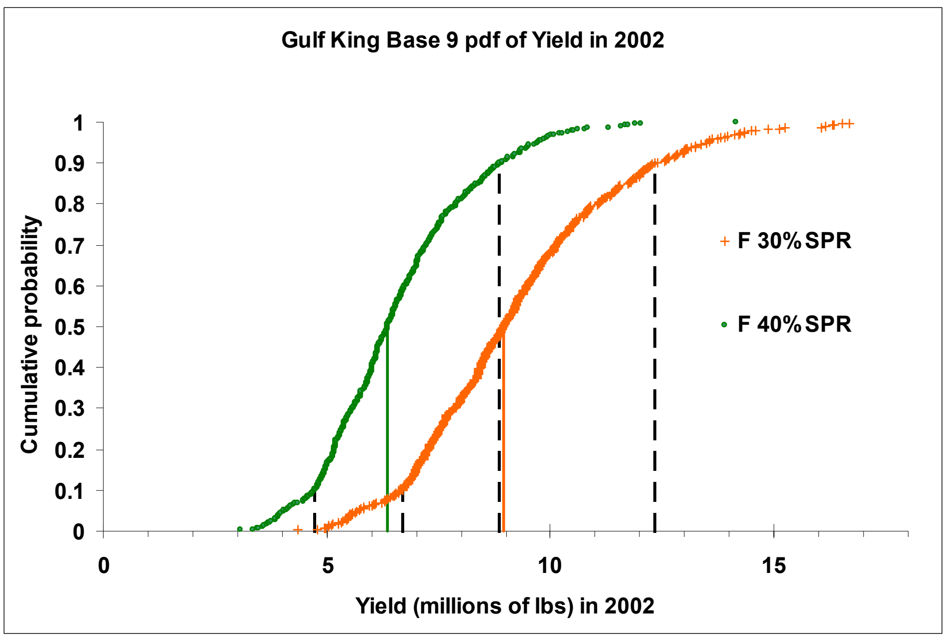


Figure 27. Frequency distribution of 500 bootstraps range of ABC based on probability of F exceeding $F_{30\%\ SPR}$ and $F_{40\%SPR}$ in the 2002/2003 fishing year for Gulf king mackerel from two index scenarios. Vertical solid lines represent 0.5 percentile; broken lines represent 0.1 and 0.9 percentiles of the distributions.

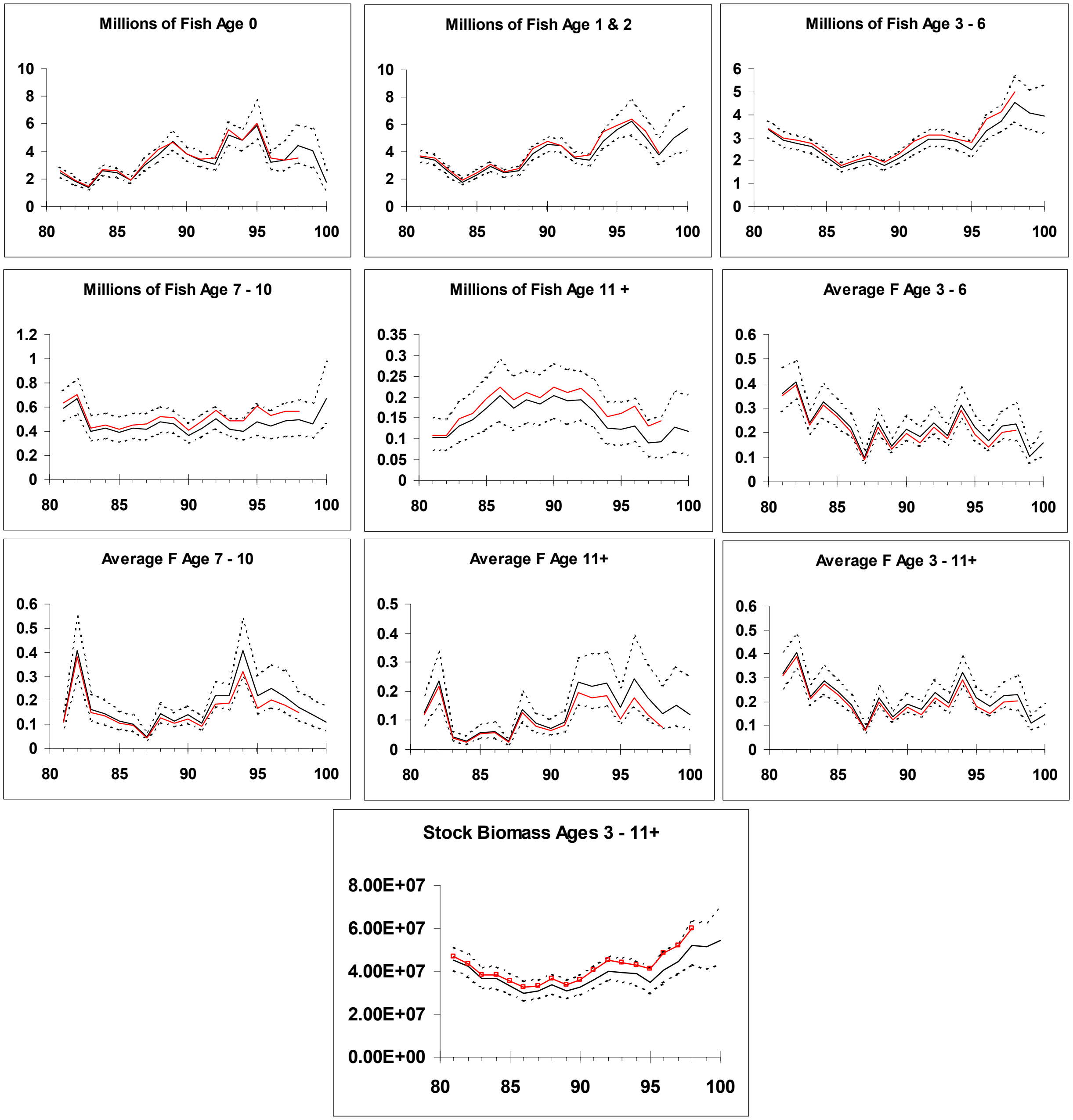


Figure 28 Sensitivity Analyses: 2000 Catch at Age matrix. Gulf king mackerel estimates of population dynamics from the tuned VPA with the CAA matrix use in 2000 assessment and updates for catch at age in fishing years 1999 and 2000. (See text for more details). For comparison equivalent values from the 2000 assessment are also plotted (squared markers).

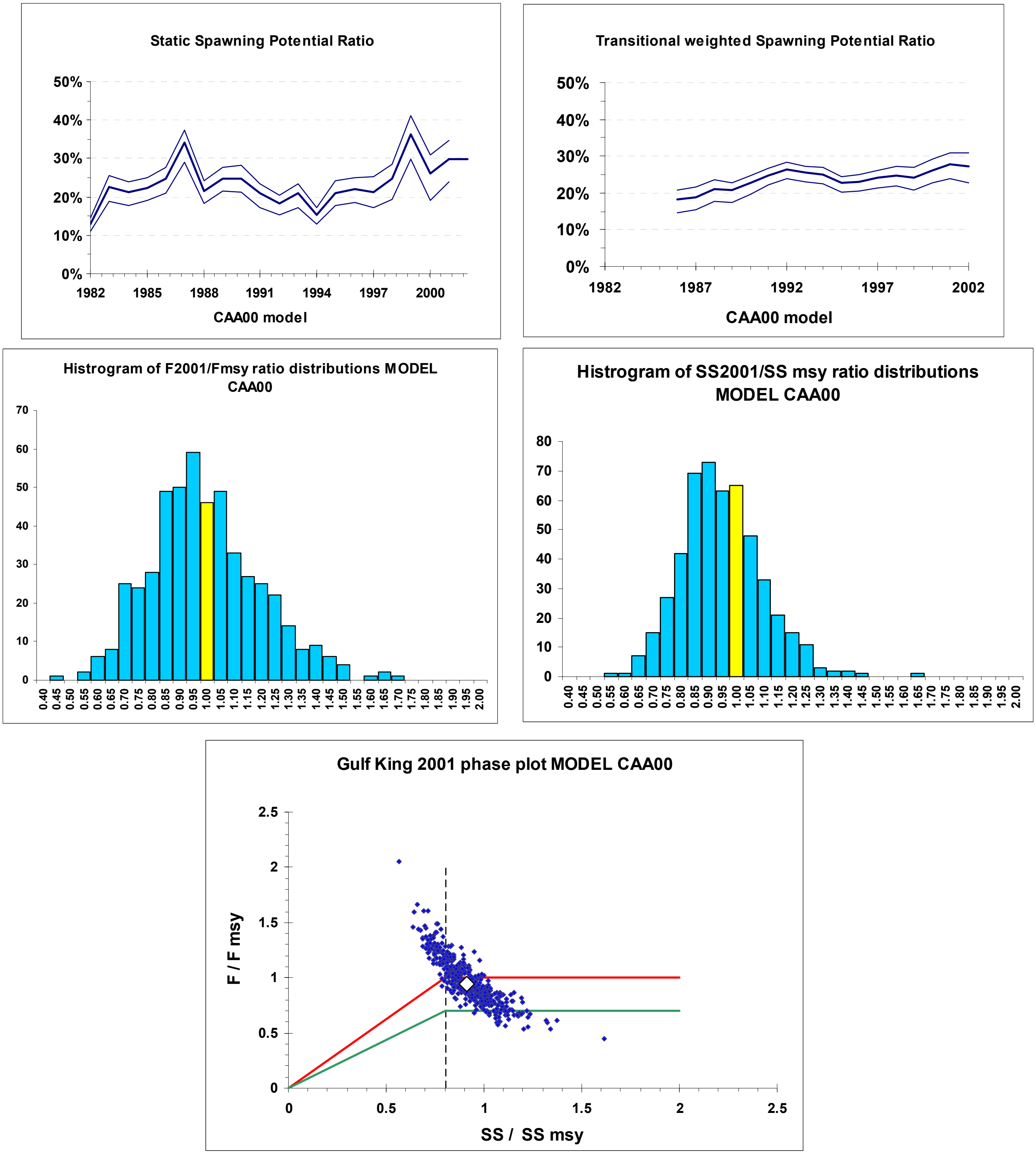


Figure 29. Sensitivity Analysis. 2000 Catch at age matrix. Gulf king mackerel estimates of static and transitional SPR (top row), frequency distribution of F_{2001}/F_{MSY} (left) and SS_{2001}/SS_{MSY} (right) ratios from 500 bootstraps (middle row), and Phase plot of 500 bootstraps for the CAA00 scenario. The bent 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

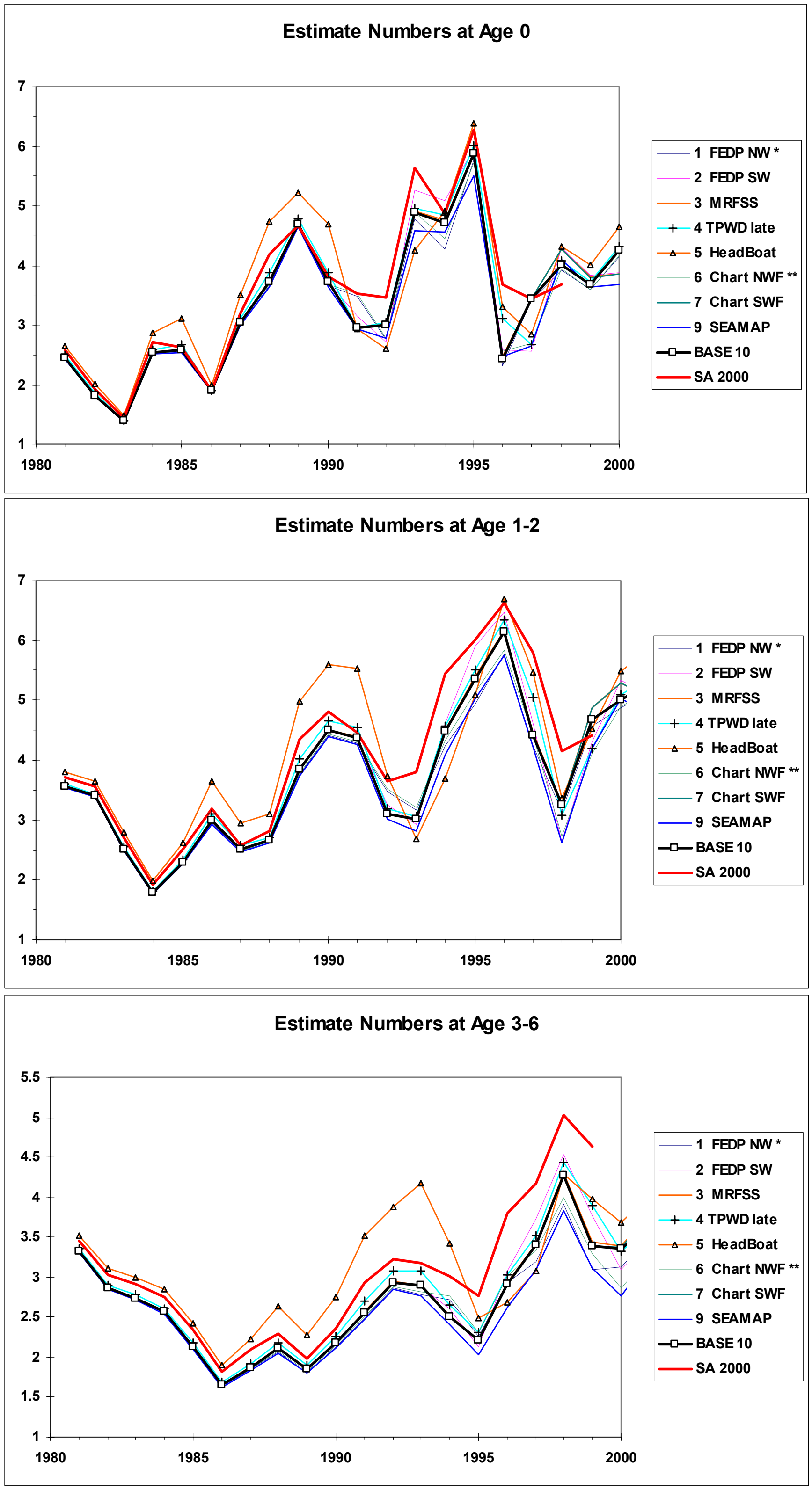


Figure 30. Sensitivity Analyses: Index removal. Estimates of Gulf king mackerel population stock by age classes from tuned VPA results where in each run a different index of abundance was remove from the input file. The labels 1 through 9 indicate which index was omitted from that particular run. Base run is the Base 10 model (square markers), for comparison purposes equivalent estimates from the 2000 assessment are also ploted (thick line). Y-axis represents millions of fish. See text for more details and results interpretation.

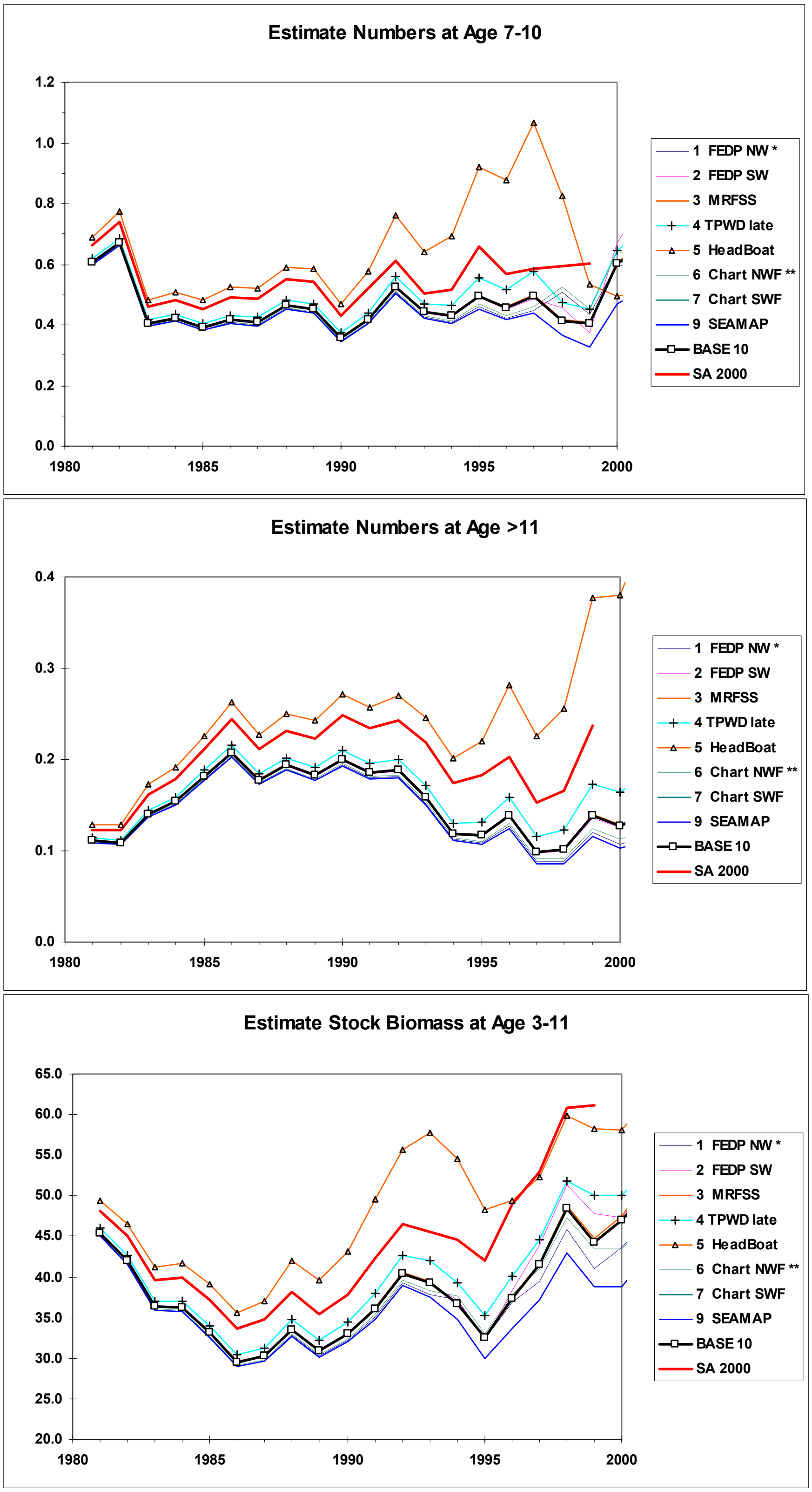


Figure 31. Sensitivity Analyses: Index removal. Estimates of Gulf king mackerel population stock by age classes from tuned VPA results where in each run a different index of abundance was remove from the input file. The labels 1 through 9 indicate which index was omitted from that particular run. Base run is the Base 10 model (square markers), for comparison purposes equivalent estimates from the 2000 assessment are also plotted (thick line through 1998). Y-axis represents millions of fish or million pounds (stock biomass). See text for more details and results interpretation.

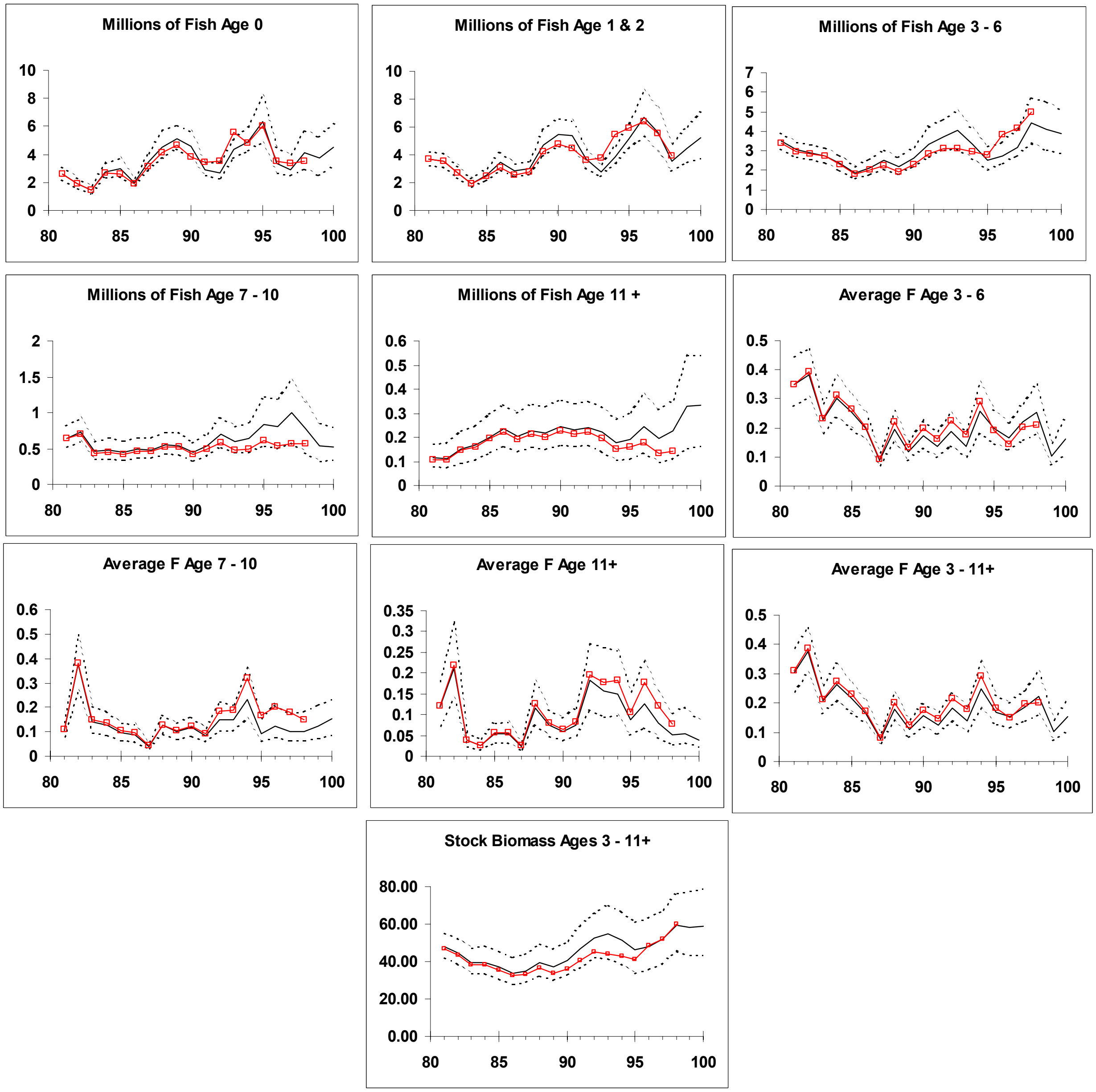


Figure 32. Sensitivity Analyses: Index removal. Gulf king mackerel population trends from tuned VPA with 80% confidence intervals; model Base 10 without the HeadBoat index. For comparison, equivalent estimates from the 2000 assessments are also shown (square markers line).

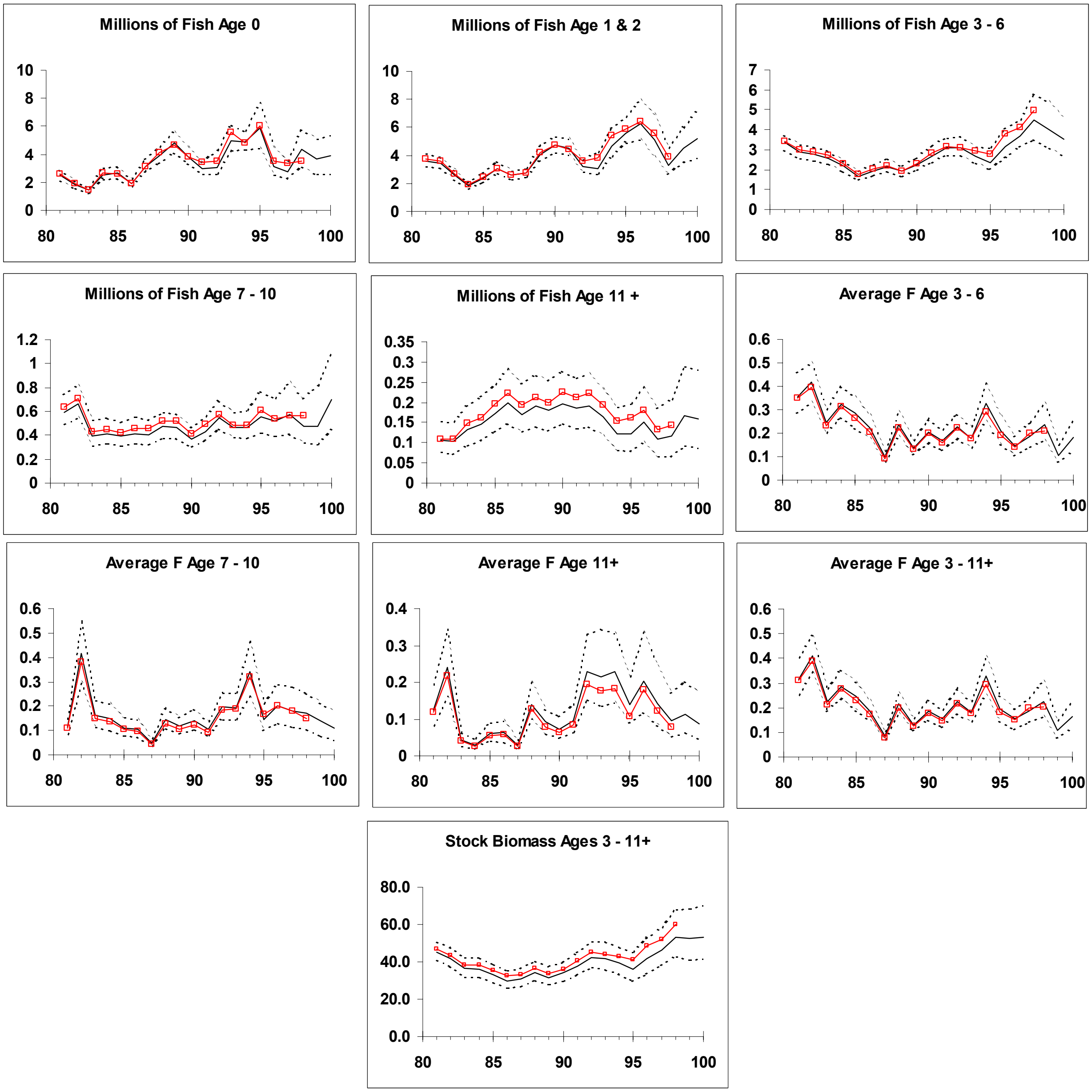


Figure 33. Sensitivity Analyses: Index removal. Gulf king mackerel population trends from tuned VPA with 80% confidence intervals, model Base 10 without the late TPWD (1986-2000) index. For comparison, equivalent estimates from the 2000 assessments are also shown (square markers line). Stock biomass units are millions of pounds.

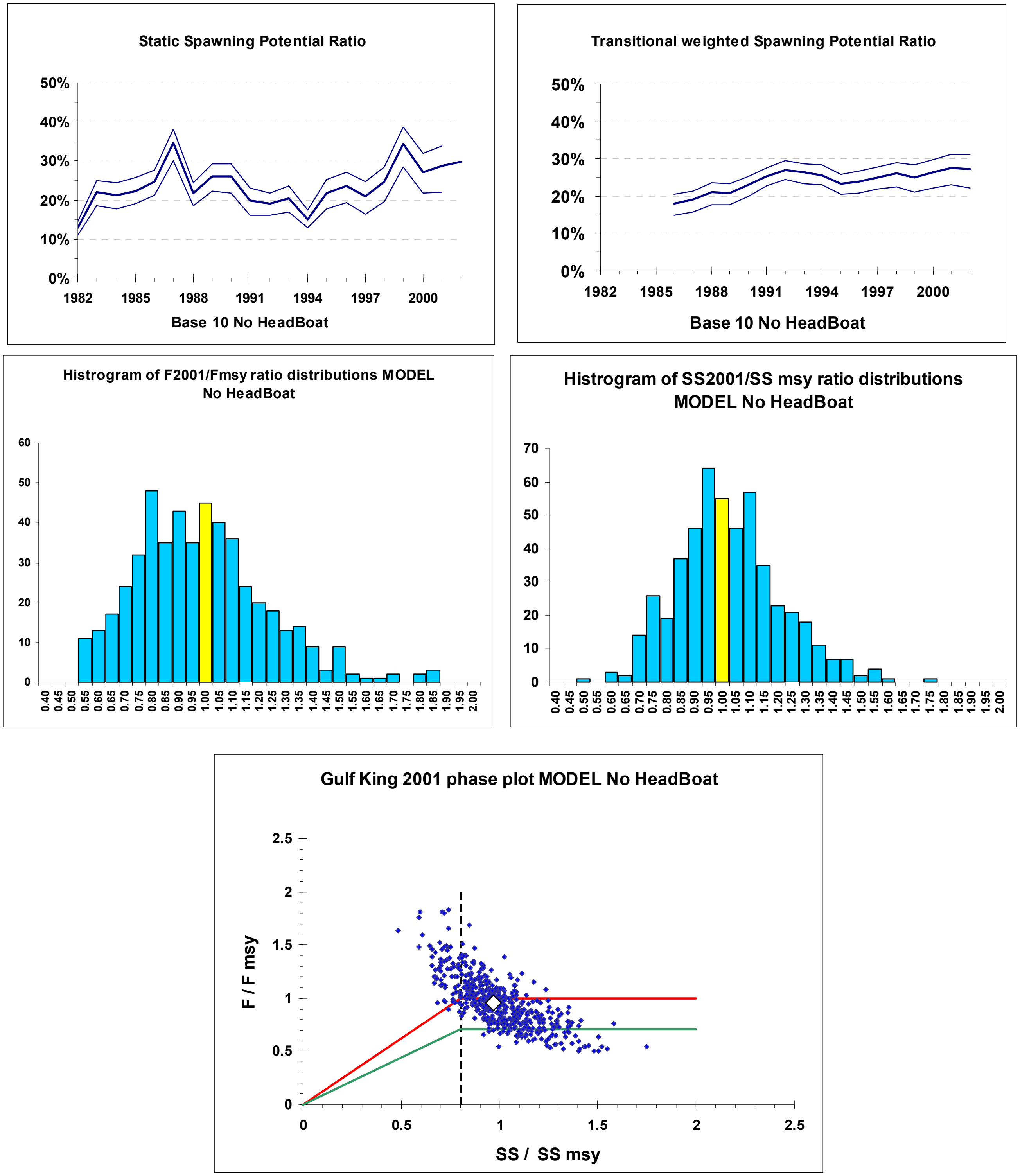


Figure 34. Sensitivity Analysis. Index removal. Gulf king mackerel estimates of static and transitional SPR (top row), frequency distribution of F_{2001}/F_{MSY} (left) and SS_{2001}/SS_{MSY} (right) ratios from 500 bootstraps (middle row), and Phase plot of 500 bootstraps for the Base 10 model scenario where the HeadBoat index was omitted. The bent 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.

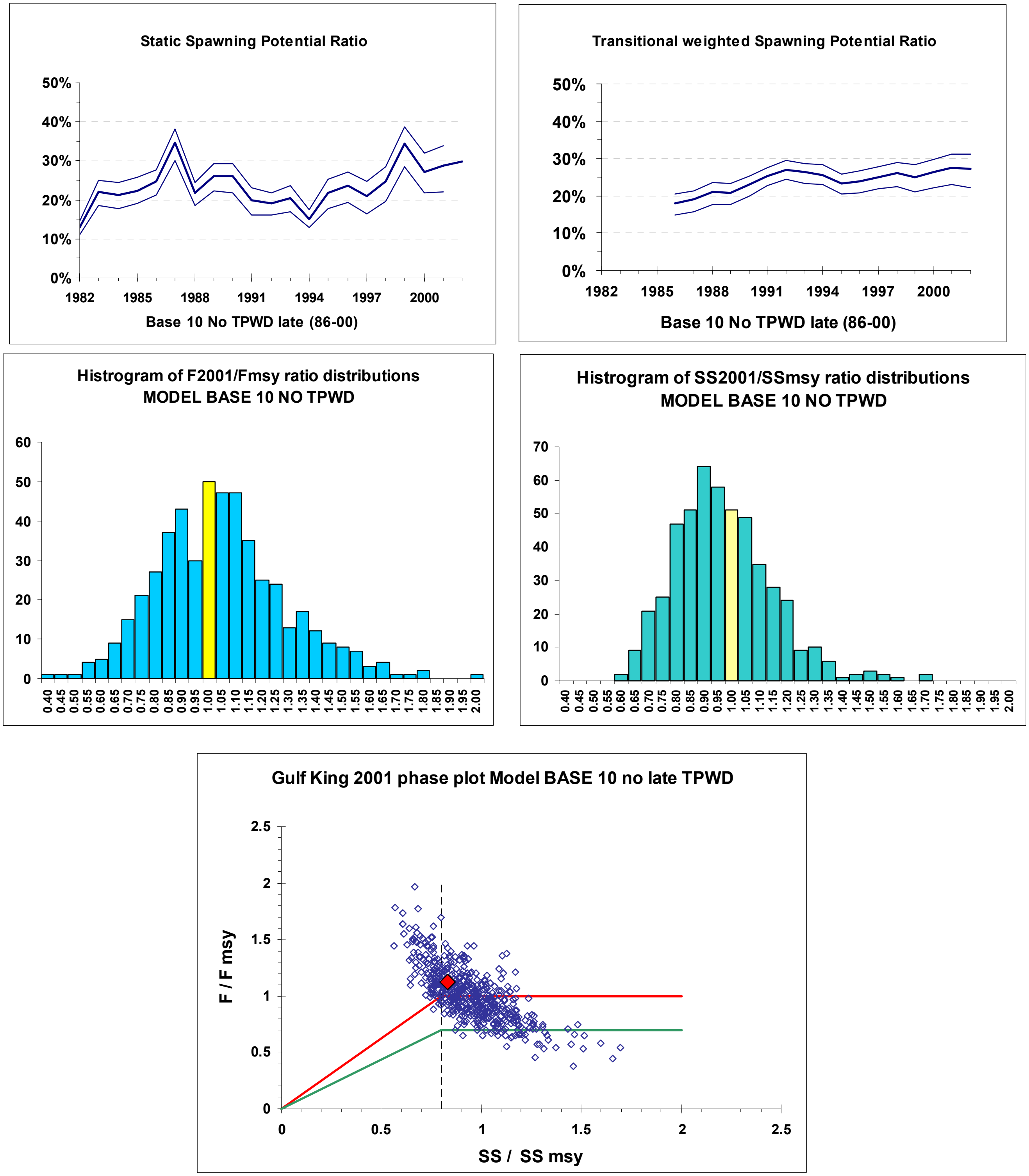


Figure 35. Sensitivity Analysis. Index removal. Gulf king mackerel estimates of static and transitional SPR (top row), frequency distribution of F_{2001}/F_{MSY} (left) and SS_{2001}/SS_{MSY} (right) ratios from 500 bootstraps (middle row), and Phase plot of 500 bootstraps for the Base 10 model scenario where the late TPWD index was omitted. The bent 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.

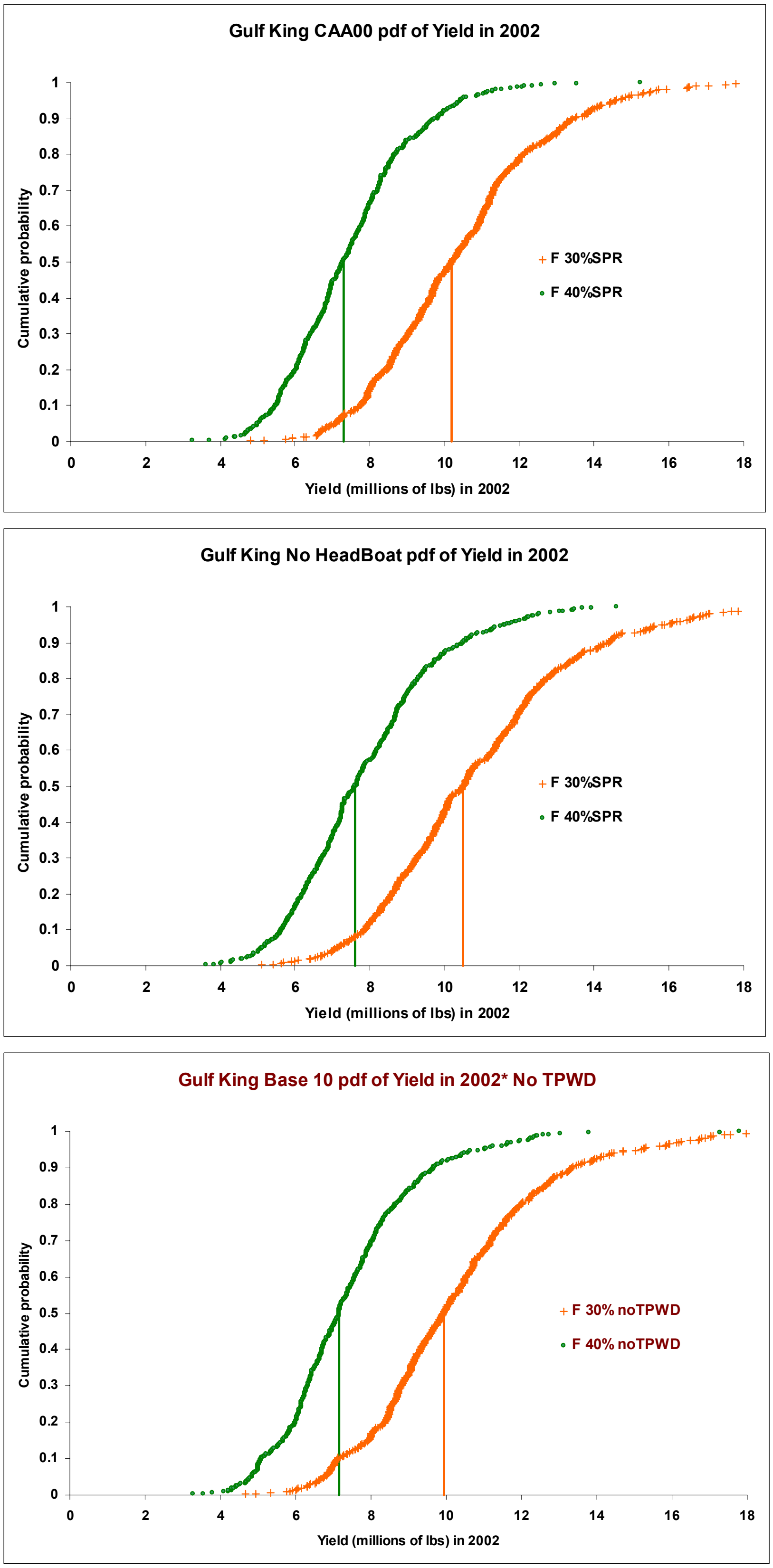


Figure 36. Sensitivity Analysis. Frequency distribution of 500 bootstraps range of ABC based on probability of F exceeding $F_{30\%\ SPR}$ and $F_{40\%SPR}$ in the 2002/2003 fishing year for Gulf king mackerel from three sensitivity scenarios: Top CAA00 sensitivity run. Middle and bottom from Index removal, no HeadBoat case and no late TPWD case, respectively. Vertical solid lines represent 0.5 percentile.