2003 REPORT OF THE MACKEREL STOCK ASSESSMENT PANEL

Authors: GMFMC and SAFMC mackerel assessment panel

SEDAR28-RD02

24 October 2011

9/2/03

2003 REPORT
OF THE
MACKEREL STOCK ASSESSMENT PANEL

Prepared by the Mackerel Stock Assessment Panel
at the Panel Meeting Held May 19-21, 2003

Gulf of Mexico Fishery Management Council
The Commons at Rivergate
3018 U.S. Highway 301 North, Suite 1000
Tampa, Florida 33619-2266
813-228-2815
813-225-7015 Fax
gulfcouncil@gulfcouncil.org

and

South Atlantic Fishery Management Council
Southpark Building, Suite 306
1 Southpark Circle
Charleston, South Carolina 29407-4699
803-571-4366

This is a publication of the Gulf of Mexico Fishery Management Council and South Atlantic Fishery Management Council pursuant to National Oceanic and Atmospheric Administration Award No. NA17FC2203 and NA17FC1053.

SUMMARY OF RECOMMENDATIONS FOR 2003/04

GROUP	Description	Value	Projected Status
King mackerel: Atlantic migratory group	ABC (Range) @ F_{OY}[a]	5.2 (3.8 - 7.5) million lbs	
	MSY[b] (Range)	5.9 (4.3 - 9.1) million lbs	
	Percentage of $F_{2002/03}$ > MFMT	4%	not overfishing[c]
	Percentage of B_{2003} < MSST	7%	not overfished[d]
Spanish mackerel: Atlantic migratory group	ABC (Range) @ F_{OY}[a]	6.7 (5.2 - 8.4) million lbs	
	MSY[b] (Range)	5.2 (4.4 - 6.4) million lbs	
	Percentage of $F_{2002/03}$ > MFMT	4%	not overfishing[c]
	Percentage of B_{2003} < MSST	< 1%	not overfished[d]
Spanish mackerel: Gulf migratory group	ABC @ F_{OY}[a]	6.3 (4.1 -9.2) million lbs	
	ABC (Range) @ $F_{30\%SPR}$[e]	9.0 (6.0 - 12.8) million lbs	
	MSY[b] (Range)	7.1 (5.5 - 9.2) million lbs	
	Percentage of $F_{2002/03}$ > MFMT	9%	not overfishing[c]
	Percentage of B_{2003} < MSST	3%	not overfished[d]

a. Acceptable biological catch (ABC) is recommended as the median probability of achieving the management target (yield at F_{OY}). The range given is yield corresponding to between the 20% and 80% probabilities of achieving F_{OY} (specified as $F_{40\%SPR}$ by both Councils) from the 2003 base virtual population analysis (VPA) model.
b. Maximum sustainable yield (MSY) is the maximum long-term yield when a stock is at equilibrium. Given are the median estimate of MSY and the 20th to 80th percentile range of estimated MSY from the 2003 assessment=s base model.
c. The MSAP defines overfishing as occurring when current F has greater than a 50% probability of exceeding MFMT.
d. The MSAP defines overfished as the condition when current biomass (B) has greater than a 50% probability of being less than MSST.
e. The MSAP=s recommendation for ABC for this migratory group is the median probability of achieving $F_{40\%SPR}$, but the median probability of not exceeding $F_{30\%SPR}$ is also provided as the upper limit of ABC defined by the GMFMC.

TABLE OF CONTENTS

2003 REPORT OF THE MACKEREL STOCK ASSESSMENT PANEL (MSAP)
May 19-21, 2003
MIAMI, FLORIDA

I. INTRODUCTION

At the request of the Gulf of Mexico and South Atlantic Fishery Management Councils (GMFMC and SAFMC, respectively), the Mackerel Stock Assessment Panel (MSAP) met in Miami from May 19-21, 2003. The tasks for the MSAP were specified by the Councils in Amendment 1 to the Fishery Management Plan (FMP) for the Coastal Migratory Pelagic Resources (mackerels and other coastal pelagics) dated April, 1985; previous MSAP reports reflect actions required by subsequent amendments. Amendment 8 and the Councils= generic SFA Amendments constitute a modified framework that respecifies the Panel=s charge. Amendment 6 required full stock assessments every other year and Amendment 8 required full stock assessments in even numbered years; however, full assessments have not been performed for Atlantic king and Spanish mackerel and Gulf Spanish mackerel migratory groups since 1998. In 2003, full assessments were conducted for Atlantic king and Spanish and Gulf Spanish mackerel but not for Gulf king mackerel. Based on MSAP recommendations, the Councils adopted $F_{30\%SPR}$ as the maximum fishing mortality threshold (MFMT) for all four mackerel migratory groups (Gulf and Atlantic king and Spanish mackerels). The proxy for maximum sustainable yield (MSY) for a given stock is computed as the long-term yield at $F_{30\%SPR}$ when the stock is at equilibrium. Following the Technical Guidelines, the MSAP recommended adopting (1.0 - M)*B_{MSY} as the minimum stock size threshold (MSST) for all four migratory groups, which has been accepted by both councils.

The list of documents reviewed by the Panel is included in the Literature Cited and Documents Reviewed section. Copies of documents are available from the Council or the Southeast Fisheries Science Center (SEFSC).

II. CONSIDERATION OF MSY, B_{MSY}, MSST, MFMT, AND CONTROL RULES

MSY, B_{MSY}, MSST, and MFMT

Section 303 of the Magnuson-Stevens Act requires the regional fishery management councils to assess quantitatively the condition of stocks under their management and establish stock status benchmarks or other criteria within their FMPs necessary to determine if stocks are overfished or subject to overfishing. Such benchmarks are also necessary to measure progress in rebuilding overfished stocks and to maintain healthy stocks at levels capable of producing optimum yield (OY). These statutory requirements necessitate incorporating biomass-based estimates of certain fish stock parameters into each FMP. Stock parameters include: 1) maximum sustainable yield (MSY); 2) the stock size that will produce MSY (B_{MSY}); 3) the minimum stock size threshold (MSST), which is a stock status benchmark indicating the minimum stock size that is required to produce MSY (below which the stock would be considered overfished); and, 4) the maximum fishing mortality threshold (MFMT), which is the level or rate of fishing mortality that, if exceeded, will result in overfishing and jeopardize the capacity of a stock to produce MSY on a continuing basis.

Stock recruit models first were developed for Gulf and South Atlantic king and Spanish mackerels in order to estimate migratory group-specific spawning stock size at MSY (B_{MSY}). (Note: for detailed derivation of stock recruit models see MSAP 1999). In each empirically-derived model, recruitment is assumed to increase to some level of spawning stock, and then to remain at the average recruitment for higher spawning stock values. To estimate B_{MSY}, the $F_{30\%SPR}$ replacement line was plotted on each stock recruit model and B_{MSY} was identified as the spawning stock size where those lines crossed.

Control Rules

The evaluation of a stock under control rules is based on its status relative to B_{MSY} and the long-term maximum sustainable fishing mortality rate associated with that spawning stock biomass, F_{MSY}. If the spawning stock size is greater than MSST, the stock is not considered overfished. Similarly, if the current fishing mortality rate is less than F_{MSY}, the fishery is not considered overfishing. Evaluation of stock condition is simplified by calculating the ratio of current F to F_{MSY} and current B to B_{MSY} to determine if overfishing or overfished conditions exist, respectively.

III. OVERFISHED, OVERFISHING, AND TARGET (OPTIMUM YIELD) CRITERIA

Overfished

Compatible with the Technical Guidelines, the minimum stock size threshold (MSST) recommended by the MSAP for mackerels is (1-M)*B_{MSY} (i.e., the spawning stock biomass that can support MSY but reduced by the natural mortality rate [M]). Both the SAFMC and GMFMC have accepted MSST as such for Atlantic and Gulf king and Spanish mackerels. Thus, MSSTs for Gulf and Atlantic king mackerel migratory groups are specified as 80% and 85%, respectively, of the spawning stock biomass that will support MSY, while MSST for both Gulf and Atlantic Spanish mackerel is specified as 70% of the spawning stock biomass that will support MSY. The determination of whether or not spawning stock size has fallen below MSST (i.e., whether or not the stock is overfished) depends on the acceptable level of risk chosen by the respective Council. The GMFMC has adopted a 50% (median) probability that a given stock=s biomass is less than MSST as an acceptable risk level and that risk level is used here to evaluate stock status relative to MSST for Gulf mackerel migratory groups. The SAFMC has not specified an acceptable risk level, but a 50% probability was also used to evaluate stock status of relative to MSST for Atlantic mackerel migratory groups.

Overfishing

The GMFMC and SAFMC specified $F_{30\%SPR}$ as a proxy for F_{MSY} for respective migratory groups of both king and Spanish mackerels. Therefore, the maximum fishing mortality threshold (MFMT) for all four migratory groups is defined as $F_{30\%SPR}$. When a stock or migratory group is not overfished, the act of overfishing is defined as harvesting at a rate that exceeds the MFMT; however, the determination of whether or not overfishing is occurring depends on the acceptable level of risk chosen by the respective Council. The GMFMC has adopted a 50% (median) probability that a fishing mortality for a given stock=s is greater than MFMT as an acceptable risk level, and that risk level is used here to whether MFMT was exceeded (i.e., overfishing occurred) for Gulf mackerel migratory groups. The SAFMC has not specified an acceptable risk level, but a 50% probability was also used to evaluate whether overfishing occurred for Atlantic mackerel migratory groups.

Target Optimum Yield (OY)

The SAFMC and GMFMC have established OY for Atlantic and Gulf king and Spanish mackerels as the long-term yield associated with $F_{40\%SPR}$ when a stock is at equilibrium. The MSAP=s recommended ABC for each of these stocks is made based on the median probability of achieving this target level. For Gulf mackerel migratory groups, the MSAP also provides the GMFMC with an estimate of the yield that would have a 50% probability of not exceeding the yield at $F_{30\%SPR.}$

Rebuilding Program

When a stock or migratory group is overfished, a rebuilding program that makes consistent progress toward restoring stock condition must be implemented and continued until the stock is restored beyond the overfished condition. The rebuilding program must be designed to achieve recovery within an acceptable time frame specified by the Councils. The Councils will continue to rebuild the stock until the stock biomass is restored to greater than B_{MSY} within an unspecified time frame (Amendment 8).

Risk and Probability

Virtual population analysis (VPA) (FADAPT 3.0; Restrepo 1996) was performed for Atlantic king and Atlantic and Gulf Spanish mackerel migratory groups to evaluate stock status relative to SFA benchmarks. As in the past, uncertainty was incorporated into assessment estimates with a mixed Monte Carlo-Bootstrap approach that accounted for variability in natural mortality, tuning indices, and numbers of fish-at-age. Outcomes from model runs (bootstraps) were used to construct probability distributions of fishing mortality rate (F) and spawning stock size (B) estimates. Estimates of F and B from each model run were expressed as ratios to F_{MSY} and B_{MSY}, and stock condition was evaluated based on the percentage of ratios that were greater that MFMT and/or less than MSST. The Technical Guidelines (Restrepo et al. 1998) recommend that managers (i.e., the Councils) choose low levels of risk such as having only 20-30% of the outcomes exceeding MFMT or falling below MSST as a precautionary approach. Following this logic, the MSAP recommended to the GMFMC in March 2001 that the probability B is less than MSST or F is greater than MFMT should not exceed 30%. However, the GMFMC has adopted the 50% probability level as acceptable risk and stock status is evaluated in this document based on that risk level.

The MSAP recommends ABC for each mackerel migratory group based on the probability a given yield will achieve a reference target (F_{OY}) or exceed a reference threshold (F_{MSY}) in the next fishing year. The inclusion of probabilities is intended to portray the risk associated with a given conclusion or action, reduce reliance on point estimates, and better represent the imprecision and uncertainty of parameter estimates. The approach followed by the MSAP, which is consistent with Standard 1 of the SFA and the Technical Guidelines (Restrepo et. al, 1998), is to recommend an ABC for each stock that has a median probability of achieving F_{OY}.

IV. ASSESSMENT AND STATUS OF STOCKS

A. Atlantic King Mackerel Migratory Group

Landings and History of Management

Catches since 1981/82 have ranged from a high of 9.6 million pounds in 1985/86 to a low of 5.7 million pounds in 1999/00 (Table 1 and Figure 1). In recent years, TAC has been set at 10.0 million pounds, but landings have only been between 50 and 74% of TAC since the 1999/00 fishing year.

Assessment methods

A full assessment was performed for Atlantic king mackerel with estimated landings through 2001/02 and projected landings through 2002/03 (SFD 2003). Five standardized indices of relative abundance were computed from catch per unit effort (CPUE) data from multiple sources as tuning analyses in the base VPA model. A standardized index was developed from the Southeast Area Monitoring and Assessment Program=s (SEAMAP) shallow trawl survey catch rates as a fishery-independent index of age-0 fish. Three fishery-dependent standardized indices used to tune the base model were developed from the Florida Fish and Wildlife Conservation Commission Marine Fisheries Trip Ticket Program (ages 1-11), the Marine Recreational Fishery Statistics Survey (MRFSS) (ages 1-11), the NMFS Beaufort Laboratory Headboat Survey (ages 1-11), respectively. An additional tuning index developed from North Carolina commercial CPUE data (ages 1-11) was included in the Afull index model@ (SFD 2003; Oriz and Sabo 2003); however, the MSAP concluded the base model was most appropriate to estimate stock status until properties of the new index could be evaluated more rigorously (see FUTURE RESEARCH NEEDS below).

One modification to the assessment=s base model was requested by the MSAP. The MSAP recommended recruitment be estimated as number of age-1 because the model appeared to estimate age-0 abundance poorly. Therefore, stock status estimates and the ABC recommendation were derived from the base model but using estimated abundance of age-1 fish to compute the stock-recruitment relationship. It should be noted, however, that this change had only minor effects on F/F_{MSY}, B/B_{MSY}, and ABC.

As in the past, uncertainty was incorporated into estimates of F and B with a mixed Monte Carlo-Bootstrap approach that accounted for variability in natural mortality, tuning indices, and numbers of fish-at-age. The model used a uniform probability distribution for natural mortality rates from 0.15 to 0.25 per year, centering on 0.2 per year.

Trends in Recruitment

The general trend in estimated recruitment (age-1 fish) has been an increase from 1992 through 1999, with one low year in 1998 (Figure 2).

Estimated $F_{2002/03}/F_{MSY}$

The median estimate of F/F_{MSY} for Atlantic king mackerel was 0.56 for fishing year 2002/03 (Figure 3) and the percentage of estimated $F_{2002/03}/F_{MSY}$ greater than 1.0 was 4% (n = 19 of 448 bootstraps). Based on the acceptable risk level chosen by the SAFMC, that there should be no greater than a 50% probability that current F exceeds MFMT, the MSAP=s estimation is that overfishing did not occur in 2002/03 for Atlantic king mackerel.

Estimated B_{2003}/B_{MSY}

The median estimate of B_{2003}/B_{MSY} for Atlantic king mackerel was 1.22 and the estimated percentage of B_{2003} less than MSST was 7% (n = 32 of 448) (Figure 4). Based on the acceptable risk level chosen by the SAFMC, that there should be no greater than a 50% probability that current B is less than MSST, the MSAP estimates Atlantic kings were not overfished in 2002/03.

Discussion of Stock Status

Current estimates indicate there were high probabilities that fishing mortality rate on Atlantic king mackerel in fishing year 2002/03 was less than MFMT and the spawning biomass was above MSST (Figure 5). Therefore, the MSAP considers Gulf kings were not overfished and overfishing was not occurring in fishing year 2002/03.

Estimated Atlantic king mackerel stock size has increased since the mid 1990s (Figure 6); however, the estimate of MSY for this migratory group is much lower in the current assessment (5.9 million lbs.) than was estimated in the last full assessment in 1998 (10.4 million lbs.). The MSAP reviewed the data inputs in the base VPA model, as well as model fit, and concluded this decrease in estimated stock productivity was due to two factors. First, it appears for Atlantic king mackerel that cohorts must be present in landings for several years before their abundance can be well estimated. Therefore, several cohorts were estimated to be much larger in the 1998 assessment than retrospective estimates for the same cohorts in the 2003 assessment (Figure

7a,b). A second reason for the difference in estimated MSY is the selectivity-at-age vector is markedly different between the two assessments (Figure 8), with ages 4+ estimated to be more or less fully selected for the most recent years in the current assessment. The effect of these two factors is that certain year classes were estimated to be smaller in the current assessment than in 1998 and the change in estimated selectivities results in lower yield per recruit; therefore, estimated MSY decreased from the 1998 assessment to the 2003 assessment.

As part of its discussion of differences in estimates of cohort abundance and stock productivity between the two assessments, the MSAP examined the history of management advice provided by the MSAP to the SAMFC. The consensus among MSAP members was that variability in estimates of stock productivity of this mackerel migratory group across the time series of assessment and management likely stems from the phenomenon discussed above that cohorts must be present in landings for several years before their abundance and cohort-specific selectivities can be well estimated. Despite the variability in estimated stock productivity and the periodically high TAC adopted by the SAFMC (Table 1), the MSAP noted landings have averaged close to the median estimate of MSY from the 2003 base model (5.9 million lbs.), and certainly have been within the 80% confidence interval of the 2003 estimated MSY (4.3 - 9.1 million pounds).

Acceptable Biological Catch (ABC)

The SAMFC's stated objective is to select a total allowable catch (TAC) for Atlantic king mackerel that has a median probability of achieving its management target, OY, defined as the yield associated with a fishing mortality rate of $F_{40\%SPR}$. Therefore, the MSAP recommends ABC for 2003/04 as the median estimate of catch at $F_{40\%SPR}$, which is 5.2 million pounds (20^{th} - 80^{th} percentile range = 3.8 - 7.5 million pounds) (Figure 9).

B. Atlantic Spanish Mackerel Migratory Group

Landings and History of Management

Catches since 1984/85 have ranged from 3.1 million pounds in 1995/96 to 7.0 million pounds in 1991/92 to (Table 2 and Figure 10). The low point in 1995/96 has been attributed to the Florida net ban, but commercial and total catches have increased steadily since 1995/96.

Assessment methods

The full assessment performed for Atlantic Spanish mackerel (Ortiz et al. 2002) is the first full assessment since 1998. Catches, length and age samples, and standardized tuning index values were added for fishing years 1996/1997 through 2001/2002; projected landings through 2002/03 also were included. Uncertainty was incorporated into population estimates several ways: a mixed Monte Carlo-Bootstrap approach that accounted for variability in natural mortality, tuning indices, and numbers of fish-at-age; retrospective analyses; and sensitivity runs. Two model configurations were considered, a base run similar to the 1998 full assessment, and a ‘full index’ run that included two additional indices: North Carolina Pamlico Sound Survey CPUE and NC GLM modeled commercial fishery CPUE. Surveys included in the base configuration in the 1998 assessment were selected following a comprehensive review of available surveys, and additional surveys must be similarly reviewed to determine whether or not the survey is representative of stock abundance . The panel did not feel the additional surveys in the full index configuration have been thoroughly reviewed and documented (see FUTURE RESEARCH NEEDS below). Further, a cursory review of the methods, coupled with the low catch rates and very variable PSE s for the Pamlico Sound survey suggest it is unlikely this survey is representative of stock abundance. Sensitivity comparisons of the base and the full survey configurations show little differences in key results. For these reasons, the Panel supports the base configuration and the following results refer to that run.

Trends in Recruitment

Estimated recruitment fluctuated between 6 and 11 million age-0 fish from 1984 through 1997, and increased slightly to around 13 million fish in 1998 (Figure 11).

Estimated of $F_{2002/03}/F_{MSY}$

Based on projected landings for the 2002/03 fishing year, the median estimate of F/F_{MSY} was 0.58 and the percentage of estimated $F_{2002/03}/F_{MSY}$ greater than 1.0 was 3% (n = 14 of 500 bootstraps) (Figure 12). Therefore, there is only a 3% chance that overfishing of Atlantic Spanish mackerel occurred during the 2002/03 fishing year.

Estimated B_{2003}/B_{MSY}

The median estimate of B_{2003}/B_{MSY} was 1.78, and the estimated percentage of B_{2003} less than MSST was < 1% (n = 3 of 500 bootstraps) (Figure 13). Therefore, there is less than a 1% probability Atlantic Spanish mackerel were overfished in 2003.

Discussion of Stock Status

Estimated fishing mortality for Atlantic Spanish mackerel has been below F_{MSY} and F_{OY} since 1995. Estimated stock abundance has increased steadily since 1995 and is now at a high for the analysis period (Figure 14). In fact, estimated stock biomass has more than doubled since 1995. Probabilities the stock is overfished or that overfishing occurred in the most recent fishing year are less than 5% (Figure 15); therefore, the MSAP concludes Atlantic Spanish are not overfished and overfishing did not occur in 2002/03.

Although all measures of stock status are well within desirable ranges, the median estimate of MSY dropped from 6.4 million pounds in the 1998 assessment (last full assessment) to 5.2 million pounds in the current assessment. Much of the decline is believed due to lower estimates of recruitment between the 2003 and the 1998 assessments. It should also be noted, however, that the confidence intervals of the estimates overlap and the median MSY estimate from the 1998 assessment is similar to the upper 80% confidence interval (6.4 million pounds) estimated in the current estimate.

Acceptable Biological Catch (ABC)

The SAMFC's stated objective is to select a total allowable catch (TAC) for Atlantic king mackerel that has a median probability of achieving its management target, OY, defined as the yield associated with a fishing mortality rate of $F_{40\%SPR}$. Therefore, the MSAP recommends ABC for 2003/04 as the median estimate of catch at $F_{40\%SPR}$, which is 6.7 million pounds (20^{th} - 80^{th} percentile range = 5.2 - 8.4 million pounds) (Figure 16). The MSAP cautions the SAMFC, however, that its ABC recommendation based on the median probability of achieving the management target of $F_{40\%SPR}$ exceeds the median estimate of MSY (5.2 million lbs.). While it is unlikely the fishery currently has the capacity to realize a TAC of 6.7 million lbs., if the fishery developed greater capacity and TAC was realized at a level of 6.7 million pounds for several years, then fishing mortality rates would increase and eventually may exceed $F_{30\%SPR}$. Furthermore, fishing at that level over time eventually would reduce spawning stock biomass to a level below that which is capable of producing MSY on a continuing basis (i.e., below B_{MSY}).

C. Gulf Spanish Mackerel Migratory Group

Landings and History of Management

Catches since 1981/82 have ranged from a high of 10.1 million pounds in 1987/88 to a low of 2.1 million pounds in 1996/97 (Table 3 and Figure 17). Total landings generally increased after 1996/97 with most of the increase coming from the recreational sector of the fishery.

Assessment methods

A full assessment was performed for Gulf Spanish mackerel with estimated landings through 2001/02 and projected landings through 2002/03 (SFD 2003). As in the past, uncertainty was incorporated into estimates of F and B with a mixed Monte Carlo-Bootstrap approach that accounted for variability in natural mortality, tuning indices, and numbers of fish-at-age. The model used an equal probability distribution for natural mortality rates from 0.25 to 0.35 per year, centering on 0.3 per year. Five standardized indices of relative abundance were used to tune the analyses (NMFS=s bycatch, Florida trip ticket (FWC), MRFSS, Texas recreational survey (TPWD) and NW Florida Charter). The NMFS’s bycatch index is used to estimate abundance of age-0 fish. In addition, the MRFSS and TPWD index estimates abundance of ages 1-3; the Florida trip ticket index estimates ages 1-7; and, the NW Florida charter index estimates ages 1-2.

Stock status of Gulf Spanish mackerel has been evaluated based on 500 model runs (bootstraps) used to construct probability distributions of the ratio of current fishing mortality rate ($F_{2002/03}$) to F_{MSY} and the ratio of spawning stock biomass (B_{2003}) to spawning stock biomass at MSY (B_{MSY}). Likewise, ABC for 2003/04 has been recommended based on projected bootstrap distributions of the probability that different yields would exceed $F_{30\%SPR}$ (F_{MSY}) and/or achieve $F_{40\%SPR}$ (as a proxy for F_{OY}).

Trends in Recruitment

Estimated recruitment, represented by the number of age-0 fish, has fluctuate throughout the period examined, with the possibility of a slightly increasing trend in recent years (Figure 18).

Estimated $F_{2002/03}/F_{MSY}$

The median estimate of F/F_{MSY} for Gulf Spanish mackerel was 0.53 in fishing year 2002/03 (Figure 19) and the percentage of estimated $F_{2002/03}/F_{MSY}$ greater than 1.0 was 9% (n = 44 of 500 bootstraps). Based on the acceptable risk level chosen by the GMFMC, that there should be no greater than a 50% probability that current F exceeds MFMT, the MSAP=s estimation is that overfishing did not occur in 2002/03 for Gulf Spanish mackerel. It also should be noted that landings have been less than TAC and 2002/03 commercial landings were only 30.8 percent of their allocation (Table 3, Figure 17).

Estimated B_{2003}/B_{MSY}

The median estimate of B_{2003}/B_{MSY} for Gulf Spanish mackerel was 1.34 and the estimated percentage of B_{2003} less than MSST was 3% (n = 16 of 500 bootstraps) (Figure 20). Based on the acceptable risk level chosen by the GMFMC, that there should be no greater than a 50% probability that current B is less than MSST, the MSAP estimation is that Gulf Spanish were not overfished in 2002/03. Estimated spawning stock size continued to increase in 2002/2003 (Figure 21).

Discussion of Stock Status

Landings of Gulf Spanish mackerel have been lower than TAC since 1989/90 (Table 3). Lower landings results in lower estimates of fishing mortality, hence spawning biomass projections increase (Figure 20). Current estimates indicate the fishing mortality rate on Gulf Spanish mackerel in fishing year 2002/03 is well below MFMT and the spawning biomass is well above MSST (Figure 22). Therefore, the MSAP considers Gulf Spanish mackerel are not overfished and overfishing did not occur in fishing year 2002/03.

Although all measures of stock status are well within desirable ranges, the median estimate of MSY dropped from 8.5 million pounds in the 1998 assessment (last full assessment) to 7.1 million pounds in the current assessment. Much of the decline is believed due to lower estimates of recruitment between the 2003 and the 1998 assessments. It should also be noted, however, that the confidence intervals of the estimates overlap and the median MSY estimate from the 1998 assessment is within the 80% confidence interval (5.5 - 9.2 million pounds) estimated in the current estimate.

Acceptable Biological Catch (ABC)

Given the GMFMC's objective not to exceed MFMT ($F_{30\%SPR}$), the MSAP recommends the Council select a total allowable catch (TAC) that is consistent with OY, which is defined by the GMFMC of yield associated with a fishing mortality rate of $F_{40\%SPR}$. Therefore, the MSAP recommends an ABC of 6.3 million pounds (20^{th} - 80^{th} percentile range = 4.1 - 9.2 million pounds). The rationale behind this recommendation is that an ABC of 6.3 million pounds has a 50% probability of achieving the OY target (yield at $F_{40\%SPR}$), but a low probability (23%) that it will exceed MFMT ($F_{30\%SPR}$) (Figure 23). It should be noted that the lower that TAC is set in the range of ABC the lower the probability of overfishing during the 2003/04 fishing year.

In the recent past, the GMFMC has disregarded the MSAP's ABC recommendation and set TAC for Gulf Spanish at the median probability of not exceeding $F_{30\%SPR}$. Based on the current assessment, that strategy would lead the GMFMC to set TAC at 9.0 million pounds. The MSAP cautions that if the fishery produced landings at a level of 9.0 million pounds for several years, then fishing mortality rates would increase and eventually may exceed $F_{30\%SPR}$. Furthermore, fishing at that level over time eventually would reduce spawning stock biomass to a level below that which is capable of producing MSY on a continuing basis (i.e., below B_{MSY}).

V. OTHER MATERIAL REVIEWED

A. Further Notes on the Otolith Samples Available for Ageing Gulf King Mackerel in the 2000 and 2002 Stock Assessments

Stock assessment of Gulf king mackerel has been conducted since 1985 using age-based assessment methods (VPA). The fundamental information base consists of annual catch in numbers-at-age developed by applying sex and year stratified age-length-keys (ALK) to corresponding sex-year stratified landings expressed as length frequencies. Following recommendations by the MSAP, when a sex-year stratification shows insufficient ALKs for robust catch-at-age estimation, a stochastic procedure developed by Shepherd (1985) is applied. In the 2002 Gulf king mackerel assessment, there was a significant movement of fish from older to younger ages in the catch-at-age matrices when 289 fish that had been miscoded were added to the 1995-1997 period. Consequently, fishing mortality estimates increased and population abundance estimates decreased relative to the 2000 full assessment. The observed changes are indicative of a significant stratification in the exploitation pattern of the revised ageing dataset. Therefore, the Panel recommended an evaluation of the observed catch-at-age matrix differences to include analyses of the length-quarter-gear stratifications that are responsible for the significant changes observed. This recommendation also implied an evaluation of the distribution of age at size within sex-season-year cells as well as an evaluation through simulation of the robustness of the ALK approach to construct catch-at-age matrices.

Analyses conducted by Cummings and Turner (2003) addressing the panel=s recommendations indicated differences in catch-at-age estimates between the 2000 and 2002assessments only existed in the fourth quarter of 1995, 1996, and 1997, but these differences were not due to switching between age from length assignment methods. Therefore, while the quarter in which differences exist has been identified, the cause of the changes between years remains unclear. The MSAP recommends NMFS biologist continue to examine this question. In particular, NMFS biologist should examine within length bin changes in age-length distributions that likely occurred due to inclusion of the 289 originally miscoded fish in 2002 of the ALKs and explore whether quarterly ALKs may be more appropriate than applying an annual ALK across all quarters.

VI. FUTURE RESEARCH NEEDS

The Panel identified several areas where additional research is needed to improve the quality, cost-effectiveness, and reliability of future stock assessments.

A. Examination of differences in population dynamic characteristics and mixing between Atlantic and east and west Gulf king mackerel migratory groups

The present management regime specifies two migratory groups of king mackerel based on tagging data, growth rate differences, and temporal differences in the fisheries: the Gulf migratory group and the Atlantic migratory group. The Gulf migratory subgroup is assessed as one unit, but for management two migratory subgroups are assumed to occur: the eastern Gulf of Mexico migratory subgroup and the western Gulf of Mexico migratory subgroup. There is a need to examine potential differences that may exist between these two subgroups and to estimate mixing rates between them. First, basic life history parameter characterization (e.g., age and growth, reproductive biology) is needed to determine if population dynamics differ between eastern and western Gulf king mackerel. Furthermore, we recommended studies based on microsatellite DNA loci, otolith shape analysis, and otolith microchemistry be undertaken to estimate mixing proportions and population structure between assumed migratory groups in the Gulf of Mexico.

B. Re-examination of recent growth information

Growth equations by sex used in the mackerel stock assessments were developed in the 1980s. Effects of exploitation and environmental change may have affected growth, therefore, the Panel recommends re-examination of these growth functions by using more recently collected age data for age-length-key generation.

C. Workshop to evaluate additional tuning indices for mackerel VPAs

The MSAP met in July of 1996 to review and evaluate existing CPUE indices used in tuning mackerel VPAs. Since that time, new indices or modifications of existing indices have become available. The panel request a workshop to reevaluate the adequacy of existing CPUE indices and evaluate any new indices currently available. The workshop should include presentations by personnel directly involved in the studies with emphasis on how CPUE indices relate to estimated mackerel abundance. The workshop should also establish a procedure for incorporating newly developed indices into future mackerel assessments.

D. Evaluation of age-length-key versus stochastic methodologies to estimate age at length for mackerel migratory groups

The panel recommends examining the use of the stochastic growth model for converting landings by length to landings by age in the absence of adequate age sampling. Annual age length keys may be more accurate than the stochastic method for poorly sampled quarters. If the stochastic method is retained, then the potential for changes in growth over time needs to be evaluated, and the stochastic growth model updated accordingly. Annually estimated stochastic model parameters should be considered.

The panel recommends future assessments of Atlantic king mackerel include a sensitivity run that begins the assessment with the 1986/1987 fishing year, to avoid including those early years when age sampling was inadequate and age estimation is based wholly on the stochastic growth model. Following the1986/87 fishing year when age-length keys were first used to estimate age, there is a shift in estimated catch at age distributions; the modal age in the catch is much more consistent among years; and, cohorts can be tracked in the catch more consistently.

Lastly, future mackerel assessments should report information on catch sampling intensity by sex, state, area, year, and quarter, such as the number of trips sampled, pounds sampled, number of aged samples, number of length samples, etc.

E. Consideration of an alternative time period for the Atlantic king mackerel assessment.

The MSAP recommends future assessments of Atlantic group king mackerel include a sensitivity run that begins the assessment with the 1986/1987 fishing year to avoid including those early years when age sampling was inadequate and age estimation was based wholly on the stochastic growth model. Since the 1986/87 fishing year when age-length keys were first used to estimate age, there is a shift in estimated catch at age distributions; the modal age in the catch is much more consistent among years; and, cohorts can be tracked in the catch more consistently.

F. Consideration of selectivity patterns for estimating management benchmarks.

Estimates of key management parameters such as MSY, B_{MSY}, and F_{MSY} vary considerably across assessments for king and Spanish mackerel. One reason cited is that selectivity at age varied noticeably between the current and the previous (1998) assessment. The potential for selectivity estimated by FADAPT to vary in response to varying cohort abundance, rather than true changes in fishery selectivity, should be investigated. Methods of estimating selectivity patterns that are more reflective of long-term equilibrium conditions should be developed and considered when estimating values of long-term equilibrium measures such as MSY, B_{MSY}, and F_{MSY}.

G. Sampling intensity should be fully reported

Future mackerel assessments should report information on catch sampling intensity by sex, state, area, year, and quarter, such as the number of trips sampled, pounds sampled, number of aged samples, number of length samples, etc.

H. Consideration of bycatch

Current assessments for Atlantic king and Spanish mackerel stocks did not include mortality due to shrimp trawl bycatch. Given the magnitude of bycatch estimated in the 1998 assessments for these stocks, the MSAP feel estimates of this source of mortality should be updated and included in subsequent assessments. For Gulf king and Spanish mackerel stocks, there is a need to update estimates of bycatch since the implementation of BRDs. The current assessment models assumed a reduction in bycatch as a fixed annual percent reduction; however, the actual reduction in bycatch of mackerels needs to be verified with current data.

VII. 2003 ASSESSMENT CONSIDERATIONS

The MSAP recommends the NMFS conduct full assessments for Atlantic and Gulf group king and Spanish mackerels in 2004. Assessments should include, to the extent possible, data available through the 2003/04 fishing year.

VIII. LITERATURE CITED AND DOCUMENTS REVIEWED

Cummings, N. J. and D. A. Devries. 2003. Updated information on the otolith ageing data used in the 2003 king and Spanish mackerel stock assessment analyses. Sustainable Fisheries Division Contribution No. SFD 2003-011. National Marine Fisheries Service, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, Florida 33149. 16 pp.

Cummings, N. J. and S. C. Turner. 2003. Further notes on the otolith samples available for ageing Gulf king mackerel in the 2000 and 2002 stock assessments. Sustainable Fisheries Division Contribution No. SFD 2003-009. National Marine Fisheries Service, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, Florida 33149. 27 pp.

MSAP 1999. 1999 Report of the MSAP. Gulf of Mexico Fishery Management Council, 3018 U.S. Highway 301, North, Tampa, Florida 33619. 25 pp.

Ortiz, M. 2003. Standardized catch rates of king mackerel, *Scomberomorus cavalla*, and Spanish mackerel, *Scomberomorus maculatus*, from the U.S. Gulf of Mexico and South Atlantic recreational fisheries. Sustainable Fisheries Division Contribution No. SFD 02/03-006. National Marine Fisheries Service, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, Florida 33149. 31 pp.

Ortiz, M. and L. Sabo. 2003. Standardized catch rates of Spanish and king mackerel (*Scomberomorus maculatus* and *S. cavalla*) from the North Carolina commercial fisheries. Sustainable Fisheries Division Contribution No. SFD 02/03-005. National Marine Fisheries Service, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, Florida 33149.

Restrepo, V.R. 1996. FADAPT Version 3.0: A Guide. Unpublished manuscript, available from author. University of Miami RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149.

Restrepo, V.R, G.G. Thompson, P.M. Mace, W.L. Gabriel, L.L. Low, A.D. MacCall, R.D. Methot, J.E. Powers, B.L. Taylor, P.R. Wade, and J.F. Witzig. 1998. Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. DOC, NOAA, NMFS, NOAA Technical Memorandum NMFS-F/SPO-31. 54 pp.

Shepard, J. G. 1985. Deconvolution of length compositions. ICES Methods Working Group. Working Paper. 7 pp.

Sustainable Fisheries Division. 2003. Stock assessment analyses on Spanish and king mackerel stocks. Sustainable Fisheries Division No. SFD 2003-008. National Marine Fisheries Service, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, Florida 33149. 108 pp.

IX. LIST OF PANEL MEMBERS AND ATTENDEES

Members:

John Carmichael
Nelson Ehrhardt; absent
Doug Gregory; absent
Robert Muller; absent
William Patterson
Joe Shepard

Observers:

Myron Fischer - Gulf of Mexico Fishery Management Council Member
George Geiger – South Atlantic Fishery Management Council Member
Rick Leard - Gulf of Mexico Fishery Management Council Staff
Greg Waugh - South Atlantic Fishery Management Council Staff

Nancy Cummings - NMFS, SEFSC, Miami
Mauricio Ortiz - NMFS, SEFSC, Miami
Steve Turner - NMFS, SEFSC, Miami
Jerry Scott - NMFS, SEFSC, Miami
Liz Brooks - NMFS, SEFSC, Miami
David Die - NMFS, SEFSC, Miami
Ching-ping Chih - NMFS, SEFSC, Miami
Al Jones – SSC member, GMFMC
Nadiera Maharaj – Reefkeeper International
Nancy Wallace – Atlantic States Marine Fisheries Commission

X. TABLES

Table 1. Atlantic group king mackerel management regulations and harvest. Pounds are in millions.

Fishing Year	ABC RANGE[1] (lbs.)	TAC (lbs.)	Rec. Alloc./Quota[2] (lbs. / numbers)	Rec. Bag Limit	Commercial Allocation	Annual Harvest Levels		
						Com	Rec	Total[3]
1986/87	6.9 -15.4	9.68		3	3.59 (PS=0.40)	2.840	5.980	8.820
1987/88	6.9 -15.4	9.68	6.09	3	3.59 (PS=0.40)	3.453	3.905	7.357
1988/89	5.5 -10.7	7.00	4.40	2 in FL, 3 GA-NC	2.60 (PS=0.40)	3.091	4.881	7.972
1989/90	6.9 -15.4	9.00	5.66 / 666,000	2 in FL, 3 GA-NC	3.34	2.635	3.400	6.036
1990/91	6.5 -15.7	8.30	5.22 / 601,000	2 in FL, 3 GA-NY	3.08	2.676	3.718	6.394
1991/92	9.6 -15.5	10.50	6.60 / 735,000	5 in FL-NY	3.90	2.516	5.822	8.338
1992/93	8.6 -12.0	10.50	6.60 / 834,000[4]	2 in FL, 5 GA-NY	3.90	2.227	6.251	8.477
1993/94	9.9 -14.6	10.50	6.60 / 854,000	2 in FL, 5 GA-NY	3.90	2.018	4.438	6.456
1994/95	7.6 -10.3	10.00	6.29 / 709,000	2 in FL, 5 GA-NY	3.71	2.197	3.728	5.925
1995/96	7.3 -15.5	7.30	4.60 / 454,000	2 in FL, 3[5] GA-NY	2.70	1.870	4.153	6.023
1996/97	4.1 - 6.8	6.80	4.28 / 438,525	2 in FL, 3 GA-NY	2.52	2.702	3.990	6.692
1997/98	4.1 - 6.8	6.80	4.28 / 438,525	2 in FL, 3 GA-NY	2.52	2.684	5.158	7.843
1998/99	8.4 - 11.9	8.40	5.28 / 504,780	2 in FL, 3 GA-NY	3.12	2.549	4.268	6.816
1999/00	8.9 - 13.3	10.0	6.3 / 601,338	2 in FL, 3 GA-NY	3.7	2.238	3.574	5.812
2000/01	8.9 - 13.3	10.0	6.3 / 601,338	2 in FL, 3 GA-NY	3.7	2.073	5.301	7.374
2001/02	8.9 - 13.3	10.0	6.3 / 601,338	2 in FL, 3 GA-NY	3.7	2.017	4.037	6.054

[1] The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target; the Panel's best estimate of ABC has been intermediate to the end-points of this range.
[2] Recreational quota in numbers is the allocation divided by an estimate of annual average weight
[3] Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.
[4] Bag limit will not be reduced to zero when allocation reached, beginning fishing year 1992.
[5] Bag limit reduced from 5 to 3 effective 1/1/96.
[6] Estimated catch equal to the recreational allocation of TAC.

Table 2. Atlantic group Spanish mackerel management regulations. Pounds are in millions.

Fishing Year	ABC RANGE[1]	TAC (lbs)	Rec. Alloc./Quota [2] (lbs / numbers)	Rec. Bag Limit	Com. Alloc. (lbs)	Harvest Levels[3]		
						Com	Rec	Total
1987/88	1.7 - 3.1	3.1	0.74	4 in FL, 10 GA-NC	2.36	3.559	1.474	5.033
1988/89	1.3 - 5.5	4.0	0.96	4 in FL, 10 GA-NC	3.04	3.524	2.740	6.264
1989/90	4.1 - 7.4	6.0	2.76 / 1,725,000 [4]	4 in FL, 10 GA-NC	3.24	3.963	1.569	5.533
1990/91	4.2 - 6.6	5.0	1.86 / 1,216,000	4 in FL, 10 GA-NC	3.14	3.560	2.075	5.635
1991/92	5.5 - 13.5	7.0	3.50 / 2,778,000	5 in FL, 10 GA-NC	3.50	4.739	2.287	7.023
1992/93	4.9 - 7.9	7.0	3.50 / 2,536,000 [5]	10 FL - NY	3.50	3.716	1.995	5.712
1993/94	7.3 - 13.0	9.0	4.50 / 3,214,000	10 FL - NY	4.50	4.813	1.493	6.306
1994/95	4.1 - 9.2	9.2	4.60 / 3,262,000	10 FL - NY	4.60	5.233	1.378	6.611
1995/96	4.9 - 14.7	9.4	4.70 / 3,113,000	10 FL - NY	4.70	2.009	1.089	3.098
1996/97	5.0 - 7.0	7.0	3.50 / 2,713,000	10 FL - NY	3.50	3.099	0.849	3.948
1997/98	5.8 - 9.4	8.0	4.00 / 2,564,000	10 FL - NY	4.00	3.056	1.660	4.716
1998/99	5.4 - 8.2	8.0	4.00 / 2,564,000	10 FL - NY	4.00	3.272	0.817	4.090
1999/00	5.7 - 9.0	7.04	3.17 /	10 FL - NY	3.52	2.342	1.505	3.847
2000/01	5.7 - 9.0	7.04	3.17 / 2,032,000	15 FL - NY	3.87	2.795	2.699	5.494
2001/02	5.7 - 9.0	7.04	3.17 / 2,032,000	15 FL - NY	3.87	3.058	2.019	5.077

[1] The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target; the Panel's best estimate of ABC has been intermediate to the end-points of this range.
[2] Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).
[3] Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.
[4] Allocations and rec. quota are as revised October 14, 1989.
[5] Bag limit will not be reduced to zero when allocation reached, beginning fishing year 1992.
[6] Estimated catch equal to the recreational allocation of TAC.

Table 3. Gulf group Spanish mackerel management regulations. Pounds are in millions. Prior to fishing year 1990, management was based upon a July-June fishing year. The regulations shown for fishing year 1987 and later are relative to the July-June fishing year.

Fishing Year	ABC RANGE[1] (lbs)	TAC (lbs)	Rec. Alloc./Quota[2] (lbs / numbers)	Rec. Bag Limit	Com. Alloc. (lbs)	Annual Harvest Levels[3]		
						Com	Rec	Total
1987/88	1.9 - 4.0	2.50	1.08	3	1.42	2.581	3.124	5.705
1988/89	1.9 - 7.1	5.00	2.15	4 FL, 10 AL-TX	2.85	3.902	2.177	6.079
1989/90	4.9 - 6.5	5.25	2.26 / 1,614,000	4 FL, 10 AL-TX	2.99	2.145	1.856	4.001
1990/91	3.9 - 7.4	5.25	2.26 / 1,569,000	3 TX, 4 FL[4], 10 AL-LA	2.99	2.074	2.138	4.213
1991/92	7.1 - 12.2	8.60	3.70 / 2,721,000	3 TX, 5 FL, 10 AL-LA	4.90	4.163	2.889	7.053
1992/93	5.1 - 9.8	8.60	3.70 / 3,274,000[5]	7 TX, 10 FL-LA	4.90	3.113	3.130	6.243
1993/94	4.7 - 8.7	8.60	3.70 / 3,274,000	7 TX, 10 FL-LA	4.90	2.614	2.696	5.309
1994/95	4.4 - 8.7	8.60	3.70 / 2,202,000	7 TX, 10 FL-LA	4.90	2.544	1.556	4.100
1995/96	4.0 - 10.7	8.60	3.70 / 2,782,000	7 TX, 10 FL-LA	4.90	1.075	1.575	2.650
1996/97	1.6 - 9.5	7.00	3.01 /	7 TX, 10 FL-LA	3.99	0.617	2.042	2.659
1997/98	5.5 - 13.9	7.00	3.01 /	7 TX, 10 FL-LA	3.99	0.356	2.455	2.810
1998/99	7.3-14.1	7.00	3.01 /	7 TX, 10 FL-LA	3.99	1.074	2.080	3.154
1999/00	9.1 - 17.1	9.1	3.9 /	7 TX, 10 FL-LA	5.2	1.056	3.355	4.411
2000/01	9.1 - 17.1	9.1	3.9 /	15 TX - FL	5.2	1.036	2.964	3.999
2001/02	9.1 - 17.1	9.1	3.9 /	15 TX - FL	5.2	0.788	3.038	3.826

[1] The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target; the Panel's best estimate of ABC has been intermediate to the end-points.
[2] Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).
[3] Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.
[4] Rec. bag limit in Fl changed from 4 to 5 on 1/1/91, and changed from 5 to 10 on 1/1/93.
[5] Bag limit will not be reduced to zero when allocation reached, beginning fishing year 1992
[6] Estimated catch equal to the recreational allocation of TAC.

XI. FIGURES

Figure 1. Atlantic king mackerel TAC and commercial and recreational landings.

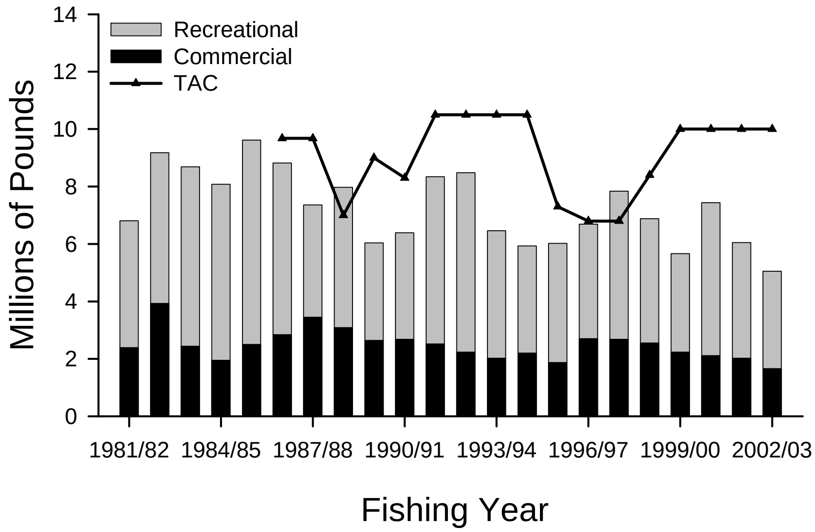


Figure 2. Estimated abundance of age-1 Atlantic king mackerel recruits from the 2003 base model with the stock-recruit relationship estimated with age-1 recruits. Eighty percent confidence intervals also are plotted.

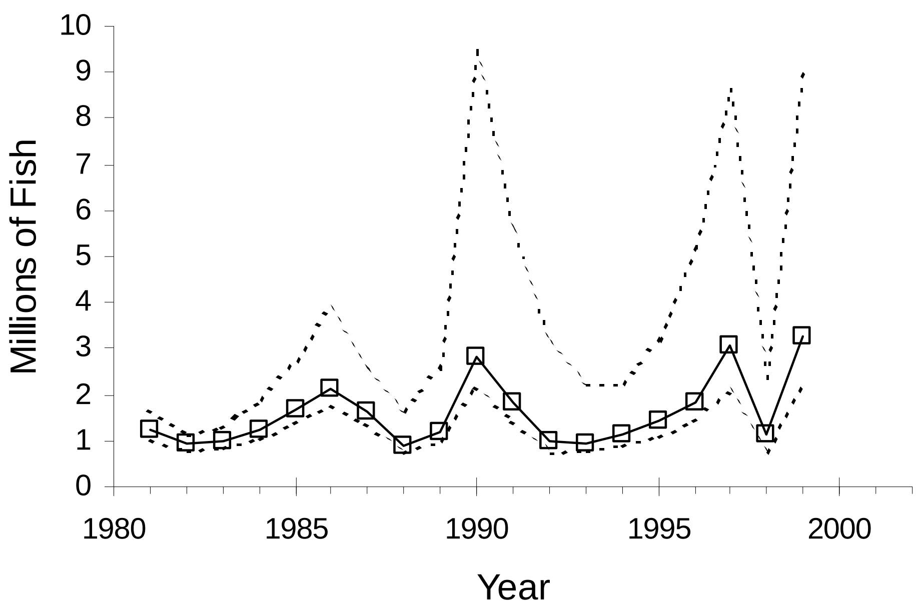


Figure 3. Estimated Atlantic king mackerel $F_{2002/03}/F_{MSY}$ from the 2003 base model with the stock-recruit relationship estimated with age-1 recruits.

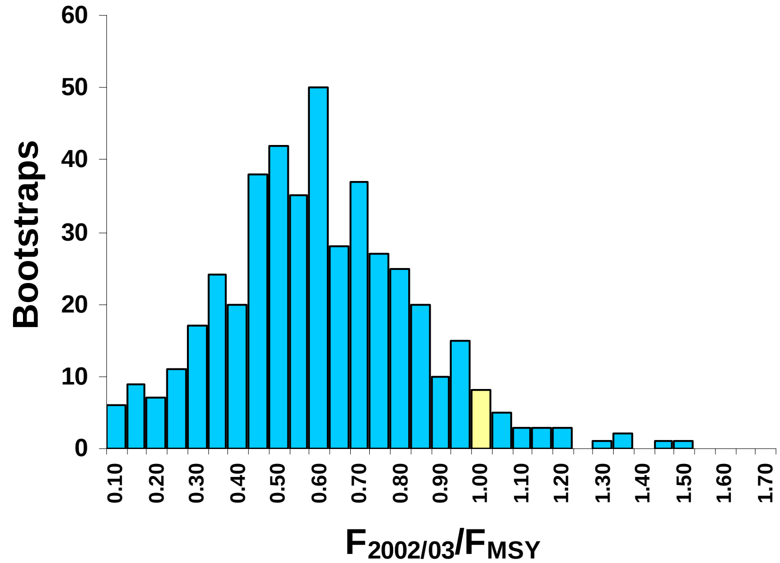


Figure 4. Estimated Atlantic king mackerel B_{2003}/B_{MSY} from the 2003 base model with the stock-recruit relationship estimated with age-1 recruits.

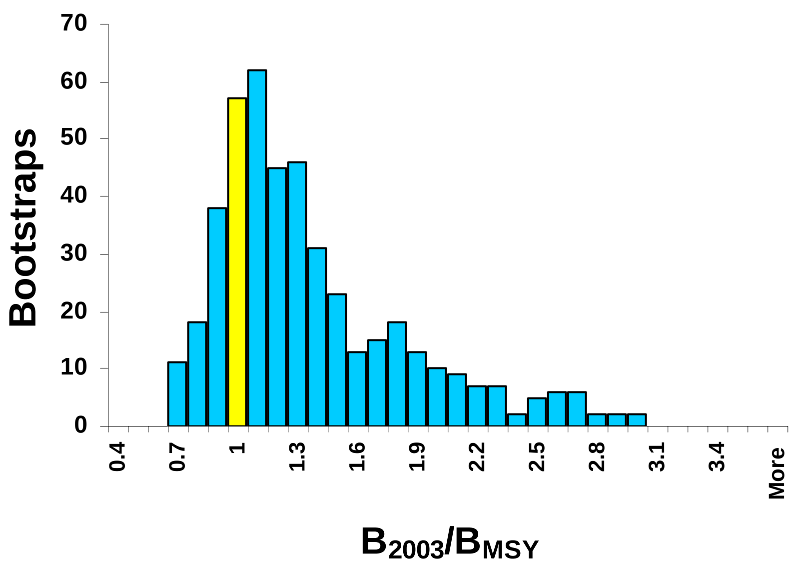


Figure 5. Atlantic king mackerel phase plot from the 2003 base model with the stock-recruit relationship estimated with age-1 recruits.

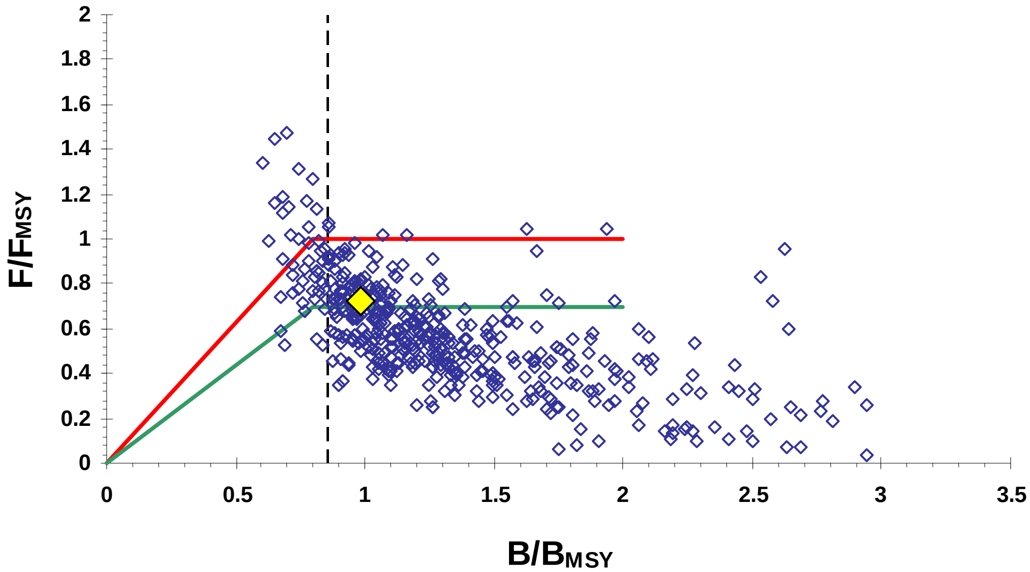


Figure 6. Estimated Atlantic king mackerel stock abundance from the 2003 base model with the stock-recruit relationship estimated with age-1 recruits.

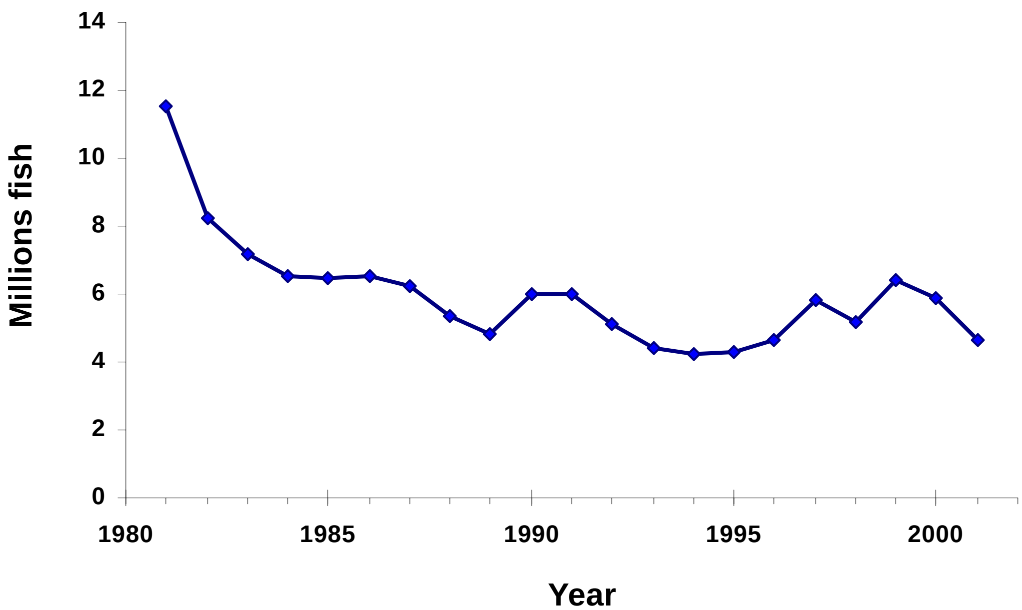
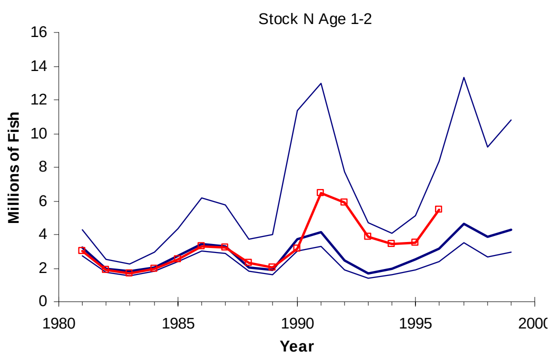


Figure 7. Differences in Atlantic king mackerel estimated abundance between the 1998 assessment (red) and the 2003 base model (solid blue) with the stock-recruit relationship estimated with age-1 recruits for A) ages 1 - 2 and B) ages 3 - 6. Eighty percent confidence intervals for 2003 base model estimates also are plotted as dashed lines.

A.



B.

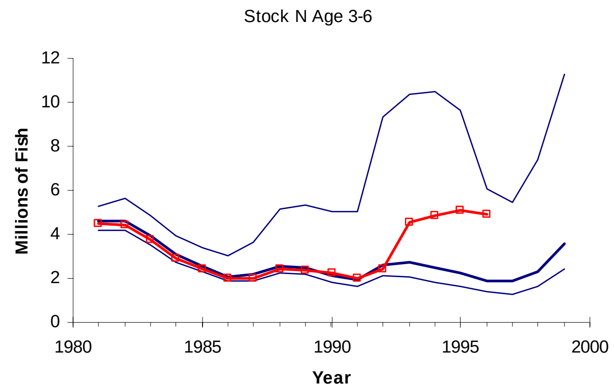


Figure 8. Atlantic king mackerel selectivity vectors estimated as the geometric mean across three years for 1994-96 in the 1998 assessment and the 2003 base model with the stock-recruit relationship estimated with age-1 recruits, and for 1999-2001 in the 2003 base model with the stock-recruit relationship estimated with age-1 recruits.

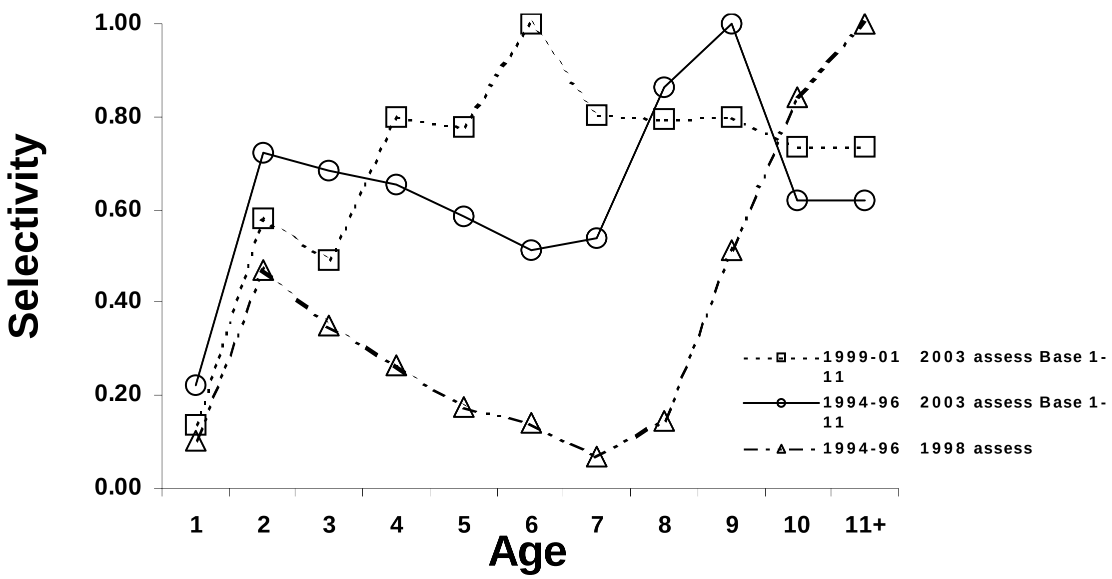


Figure 9. Probability density functions of Atlantic king mackerel allowable biological catch estimated for 2003/04 with the 2003 base model, with the stock-recruit relationship estimated with age-1 recruits, for $F_{30\%SPR}$ and $F_{40\%SPR}$ fishing mortalities in the 2003/04 fishing year. Cumulative probabilities are the probability a given yield will exceed $F_{30\%SPR}$ or $F_{40\%SPR}$.

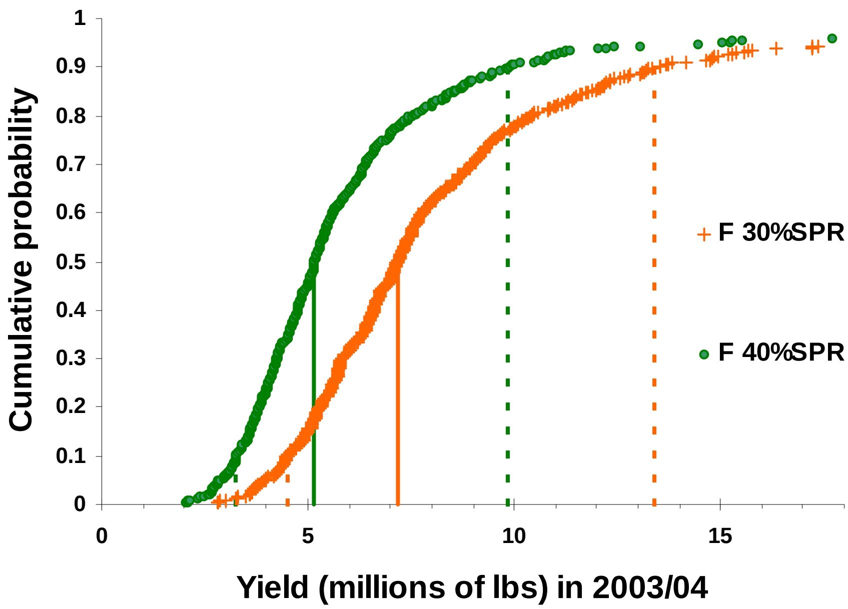


Figure 10. Atlantic Spanish mackerel TAC and commercial and recreational landings.

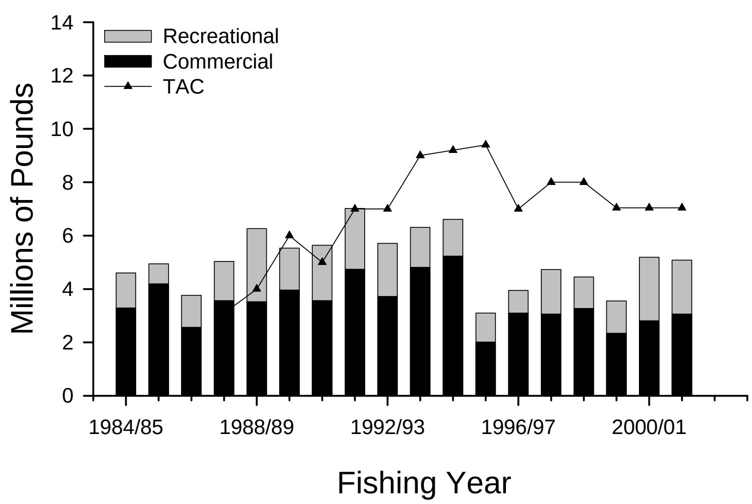


Figure 11. Estimated abundance of age-0 Atlantic Spanish mackerel recruits from the 2003 base model.

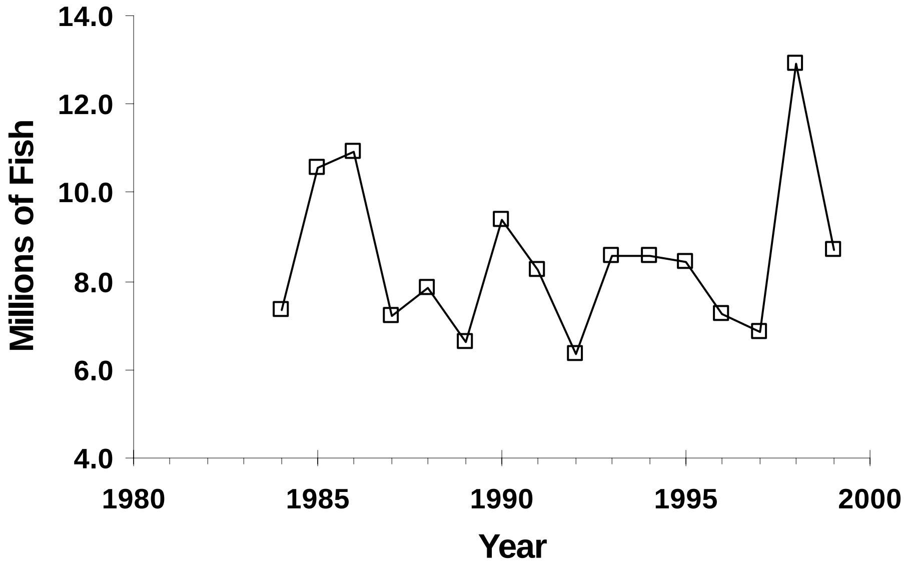


Figure 12. Atlantic Spanish mackerel estimated $F_{2002/03}/F_{MSY}$ from the 2003 base model.

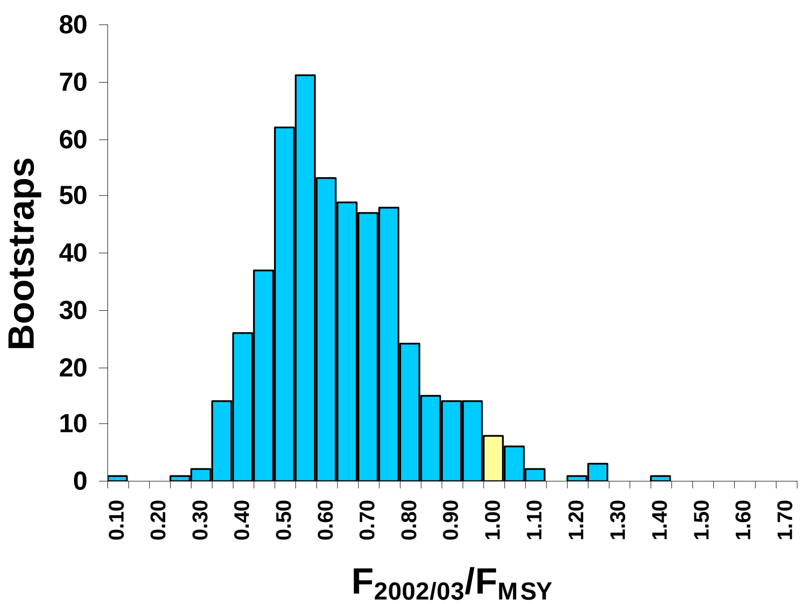


Figure 13. Atlantic Spanish mackerel estimated B_{2003}/B_{MSY} from the 2003 base model.

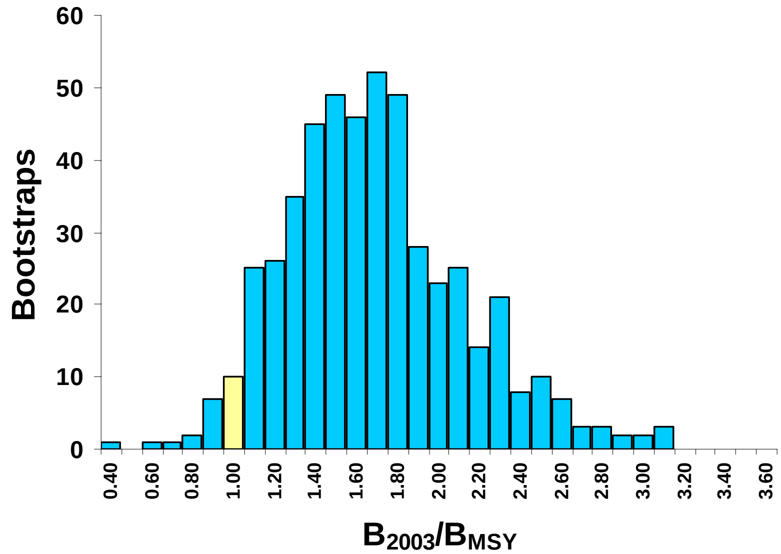


Figure 14. Estimated Atlantic Spanish mackerel stock abundance from the 2003 base model.

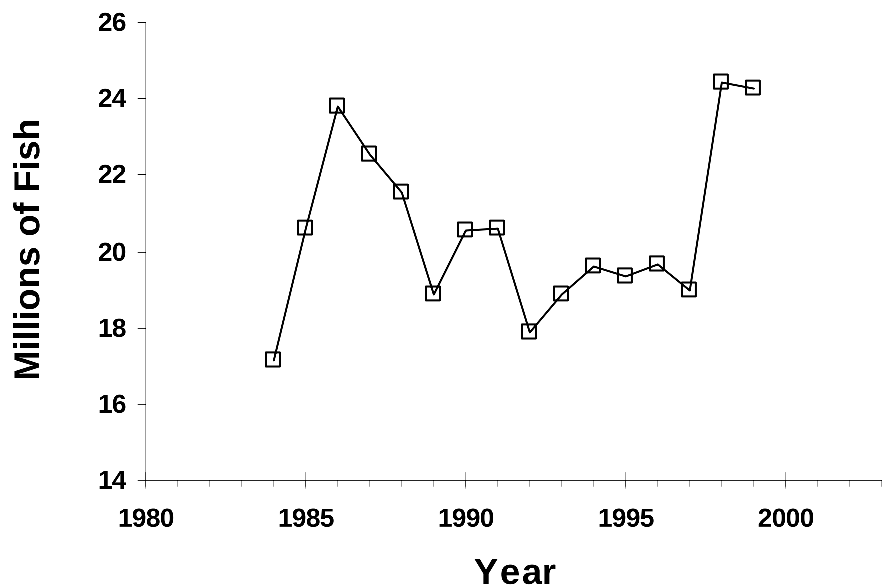


Figure 15. Atlantic Spanish mackerel phase plot from the 2003 base model.

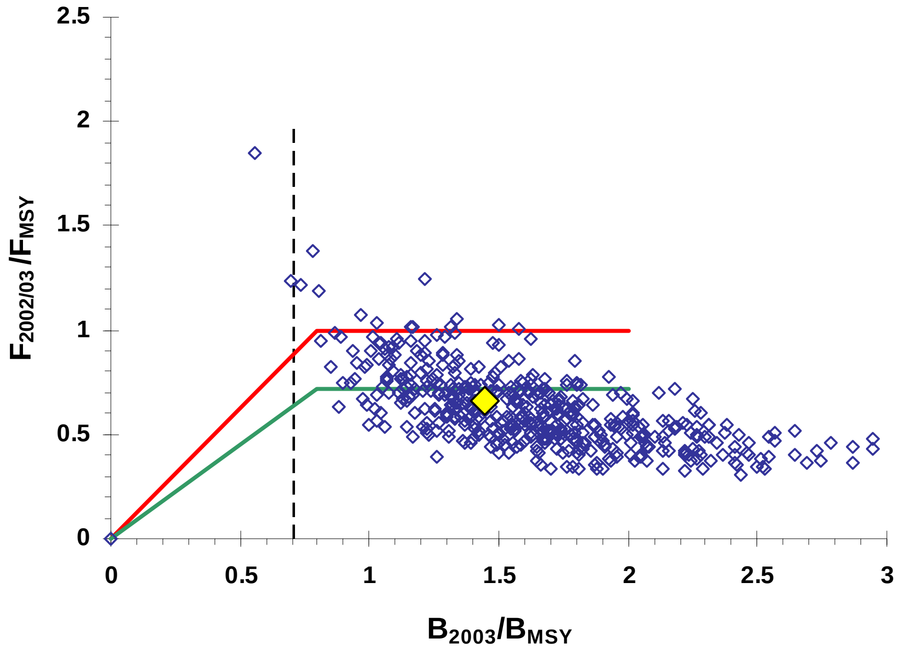


Figure 16. Probability density functions of Atlantic Spanish mackerel allowable biological catch for 2003/04estimated with the base model for $F_{30\%SPR}$ and $F_{40\%SPR}$ fishing mortalities in the 2003/04 fishing year. Cumulative probabilities are the probability a given yield will exceed $F_{30\%SPR}$ or$F_{40\%SPR}$.

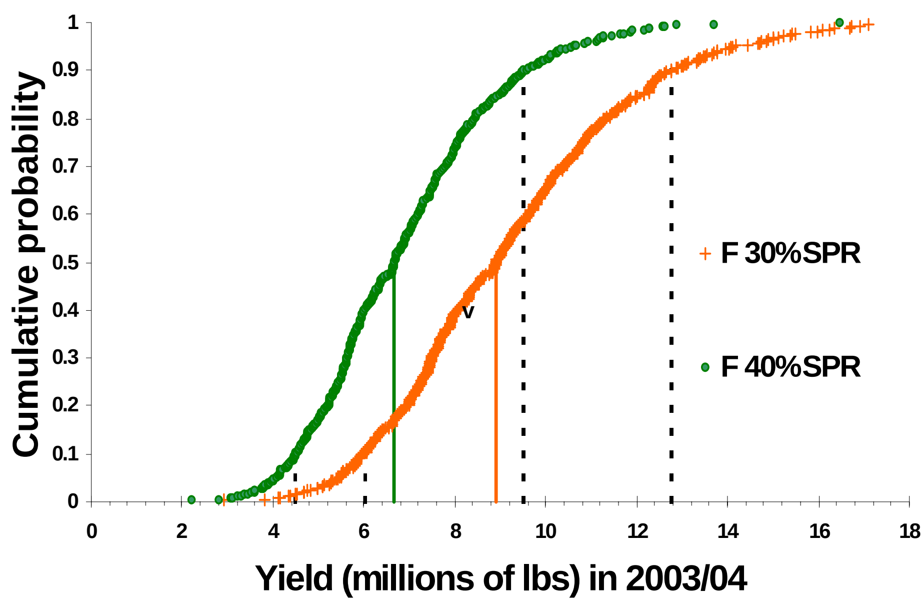


Figure 17. Gulf Spanish mackerel TAC and commercial and recreational landings.

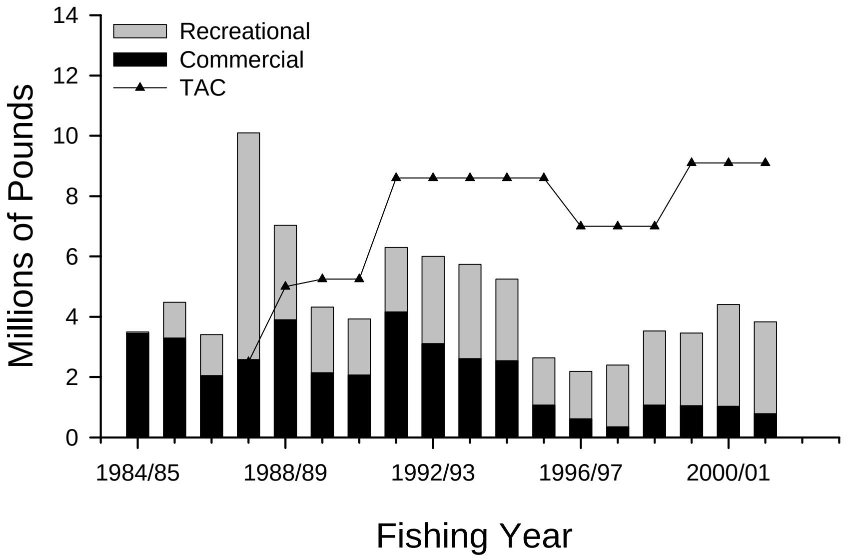


Figure 18. Estimated abundance of age-0 Gulf Spanish mackerel recruits from the 2003 base model.

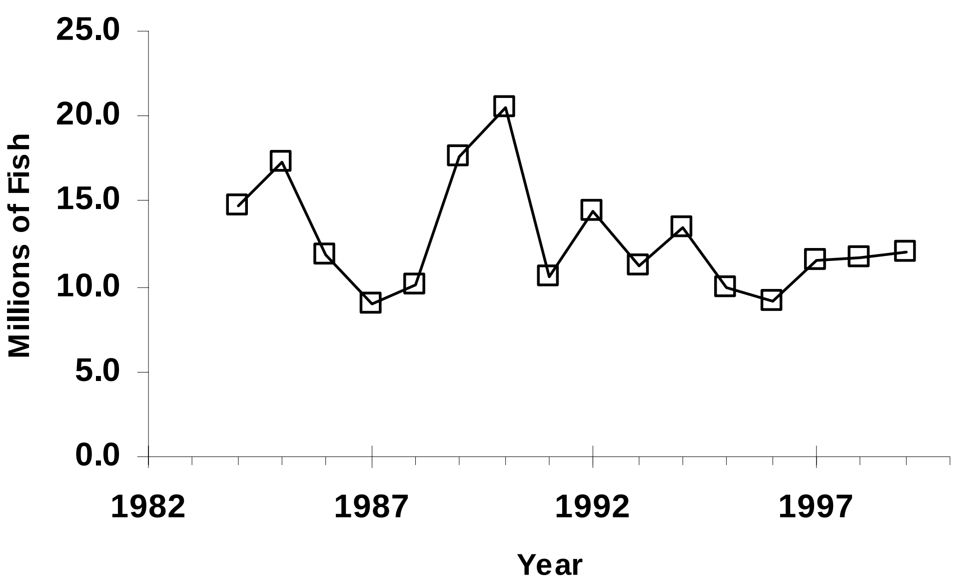


Figure 19. Gulf Spanish mackerel estimated $F_{2002/03}/F_{MSY}$ from the 2003 base model.

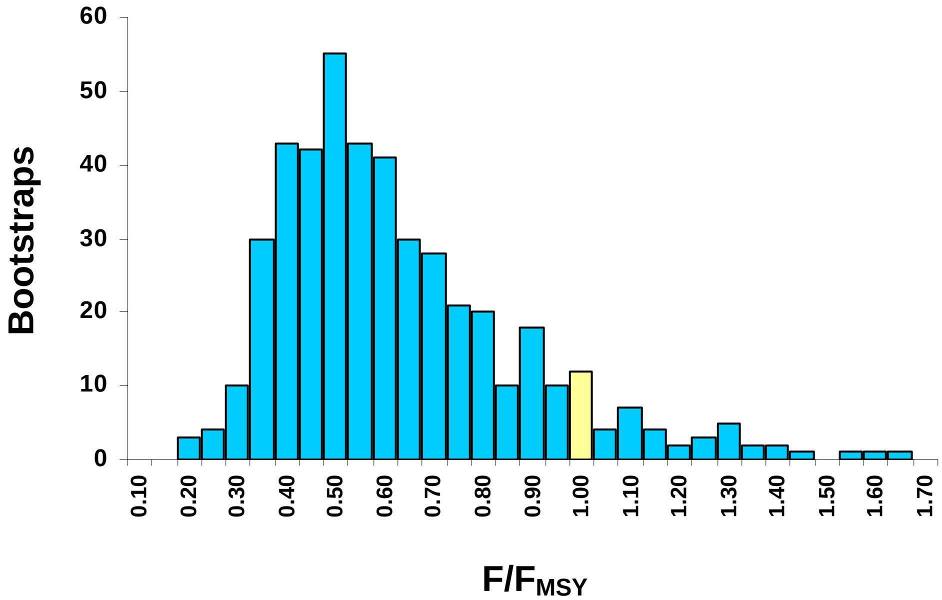


Figure 20. Gulf Spanish mackerel estimated B_{2003}/B_{MSY} from the 2003 base model.

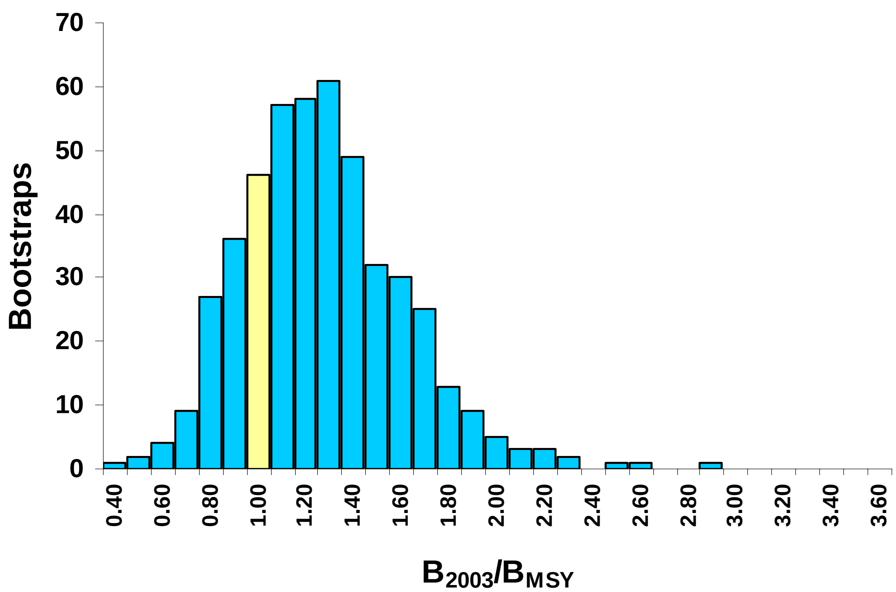


Figure 21. Estimated Gulf Spanish mackerel stock abundance from the 2003 base model.

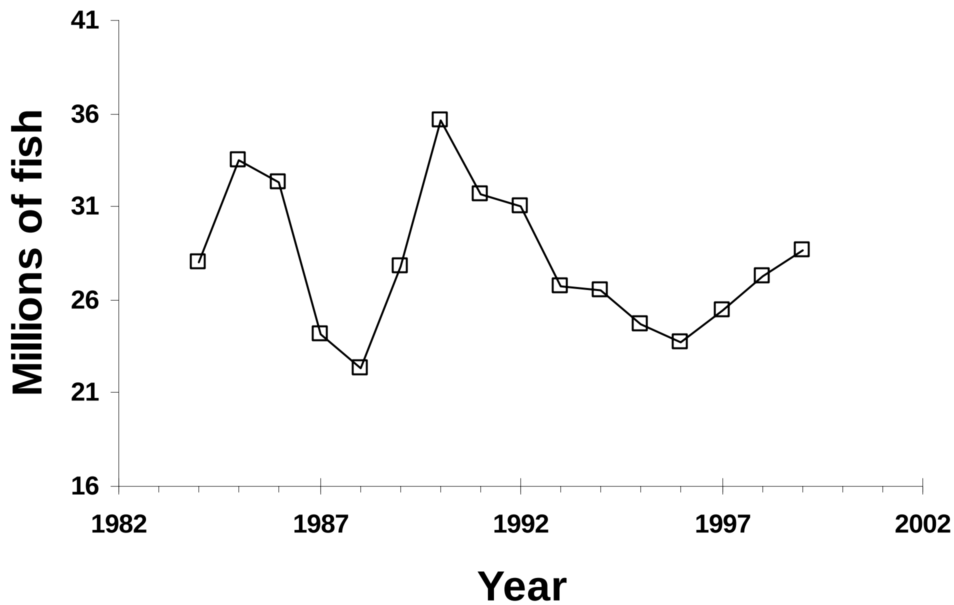


Figure 22. Gulf Spanish mackerel phase plot from the 2003 base model.

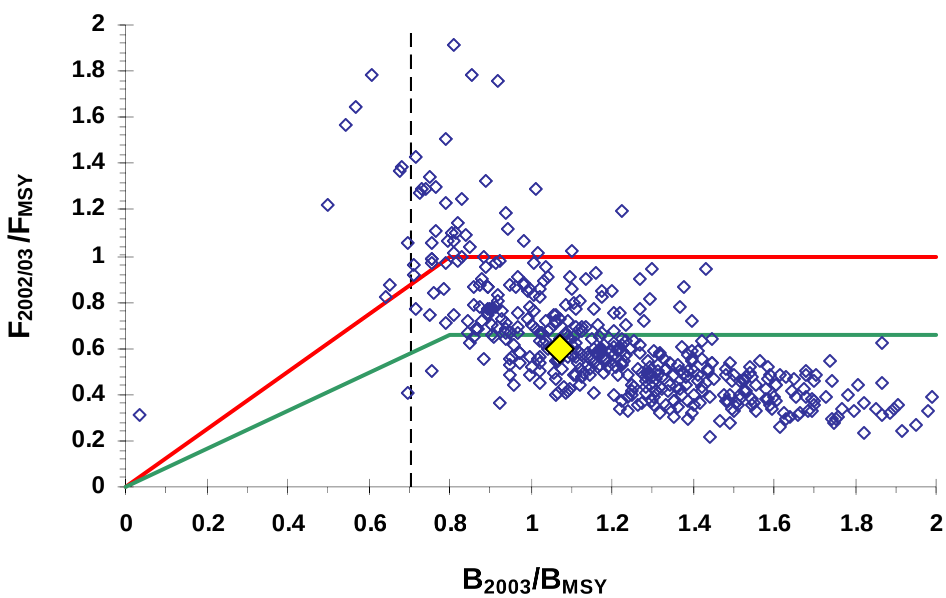


Figure 23. Probability density functions of Gulf Spanish mackerel allowable biological catch for 2003/04 estimated with the base model for $F_{30\%SPR}$ and $F_{40\%SPR}$ fishing mortalities in the 2003/04 fishing year. Cumulative probabilities are the probability a given yield will exceed $F_{30\%SPR}$ or$F_{40\%SPR}$.