DRAFT
STATUS OF RED GROUPER IN UNITED STATES WATERS OF THE GULF OF MEXICO DURING 1986-2001

revised

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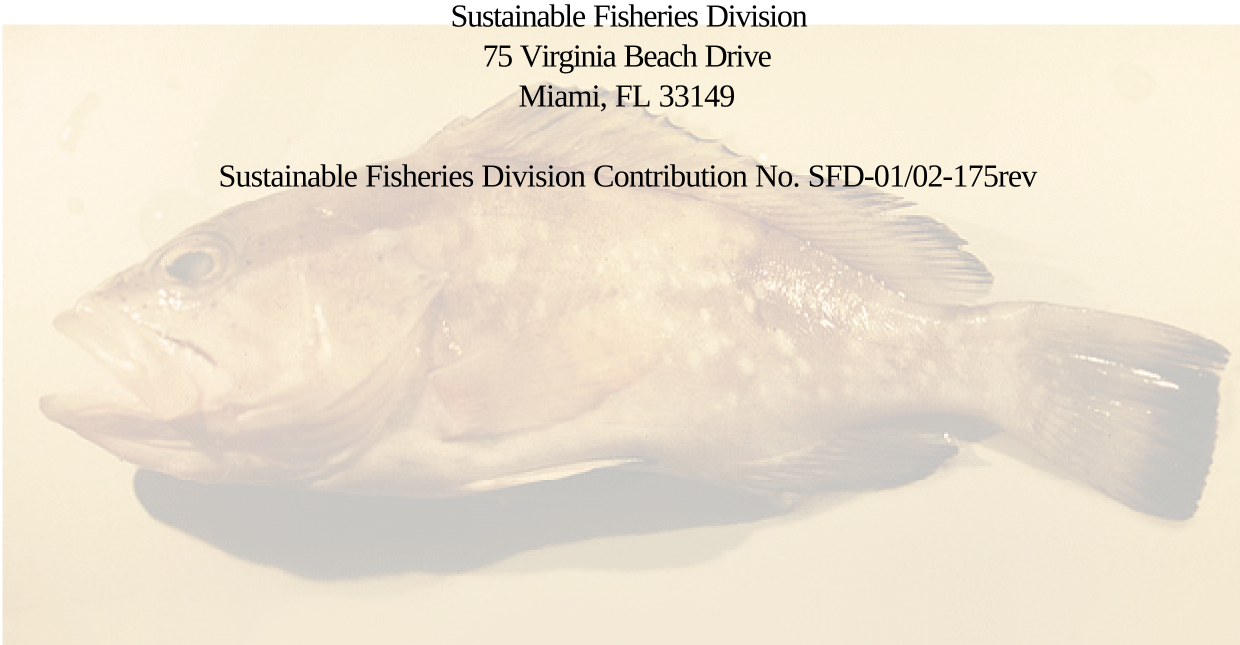

photograph by Pat O'Donnell, Florida Institute of Marine Research

Introduction

The primary objective of the analyses documented in this report was to update the assessment of Schirripa *et al.* (1999) as used by the Gulf of Mexico Fishery Management Council's Reef Fish Stock Assessment Panel (RFSAP) for developing management advice (RFSAP 2000). Sensitivity of the assessment to new biological information and other aspects was also examined.

At the Reef Fish Stock Assessment Panel meeting 17-20 September 2002 in Miami, FL the panel asked for clarification on some aspects of the 6 September 2002 version of this document and additional information and analyses were presented. In this revised document clarifications have been added and an addendum with information presented to the Panel during and after the meeting has been added. The primary modifications to the original report included: (1) clarification that yield is reported in gutted weight, (2) clarification of the approach used in calculating sampled age composition, (3) inclusion of relevant equations in the description of the estimation of derived age composition and associated dead discards, and (4) standardization of the labels (FECvsTL, FECvsAge, *etc.*) for the per capita fecundity functions to maintain consistency with the labeling used with additional analyses developed at the meeting. The addendum includes: estimated landings and harvest in mt, further comparisons of derived and sampled age composition, the weighting factors used in ASAP, additional analyses of per capita fecundity, and additional stock assessments and projections.

BIOLOGICAL INFORMATION

size information

Weights were tabulated and reported in kg and mt. All weights presented in the report are gutted weights.

The equations used to convert fork and standard length to total length, total length to gutted weight and whole weight to gutted weight were from Goodyear and Schirripa (1993) and are presented in Table 1. Those equations were in inches and pounds, so observations in metric units were converted as necessary.

Mean weights were used to calculate (1) the recreational yield from observed numbers caught and (2) the number of fish caught by the commercial sector (see below). When available, observed weights were used, otherwise weights were calculated from length. If both length and weight were available for a fish, then the data were examined to determine whether the information appeared reasonable. Following the approach used by Schirripa *et al.* (1999), if a predicted weight was less than 75% or greater than 150% of an observed weight, then the weight was rejected and the observed length was retained.

Length was used in determining the age composition of the catch. Following Schirripa *et al.* (1999) the lengths from four recreational modes (shore, headboat, charter and private) in inches were used. The observed annual length frequencies by mode are presented in Table 2; shore mode is not shown because there were less than 25 observed lengths in any year. Headboat was the only mode with more than 100 observed lengths in every year; for both charter and private modes there were less than 100 observed lengths in six years. Overall the private mode had the fewest observed lengths.. Also, following Schirripa *et al.*(1999), the lengths from two commercial groups (longline and handline plus other) were used and the associated annual size frequencies are shown in Table 3. For the longline fishery there were roughly 1,000 to 40,000 fish measured annually while for the handline and other fisheries there were about 1,000 to 10,000 measured annually.

sampled age composition

Two types of age composition information were used in the various assessments reported in this document. One type, referred to as derived age composition, was calculated primarily from the observed length samples by use of the probabilistic method of Goodyear (1997). Derived age composition was the only type of age composition used in the previous assessment.

The second type of age composition used in the assessments was based on ages read from otoliths (Lombari-Carlson *et al.* 2002) and will be referred to as sampled age composition. In a review of the 1999 red grouper assessment Sullivan (1999) recommended that age composition from samples be incorporated in the assessment. This section briefly notes a few aspects of the samples provided by the NMFS Panama City Laboratory and the development of effective weights applied to these samples in ASAP.

Lombardi-Carlson *et al.* (2002) provided information on the age composition of the red grouper catch in the Gulf of Mexico. Their Table 1 showed that the sampling levels differed among sectors (commercial and recreational) and among commercial gears and recreational modes; almost 80% of the samples came from the commercial sector and most were from longline. The majority of the samples were from central and northwestern Florida.

The assessment program (ASAP, Legault and Restrepo 1998, Schirripa *et al.* 1999) measures the disparity between the observed and model-predicted frequency distribution of age by use of a multinomial negative log-likelihood function,

$$L = \sum_{a,i} n_{i,y} o_{i,a,y} \ln(p_{i,a,y})$$

where $o_{i,a,y}$ is the observed relative frequency of age class a in the catch of fishery i during year y,$p_{i,a,y}$ is the corresponding model prediction and n is the effective sample size. Inasmuch as the available age data were randomly sampled from various strata within a fishery, but not necessarily in proportion to the catch corresponding to those strata, the age composition of the fishery was computed as a catch-weighted average:

$$o_{i,a,y} = \frac{\sum_s C_{i,s,y} f_{i,s,a,y}}{n_{i,y} \sum_s c_{i,s,y}}$$

$$n_{i,y} = \sum_a \left(\frac{\sum_s C_{i,s,y} f_{i,s,a,y}}{\sum_s C_{i,s,y}} \right)$$

where $f_{i,s,a,y}$ is the observed frequency of age *a* in the sample and $C_{i,s,y}$ is the total catch from strata *s* of fishery *i* in year *y*.

Weighted age compositions were computed for each of the three fishery categories included in the assessment (longline, handline plus other commercial gears and recreational) with geographic (northwest FL, central west FL and southwest FL) and gear/mode strata. For longline there were three geographic strata; for handline and other gears there were six strata (three geographic and two gears: handline and trap), and for recreational there were three strata (headboat, charter and private: geographic stratification could not be used because MRFSS estimates were for the entire west Florida)..

The weighted, sampled age composition for the three fishery categories with the effective sample sizes are presented in Table 4. The only category with effective sample sizes over 50 in most years was longline. Examination of the annual relative frequencies for longline indicates that the modal age ranged from 6 to 8 and most often was 7 (Figure 1).

growth

The growth equation used in the previous assessment (Goodyear 1994) was used (Table 1). The catches and catch rates were tabulated on an annual basis, so the age composition for the assessment was also tabulated on an annual basis. The growth curve used was based on otoliths which were assumed to form a mark 1 June each year; to convert the timing of the growth curve to a calendar year, the fraction of a year from Jan. 1 to June 1 was added to t_0; therefore age 1 fish in the assessment were actually aged 0.6 to 1.59.

Lombardi-Carlson *et. al.* (2002) presented growth equations derived from the 1992-2001 ageing analyses. Their Richards function was compared to the equation used in the previous assessment (Goodyear 1994) and found to be similar within the range of ages for which observations existed (Figure 2) but to diverge outside of that range, particularly at younger ages. The implications of alternative growth curves have not been investigated.

reproduction

The previous assessment (Schirripa et al. 1999) modeled the per capita fecundity of the red grouper population as the product of gonad weight and the proportion of each age class that was female. Gonad weight (GW) was expressed as a power function of total length (TL), $GW=2.073E\text{-}07\ TL^{6.092}$, which was converted to a function of age via the growth equation. The proportion female was expressed by a logistic function of age fit to data from Moe (1969) and Koenig (1993). Females older than two years were assumed to be mature and the abundance of males was assumed not to be limiting.

Collins et al. (2002) have recently analyzed over 2,000 red grouper gonads sampled from the eastern Gulf of Mexico during 1992 to 2001. They expressed batch fecundity (BF) in number of eggs as an exponential function of total length, $BF = 6742.1e^{0.0058TL}$, or total age, $BF = 67085e^{0.1616age}$. Inasmuch as the assessment requires fecundity at age, the batch fecundity at length curve must be converted to batch fecundity at age by use of a growth equation (just as Shirripa et al. 1999 did with gonad weight). The converted length curve, however, is rather different from the age curve– having a much slower ascent

(Figure 3). For statistical reasons one would normally prefer a curve fit directly to age over the use of an imprecise growth equation to convert a curve fit to length. However the region of the batch fecundity at age curve with the steepest ascent is largely beyond the range of the data and is heavily influenced by a single large batch fecundity observation at age 21 (Figure 3). For these reason we have preferred the age-converted batch fecundity at length curve for this assessment.

Collins et al. (2002) also provided age-specific data on the sex ratio and proportion of the female population that is actively spawning, which were used along with the equivalent data from Moe (1969) and Koenig (1993) to develop age-specific ogives (see Figure 4). The product of the fitted sex-ratio (proportion female), proportion active and batch fecundity estimates was taken as a measure of the per capita number of eggs produced by each age class (spawning frequency did not vary demonstrably with age).

Two per capita fecundity curves, one using the batch fecundity curve based on age FECvsAGE) and the other using the age-converted batch fecundity curve based on length (FECvsTL), are compared with the gonad weight curve (GWTvsTL) developed by Schirripa et al. (1999) in Table 5 and Figure 5. The FECvsTL and GWTvsTL curves are fairly similar, largely because the relative relationship between batch fecundity and length is similar to that between gonad weight and length (Figure 3). The main differences between the FECvsTL and GWTvsTL curves are the former's use of activity at age information (the latter assumes that all age classes older than 2 are equally active) and its prediction of relatively more production from very young animals. The FECvsAGE curve is fundamentally different from the other two inasmuch as it predicts that per capita fecundity continues to increase with age despite the decreasing fraction of females. This is because the fitted batch fecundity at age curve increases much faster than the age-converted batch fecundity at length curve as discussed above.

Additional analyses related to per capita fecundity were conducted by the RFSAP at the September meeting and are documented in the addendum.

REMOVALS

Yield, harvest and catch

Catch is generally used to refer to the number of fish caught and often includes live releases. Harvest is used to refer to the number of fish killed in the fishing process and may include fish landed, discarded dead at sea and fish used for bait; this is particularly used for the AB1 estimates from MRFSS (Marine Recreational Fisheries Statistics Survey, A=observed kill, B1=unobserved kill). Yield is used to refer to landings in weight for the commercial fishery and the headboat fishery; it is also used to refer to weight of the harvest (MRFSS). Yields are reported in gutted weight.

Commercial Yield

Commercial yields were tabulated from the Accumulated Landings System (ALS) data base maintained at the Southeast Fisheries Science Center (SEFSC). Yields in the ALS data base are generally recorded in whole units. For groupers a conversion factor of 1.18 was used to convert gutted weight to whole weight in the ALS (Goodyear and Schirripa 1993); that same conversion factor was used to reconvert to gutted weight for use in this assessment.

The Accumulated Landings System consists of subsets with different degrees of resolution. The primary data base consists of dealer reports of landed yield by year, month and species; for some states that information also includes gear and fishing area (water body), but not for Florida in 1986-1996 nor Louisiana and Texas since the early 1990's. Information on grouper landings by species is available only from 1986 and later; prior to that time only unclassified groupers were recorded; since 1986 unclassified grouper have been recorded, but the quantity has declined substantially. A portion of the unclassified groupers were assumed to be red grouper; that proportion was calculated by dividing the west Florida landing of red grouper by the west Florida landings of all identified groupers (excluding goliath and warsaw) as had Schirripa *et al.* (1999).

All reported commercial landings of red grouper from west Florida through Texas were tabulated by year as done in the previous assessment. Landings recorded from Florida inland counties were not included. Reported red grouper, the proportion of unclassified grouper assumed to be red grouper and the total calculated red grouper (used for assessment) are presented in Table 6. The total calculated commercial landings are shown by state in Table 7.

Yield for each of two gear categories was used in the program used to create derived age composition and in the assessment; those categories were (1) longline and (2) handline combined with other gears. For 1986 through 1989 the annual proportion of the total commercial landings by longline was assumed from Schirripa *et al.* (1999). For 1990-2001 the annual proportions by gear category were calculated from reef fish log books; the calculated landings by the two gear categories are presented in Table 8. The 1990-1997 proportions by gear calculated for this assessment were moderately different from the proportions calculated from the inputs by gear to the 1999 assessment (Figure 6).

Additionally the number of commercially caught fish by gear and region for 1992-2001 was used in the assessment runs which included the sampled age composition. As with the yield by gear, the distribution of yield by gear and region was calculated from log books. Three gear categories (longline, trap, and handline combined with others) and three regions (southwest FL -shrimp grids 1-4, central west FL - grids 5-6 and northwest FL and west - grids 7+) were used. Average weights for converting yield to number were from TIP (trip interview program) data by the same gear categories and regions; if there were less than 25 observed sizes for calculating a mean weight by year, gear group and region, then a mean for that year and gear group was used, and if there were insufficient observations for that strata then an overall mean (all years, gears and regions was used).

Recreational Catch and Yield

Recreational catches (harvests and releases) were tabulated from the MRFSS, the SEFSC Headboat Survey and the Texas Parks and Wildlife (TPWD) data sets. MRFSS data was available through 2001, headboat catch estimates were available through 1999 and TPWD estimates were available through 2000. For MRFSS both harvests (A+B1) and live releases (B2) were tabulated; estimated weight of the harvest was calculated from mean weights derived from observed weights and weights predicted from lengths if weight was not recorded. For the headboat data the numbers of fish landed and the associated yields were tabulated from the Headboat Survey estimates. For the headboat survey the average catch and yield from 1995-1999 was used to estimate the 2000 and 2001 values. Red grouper were not recorded in the

TPWD data set during 1986-2000, though small numbers were recorded as landed in the headboat survey.

The total recreational harvests by state and by mode are presented in Tables 9 and 10. Schirripa *et al.* (1999) used total annual harvests by mode; to provide an indication of the variability in estimated harvests, coefficients of variation about the MRFSS estimates for west Florida harvests by year and mode are provided in Table 11.

The estimated weight of the recreational harvest is presented in Addendum-Table 1.

Estimates of live releases are also provided by the MRFSS and these are presented by state and mode in Tables 12 and 13. The ageing approach used by Schirripa *et al.* (1999) incorporated a method of estimating numbers released dead by all parts of the recreational fishery which used annual ratios of live releases to total catch (harvests plus releases) estimated from the MRFSS data. The annual proportions of the total catch which was released is presented in Table 14; especially in 1986-1988 those proportions differed from the proportions used for the 1999 assessment (Figure 7).

DERIVED AGE COMPOSITION OF REMOVALS

The second type of age composition information used in the assessments, derived age composition, was calculated primarily from the observed length samples, the annual probabilistic age composition derived from the length samples using a growth curve (Goodyear 1997) and the annual harvest or yield. No independent abundance information was incorporated in the procedure (the independent index was assumed constant for all year classes), mortality rates (M and F) were constant and the ageing procedure was not iterated (Schirripa *et al.* 1999).

For each sampled length (L) the probability of age ($p_{a,L}$) is assumed to be from a normal distribution with mean $\bar{L}_a$ [computed from the von Bertalanfy growth equation using an adjustment to t_0 in that curve to shift the curve from the marking time (assumed 1 June) to January 1 (Table 1) and taking into account the date when the sample was taken], and the standard deviation of length at age, s_a (derived from the product of a constant coefficient of variation of length at age (0.16), and the mean length at each age). The value of $p_{a,L}$ is obtained from the difference in cumulative probabilities of age for lengths slightly above and below the sampled length:

$$p_{a,L} = \frac{[prob(L + 0.05s_a - \bar{L}_a) - prob(L - 0.05s_a - \bar{L}_a)]\, W_{ya}}{\sum_{a=j}^{20} [prob(L + 0.05s_a - \bar{L}_a) - prob(L - 0.05s_a - \bar{L}_a)]\, W_{ya}}$$

where age j is the youngest age considered vulnerable to the fishery (age 1 for recreational fisheries and age 2 for commercial fisheries) and W_{ya} is a weighting factor derived from an annual recruitment index (I) and fishing (F_{ya})and the natural mortality (M) rates (the index values and mortality rates were all assumed constant for this assessment):

$$W_{ya} = I_{y-a} \exp-(F_{ya} + M)$$

The frequency at age was then calculated from all the length samples:

$$f_{yak} = \sum_{a=j}^{20} \sum_{L} p_{a:L} m_{Lk}$$

where m_{Lk} is the number of fish measured at each length, for gear (or mode), k, and L represents each length in the samples.

The landed catch at age for the commercial fishery is calculated as:

$$C_{yak} = f_{yak} \frac{Y_{yk}}{w_{yk}}$$

where Y_{yk} is the landed yield by year and gear group (longline and handline plus other) and w_{yk} is the total weight of the of the measured fish (from the observed or estimated weight of a measured fish) by year and gear group. If less than 25 lengths were available to compute f_{yak}, the overall age composition for that year and sector (commercial or recreational) was used.

For the recreational fishery the harvested (A+B1 for MRFSS and landings for the Texas and headboat data sets) catch at age is calculated as:

$$C_{yak} = \frac{f_{yak}}{\sum_{a=0}^{20} f_{yak}} H_{yk}$$

where H_{yk} refers to the number of fish harvested by year and mode.

The number of fish discarded at age was calculated in the ageing procedure as was done for the previous assessment. The average probability (g) that the minimum size (msize) in a year (y) is greater than the mean length (L) for a given age on a given day (d) is computed as

$$g_{ya} = \frac{\sum_{d=1}^{n} prob(msize_y > \overline{L}_{ad})}{n}$$

where n is the number of days over which the probabilities are computed and the mean length is computed from the growth equation.

Commercial discards

The number estimated to have been discarded dead from the commercial fishery, D_{yak}, was initially modeled as:

$$D_{yak} = G_{yak}\left(\frac{1-g_{ya}}{g_{ya}}\right)d_k$$

where d_k is the discard mortality rate for gear or mode, k, (0.33 for handline combined with other gears, 0.33 or 0.90 for longline, and 0.1 for all recreational modes) and G_{yak} is landed catch of fish greater than or equal to the minimum size in year y, at age a by gear k. For all commercial discard estimates the youngest age considered vulnerable to fishing was age 2.

For commercial longline catches, the modeled number of dead discards, D_{yag}, was further modified because at-sea observers recorded a release fraction, r, in 1994 which was lower than that estimated through modeling. The observed release fraction used in the previous assessment was 0.469 (1446/3080) and it was assumed for all years 1990 and later when the minimum size for catches in federal waters was in place. The revised longline discards, D', was calculated as:

$$D'_{yak} = D_{yak}\left(\frac{r}{\frac{D_{yak}}{\left(G_{yk}+D_{yak}\right)}}\right)d_k$$

Recreational discards

For the recreational fishery an estimate of the discards (B2) was available from MRFSS estimates. That information was used in estimating the total dead discards. The total number of recreational fish released alive was then calculated as:

$$R_y = H_y\left(\frac{r_y}{1-r_y}\right)$$

where H_y is number of fish harvested (MRFSS A+B1, plus headboat landings, plus Texas landings) and r_y is the proportion released alive from MRFSS (B2/(A+B1+B2)) (Table 14).

The average probability that the minimum size is smaller than the mean length at age (s_{ya}) is the reciprocal of g_{ya} given above. It is then weighted by the an input selectivity at age (S_{ya}, with values of 0.67, 0.92 and 0.99 for ages 1-3 years, then 1.0 for the ages 4 and older) and re-normalized

$$s'_{ya} = \frac{s_{ya} S_a}{\sum_{a=1}^{20} s_{ya} S_a}$$

Total recreational discards by year and age were then computed as

$$D_{yak} = R_y s'_{ya} d_k$$

Two sets of derived age composition were created: one for 1986-1997 to examine the effects of differences in the proportions of recreational fish released (Figure 7) and the other with information for 1986-2001. The alternative, derived age composition for the 33% mortality assumption for longline discards is shown in Table 15 for 1986-1997 and Table 16 for 1986-2001.

The derived age composition for longline is shown in Figure 8 and can be compared to the sampled longline age composition shown in Figure 1. The modal age in the derived age composition ranged from 3 to 6 and was 5 in 1991through 2001 which was about 2 years younger than the modal age from the sampled age composition. An alternative figure with these age compositions compared was requested by the RFSAP at the meeting in September 2002 is shown in Addendum Figure A1.

INDICES OF ABUNDANCE

Several indices of abundance were developed based on observations of catch-per-unit-effort (CPUE) and limited fishery-independent surveys. The data were standardized using essentially the same methods as outlined by Schirripa et al (1999). The results are summarized in Table 17 and Figure 9.

Commercial operating units.

Schirripa et al. (1999) developed a CPUE index based on the total commercial landings and estimates of the U.S. fleet effort derived from the NMFS operating units file. Due to time limitations, no attempt was made to update this index to 2001. However, this should be of little consequence because the recent time period is amply covered by the logbook indices discussed below.

Reeffish Logbooks.

Data available from the Reeffish Logbook Program were used to develop standardized CPUE series for commercial fish traps, handlines and bottom longlines from August 1990 to December 2001. The Reeffish Logbook Program was initiated in 1990. At that time the program required all vessels holding reeffish permits in Alabama, Mississippi, Louisiana and Texas, as well as all trap fishermen in Florida, to report on each fishing trip made. For other Florida permitted vessels, only a randomly selected sub-sample (20%) were required to report until 1993, when mandatory reporting for all Florida vessels began. Only landings (in pounds) were recorded; releases were not and discards were generally not recorded. Thus, these CPUE series are really harvest per unit effort (HPUE) measures and are affected to varying degrees by size regulations.

The standardization procedures were intended as an update to the analyses conducted for the last assessment and therefore followed the methods detailed in Schirripa et al. (1999). Only trips landing red grouper were used. Catch was defined as total pounds landed in whole weight. Effort was defined as hook*hours for handline and days-at-sea for bottom longline and trap gears (the description by Schirripa et al. 1999 mistakenly indicates otherwise). Standardized indices were developed using generalized log-linear models where catch rates were modeled as a function of the factors YEAR, MONTH, and GRID (fishing area). (Much of the data were inadvertently excluded during the trap CPUE analysis conducted for the previous assessment. This has been corrected for the current, updated analysis).

MRFSS recreational.

The catches of recreational vessels fishing in the Gulf of Mexico and Atlantic Ocean are monitored by the National Marine Fisheries Service's Marine Recreational Fisheries Statistical Survey (MRFSS). Anglers intercepted at fishing access sites are interviewed to determine, among other things, the number of each species that were landed and observed by a sampler (type A), the number of fish killed not seen by an sampler (B1, including dead discards) and the number released alive (B2). They are also asked the number of hours they spent fishing. Thus, it is possible to construct catch per unit effort (CPUE) indices of abundance by dividing the total catch (A+B1+B2) by the number of angler-hours (number of anglers in the party times the number of hours fished). One may also compute harvest per unit effort (HPUE), using the type A and B1 catches, but this measure is directly affected by size and bag limit regulations.

A GLM standardization procedure was adopted following the methods used for the previous assessment, where the CPUE of private vessels was expressed as a linear function of the factors YEAR COUNTY (the description given by Schirripa et al. mistakenly asserts that both private and charter vessels were used and attributed significant effect to year, month, area and mode).

Fishery independent.

Fishery independent trap and video surveys were conducted as part of the Southeast Area Monitoring Program (SEAMAP) during the months of June, July and August from 1992-1997 (data courtesy of C. T. Gledhill). An abbreviated video survey was conducted in 2001, and a complete survey in 2002, however the data are still being quality assured. The trap survey was not continued in 2001 or 2002 and therefore not updated. Accordingly, no updates were possible and the indices from the previous assessment were retained.

Tag-recapture index.

Estimates of the loss rate of red grouper tagged by the Mote Tagging program were derived using the methods discussed in Legault et al. (1999). As was done in the previous assessment, these estimates were converted to a relative abundance index by solving the catch equation for numbers of fish (where the catches were the MRFSS estimates of the number of fish released alive and the natural mortality rate was assumed to be 0.2 yr^{-1}). This conversion approach makes the implicit assumptions that tag shedding is negligible and that the tagged fish mix randomly with the untagged population, neither of which appear to be true of red grouper. However, we found the relative abundance index to be relatively insensitive to the assumed levels of tag-shedding and incomplete mixing (Figure 10). No doubt the relative index would be more sensitive to systematic changes in the level of mixing or tag shedding, but this is akin to asserting that CPUE indices are sensitive to systematic changes in factors not included in the standardization process. Accordingly, while further investigation is warranted, we can offer little basis for rejecting it over some of the CPUE indices used in this assessment. (In principle, a more appropriate use of the loss rate estimates would be to treat them as an index of relative mortality rate in the manner of Porch 2001, but there was insufficient time to incorporate this approach into the ASAP model for this assessment.)

POSSIBLE CURRENT CONDITION OF THE STOCK

The condition of the Gulf of Mexico red grouper stock was evaluated using the ASAP model (Legault and Restrepo, 1998) applied as described in the previous assessment (Schirripa et al., 1999), but with modifications introduced during the 2000 meeting of the RFSAP (see Table A2 in the addendum) . The analyses were conducted in three phases. In the first phase, the two runs judged by the RFSAP (2000) to provide the best scientific advice were re-run using the revised derived catch at age, revised discard estimates and trap CPUE series discussed earlier. The purpose of these runs was to determine if substantially different advice would have been given had these revisions been made in 2000. The second phase of the analysis includes catches estimated using the revised commercial yield ratio (Figure 6) and updates information to the year 2001. The third phase expands on the phase 2 model by including age composition data. The effects of a change in the fecundity-at-age vector and various alternative treatments of the CPUE series are also examined.

Phase 1: Revised catch, discard and trap CPUE information

The 2000 RFSAP based its advice largely on the results from two ASAP models (one assuming a steepness value of 0.7 for the stock-recruitment relationship and the other assuming a steepness value of 0.8) with the following specifications:

- "short" time series (1986-1997) of catch, discard and CPUE estimates.
- discards estimated via the "probabilistic" method tuned so that the predicted discard rate in 1994 matched the observed discard rate from 1994 observed program (NMFS 1995).
- 33% release mortality rate for commerical fisheries

These runs were repeated exactly as specified in 2000 except using the revisions to the derived catch at age, discard, and commercial trap CPUE discussed earlier. The effect of assuming 90% release mortality of longline caught fish was also examined (a total of four runs– two levels of steepness and two levels of longline release mortality).

The results are summarized in Table 18 and Figure 11. The estimates of MSY remain near 3000 mt. The estimates of $F_{current}$ and F_{MSY} have both increased relative to the previous assessment, whereas the estimates of SS_{1997} and SS_{MSY} have decreased. The net effect is that the population is estimated to be overfished to a lesser extent than formerly indicated. Nevertheless, the estimated date of recovery to SS_{MSY} under no fishing (t_{min}) is the same (2002-2004).

As noted in the previous assessment, the estimates of stock status are somewhat less optimistic under the higher (90%) release mortality assumption.

Phase 2: Data updated to 2001

The runs in this phase were conducted as described for phase 1 with the addition of using the derived catch at age using the revised commercial yield ratio, and catch and cpue updated to 2001. The estimated trends in SS and SS/SS_{MSY} are contrasted with those from phase 1 (data to 1997) and the projections results examined by RFSAP (2000) in Figure 12. The estimates of SS are nearly identical for all runs, however the projections from the previous assessment predicted a downturn after 1999 in contrast to the upswing estimated with the latest data. The difference is largely attributable to estimates of recruitment that exceeded the expectation of the Beverton and Holt spawner-recruit relationship used in the projections (Figure 13). The estimated trends in SS/SS_{MSY} are more sensitive to the various model treatments than are the trends in SS (Figure 12).

Applications of ASAP to the updated (1986-2001) catch and CPUE information led to somewhat less optimistic SS/SS_{MSY} ratios for 1997 than did applications to the shorter time series (1986-1997). The status in 2001 is estimated to have improved relative to the status in 1997 for all models, but remains overfished (Figure 14, Table 19). Higher levels of steepness and lower levels of longline release mortality favor somewhat more optimistic estimates of stock status. The estimates of MSY are 10 - 20% higher than estimated from the 1986-1997 data (3300 - 3600 MT). The estimates of $F_{current}$ and F_{MSY} are similar to the previous assessment, whereas the estimates of SS_{2001} and SS_{MSY} have both increased. The catch expected to permit the population to recover to SS_{MSY} by 2012 is between 2600 and 3100 MT (about 20% less than MSY).

Phase 3: Addition of sampled age composition data and sensitivity analyses

The runs in phase 3 were conducted exactly as described for phase 2 except for the additional use of age composition data derived from otoliths taken from a sample of the catch (see Lombardi-Carlson et al., 2002). Also sensitivity runs were made to examine the effects of a new fecundity at age vector (see section on reproduction), down-weighting the indices of abundance to account for variations in the degree to which they reflect population abundance ($CV_{index} = SQRT(0.2*0.2 + CV_{GLM}*CV_{GLM})$, adjusting the CPUE indices downwards by 25% to account for increases in efficiency associated with increased use of GPS plotters, and splitting the historical CPUE series into pre- and post-size limit (1990) eras.

Base run

Estimates were made using the two different levels of steepness (0.7 and 0.8) and longline release mortality (33% and 90%). The estimated levels of spawning stock (in collective gonad weight) are similar for all five models (Figure 15), as are the abundance and fishing mortality rate estimates (Figure 16, one case shown). However, the estimates of SS_{MSY} are sensitive to the level of steepness assumed– generally leading to more optimistic perceptions of stock status (no longer overfished) as steepness increases. As was true of the previous assessment, there is insufficient contrast in the SS and recruitment series to allow steepness to be reliably estimated, although the model does favor the higher steepness (i.e., the objective function attains a lower value with the higher steepness).

The phase 3 base run results are contrasted with the corresponding phase 2 results in Figure 17.

The use of the sampled age composition data causes the estimates of SS and SS/SS_{MSY} to increase faster than when such data are excluded, resulting in a somewhat more optimistic picture of stock status.

Sensitivity runs

The results of the sensitivity runs are contrasted with those of the base runs in Figure 18 and Table 20. The use of the new fecundity at age vector has the most pronounced effect, moving the estimated stock status from overfished to merely below SS_{MSY} (but above MSST=0.8 SS_{MSY}) with a steepness of 0.7 and above SS_{MSY} with a steepness of 8. However, adjusting the CPUE series downwards to account for increased use of GPS plotters moved the estimated status back to overfished, even with a steepness of 0.8. Downweighting the indices of abundance and splitting the historical CPUE index had relatively little effect.

Recommendations

A fuller evaluation of the inclusion of longer catch and catch rate series may provide additional contrast in the data to provide a stronger basis for stock status evaluations.

Additional research on index standardization for red grouper and application of indices of abundance in the assessment model is warranted.

Fishery independent indices of abundance with amble spatial and temporal coverage are needed

Research into improved models of fecundity at age and methods to incorporate uncertainty in these estimates is warranted given the sensitivity of the assessment results to these estimates.

Information is needed on fish released at sea including amounts for most sectors, size composition from all sectors and their fate.

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Table 1. Size conversion equations used to convert red grouper sizes to total length, gutted weight and age.

to	from	equation	source
TL (in)	FL (in)	TL = -0.134 + FL * 1.052	Goodyear and Schirripa (1993)
TL (in)	SL (in)	TL = 0.819 + FL * 1.185	Goodyear and Schirripa (1993)
gutted wt (lb)	TL (in)	gwt = 0.00112 * FL ** 2.76	Goodyear and Schirripa (1993)
gutted wt (lb)	FL (in)	gwt = 0.000506 * FL ** 3.04	Goodyear and Schirripa (1993)
whole wt (lb)	TL (in)	wwt = 0.000399 * TL ** 3.1	Goodyear and Schirripa (1993)
gutted wt	whole wt	gwt = wwt / 1.048	Goodyear and Schirripa (1993)
age (years)	TL (in)	TL = 31.81 * (1 - exp (-0.210 * (age + 0.30))	Goodyear (1994)
age (years)	TL (in)	TL = 31.81 * (1 - exp (-0.210 * (age + 0.30 + 0.416))	Goodyear (1994) with calendar year adjustment[1]

[1]The calendar year adjustment is used to shift the curve from the apparent marking date of 1 June to 1 January so that in the assessment all fish in a cohort would be assigned to the same year class; thus the assessment age of 1 year corresponds to an approximate true age of 0.6 to 1.59 years.

Table 2a. Length samples used for calculating age composition of the recreational landings by year and mode. Headboat mode.Lengths are in inches.

headboat mode																
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
10	14	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
11	11	0	0	10	0	0	0	1	0	0	0	0	0	0	0	
12	11	13	5	36	1	0	0	0	0	0	0	4	0	0	0	
13	35	37	21	117	7	0	0	1	0	0	0	1	0	0	0	
14	65	83	56	117	12	0	0	1	1	0	1	0	0	0	0	
15	76	78	64	89	7	0	0	0	0	0	0	4	1	0	0	
16	66	84	36	53	7	0	0	2	0	0	0	0	0	0	0	
17	55	68	37	71	13	1	0	0	0	0	0	0	0	0	0	
18	59	55	41	52	12	1	1	2	0	0	0	0	1	0	1	
19	46	72	38	76	22	4	3	5	5	3	12	16	26	14	15	
20	39	65	23	37	25	25	14	23	33	24	50	58	50	45	38	
21	44	67	42	58	73	24	26	20	32	40	47	40	48	67	45	
22	18	31	21	23	31	11	9	19	18	20	42	29	42	28	25	
23	8	19	12	13	19	12	5	4	5	22	24	23	14	16	15	
24	22	26	25	34	42	10	8	10	10	11	15	38	35	40	24	
25	20	17	12	18	20	9	3	9	8	8	23	13	8	12	8	
26	13	15	13	23	19	9	6	6	7	8	13	6	4	15	8	
27	10	12	8	25	17	6	5	4	1	7	11	6	14	8	4	
28	8	9	5	4	8	3	4	3	7	1	9	7	8	2	1	
29	5	4	7	10	6	4	6	0	1	3	2	10	2	4	0	
30	2	1	3	3	6	2	2	4	2	0	6	3	5	4	0	
31	5	4	1	8	4	2	5	0	0	0	0	8	0	3	0	
32	2	2	1	3	2	7	1	5	0	1	1	0	0	0	1	
33	1	2	0	1	3	9	0	0	0	1	0	4	0	0	0	
34	0	0	2	0	1	4	2	1	1	0	0	0	0	0	0	
35	1	1	0	1	0	2	0	1	4	0	0	0	0	1	0	
36	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	
37	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
39	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
42	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
total	639	765	474	882	359	145	100	121	135	149	256	270	259	259	185	

Table 2b. Length samples used for calculating age composition of the recreational landings by year and mode. Charter mode. Lengths are in inches.

charter mode																
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
12	1	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0
13	3	6	0	0	0	4	0	0	0	0	0	0	0	0	1	0
14	2	2	3	1	0	8	0	0	0	0	0	0	3	0	0	0
15	4	3	3	5	0	4	0	0	0	0	0	0	3	0	4	0
16	4	1	9	9	0	0	0	0	0	0	0	0	10	0	0	0
17	10	3	3	12	0	16	0	0	0	0	0	0	4	0	0	0
18	4	1	4	5	0	14	5	0	0	0	4	0	14	0	2	0
19	4	1	6	6	1	9	5	2	18	3	13	4	13	11	24	24
20	2	3	5	10	3	20	19	13	64	4	51	25	43	40	97	67
21	2	2	1	2	1	11	31	7	57	20	59	46	52	55	72	79
22	1	4	5	3	3	14	19	11	32	9	62	38	36	54	37	79
23	1	0	2	3	2	4	18	13	33	13	53	40	55	29	37	54
24	1	1	1	0	1	4	17	22	16	3	36	31	54	34	22	31
25	0	0	2	0	2	8	6	13	7	8	19	22	57	35	14	21
26	0	1	3	0	0	0	8	12	17	6	35	32	27	22	21	15
27	0	1	0	1	0	8	14	20	32	7	14	13	24	17	15	11
28	0	0	1	1	0	4	18	48	14	6	12	30	9	12	25	10
29	0	1	1	0	0	4	18	32	12	6	14	4	25	7	9	6
30	0	1	0	0	0	0	24	20	8	0	9	9	8	2	6	4
31	0	0	0	0	0	4	5	20	8	1	8	12	9	7	4	4
32	0	0	0	0	0	0	8	16	8	0	0	0	4	0	1	5
33	0	0	0	0	0	0	5	0	12	0	8	8	0	4	2	0
34	0	0	0	0	0	0	0	4	4	1	0	0	4	4	2	1
35	0	0	0	0	0	12	0	0	0	0	0	4	4	0	0	0
36	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
total	39	32	49	59	13	152	221	253	342	87	401	318	458	334	395	411

Table 2c. Length samples used for calculating age composition of the recreational landings by year and mode. Private mode. Lengths are in inches.

private mode																
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0
11	0	6	2	2	1	0	0	0	0	0	0	0	0	0	0	0
12	4	6	10	5	0	0	0	0	0	0	0	0	0	0	0	0
13	1	9	12	13	0	0	0	0	0	0	0	0	0	1	0	0
14	4	16	20	6	0	0	0	1	0	0	0	0	0	0	0	0
15	3	9	17	19	0	0	1	0	0	0	0	0	0	0	0	0
16	6	10	31	30	0	0	0	1	0	0	0	0	0	3	3	0
17	2	10	17	12	0	0	0	3	0	0	0	0	0	1	4	0
18	3	5	7	15	2	1	0	0	0	0	0	2	2	2	2	0
19	2	11	11	7	4	3	9	12	9	8	3	0	4	2	4	2
20	2	11	11	18	3	13	41	24	16	17	4	1	14	13	16	22
21	4	3	15	12	7	22	44	25	23	14	6	9	22	26	31	21
22	2	6	11	2	5	16	36	21	16	17	5	16	15	21	17	22
23	1	3	8	2	3	13	23	17	21	17	13	7	7	16	15	15
24	0	1	8	7	6	7	28	9	16	15	7	6	4	18	10	10
25	0	1	5	3	1	10	21	11	5	18	3	4	10	15	9	8
26	0	2	3	2	6	3	14	6	5	9	4	3	7	5	9	7
27	0	1	0	0	3	2	8	2	4	6	2	0	5	6	6	3
28	0	1	0	0	0	0	3	1	2	5	4	0	3	6	4	4
29	0	0	1	0	0	1	1	0	2	1	0	0	2	4	6	3
30	0	0	0	0	1	0	1	0	1	0	0	0	0	3	3	1
31	0	1	0	0	0	0	1	1	0	2	1	0	1	0	5	1
32	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
33	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1
34	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
total	34	118	189	155	43	92	232	134	120	129	52	49	97	142	146	121

Table 3a. Length samples used for calculating age composition of the commercial landings by year and gear. Longline. Lengths are in inches.

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
longline																
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	6	4	15	-	-	-	-	-	-	-	-	-	2	-	-	-
12	70	28	63	6	-	-	-	-	-	-	-	-	-	-	-	-
13	339	149	157	17	1	-	-	-	-	-	-	-	-	-	-	-
14	420	186	109	31	-	-	-	-	-	-	-	1	-	-	-	-
15	383	193	99	34	-	-	1	-	-	-	-	1	-	2	-	-
16	269	172	96	39	-	-	-	-	-	-	-	-	2	2	-	-
17	331	166	112	42	4	-	3	1	1	1	3	3	6	2	1	1
18	386	178	103	35	12	9	4	5	2	29	34	34	31	68	24	21
19	420	175	113	68	86	96	103	124	138	288	333	407	722	1,151	634	437
20	366	184	94	101	444	676	611	663	713	1,322	1,126	1,627	2,733	4,775	2,800	2,158
21	278	142	76	86	751	1,156	947	889	946	1,507	1,395	2,049	3,089	5,580	3,510	2,855
22	364	158	44	159	1,176	1,903	1,129	1,029	880	1,212	1,164	1,723	2,994	5,139	3,123	2,399
23	364	128	48	125	906	1,076	762	908	733	1,023	1,015	1,353	2,798	4,678	3,087	2,217
24	303	142	35	185	1,074	1,325	814	1,034	814	927	944	1,208	2,749	3,618	2,318	1,609
25	307	132	54	110	818	802	675	1,107	840	978	823	1,056	3,110	3,744	2,589	1,640
26	223	131	29	113	1,056	1,105	752	936	818	902	736	992	2,958	3,624	2,646	1,655
27	163	64	34	83	762	798	553	697	590	750	596	746	2,428	3,044	2,209	1,353
28	177	95	30	91	958	1,054	669	698	524	714	516	662	2,006	2,982	2,317	1,273
29	168	64	16	62	577	699	412	469	407	543	386	559	1,276	2,247	1,695	994
30	121	56	16	85	726	792	403	440	297	374	237	505	820	1,366	1,188	579
31	89	29	15	77	547	484	302	362	223	262	167	319	578	1,019	863	368
32	66	22	5	25	328	204	158	175	111	144	97	201	328	614	538	204
33	60	22	3	48	255	199	116	107	73	74	55	121	201	306	337	115
34	46	13	4	16	139	98	43	46	41	42	22	41	83	170	168	73
35	28	10	4	10	87	66	35	32	19	11	9	21	43	66	69	49
36	12	6	1	4	43	18	15	9	4	6	6	7	10	18	17	8
37	1	1	-	4	27	9	7	6	2	1	1	1	2	5	2	7
38	1	1	-	-	7	1	1	-	-	2	-	-	-	-	-	1
39	-	-	-	2	6	-	-	-	-	-	-	1	1	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
42	-	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
total	5,750	2,634	1,374	1,103	10,438	12,536	8,453	9,540	8,092	10,966	9,655	13,626	28,933	44,202	30,069	19,388

Table 3b. Length samples used for calculating age composition of the commercial landings by year and gear. Handline and other gears. Lengths are in inches

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
handline+																
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	1	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
12	104	71	122	70	9	2	-	-	-	-	-	-	-	-	-	-
13	213	236	218	140	19	7	7	-	-	1	-	-	2	-	5	-
14	165	189	129	144	10	11	9	1	-	2	2	-	1	-	20	1
15	139	214	119	85	8	15	14	1	-	3	3	1	1	1	24	6
16	100	164	93	102	15	9	3	1	-	-	13	3	-	-	11	7
17	95	137	71	82	9	17	6	3	2	7	11	10	4	2	9	9
18	123	144	74	77	11	24	6	9	16	24	51	31	16	6	28	15
19	124	122	57	52	30	69	70	51	139	169	168	129	152	242	387	348
20	97	108	38	41	96	322	369	267	398	449	587	618	530	968	1,227	1,398
21	97	94	45	36	79	297	382	280	450	439	561	549	599	1,034	1,280	1,613
22	80	79	42	38	116	325	369	302	361	404	480	513	492	1,060	1,060	1,458
23	58	76	30	30	112	256	283	260	292	343	362	405	430	992	1,021	1,221
24	77	88	30	24	98	295	321	323	288	352	311	330	401	763	839	845
25	69	93	27	21	81	224	281	343	321	288	319	323	411	809	940	739
26	65	69	13	10	89	171	259	231	296	263	247	273	408	717	899	734
27	47	69	20	12	81	144	212	239	235	226	174	211	343	550	755	657
28	30	63	17	5	120	159	216	187	186	199	175	197	276	548	697	655
29	21	53	11	3	90	87	133	133	139	113	138	114	164	375	467	474
30	19	27	8	-	94	79	149	128	126	90	95	94	104	248	301	305
31	9	34	7	2	61	55	79	81	110	80	64	72	77	148	211	202
32	11	11	4	-	35	42	42	37	51	51	46	50	56	92	124	123
33	6	14	3	-	20	26	39	29	28	22	25	16	28	42	54	56
34	5	16	2	-	15	10	26	17	12	16	6	8	10	27	27	24
35	9	8	2	-	9	9	10	7	1	3	2	5	4	15	7	12
36	4	6	-	-	4	-	4	1	1	4	1	1	-	1	2	2
37	2	4	-	-	3	1	4	1	-	-	-	-	-	1	2	1
38	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
39	-	-	-	-	1	-	-	-	1	-	-	1	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
total	1,763	2,168	1,183	968	1,316	2,626	3,251	2,709	3,182	3,499	3,761	3,896	4,452	8,512	9,500	9,622

Table 4. Weighted age samples and total effective sample size for the three fishery categories used in the assessment (handline- HL, longline- LL and recreational- rec).

fishery	year	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14	AGE15	AGE16	AGE17	AGE18	AGE19	AGE20	effective sample size
HL+	1992	0.0	0.0	0.0	0.0	0.0	2.3	3.0	3.0	1.8	0.0	1.0	0.3	0.2	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	12.0
HL+	1993	0.0	0.0	0.0	0.1	3.3	3.4	8.7	8.0	6.7	0.8	1.1	0.1	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	32.8
HL+	1994	0.0	0.0	0.0	0.4	6.6	9.5	5.0	2.3	1.8	0.9	0.8	0.4	0.4	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.3	29.2
HL+	1995	0.0	0.0	0.0	0.0	0.5	4.8	9.1	5.7	2.7	1.3	0.8	0.3	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	26.1
HL+	1996	0.0	0.0	0.0	0.0	0.0	1.2	4.5	3.5	1.3	1.3	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.3
HL+	1997	0.0	0.0	0.0	0.0	0.3	2.4	2.5	2.1	1.7	0.1	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5
HL+	1998	0.0	0.0	0.0	0.5	1.5	3.8	2.0	2.9	1.3	1.4	1.8	0.0	0.1	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	15.6
HL+	1999	0.0	0.0	0.0	0.0	0.3	2.8	2.1	3.1	7.6	3.5	2.4	0.4	0.4	0.7	0.1	0.0	0.0	0.4	0.0	0.0	0.0	23.8
HL+	2000	0.0	0.0	0.0	0.0	9.5	4.4	8.6	5.5	4.9	3.7	2.9	2.1	0.9	1.1	0.8	0.6	0.0	0.0	0.0	0.3	0.3	45.8
HL+	2001	0.0	0.0	0.0	0.0	4.6	45.2	13.9	19.3	11.9	4.0	8.7	5.3	2.9	3.8	1.7	1.2	2.3	1.2	0.3	0.0	0.1	126.8
LL	1992	0.0	0.0	0.0	0.0	0.0	7.0	13.4	21.4	12.9	7.5	1.5	0.5	1.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	65.7
LL	1993	0.0	0.0	0.0	0.0	5.5	12.9	28.5	25.9	9.7	6.5	3.2	1.9	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.4
LL	1994	0.0	0.0	0.0	0.0	3.2	1.9	2.6	3.2	1.3	1.3	1.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0
LL	1995	0.0	0.0	0.0	0.0	0.6	3.5	19.3	11.3	18.0	10.7	7.3	1.7	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	74.0
LL	1996	0.0	0.0	0.0	0.0	0.6	3.1	8.6	15.9	4.9	15.3	7.3	1.2	0.6	0.0	0.0	0.6	0.0	0.6	0.0	0.0	0.0	58.6
LL	1997	0.0	0.0	0.0	0.0	0.6	0.3	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	2.0
LL	1998	0.0	0.0	0.0	0.0	2.1	6.4	7.5	13.4	10.2	7.0	1.6	3.7	2.1	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	55.1
LL	1999	0.0	0.0	0.0	0.0	1.8	17.0	37.0	61.1	97.7	80.4	37.5	23.9	12.8	5.8	3.0	1.8	0.6	0.0	0.6	0.0	0.6	381.6
LL	2000	0.0	0.0	0.0	0.0	2.4	7.3	29.6	25.8	28.9	23.3	19.1	19.9	7.8	4.0	2.3	1.7	1.7	0.0	0.6	0.6	1.1	176.0
LL	2001	0.0	0.0	0.0	0.0	1.2	58.9	30.5	56.9	30.5	17.7	24.6	19.6	15.4	4.2	6.1	5.3	2.0	1.7	1.1	1.2	3.5	280.5
rec	1992	0.0	0.0	0.0	0.0	0.2	1.1	0.2	0.1	0.5	0.3	0.5	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
rec	1993	0.0	0.0	0.0	0.1	1.5	0.4	0.6	1.3	1.0	0.6	0.1	0.3	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	6.1
rec	1994	0.0	0.0	0.0	0.4	1.6	1.4	1.1	0.7	1.1	0.3	0.3	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	7.8
rec	1995	0.0	0.0	0.0	0.0	1.1	5.3	6.2	4.0	2.9	2.5	0.6	1.1	0.9	0.3	0.8	0.0	0.1	0.0	0.0	0.0	0.5	26.4
rec	1996	0.0	0.0	0.0	0.1	0.0	4.4	12.2	6.4	2.3	1.5	0.7	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	28.0
rec	1997	0.0	0.0	0.0	0.7	0.3	2.0	5.9	7.7	2.5	0.3	0.1	0.6	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	21.4
rec	1998	0.0	0.0	0.0	0.0	1.4	1.4	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3
rec	1999	0.0	0.0	0.0	0.1	1.0	3.6	1.2	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	6.4
rec	2000	0.0	0.0	0.0	0.0	1.0	0.7	1.0	0.5	1.0	0.8	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	5.4
rec	2001	0.0	0.0	0.0	0.0	0.7	4.3	1.8	1.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	8.6

Table 5. Summary of reproductive parameters used in this assessment. Values for age 20 plus-group were computed by prorating the values for ages 20 to 30 assuming a total mortality rate of 0.4 yr^{-1} (as done by Schirripa et al. 1999). The per capita fecundity is the product of the proportion female, proportion mature, and batch fecundity. The relative per capita fecundity is the per capita fecundity scaled by the average over all ages. The column labeled "Schirripa" is the vector used in the previous assessment (also scaled by its mean).

Age	proportion female	proportion active	batch fecundity (millions of ova)		relative per capita fecundity		
			by age	by length	by age	by length	Schirripa
1	0.940	0.000	0.000	0.000	0.000	0.000	0.000
2	0.929	0.000	0.000	0.000	0.000	0.000	0.000
3	0.916	0.505	0.109	0.110	0.223	0.245	0.043
4	0.901	0.537	0.128	0.144	0.274	0.334	0.122
5	0.884	0.565	0.151	0.183	0.332	0.438	0.252
6	0.864	0.590	0.177	0.226	0.399	0.554	0.426
7	0.842	0.612	0.208	0.274	0.474	0.678	0.626
8	0.816	0.632	0.244	0.325	0.557	0.806	0.835
9	0.788	0.650	0.287	0.380	0.650	0.933	1.032
10	0.756	0.667	0.338	0.436	0.752	1.053	1.206
11	0.721	0.682	0.397	0.493	0.862	1.162	1.345
12	0.683	0.695	0.466	0.550	0.979	1.255	1.445
13	0.643	0.708	0.548	0.608	1.103	1.327	1.504
14	0.601	0.719	0.644	0.664	1.230	1.377	1.523
15	0.557	0.730	0.757	0.719	1.360	1.402	1.505
16	0.512	0.740	0.890	0.772	1.490	1.403	1.454
17	0.467	0.749	1.046	0.823	1.617	1.381	1.378
18	0.423	0.757	1.230	0.871	1.739	1.338	1.282
19	0.379	0.765	1.446	0.917	1.854	1.277	1.172
20	0.338	0.773	1.699	0.960	2.105	1.035	0.850

Table 6. Annual commercial reported and calculated red grouper (mt) in the U.S. Gulf of Mexico catches and proportion of unclassified groupers considered red grouper in west Florida.

	proportion red grouper in unclassified	reported red grouper (mt)	calculated red grouper (mt)
1986	0.680	2,869	2,937
1987	0.710	3,041	3,129
1988	0.660	2,123	2,220
1989	0.750	3,393	3,446
1990	0.629	2,166	2,197
1991	0.661	2,312	2,329
1992	0.607	1,919	1,930
1993	0.695	2,891	2,903
1994	0.641	2,233	2,241
1995	0.656	2,159	2,164
1996	0.659	2,028	2,030
1997	0.646	2,216	2,217
1998	0.540	1,801	1,804
1999	0.654	2,698	2,700
2000	0.625	2,635	2,636
2001	0.580	2,639	2,640

Table 7. Annual calculated red grouper from the commercial fishery by state. Calculated red grouper includes reported plus a portion of unclassified.

	AL	LA	MI	TX	wFL	total
1986	-	1	-	-	2,936	2,937
1987	-	0	-	-	3,129	3,129
1988	-	0	-	-	2,220	2,220
1989	4	0	-	-	3,442	3,446
1990	-	-	-	-	2,197	2,197
1991	-	0	-	-	2,329	2,329
1992	-	0	-	-	1,930	1,930
1993	-	0	-	-	2,902	2,903
1994	0	1	-	-	2,240	2,241
1995	-	-	-	-	2,164	2,164
1996	-	-	-	-	2,030	2,030
1997	-	0	-	-	2,217	2,217
1998	3	-	-	-	1,801	1,804
1999	-	1	0	-	2,700	2,700
2000	-	0	-	-	2,636	2,636
2001	-	1	-	-	2,639	2,640

Table 8. U.S. Gulf of Mexico commercial landings of calculated red grouper (reported plus a portion of unclassified groupers) by gear (mt).

	longline	handline+	total
1986	1,202	1,735	2,937
1987	1,601	1,529	3,129
1988	956	1,264	2,220
1989	1,289	2,156	3,446
1990	1,225	972	2,197
1991	1,254	1,075	2,329
1992	663	1,267	1,930
1993	1,960	943	2,903
1994	1,237	1,004	2,241
1995	1,128	1,036	2,164
1996	1,364	665	2,030
1997	1,434	783	2,217
1998	1,302	502	1,804
1999	1,783	918	2,700
2000	1,346	1,290	2,636
2001	1,546	1,094	2,640

Table 9. Recreational harvest (number of fish) of red grouper in the Gulf of Mexico by state.

	TX	LA	MS	AL	wFL	total
1986	5	-	-	1,210	821,209	822,424
1987	1	-	-	932	442,653	443,586
1988	10	-	-	648	738,163	738,821
1989	1	1	-	302	826,037	826,341
1990	1	-	-	272	219,595	219,868
1991	-	696	-	244	295,642	296,581
1992	2	1	-	172	469,424	469,599
1993	5	5	-	1,161	371,673	372,844
1994	-	-	-	723	320,697	321,420
1995	2	-	-	1,037	327,959	328,999
1996	2	-	-	2,177	148,109	150,288
1997	-	-	-	1,165	97,186	98,351
1998	-	9	-	841	117,742	118,592
1999	-	5	-	783	176,581	177,368
2000	-	3	-	1,063	257,869	258,935
2001	-	3	-	1,083	208,511	209,597

Table 10. Recreational harvest (number of fish)of red grouper in the Gulf of Mexico by mode.

	shore	headboat	charter	private	total
1986	5,863	34,512	111,071	670,984	822,430
1987	10,105	27,678	68,301	337,531	443,616
1988	7,601	28,333	71,071	631,814	738,819
1989	-	50,987	62,766	712,589	826,342
1990	13,506	18,653	70,962	116,750	219,871
1991	9,378	10,136	12,926	264,147	296,586
1992	24,264	9,654	53,094	382,585	469,598
1993	16,797	9,779	31,021	315,253	372,849
1994	3,770	10,303	38,186	269,162	321,421
1995	1,315	15,094	86,255	226,334	328,998
1996	-	16,216	28,042	106,029	150,286
1997	1,369	5,692	26,557	64,735	98,353
1998	901	6,531	29,546	81,619	118,597
1999	-	7,597	25,039	144,732	177,368
2000	-	10,226	30,858	217,853	258,937
2001	-	10,226	42,710	156,663	209,599

Table 11. Coefficients of variation about annual estimates of recreational harvest from MRFSS for red grouper from west Florida by mode.

	shore	charter	private
1986	100	20	20
1987	95	24	13
1988	73	21	13
1989		24	12
1990	91	60	17
1991	37	37	13
1992	30	15	8
1993	45	18	13
1994	59	15	11
1995	71	38	14
1996		51	14
1997	100	47	17
1998	100	30	14
1999		15	13
2000		13	14
2001		12	14

Table 12. MRFSS estimates of the number of red grouper released alive by state in the Gulf of Mexico.

	LA	MS	AL	wFL	total
1986	-	-	-	559,543	559,543
1987	-	-	-	489,823	489,823
1988	-	-	-	893,491	893,491
1989	-	-	-	2,034,825	2,034,825
1990	-	-	179	1,689,989	1,690,168
1991	-	-	-	3,012,905	3,012,905
1992	-	-	-	2,740,258	2,740,258
1993	-	-	-	1,708,137	1,708,137
1994	-	-	-	1,707,586	1,707,586
1995	-	-	-	1,712,438	1,712,438
1996	-	-	-	1,099,000	1,099,000
1997	-	-	-	1,129,070	1,129,070
1998	-	-	-	1,475,413	1,475,413
1999	-	-	-	1,994,645	1,994,645
2000	-	-	-	1,787,640	1,787,640
2001	-	-	126	1,557,902	1,558,028

Table 13. MRFSS estimates of the number of red grouper released alive by mode in the Gulf of Mexico.

	shore	charter	private	total
1986	5,863	109,419	444,261	559,543
1987	-	86,356	403,467	489,823
1988	11,632	64,532	817,327	893,491
1989	1,794	155,246	1,877,785	2,034,825
1990	20,881	310,878	1,358,409	1,690,168
1991	33,429	56,522	2,922,955	3,012,905
1992	81,896	207,621	2,450,741	2,740,258
1993	7,567	79,105	1,621,466	1,708,137
1994	16,405	144,420	1,546,760	1,707,586
1995	5,099	226,189	1,481,149	1,712,438
1996	14,287	90,321	994,391	1,099,000
1997	8,894	151,706	968,470	1,129,070
1998	9,758	172,154	1,293,502	1,475,413
1999	6,049	231,609	1,756,987	1,994,645
2000	7,793	91,529	1,688,318	1,787,640
2001	3,234	122,511	1,432,283	1,558,028

Table 14. Proportions of the total estimate catch from MRFSS (A+B1+B2) which was released alive (B2).

1986	0.415
1987	0.541
1988	0.557
1989	0.724
1990	0.894
1991	0.913
1992	0.856
1993	0.825
1994	0.846
1995	0.845
1996	0.891
1997	0.924
1998	0.929
1999	0.922
2000	0.878
2001	0.887

Table 15. Alternative derived age composition for 1986-1997 assuming longline discard mortality of 0.33..

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	69,996	53,005	88,446	195,692	64,583	104,927	95,944	59,366	59,624	62,270	40,525	39,312
2	452,470	363,692	549,670	678,459	86,783	163,360	115,829	112,367	175,566	166,524	168,730	168,682
3	539,337	414,122	546,550	762,851	125,286	205,332	164,645	180,262	181,724	199,596	162,886	163,988
4	406,850	305,758	360,896	507,807	152,701	244,790	243,894	257,899	233,433	245,109	183,134	191,404
5	268,678	218,195	225,998	310,060	150,482	222,250	234,708	256,802	220,872	226,052	163,369	169,430
6	170,920	155,552	140,650	186,796	128,081	167,424	179,387	205,742	169,947	172,837	122,490	126,164
7	108,950	109,262	88,455	113,107	99,372	116,133	124,832	148,200	118,989	120,304	84,134	87,028
8	70,188	75,342	56,136	69,380	72,586	77,753	83,346	101,111	79,560	79,934	55,357	57,886
9	45,671	51,200	35,825	43,165	51,010	51,235	54,599	67,087	52,007	51,959	35,714	37,823
10	29,926	34,455	22,958	27,196	35,008	33,530	35,487	43,921	33,667	33,482	22,880	24,524
11	19,696	23,047	14,771	17,318	23,694	21,898	23,021	28,607	21,739	21,542	14,654	15,872
12	13,002	15,366	9,545	11,127	15,912	14,310	14,952	18,621	14,057	13,888	9,417	10,287
13	8,600	10,229	6,195	7,203	10,643	9,370	9,737	12,141	9,117	8,989	6,077	6,686
14	5,700	6,806	4,038	4,691	7,105	6,150	6,363	7,939	5,937	5,842	3,942	4,363
15	3,783	4,530	2,643	3,071	4,740	4,048	4,173	5,206	3,880	3,814	2,569	2,856
16	2,515	3,017	1,737	2,019	3,162	2,672	2,745	3,425	2,548	2,499	1,682	1,878
17	1,673	2,011	1,145	1,332	2,111	1,766	1,811	2,260	1,677	1,645	1,106	1,237
18	1,116	1,341	757	882	1,409	1,171	1,198	1,494	1,108	1,086	729	817
19	744	895	501	585	943	779	794	992	734	718	483	543
20	1,483	1,784	985	1,156	1,880	1,534	1,563	1,952	1,439	1,406	942	1,064
total	2,221,298	1,849,609	2,157,901	2,943,897	1,037,491	1,450,433	1,399,028	1,515,395	1,387,626	1,419,497	1,080,819	1,111,845

Table 16. Derived age composition for 1986-2001 assuming longline discard mortality of 0.33.

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	70,061	53,057	88,612	195,788	64,630	105,219	95,916	59,656	59,689	60,818	41,527	40,435	52,501	70,972	62,991	55,642
2	452,845	363,862	556,278	679,458	88,962	166,424	117,179	112,843	176,159	163,151	190,996	179,627	134,740	172,371	164,271	141,881
3	539,656	414,268	551,324	763,931	127,713	208,692	165,410	177,377	180,507	196,676	180,113	173,773	134,296	190,344	200,688	192,575
4	407,096	305,900	361,437	508,644	153,858	247,239	242,048	254,897	232,098	242,615	202,139	203,363	157,310	235,189	242,387	253,875
5	268,766	218,296	225,574	310,691	150,673	223,926	232,925	255,473	220,234	223,931	181,101	180,833	147,260	224,516	224,336	234,682
6	170,934	155,608	140,352	187,266	128,002	168,336	179,369	205,719	169,989	171,117	136,342	135,104	115,640	176,172	176,271	178,415
7	108,956	109,296	88,270	113,445	99,300	116,550	126,024	148,895	119,382	119,015	93,951	93,507	82,192	125,023	127,296	124,324
8	70,198	75,364	55,988	69,618	72,548	77,945	84,870	101,991	80,048	79,019	61,960	62,391	55,325	84,158	87,502	82,916
9	45,682	51,214	35,695	43,326	50,994	51,347	55,969	67,875	52,457	51,331	40,040	40,873	36,229	55,148	58,425	54,088
10	29,935	34,463	22,849	27,305	35,000	33,612	36,555	44,535	34,033	33,059	25,681	26,555	23,438	35,712	38,409	34,946
11	19,704	23,053	14,686	17,391	23,689	21,966	23,794	29,054	22,013	21,260	16,462	17,212	15,110	23,042	25,074	22,524
12	13,008	15,370	9,480	11,176	15,909	14,364	15,491	18,934	14,255	13,702	10,585	11,170	9,753	14,881	16,339	14,540
13	8,606	10,231	6,149	7,234	10,640	9,412	10,108	12,355	9,257	8,863	6,837	7,268	6,312	9,640	10,656	9,418
14	5,702	6,808	4,005	4,713	7,104	6,184	6,614	8,083	6,035	5,760	4,436	4,745	4,104	6,270	6,968	6,126
15	3,785	4,531	2,621	3,086	4,739	4,073	4,340	5,304	3,948	3,760	2,892	3,108	2,678	4,095	4,569	4,001
16	2,516	3,017	1,721	2,028	3,163	2,689	2,857	3,492	2,592	2,464	1,893	2,043	1,757	2,686	3,005	2,623
17	1,675	2,011	1,134	1,338	2,111	1,780	1,887	2,305	1,708	1,620	1,244	1,348	1,155	1,768	1,981	1,727
18	1,116	1,341	749	885	1,409	1,181	1,249	1,525	1,129	1,068	820	890	762	1,165	1,311	1,140
19	744	895	496	587	941	784	828	1,012	747	708	544	591	504	772	868	754
20	1,484	1,784	974	1,160	1,877	1,548	1,627	1,990	1,473	1,387	1,062	1,162	990	1,516	1,710	1,480
total	2,222,469	1,850,369	2,168,394	2,949,070	1,043,264	1,463,270	1,405,060	1,513,317	1,387,754	1,401,324	1,200,625	1,185,999	982,056	1,435,439	1,455,058	1,417,677

Table 17. Indices of abundance and corresponding coefficients of variation (cv) used in the red grouper assessment.

	comm. handline (logbook)		comm. longline (logbook)		comm. trap (logbook)		MRFSS private		trap survey		video survey		Mote tagging		operating units	
year	index	cv	index	cv	index	cv	index	cv	index	cv	index	cv	index	cv	index	cv
1981							0.4043	0.1555							1.5103	1.0000
1982							0.6877	0.0674							1.4992	1.0000
1983							0.7297	0.0950							1.2943	1.0000
1984							0.9563	0.0666							1.5662	1.0000
1985							0.6775	0.0830							1.8628	1.0000
1986							0.8396	0.0383							1.6760	1.0000
1987							0.6350	0.0486							1.3132	1.0000
1988							0.6703	0.0441							1.1015	1.0000
1989							0.9616	0.0392							1.8374	1.0000
1990	0.9733	0.3379	0.9658	0.2316	0.9125	0.2233	0.8866	0.0446							0.7312	1.0000
1991	1.0297	0.0455	0.7363	0.1237	1.2077	0.1208	1.3364	0.0385					1.7901	0.1300	0.7996	1.0000
1992	1.0728	0.0427	0.6415	0.1316	0.8164	0.1200	1.2249	0.0282	0.8776	0.3480	0.2938	0.2730	1.4199	0.0800	0.9613	1.0000
1993	0.8378	0.0274	1.3691	0.1158	0.7712	0.1176	1.0972	0.0361	0.6883	0.3190	0.5911	0.1780	0.9547	0.1100	1.0210	1.0000
1994	0.9611	0.0255	0.8571	0.1149	0.7987	0.1192	1.1374	0.0333	3.0335	0.2430	0.6293	0.1730	1.2023	0.1900	0.8769	1.0000
1995	0.9771	0.0250	0.8526	0.1151	0.8893	0.1193	1.1088	0.0361	0.6452	0.3810	1.2454	0.1900	1.0659	0.2200	0.6804	1.0000
1996	0.7443	0.0254	0.9740	0.1152	0.6325	0.1204	0.8808	0.0385	0.6734	0.3720	1.2311	0.1650	0.7198	0.3000	0.4533	1.0000
1997	0.8389	0.0248	1.0230	0.1149	0.9336	0.1216	0.9294	0.0363	0.0819	0.8390	2.0093	0.1330	0.5098	0.1100	0.5482	1.0000
1998	0.7620	0.0244	1.1179	0.1150	0.7038	0.1273	1.0984	0.0299					0.6964	0.1000		
1999	1.0286	0.0232	1.3124	0.1154	1.3769	0.1235	1.1310	0.0248					1.0283	0.1400		
2000	1.2968	0.0226	0.9523	0.1155	1.6399	0.1229	1.0645	0.0285					0.8753	0.1300		
2001	1.4776	0.0231	1.1980	0.1154	1.3175	0.1269	0.9982	0.0297					0.7375	0.1700		

Table 18. Population estimates based on the original 1986-1997 catch/discard data (RFSAP 2000) contrasted with corresponding estimates obtained from the revised catch/discard data.

	Steepness = 0.7			Steepness = 0.8			
	revised (33%)	revised (90%)	original	revised (33%)	revised (90%)	original	Comments
MSY	2.908	2.905	3.181	2.819	2.799	3.041	1000's MT
$F_{current}$	0.344	0.371	0.302	0.344	0.372	0.302	
F_{MSY}	0.298	0.296	0.223	0.365	0.360	0.270	
$F_{current}/F_{MSY}$	1.153	1.253	1.356	0.945	1.032	1.117	> 1 = overfishing
SS_{97}	233.7	217.8	244.3	234.7	227.7	246.3	MT gonad weight
SS_{MSY}	379.8	390.9	433.2	314.6	323.3	350.7	MT gonad weight
SS_{97}/SS_{MSY}	0.615	0.557	0.564	0.746	0.704	0.702	< 0.8 = overfished
T_{min}	2004	2004	2004	2002	2003	2002	recovery at F=0

Table 19. Population estimates from phase 2 (1986-2001data using methods of previous assessment) assuming 33% or 90% mortality of longline releases. The quantitiy *SS* is spawning stock in MT gonad weight. The*MSY*, *OY* (F=0.75F_{MSY}), and $C_{recover}$ (catch expected to permit recovery to SS_{MSY} by 2012) are in MT.

	Release mortality = 33%		Release mortality = 90%	
	steepness=0.7	steepness=0.8	steepness=0.7	steepness=0.8
MSY	3564	3283	3592	3292
OY	3474	3211	3502	3220
OY/MSY	0.975	0.978	0.975	0.978
$F_{0.1}$	0.239	0.239	0.236	0.236
F_{max}	0.482	0.482	0.472	0.473
$F_{30\%}$	0.470	0.470	0.470	0.471
$F_{40\%}$	0.313	0.314	0.314	0.314
F_{MSY}	0.285	0.344	0.282	0.340
F_{OY}	0.214	0.258	0.212	0.255
F_{OY}/F_{MSY}	0.750	0.750	0.750	0.750
$F_{current}$	0.360	0.364	0.372	0.376
$F_{current}/F_{MSY}$	1.265	1.058	1.318	1.106
$F_{current}/F_{OY}$	1.687	1.411	1.757	1.474
SS_{MSY}	484	382	501	395
SS_{OY}	600	473	620	488
SS_{OY}/SS_{MSY}	1.238	1.238	1.236	1.236
SS_{2001}	299	296	300	298
SS_{2001}/SS_{MSY}	0.617	0.775	0.599	0.754
SS_{2001}/SS_{OY}	0.498	0.626	0.485	0.610
T_{min}	2005	2004	2006	2004
$C_{recover}$	2690	3100	2630	3050

Table 20. Population estimates from phase 3 (1986-2001data using methods of previous assessment plus sampled age composition) assuming 33% or 90% mortality of longline releases. The quantities *MSY*, *OY* (F=0.75F_{MSY}), and $C_{recover}$ (catch expected to permit recovery to SS_{MSY} by 2012) are in MT gutted weight. $C_{recover}$ is replaced by *OY* when SS/SS_{MSY}>0.8. The spawning stock *SS* is in MT gonad weight in the case of the base model, but is unitless (relative) in the case of the new fecundity vector.

	base				use new fecundity				adjust cpue		downwt indices		split hist. cpue	
	RM= 33%		RM = 90%		RM= 33%		RM = 90%		33%	90%	33%	90%	33%	90%
	h=0.7	h=0.8	h=0.7	h=0.8	h=0.7	h=0.8	h=0.7	h=0.8	h=0.8	h=0.8	h=0.8	h=0.8	h=0.8	h=0.8
MSY	3571	3344	3596	3353	3374	3281	3388	3284	2946	2957	3219	3239	3372	3379
OY	3480	3270	3504	3279	3301	3217	3314	3220	2880	2891	3146	3166	3297	3304
OY/MSY	0.974	0.978	0.975	0.978	0.978	0.981	0.978	0.981	0.977	0.977	0.977	0.977	0.978	0.978
$F_{0.1}$	0.238	0.238	0.235	0.235	0.238	0.238	0.235	0.235	0.235	0.232	0.230	0.228	0.238	0.235
F_{max}	0.475	0.476	0.468	0.469	0.476	0.476	0.469	0.469	0.463	0.455	0.449	0.445	0.475	0.468
$F_{30\%}$	0.463	0.464	0.465	0.466	0.702	0.703	0.707	0.708	0.453	0.454	0.432	0.436	0.463	0.465
$F_{40\%}$	0.310	0.310	0.311	0.311	0.437	0.437	0.439	0.440	0.304	0.305	0.291	0.293	0.310	0.311
F_{MSY}	0.281	0.340	0.280	0.337	0.329	0.382	0.326	0.378	0.332	0.329	0.321	0.320	0.340	0.337
F_{OY}	0.211	0.255	0.210	0.253	0.247	0.286	0.245	0.283	0.249	0.247	0.241	0.240	0.255	0.253
F_{OY}/F_{MSY}	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
$F_{current}$	0.314	0.316	0.322	0.324	0.316	0.317	0.324	0.325	0.363	0.370	0.311	0.321	0.310	0.318
$F_{current}/F_{MSY}$	1.117	0.930	1.152	0.962	0.961	0.829	0.993	0.860	1.092	1.126	0.969	1.005	0.913	0.946
$F_{current}/F_{OY}$	1.489	1.239	1.536	1.282	1.281	1.105	1.325	1.146	1.455	1.501	1.292	1.340	1.218	1.261
SS_{MSY}	487	391	503	404	5746	5086	5925	5242	349	360	377	391	394	407
SS_{OY}	604	485	623	499	6816	5998	7019	6172	433	446	469	485	489	503
SS_{OY}/SS_{MSY}	1.239	1.239	1.238	1.237	1.186	1.179	1.185	1.177	1.241	1.239	1.244	1.242	1.239	1.237
SS_{2001}	338	337	342	341	5327	5321	5415	5409	279	282	344	346	343	347
SS_{2001}/SS_{MSY}	0.694	0.862	0.680	0.845	0.927	1.046	0.914	1.032	0.799	0.784	0.911	0.886	0.870	0.852
SS_{2001}/SS_{OY}	0.560	0.695	0.549	0.683	0.782	0.887	0.772	0.876	0.644	0.633	0.732	0.714	0.702	0.689
T_{min}	2005	2004	2005	2004	2004	2001	2004	2001	2004	2005	2004	2004	2004	2004
$C_{recover}$	2980	3270	2950	3279	3301	3217	3300	3220	2610	2580	3146	3140	3297	3304

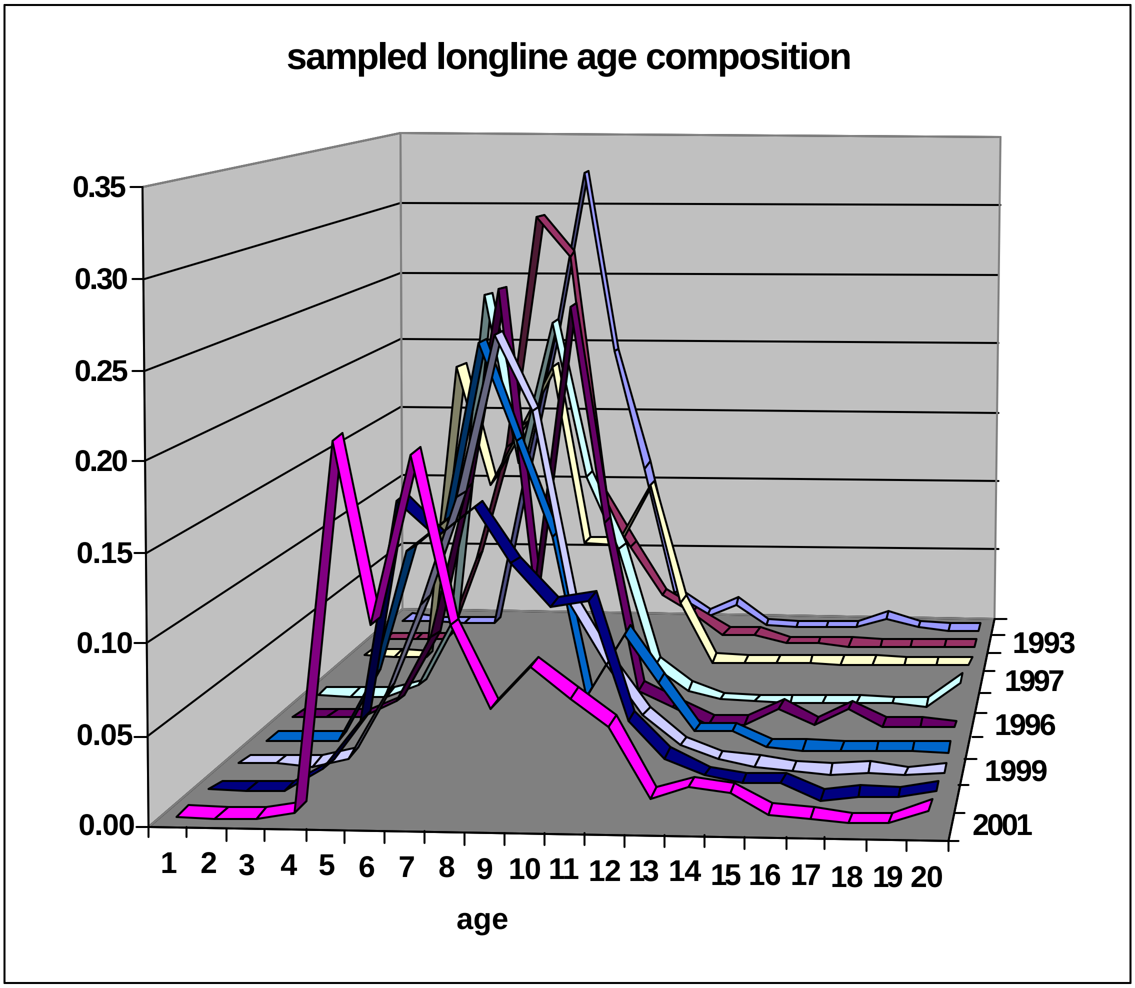


Figure 1. Weighted, sampled age composition from the longline fishery. The age composition for 1997 is not shown, because effective sample size was about 2 fish.

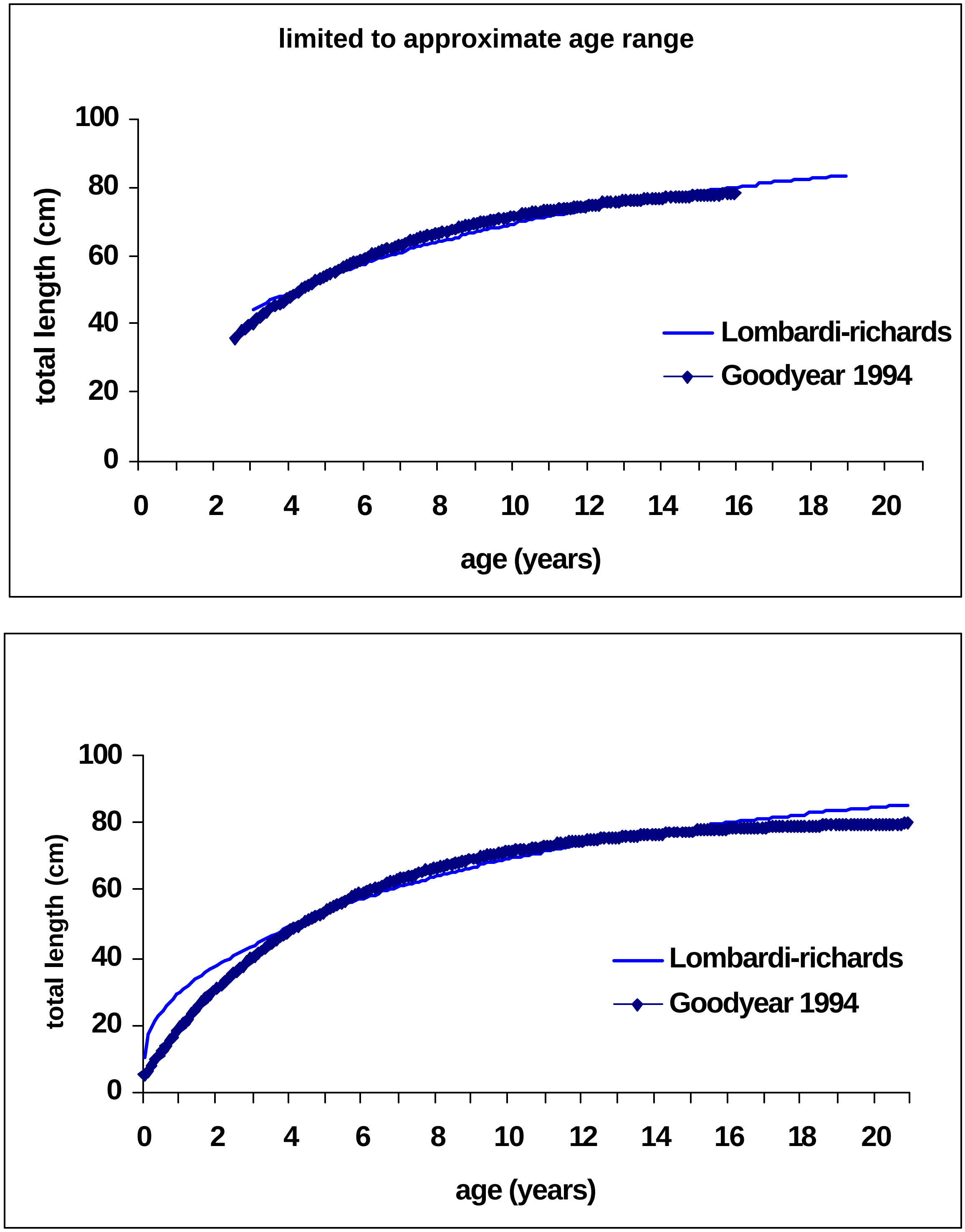


Figure 2. Estimated length (cm) at age for red grouper from Goodyear (1994) and the Richards curve from Lombardi-Carlson *et al*. (2002). In the upper panel each curve is shown for the approximate range of ages to which the curves were fit.

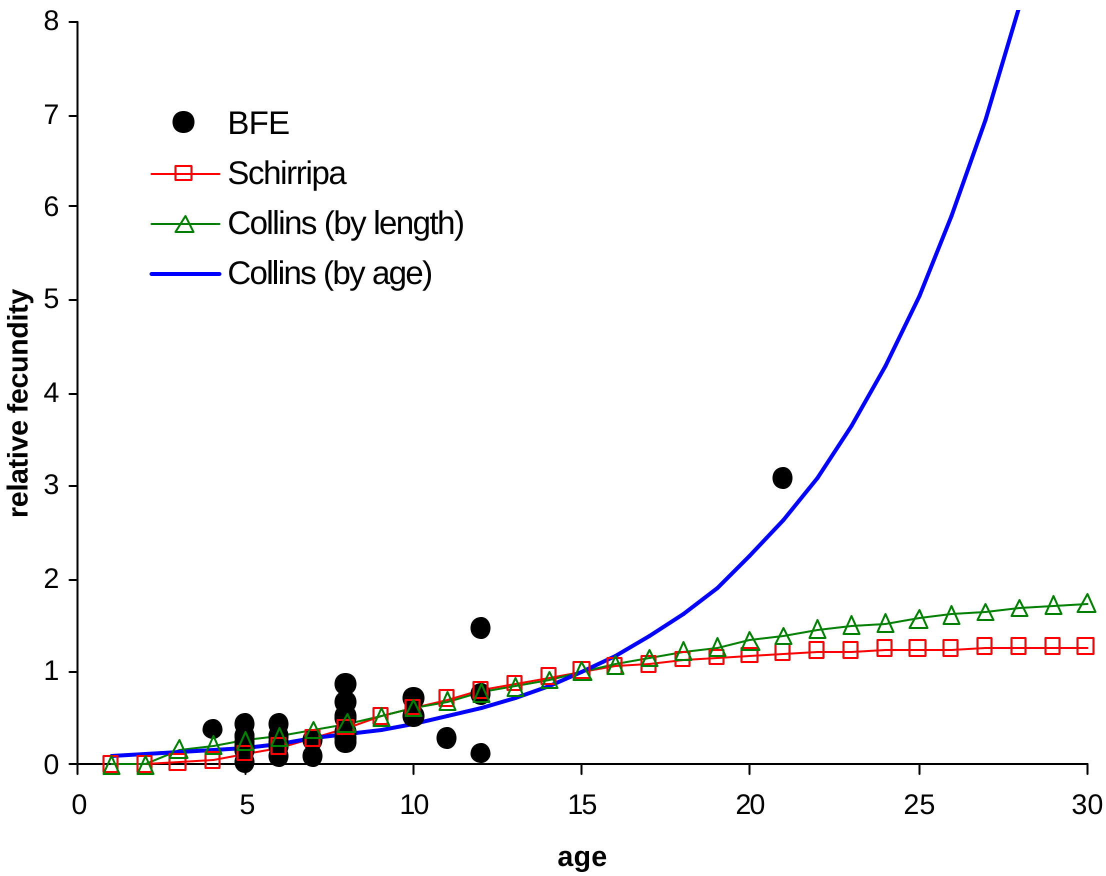


Figure 3. Relative fecundity of mature, active females. Circles are observations of batch fecundity (BFE) from Collins et al. 2002. The curve labeled “Shirripa” is the power function used by Schirripa et al 1999 to express gonad weight as function of length (converted to a function of age by use of the growth curve). The curve labeled “Collins (by length)” is the exponential function given by Collins et al. 2002 to express batch fecundity as function of length (converted to a function of age by use of the growth curve). The curve labeled “Collins (by age)” is the exponential function given by Collins et al. 2002 to express batch fecundity as function of age.

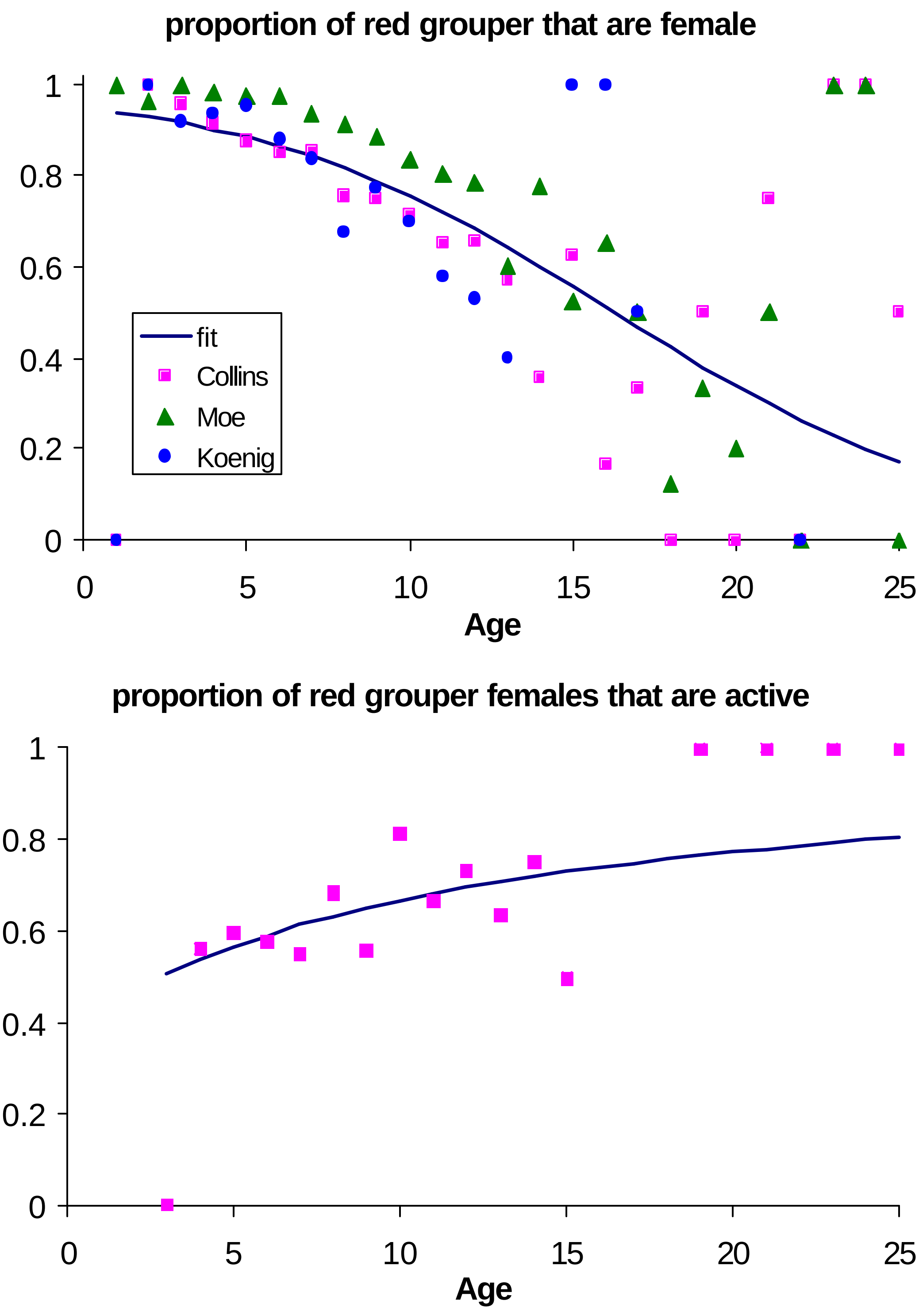


Figure 4. Top panel) Descending logistic curve fit to proportion of sampled red grouper identified as female. Bottom panel) Asymptotic curve fit to proportion of females identified as active. Data (weighted by sample size) were obtained from Moe (1969), Koenig (1993), and Collins et al. (2002) as indicated by the legend.

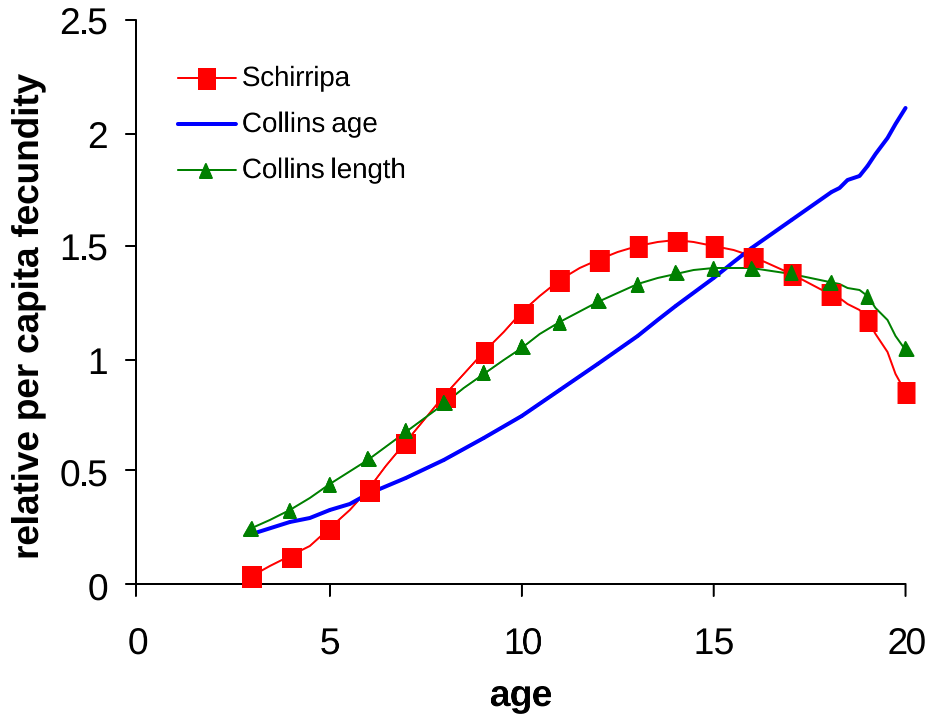


Figure 5. Comparison of relative fecundity at age derived by Schirripa *et al*. (1999) and for this assessment.

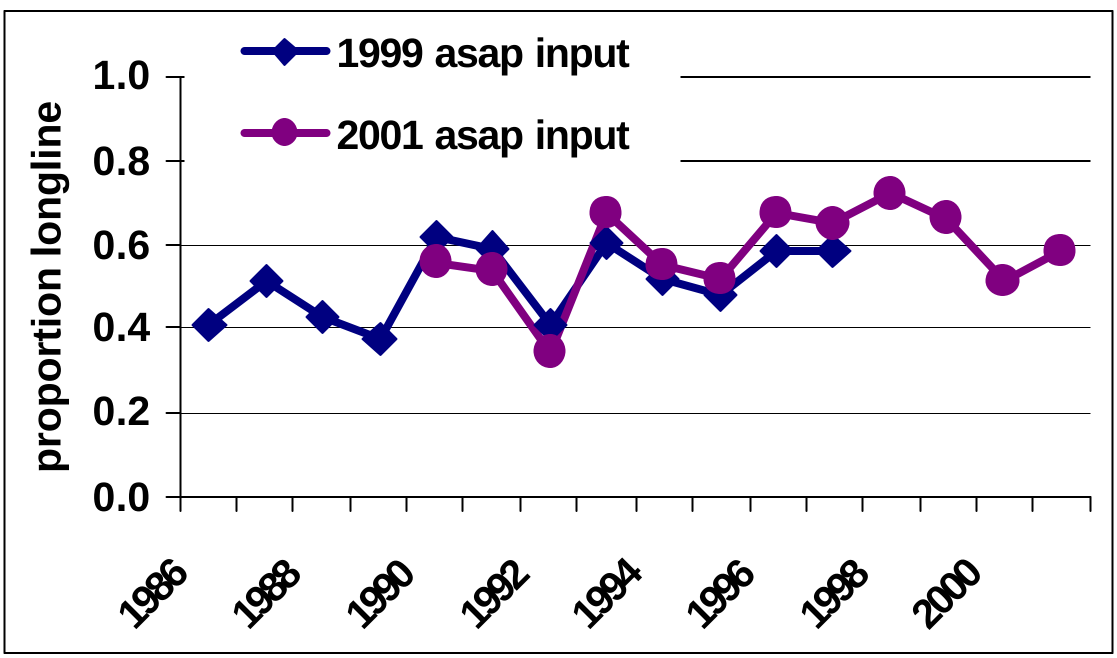


Figure 6. Proportions of longline in the commercial catch calculated from the 1999 input to ASAP and from reef fish log books (2001 input to ASAP).

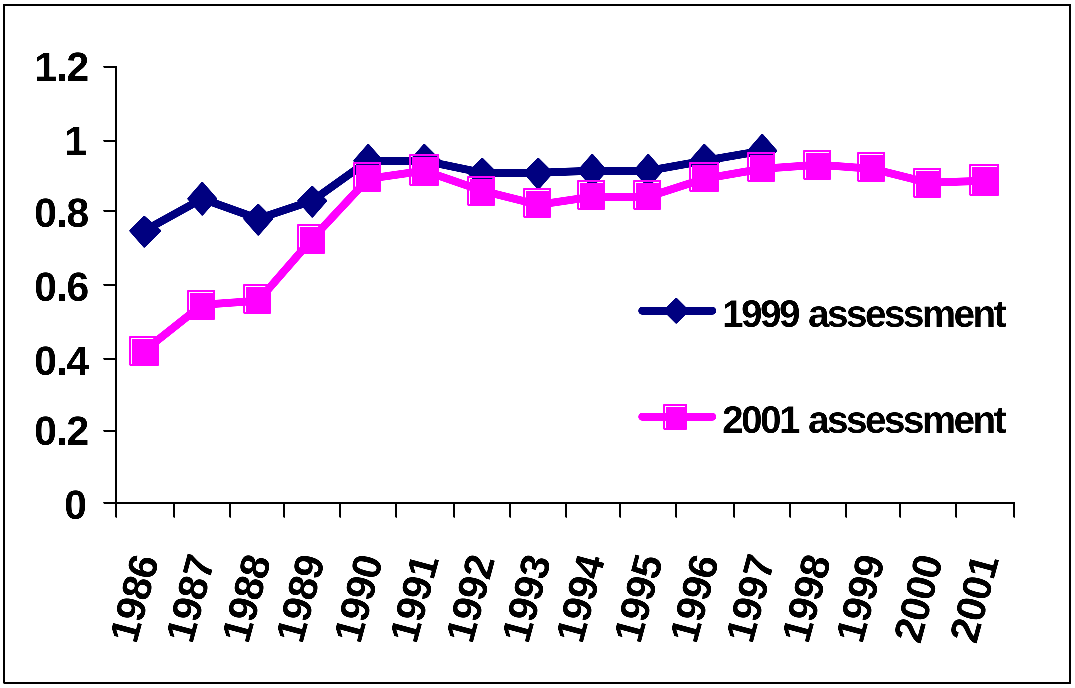


Figure 7. Proportions of MRFSS estimated catches which were released alive.

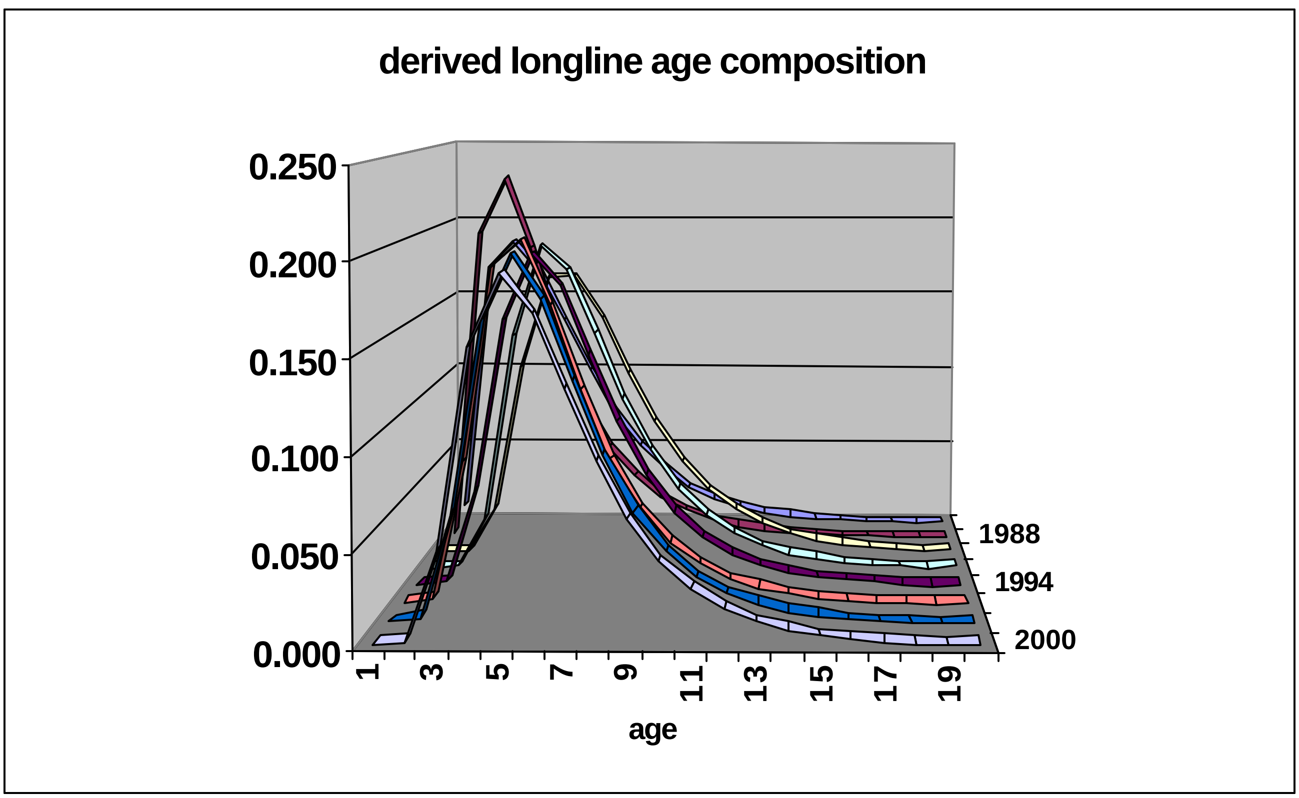
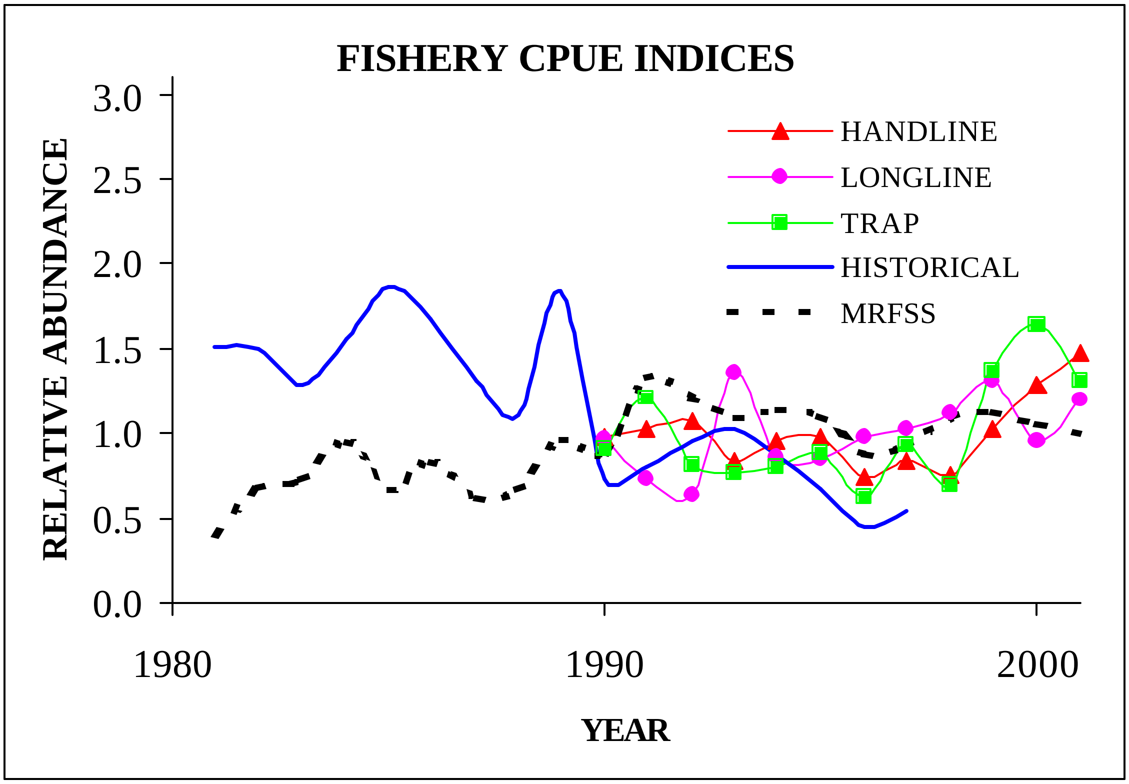


Figure 8. Relative derived age composition for even numbered years from 1986-2000.



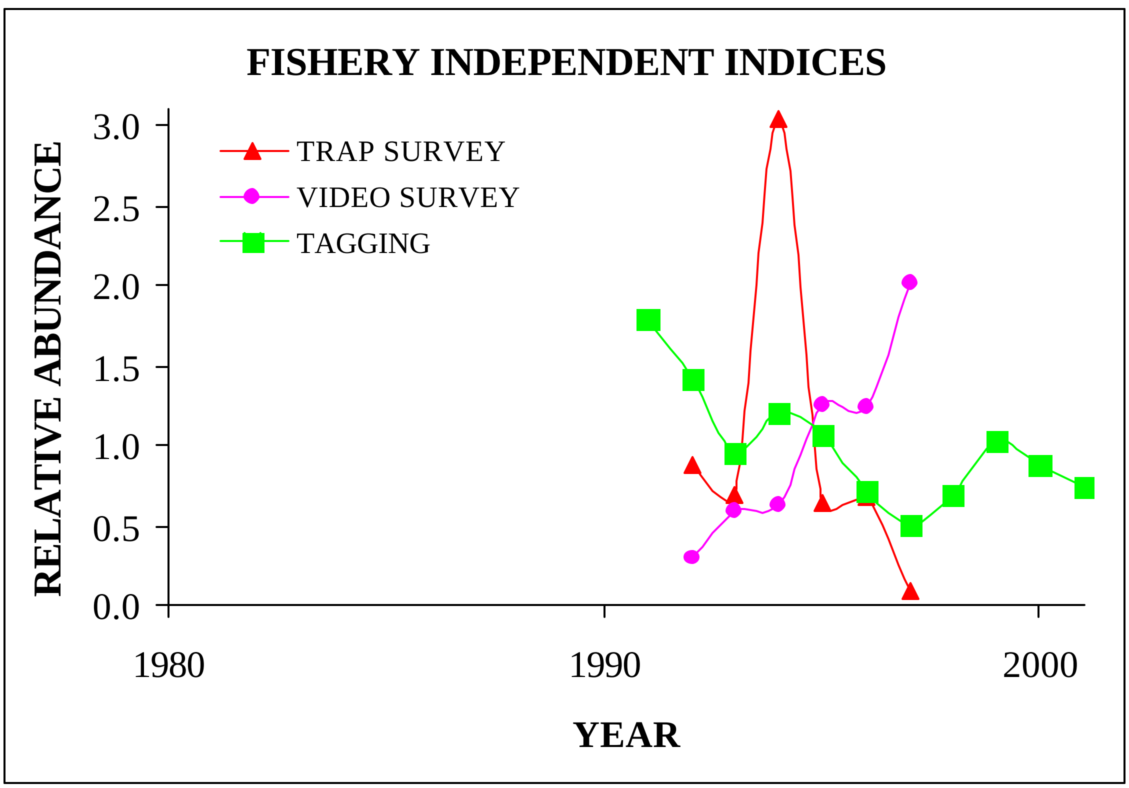


Figure 9. Indices of abundance used in the red grouper assessment.

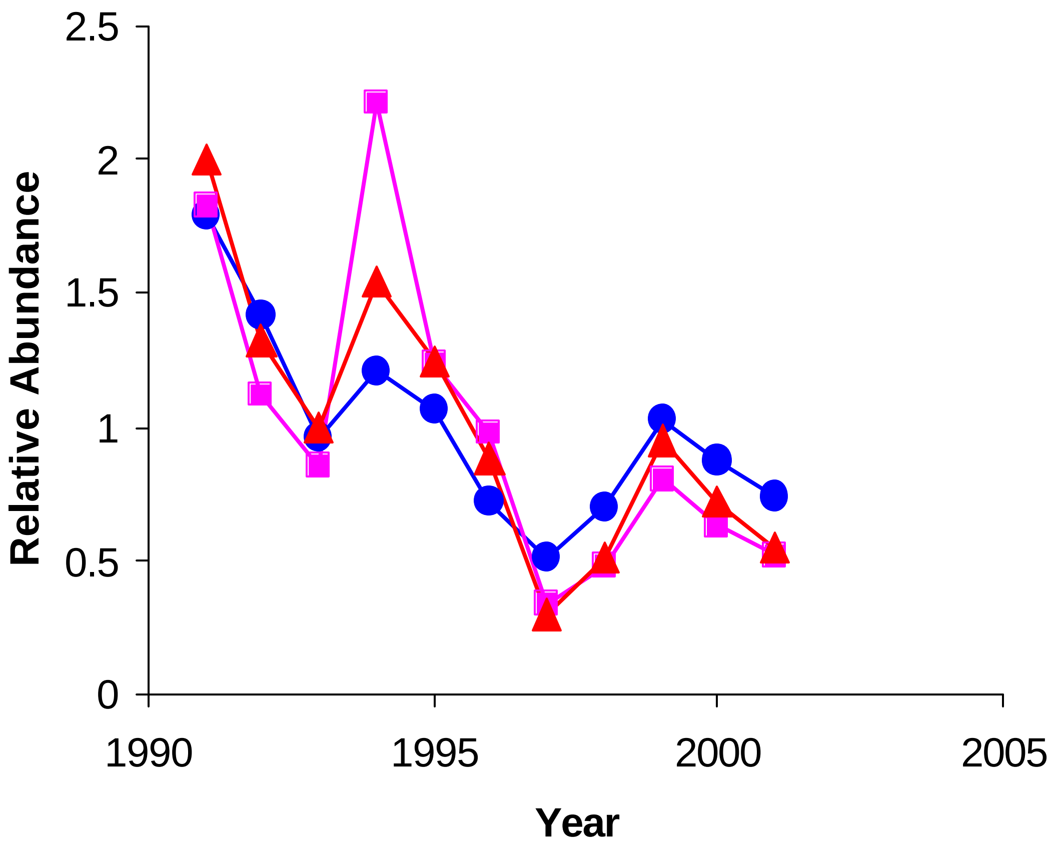


Figure 10. Relative indices of abundance derived from the Mote Marine Laboratory tagging data assuming no tag shedding and complete mixing (circles), high tag shedding rates of 0.8 yr^{-1} with complete mixing (squares) and no tag shedding with little mixing such that the F on the tagged population is 10 times higher than the F on the untagged population (triangles). The major difference is in 1994, where the estimates of total loss rate were lowest (hence the effect of subtracting out the high tag shedding rate is proportionately the greatest).

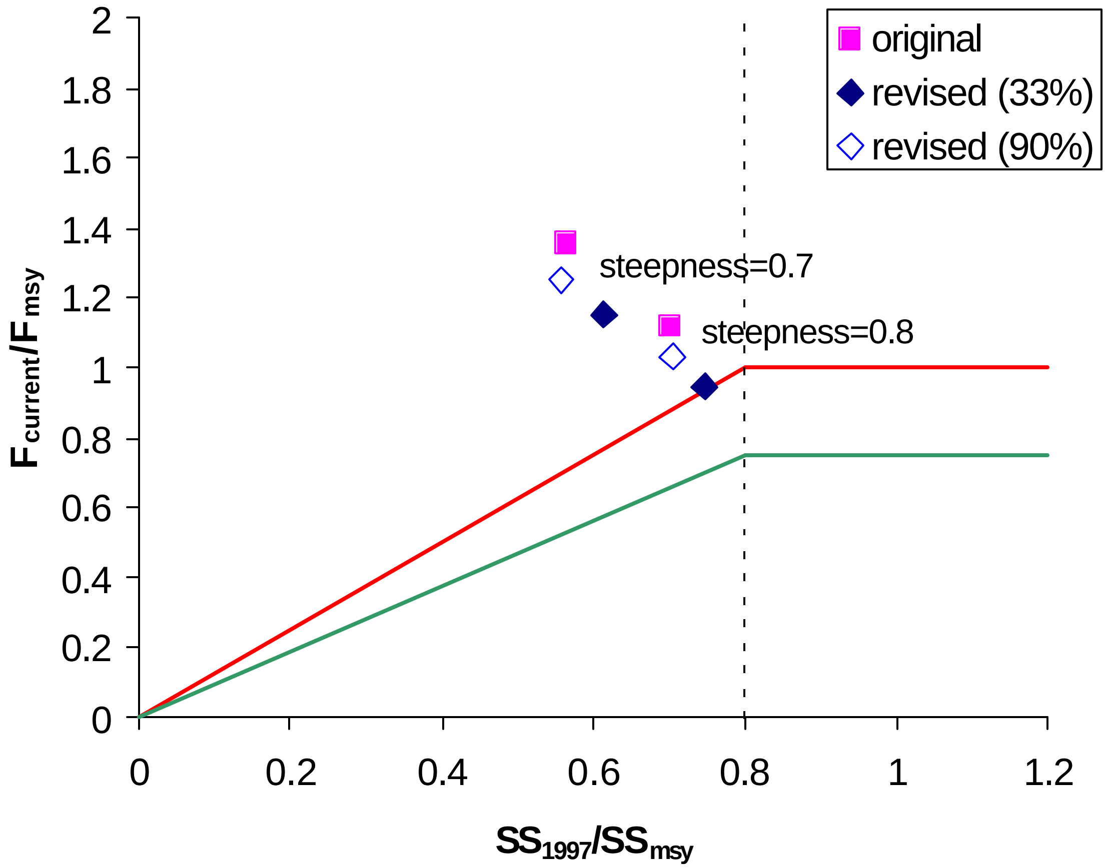


Figure 11. Control rule diagram contrasting the stock status estimates provided to the 2000 RFSAP (assuming 33% mortality of longline releases) with the corresponding estimates obtained using the revised catch/discard data (assuming either 33% or 90% mortality of longline releases). Lower solid line represents OY (where $F_{OY} = 0.75F_{MSY}$). The estimated fishing mortality rate for 1997 is used for $F_{current}$.

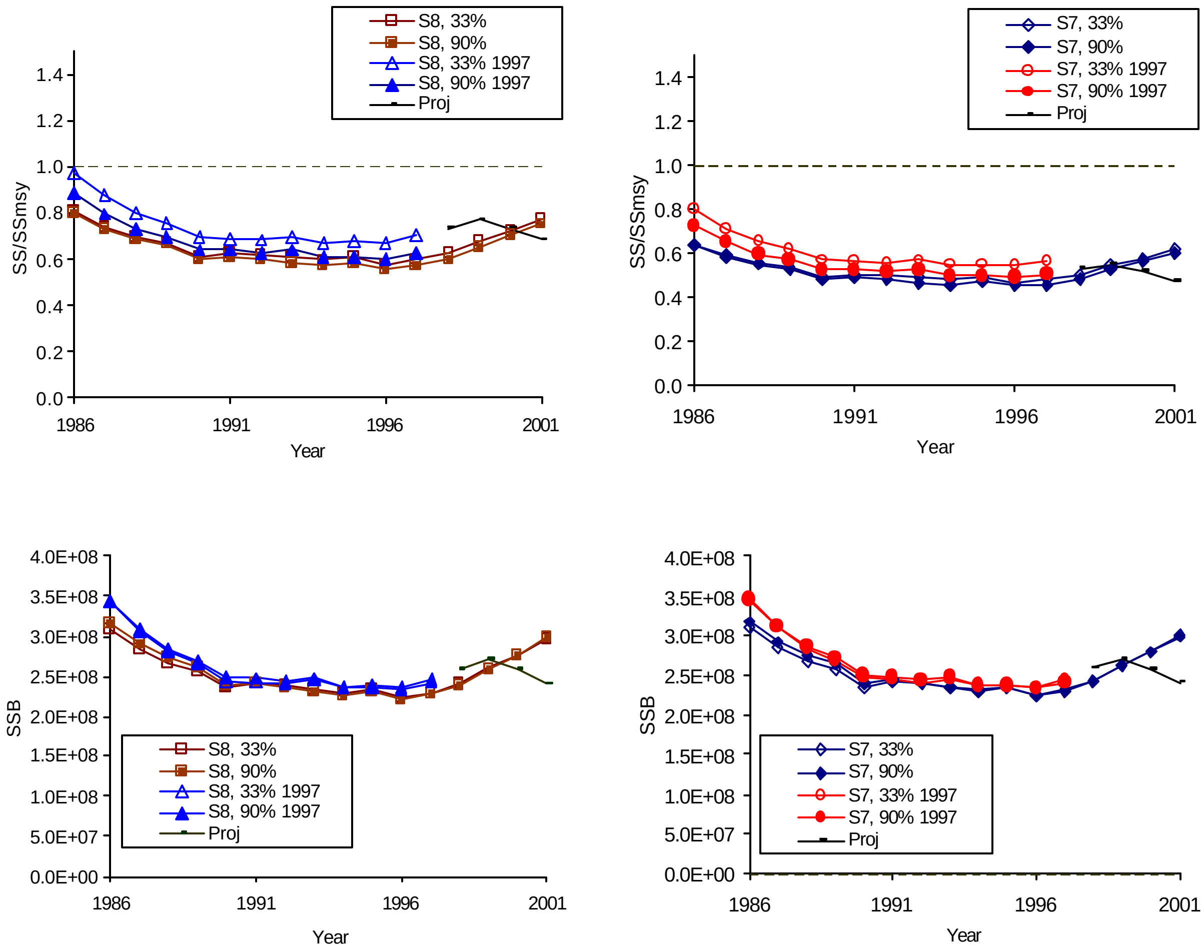


Figure 12. Comparison of time-series trajectory of estimated SS/SS_{MSY} (Upper) and SS (lower) across ASAP model formulations using the same model structure as applied by the RFSAP for the catch and effort data through 1997 (phase 1) and the catch-effort data through 2001 (phase 2). The line indicated as Proj represents the projected SSB from the 1999 assessment based on catch information alone. The 2 panels on the left represent steepness 0.8 while those on the right represent steepness values of 0.7

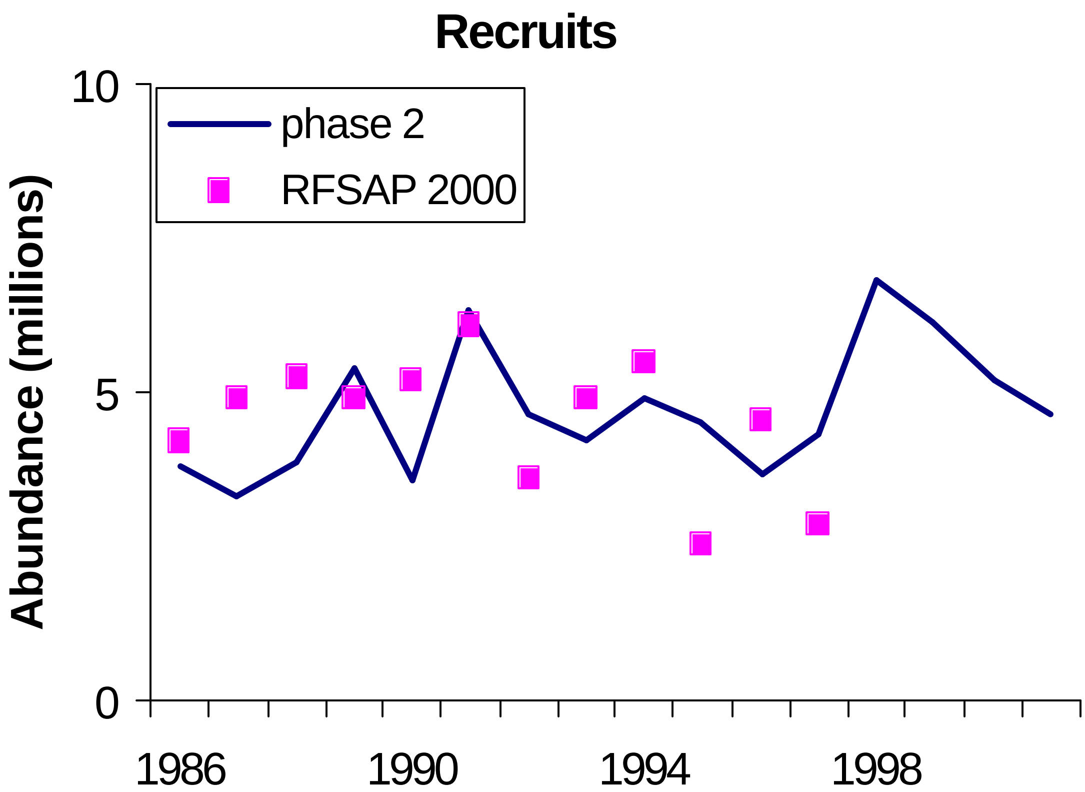


Figure 13. Estimates of annual recruitment (age 1) from the models used by RFSAP (2000) contrasted with the estimates from the phase 2 models presented here.

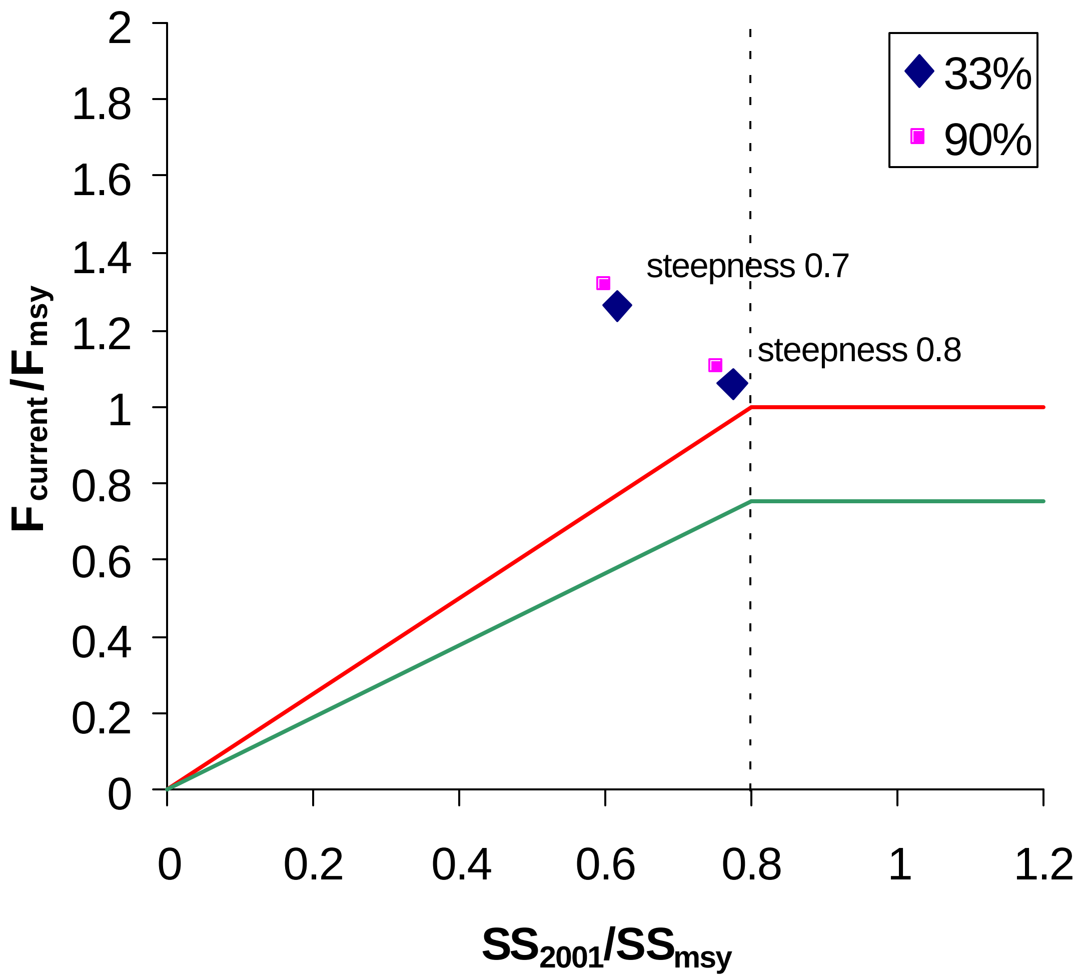
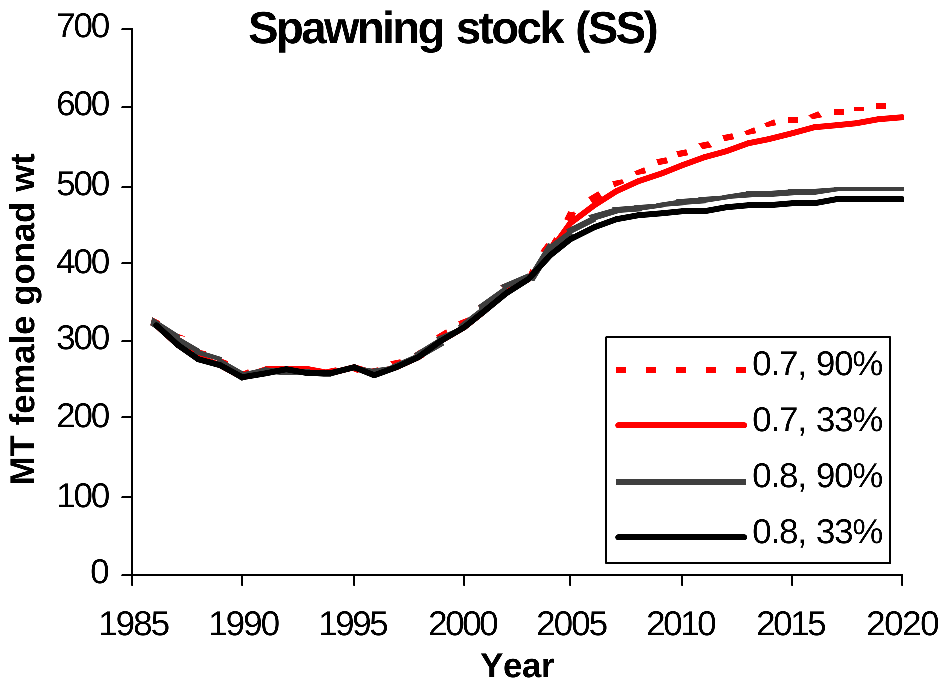


Figure 14. Control rule diagram contrasting the stock status estimates from phase 2 (data from 1986-2001, methods as in previous assessment) assuming either 33% or 90% mortality of longline releases. Lower solid line represents OY (where F_{OY}=0.75F_{MSY}). The estimated fishing mortality rate for 2001 is used for $F_{current}$.



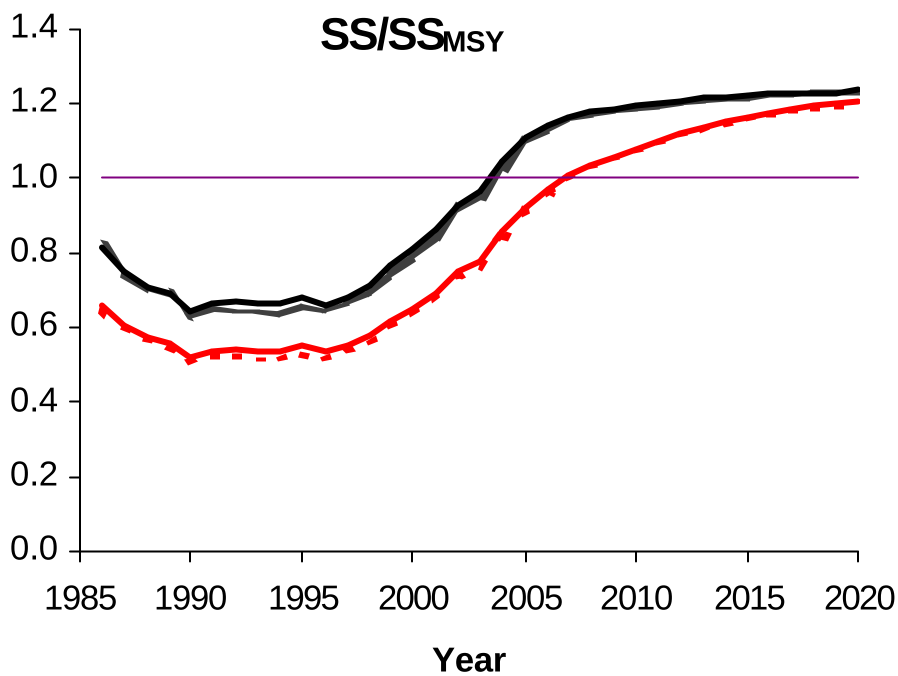


Figure 15. Spawning stock estimates from the four base runs of phase 3 (using directly aged samples of the catch) projected to the year 2020 at $F_{OY} = 0.75F_{MSY}$ levels.

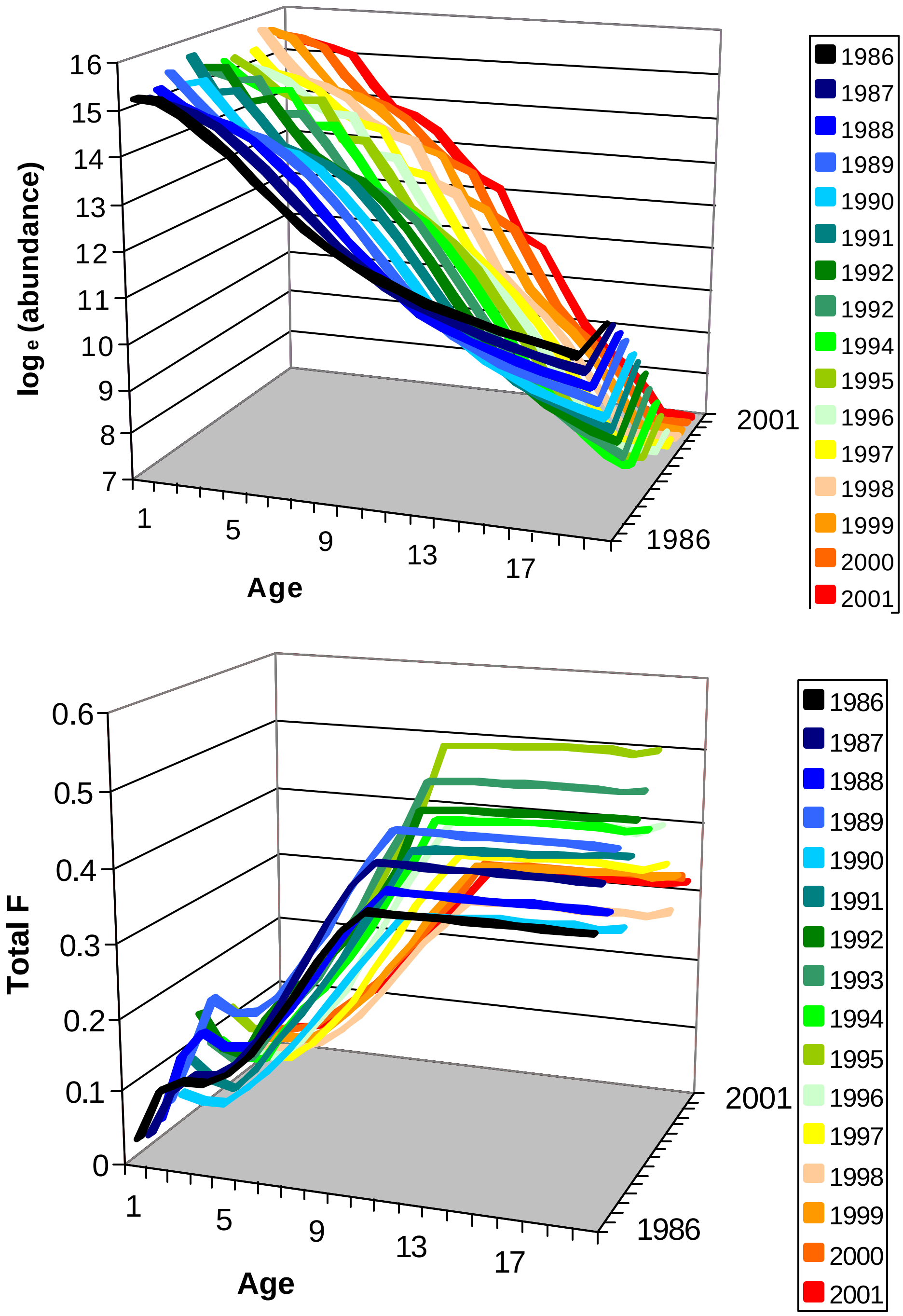


Figure 16. Estimates of abundance (log scale) and fishing mortality rate from phase 3 model with steepness=0.8 and longline release mortality = 33%.

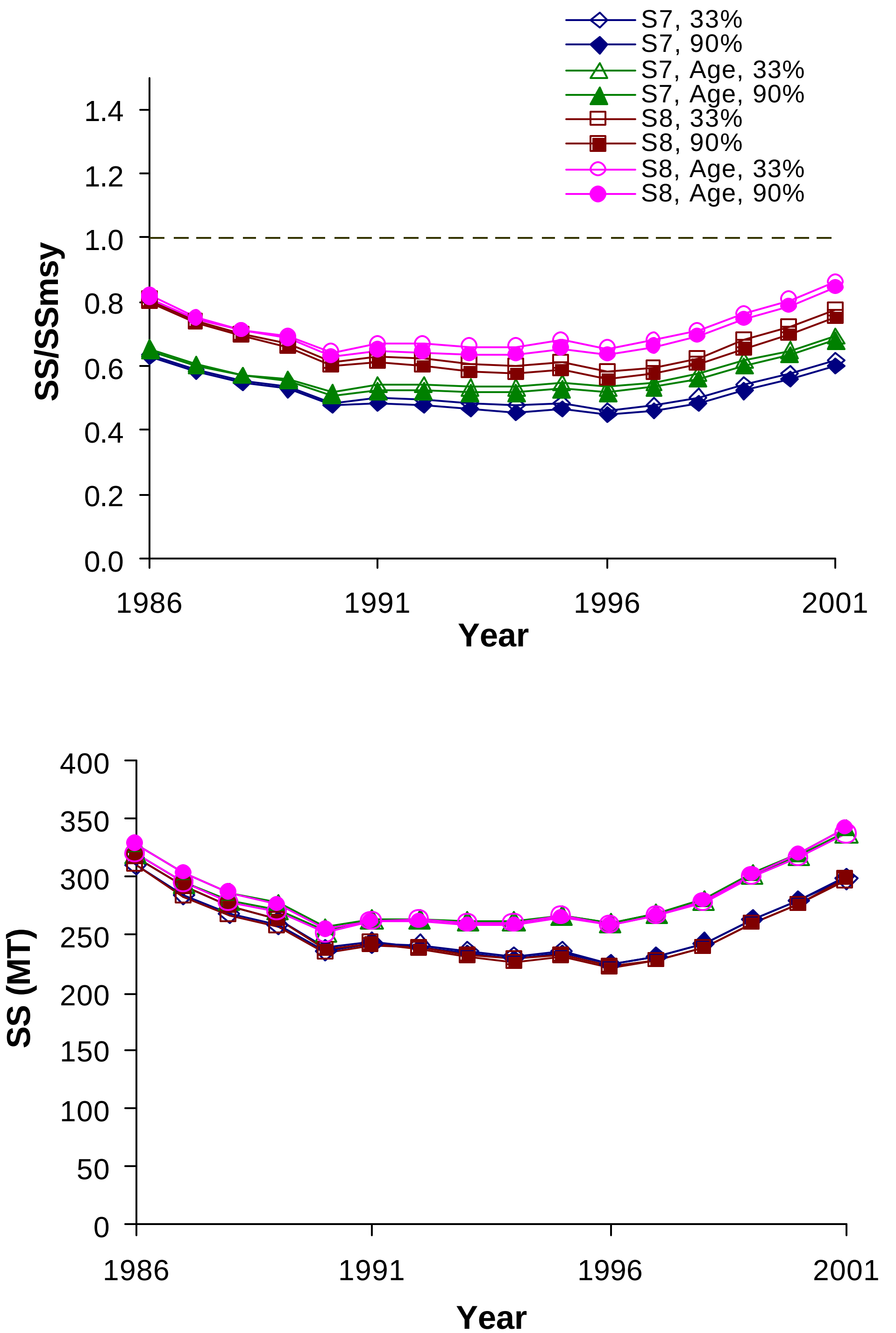


Figure 17. Comparison of time-series trajectory of estimated SS/Ssmsy (Upper) and SSB (lower) across ASAP model formulations using the same model structure as applied used by the RFSAP for the catch and effort data through 2001, with (phase 3) and without (phase 2) the direct age sample information in the model fit (the words 'age' in the legend indicate 'with direct age samples')..

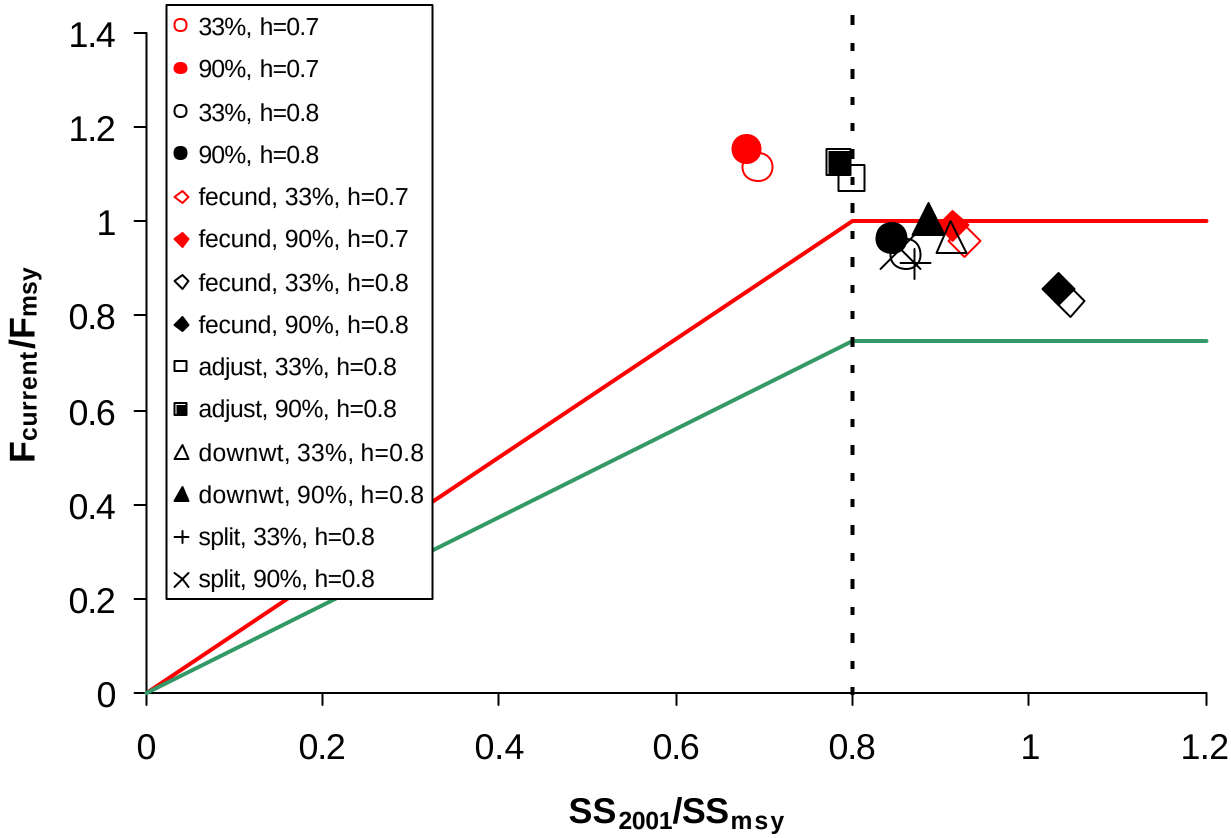


Figure 18. Control rule diagram contrasting the stock status estimates from phase 3 (data from 1986-2001, methods as in previous assessment plus sampled age composition) assuming either 33% or 90% mortality of longline releases. Lower solid line represents OY (where $F_{OY}=0.75F_{MSY}$). The estimated fishing mortality rate for 2001 is used for $F_{current}$.

ADDENDUM

The RFSAP (September 2002) reviewed the status of red grouper in the Gulf of Mexico using the September 6, 2002 version of this document and requested some additional information and some additional analyses. This addendum documents additional information and analyses provided to the RFSAP during and after the September 17-20 meeting in Miami.

Inputs

Estimated yield by sector is presented in Table A1.

The sampled age composition (from Lombardi *et al.* 2002) and the derived age composition (from catch, size composition and an ageing algorithm) are contrasted in Figure 1.

The weighting factors used in the ASAP runs are presented in Table A2. All but the weighting factors for the sampled age composition were the same as used for the runs for the RFSAP 2000 management advice unless otherwise noted in the text (some sensitivity runs). The sampled age composition was not available for the previous assessment, so those weighting factors were derived from as described in the main part of this report.

Assessment

The RFSAP (September, 2002) reviewed the results of the September 6, 2002 version of the above assessment and noted that they were most sensitive to the form of the fecundity at age vector. They agreed that it was reasonable to use the most recent information on age composition (Lombardi et al., 2002) and reproduction (Collins et al, 2002). However, concern was expressed regarding the most appropriate use of the new reproductive information. Accordingly, the RFSAP requested two additional sets of runs patterned after the base model described above but using either the batch fecundity at age relationship (FECvsAGE) discussed earlier or a new gonad weight at age relationship (GWTvsAGE) derived at the meeting (for details see Figures A2 and A3, Table A3). The release mortality for the longline fleet was assumed to be 33% and steepness was assumed to be either 0.7 or 0.8 (the RFSAP continues to believe there is little basis for deciding between the two steepness values).

The stock-status estimates obtained under the two alternative reproductive scenarios are compared to those of the original 'base' run in Figure A4 and Table A4. The base run, which used the FECvsTL vector, gave the most optimistic picture of stock status (not overfished and no overfishing regardless of steepness). The runs using the GWTvsAGE and FECvsAGE vectors were somewhat less optimistic, suggesting the stock was not overfished, but that overfishing was occurring (with steepness values of 0.7 or less). This result was somewhat unexpected inasmuch as the FECvsAGE vector ascribes relatively more productivity to age 15 and older animals than either of the competing fecundity vectors (see Figure 5) and it is the older animals which are estimated to have declined the most. However, even under virgin conditions only a small proportion of fish survive beyond age 15 where this divergence in relative fecundity estimates occurs, hence these older age groups contribute little to the overall fecundity of the stock (Figure A5). Instead, the assessment is most sensitive to the differences in the modeled fecundity of younger fish. A comparison of the four fecundity curves in Figure A3 reveals that the curves based on the new fecundity data (Collins et al., 2002) ascribe relatively greater productivity to ages 3-5 than the GWTvsTL curve derived by Schirripa et al. (1999). Of the new curves, the FECvsTL vector ascribes the most productivity to ages 3-5, which are the age groups that have declined the least, therefore it leads to the most optimistic outcome.

The RFSAP believed that, of the four vectors examined, the GWTvsAGE fecundity vector was the most appropriate. It was preferred over the original GWTvsTL vector derived by Schirripa et al. (1999) because it incorporated additional data (Collins et al, 2002) and avoided the possible inaccuracies that may occur when converting length to age via a growth curve. It was favored over the corresponding batch fecundity curves because there were a great deal more observations of gonad weight than batch fecundity, making the relationship with age better determined, and also to maintain some continuity with the method used in the last assessment. Accordingly, the RFSAP requested projections of the constant harvest and constant effort scenarios that would lead to recovery above SS_{MSY} by 2012. These are shown in Figures A6 and A7, respectively.

Finally, there was some discussion regarding the danger of defining control rules in terms of benchmarks such as

MSY that depend upon the relationship between fecundity and age when that relationship is not well known. Concern was expressed that information collected in the future may lead to a different perception of the relative fecundity of younger red grouper, which in turn might lead to a different perception of stock status and different management advice. It was pointed out that alternative benchmarks based on yield per recruit theory, such as $F_{0.1}$ and $SS_{F0.1}$, were less variable across model formulations than the MSY related statistics (see Tables 20 and A4). In the present case, an $F_{0.1}$-based control rule would suggest that the Gulf of Mexico red grouper stock is overfished and that overfishing is occurring regardless of the choice of fecundity vector (see Figure A8, Table A4). Nevertheless, the stock is estimated to recover to $SS_{F0.1}$ levels by 2012 if F is reduced to slightly less than $F_{0.1}$ (Figure A9).

Table A1. Red grouper landed (longline, handline+ and headboat) and harvested (charter and private+shore) yield. Handline+ indicates handline and other commercial gears exclusive of bottom and vertical longlines. Unless otherwise noted, data are in metric tons (mt). Headboat landings for 2000 and 2001 were estimated from recent years.

	headboat	charter	private+ shore	longline	handline+	total	
						mt	1000 lb
1986	57	142	866	1,202	1,735	4,003	8824
1987	45	83	444	1,601	1,529	3,701	8158
1988	48	108	975	956	1,264	3,351	7387
1989	65	86	980	1,289	2,156	4,577	10090
1990	54	206	373	1,225	972	2,830	6239
1991	29	34	727	1,254	1,075	3,120	6879
1992	26	151	1,153	663	1,267	3,260	7187
1993	37	82	875	1,960	943	3,897	8591
1994	27	108	753	1,237	1,004	3,129	6899
1995	45	260	684	1,128	1,036	3,152	6950
1996	40	81	307	1,364	665	2,458	5419
1997	16	78	196	1,434	783	2,507	5527
1998	19	85	233	1,302	502	2,141	4719
1999	25	73	422	1,783	918	3,220	7098
2000	29	91	646	1,346	1,290	3,402	7499
2001	29	123	450	1,546	1,094	3,242	7147

Table A2. Likelihood distributions and weighting factors (l) used in the present ASAP analyses. Values of l differ in some cases from those presented in Table 59 of Schirripa et al. (1999), however they are the same as the values used for the runs upon which the 2000 RFSAP based its advice. In the case of catch and discard at age proportions, the l's are effective sample sizes. In the case of other data types, they are effectively the reciprocal of the variance

Component	nobs	λ	distribution
Total catch in weight			
Commercial Longline	16	100.5	Lognormal
Commercial Other	16	100.5	Lognormal
Recreational	16	100.5	Lognormal
Total discards in weight			
Commercial Longline	16	25	Lognormal
Commercial Other	16	25	Lognormal
Recreational	16	25	Lognormal
Derived age composition of catch			
Commercial Longline	16x20	100	Multinomial
Commercial Other	16x20	200	Multinomial
Recreational	16x20	150	Multinomial
Derived age composition of discards			
Commercial Longline	16x20	25	Multinomial
Commercial Other	16x20	25	Multinomial
Recreational	16x20	100	Multinomial
Sampled age composition of catch			
Commercial Longline	10x20	annual values	Multinomial
Commercial Other	10x20	(see Table 4)	Multinomial
Recreational	10x20		Multinomial
Indices of abundance			
Trap	6		
Video	6	lognormal distributed with	
MRFSS	16		
Logbook - Handline	8	$l = 1/\log_e(1+CV^2)$	
Logbook - Longline	8		
Logbook - Trap	8	(annual values of *CV* shown	
Tagging	7	in Table 17)	
US Historical	16		
Catchability deviations			
Trap	6	10000	Lognormal
Video	6	10000	Lognormal
MRFSS	16	10000	Lognormal
Logbook - Handline	8	10000	Lognormal
Logbook - Longline	8	10000	Lognormal
Logbook - Trap	8	10000	Lognormal
Tagging	7	10000	Lognormal
US Historical	16	10000	Lognormal
Fmult deviations			
Commercial Longline	15	7	Lognormal
Commercial Other	15	11	Lognormal
Recreational	15	11	Lognormal
Selectivity deviations			
Commercial Longline	14	1000	Lognormal
Commercial Other	14	1000	Lognormal
Recreational	14	1000	Lognormal
N at age in year 1	19	4.48	Lognormal
Stock-recruitment fit	16	4.48	Lognormal
Recruitment deviations	16	8.96	Lognormal
Selectivity curvature over age	720	1000	Lognormal
Selectivity curvature over time	840	100.5	Lognormal

Table A3. Summary of reproductive parameters used to construct the GWTvsAGE vector derived during the September 2002 RFSAP meeting. Values for per capita fecundity of age 20 plus-group were computed by prorating the values for ages 20 to 30 assuming a total mortality rate of 0.4 yr^{-1} (as done by Schirripa et al. 1999). The per capita fecundity is the product of the proportion female and gonad weight (the RFSAP elected not to incorporate the percent activity estimates, believing that the use of gonad weight observations implicitly included to some degree a measure of activity). The relative per capita fecundity is the per capita fecundity scaled by the average over all ages.

Age	proportion female	gonad weight by age	relative per capita fecundity
1	0.940	0.000	0.000
2	0.929	0.000	0.000
3	0.916	27.130	0.148
4	0.901	44.574	0.239
5	0.884	65.513	0.344
6	0.864	89.740	0.461
7	0.842	117.092	0.585
8	0.816	147.439	0.715
9	0.788	180.674	0.845
10	0.756	216.704	0.973
11	0.721	255.449	1.094
12	0.683	296.840	1.205
13	0.643	340.813	1.302
14	0.601	387.314	1.382
15	0.557	436.290	1.443
16	0.512	487.696	1.483
17	0.467	541.488	1.501
18	0.423	597.628	1.499
19	0.379	656.079	1.477
20	0.338	716.807	***1.308***

*plus group

Table A4. Comparison of stock status estimates from phase 3 model (1986-2001data using methods of previous assessment plus sampled age composition, 33% mortality of longline releases) using each of the three new fecundity vectors. The quantities *MSY*, *OY* (F_{OY}=0.75F_{MSY}), and $C_{recover}$ (catch expected to permit recovery to SS_{MSY} by 2012) are in MT gutted weight. Spawning stock *SS* in the case of the GWTvsAGE model is in MT gonad weight, otherwise its is dimensionless (relative fecundity).

	FECvsTL		FECvsAGE		GWTvsAGE	
	h=0.7	h=0.8	h=0.7	h=0.8	h=0.7	h=0.8
MSY	3374	3281	3381	3276	3429	3295
OY	3301	3217	3308	3212	3350	3229
OY/MSY	0.978	0.981	0.978	0.981	0.977	0.980
$F_{0.1}$	0.238	0.238	0.238	0.238	0.238	0.238
F_{max}	0.476	0.476	0.476	0.476	0.476	0.476
$F_{30\%}$	0.702	0.703	0.581	0.581	0.563	0.563
$F_{40\%}$	0.437	0.437	0.343	0.344	0.354	0.354
F_{MSY}	0.329	0.382	0.312	0.371	0.306	0.364
F_{OY}	0.247	0.286	0.234	0.278	0.229	0.273
F_{OY}/F_{MSY}	0.750	0.750	0.750	0.750	0.750	0.750
F_{2001}	0.316	0.317	0.315	0.317	0.315	0.316
F_{2001}/F_{MSY}	0.961	0.829	1.012	0.853	1.031	0.869
F_{2001}/F_{OY}	1.281	1.105	1.350	1.137	1.374	1.159
$F_{2001}/F_{0.1}$	1.329	1.332	1.328	1.332	1.327	1.331
SS_{MSY}	5746	5086	4585	3973	840	715
SS_{OY}	6816	5998	5482	4704	1015	859
$SS_{F0.1}$	6953	6595	5430	5121	993	930
SS_{OY}/SS_{MSY}	1.186	1.179	1.196	1.184	1.208	1.201
SS_{2001}	5327	5321	4150	4146	705	704
SS_{2001}/SS_{MSY}	0.927	1.046	0.905	1.043	0.840	0.985
SS_{2001}/SS_{OY}	0.782	0.887	0.757	0.881	0.695	0.820
$SS_{2001}/SS_{F0.1}$	0.766	0.807	0.764	0.810	0.710	0.758
T_{min}	2004	2001	2004	2001	2004	2002
$C_{recover}$	3301	3217	3230	3212	3190	3229

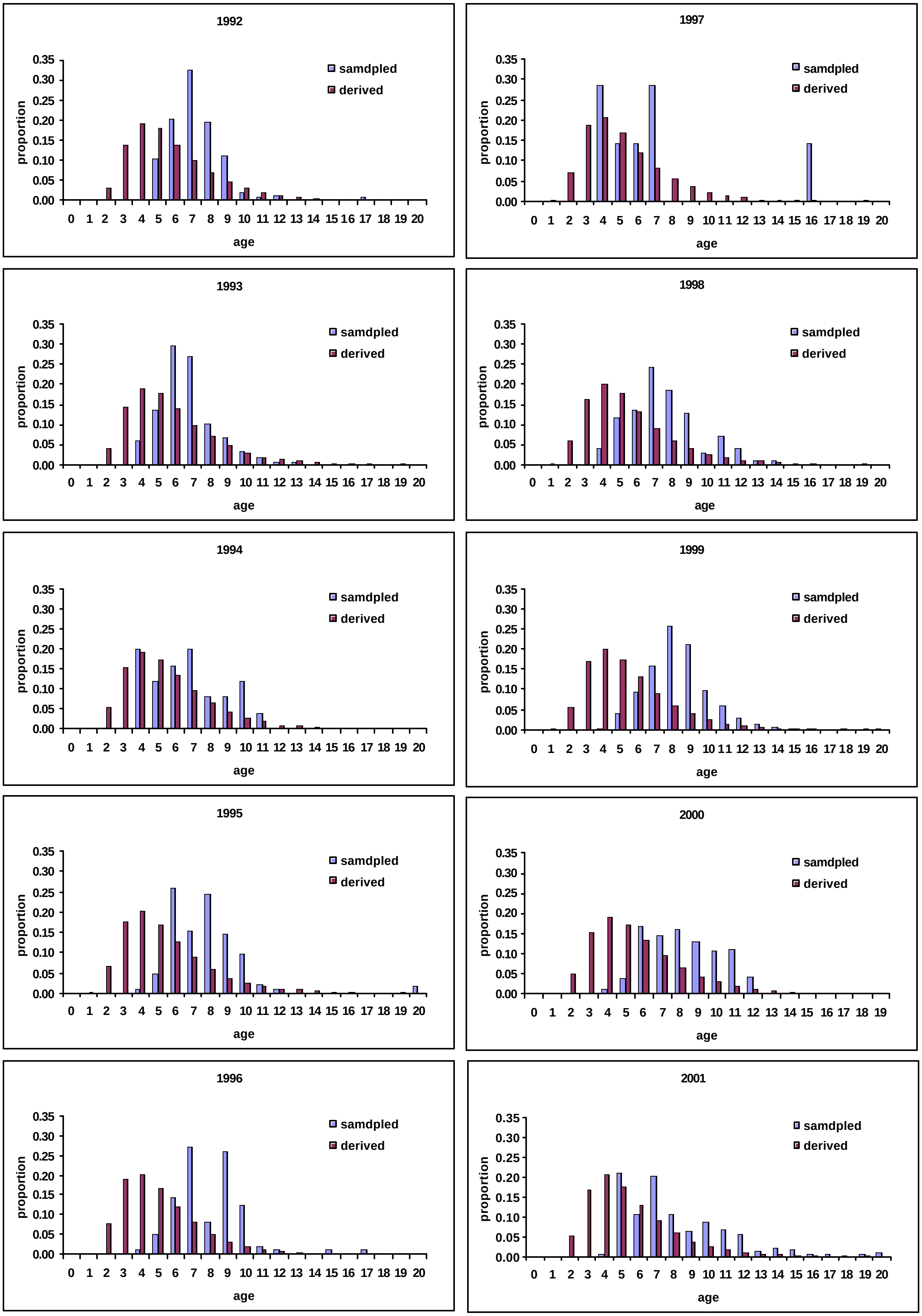


Figure A1. Comparison of sampled (left bar in each age) and derived age composition for red grouper caught by longline. The sampled age composition is weighted to account for geographic differences in the geographic distribution of the samples and longline catches.

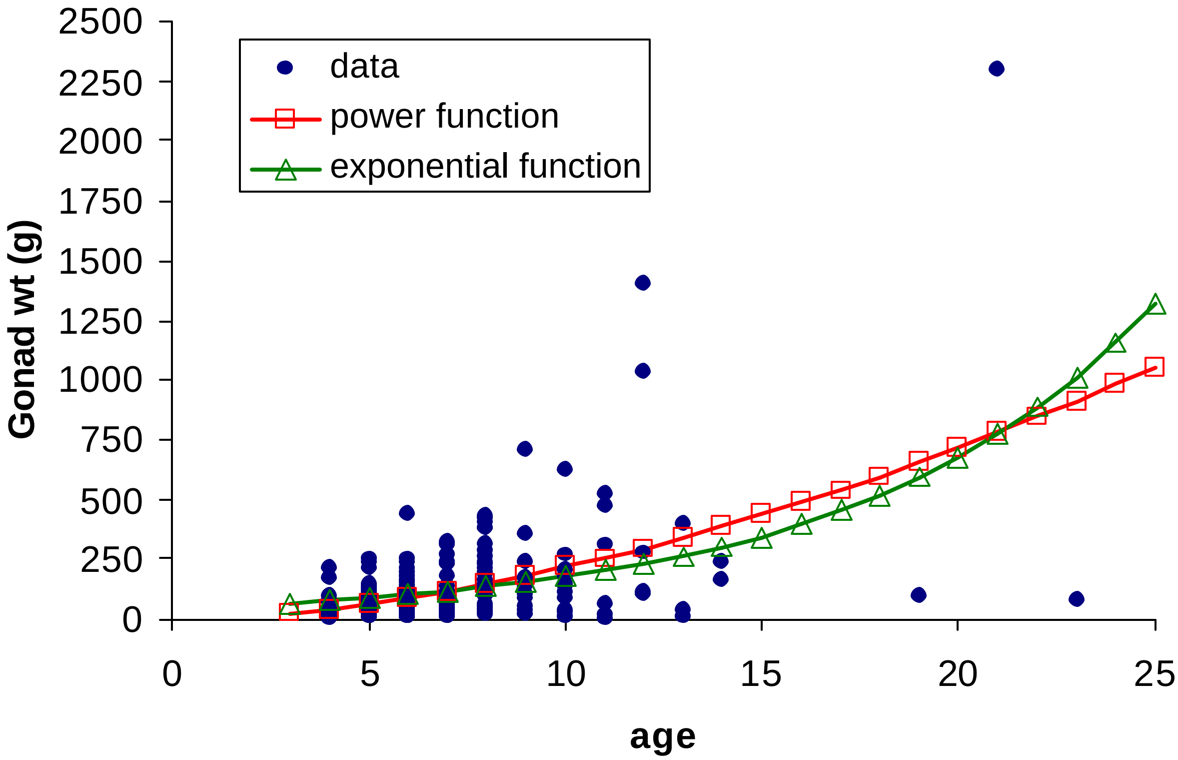


Figure A2. Least-squares fits of the power function (GWT = 4.0739age$^{1.7259}$) and exponential function (46.130$e^{0.13425age}$) to gonad weight at age data collected by Collins et al (2002). The power function gave the best fit (lowest residual sum of squares). Only gonad weights of active females (vitellogenic or hydrated ova present, but excluding spent ovaries) sampled during the peak spawning months (March, April and May) were used. This is essentially an update of the data from the previous assessment (Schirripa and Legault 1999, Figure 8), but instead the curve fit is based only on those females whose ages were determined directly (Lombardi-Carlson et al. 2002) rather than estimated from length by use of a growth curve.

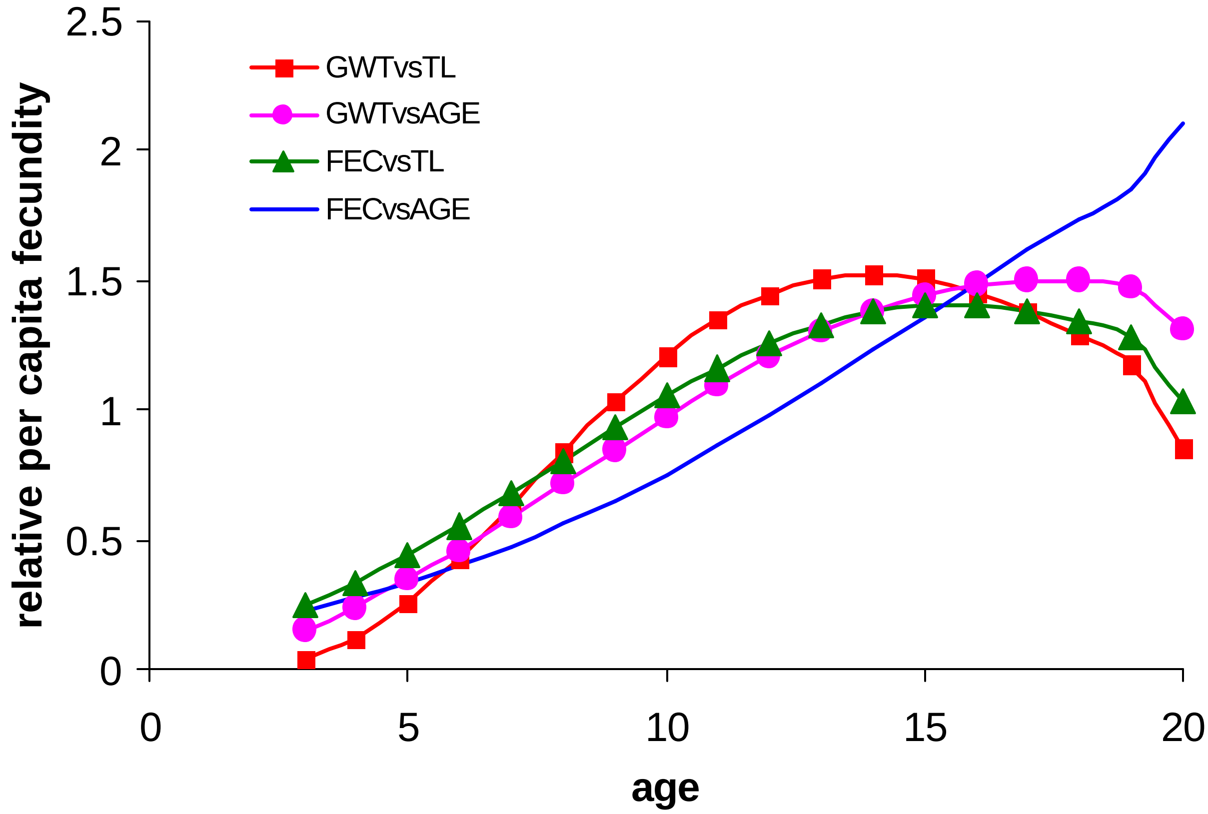


Figure A3. Comparison of the four measures of per capita fecundity on a relative scale. Note that the vectors based on gonad weight do not include estimates of the percent of females active in any given spawning year (the RFSAP felt that percent activity was, to some degree, implicitly accounted for in that gonad weight would be lower for inactive females).

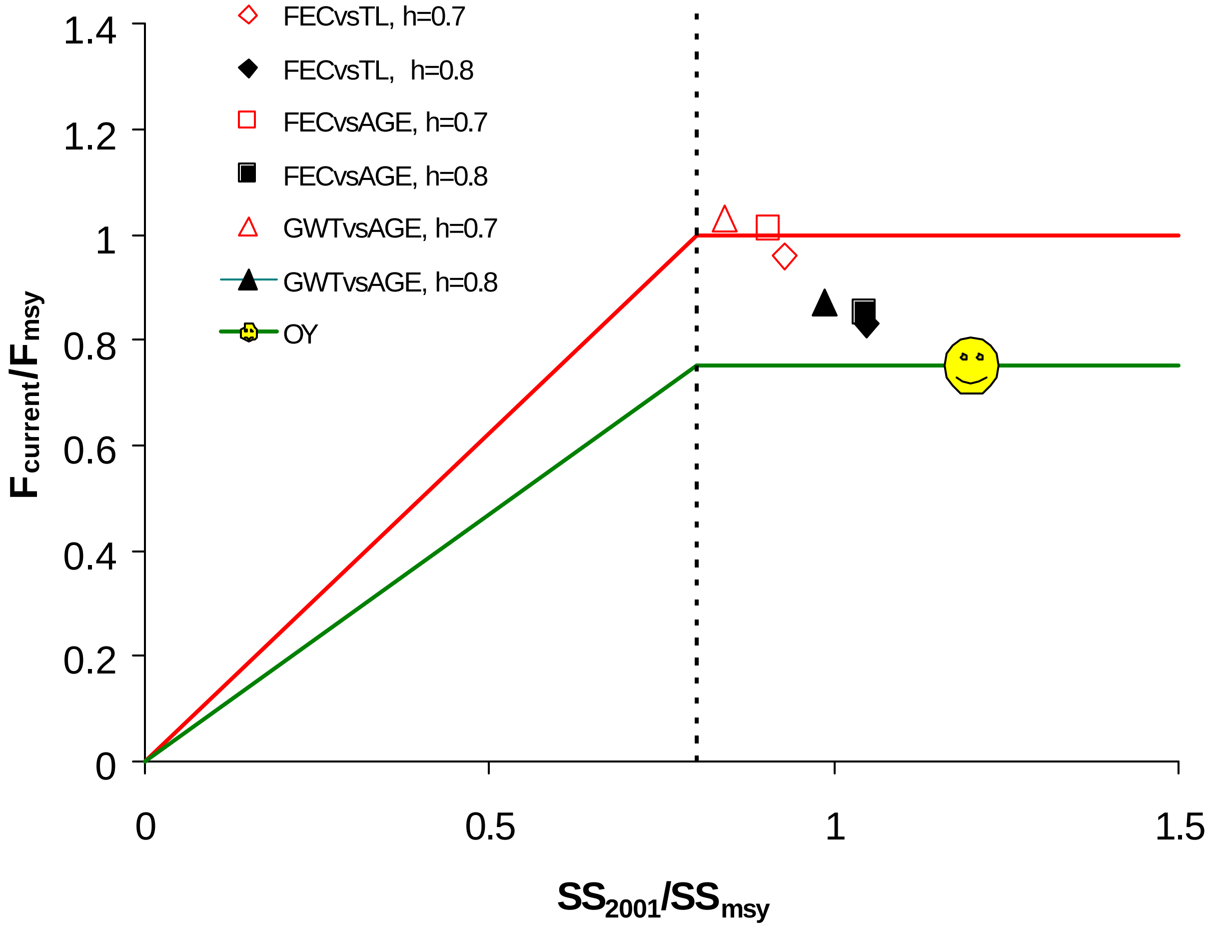


Figure A4. Control rule diagram contrasting the stock status estimates from the runs requested by the 2002 RFSAP. Lower solid line represents control rule for management based on an OY target (point marked by the 'happy face'). $F_{current}$ is the apical (fully-selected) fishing mortality rate in 2001. Vertical dashed line represents the minimum stock size threshold (0.8).

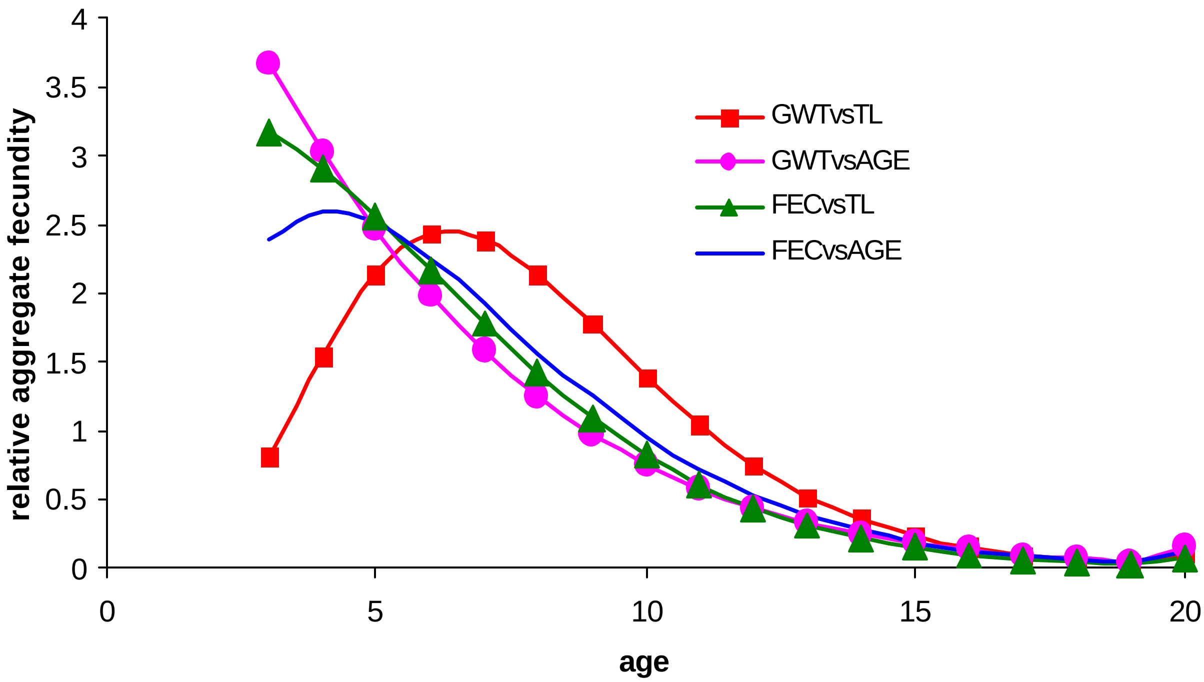


Figure A5. Relative fecundity of each age class under virgin condition assuming a natural mortality rate of 0.2 yr^{-1} (this is the product of the per capita fecundity at age and the relative abundance of each age class, normalized to average a value of 1.0).

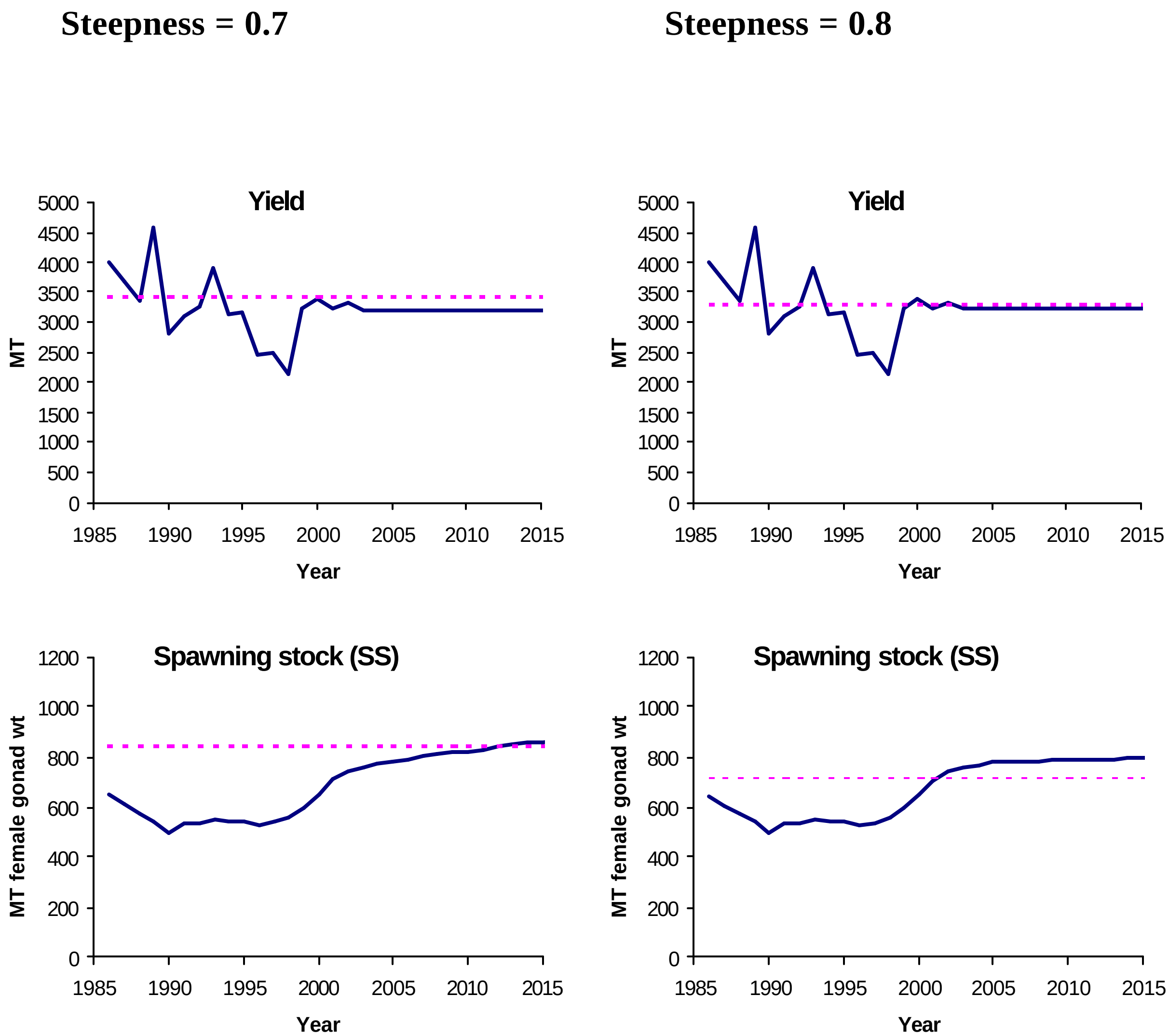


Figure A6. Projections of landings and aggregate fecundity (spawning stock) under the constant level of landings that will permit recovery to SS_{MSY} by 2012 assuming fecundity at age follows the GWTvsAGE vector. In the case where steepness = 0.7, $C_{recover}$ = 3190 mt (gutted weight). However, if steepness = 0.8 the stock is estimated to recover even if C > MSY, therefore a projection with $C_{recover}$ set to OY (= 3229 mt) is shown instead. Dashed lines represent equilibrium yield (landings) and spawning stock corresponding to F_{MSY}. All projections assumes the landings in 2002 are equal to the average from 2000 and 2001, future selectivity = estimated selectivity for 2001, and future recruitment is a deterministic Beverton and Holt function of projected spawning stock.

Steepness = 0.7 **Steepness = 0.8**

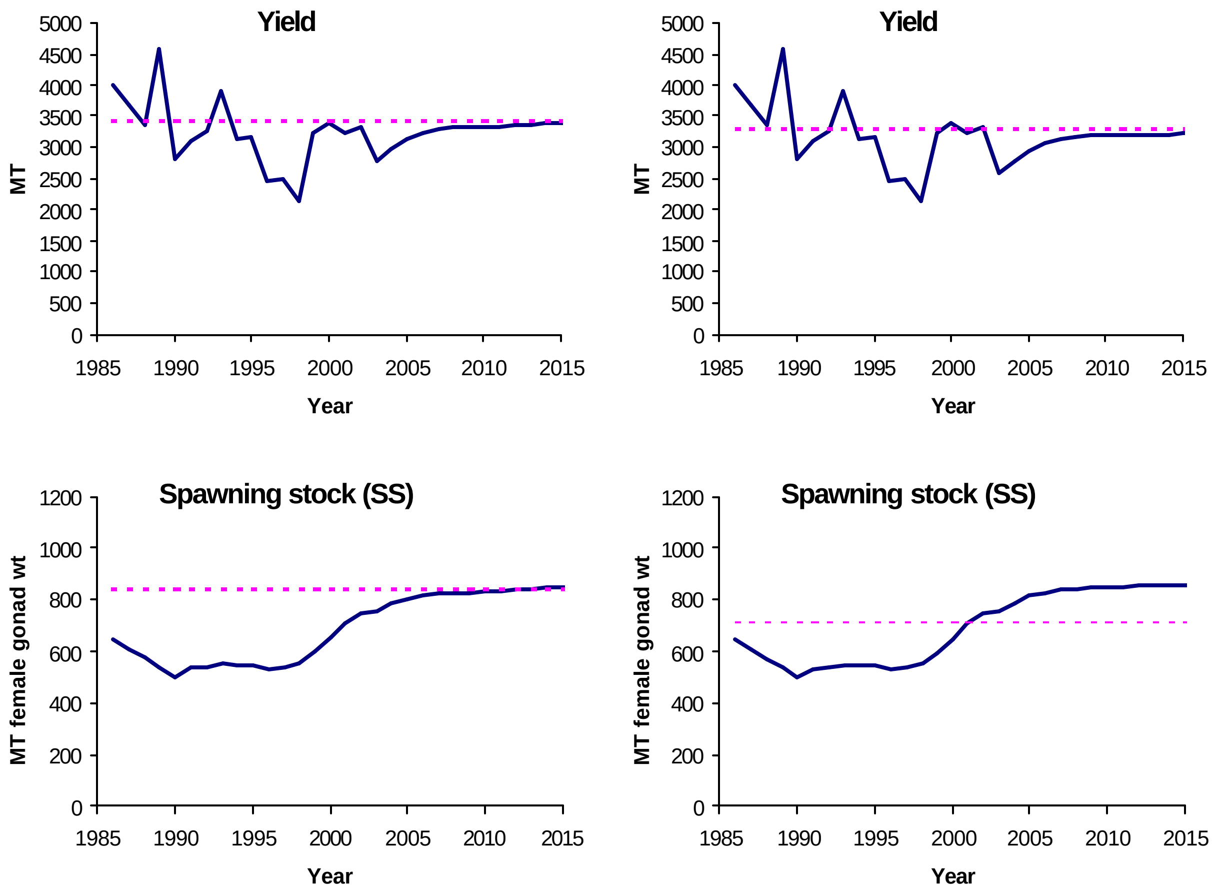


Figure A7. Projections of landings and aggregate fecundity (spawning stock) under the constant level of fishing mortality rate that permits recovery to SS_{MSY} by 2012 assuming fecundity at age follows the GWTvsAGE vector. In the case where steepness = 0.7, $F_{recover}$ = 0.298. However, if steepness = 0.8 the stock is estimated to recover even if $F > F_{MSY}$, therefore a projection with $F_{recover}$ set to F_{OY} (= 0.273) is shown instead. Dashed lines represent equilibrium yield (landings in gutted weight) and spawning stock corresponding to F_{MSY}. All projections assume the landings in 2002 are equal to the average from 2000 and 2001, future selectivity = estimated selectivity for 2001, and future recruitment is a deterministic Beverton and Holt function of projected spawning stock.

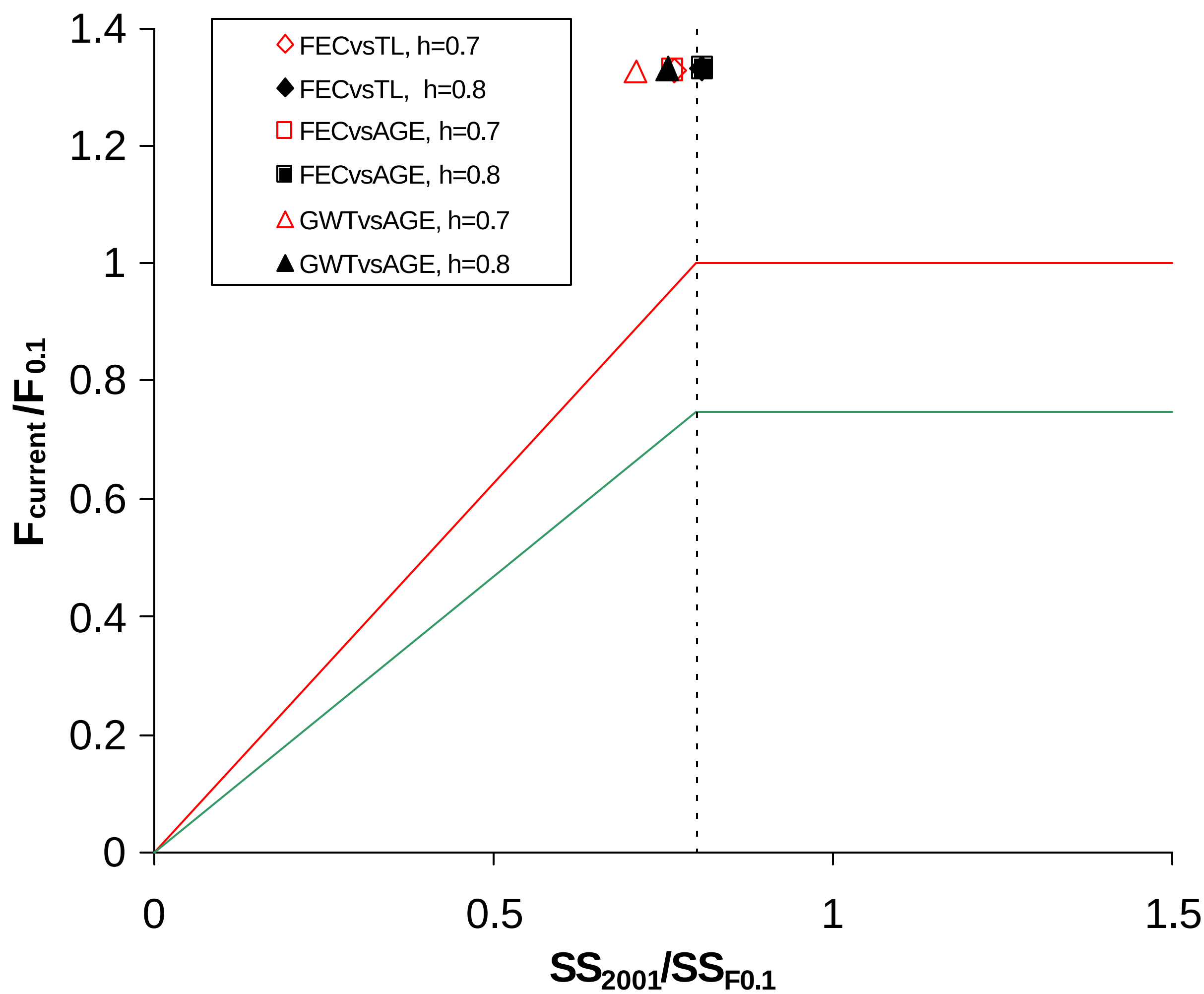


Figure A8. Control rule diagram expressed in terms of $F_{0.1}$ benchmarks. Lower line would represent $F_{OY} = 0.75F_{0.1}$. $F_{current}$ is the apical (fully-selected) fishing mortality rate in 2001. Vertical dashed line is the minimum stock size threshold (0.8).

Steepness = 0.7 **Steepness = 0.8**

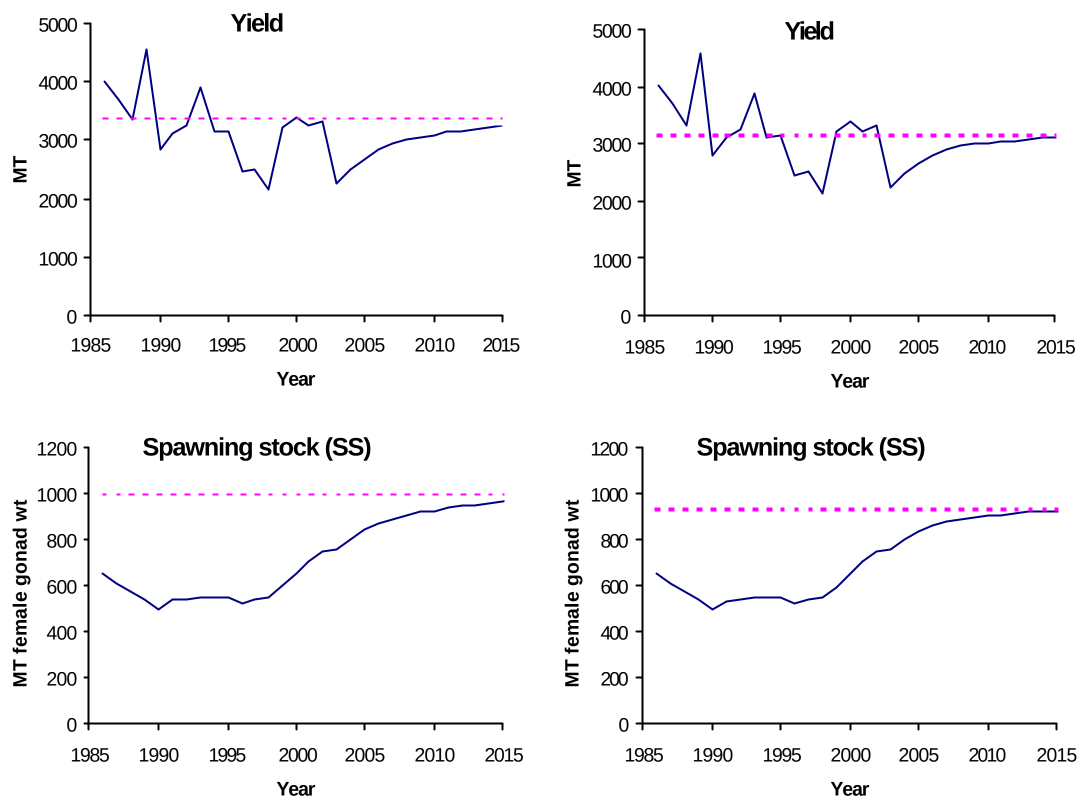


Figure A9. Projections of landings and aggregate fecundity (spawning stock) under a constant level of fishing mortality rate equal to $F_{0.1}$ (0.238 yr^{-1}) assuming fecundity at age follows the GWTvsAGE vector. Dashed lines represent equilibrium yield (landings in gutted weight) and spawning stock corresponding to $F_{0.1}$. All projections assume the landings in 2002 are equal to the average from 2000 and 2001, future selectivity = estimated selectivity for 2001, and future recruitment is a deterministic Beverton and Holt function of projected spawning stock