Final Model for Gulf of Mexico Gag Grouper as Recommended by the SEDAR Grouper Review Panel: Revised results and projections

Southeast Fishery Science Center

SEDAR33-RD08

13 March 2013

Please cite as:

Southeast Fisheries Science Center. 2007. Final Model for Gulf of Mexico Gag Grouper as Recommended by the SEDAR Grouper Review Panel: Revised results and projections. SEDAR33-RD08. SEDAR, North Charleston, SC. 36 pp.

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September 5, 2007

The SEDAR-12 Grouper Review Panel (RP) that met May 8-10, 2007 in St. Petersburg, FL, recommended additional analyses for the stock of gag grouper in the Gulf of Mexico. Briefly, the RP concluded that minimum size restrictions are the primary reason recreational anglers discard gag grouper and that the assumed size distribution of these discards should reflect this. They also concluded that the spatial distribution of the size-at-depth information used previously for the recreational fishery was not representative of the distribution of the fishery as a whole (coming mostly from the Florida Panhandle where deeper waters are closer to shore). In contrast, the MRFSS B2 estimates indicate a high proportion of the recreational fishery takes place in state waters (inside 10 miles) off peninsular Florida, where the average depth is on the order of 10 meters. Thus, the original depth-at-size matrix was likely biased. Therefore, the RP recommended instead partitioning discards (B2 MRFSS/Headboat) by regions (< 10 miles or > 10 miles) and assigning average depths to each of these regions based on examination of depth contour plots and consultations with fishermen. The RP also requested sensitivity analyses regarding the age range used to scale the Lorenzen's natural mortality at age curve.

The results from the runs based on the RP recommendations were summarized in an earlier document (dated July 12, 2007) entitled "Status of Gulf of Mexico Gag Grouper: Results and Projected Implications of the Revision and Sensitivity Runs Suggested by the Grouper Review Panel". Given this information, the Gulf of Mexico Fishery Management Councils SSC recommended basing management advice on the run where the Lorenzen curve was scaled such that the cumulative natural mortality on the "fully recruited" age classes (in this case Ages 3 and older) was equal to that of the constant natural rate obtained via the Hoenig regression on maximum age. Subsequently, however, it was found that the estimates of recreational dead discards used in the model were incorrect, due to an error in the conversion of dead discard weight estimates from kilograms to pounds. In effect, this caused the model to underestimate the number of discarded gag by a factor of about two.

This report constitutes a revision of the aforementioned document. It presents the updated model results after correcting the recreational discards. In this regard, it should also be noted that the "final" run highlighted in this report uses the Lorenzen natural mortality curve that was scaled over ages 3 and older; whereas in the earlier document, the "final" run used the Lorenzen curve that was scaled over all ages (0 and older).

Review of catch and effort input data

The following is a brief explanation of the data inputs and modifications for the current CASAL Gag GOM model evaluation.

Commercial landings

Commercial landings were available since 1963. All commercial landings were converted to gutted weight, and partitioned into the following fisheries: commercial longline (1979-2004), commercial handline (1963-2004), and "other commercial fisheries" (1963-2004). The last category included: landings from trawls, traps, spear fishing, and "unclassified" from several years. The handline fishery also groups several gears (electric reels, hand reels, handlines and commercial rod and reel). Commercial landings also reflected the conversion of black grouper landings to gag grouper due to miss-identification problems, particularly for the North Gulf of Mexico (see SEDAR-10 Data Workshop report for further details).

The SEDAR-10 Data Workshop (DW) group recommended extending the historical landing series as far back as possible, following the protocol(s) for reconstructing commercial catch trends of red snapper. The earliest estimated Gag Gulf catches are from 1880; however, the SEDAR-10 assessment workshop (AW), the review workshop (RW) and the Grouper Review Panel (RP) recommended using the commercial catch series starting in 1963 owing to the lack of information on the water body of capture prior to that time (i.e., the inability to distinguish landings of fish that were originally caught in Mexico waters). Table 1 shows the 'final' working estimates of commercial catch; there were no modifications in the commercial catch series proposed by the RP. [See text in SEDAR10-AW report for further details in the procedures for estimation of historical commercial catch.]

Commercial Discards

A preliminary report of commercial discards was presented at the SEDAR10-DW, from logbooks submitted by fisherman (McCarthy 2006). The Catch group concluded that those estimates were limited and of few years/vessels, and recommended not to use them for estimating commercial discards. The DW concluded that commercial discards are exclusively due to minimum size regulations, which started in 1990 in Federal waters. Thus, it was assumed that commercial fisheries did not discard Gag grouper prior to 1990, and after that discarded only fish below the legal size limit. The size distribution of discarded fish was estimated from the cumulative size frequency distribution observed for the respective commercial sectors (handline, longline, other) during 1984-1989 up to the corresponding minimum size. From 1990 to June-2000 the minimum size regulation of Gag for commercial fisheries was 20 inches (51 cm TL). From Jul-2000 to the present the minimum size increased to 24 inches (61 cm TL).

Recreational Catch

Estimates of recreational retained catch (A+B1) and discards (B2) were available for the Gulf of Mexico from MRFSS since 1981 and from the Headboat survey since 1986. Texas Parks and Wildlife Division (TPWD) provided estimates of recreational landings in Texas, but not discards. For modeling purposes, the recreational fisheries were classified into two sectors: Headboat (1986-2004) and other recreational (MRFSS; 1981-2004). There were some adjustments to the estimates of AB1 (kept recreational catch) and B2 (discards) in response to the re-classification of black grouper as gag grouper for most of the Gulf with exception of the Florida Keys catches [See SEDAR-10 DW report]. Ratios of discards to retained catch for the Headboat fishery are based on the ratios of discards from the MRFSS estimates. In addition, it was known that a substantial recreational fishery existed for Gag in 1980 and prior years, therefore the AW recommended extrapolating back to 1960 using indicators that take into account human coastal population, commercial catch, number of vessels and estimated total expenditure in dollars for recreational fisheries (SEDAR-10 RW report). The historical discards (back to 1960) were determined from the extrapolated historical recreational catch using the ratios of 1981-1989 discards/kept fish, period of non-minimum size restrictions. The size composition of the AB1 retained catch was determined from size samples collected by MRFSS and other sources (SEDAR-10 DW report). Very limited size data have been collected on discarded fish from recreational fisheries.

Estimation of Dead Discards

The SEDAR10-DW concluded that the mortality of discarded gag grouper is highly correlated with the depth of capture of the fish and recommended to include this information in the estimation of release mortality for gag grouper (SEDAR-10 DW report). Based on several research studies, a depth-mortality logistic function was estimated (Fig 1). Overall, 50% mortality was observed with fish caught at about 45 m deep (150 feet), and above 95% for fish caught at 100 m or deeper (300 feet). Gag grouper show an ontogenic migration pattern, where larger fish move offshore to greater depths, while young and smaller fish tend to concentrate in shallow waters. Size-at depth data were available from the TIP survey, GULFIN and other survey data (Mote Marine Laboratory). In general, most of the size-depth information came from commercial samples (about 72 thousand samples), with very few from recreational fisheries (382 samples). Appendix 3.2 in the SEDAR Grouper Assessment Review (supplement 1, June 2007) summarizes the spatial-temporal distribution of the size-depth samples available. In general, the information corroborates the notion of larger fish at greater depths; however, it is also clear that all sizes are present even at the greatest depths (65+ m).

The size-at-depth data allows the estimation of two probability matrices of size at depth, one for the commercial fisheries, and one for recreational fisheries (in both cases assumed to be constant through the years). These size-at-depth matrices allow converting Discards-at-size (DAS) into Discards-at-size-at-depth (DAS-AD). Once DAS-AD was available, the depth-mortality function could be applied to estimate the portion of dead-discards-at-size (DDAS). For the commercial discards, the frequency size distribution was assumed to be that of the illegal size fish (below minimum size regulations) of 1984-1989. Of note, it was assumed that prior to 1990 there were no discards on commercial fisheries, so this size frequency and dead discards estimation is only for 1990 forward.

In the case of the recreational fisheries, the SEDAR Review Panel considered that the recreational size-at-depth information was limited, restricted to a small area (off the Panhandle coast, FL) where deep water is close to shore, and that this sample did not represent the main recreational fisheries operations of the rest of the Florida West Coast (where the shallow waters extend for several miles off the coast, Fig 2). Therefore, the Review Panel concluded that the size-at-depth recreational matrix was likely biased, and recommended an alternative procedure to estimate average depth of discards for these fisheries. The alternative method was based on an analysis of the distribution of B2 MRFSS discards among 3 zones: inshore, ocean < 10 m, ocean >10 m; and 2 regions: Panhandle FL and Peninsular FL (including the Florida Keys). The Review Panel recommended using these strata to partition all recreational discards (B2), assigning an average depth for each stratum based on depth-contour plots and information from recreational anglers and scientists familiar with these fisheries. Table 2 shows the assigned depth and correspondent mortality-at-depth for each stratum. Furthermore, as most of the recreational catch of gag is from the Florida West coast, discards from Alabama, Mississippi and Louisiana were treated similar to those from the Panhandle region and discards from Texas were treated similar to those from the Peninsula region. The partitioning of B2 discards was done for each year-area-region (1981-2004). For the years prior to 1981, it was assumed that dead-discards were the same proportion as the 1981-1989 average of dead-discard/kept fish of the overall recreational estimates.

The SEDAR Review Panel also concluded that discards from recreational fisheries were due primarily to size regulations, thus recommending that discard size distributions are of fish below 20 inches (51 cm TL) from 1990 to 1999 and fish below 22 inches (56 cm TL) from 2000-2004. Prior to 1990, when no federal size regulations were in effect, size distribution of discards was assumed to be of fish below 16 inches (41 cm TL) in accordance with consultations with recreational fisherman after the Review Panel meeting. Because no direct size samples are available from discarded fish, the size frequency distribution was estimated from samples of sub-legal sized fish included in data sets from the TIP, Headboat bioprofile, GULFIN, and Mote Marine surveys. It was confirmed during the SEDAR Grouper Review Panel that the distribution of sub-legal size fish in these samples was similar to those collected during the 2005 and 2006 FWC Headboat survey (SEDAR-12 Review Panel report). Table 1 shows the 'revised final' working estimates of recreational catch. These are somewhat less than the values estimated for the SEDAR 10 AW owing to the reduced average weight (the fish now being assumed smaller) and reduced mortality rate (the fish now being assumed to have been caught in shallower water on average). Figure 3 shows the differences in terms of the total biomass of removals, and Figure 4 shows the differences in terms of the total number of removals. Table 1B presents the estimated numbers and weight of landed, discards, and dead-discards for the recreational fisheries of Gag Gulf stock. Under the assumption that most discarding occurs because of the minimum size limit, the average weight of dead discarded fish in the last five years was about 2.3 lbs, while the average weight of landed fish was about 7.8 lbs.

Catch At Age

CAS tables from commercial and recreational kept, and commercial/recreational dead discards were converted to Catch at Age (CAA) following the procedures described in SEDAR10-AW02 document. Briefly, age-length-keys (ALK) were used when sufficient age samples were available (1991-2004), otherwise a stochastic length deconvolution method (SAR) was used (1984-1990) (Table 6 SEDAR10-AW02). In the assessment model CASAL, partial CAAs were input for each of the five fisheries, 3 commercial (handline, longline, others) and 2 recreational (Headboat, MRFSS).

Given the changes in assumptions regarding the size distribution of dead-discards in the recreational fisheries and their significant contribution to the total removals, the annual recreational CAA distributions shifted towards younger ages compared to the CAA of the final model in SEDAR10-RW (Fig 5 and Fig 6). The proportion classified as ages 1, 2 and 3 increased, while the proportion classified as ages 4 and older decreased. In addition, the total number of removals by year also decreased, as more recreational discard fish were allocated to shallow mean depths, thus reducing their discard mortality.

Maturity

No changes were recommended for Gag Gulf maturity vector. As indicated in prior reports (SEDAR 10 Report), spawning biomass results represent female biomass only for this stock. Gag is a protogynous species, maturing first as females (50% mature females at 3.7 years old) and then becoming males (50% mature males at 10.8 years old) (Table 3 Maturity column).

Natural Mortality

Following the recommendations of the SEDAR10-AW and RW, the natural mortality rate (M) of Gulf of Mexico gag grouper was modeled as a declining 'Lorenzen' function of size, translated to age by the use of a growth curve. The Lorenzen curve was rescaled such that the average value of M over a selected age range was the same as the point estimate from Hoenig's (1983) regression (using age 30 as the maximum, see the Grouper assessment review, Supplement 1, for more details). The scaling was originally conducted over all ages (0-30+); i.e., the cumulative mortality rate from ages 0 to 30 was equal to 31 times the Hoenig point estimate. The SEDAR-12 Review Panel recommended evaluating the effects of alternative M vectors that result with modifications of the age range (first age to include) used to scale the Lorenzen curve. Sensitivity runs were conducted with M vectors estimated by rescaling the Lorenzen curve over the following age ranges: i) Age 1-30, ii) Age 2-30, iii) Age 3-30, iv) Age 4-30 and v) Age 5-30. Table 3 and Figure 7 present the estimated M(age) vector for each case, and Figure 5 also shows the per recruit survival under each one of the M(age) cases. A catch curve analysis shows that estimated total removals (landings and dead discards) peak between ages 2 and 4, with an average for the full cohorts available in the series (cohorts 1984-1992) of age 3 (Fig 8). Thus, age 3 likely represents the 'fully-selected' age that should have been used for catch curve analyses of the sort upon which Hoenig's regression was based. The Gulf of Mexico Fishery Management Council's SSC recommended using the M(age) vector estimated with the age range 3-30+ as the final Model. Sensitivity runs were conducted for the other cases.

Size at age

Size at age follows the von Bertalanffy growth model estimated and adopted by the SEDAR10-DW. This model includes a modification to estimate growth parameters from samples subject to biases due to minimum size restrictions.

Indices of Abundance

Relative indices of abundance were derived from SEAMAP Video Surveys (for all gag and for mature male gag) and fishery dependent sources (MRFSS 1981-2004, Headboat 1986-2004, Handline 1990-2004, and Longline 1990-2004). No modifications were recommended for these indices. Detailed description of the standardization methods and estimation are provided in the SEDAR10-DW report CPUE section. Because of the changes in minimum size regulations (1990, and 2000), some of the fishery dependent indices were split at these years. In the assessment model CASAL, each time period is associated with a different catchability coefficient for the catch and fishery-index.

Application of CASAL Model

The CASAL model used to assess the Gulf of Mexico gag stock was configured as described in the SEDAR 10 RW report, briefly:

- An age structured model, starting with age 1 to age 12+, where age 12 represents ages 12 and older fish (a plus group).
- Age dependent, Lorenzen natural mortality vector using ages 3-30+ as age range for estimation of Lorenzen's curve in final model (other age ranges examined as sensitivity analyses). Natural mortality for the age 12+ in the CASAL model was estimated as the survival weighted-average of ages 12 to 30+.
- Size at age following a von Bertalanffy growth model SEDAR10- DW.
- Beverton-Holt stock recruitment relationship, but with large recruitment deviations allowed.
- Reproductive potential measured in terms of female spawning biomass (maturity at age * proportion female at age * average weight at age).
- Four fishery-dependent CPUE series (indices of abundance): Handline, Longline, Headboat, and MRFSS. Handline, Longline and Headboat indices were split at 1989/90 and 1999/00 when management regulations of minimum size were implemented and considered to affect the landings of those fisheries.
- Two fishery independent indices of abundance: Video SEAMAP survey and the Copper belly (adult male) video survey.
- Five major fisheries; three commercial (Handline, Longline and Others) and two recreational (Headboat and MRFSS).
- Five series of age-composition data, one for each fishery, from 1984 to 2004.
- Constant catchability coefficients q's within fishery and associated index time series. Thus Handline, Longline and Headboat fisheries were split similar to their respective indices of abundance.
- Selectivity by fishery/index was assumed to follow a parametric function; double logistic for all; except Longline fishery logistic. Function parameters were estimated by the model.
- Penalties for total catch in each fishery to be realized, and for the average log-scale recruitment deviations to be one.

The main input differences between the model adopted by the SEDAR10-RW (Jul-06) and the final model presented here are:

1. Discards from the recreational fisheries are now assumed to be strictly due to the minimum size restrictions (20" from 1990 to 1999, and below 22" thereafter). Prior to 1990 a practical size limit of 16" was assumed based on discussions with anglers after the Review panel meeting.
2. Discards from recreational fisheries (B2) are now partitioned between areas (inshore, ocean<10, ocean>10) and regions (Panhandle, Peninsula+FLKeys) for each year based

on the proportions of B2 derived from the MRFSS estimates of Florida West coast (Web MRFSS estimates). Then for each stratum an average depth was assigned based on consultations with recreational anglers and scientists familiar with these fisheries. Dead-discards were then estimated by multiplying the yearly B2 estimates for each stratum by the discard mortality rate associated with the average depth of that stratum.

3. The Lorenzen natural mortality model was scaled over ages 3-30 (rather than ages 0-30)

In all other matters, the CASAL runs were identical to those adopted by the SEDAR 10 review panel for Gulf of Mexico gag.

Model fits and parameter estimates

The CASAL assessment final model estimated a gag stock unexploited biomass (Virgin Biomass) of about 94 million pounds (mp), and a biomass at the start of the catch series (1963) of about 74 mp (Table 4). The overall trend estimated by the model shows a rapid decline of total biomass from 1963 to early 1980's (Fig 9 total biomass plot). Total biomass continue to decline through the early 1990's until 1995 when the trend shifted increasing total biomass until recent years, reaching about 38 mp in 2004. Figure 9 shows comparison of the biomass trends for the Final model and the model reported in SEDAR-10 Jul-06. Total biomass trends differ between the models after 1984. In the case of the SEDAR10-Jul06 run, the stock biomass starts to increase in 1990 and rapidly reaches a peak in 2002. In the Final Model, stock biomass shows continued declines until 1993 and then begins to increase, but not nearly to the levels estimated by the SEDAR-10 Jul06 run (Fig 9). Similar trends are estimated for the spawning stock biomass (SSB) component, with initial declines from 1963 through 1980 follow by a relative stable SSB in the late 80's early 90's. However in the SEDAR-10 Jul06 run, the SSB in the 2000's rapidly increases reaching higher estimates than any historical values, while the Final model run shows a much smaller SSB, about half of what it was in 1963 (SSB 2004 = 27 mp, Fig 9 Spawning Stock Biomass plot).

Trends of the stock size shows similar patterns between models, with equivalent numbers of fish between 1963 and 1989 (Fig 9 Stock size plot). However, the magnitude of stock size differs from 1990 forward; the Final Model estimated a smaller total stock of about 9.1 million fish in 1998-04 years, while the SEDAR-10 Jul06 model estimated 11.2 million fish on average for the same years. Trends of recruits (age 1 class) are similar but differ in magnitude. Larger recruitments were predicted in the SEDAR10-Jul06 run compared to the estimates from the Final Model run. The geometric mean recruitment from 1984 to 2004 was estimated at 2.05 million fish in the Final Model. Peaks of recruitments are similar between scenarios but the magnitude of them is much lower in the Final Model (Fig 9 Recruits plot).

In terms of exploitation rates, both models estimated similar trends. Figure 9 shows the estimated annual fishing mortality rate (F) for both runs. The Final Model estimated consistent lower F rates in the more recent years. Estimated F in 2004 is about 0.40 for the Final Model.

Fits to indices and partial Catch-at-age of the Final Model are shown in Figures 10 and 11, respectively. The estimated selectivity by fishery shows the expected patterns. In the case of the Final Model, the estimated selectivity's of the recreational fisheries were shifted towards smaller-younger age classes under the assumption that dead discards are due to minimum size restrictions (Fig 12). Selectivity for the commercial components was similar between runs (Fig 13).

Stock status estimates

Following the recommendations of the SEDAR10-AW and RW, estimates of benchmarks were calculated based on recruitment estimates for the period when relative indices of abundance and age composition data were available [1984-2004]. Specifically, the expected future recruitment was estimated as the geometric mean of the estimates for 1984-2004 (2.05 million recruits Final Model). Future selectivity was assumed to remain similar to the patterns estimated for the last 4 years (2001-2004). Projections and benchmark estimates were calculated using the age-structured software (PRO-2BOX).

Table 5 summarizes the estimated benchmarks for the Final Model. MSY was estimated at 4.9 million pounds (mp), and the fishing mortality rate of F_{MAX} was 0.20. Note that the estimates of MSY and yield per recruit statistics were computed by optimizing the landings (kept catch) component of the fisheries. All references of spawning biomass in this table correspond to the female component of the stock exclusively, where spawning biomass is defined as the mean weight times the proportion female times the proportion mature. Spawning biomass at Fmax was estimated at 27.3 mp.

The ratio of SSB_{2004} to the suggested proxy for SSB_{MSY} (SSB_{MAX}) was estimated to be 0.99 for the Final Model. And the ratio of F_{2004} to F_{MAX} was 1.97. In that case the interpretation of stock status depends on the definition of MSST. If the lower limit allowed by law (half the MSY level) or the default control rule of (1-M)*SSB_{MSY} were to be adopted, then the stock would not be deemed overfished. However, the models suggest the stock is currently experiencing overfishing.

Natural Mortality Sensitivity Runs

The sensitivity runs with alternative M (age) vectors were run with the model recommended by the SEDAR-12 Review Panel. Note that the natural mortality rate of all age classes increases as the first age-class used in the rescaling procedure is moved from age 0 towards age 5. Table 6 presents a summary of the estimated population parameters under each scenario. Increase of natural mortality on all ages implies a lower survival per recruit, thus the model in general estimated larger recruitment of age 1 gag, from 1.66 M (age0-30) to 2.97 M (age5-30) million fish. The population model also estimated lower steepness as M (age) increased from 0.846 M (age0-30) to 0.699 M (age5-30). The lower steepness was compensated by a lower virgin biomass, and also greater initial biomass, with exception of the M (age5-30) case.

Estimated fishing mortality at 2004 was lower as the first age-class for M increases M (0-30) from 0.45 to 0.38 for M (5-30) (Table 7). Table 7 presents the estimated benchmarks assuming a constant recruitment (geometric mean of the model estimated Age 1 numbers 1984-2004) for each case. Biomass references decreased as M (age) increased. MSY estimates ranged from 5.5 million lbs M (age0-30) to 4.8 million lbs M (age5-30). Similarly, estimates of spawning biomass at different references (MSY, Fmax, $F_{0.1}$, SPR20%, SPR30%, SPR40%) were all lower as the first age for M (age) increased. For example, SSB_{Fmax} was estimated 33.2 million lbs M (age0-30) and 26.2.0 million lbs M (age5-30). Estimates of yield per recruit did also decrease as the first age for M (age) increased. Reference points of fishing mortality instead, increase with increase of the first age for M (age) vector. Fmax was estimated in the M (age0-30) case at .017, and for M (age5-30) at 0.21

Projections

The following section describes the deterministic projections from the Final Model. The projections use the software package PRO-2BOX, with inputs from the CASAL fitting model outputs. Projections, assume the following conditions:

a) Recruitment in the future, from 2005 forward, was assumed constant at a value corresponding to the geometric mean of the estimated recruits (Age 1) by CASAL from the period 1984-2004 (2,048,560 million fish) as agreed to by the SEDAR-10 Review and Assessment Workshop groups.
b) Selectivity remains, on average, about the same as the average selectivity estimated over the last 4 years when data were available (2001-2004).
c) Preliminary observed landings were used for 2005 (6,021,449 lbs landings, and 592,132 lbs dead discards) and 2006 (3,272,641 lbs landings, and 429,952 lbs dead discards) and it is assumed that the landings in 2007 would be at about 2006 levels (because 2007 is not yet complete).
d) Random fluctuations in recruitment and parameter uncertainty were not modeled for this exercise, therefore these deterministic results should be regarded as equivalent to the 50th percentile, i.e., there is a 50% chance that the actual stock will be in worse condition than the projections indicate and a 50% chance that it will be in better condition than the projections indicate.

Projections of constant catch start in 2008 with values ranging 0 to 6 million pounds of landed catch. Projections were also carried out for the fishing mortality rate that maximizes yield per recruit (Fmax, the SEDAR-12 Review Panel recommended proxy for MSY) and Fmax75% (75% of Fmax, the recommended OY). Other projections included constant fishing rates of F 0.05 to F 0.50, F2004 (current) and F 20%, 30% and 40% SPR. The predicted trends of total biomass, spawning stock biomass, F, yields, and ratios of SSB/SSBFmax and F/Fmax are summarized in Table 8 and Figure 18. There a several important results to highlight:

1) The results suggest that, even though the estimated catch for 2005-07 were below the 2004 catch (35% less in 2005, 64% less in 2006/07), the spawning stock biomass continued decreasing relative to the 2004 level. Thus, it is unlikely that gag stock can continue to support the high catch levels of the recent past in the absence of a fortuitous strong year classes.

2) The projections suggest that constant catch allocations at or below 4 million pounds (total landings) are required to halt the projected decline of the SSB after 2007.

3) The projections suggest that, if the objective is to end overfishing immediately (fish at Fmax), then landings will likely need to be reduced to about 4.1 million pounds, and if the objective is to fish at 75%Fmax (OY) levels, then landings will need to be reduced to nearly 3.1 million pounds.

4) Once the stock is recovered, the maximum long-term equilibrium yield is expected to be 4.9 mp. The optimum long-term equilibrium yield (OY) is expected to be 4.8 mp.

Effect of Updated Discards on Management Advice

This section details how management advice might be affected by the correction of the weight of the recreational dead discards. In this comparison, it is presumed that correction itself would not have affected the SSC's choice to base management advice on the model that used the Lorenzen natural mortality curve scaled over the fully-selected age classes (ages 3 and older) because that choice was based on the principle that Hoenig's regression was applied to fully selected age classes. Hence, the model results being compared here are the two runs with the Lorenzen natural mortality rate scaled over ages 3-30, one reported on previously (July, 2007) with the incorrect discard weights and the final model reported on here with the correct discard weights.

The use of the correct conversion factors (kilograms to pounds) essentially implies the number of discards from the recreational fishery were about twice that previously assumed by the models reported on in July of 2007. Inasmuch as the discards are assumed to be predominantly younger undersized fish, the model logically compensates for the increase in dead discards by estimating approximately 30% higher recruitment levels. On the other hand, the fishing mortality rate and spawning biomass estimates, which reflect processes operating on older fish, are less sensitive to the change in the perceived number of discards (Table 9). As a result, the revised model run infers a potentially more productive stock, but a slightly less optimistic view of the stock status. Nevertheless, with respect to the key status determination criteria, there are no major changes. The stock is still considered to be undergoing essentially the same degree of overfishing (i.e. the F_{2004}/F_{max} ratio remains approximately 2.0), and the ratio of spawning stock biomass in 2004 to SSBmax is now estimated to be 0.99, which still exceeds any reasonable definition of an overfished condition (MSST).

The greatest impact in terms of management advice is on the estimated values of equilibrium yield (MSY and OY) and allowable biological catch. Inasmuch as the benchmark calculations and projections assume that recent average recruitment levels will continue into the future, the 30% increase in recruitment translates into a corresponding increase in the estimate of MSY (from 3.7 mp to 4.9 mp). Likewise, the level of catch that ends overfishing in 2008 (such that F=Fmax) increases from 3.1 to 4.1 mp, and the level of catch that achieves Foy (F=0.75Fmax) increases from 2.4 to 3.1 mp.

References

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SEDAR 10 Stock Assessment Report. Gulf of Mexico Gag Grouper SEDAR-10

SEDAR 12 Grouper Assessment Review Report.

Table 1. Final estimates of total gag grouper removals (landings + dead discards) from commercial and recreational fisheries 1963-2004 Final Model. Discards of recreational fisheries B2 were partitioned by year/area/region and assigned a discard mortality rate based on average depth to estimate the number of discards that died (see text for further details). Values in thousand pounds

Year	Longline	Handline	Others	MRFSS	Headboat	Total
1963	-	1,289	1	444	-	1,734
1964	-	1,632	9	479	-	2,121
1965	-	1,816	1	514	-	2,331
1966	-	1,457	1	547	-	2,005
1967	-	1,156	10	581	-	1,747
1968	-	1,192	4	618	-	1,814
1969	-	1,377	3	656	-	2,036
1970	-	1,284	3	697	-	1,983
1971	-	1,377	3	783	-	2,162
1972	-	1,460	4	879	-	2,343
1973	-	1,081	5	987	-	2,073
1974	-	1,184	1	1,108	-	2,293
1975	-	1,447	4	1,243	-	2,694
1976	-	1,198	9	1,396	-	2,603
1977	-	977	8	1,567	-	2,552
1978	-	875	11	1,762	-	2,648
1979	1	1,342	10	1,980	-	3,333
1980	89	1,318	12	2,212	-	3,631
1981	467	1,499	16	1,876	-	3,858
1982	1,010	1,335	14	3,248	-	5,607
1983	681	1,039	18	6,446	-	8,185
1984	433	1,098	18	1,975	-	3,525
1985	381	1,398	28	6,619	-	8,426
1986	517	1,155	29	3,442	279	5,423
1987	656	853	30	2,312	193	4,043
1988	402	791	23	3,668	151	5,035
1989	426	1,235	31	2,100	294	4,087
1990	623	1,130	41	1,244	209	3,246
1991	510	993	63	2,942	107	4,615
1992	593	1,003	69	2,415	127	4,205
1993	480	1,280	106	2,948	177	4,991
1994	352	1,148	119	2,324	195	4,138
1995	391	1,157	105	3,357	137	5,146
1996	394	1,106	68	2,821	121	4,509
1997	415	1,101	83	2,946	105	4,649
1998	603	1,848	82	4,113	258	6,903
1999	549	1,481	68	4,111	211	6,420
2000	621	1,596	81	5,497	219	8,015
2001	1,011	2,065	101	4,776	129	8,081
2002	1,041	1,910	62	5,475	96	8,584
2003	1,138	1,461	67	5,199	140	8,004
2004	1,138	1,737	73	7,048	209	10,205

Table 1b. Final Model estimates of landed (AB1), discards (B2) and dead discards from recreational fisheries of gag 1963-2004. AB1 and B2 numbers are provided since 1981; values for 1980 and prior years are estimated. Dead discards were estimated based on area and regions of capture and mean assigned depth by area/region times the depth-mortality function show in Fig 1 (see text for further details).

	Recreational Fisheries						
	Numbers of fish			**weight pounds**		**Average weight**	
Year	Landed	Discards (B2)	Dead discards	Landed	Dead discards	Landed	Dead discards
1963	63,393	0	-	443,897	-	7.00	-
1964	68,470	0	-	479,445	-	7.00	-
1965	73,953	529	-	514,410	-	6.96	-
1966	79,347	1,960	106	546,602	137	6.89	1.29
1967	84,312	3,617	394	580,651	509	6.89	1.29
1968	89,564	5,527	727	616,649	939	6.88	1.29
1969	95,117	7,719	1,111	654,688	1,434	6.88	1.29
1970	100,984	10,227	1,551	694,864	2,004	6.88	1.29
1971	107,181	13,848	2,055	780,084	2,655	7.28	1.29
1972	120,326	18,293	2,783	875,474	3,594	7.28	1.29
1973	135,040	23,726	3,676	982,200	4,748	7.27	1.29
1974	151,502	30,337	4,768	1,101,554	6,158	7.27	1.29
1975	169,912	38,344	6,096	1,234,688	7,874	7.27	1.29
1976	190,448	48,104	7,705	1,385,894	9,952	7.28	1.29
1977	213,771	59,885	9,666	1,555,013	12,485	7.27	1.29
1978	239,857	74,154	12,033	1,746,131	15,543	7.28	1.29
1979	269,337	91,334	14,901	1,960,352	19,247	7.28	1.29
1980	302,380	111,361	18,353	2,188,258	23,706	7.24	1.29
1981	252,199	248,721	37,690	1,831,969	44,442	7.26	1.18
1982	485,013	115,428	20,524	3,221,476	26,620	6.64	1.30
1983	998,192	427,199	51,921	6,386,544	59,835	6.40	1.15
1984	309,675	72,578	17,491	1,951,025	24,083	6.30	1.38
1985	872,036	156,747	34,707	6,568,709	50,289	7.53	1.45
1986	623,483	385,172	89,492	3,597,597	124,010	5.77	1.39
1987	408,924	241,070	43,590	2,447,576	57,390	5.99	1.32
1988	590,684	253,338	55,907	3,749,612	69,352	6.35	1.24
1989	378,695	509,130	66,201	2,312,789	81,270	6.11	1.23
1990	179,068	410,624	94,164	1,262,592	189,729	7.05	2.01
1991	269,605	872,238	163,768	2,739,339	310,147	10.16	1.89
1992	248,737	735,921	144,197	2,249,263	292,062	9.04	2.03
1993	350,576	1,303,751	282,629	2,791,364	333,637	7.96	1.18
1994	280,025	1,887,900	346,864	1,997,139	522,261	7.13	1.51
1995	422,539	1,876,261	422,986	2,703,748	789,880	6.40	1.87
1996	350,232	1,239,252	261,520	2,351,626	589,962	6.71	2.26
1997	391,680	1,735,041	313,531	2,577,560	472,936	6.58	1.51
1998	528,844	2,176,986	466,031	3,521,267	849,510	6.66	1.82
1999	549,701	1,520,276	332,496	3,724,266	598,122	6.78	1.80
2000	724,709	1,452,424	306,663	4,966,289	750,483	6.85	2.45
2001	476,643	1,938,186	431,552	4,031,831	872,848	8.46	2.02
2002	518,012	2,510,810	529,389	4,437,382	1,133,666	8.57	2.14
2003	503,665	3,434,530	741,118	3,775,128	1,563,001	7.50	2.11
2004	653,529	3,610,622	799,948	4,911,613	2,345,702	7.52	2.93

Table 2. Assigned average depth (m) and corresponding discard mortality (% mort) for each of the regions (Panhandle and Peninsula/ Florida Keys) and depth zones (inshore, Ocean < 10 miles, and Ocean > 10 miles) used to estimated dead discards of B2- recreational discards.

Region	Zone	Average depth (m)	%mort
Panhandle	Inshore	10	11
Panhandle	Ocean<10	20	18
Panhandle	Ocean>10	40	42
Peninsula/Keys	Inshore & Ocean<10	10	11
Peninsula/Keys	Ocean>10	30	29

Table 3. Gag female maturity by age and estimated natural mortality at age M (age) vectors obtained by rescaling the Lorenzen's curve over different age ranges. * The final model used MAA (ages 3-30+) vector.

Age	Maturity Female %	MAA (age 0-30)	MAA (age1-30)	MAA (age2-30)	MAA* (age3-30)	MAA (age4-30)	MAA (age5-30)
1	0.0%	0.342	0.389	0.414	0.432	0.446	0.456
2	0.0%	0.246	0.280	0.298	0.311	0.321	0.328
3	16.8%	0.199	0.226	0.241	0.251	0.259	0.265
4	72.8%	0.171	0.194	0.207	0.216	0.223	0.228
5	95.0%	0.152	0.173	0.185	0.193	0.199	0.204
6	100.0%	0.139	0.159	0.169	0.176	0.182	0.186
7	99.7%	0.130	0.148	0.158	0.164	0.170	0.174
8	96.6%	0.123	0.140	0.149	0.155	0.160	0.164
9	90.7%	0.117	0.133	0.142	0.148	0.153	0.156
10	82.0%	0.113	0.128	0.137	0.143	0.147	0.150
11	70.6%	0.109	0.124	0.132	0.138	0.142	0.146
12+	57.5%	0.098	0.112	0.119	0.125	0.129	0.132

Table 4. Final Model CASAL estimates of total biomass, female spawning biomass, recruits (age 1), fishing mortality rate and removals from the Gulf of Mexico gag stock as recommended by the SEDAR-12 Grouper Review Panel May 07.

Year	Total Biomass	Spawning Stock Biomass	Recruits	F	Yield (landings + Dead Disc)
	1000 lbs	1000 lbs	Age1	annual rate	1000 lbs
1963	74,621	52,165	501,420	0.030	1,736
1964	72,212	50,907	459,777	0.037	2,123
1965	68,944	49,210	423,228	0.042	2,333
1966	65,037	46,405	391,425	0.041	2,006
1967	61,100	43,155	364,014	0.042	1,748
1968	57,150	39,738	340,690	0.048	1,816
1969	52,960	36,130	320,312	0.060	2,038
1970	48,483	32,395	300,701	0.068	1,985
1971	44,076	28,859	279,880	0.085	2,164
1972	39,573	25,473	258,167	0.107	2,346
1973	35,026	22,310	229,988	0.126	2,075
1974	30,896	19,658	1,746,770	0.160	2,295
1975	28,386	17,038	252,824	0.196	2,696
1976	25,328	14,870	960,799	0.205	2,606
1977	23,225	14,520	1,531,610	0.216	2,555
1978	22,255	13,660	1,464,380	0.225	2,650
1979	21,920	13,296	1,896,350	0.251	3,336
1980	21,954	13,536	2,279,230	0.259	3,634
1981	22,834	14,165	2,681,810	0.247	3,861
1982	24,814	15,588	2,586,920	0.334	5,612
1983	25,840	16,677	1,736,540	0.474	8,192
1984	23,577	16,021	1,567,750	0.205	3,528
1985	25,600	18,946	1,506,630	0.478	8,434
1986	22,062	16,575	1,255,570	0.337	5,428
1987	20,824	15,679	1,211,700	0.256	4,047
1988	20,685	15,720	1,055,470	0.348	5,040
1989	19,102	14,462	764,216	0.297	4,091
1990	17,894	13,631	2,312,810	0.243	3,249
1991	18,841	13,311	1,688,820	0.369	4,619
1992	18,547	11,929	1,451,570	0.337	4,209
1993	18,643	12,466	1,734,970	0.407	4,995
1994	18,170	12,427	3,546,660	0.332	4,142
1995	20,556	12,802	2,217,190	0.381	5,151
1996	21,920	13,265	2,122,350	0.300	4,513
1997	24,066	16,353	5,102,580	0.267	4,654
1998	29,187	19,021	2,645,710	0.356	6,909
1999	31,485	20,167	1,655,800	0.284	6,426
2000	33,173	24,618	4,137,370	0.334	8,022
2001	34,710	25,826	3,119,050	0.338	8,088
2002	35,880	25,208	2,803,990	0.345	8,592
2003	36,253	26,042	3,764,210	0.311	8,012
2004	37,957	27,213	2,395,580	0.396	10,215

Table 5. Estimated benchmarks from the Final Model recommended by the Review Panel (SEDAR-12). Benchmarks assume constant recruitment (geometric mean 1984-2004) and average selectivity of last four years (2001-04). Units of biomass are pounds (MSY, SSB, Yield, Biomass, SSB virgin, YPR). The proxy for MSY is the equilibrium yield (weight of landings) associated with fishing to maximize the yield per recruit. The term virgin refers to the status of the stock before fishing commenced.

Estimate	Final Model
Virgin Biomass	94,434,141
Biomass 1963	52,164,906
SSB 2004	27,006,631
F 2004	0.396
Virgin Recruitment (million)	2.15
Obj Function	8844.86
MSY	4,941,640
F at max. Y/R	0.201
Yield 75% of Fmax	4,824,244
F 75% of Fmax	0.151
Y/R maximum	2.4
S/R at Fmax	6.05
SPR at Fmax	0.38
SSB at Fmax	27,318,364
SSB at 75% Fmax	33,507,402
F 0.1	0.129
Y/R at F0.1	2.3
SSB at F0.1	36,796,479
F 20% SPR	0.392
F 30% SPR	0.267
F 40% SPR	0.190
F2004/Fmax	1.97
SSB2004/SSBmax	0.99

Table 6. Model estimates of selected population parameters under the different natural mortality at age vectors, M (age), estimated by re-scaling the Lorenzen's curve over the given age ranges. Biomass units are in pounds. Obj Function represents the estimated log-likelihood of the model fit.

Estimate	**M(age0-30)**	**M(age1-30)**	**M(age2-30)**	**M(age3-30)**	**M(age4-30)**	**M(age5-30)**
Virgin Biomass	120,504,909	104,728,407	98,028,337	94,434,141	93,316,838	115,452,575
Biomass 1963	39,404,548	45,297,285	46,884,172	52,164,906	51,758,153	34,801,736
SSB 2004	23,920,159	25,529,533	26,389,336	27,006,631	27,491,648	27,910,526
F 2004	0.45	0.42	0.41	0.40	0.39	0.38
Virgin Recruitment	1.66	1.89	2.03	2.15	2.27	2.97
Steepness	0.8464	0.8212	0.8088	0.7940	0.7803	0.6990
Obj Function	8839.06	8841.71	8843.41	8844.86	8844.03	8846.96

Table 7. Sensitivity runs. Reference points for different vectors of natural mortality at age M (age) runs. Final model used the vector of M (age3-30)*. Biomass units in pounds, note that benchmark estimates of Fmax and Fmsy, and SSBmax and SSBmsy are identical because of the assumption of constant recruitment.

Reference Point	M(age0-30)	M(age1-30)	M(age2-30)	M(age3-30)*	M(age4-30)	M(age5-30)
F at MSY	0.17	0.19	0.19	0.20	0.21	0.21
MSY	5,525,072	5,172,089	5,023,917	4,941,640	4,889,898	4,849,046
Y/R at MSY	3.5	2.9	2.6	2.4	2.3	2.2
S/R at MSY	9.61	7.51	6.60	6.05	5.67	5.39
SPR AT MSY	0.39	0.39	0.39	0.38	0.38	0.38
SSB AT MSY	33,227,636	29,781,810	28,236,810	27,318,364	26,701,731	26,217,817
F at max. Y/R	0.17	0.19	0.19	0.20	0.21	0.21
Y/R maximum	3.5	2.9	2.6	2.4	2.3	2.2
S/R at Fmax	9.61	7.51	6.60	6.05	5.67	5.39
SPR at Fmax	0.39	0.39	0.39	0.38	0.38	0.38
SSB at Fmax	33,227,636	29,781,810	28,236,810	27,318,364	26,701,731	26,217,817
F 0.1	0.11	0.12	0.12	0.13	0.13	0.14
Y/R at F0.1	3.3	2.7	2.4	2.3	2.2	2.1
S/R at F0.1	12.77	10.06	8.89	8.15	7.66	7.27
SPR at F0.1	0.52	0.52	0.52	0.52	0.52	0.51
SSB at F0.1	44,140,078	39,902,352	38,029,525	36,796,479	36,045,585	35,363,695
F 20% SPR	0.34	0.37	0.38	0.39	0.40	0.41
Y/R at F20	3.0	2.5	2.3	2.1	2.0	1.9
S/R at F20	4.92	3.88	3.44	3.17	2.98	2.84
SSB at F20	17,007,387	15,404,450	14,730,078	14,308,091	14,027,486	13,821,332
F 30% SPR	0.23	0.25	0.26	0.27	0.27	0.28
Y/R at F30	3.4	2.8	2.5	2.4	2.2	2.1
S/R at F30	7.38	5.83	5.16	4.74	4.46	4.26
SSB at F30	25,494,259	23,127,597	22,063,425	21,407,528	21,022,909	20,716,842
F 40% SPR	0.16	0.18	0.18	0.19	0.19	0.20
Y/R at F40	3.5	2.9	2.6	2.4	2.3	2.2
S/R at F40	9.84	7.77	6.87	6.32	5.96	5.68
SSB at F40	33,991,537	30,798,803	29,398,206	28,523,191	28,072,125	27,647,074
F 90% max Y/R	0.09	0.10	0.11	0.11	0.11	0.11
Y 90% max Y/R	4,959,387	4,646,419	4,520,910	4,434,158	4,392,403	4,354,329
Y/R 90% max Y/R	3.2	2.6	2.3	2.2	2.1	2.0
S/R 90% max Y/R	14.04	11.03	9.70	8.96	8.40	8.00
SSB 90% max Y/R	48,513,389	43,730,680	41,520,766	40,443,587	39,542,998	38,906,965

Table 8. Summary of Final Model projection results. Biomass units in millions of pounds. F_{apex} is the fishing mortality rate on the most vulnerable age class. F_{max} is the value of F_{apex} that maximizes the yield per recruit, F_{75max} is 75% of $F_{max.}$, F_{90max} is 90% of Fmax, and Fcurr is the average F of 2001-04. 2004 last year of model fit, 2005-07 preliminary estimates of landings and dead discards, 2008 and forward projections at each scenario (see text for further details).

Projections							
Measure	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Fishable Biomass							
Catch 0 mp	26.83	23.10	22.95	24.23	0.00	0.00	0.00
Catch 1 mp	26.83	23.10	22.95	24.23	26.83	31.11	35.54
Catch 2 mp	26.83	23.10	22.95	24.23	26.37	29.54	32.85
Catch 3 mp	26.83	23.10	22.95	24.23	25.88	27.98	30.16
Catch 4 mp	26.83	23.10	22.95	24.23	25.38	26.39	27.45
Catch 5 mp	26.83	23.10	22.95	24.23	24.89	24.80	24.69
Catch 6 mp	26.83	23.10	22.95	24.23	24.38	23.21	21.94
F 0.05	26.83	23.10	22.95	24.23	26.81	30.89	34.97
F 0.10	26.83	23.10	22.95	24.23	26.30	29.23	32.01
F 0.20	26.83	23.10	22.95	24.23	25.35	26.19	26.92
F 0.25	26.83	23.10	22.95	24.23	24.89	24.82	24.71
F 0.30	26.83	23.10	22.95	24.23	24.43	23.52	22.73
F 0.40	26.83	23.10	22.95	24.23	23.57	21.14	19.28
F 0.50	26.83	23.10	22.95	24.23	22.75	19.04	16.42
F 75max	26.83	23.10	22.95	24.23	25.82	27.62	29.30
F 90max	26.83	23.10	22.95	24.23	26.21	28.97	31.55
F0.1	26.83	23.10	22.95	24.23	26.01	28.31	30.40
F20%SPR	26.83	23.10	22.95	24.23	23.63	21.32	19.52
F30%SPR	26.83	23.10	22.95	24.23	24.74	24.36	24.01
F40%SPR	26.83	23.10	22.95	24.23	25.44	26.48	27.36
Fcurr	26.83	23.10	22.95	24.23	24.03	22.38	21.05
Fmax	26.83	23.10	22.95	24.23	25.33	26.17	26.85
Fmsy	26.83	23.10	22.95	24.23	25.33	26.17	26.85
Total Biomass							
Catch 0 mp	34.68	31.99	32.34	34.52	38.78	45.57	52.65
Catch 1 mp	34.68	31.99	32.34	34.52	38.16	43.63	49.32
Catch 2 mp	34.68	31.99	32.34	34.52	37.54	41.67	45.97
Catch 3 mp	34.68	31.99	32.34	34.52	36.93	39.71	42.59
Catch 4 mp	34.68	31.99	32.34	34.52	36.31	37.72	39.18
Catch 5 mp	34.68	31.99	32.34	34.52	35.67	35.71	35.74
Catch 6 mp	34.68	31.99	32.34	34.52	35.01	33.71	32.23
F 0.05	34.68	31.99	32.34	34.52	38.12	43.36	48.59
F 0.10	34.68	31.99	32.34	34.52	37.48	41.29	44.91
F 0.20	34.68	31.99	32.34	34.52	36.27	37.48	38.54
F 0.25	34.68	31.99	32.34	34.52	35.67	35.74	35.76
F 0.30	34.68	31.99	32.34	34.52	35.10	34.08	33.22
F 0.40	34.68	31.99	32.34	34.52	33.97	31.06	28.81
F 0.50	34.68	31.99	32.34	34.52	32.94	28.37	25.15
F 75max	34.68	31.99	32.34	34.52	36.84	39.29	41.51
F 90max	34.68	31.99	32.34	34.52	37.37	40.94	44.33
F0.1	34.68	31.99	32.34	34.52	37.13	40.12	42.92
F20%SPR	34.68	31.99	32.34	34.52	34.06	31.28	29.12
F30%SPR	34.68	31.99	32.34	34.52	35.47	35.14	34.86
F40%SPR	34.68	31.99	32.34	34.52	36.38	37.83	39.09
Fcurr	34.68	31.99	32.34	34.52	34.57	32.65	31.09
Fmax	34.68	31.99	32.34	34.52	36.24	37.43	38.45
Fmsy	34.68	31.99	32.34	34.52	36.24	37.43	38.45
F apex							
Catch 0 mp	0.40	0.32	0.18	0.17	0.00	0.00	0.00
Catch 1 mp	0.40	0.32	0.18	0.17	0.05	0.04	0.03
Catch 2 mp	0.40	0.32	0.18	0.17	0.09	0.08	0.07
Catch 3 mp	0.40	0.32	0.18	0.17	0.14	0.13	0.12
Catch 4 mp	0.40	0.32	0.18	0.17	0.20	0.19	0.18
Catch 5 mp	0.40	0.32	0.18	0.17	0.25	0.25	0.25
Catch 6 mp	0.40	0.32	0.18	0.17	0.31	0.32	0.34
F 0.05	0.40	0.32	0.18	0.17	0.05	0.05	0.05
F 0.10	0.40	0.32	0.18	0.17	0.10	0.10	0.10
F 0.20	0.40	0.32	0.18	0.17	0.20	0.20	0.20
F 0.25	0.40	0.32	0.18	0.17	0.25	0.25	0.25
F 0.30	0.40	0.32	0.18	0.17	0.30	0.30	0.30
F 0.40	0.40	0.32	0.18	0.17	0.40	0.40	0.40
F 0.50	0.40	0.32	0.18	0.17	0.50	0.50	0.50
F 75max	0.40	0.32	0.18	0.17	0.15	0.15	0.15
F 90max	0.40	0.32	0.18	0.17	0.11	0.11	0.11
F0.1	0.40	0.32	0.18	0.17	0.13	0.13	0.13
F20%SPR	0.40	0.32	0.18	0.17	0.39	0.39	0.39
F30%SPR	0.40	0.32	0.18	0.17	0.27	0.27	0.27
F40%SPR	0.40	0.32	0.18	0.17	0.19	0.19	0.19
Fcurr	0.40	0.32	0.18	0.17	0.35	0.35	0.35
Fmax	0.40	0.32	0.18	0.17	0.20	0.20	0.20
Fmsy	0.40	0.32	0.18	0.17	0.20	0.20	0.20

Projections							
Measure	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Spawning stock biomass							
Catch 0 mp	27.01	23.72	21.87	23.10	24.16	29.50	35.36
Catch 1 mp	27.01	23.72	21.87	23.10	24.16	28.40	33.09
Catch 2 mp	27.01	23.72	21.87	23.10	24.16	27.32	30.82
Catch 3 mp	27.01	23.72	21.87	23.10	24.16	26.26	28.55
Catch 4 mp	27.01	23.72	21.87	23.10	24.16	25.18	26.30
Catch 5 mp	27.01	23.72	21.87	23.10	24.16	24.10	24.03
Catch 6 mp	27.01	23.72	21.87	23.10	24.16	23.04	21.78
F 0.05	27.01	23.72	21.87	23.10	24.16	28.33	32.72
F 0.10	27.01	23.72	21.87	23.10	24.16	27.21	30.27
F 0.20	27.01	23.72	21.87	23.10	24.16	25.09	25.97
F 0.25	27.01	23.72	21.87	23.10	24.16	24.10	24.05
F 0.30	27.01	23.72	21.87	23.10	24.16	23.15	22.29
F 0.40	27.01	23.72	21.87	23.10	24.16	21.37	19.16
F 0.50	27.01	23.72	21.87	23.10	24.16	19.73	16.50
F 75max	27.01	23.72	21.87	23.10	24.16	26.10	28.00
F 90max	27.01	23.72	21.87	23.10	24.16	27.01	29.89
F0.1	27.01	23.72	21.87	23.10	24.16	26.57	28.95
F20%SPR	27.01	23.72	21.87	23.10	24.16	21.50	19.39
F30%SPR	27.01	23.72	21.87	23.10	24.16	23.77	23.41
F40%SPR	27.01	23.72	21.87	23.10	24.16	25.29	26.35
Fcurr	27.01	23.72	21.87	23.10	24.16	22.31	20.78
Fmax	27.01	23.72	21.87	23.10	24.16	25.07	25.90
Fmsy	27.01	23.72	21.87	23.10	24.16	25.07	25.90
SSB/SSBfmax							
Catch 0 mp	0.99	0.87	0.80	0.85	0.88	1.08	1.29
Catch 1 mp	0.99	0.87	0.80	0.85	0.88	1.04	1.21
Catch 2 mp	0.99	0.87	0.80	0.85	0.88	1.00	1.13
Catch 3 mp	0.99	0.87	0.80	0.85	0.88	0.96	1.05
Catch 4 mp	0.99	0.87	0.80	0.85	0.88	0.92	0.96
Catch 5 mp	0.99	0.87	0.80	0.85	0.88	0.88	0.88
Catch 6 mp	0.99	0.87	0.80	0.85	0.88	0.84	0.80
F 0.05	0.99	0.87	0.80	0.85	0.88	1.04	1.20
F 0.10	0.99	0.87	0.80	0.85	0.88	1.00	1.11
F 0.20	0.99	0.87	0.80	0.85	0.88	0.92	0.95
F 0.25	0.99	0.87	0.80	0.85	0.88	0.88	0.88
F 0.30	0.99	0.87	0.80	0.85	0.88	0.85	0.82
F 0.40	0.99	0.87	0.80	0.85	0.88	0.78	0.70
F 0.50	0.99	0.87	0.80	0.85	0.88	0.72	0.60
F 75max	0.99	0.87	0.80	0.85	0.88	0.96	1.02
F 90max	0.99	0.87	0.80	0.85	0.88	0.99	1.09
F0.1	0.99	0.87	0.80	0.85	0.88	0.97	1.06
F20%SPR	0.99	0.87	0.80	0.85	0.88	0.79	0.71
F30%SPR	0.99	0.87	0.80	0.85	0.88	0.87	0.86
F40%SPR	0.99	0.87	0.80	0.85	0.88	0.93	0.96
Fcurr	0.99	0.87	0.80	0.85	0.88	0.82	0.76
Fmax	0.99	0.87	0.80	0.85	0.88	0.92	0.95
Fmsy	0.99	0.87	0.80	0.85	0.88	0.92	0.95
Yield							
Catch 0 mp	7.59	6.02	3.27	3.27	0.00	0.00	0.00
Catch 1 mp	7.59	6.02	3.27	3.27	1.00	1.00	1.00
Catch 2 mp	7.59	6.02	3.27	3.27	2.00	2.00	2.00
Catch 3 mp	7.59	6.02	3.27	3.27	3.00	3.00	3.00
Catch 4 mp	7.59	6.02	3.27	3.27	4.00	4.00	4.00
Catch 5 mp	7.59	6.02	3.27	3.27	5.00	5.00	5.00
Catch 6 mp	7.59	6.02	3.27	3.27	6.00	6.00	6.00
F 0.05	7.59	6.02	3.27	3.27	1.08	1.26	1.45
F 0.10	7.59	6.02	3.27	3.27	2.12	2.38	2.64
F 0.20	7.59	6.02	3.27	3.27	4.07	4.23	4.38
F 0.25	7.59	6.02	3.27	3.27	5.00	4.99	4.98
F 0.30	7.59	6.02	3.27	3.27	5.88	5.65	5.45
F 0.40	7.59	6.02	3.27	3.27	7.56	6.73	6.06
F 0.50	7.59	6.02	3.27	3.27	9.11	7.51	6.33
F 75max	7.59	6.02	3.27	3.27	3.13	3.38	3.62
F 90max	7.59	6.02	3.27	3.27	2.29	2.55	2.82
F0.1	7.59	6.02	3.27	3.27	2.71	2.97	3.23
F20%SPR	7.59	6.02	3.27	3.27	7.44	6.66	6.03
F30%SPR	7.59	6.02	3.27	3.27	5.31	5.23	5.16
F40%SPR	7.59	6.02	3.27	3.27	3.89	4.07	4.24
Fcurr	7.59	6.02	3.27	3.27	6.68	6.19	5.78
Fmax	7.59	6.02	3.27	3.27	4.10	4.25	4.39
Fmsy	7.59	6.02	3.27	3.27	4.10	4.25	4.39

Projections

Measure	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
F/Fmax							
Catch 0 mp	1.97	1.61	0.88	0.83	0.00	0.00	0.00
Catch 1 mp	1.97	1.61	0.88	0.83	0.23	0.20	0.17
Catch 2 mp	1.97	1.61	0.88	0.83	0.47	0.41	0.37
Catch 3 mp	1.97	1.61	0.88	0.83	0.72	0.66	0.60
Catch 4 mp	1.97	1.61	0.88	0.83	0.97	0.93	0.89
Catch 5 mp	1.97	1.61	0.88	0.83	1.24	1.24	1.25
Catch 6 mp	1.97	1.61	0.88	0.83	1.52	1.60	1.70
F 0.05	1.97	1.61	0.88	0.83	0.25	0.25	0.25
F 0.10	1.97	1.61	0.88	0.83	0.50	0.50	0.50
F 0.20	1.97	1.61	0.88	0.83	0.99	0.99	0.99
F 0.25	1.97	1.61	0.88	0.83	1.24	1.24	1.24
F 0.30	1.97	1.61	0.88	0.83	1.49	1.49	1.49
F 0.40	1.97	1.61	0.88	0.83	1.99	1.99	1.99
F 0.50	1.97	1.61	0.88	0.83	2.48	2.48	2.48
F 75max	1.97	1.61	0.88	0.83	0.75	0.75	0.75
F 90max	1.97	1.61	0.88	0.83	0.54	0.54	0.54
F0.1	1.97	1.61	0.88	0.83	0.64	0.64	0.64
F20%SPR	1.97	1.61	0.88	0.83	1.95	1.95	1.95
F30%SPR	1.97	1.61	0.88	0.83	1.33	1.33	1.33
F40%SPR	1.97	1.61	0.88	0.83	0.95	0.95	0.95
Fcurr	1.97	1.61	0.88	0.83	1.72	1.72	1.72
Fmax	1.97	1.61	0.88	0.83	1.00	1.00	1.00
Fmsy	1.97	1.61	0.88	0.83	1.00	1.00	1.00

Table 9. Estimated benchmarks from the Final Model with the corrected dead discard weight compared with the previously presented version with incorrect values. In both cases the benchmarks assume constant recruitment (geometric mean 1984-2004) and average selectivity of last four years (2001-04). Units of biomass are pounds (MSY, SSB, Yield, Biomass, SSB virgin, YPR). The proxy for MSY is the equilibrium yield (weight of landings) associated with fishing to maximize the yield per recruit. The term virgin refers to the status of the stock before fishing commenced

Estimate	Correct dead discards wgt	Wrong dead discards wgt
Virgin Biomass	94,434,141	112,602,438
Biomass 1963	52,164,906	58,695,660
SSB 2004	27,006,631	25,296,064
F 2004	0.396	0.373
Avg Recruitment 84-04	2.05	1.53
MSY	4,941,640	3,704,781
F at max. Y/R	0.201	0.194
F 75% of Fmax	0.151	0.146
Y/R maximum	2.4	2.4
S/R at Fmax	6.05	5.69
SPR at Fmax	0.38	0.38
SSB at Fmax	27,318,364	19,175,744
SSB at 75% Fmax	33,507,402	23,680,296
F 0.1	0.129	0.125
Y/R at F0.1	2.3	2.3
SSB at F0.1	36,796,479	26,019,841
F 20% SPR	0.392	0.362
F 30% SPR	0.267	0.249
F 40% SPR	0.190	0.178
Y 75% of Fmax	4,824,244	3,616,331
F2004/Fmax	1.97	1.92
SSB2004/SSBmax	0.99	1.32

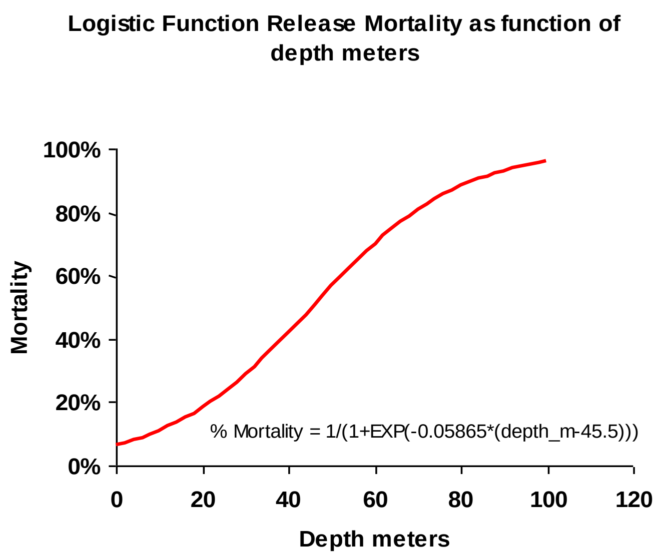


Figure 1. Estimated depth-mortality function for Gag Gulf of Mexico stock from research data compiled by the life historic group at the SEDAR10-Data Workshop.

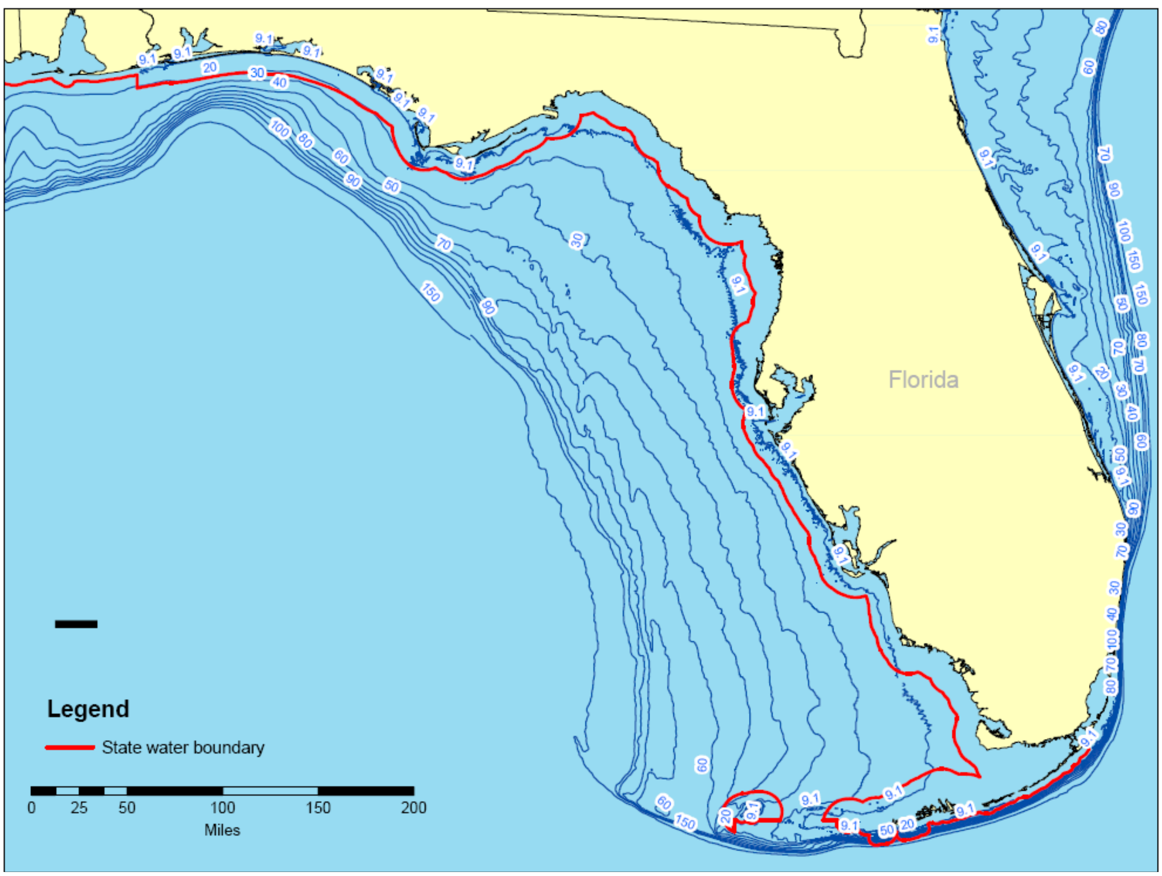


Figure 2. Depth contours for the Florida West coast. Red line defines the boundary for State waters. Courtesy of the SERO.

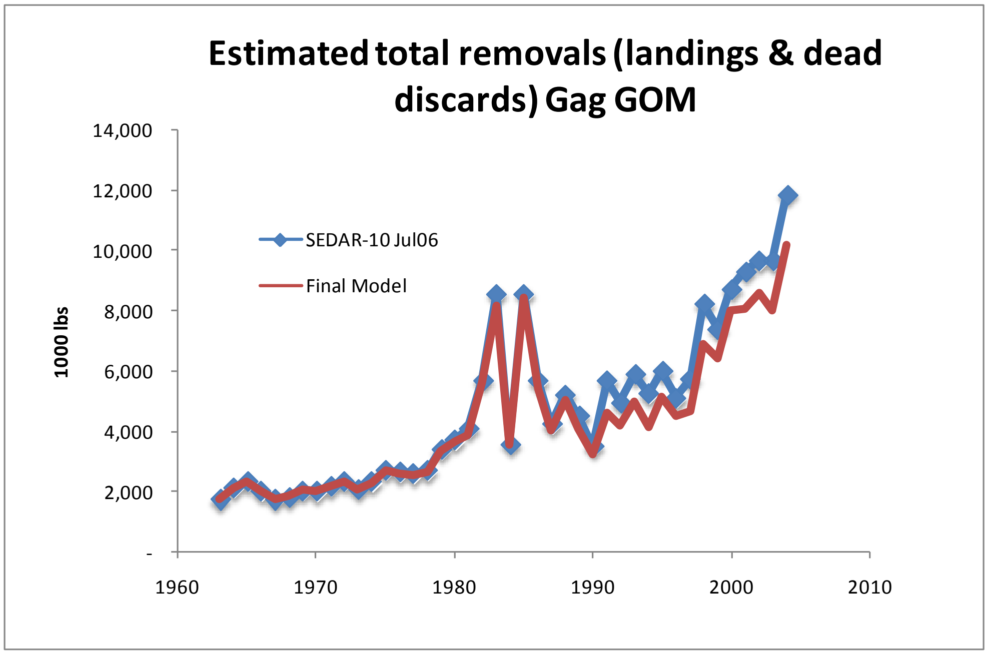


Figure 3. Comparison of estimated total removals (landings + dead discards) in weight for Gulf of Mexico gag grouper between the Final Model and the SEDAR10-Jul06 model.

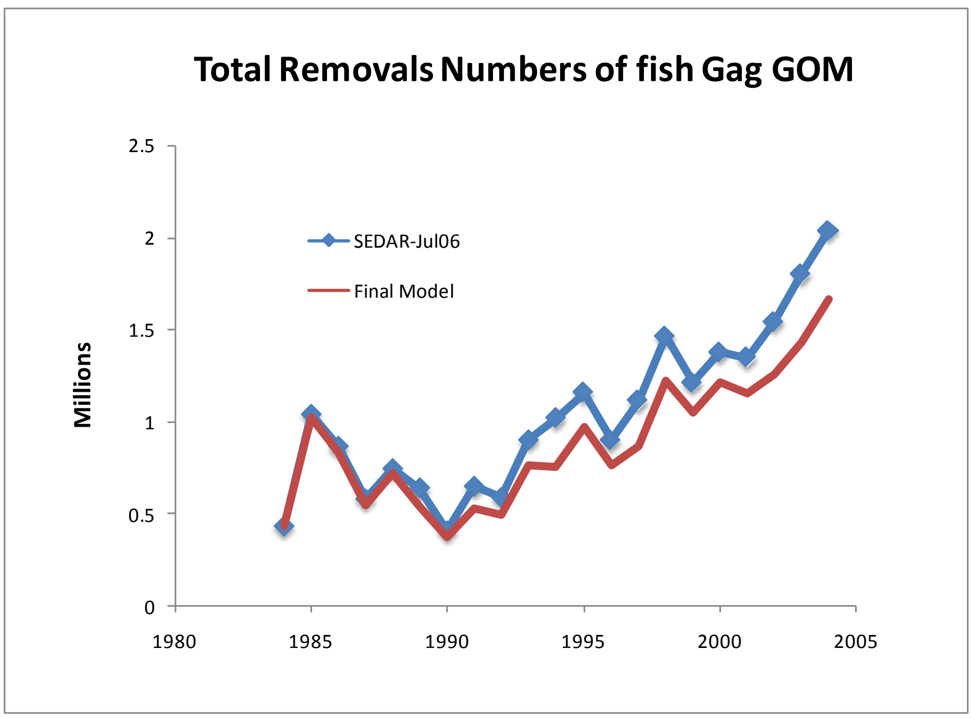


Figure 4. Comparison of estimated total removals in numbers of fish (landings + dead discards) for Gulf of Mexico gag grouper between the Final Model and the SEDAR10-Jul06 model.

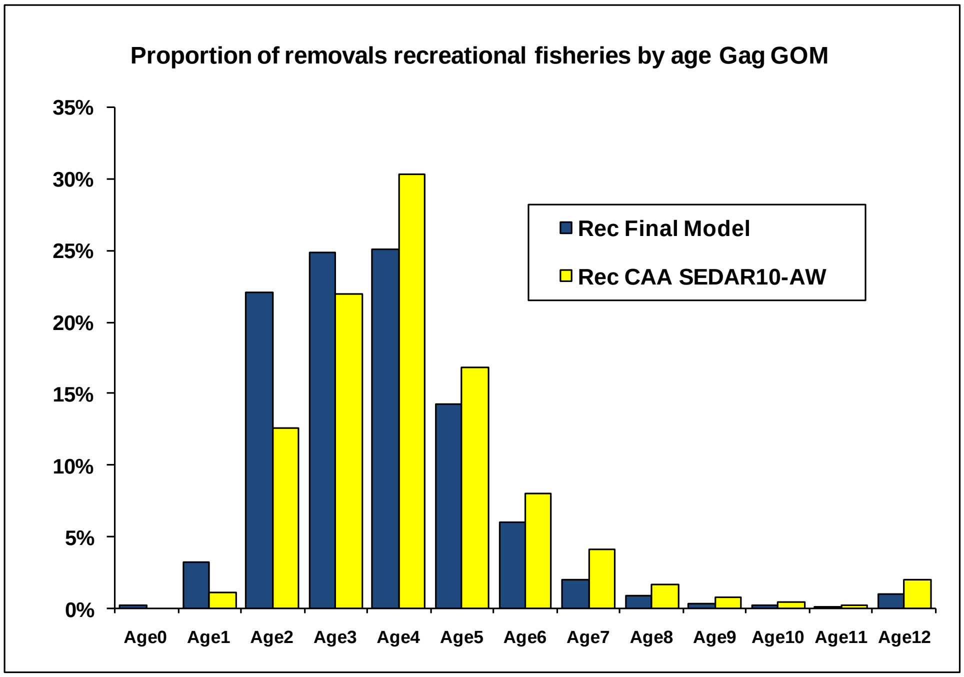


Figure 5. Average proportion of Catch at Age (CAA) for the recreational fisheries removals (landings + dead discards) between the SEDAR-10 Jul06 model and the Final Model.

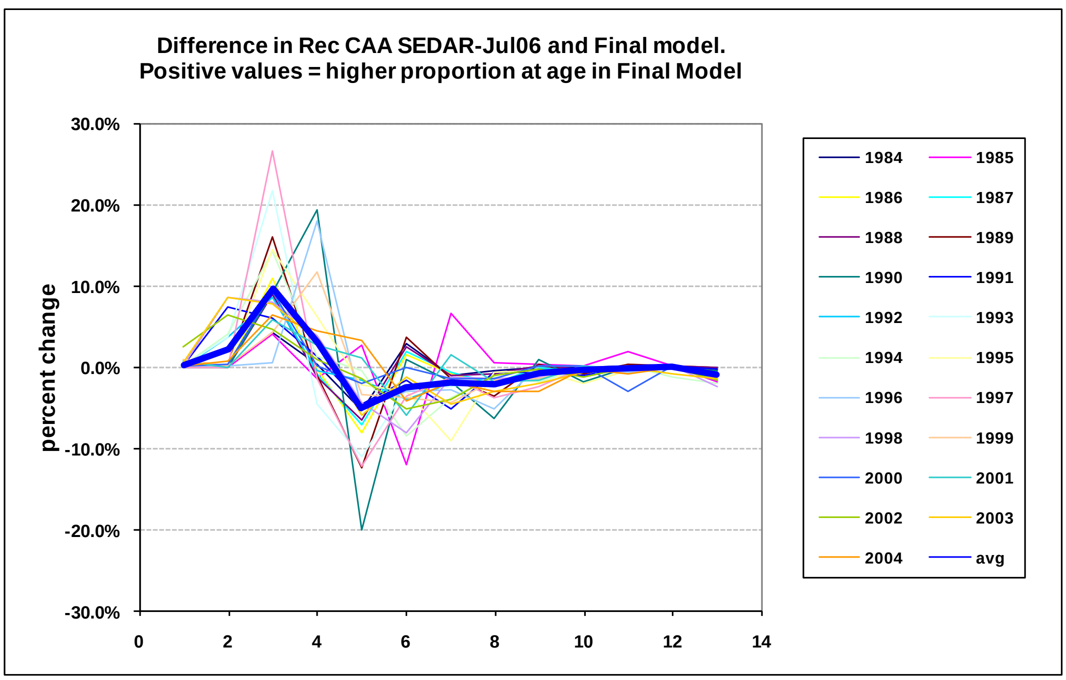


Figure 6. Differences in the recreational Catch-at-age (CAA) between the SEDAR10-Jul06 and Final Model. Positive deviations indicate a higher proportion at age in the Final Model. Thick line is the average over all years. The x-axis is the age-class.

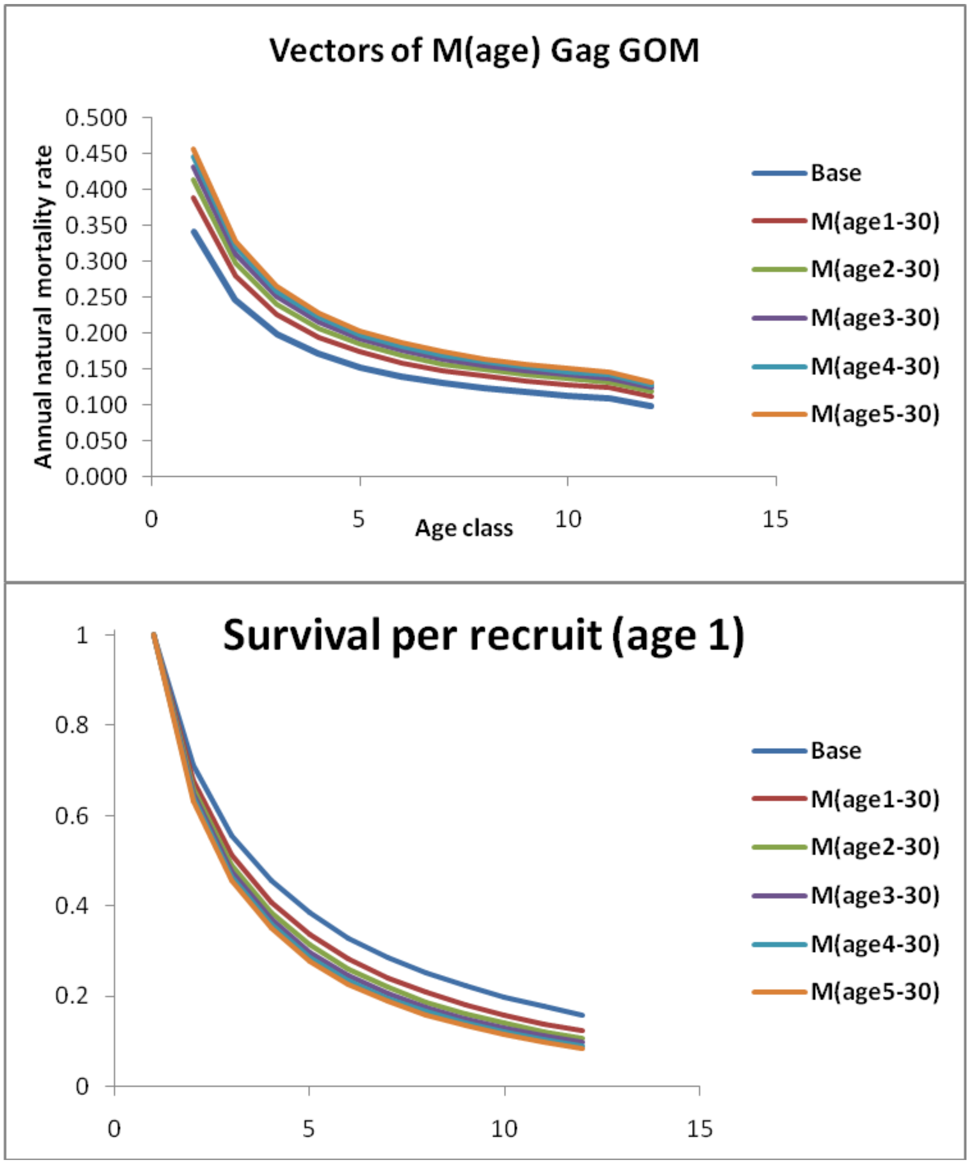


Figure 7. Upper plot show the natural mortality at age vector, M (age), obtained by scaling the Lorenzen curve over the different age ranges. The base case used all ages from 0 to 30. Bottom plot shows the survival per recruit (age-1) under the different natural mortality M (age) vectors.

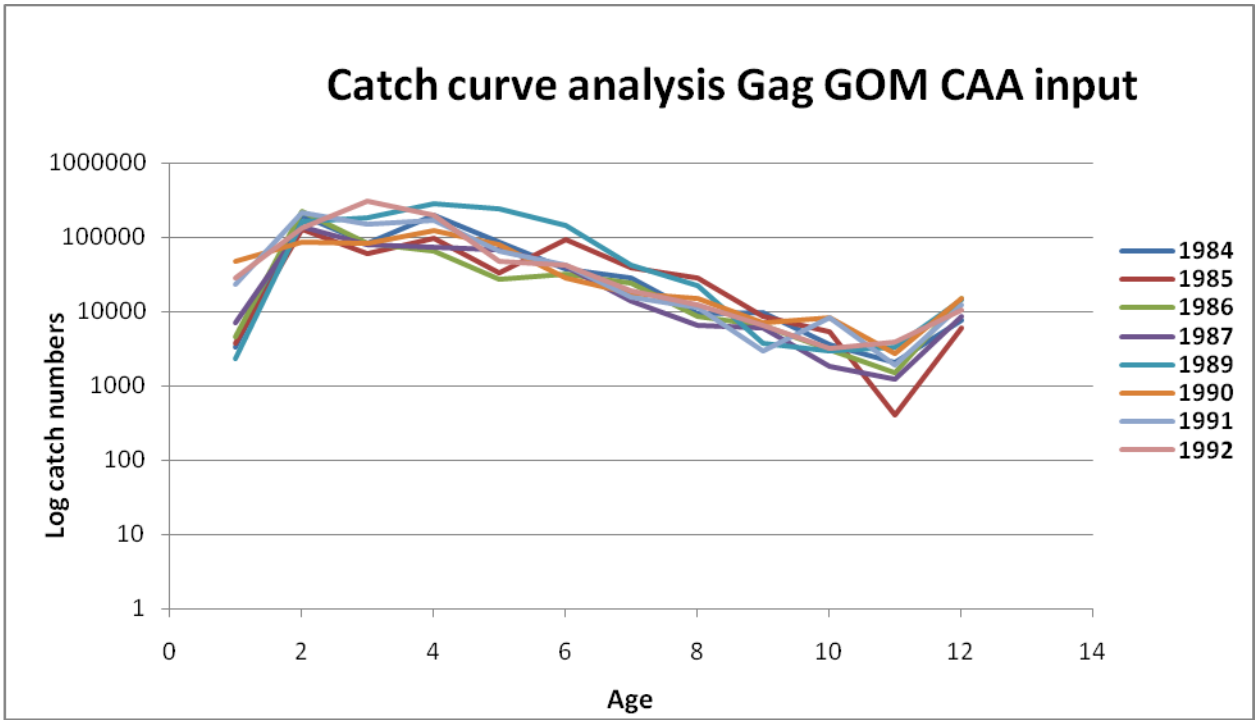


Figure 8. Catch curve analysis of cohorts 1984-1992 gag Gulf stock derived from the catch-at-age input to CASAL Final Model. Age class 3 was determined as the ‘fully recruited’ age class.

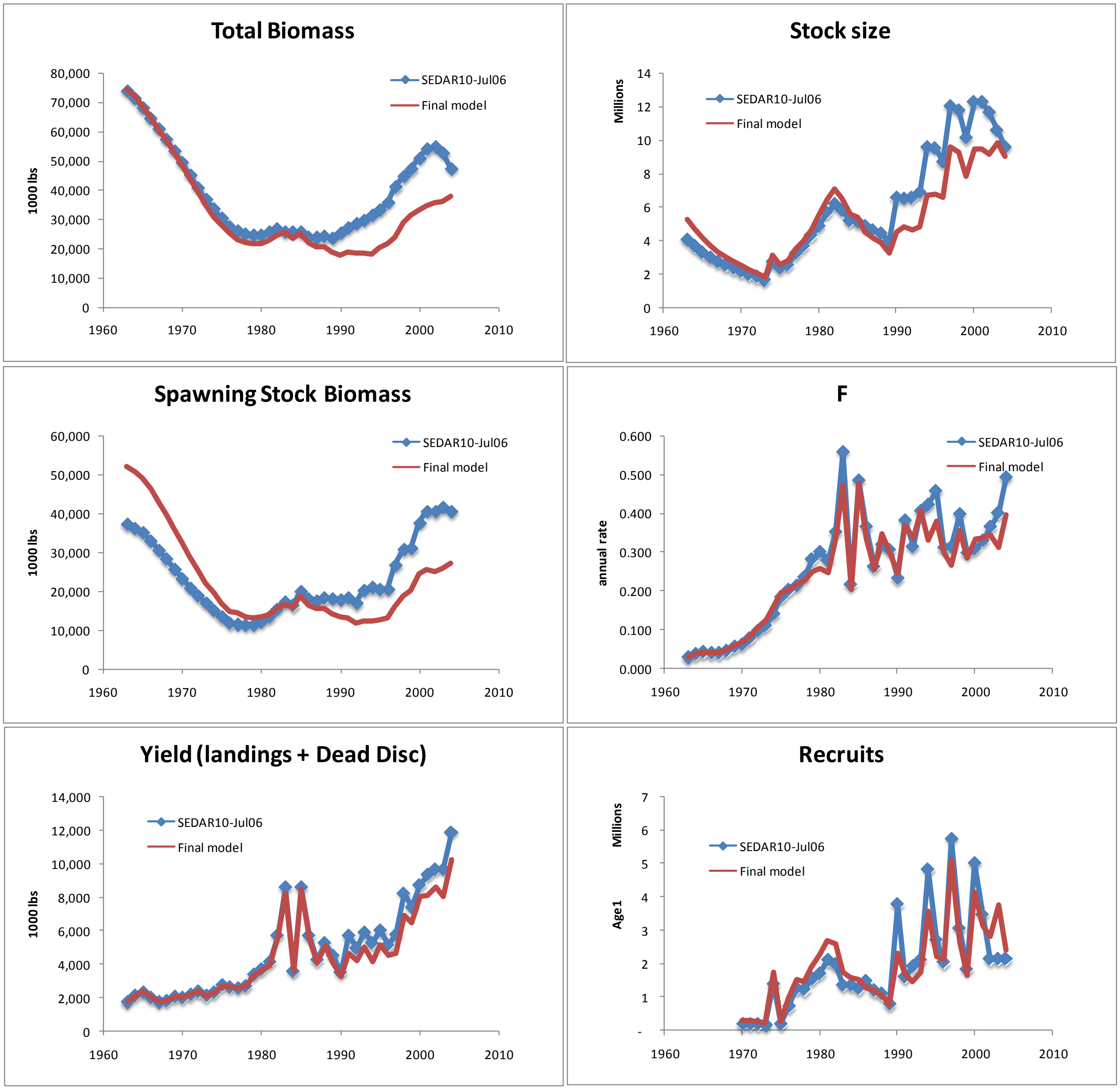


Figure 9. Estimates of Total Biomass, Stock Size, Spawning Stock Biomass (female component), fishing mortality rate (F), Yield (landings & dead discards) and recruitment from the CASAL Final Model (solid red line). For comparison estimates from the SEDAR-10 Jul06 run are shown (diamond marker line).

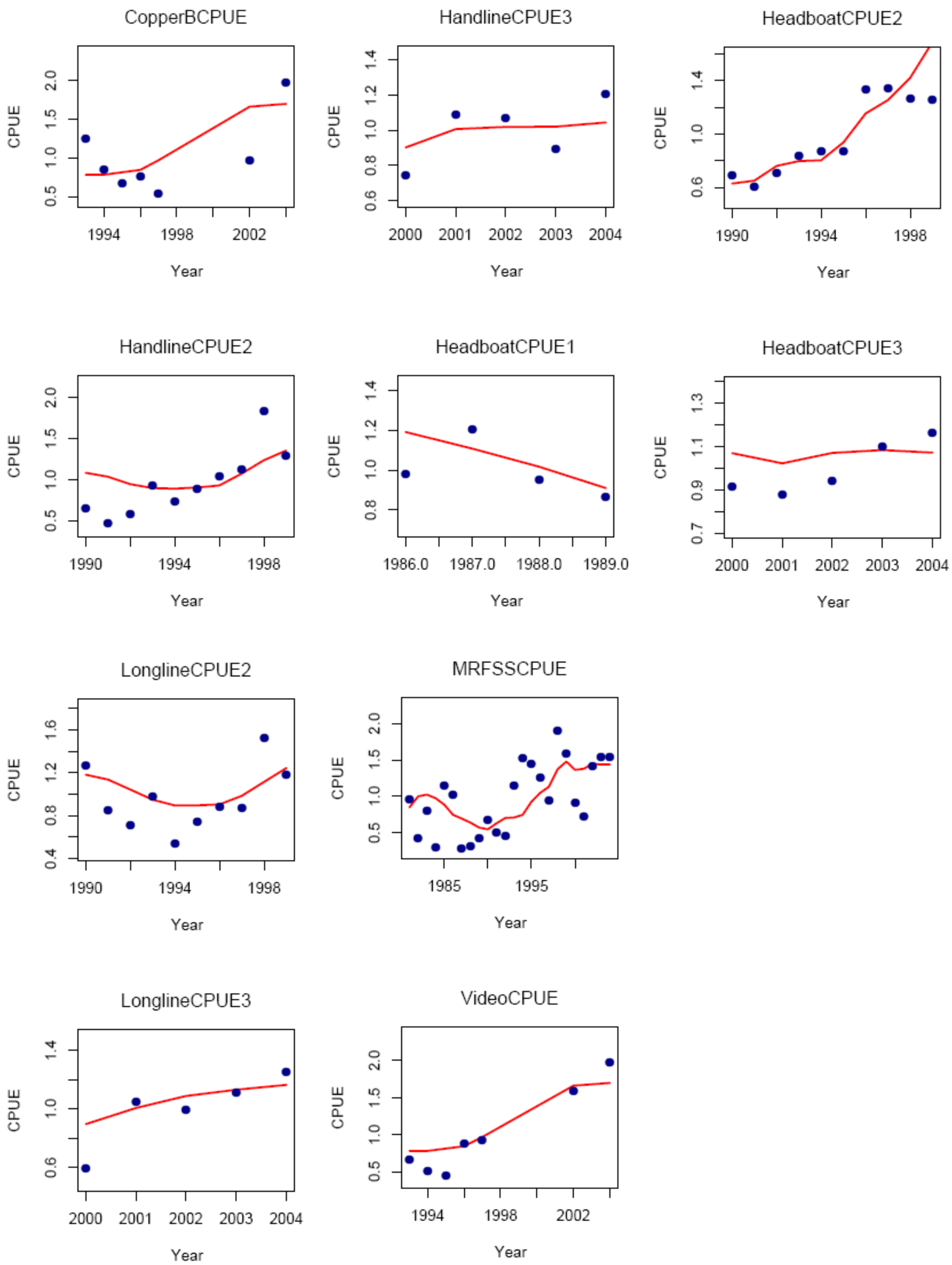


Figure 10. Plots of observed (blue dots) and fitted (red solid line) relative indices of abundance for Gag Gulf stock Final Model. SEAMAP video survey indices (CopperB & Video) are fisheries independent indices, all other are fishery dependent relative indices of abundance.

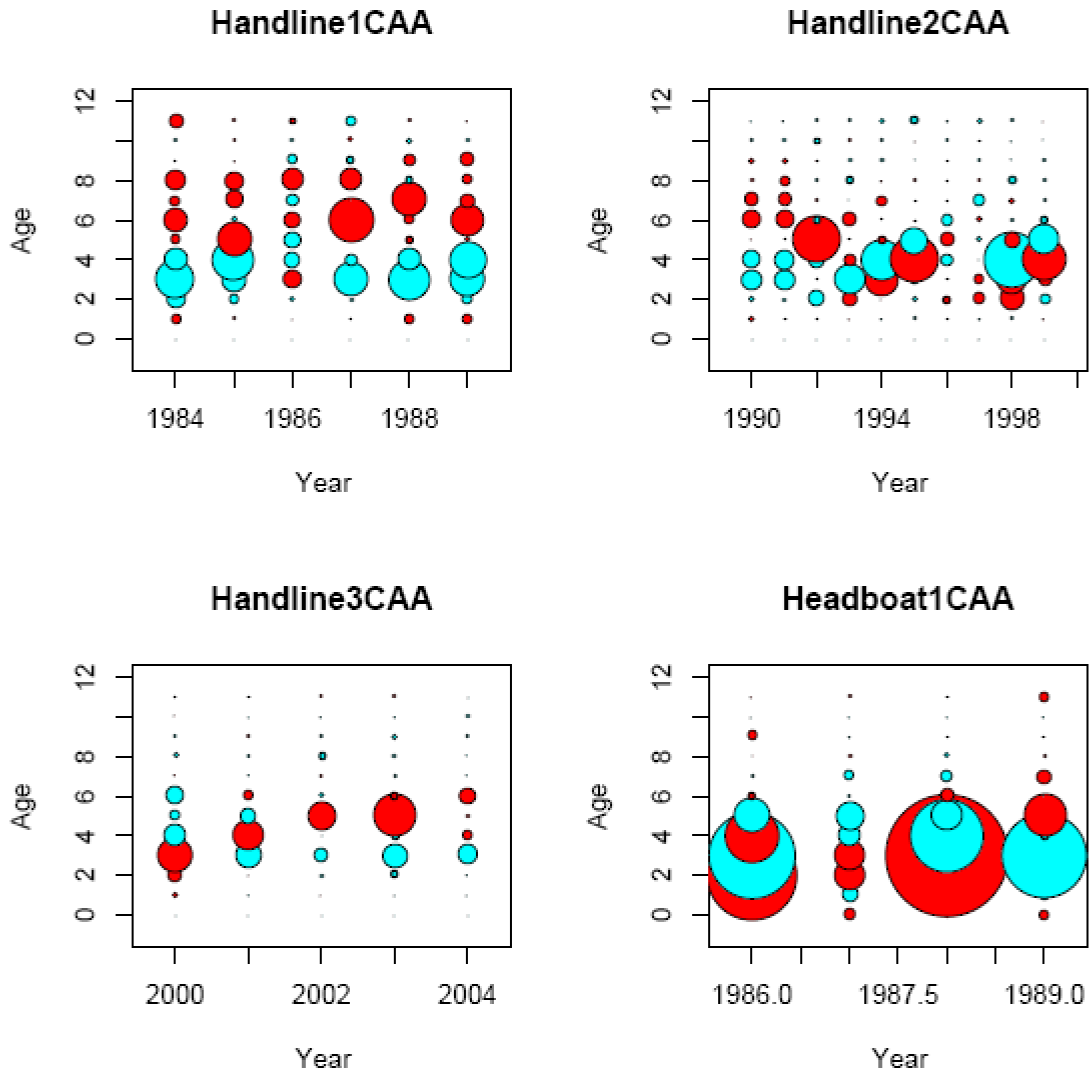
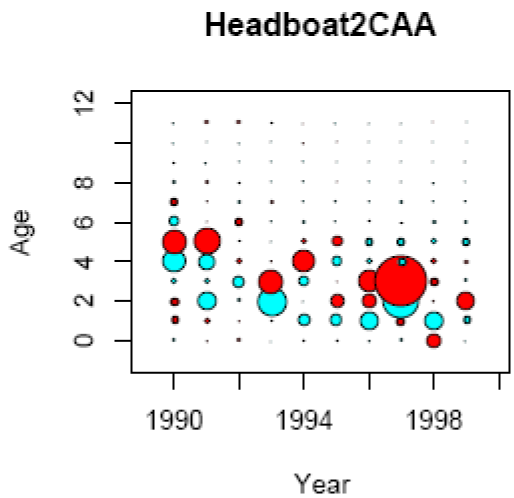
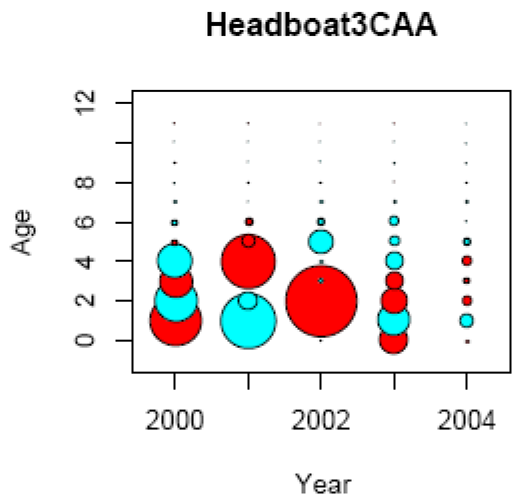
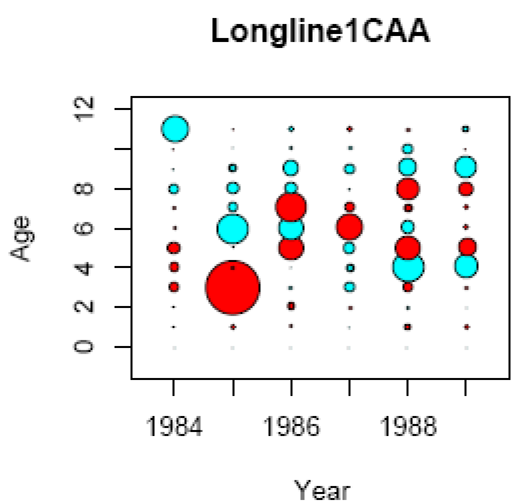
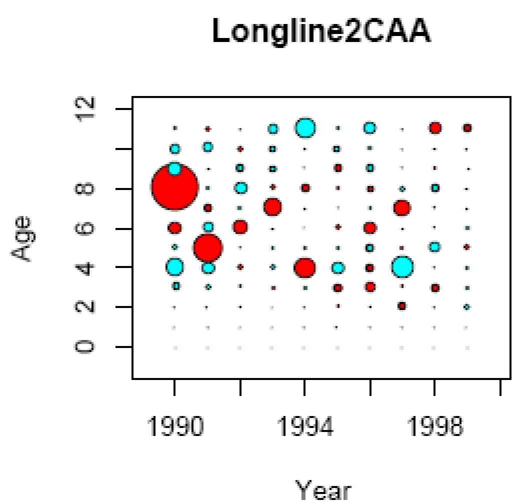


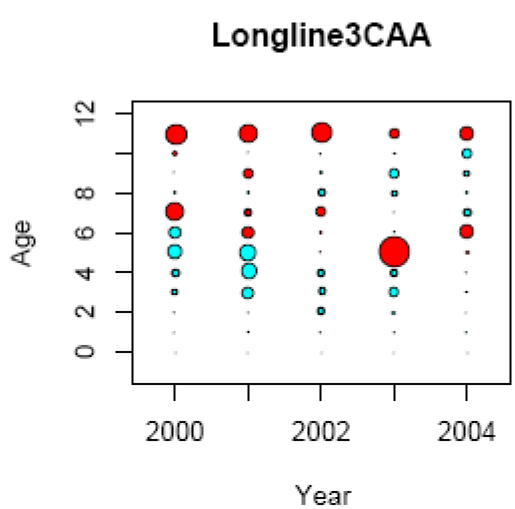
Figure 11. Bubble plots of fit(s) to partial CAA inputs from the Final Model by fishery. Size of the bubble is proportional to the residual magnitude, light blue circles indicate negative residuals, and red circles indicate positive residuals by age and year.

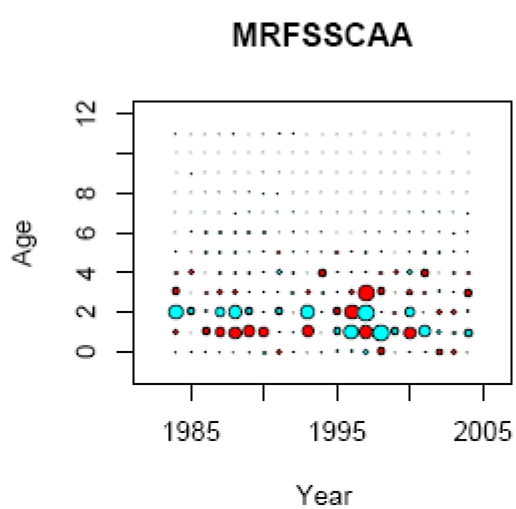

Headboat2CAA
Age
0
2
4
6
8
12
1990
1994
1998
Year


Headboat3CAA
Age
0
2
4
6
8
12
2000
2002
2004
Year


Longline1CAA
Age
0
2
4
6
8
12
1984
1986
1988
Year


Longline2CAA
Age
0
2
4
6
8
12
1990
1994
1998
Year


Longline3CAA
Age
0
2
4
6
8
12
2000
2002
2004
Year


MRFSSCAA
Age
0
2
4
6
8
12
1985
1995
2005
Year

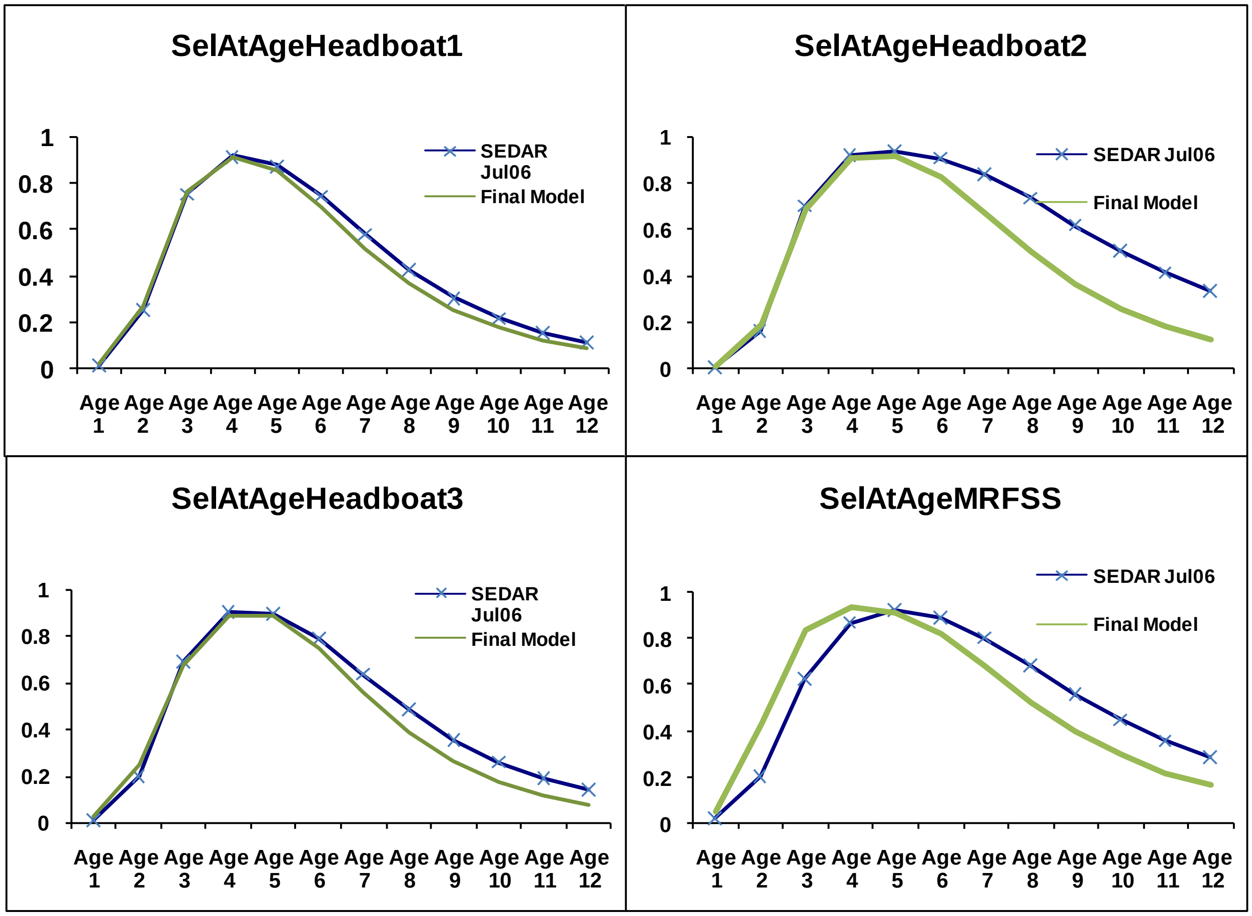


Figure 12. Model estimated selectivity at age for the recreational fisheries. Comparison of the selectivity curves between SEDAR10-Jul06 (blue marker line) model and Final Model (solid green line).

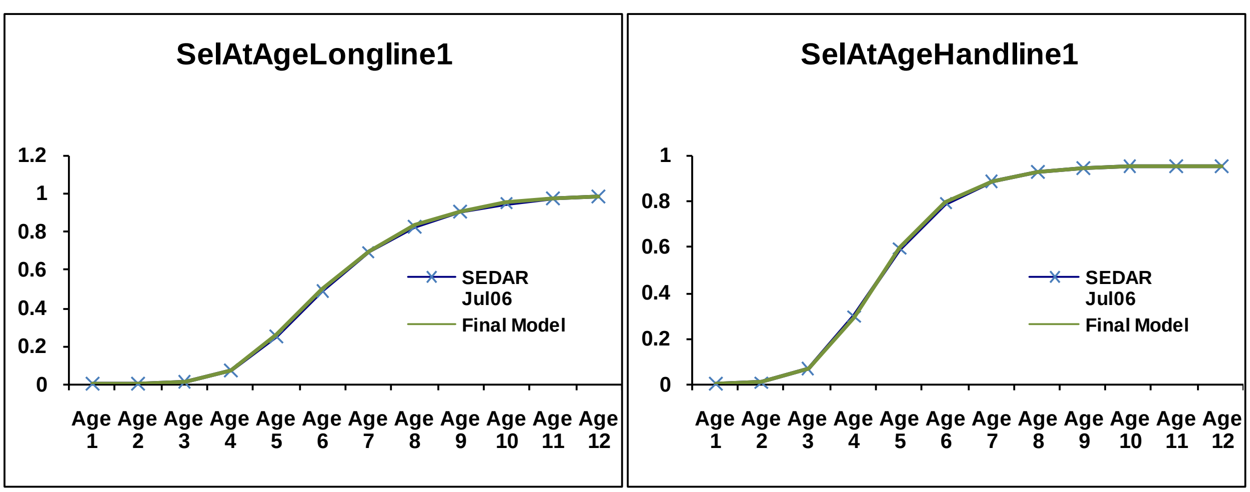


Figure 13. Model estimated selectivity at age for the commercial fisheries. Comparison of the selectivity curves between SEDAR10-Jul06 (blue marker line) model and Final Model (solid green line).

Figure 14. Final Model Stock Projections under scenarios of constant catch (left column plots) of 0, 1, 2, 3, 4, 5 and 6 million pounds starting in 2008 year, and constant fishing mortality rate (center and right column plots) of F 0.05, 0.10, 0.15, 0.20. 0.25, 0.30, 0.40, 0.50., $F_{75\%max}$, $F_{90\%max}$ (center plots), $F_{0.1}$, $F_{20\%SPR}$, $F_{30\%SPR}$, $F_{40\%SPR}$, F_{Curr} (avg F of 2001-04), F_{max}, and F_{MSY} (right plots) starting in 2008 (see text for details).

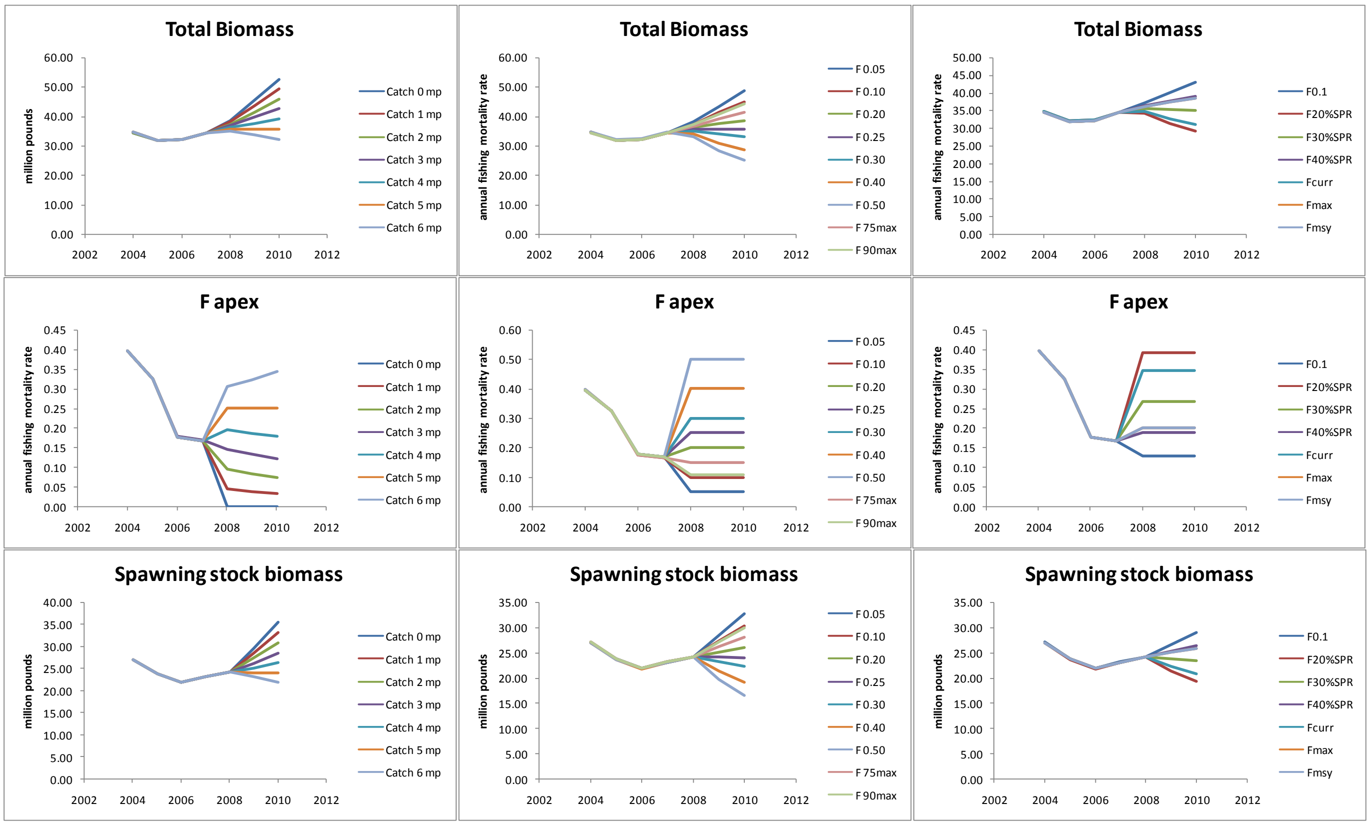


Figure 14 continuation. Final Model Stock Projections under scenarios of constant catch (left column plots) of 0, 1, 2, 3, 4, 5 and 6 million pounds starting in 2008 year, and constant fishing mortality rate (center and right column plots) of F 0.05, 0.10, 0.15, 0.20. 0.25, 0.30, 0.40, 0.50., $F_{75\%max}$, $F_{90\%max}$ (center plots), $F_{0.1}$, $F_{20\%SPR}$, $F_{30\%SPR}$, $F_{40\%SPR}$, F_{Curr} (avg F of 2001-04), F_{max}, and F_{MSY} (right plots) starting in 2008 (see text for details).