**Projections of Gulf of Mexico greater amberjack, *Seriola dumerili*, from 2003 through 2012**

by

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February 27, 2002

SFD-01/02- 150

Projections of Gulf of Mexico greater amberjack were conducted at the request the Gulf of Mexico Fishery Management Council (memorandum from W. Swingle to J. Powers dated 5 Feb. 2002). The basic information and approaches were those used by the Reef Fish Stock Assessment Panel in developing their management advice (Anon. 2000) from the assessment of Turner *et al.* (2000). Projections were conducted to estimate yield streams associated with $F_{30\%}$ and $F_{40\%}$, (fishing mortality rates which result in equilibrium spawning potential ratios [SPRs] of 30% and 40%), to illustrate two constant catch rebuilding scenarios which would rebuild the stock to $SSB_{30\%}$ (spawning stock biomass at 30% SPR) within 10 years, and a scenario with constant catch followed by constant fishing mortality rate. The first constant catch scenario held catch constant for 10 years starting in 2003, while the second catch constant scenario and the scenario with constant catch followed by constant fishing mortality rate used two five year periods.

## Materials and Methods

### *Catches*

Turner *et al.*'s assessment used catches through 1998. For these projections 1999 through 2002 catches were tabulated and/or estimated. Catches in 2002 were estimated from the average of the catches in 1999-2001.

Commercial landings were tabulated for 1999-2000 and parts of 2001 from the accumulated landings data base at the Southeast Fisheries Science Center (SEFSC). Catches from month-state

strata in 2001 for which reported commercial landings were considered incomplete (Josh Bennet, pers comm); generally those incomplete catches were estimated from state specific monthly averages from 1998-2000 (the exception was Louisiana for which the reported 2001 total was used even though possibly incomplete, because it was slightly larger than the sum of (1) the reported landings for months considered complete and (2) the estimated landings for the months considered incomplete). Commercial dead discards in 1999-2001 were estimated as a fraction of the number of fish landed; that fraction discarded dead was the same as used by Cummings *et al.* (2000). The number of greater amberjack landed by the commercial fishery was calculated using the 1996-1998 average weight from Cummings *et. al.* and the weight of the discards was estimated using that same average.

Recreational harvest and additional dead discards were tabulated and/or estimated for the MRFSS (Marine Recreational Fisheries Statistics Survey), headboat and Texas Parks and Wildlife Department data sets. Harvest refers to A+B1 for MRFSS and the catches reported by the headboat and Texas surveys; the B1 catches may include some fish discarded dead at sea as well as landed fish and fish used as bait. Dead discards as used in this document for MRFSS refers to the proportion of the released alive catch (B2) which are assumed to eventually die due to being released. MRFSS estimates were available through 2001; the estimates based on the old charter boat survey methodology were used to maintain consistency in the time series. Twenty percent of the fish released alive (B2) were assumed to die and their sizes were assumed to be the same as for the landed catch following the approach of Cummings *et al.* (2000). Headboat and Texas estimates were only available for 1999; harvest estimates for 2000 and 2001 were calculated from the average of 1997-1999 harvest estimates from those surveys. Headboat dead discards were estimated as a constant fraction of the harvest, as had Cummings *et al.* (2000). Texas dead discards were estimated using the annual fraction of dead discards calculated from the MRFSS data. Dead discards were assumed to have the same average weight as the landed catch. For the headboat fishery the 1999 average weight was available and used for that year; the average of the 1997-1999 average weights was used for 2000 and 2001. For the Texas data the annual MRFSS averages were used. The estimates of dead discards from the MRFSS statistics increased substantially in 2001; while the estimates of B2 catches were higher for most waves in 2001 compared to previous years, large increases in the first two waves accounted for much of the increase and could be statistical artifacts rather than an indication of a new pattern in the fishery.

*Projections*

The projections were based on bootstrapped VPA results reported in Turner *et al.* (2000) for the VPA which used three indices of abundance, an F-ratio of 1 (used to calculate the fishing mortality rate on the oldest age group in the VPA in each year) and a hockey stick stock recruitment relationship. Turner *et al.* conducted 800 bootstraps; 200 with an assumed natural mortality rate (M) of 0.15, 400 with an assumed M of 0.25 and 200 with an assumed M of 0.35.

Projections were conducted for 2003 through 2012 so that rebuilding periods of 10 years could be considered. Two constant fishing mortality rate scenarios, two constant catch scenario and

one combined (constant catch followed by constant fishing mortality) scenario were projected. The constant fishing mortality rates used $F_{30\%}$ and $F_{40\%}$. One constant catch scenario was for 10 years and the other was for two five year periods. Constant catch scenarios were chosen so that (1) median fishing mortality rates did not exceed $F_{30\%}$ (assumed to be the $F_{MSY}$ proxy) in any year and (2) by 2012 (a) the median fishing mortality rate equal to or less than $F_{40\%}$ (assumed to be the proxy for $F_{OY}$) and (b) the spawning stock size was equal to or greater than the minimum stock size threshold [MSST which was defined as SSB*(1-M)].

**Results**

The total weight of removals (landings plus dead discards) in 1999 and 2000 (1,473,729 and 1,769,119 lb respectively, Table 1) were lower than the 2,035,167 lb assumed for the projections in the 2000 assessment (Turner *et al.* 2000). In contrast the estimated 2001 removals were larger than the projected yields in 2001 under the $F_{30\%}$ and $F_{40\%}$ scenarios used by the Stock Assessment Panel in 2000 for formulating their management advice.

The weight of dead discards is included in the projected removals. In the most recent three years (1999-2001) dead discards have accounted for 23% (13-40%) of the total weight of greater amberjack killed by fishing in the Gulf of Mexico (Table 1). Projected removal weight should be reduced by the fraction that would be discarded dead to estimate projected harvest (commercial landings and recreational A+B1).

The dispersion in estimated status of the resource with respect to management reference points ($F_{30\%}$ and $SSB_{30\%}$) at the start of 2003 is shown in Figure 1. That dispersion is much broader than at the start of 1999 (Turner *et al.* 2000) as shown in Figure 2 (from Turner *et al.* Figure 16), because of the variability in recruitment projected from 1999-2002. Also notable from Figures 1 and 2 is the projected improvement in the status relative to management reference points; that improvement would be due to increasing recruitment projected from increasing spawning stock size and the assumed stock recruitment relationship (Figure 3 which is from Figure 15 in Turner *et al.*).

The projections indicated rapid recovery of spawning stock biomass from the levels in the late 1990s. At least one reason for the rapid recovery is the increase in recruitment with increasing spawning stock biomass modeled by the stock recruitment relationship adopted by the Panel. If recruitment actually increases more slowly, the projections would be overly optimistic. The three observations with the higher recruitment and spawning stock sizes in Figure 3 were from the earliest years in the VPA (1987-1989) while other lower observations were from 1990-1995 (the 1996-1998 observations were not included in the estimation of the stock-recruitment function because of uncertainty in most recent recruitments in VPA). Whether these differences in stock recruitment levels reflect amberjack population dynamics, environmental changes or problems with historical data is not known.

Preliminary examination of projections showed that a harvest of 4 million pounds in 2003 would be obtained by fishing at $F_{30\%}$ and that in subsequent years fishing mortality would not exceed $F_{30\%}$ if that level were maintained. Similarly, preliminary examination of projections from 2008-2012 (after 4 million lb constant catch in 2003-2007) indicated that a harvest of 7.5 million pounds would result in a fishing mortality rate slightly less than $F_{40\%}$ in 2012. Therefore the two constant catch scenarios were defined as (1) 4 million lb in 2003-2012 and (2) 4 million lb in 2003-2007 and 7.5 million lb in 2008-2012.

The results of the five projected scenarios are shown in Table 2 which includes information on input weight of the removals (landings and dead discards) for 1987-2002 and the projected yields, spawning stock biomass with respect to $SSB_{30\%}$ and $SSB_{40\%}$ and fishing mortality rates with respect to $F_{30\%}$ and $F_{40\%}$. Empirical 80% confidence limits are given.

The trends in management reference point statistics (median spawning stock biomass and fishing mortality rate relative to the management benchmarks estimated from the 1996-1998 selectivity pattern) are shown in Figure 4. The VPA results (1987-1998) indicated that spawning stock had been over-fished and that the fishing mortality rate declined from the early 1990's to 1998. The projections indicated continued reductions in fishing mortality rate through 2002 with little increase in the spawning stock. After 2002 the spawning stock was projected to increase.

The trends in median historical and projected weight of the removals (landings and dead discards) are shown in Figure 5.

The distribution of projected yields in 2003, 2005, 2008 and 2012 from the constant fishing mortality rate scenarios are shown in Figure 6. The broad range in yields under constant fishing mortality rate scenarios is reflective of the wide variation in projected population sizes.

The distribution of projected fishing mortality rates in 2003, 2005, 2008 and 2012 from constant catch scenarios are shown in Figure 7. The median estimates of $F_{30\%}$ and $F_{40\%}$ from the analyses reported on Turner *et al.* (2000) were 0.18 and 0.25 (the deterministic estimates were 0.12 and 0.17 respectively with the difference between the deterministic and the median indicating non-linear estimation bias). The relatively high frequency of projected fishing mortality rates above those levels in 2003 (4 million lb removal) and especially in 2008 and 2012 under the scenario with two constant catches shows that fishing mortality rates would be excessive for many of the simulated populations.

In Figure 9 the probabilities that fishing mortality rates would exceed $F_{30\%}$ are shown for the constant catch scenarios; they are about 50% in 2003 and decline to about 20% by 2007, but increase in 2008 to about 35% under the scenario which included removing 7.5 million lb in that year. The probabilities that the spawning stock biomass would be less that $SSB_{30\%}$ declined from about 90% in 2003 to roughly 3-30% in 2012, while the probability that spawning stock biomass would be less than MSST (the minimum stock size threshold - assumed to be $(1\text{-}M)*SSB_{30\%}$) declined from near 100% to

25-65% in 2012 (Figure 9).

**Discussion**

Projections are inherently uncertain because future stock and fishery conditions can not be known. In these projections the level of uncertainty in increased because the earliest projected removals (in 2003) occur five years after the latest population estimates derived from the VPA rather than the usual 2-3 years.

**Literature Cited**

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Table 1. Gulf of Mexico greater amberjack removals (in pounds) for 1999-2002. The 2002 weight was estimated from the average of the 1999-2001 values so sector specific removals were not calculated. For the recreational fisheries harvest which includes landings and may include any fish used as bait and/or discarded dead, while dead discards refers to fish released alive which eventually are assumed to die.

| | commercial | | MRFSS | | headboat | | Texas PWD | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | landings | dead discards | harvest | dead discards | harvest | dead discards | harvest | dead discards | harvest | dead discards | total |
| 1999 | 622,081 | 90,742 | 580,815 | 97,067 | 73,509 | 6,836 | 2,317 | 362 | 1,278,721 | 195,008 | 1,473,729 |
| 2000 | 794,952 | 115,959 | 609,631 | 137,710 | 95,397 | 8,872 | 5,392 | 1,205 | 1,505,372 | 263,746 | 1,769,119 |
| 2001 | 661,668 | 96,517 | 775,133 | 916,803 | 95,397 | 8,872 | 6,186 | 6,012 | 1,538,385 | 1,028,204 | 2,566,588 |
| 2002 | | | | | | | | | | | 1,936,479 |

Table 2. Input (1987-2002) and projected (2003-2012) yield, relative spawning stock biomass (SSB) and fishing mortality rates (F) for Gulf of Mexico greater amberjack. Empirical 80% confidence limits are shown.

| scenario | year | low | median | high | low | median | high | low | median | high | low | median | high | low | median | high |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1987 | 10230. | 10230. | 10230. | 0.14 | 0.34 | 0.70 | 0.16 | 0.45 | 1.08 | 1.61 | 2.48 | 4.15 | 2.26 | 3.46 | 5.88 |
| | 1988 | 9648. | 9648. | 9648. | 0.16 | 0.37 | 0.73 | 0.18 | 0.50 | 1.12 | 2.13 | 3.33 | 5.47 | 2.99 | 4.65 | 7.75 |
| | 1989 | 13730. | 13730. | 13730. | 0.12 | 0.27 | 0.52 | 0.14 | 0.36 | 0.80 | 2.77 | 4.28 | 6.95 | 3.89 | 5.97 | 9.84 |
| | 1990 | 3119. | 3119. | 3119. | 0.07 | 0.18 | 0.35 | 0.09 | 0.24 | 0.53 | 1.35 | 2.13 | 3.54 | 1.89 | 2.97 | 5.01 |
| | 1991 | 7102. | 7102. | 7102. | 0.09 | 0.21 | 0.40 | 0.11 | 0.28 | 0.61 | 1.66 | 2.55 | 4.14 | 2.34 | 3.56 | 5.86 |
| | 1992 | 9311. | 9311. | 9311. | 0.10 | 0.23 | 0.43 | 0.12 | 0.31 | 0.66 | 2.17 | 3.30 | 5.34 | 3.04 | 4.62 | 7.55 |
| | 1993 | 7436. | 7436. | 7436. | 0.08 | 0.19 | 0.36 | 0.10 | 0.25 | 0.55 | 2.38 | 3.70 | 6.08 | 3.34 | 5.17 | 8.59 |
| | 1994 | 5070. | 5070. | 5070. | 0.06 | 0.15 | 0.29 | 0.07 | 0.20 | 0.45 | 2.12 | 3.36 | 5.69 | 2.96 | 4.72 | 8.07 |
| | 1995 | 2731. | 2731. | 2731. | 0.05 | 0.13 | 0.26 | 0.06 | 0.17 | 0.39 | 1.22 | 1.97 | 3.47 | 1.71 | 2.76 | 4.93 |
| | 1996 | 3245. | 3245. | 3245. | 0.06 | 0.15 | 0.31 | 0.07 | 0.21 | 0.48 | 1.23 | 1.99 | 3.59 | 1.72 | 2.78 | 5.08 |
| | 1997 | 2777. | 2777. | 2777. | 0.08 | 0.20 | 0.41 | 0.09 | 0.27 | 0.62 | 0.94 | 1.51 | 2.76 | 1.31 | 2.11 | 3.91 |
| | 1998 | 2611. | 2611. | 2611. | 0.10 | 0.25 | 0.48 | 0.12 | 0.33 | 0.73 | 0.86 | 1.75 | 3.51 | 1.21 | 2.44 | 4.91 |
| | 1999 | 1474. | 1474. | 1474. | 0.11 | 0.23 | 0.43 | 0.12 | 0.31 | 0.66 | 0.46 | 0.75 | 1.25 | 0.65 | 1.06 | 1.74 |
| | 2000 | 1769. | 1769. | 1769. | 0.11 | 0.22 | 0.43 | 0.13 | 0.30 | 0.64 | 0.53 | 0.91 | 1.52 | 0.75 | 1.27 | 2.13 |
| | 2001 | 2567. | 2567. | 2567. | 0.10 | 0.20 | 0.39 | 0.12 | 0.27 | 0.56 | 0.63 | 1.09 | 1.91 | 0.89 | 1.53 | 2.70 |
| | 2002 | 1936. | 1936. | 1936. | 0.12 | 0.25 | 0.49 | 0.15 | 0.34 | 0.71 | 0.35 | 0.62 | 1.15 | 0.49 | 0.86 | 1.61 |
| F 30% SPR | 2003 | 2044. | 3991. | 6826. | 0.19 | 0.37 | 0.72 | 0.24 | 0.50 | 1.03 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |
| F 30% SPR | 2004 | 2339. | 4647. | 7680. | 0.24 | 0.44 | 0.76 | 0.31 | 0.59 | 1.08 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |
| F 30% SPR | 2005 | 2744. | 5439. | 8408. | 0.26 | 0.49 | 0.83 | 0.35 | 0.65 | 1.15 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |
| F 30% SPR | 2006 | 3237. | 6326. | 9160. | 0.32 | 0.57 | 0.94 | 0.43 | 0.76 | 1.27 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |
| F 30% SPR | 2007 | 3785. | 7127. | 9805. | 0.37 | 0.66 | 1.02 | 0.51 | 0.87 | 1.44 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |
| F 30% SPR | 2008 | 4132. | 7707. | 10420. | 0.43 | 0.74 | 1.11 | 0.59 | 0.96 | 1.50 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |
| F 30% SPR | 2009 | 4608. | 8142. | 10770. | 0.48 | 0.79 | 1.16 | 0.65 | 1.03 | 1.58 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |
| F 30% SPR | 2010 | 5000. | 8499. | 10960. | 0.53 | 0.83 | 1.21 | 0.73 | 1.08 | 1.64 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |
| F 30% SPR | 2011 | 5636. | 8762. | 11180. | 0.57 | 0.88 | 1.23 | 0.79 | 1.15 | 1.68 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |
| F 30% SPR | 2012 | 6050. | 8973. | 11460. | 0.62 | 0.91 | 1.26 | 0.85 | 1.19 | 1.73 | 1.00 | 1.00 | 1.00 | 1.38 | 1.40 | 1.42 |

Table 2. continued.

| scenario | year | low | median | high | low | median | high | low | median | high | low | median | high | low | median | high |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F 40% SPR | 2003 | 1514. | 2917. | 4994. | 0.19 | 0.38 | 0.74 | 0.24 | 0.52 | 1.07 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2004 | 1808. | 3600. | 5879. | 0.26 | 0.48 | 0.85 | 0.34 | 0.65 | 1.20 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2005 | 2227. | 4320. | 6699. | 0.30 | 0.56 | 0.96 | 0.40 | 0.76 | 1.36 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2006 | 2763. | 5162. | 7440. | 0.38 | 0.68 | 1.11 | 0.50 | 0.90 | 1.55 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2007 | 3346. | 5945. | 8170. | 0.47 | 0.81 | 1.26 | 0.63 | 1.06 | 1.78 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2008 | 3903. | 6527. | 8787. | 0.56 | 0.92 | 1.38 | 0.75 | 1.20 | 1.89 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2009 | 4462. | 7014. | 9146. | 0.66 | 1.00 | 1.49 | 0.88 | 1.31 | 2.01 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2010 | 5016. | 7401. | 9437. | 0.74 | 1.06 | 1.54 | 0.97 | 1.41 | 2.11 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2011 | 5494. | 7683. | 9713. | 0.82 | 1.14 | 1.58 | 1.07 | 1.50 | 2.19 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2012 | 5913. | 7919. | 9919. | 0.89 | 1.19 | 1.65 | 1.15 | 1.58 | 2.26 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| 4 million | 2003 | 4000. | 4000. | 4000. | 0.17 | 0.37 | 0.75 | 0.21 | 0.49 | 1.08 | 0.55 | 1.00 | 2.18 | 0.79 | 1.40 | 3.03 |
| 4 million | 2004 | 4000. | 4000. | 4000. | 0.16 | 0.43 | 0.92 | 0.21 | 0.57 | 1.26 | 0.46 | 0.84 | 2.31 | 0.64 | 1.18 | 3.23 |
| 4 million | 2005 | 4000. | 4000. | 4000. | 0.14 | 0.51 | 1.07 | 0.18 | 0.67 | 1.49 | 0.38 | 0.70 | 2.24 | 0.54 | 0.98 | 3.13 |
| 4 million | 2006 | 4000. | 4000. | 4000. | 0.15 | 0.65 | 1.30 | 0.20 | 0.85 | 1.78 | 0.33 | 0.56 | 2.14 | 0.46 | 0.79 | 2.96 |
| 4 million | 2007 | 4000. | 4000. | 4000. | 0.15 | 0.81 | 1.54 | 0.22 | 1.05 | 2.18 | 0.29 | 0.47 | 2.29 | 0.41 | 0.66 | 3.17 |
| 4 million | 2008 | 4000. | 4000. | 4000. | 0.15 | 0.97 | 1.75 | 0.20 | 1.23 | 2.48 | 0.26 | 0.41 | 2.28 | 0.37 | 0.57 | 3.16 |
| 4 million | 2009 | 4000. | 4000. | 4000. | 0.14 | 1.12 | 1.99 | 0.21 | 1.43 | 2.69 | 0.24 | 0.36 | 2.31 | 0.34 | 0.51 | 3.24 |
| 4 million | 2010 | 4000. | 4000. | 4000. | 0.12 | 1.27 | 2.19 | 0.16 | 1.63 | 2.98 | 0.22 | 0.33 | 2.66 | 0.31 | 0.47 | 3.68 |
| 4 million | 2011 | 4000. | 4000. | 4000. | 0.07 | 1.39 | 2.31 | 0.09 | 1.81 | 3.17 | 0.21 | 0.30 | 4.17 | 0.29 | 0.43 | 5.86 |
| 4 million | 2012 | 3838. | 4000. | 4000. | 0.02 | 1.53 | 2.42 | 0.03 | 1.96 | 3.36 | 0.20 | 0.29 | 8.36 | 0.28 | 0.40 | 11.80 |
| 4 million | 2003 | 4000. | 4000. | 4000. | 0.17 | 0.37 | 0.75 | 0.21 | 0.49 | 1.08 | 0.55 | 1.00 | 2.18 | 0.79 | 1.40 | 3.03 |
| 4 million | 2004 | 4000. | 4000. | 4000. | 0.16 | 0.43 | 0.92 | 0.21 | 0.57 | 1.26 | 0.46 | 0.84 | 2.31 | 0.64 | 1.18 | 3.23 |
| 4 million | 2005 | 4000. | 4000. | 4000. | 0.14 | 0.51 | 1.07 | 0.18 | 0.67 | 1.49 | 0.38 | 0.70 | 2.24 | 0.54 | 0.98 | 3.13 |
| 4 million | 2006 | 4000. | 4000. | 4000. | 0.15 | 0.65 | 1.30 | 0.20 | 0.85 | 1.78 | 0.33 | 0.56 | 2.14 | 0.46 | 0.79 | 2.96 |
| 4 million | 2007 | 4000. | 4000. | 4000. | 0.15 | 0.81 | 1.54 | 0.22 | 1.05 | 2.18 | 0.29 | 0.47 | 2.29 | 0.41 | 0.66 | 3.17 |
| 7.5 million | 2008 | 7500. | 7500. | 7500. | 0.09 | 0.92 | 1.69 | 0.13 | 1.17 | 2.38 | 0.51 | 0.79 | 5.76 | 0.71 | 1.10 | 8.11 |
| 7.5 million | 2009 | 6169. | 7500. | 7500. | 0.02 | 0.99 | 1.80 | 0.03 | 1.28 | 2.46 | 0.48 | 0.76 | 8.89 | 0.69 | 1.07 | 12.35 |
| 7.5 million | 2010 | 2198. | 7500. | 7500. | 0.01 | 1.05 | 1.87 | 0.01 | 1.34 | 2.57 | 0.47 | 0.74 | 9.49 | 0.67 | 1.03 | 13.27 |
| 7.5 million | 2011 | 820. | 7500. | 7500. | 0.00 | 1.09 | 1.90 | 0.00 | 1.39 | 2.58 | 0.46 | 0.70 | 9.90 | 0.65 | 0.99 | 13.70 |
| 7.5 million | 2012 | 296. | 7500. | 7500. | 0.00 | 1.15 | 1.92 | 0.00 | 1.46 | 2.59 | 0.45 | 0.69 | 10.10 | 0.63 | 0.97 | 13.89 |
| 4 million | 2003 | 4000. | 4000. | 4000. | 0.17 | 0.37 | 0.75 | 0.21 | 0.49 | 1.08 | 0.55 | 1.00 | 2.18 | 0.79 | 1.40 | 3.03 |
| 4 million | 2004 | 4000. | 4000. | 4000. | 0.16 | 0.43 | 0.92 | 0.21 | 0.57 | 1.26 | 0.46 | 0.84 | 2.31 | 0.64 | 1.18 | 3.23 |
| 4 million | 2005 | 4000. | 4000. | 4000. | 0.14 | 0.51 | 1.07 | 0.18 | 0.67 | 1.49 | 0.38 | 0.70 | 2.24 | 0.54 | 0.98 | 3.13 |
| 4 million | 2006 | 4000. | 4000. | 4000. | 0.15 | 0.65 | 1.30 | 0.20 | 0.85 | 1.78 | 0.33 | 0.56 | 2.14 | 0.46 | 0.79 | 2.96 |
| 4 million | 2007 | 4000. | 4000. | 4000. | 0.15 | 0.81 | 1.54 | 0.22 | 1.05 | 2.18 | 0.29 | 0.47 | 2.29 | 0.41 | 0.66 | 3.17 |
| F 40% SPR | 2008 | 1477. | 6823. | 10280. | 0.18 | 0.93 | 1.66 | 0.26 | 1.20 | 2.33 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2009 | 1861. | 7175. | 10190. | 0.26 | 1.02 | 1.69 | 0.34 | 1.31 | 2.29 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2010 | 2018. | 7409. | 10200. | 0.30 | 1.07 | 1.67 | 0.43 | 1.39 | 2.30 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2011 | 2391. | 7714. | 10240. | 0.35 | 1.11 | 1.69 | 0.50 | 1.45 | 2.28 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |
| F 40% SPR | 2012 | 2901. | 7844. | 10240. | 0.42 | 1.16 | 1.67 | 0.60 | 1.52 | 2.28 | 0.70 | 0.71 | 0.72 | 1.00 | 1.00 | 1.00 |

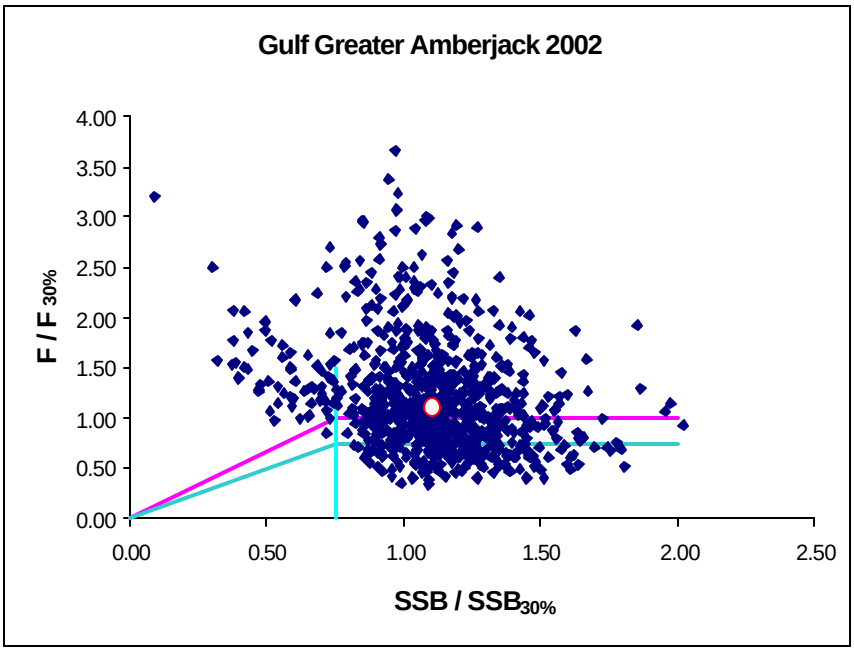


Figure 1. Dispersion of projected status of Gulf greater amberjack at the start of 2003 with respect to possible management control rules. The smaller points are individual bootstrap results and the larger point is the median.

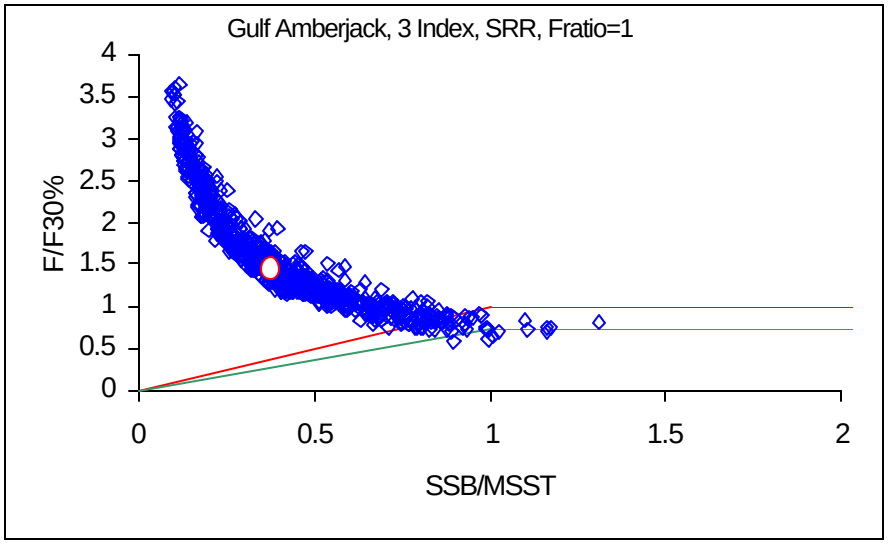


Figure 2. Dispersion of projected status of Gulf greater amberjack at the start of 1999 with respect to possible management control rules. The smaller points are individual bootstrap results and the larger point is the median.

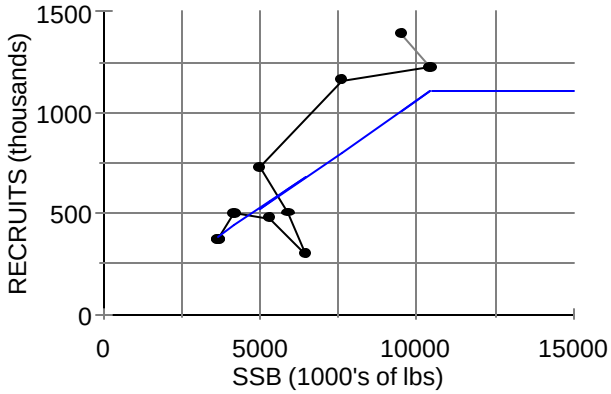


Figure 3. Hockey stick stock recruitment relationship assumed for Gulf greater amberjack projections 1999-2012.

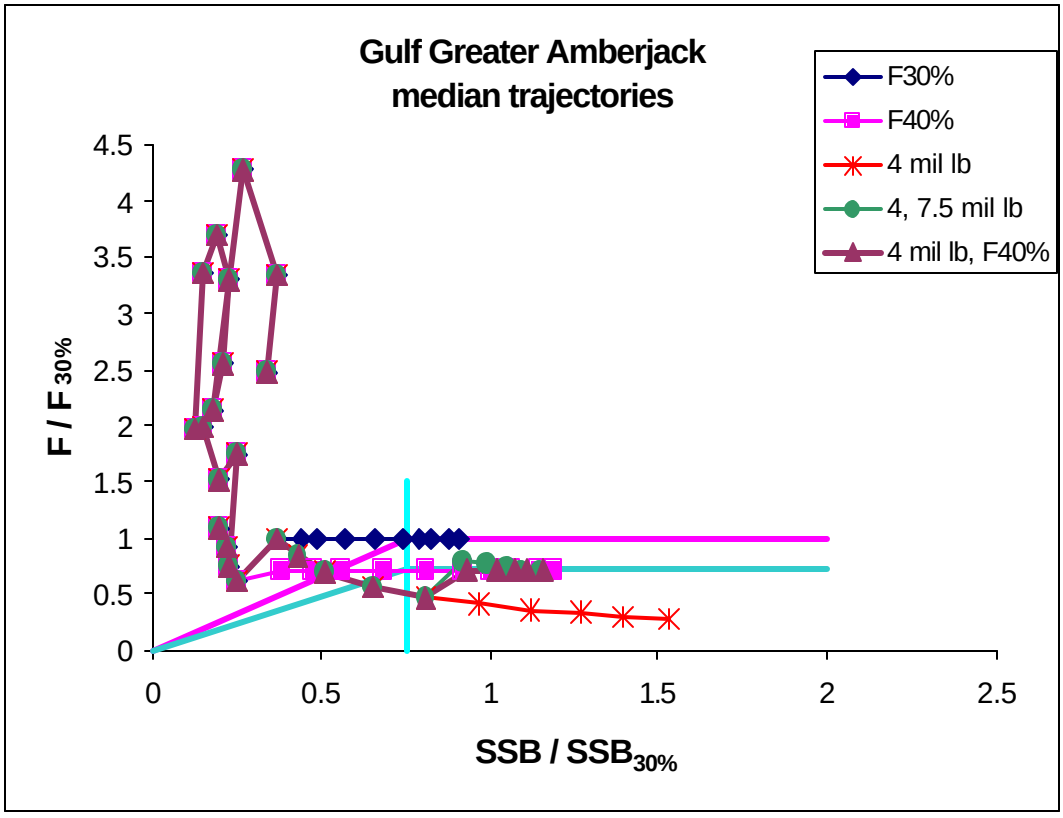


Figure 4. Spawning stock biomass (SSB) and fishing mortality rate (F) relative to the SSB and F which would produce $SPR_{30\%}$ (the MSY proxy) under the selectivity pattern of 1996-1998. Possible control rules and the MSST level associated with the M considered most likely are shown.

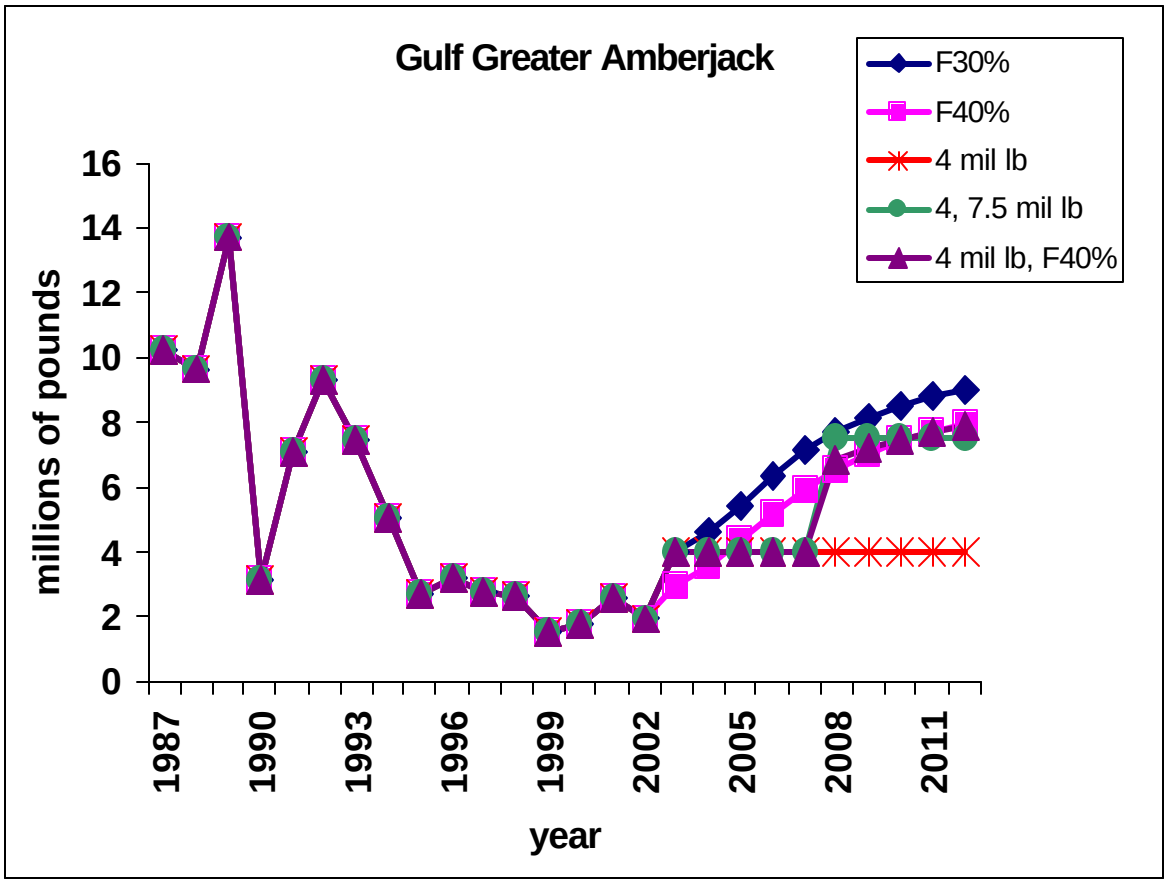


Figure 5. Historical and projected (2003-2012) median weight of removals (landings and dead discards) for Gulf greater amberjack under five projection scenarios.

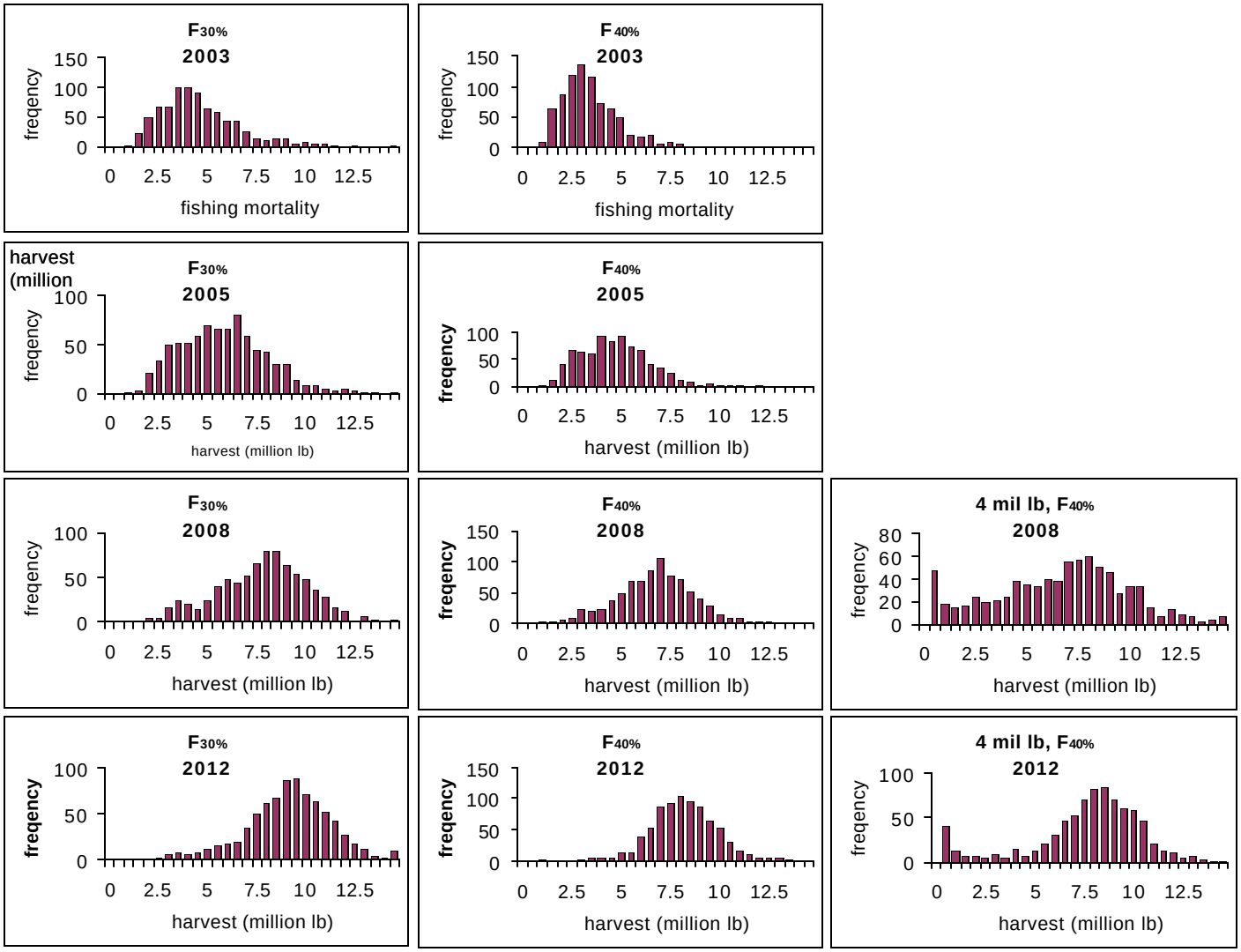


Figure 6. Distributions of projected removals (landings plus dead discards) weights in 2003, 2005, 2008 and 2012 from three projections which assumed constant fishing mortality rates for either 2003-2012 ($F_{30\%}$ and $F_{40\%}$ scenarios) or 2008-2012 (4 million lb and $F_{40\%}$ scenario).

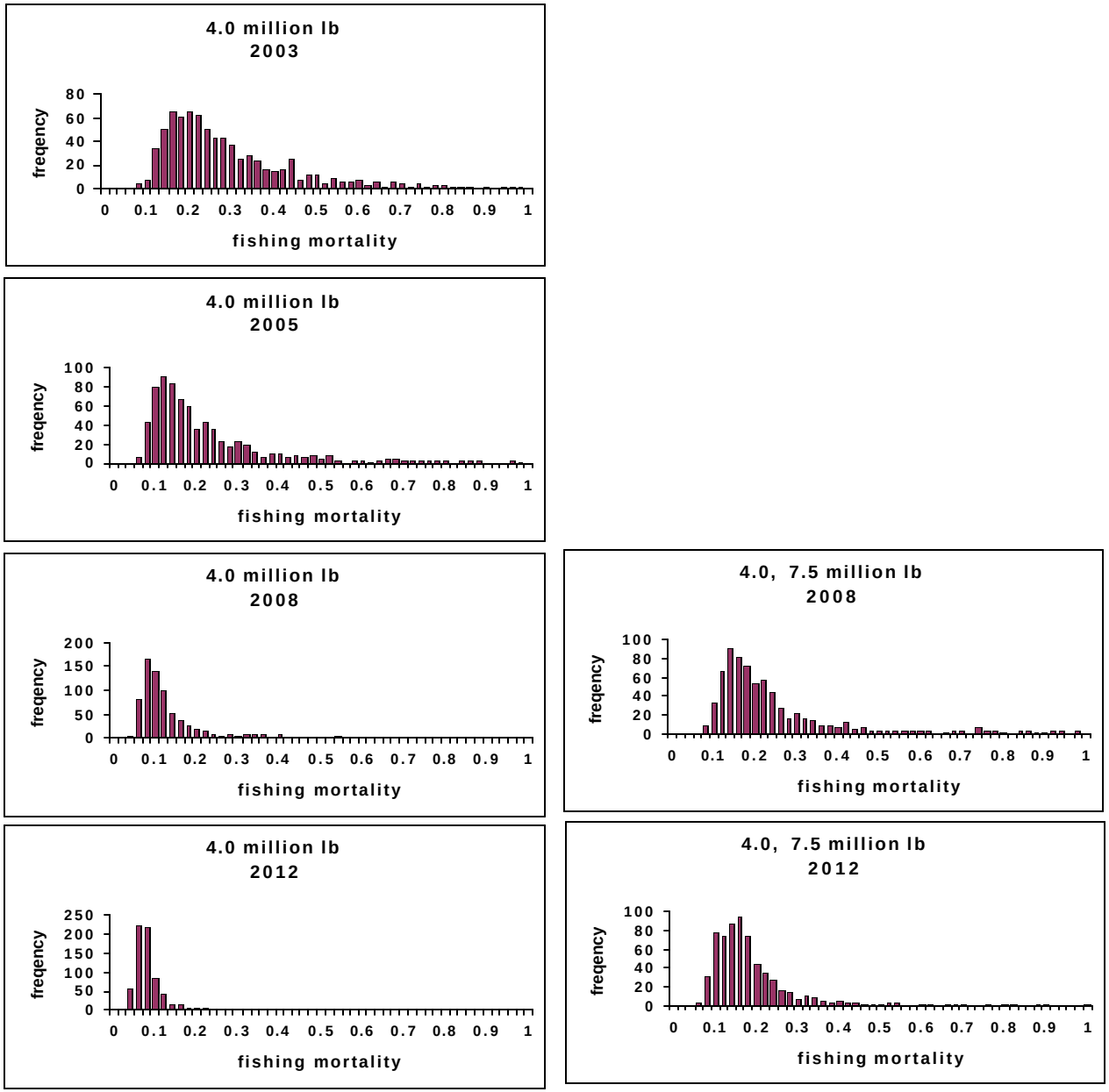


Figure 7. Distributions of projected fishing mortality rates in 2003, 2005, 2008 and 2012 from projections which assumed constant catch in 2003-2012 or 2008-2012 .

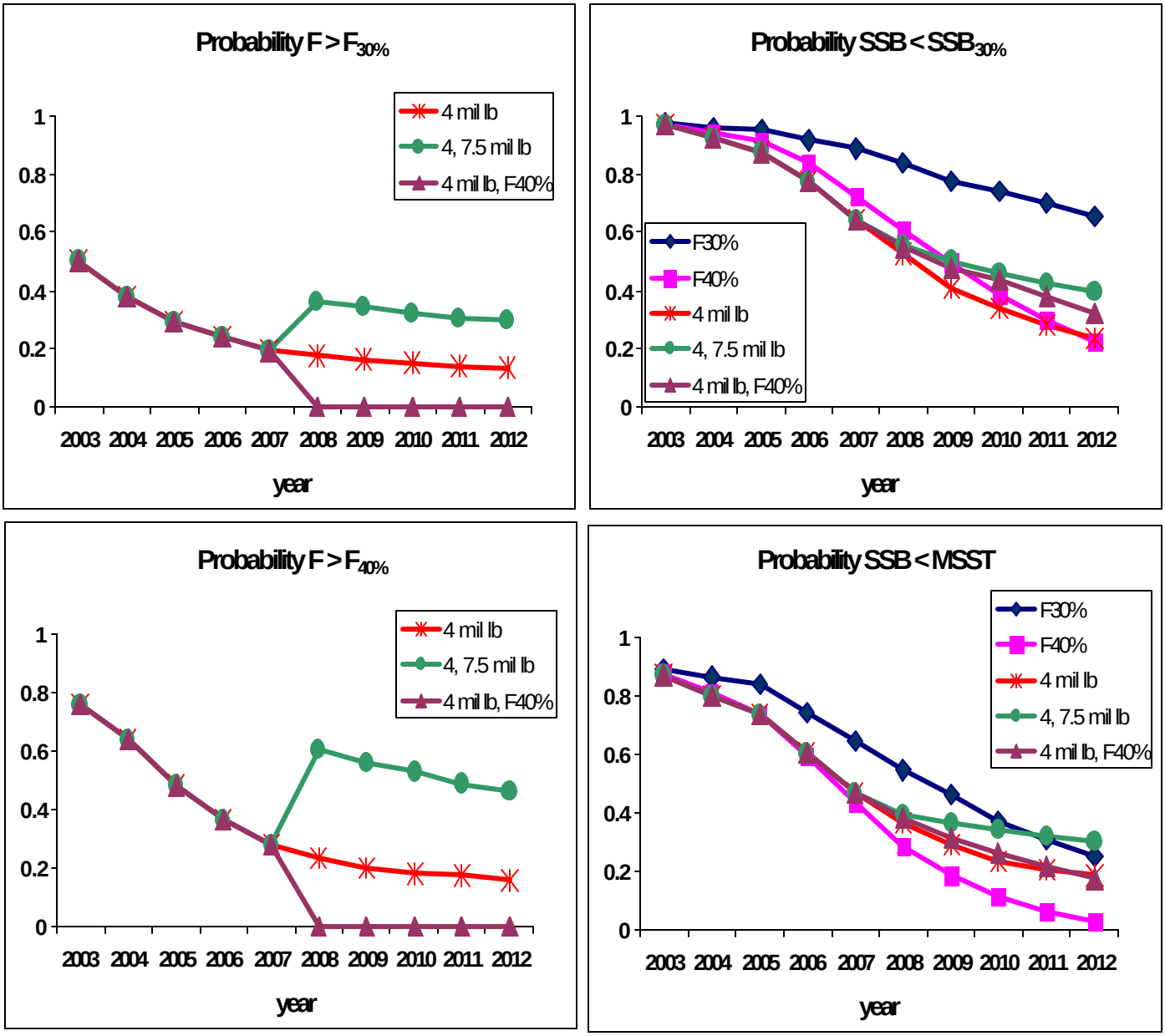


Figure 8. Projected probability that fishing mortality rate would exceed $F_{30\%}$ and $F_{40\%}$ in 2003-2012 and probabilities that spawning stock biomass would be less than $SSB_{30\%}$ and MSST (the minimum stock size threshold).