1 Revision and Corrections

1.1 Correction to recreational landings data

This section documents a correction to recreational landings data used in the stock assessment of South Atlantic red snapper.

As described in section 2.2 of the Assessment Workshop report, the assessment included observed recreational landings from Salt-Water Angling reports. These landings were reported to the level of species for red snapper in the years 1965 and 1970, and as unclassified snappers in 1960. Thus, the value in 1960 was estimated as the unweighted average ratios of red snapper to all snapper from 1965 and 1970. Linear interpolation was used to estimate the recreational landings stream in years surrounding the 1960, 1965, and 1970 point estimates.

After completion of the assessment, it was discovered that the recreational landings in 1965 and 1970 had been transposed when developing the recreational landings stream. Correction of these values affected not only the point estimates in 1965 and 1970, but also estimates in surrounding years that depended on the linear interpolations (Figure 1.1). Using the corrected recreational landings stream, the base assessment model was re-run, as described below.

1.2 Revised base run of the assessment model

This section describes results of the base assessment model incorporating the correction to recreational landings (§1.1). It also updates reference points for consistency with recommendations of the SEDAR-15 Review Panel.

1.2.1 Revisions

Using the corrected recreational landings stream, the base assessment model was re-run with no change in the weighting configuration of model components (methods and weighting configuration described fully in the Assessment Workshop report). Reference points were based on $F_{40\%}$ as a proxy for F_{MSY}, as recommended by the SEDAR-15 Review Panel. As before, these reference points depend on average selectivity across fisheries, weighted by recent fishing mortality rates. In the previous model run, average selectivity was re-scaled to a maximum of one. Because of the high discard mortalities combined with dome-shaped discard selectivity, that re-scaling of average selectivity made it difficult to compare full F and F_{MSY} (or its proxy). For improved consistency between the two, average selectivity is not re-scaled in this revised assessment. This change does not affect model fit to data or parameter estimates, but does affect the computation and value of F_{MSY} (or its proxy).

1.2.2 Results of revised base run

1.2.2.1 Comparison of estimated time series Figure 1.2 shows comparisons of estimated time series from the base model using either the previous recreational landings stream or the corrected recreational landings stream. The effect of the correction on estimated time series of recruitment, fishing mortality rate, and spawning biomass was generally small. The remainder of results focus on the model run with corrected landings.

1.2.2.2 **Measures of Overall Model Fit** Overall, the catch-at-age model fit well to the available data. Annual fits to length compositions from each fishery were reasonable in most years, as were fits to age compositions (Figure 1.3). Residuals of these fits, by year and fishery, are summarized with bubble plots; differences between annual observed and predicted vectors are summarized with angular deviation (Figure 1.4–1.11). Angular deviation is defined as the arc cosine of the dot product of two vectors.

The model was configured to fit observed commercial and recreational landings closely (Table 1.1; Figures 1.12–1.15). In addition, it fit well to observed discards (Table 1.2; Figures 1.16–1.18).

Fits to indices of abundance were reasonable (Figures 1.19–1.21). The three indices were positively correlated. Since the mid-1990s, indices showed an increasing trend in general, but during the last three years, a decreasing trend.

1.2.2.3 **Parameter Estimates** Estimates of all parameters from the catch-at-age model are shown in Appendix A. The estimated coefficient of variation of length at age was $\widehat{\mathrm{CV}} = 11.56\%$ (Figure 1.22).

1.2.2.4 **Stock Abundance and Recruitment** Estimated abundance at age shows truncation of the oldest ages during the 1950s through 1970s, from which the stock has not yet recovered (Table 1.3). Annual number of recruits is shown in Table 1.3 (age-1 column) and in Figure 1.23. Notable strength in year classes was predicted to have occurred in 1983 and 1984, and again in 1998–2000.

1.2.2.5 **Stock Biomass (total and spawning stock)** Estimated biomass at age follows a similar pattern of truncation as did abundance (Tables 1.4,1.5). Total biomass and spawning biomass show nearly identical trends—decline during the 1950s through 1970s, and stable but low levels since 1980 (Figure 1.24, Table 1.6).

1.2.2.6 **Fishery Selectivity** Estimated selectivities of landings from commercial handline shift toward older fish with implementation of each new minimum size regulation (12-inch TL in 1984 and then 20-inch TL in 1992) (Figure 1.25). In the most recent period, fish were estimated to be almost fully selected by age 4. Selectivity of landings from commercial diving was estimated to be dome-shaped with a peak between ages 5 and 10 (Figure 1.26). Similar to commercial handline, landings from the headboat fishery showed a shift toward older fish, with full selection at age 4 in the most recent period (Figure 1.27), as did landings from the general recreational fishery, with full selection at age 3 in the most recent period (Figure 1.28).

Selectivities of discard mortalities were similar across the commercial handline, headboat, and general recreational fisheries (Figure 1.29 – Figure 1.31). These selectivities included age-1 and age-2 fish in the period 1984–1991, when the 12-inch TL size limit was in place. They additionally included age-3 fish in the period 1992–2006, when the 20-inch TL size limit was in place.

Average selectivities of landings and of discard mortalities were computed from F-weighted selectivities in the most recent period of regulations (Figure 1.32). These average selectivities were used to compute benchmarks and in projections. All selectivities from the most recent period, including average selectivities, are presented in Table 1.7.

1.2.2.7 **Fishing Mortality** The estimated time series of fishing mortality rate (F) shows a generally increasing trend from the 1950s through the late 1970s, and since 1980 has fluctuated around a mean near $F = 0.92$ (Figure 1.33). In the most recent years, the majority of full F comprised commercial handline landings, general recreational landings, and general recreational discard mortalities (Figure 1.33, Table 1.8).

Full F at age is shown in Table 1.9. In any given year, the maximum F at age may be less than that year's fully selected F. This inequality is due to the combination of two features of estimated selectivities: full selection occurs at different ages among gears and several sources of mortality (commercial diving, discards) have dome-shaped selectivity.

Throughout most of the assessment period, estimated landings and discard mortalities in number of fish have been dominated by the recreational sector (Figures 1.34, 1.35). Table 1.10 shows total landings at age in numbers, Table 1.11 in metric tons, and Table 1.12 in 1000 lb.

1.2.2.8 **Stock-Recruitment Parameters** The estimated Beverton–Holt spawner-recruit curve is shown in Figure 1.36. Variability about the curve was estimated only at low levels of spawning biomass, because composition data required for estimating recruitment deviations became available only after the stock was depleted. Estimated parameters were as follows: steepness $\hat{h} = 0.95$, $\widehat{R_0} = 638166.4$, first-order autocorrelation $\hat{\varrho} = 0.36$, and bias correction $\hat{\varsigma} = 1.1$.

The RW Report states, "One of the principal difficulties with the SCA model estimate of the stock recruitment parameters is that the steepness estimate appears unrealistically high." This was a primary reason why the Review Panel recommended using $F_{40\%}$ as a proxy for F_{MSY}. Because the Review Panel believed that the value of steepness estimated within the assessment model was "unrealistically high," a value was used here for consistency with the $F_{40\%}$ proxy. That is, assuming that $F_{40\%}$ is indeed the value of F_{MSY}, one can compute the corresponding value of steepness (Figure 1.37). The value corresponding to $F_{40\%} = F_{\mathrm{MSY}}$ is $h = 0.68$, and thus this value was used to compute equilibrium levels of landings and biomass.

1.2.2.9 **Per Recruit and Equilibrium Analyses** Static spawning potential ratio (static SPR) shows a trend of marked decrease from the beginning of the assessment period until the mid 1970's, and since has remained relatively constant at levels between 1% and 3% (Figure 1.38, Table 1.6). Static SPR of each year was computed as the asymptotic spawners per recruit given that year's fishery-specific Fs and selectivities, divided by spawners per recruit that would be obtained in an unexploited stock. In this form, static SPR ranges between zero and one, and represents SPR that would be achieved under an equilibrium age structure at the current F (hence the term *static*).

Yield per recruit and spawning potential ratio were computed as functions of F (Figure 1.39), as were equilibrium landings and spawning biomass (Figures 1.40). Equilibrium landings and discards were also computed as functions of biomass B, which itself is a function of F (Figure 1.41). Per recruit analyses applied the most recent selectivity patterns averaged across fisheries, weighted by F from the last three years (2004–2006).

1.2.2.10 **Reference Points** The SEDAR-15 Review Panel did not recommend using MSY-related reference points, because they thought that data were not adequate for reliable estimation of the spawner-recruit function. Instead, they recommended using $F_{40\%}$ as a proxy for F_{MSY}. To compute biomass proxies from $F_{40\%}$, however, one must know or assume productivity of the stock. Along these lines, the Review Panel did not reject the functional form of the Beverton–Holt spawner-recruit curve, but instead thought that the parameters were not well estimated. As stated previously, a steepness of $h = 0.68$ is consistent with the Review Panel's recommendation of $F_{40\%}$, but that proxy does not provide any information about the other key parameter of the Beverton–Holt function, unfished recruitment R_0. On this parameter, the RW Report provides seemingly conflicting advice. In Table 1 of the RW Report, biomass proxies assumed fixed recruitment at the bias-corrected unfished level ($\widehat{R_0}$), yet the report also states, "...there are no data in the assessment to adequately define the asymptote of the Beverton–Holt function and hence estimates of MSY indicators cannot be considered reliable." In this revision, an attempt is made to accommodate both pieces of advice in a consistent manner, by using the bias-corrected R_0 to compute biomass proxies, while also examining the effect of variation in $\widehat{R_0}$ by ±25%. In almost all sensitivity runs of the base assessment model, $\widehat{R_0}$ falls within this range.

Assuming the Beverton–Holt spawner-recruit function, biomass proxies were computed assuming equilibrium recruitment and age structure associated with $F_{40\%}$. The bias correction (ς) was computed from the estimated variance (σ^2) of recruitment deviation: $\varsigma = \exp(\sigma^2/2)$. Then, equilibrium recruitment (R_{eq}) associated with any F is,

$$R_{eq} = \frac{R_0\left[\varsigma 0.8 h \Phi_F - 0.2(1-h)\right]}{(h-0.2)\Phi_F} \tag{1}$$

where R_0 is recruitment at the unfished level, h is steepness, and Φ_F is spawning potential ratio given growth, maturity, and total mortality at age (including natural, fishing, and discard mortality rates).

The approach described above provides reference points that are consistent with rebuilding projections (i.e., fishing at $F_{40\%}$ yields $\text{MSY}_{F_{40\%}}$ from a stock size of $SSB_{F_{40\%}}$). Reference points estimated were the proxies for F_{MSY}, MSY, B_{MSY} and SSB_{MSY}. These values were computed using $h = 0.68$ (for which $F_{40\%} = F_{\text{MSY}}$), along with $\widehat{R_0} = 638166.4$ and $\hat{\varsigma} = 1.1$ from the assessment, in addition to $R_0 = \pm 25\% \widehat{R_0}$. Also, based on $F_{40\%}$, three possible values of F at optimum yield (OY) were considered—$F_{\text{OY}} = 65\% F_{40\%}$, $F_{\text{OY}} = 75\% F_{40\%}$, and $F_{\text{OY}} = 85\% F_{40\%}$—and for each, the corresponding equilibrium yield and dead discards. These values depend on equilibrium recruitment expected from the age structure at F_{OY}, given $h = 0.68$, $\widehat{R_0} = 638166.4$, and $\hat{\varsigma} = 1.1$.

Estimates of benchmarks are summarized in Table 1.13.

1.2.2.11 **Status of the Stock and Fishery** Estimated time series of B and SSB relative to their proxy reference points show similar patterns: initial status well above the MSY proxy, decline during the 1950s through 1970s, and stable at low levels since 1980 (Figure 1.42, Table 1.6). Current stock status was estimated to be $\text{SSB}_{2006}/\text{SSB}_{F_{40\%}} = 0.029$ and $\text{SSB}_{2006}/\text{MSST} = 0.031$, indicating that the stock is overfished (Table 1.13).

The estimated time series of F relative to $F_{40\%}$ shows a generally increasing trend from the 1950s through 1980, and since has fluctuated about a mean near 8.86 (Figure 1.43, Table 1.6). The time series indicates that overfishing has been occurring without break since 1967, with the current estimate at $F_{2006}/F_{40\%} = 7.658$ (Table 1.13).

1.2.3 Comments on Assessment Results

Estimated reference points play a central role in this assessment, to gauge status of the stock and fishery. If selectivity patterns change in the future, for example as a result of new management regulations, estimates of refence points would likely change as well.

The SEDAR-15 Review Panel recommended $F_{40\%}$ as a proxy for F_{MSY}, and corresponding proxies for biomass reference points. Computation of reference points is conditional on the combined selectivities from all modeled sources of fishing mortality. In this revised assessment, the selectivity on which reference points were based was not re-scaled to one, as it was in the previous assessment. This modification was to provide improved consistency between full F and $F_{40\%}$, in particular for computing the ratio $F/F_{40\%}$, and it accounts for the bulk of the difference between the previous estimate of $F_{40\%}$ and the revised estimate. Despite this difference, however, the modification would not affect fishing mortality rates associated with $F_{40\%}$, because the product $F_{40\%}$ times selectivity would be unchanged. Furthermore, this modification would not affect biomass reference points. Changes in those reference points are due primarily to relating recruitment to stock size (as opposed to Table 1 of the RW Report, which assumed recruitment always occurred at the unfished level, regardless of stock size). Correcting the error in early recreational landings had little effect on estimated reference points.

The base run of the age-structured assessment model indicated that the stock is overfished ($\mathrm{SSB}_{2006}/\mathrm{MSST} = 0.031$) and that overfishing is occurring ($F_{2006}/F_{40\%} = 7.658$). These results were invariant to the 31 different configurations used in sensitivity runs of the AW Report, to the five additional sensitivity runs requested by the Review Panel, and to this revised run with corrected recreational landings. In addition, the same qualitative findings resulted from the age-aggregated surplus production model and its various sensitivity runs.

1.3 Revised projections

This section describes revised projections where population parameter estimates come from the assessment model with corrected recreational landings. It also updates projections to be consistent with recommendations of the SEDAR-15 Review Panel.

1.3.1 Revisions

The methods of projection, initialization, and inclusion of stochasticity were identical to those described in the AW Report. Revisions were threefold. First, parameter estimates used in the projection came from the revised assessment with corrected recreational landings, with the exception of the estimate of steepness. Second, the estimate of steepness was assumed to be $h = 0.68$ (Figure 1.37), for consistency with the Review Panel's recommendation that $F_{40\%}$ is a proxy for F_{MSY}, and so that projections are consistent with the $F_{40\%}$ reference points. Third, the rebuilding time frame was based on achieving at least a 50% probability of stock recovery to $\mathrm{SSB}_{F_{40\%}}$ under $F = 0$ using $n = 2000$ Monte Carlo replications (previously, recovery was based on SSB of the deterministic projection). These revisions led to an increase in the allowable recovery time from 34 to 49 years.

1.3.2 Projection scenarios

Several constant-F projection scenarios were considered:

- Scenario R1: $F = 0$
- Scenario R2: $F = F_{40\%}$
- Scenario R3: $F = 65\% F_{40\%}$
- Scenario R4: $F = 75\% F_{40\%}$
- Scenario R5: $F = 85\% F_{40\%}$

In addition, several discard-only projections were considered. The discard-only projections included the following scenarios:

- Scenario R6: $F = F_{\text{current}}$ excluding commercial diving, but all fish caught were released and subjected to release mortality rates used in the assessment (0.9 in the commercial sector and 0.4 in the headboat and recreational sectors)
- Scenario R7: $F = F_{40\%}$, but all fish caught were released and subjected to release mortality rates used in the assessment (0.9 in the commercial sector and 0.4 in the headboat and recreational sectors)
- Scenario R8: $F = 65\% F_{40\%}$, but all fish caught were released and subjected to release mortality rates used in the assessment (0.9 in the commercial sector and 0.4 in the headboat and recreational sectors)
- Scenario R9: $F = 75\% F_{40\%}$, but all fish caught were released and subjected to release mortality rates used in the assessment (0.9 in the commercial sector and 0.4 in the headboat and recreational sectors)
- Scenario R10: $F = 85\% F_{40\%}$, but all fish caught were released and subjected to release mortality rates used in the assessment (0.9 in the commercial sector and 0.4 in the headboat and recreational sectors)

When interpreting the discard-only projections, one should keep in mind that the distribution of full F among the various fisheries is different from that in the assessment, which may lead to some inconsistency between projections and benchmarks from the assessment (e.g., fishing at $F_{40\%}$ may lead to an equilibrium stock size other than $\text{SSB}_{F_{40\%}}$).

1.3.3 Projection results

Projection scenario R1, in which $F = 0$, predicted at least a 50% probability of recovery in 2035 (Figure 1.44, Table 1.14). That duration plus the 20-year generation time (§III(2)) defined the rebuilding time frame such that recovery occurs by the end of 2055. Thus, all remaining projections were run through the year 2055.

Projection scenario R2, in which $F = F_{40\%}$, predicted the stock to begin, but not achieve, recovery by 2055 (Figure 1.45, Table 1.15). If F is reduced to 65% or 75% of $F_{40\%}$, as in scenarios R3 and R4, respectively, the stock was predicted to recover within the rebuilding time frame (Figures 1.46–1.47, Tables 1.16–1.17). However, full stock recovery was not predicted if F is reduced to 85% of $F_{40\%}$, as in scenario R5 (Figure 1.48, Table 1.18).

Discard-only projections predicted that, under $F = F_{\text{current}}$ (minus commercial diving), disallowing the retention of red snapper would not be sufficient to rebuild the stock (Figure 1.49, Table 1.19). These results suggest that to rebuild the stock, total catches of red snapper will need to be reduced, not just landings. The stock was predicted to recover in discard-only projections R7, R8, R9, and R10, with F reduced to $F_{40\%}$, 65% of $F_{40\%}$, 75% of $F_{40\%}$, and 85% of $F_{40\%}$, respectively (Figures 1.50– 1.53, Tables 1.20–1.23).

1.3.4 Comments on Projections

As usual, projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- Initial abundance at age of the projections were based on estimates from the assessment. If those estimates are inaccurate, rebuilding will likely be affected.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect rebuilding.
- The projections assumed no change in the selectivity applied to discards. As recovery generally begins with the smallest size classes, management action may be needed to meet that assumption.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If changes in environmental or ecological conditions affect recruitment or life-history characteristics, rebuilding may be affected.
- Discard-only projections tacitly assumed that any individual fish would be caught only once per year. To the extent that this assumption is violated, discard-only projections may overestimate the velocity of recovery.
- Discard-only projections allocated sources of mortality in different proportions than those used in computing reference points. Thus discard-only projections are not consistent with reference points, in the sense that fishing at $F_{40\%}$ may lead to an equilibrium stock size other than $\mathrm{SSB}_{F_{40\%}}$.

1.3.5 Tables

Table 1.1. Red snapper: Estimated time series of landings (1000 lb) for commercial handline (L.c.hal), commercial diving (L.c.dv), headboat(L.hb), and general recreational (L.rec). General recreational includes headboat prior to 1972.

Year	L.c.hal	L.c.dv	L.hb	L.rec	Total
1945	240.87	.	.	.	240.87
1946	262.62	.	.	.	262.62
1947	284.36	.	.	292.44	576.80
1948	306.10	.	.	584.88	890.99
1949	327.84	.	.	877.32	1205.16
1950	349.59	.	.	1169.75	1519.34
1951	498.58	.	.	1462.18	1960.77
1952	374.76	.	.	1754.61	2129.37
1953	389.08	.	.	2047.02	2436.10
1954	576.87	.	.	2339.43	2916.31
1955	479.60	.	.	2631.84	3111.44
1956	469.98	.	.	2924.24	3394.22
1957	843.02	.	.	3216.63	4059.64
1958	594.66	.	.	3509.01	4103.67
1959	638.33	.	.	3801.38	4439.70
1960	652.29	.	.	4093.74	4746.02
1961	770.40	.	.	3662.58	4432.98
1962	575.91	.	.	3231.41	3807.32
1963	438.52	.	.	2800.22	3238.75
1964	486.31	.	.	2369.06	2855.37
1965	571.40	.	.	1937.88	2509.27
1966	643.46	.	.	2686.56	3330.02
1967	843.62	.	.	3435.24	4278.86
1968	938.69	.	.	4183.96	5122.66
1969	610.98	.	.	4932.76	5543.74
1970	559.14	.	.	5681.72	6240.85
1971	478.87	.	.	5191.17	5670.04
1972	414.29	.	91.92	4608.65	5114.85
1973	340.16	.	117.31	4092.66	4550.12
1974	555.20	.	77.06	3642.53	4274.78
1975	650.92	.	83.52	3145.40	3879.84
1976	547.38	.	109.28	2631.11	3287.77
1977	579.15	.	59.93	2173.90	2812.98
1978	544.96	.	62.98	1664.41	2272.34
1979	380.73	.	54.13	1207.13	1641.99
1980	352.90	.	54.66	721.87	1129.42
1981	347.26	.	116.60	283.78	747.64
1982	286.26	.	98.05	251.61	635.92
1983	290.10	.	74.01	335.49	699.61
1984	230.64	1.21	81.43	536.37	849.64
1985	223.03	2.27	132.10	568.19	925.59
1986	200.18	0.55	54.38	439.32	694.43
1987	172.78	0.42	81.83	246.47	501.50
1988	151.94	0.29	130.03	279.73	562.00
1989	242.34	1.10	70.78	304.26	618.48
1990	201.56	1.66	65.67	272.29	541.19
1991	125.38	5.27	72.02	216.35	419.00
1992	87.53	9.41	28.91	259.22	385.06
1993	206.32	5.74	42.72	258.22	513.00
1994	175.63	12.98	53.42	118.02	360.05
1995	164.06	10.16	57.47	110.01	341.71
1996	129.97	6.18	46.23	116.83	299.21
1997	98.87	7.49	51.20	113.56	271.12
1998	78.74	7.99	26.85	193.64	307.21
1999	78.95	9.88	43.56	275.98	408.38
2000	89.22	11.36	49.40	355.77	505.75
2001	169.88	19.97	68.39	364.32	622.56
2002	158.83	22.88	70.80	305.58	558.09
2003	117.18	17.27	41.35	299.24	475.05
2004	147.47	19.22	80.35	273.79	520.83
2005	115.01	9.41	58.70	275.28	458.41
2006	79.08	4.10	41.44	274.29	398.90

Table 1.2. Red snapper: Estimated time series of discard mortalities (1000 fish) for commercial handline (D.c.hal), headboat(D.hb), and general recreational (D.rec). Discards were assumed zero prior to implementation of regulations in 1984.

Year	D.c.hal	D.hb	D.rec	Total
1984	6.76	3.29	43.56	53.61
1985	3.34	2.77	29.11	35.22
1986	6.38	2.42	26.35	35.15
1987	13.81	8.17	20.64	42.62
1988	6.82	6.60	23.24	36.66
1989	2.52	1.43	9.11	13.06
1990	27.41	10.46	7.47	45.34
1991	3.70	2.15	7.19	13.04
1992	16.46	1.30	19.96	37.73
1993	16.08	9.84	21.88	47.79
1994	22.02	7.43	24.73	54.17
1995	21.74	11.32	17.97	51.03
1996	29.03	4.35	11.28	44.66
1997	30.35	1.37	8.15	39.88
1998	22.97	8.26	29.45	60.68
1999	20.66	7.31	62.20	90.18
2000	19.63	9.88	86.36	115.87
2001	21.31	18.92	79.91	120.15
2002	19.92	16.16	66.54	102.61
2003	17.04	10.24	63.92	91.20
2004	14.23	17.54	62.96	94.74
2005	13.75	15.87	60.14	89.76
2006	15.22	11.48	52.21	78.91

Table 1.3. Red snapper: Estimated abundance at age (1000 fish) at start of year

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1945	478.6	380.1	325.0	286.7	257.2	233.2	212.9	195.3	179.7	165.8	153.3	141.9	131.5	122.0	113.2	105.1	97.6	90.7	84.3	1116.4
1946	701.7	379.9	323.8	285.6	256.2	232.3	212.1	194.5	179.0	165.2	152.7	141.3	131.0	121.5	112.7	104.7	97.3	90.4	84.0	1112.0
1947	701.6	556.9	323.4	284.4	255.2	231.3	211.1	193.7	178.2	164.5	152.0	140.7	130.4	121.0	112.3	104.2	96.8	90.0	83.6	1107.3
1948	701.5	556.3	471.7	282.7	252.8	229.2	209.2	191.9	176.6	162.9	150.6	139.4	129.2	119.8	111.2	103.3	95.9	89.1	82.9	1097.0
1949	701.5	555.8	468.8	410.1	249.9	225.9	206.2	189.1	174.0	160.6	148.4	137.4	127.3	118.1	109.6	101.8	94.6	87.9	81.7	1081.2
1950	701.4	555.2	465.9	405.5	360.7	222.2	202.1	185.4	170.6	157.4	145.5	134.7	124.9	115.8	107.5	99.8	92.7	86.1	80.1	1060.0
1951	701.3	554.7	463.0	400.9	354.8	319.0	197.8	180.8	166.4	153.5	141.9	131.4	121.8	112.9	104.8	97.3	90.4	84.0	78.1	1033.8
1952	701.2	553.9	459.1	395.3	348.1	311.3	281.8	175.6	161.1	148.6	137.4	127.2	117.9	109.3	101.5	94.2	87.5	81.3	75.6	1000.6
1953	701.1	553.5	456.9	390.7	342.2	304.4	274.2	249.4	155.9	143.4	132.5	122.7	113.7	105.5	97.9	90.9	84.4	78.4	72.9	965.3
1954	700.8	552.8	453.9	386.6	336.2	297.5	266.5	241.2	220.1	138.0	127.1	117.7	109.1	101.1	93.9	87.2	81.0	75.2	69.9	925.9
1955	700.6	551.7	449.1	380.5	329.6	289.6	258.1	232.3	210.9	193.0	121.2	111.8	103.6	96.1	89.2	82.8	76.9	71.5	66.5	879.8
1956	700.2	551.0	446.1	374.6	322.8	282.5	249.9	223.8	202.2	184.0	168.7	106.1	98.0	90.9	84.3	78.3	72.8	67.6	62.8	831.9
1957	699.7	550.1	442.4	369.5	315.6	274.7	242.1	215.3	193.4	175.1	159.7	146.6	92.3	85.3	79.2	73.5	68.3	63.5	59.0	781.0
1958	699.1	548.3	434.8	360.8	306.4	264.5	231.8	205.3	183.1	165.0	149.7	136.7	125.6	79.1	73.2	68.0	63.1	58.7	54.5	722.0
1959	698.4	547.3	431.3	352.9	297.8	255.6	222.1	195.6	173.8	155.5	140.3	127.5	116.5	107.2	67.6	62.5	58.1	54.0	50.2	664.3
1960	697.5	545.6	425.5	345.9	287.8	245.4	212.1	185.2	163.7	145.8	130.6	118.1	107.4	98.2	90.4	57.0	52.8	49.1	45.6	603.9
1961	696.4	543.7	418.5	336.7	278.4	234.1	201.0	174.5	152.9	135.5	120.9	108.5	98.1	89.3	81.8	75.3	47.5	44.0	40.9	541.7
1962	695.2	542.9	417.1	331.2	271.0	226.4	191.7	165.4	144.1	126.6	112.4	100.4	90.2	81.7	74.4	68.1	62.8	39.6	36.7	486.0
1963	694.1	542.9	420.5	333.3	269.2	222.6	187.2	159.3	137.9	120.4	106.0	94.2	84.3	75.8	68.7	62.6	57.4	52.8	33.4	440.3
1964	693.3	543.0	425.2	339.8	274.0	223.6	186.1	157.3	134.3	116.5	102.0	89.9	80.0	71.6	64.4	58.4	53.3	48.8	45.0	403.5
1965	692.7	543.1	428.8	346.4	281.6	229.4	188.5	157.7	133.7	114.4	99.5	87.2	76.9	68.5	61.4	55.3	50.1	45.7	41.9	385.1
1966	692.3	543.4	432.5	352.3	289.5	237.8	195.0	161.0	135.2	114.9	98.5	85.8	75.3	66.5	59.2	53.1	47.8	43.4	39.6	369.8
1967	691.9	540.8	422.0	346.5	287.1	238.3	197.1	162.5	134.6	113.3	96.5	82.8	72.2	63.4	56.0	50.0	44.8	40.4	36.6	345.6
1968	690.8	537.3	406.2	327.0	273.1	228.6	191.1	158.8	131.3	109.1	92.0	78.4	67.4	58.8	51.7	45.7	40.8	36.6	32.9	312.2
1969	688.9	533.0	388.4	302.9	248.0	209.3	176.4	148.2	123.5	102.4	85.2	72.0	61.5	52.9	46.1	40.6	35.9	32.0	28.7	271.2
1970	686.1	528.3	371.9	279.6	221.8	183.5	155.9	132.0	111.3	93.0	77.3	64.4	54.4	46.5	40.0	35.0	30.8	27.2	24.3	227.6
1971	681.6	520.4	346.2	251.5	192.3	154.1	128.4	109.6	93.1	78.7	65.9	54.8	45.7	38.7	33.1	28.5	24.9	21.9	19.4	179.5
1972	675.2	514.9	332.8	228.4	168.7	130.3	105.2	88.0	75.4	64.3	54.4	45.6	38.0	31.7	26.8	23.0	19.8	17.3	15.2	138.3
1973	667.2	507.6	320.2	213.5	149.0	111.2	86.5	70.1	58.9	50.6	43.2	36.6	30.7	25.6	21.4	18.1	15.5	13.4	11.7	103.8
1974	461.3	499.2	306.9	199.7	135.4	95.5	71.8	56.1	45.7	38.4	33.1	28.3	24.0	20.2	16.8	14.1	11.9	10.2	8.8	75.9
1975	399.2	341.6	284.6	180.5	119.5	81.9	58.1	43.9	34.4	28.1	23.7	20.4	17.5	14.8	12.5	10.4	8.7	7.4	6.3	52.5
1976	467.7	291.6	179.8	154.5	99.7	66.7	46.0	32.8	24.9	19.6	16.0	13.5	11.6	10.0	8.5	7.1	6.0	5.0	4.2	33.7
1977	609.6	336.0	139.4	88.7	77.5	50.5	34.0	23.6	16.9	12.8	10.1	8.3	7.0	6.0	5.2	4.4	3.7	3.1	2.6	19.7
1978	668.1	425.0	135.0	57.8	37.4	33.0	21.7	14.7	10.2	7.3	5.6	4.4	3.6	3.0	2.6	2.3	1.9	1.6	1.4	9.7
1979	379.3	448.7	137.5	45.0	19.6	12.8	11.4	7.5	5.1	3.6	2.6	2.0	1.5	1.3	1.1	0.9	0.8	0.7	0.6	3.9
1980	703.4	250.1	130.3	41.2	13.7	6.0	4.0	3.5	2.3	1.6	1.1	0.8	0.6	0.5	0.4	0.3	0.3	0.3	0.2	1.4
1981	153.9	456.1	65.9	35.4	11.4	3.8	1.7	1.1	1.0	0.7	0.5	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.5
1982	310.3	107.7	186.6	27.8	15.2	4.9	1.7	0.7	0.5	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.2
1983	556.8	218.2	45.4	81.2	12.3	6.8	2.2	0.8	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1
1984	752.9	384.8	83.2	17.9	32.5	5.0	2.8	0.9	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1

Table 1.3. (continued)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1985	212.9	462.8	144.0	27.8	6.1	11.1	1.7	1.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	281.1	131.4	173.3	49.8	9.7	2.1	4.0	0.6	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	352.0	168.4	49.9	68.5	20.0	4.0	0.9	1.6	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	281.0	228.6	75.3	22.8	31.8	9.4	1.9	0.4	0.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	283.7	182.6	98.0	32.7	10.1	14.2	4.2	0.8	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	247.7	188.9	82.0	37.1	12.6	3.9	5.5	1.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	334.1	153.7	74.7	32.5	14.9	5.1	1.6	2.3	0.7	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	169.2	230.1	78.7	35.8	15.7	7.3	2.5	0.8	1.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	130.4	124.3	137.0	41.5	17.1	7.5	3.5	1.2	0.4	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	127.6	91.2	67.7	64.1	15.8	6.5	2.9	1.3	0.5	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	129.3	84.1	48.6	34.8	30.6	7.6	3.1	1.4	0.7	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	177.7	84.6	43.8	24.2	16.1	14.3	3.5	1.5	0.7	0.3	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	184.5	121.5	47.0	22.5	11.1	7.5	6.6	1.7	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	394.0	131.3	73.3	25.3	10.5	5.2	3.5	3.1	0.8	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	454.3	279.4	73.5	37.2	12.0	5.0	2.5	1.7	1.5	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	365.5	320.8	151.4	35.3	16.6	5.4	2.3	1.1	0.8	0.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	253.7	252.2	166.7	72.0	16.3	7.7	2.5	1.1	0.5	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2002	302.3	168.1	122.7	75.0	30.9	7.0	3.4	1.1	0.5	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2003	212.7	200.0	83.5	58.1	35.3	14.7	3.4	1.6	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2004	259.5	141.1	99.9	41.4	30.6	18.8	7.9	1.8	0.9	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2005	274.2	168.6	67.8	46.3	19.6	14.6	9.0	3.8	0.9	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	279.6	181.5	82.6	32.0	22.6	9.7	7.3	4.5	1.9	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	285.9	191.4	95.4	42.0	17.0	12.2	5.2	3.9	2.5	1.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 1.4. Red snapper: Estimated biomass at age (mt) at start of year

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1945	108.6	305.8	542.0	769.1	960.1	1104.5	1202.6	1259.4	1282.2	1278.4	1254.8	1217.0	1169.5	1116.0	1059.1	1000.9	942.7	885.5	830.1	11064.0
1946	159.2	305.6	539.9	766.2	956.3	1100.3	1197.9	1254.5	1277.2	1273.4	1249.9	1212.2	1165.0	1111.7	1055.0	997.0	939.0	882.1	826.8	11021.1
1947	159.2	447.9	539.4	762.9	952.3	1095.6	1192.8	1249.2	1271.8	1268.0	1244.6	1207.1	1160.0	1106.9	1050.5	992.7	935.0	878.3	823.3	10974.2
1948	159.1	447.5	786.6	758.2	943.4	1085.4	1181.7	1237.5	1259.9	1256.2	1233.0	1195.8	1149.2	1096.6	1040.7	983.5	926.3	870.1	815.6	10871.9
1949	159.1	447.1	781.8	1100.1	932.8	1069.7	1164.6	1219.7	1241.8	1238.1	1215.2	1178.6	1132.7	1080.8	1025.7	969.3	912.9	857.6	803.9	10715.1
1950	159.1	446.6	777.0	1087.7	1346.4	1052.2	1141.9	1195.8	1217.5	1213.9	1191.5	1155.6	1110.5	1059.7	1005.7	950.4	895.1	840.8	788.2	10505.8
1951	159.1	446.2	772.1	1075.3	1324.1	1510.7	1117.2	1166.3	1187.4	1183.9	1162.0	1127.0	1083.1	1033.5	980.8	926.9	873.0	820.0	768.7	10246.0
1952	159.1	445.6	765.5	1060.5	1299.1	1474.5	1591.9	1132.5	1149.3	1145.9	1124.7	1090.8	1048.3	1000.3	949.3	897.1	844.9	793.7	744.0	9917.0
1953	159.0	445.2	761.9	1048.0	1277.1	1441.9	1548.7	1608.3	1112.3	1105.4	1085.0	1052.3	1011.3	965.0	915.8	865.5	815.1	765.7	717.8	9567.2
1954	159.0	444.7	757.0	1037.0	1254.6	1409.2	1505.7	1555.6	1570.5	1063.7	1040.7	1009.3	970.0	925.6	878.4	830.1	781.8	734.4	688.4	9176.1
1955	158.9	443.8	749.0	1020.6	1230.0	1371.6	1457.8	1498.3	1504.9	1487.9	992.1	959.1	921.7	879.5	834.7	788.8	742.9	697.8	654.1	8719.3
1956	158.8	443.3	743.9	1004.9	1204.6	1338.0	1412.0	1443.6	1442.4	1418.8	1380.9	909.8	871.5	831.6	789.2	745.8	702.4	659.8	618.5	8244.5
1957	158.7	442.5	737.7	991.1	1177.8	1301.2	1367.8	1388.4	1379.9	1350.3	1307.5	1257.5	820.9	780.8	741.0	700.2	659.5	619.5	580.7	7740.8
1958	158.6	441.0	725.1	967.8	1143.7	1252.6	1309.7	1324.2	1306.7	1271.9	1225.2	1172.3	1117.2	724.1	685.0	647.3	609.7	572.7	536.9	7156.0
1959	158.4	440.3	719.2	946.6	1111.3	1210.5	1254.7	1261.8	1240.3	1198.6	1148.5	1093.2	1036.4	980.7	632.2	595.5	560.9	526.9	493.9	6583.3
1960	158.2	438.9	709.5	927.8	1074.2	1162.3	1198.1	1194.5	1167.9	1124.2	1069.5	1012.6	955.1	899.1	846.1	543.1	509.9	479.0	449.0	5984.9
1961	158.0	437.4	697.9	903.2	1038.9	1108.6	1135.2	1125.5	1090.9	1044.5	989.8	930.5	873.0	817.5	765.4	717.3	458.9	429.7	402.8	5368.8
1962	157.7	436.7	695.6	888.6	1011.4	1072.3	1082.9	1066.6	1028.1	975.9	919.8	861.3	802.3	747.4	696.1	648.9	606.1	386.7	361.4	4816.8
1963	157.5	436.7	701.3	894.2	1004.9	1054.2	1057.7	1027.4	983.8	928.7	867.8	808.2	749.9	693.6	642.6	596.0	553.7	515.8	328.5	4363.9
1964	157.3	436.8	709.1	911.6	1022.5	1059.0	1051.5	1014.8	958.2	898.6	835.0	771.0	711.6	655.5	603.0	556.3	514.2	476.5	442.9	3998.6
1965	157.1	436.9	715.1	929.3	1051.0	1086.4	1064.9	1017.0	954.1	882.4	814.6	747.9	684.3	627.1	574.5	526.3	483.9	446.1	412.5	3816.4
1966	157.1	437.2	721.3	945.1	1080.4	1126.2	1101.7	1038.7	964.4	886.1	806.7	735.8	669.5	608.2	554.3	505.7	461.7	423.4	389.5	3664.7
1967	157.0	435.0	703.8	929.6	1071.4	1128.9	1113.5	1047.9	960.4	873.2	789.9	710.5	642.2	580.2	524.2	475.7	432.6	393.8	360.4	3425.6
1968	156.7	432.2	677.3	877.1	1019.2	1082.7	1079.5	1024.3	937.0	841.1	752.8	672.9	599.8	538.3	483.6	435.1	393.5	356.9	324.3	3093.9
1969	156.3	428.7	647.7	812.4	925.5	991.1	996.4	955.6	881.5	789.7	697.8	617.2	546.6	483.8	431.8	386.3	346.4	312.5	282.8	2688.1
1970	155.6	425.0	620.3	750.0	827.6	869.0	880.7	851.6	794.0	717.3	632.6	552.3	484.1	425.7	374.7	333.0	296.9	265.6	239.1	2255.8
1971	154.6	418.7	577.4	674.5	717.5	729.7	725.1	706.8	664.5	606.7	539.6	470.2	406.8	354.0	309.6	271.4	240.4	213.8	190.8	1778.9
1972	153.2	414.2	554.9	612.6	629.6	617.3	594.1	567.8	538.1	495.4	445.3	391.3	337.9	290.3	251.2	218.8	191.1	168.8	149.8	1370.3
1973	151.4	408.3	533.9	572.6	556.1	526.8	488.7	452.5	420.4	390.2	353.6	314.1	273.5	234.5	200.3	172.6	149.8	130.6	115.1	1028.5
1974	104.6	401.6	511.8	535.7	505.5	452.4	405.5	361.9	325.7	296.4	270.8	242.5	213.4	184.5	157.4	133.9	115.0	99.5	86.5	752.4
1975	90.6	274.8	474.6	484.3	445.9	387.8	328.4	283.2	245.7	216.6	194.0	175.1	155.4	135.8	116.8	99.2	84.1	72.0	62.2	520.5
1976	106.1	234.5	299.8	414.5	372.0	315.7	259.8	211.7	177.4	150.8	130.8	115.8	103.6	91.3	79.3	67.9	57.5	48.6	41.5	333.7
1977	138.3	270.3	232.4	237.8	289.2	239.3	192.2	152.1	120.5	98.9	82.7	70.9	62.2	55.3	48.4	41.9	35.8	30.2	25.5	195.2
1978	151.6	341.9	225.1	154.9	139.5	156.3	122.4	94.5	72.8	56.4	45.6	37.7	32.0	27.9	24.6	21.5	18.5	15.8	13.3	96.5
1979	86.0	361.0	229.3	120.8	73.2	60.7	64.4	48.5	36.4	27.4	21.0	16.7	13.7	11.6	10.0	8.8	7.7	6.6	5.6	38.6
1980	159.6	201.1	217.3	110.5	51.2	28.6	22.4	22.9	16.8	12.3	9.1	6.9	5.5	4.4	3.7	3.2	2.8	2.4	2.1	14.0
1981	34.9	366.9	110.0	95.1	42.5	18.2	9.6	7.2	7.2	5.2	3.7	2.7	2.0	1.6	1.3	1.1	0.9	0.8	0.7	4.6
1982	70.4	86.6	311.1	74.7	56.8	23.4	9.5	4.8	3.5	3.4	2.4	1.7	1.3	0.9	0.7	0.6	0.5	0.4	0.4	2.4
1983	126.3	175.5	75.7	217.8	46.0	32.2	12.6	4.9	2.4	1.7	1.7	1.2	0.8	0.6	0.4	0.3	0.3	0.2	0.2	1.3
1984	170.8	309.5	138.8	47.9	121.3	23.6	15.7	5.9	2.2	1.1	0.8	0.7	0.5	0.3	0.3	0.2	0.1	0.1	0.1	0.6
1985	48.3	372.2	240.2	74.6	22.6	52.7	9.7	6.2	2.3	0.8	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.2
1986	63.8	105.7	289.1	133.7	36.4	10.2	22.4	4.0	2.5	0.9	0.3	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1
1987	79.9	135.4	83.3	183.7	74.7	18.7	5.0	10.5	1.8	1.1	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
1988	63.7	183.9	125.6	61.1	118.6	44.4	10.5	2.7	5.5	0.9	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	64.4	146.9	163.5	87.7	37.5	67.1	23.8	5.4	1.3	2.7	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	56.2	152.0	136.7	99.4	46.8	18.5	31.2	10.7	2.4	0.6	1.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	75.8	123.6	124.6	87.1	55.6	24.1	9.0	14.7	4.9	1.1	0.3	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	38.4	185.1	131.2	96.0	58.6	34.4	14.1	5.1	8.0	2.6	0.6	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	29.6	100.0	228.5	111.4	63.7	35.6	19.8	7.8	2.7	4.2	1.4	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1994	28.9	73.4	113.0	171.8	58.8	30.6	16.2	8.6	3.3	1.1	1.7	0.6	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
1995	29.3	67.7	81.0	93.3	114.3	35.8	17.6	9.0	4.7	1.8	0.6	0.9	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1996	40.3	68.1	73.1	64.8	60.3	67.6	20.0	9.5	4.7	2.4	0.9	0.3	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1997	41.9	97.8	78.5	60.3	41.5	35.3	37.5	10.7	4.9	2.4	1.2	0.4	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0
1998	89.4	105.6	122.3	67.9	39.1	24.6	19.8	20.2	5.6	2.5	1.2	0.6	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
1999	103.1	224.8	122.5	99.9	44.7	23.6	14.0	10.9	10.8	2.9	1.3	0.6	0.3	0.1	0.0	0.1	0.0	0.0	0.0	0.0
2000	82.9	258.1	252.4	94.7	62.0	25.4	12.7	7.3	5.5	5.3	1.4	0.7	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0
2001	57.6	202.9	278.0	193.1	60.7	36.5	14.2	6.8	3.8	2.8	2.7	0.7	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0
2002	68.6	135.2	204.6	201.1	115.5	33.3	18.9	7.1	3.3	1.8	1.3	1.3	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0
2003	48.3	160.9	139.3	155.8	131.9	69.5	18.9	10.4	3.8	1.7	0.9	0.7	0.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0
2004	58.9	113.5	166.6	111.1	114.2	89.0	44.4	11.6	6.2	2.2	1.0	0.5	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0
2005	62.2	135.6	113.1	124.1	73.2	69.1	51.0	24.4	6.2	3.2	1.2	0.5	0.3	0.2	0.2	0.1	0.0	0.0	0.0	0.0
2006	63.4	146.0	137.8	85.9	84.5	45.9	41.0	29.1	13.6	3.4	1.8	0.6	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0
2007	64.8	154.0	159.0	112.6	63.5	57.7	29.6	25.5	17.6	8.0	2.0	1.0	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0

Table 1.5. Red snapper: Estimated biomass at age (1000 lb) at start of year

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1945	239.4	674.1	1195.0	1695.7	2116.6	2435.1	2651.2	2776.5	2826.7	2818.4	2766.3	2683.0	2578.4	2460.4	2335.0	2206.5	2078.2	1952.2	1830.0	24392.1
1946	350.9	673.7	1190.3	1689.1	2108.4	2425.6	2640.9	2765.7	2815.8	2807.4	2755.6	2672.5	2568.4	2450.8	2325.9	2198.0	2070.1	1944.6	1822.9	24297.3
1947	350.9	987.5	1189.1	1681.9	2099.4	2415.3	2629.7	2754.0	2803.8	2795.5	2743.9	2661.2	2557.5	2440.4	2316.0	2188.6	2061.3	1936.3	1815.1	24194.1
1948	350.9	986.6	1734.2	1671.6	2079.8	2392.8	2605.2	2728.3	2777.6	2769.4	2718.3	2636.4	2533.6	2417.6	2294.4	2168.2	2042.1	1918.3	1798.2	23968.4
1949	350.8	985.6	1723.6	2425.3	2056.5	2358.3	2567.6	2688.9	2737.6	2729.5	2679.1	2598.3	2497.1	2382.8	2261.3	2136.9	2012.7	1890.6	1772.3	23622.8
1950	350.8	984.7	1713.0	2398.0	2968.2	2319.7	2517.4	2636.4	2684.1	2676.2	2626.7	2547.6	2448.3	2336.2	2217.2	2095.2	1973.3	1853.7	1737.6	23161.3
1951	350.8	983.7	1702.3	2370.6	2919.2	3330.5	2463.1	2571.2	2617.7	2610.0	2561.8	2484.6	2387.8	2278.4	2162.3	2043.4	1924.5	1807.8	1694.7	22588.6
1952	350.7	982.3	1687.7	2338.0	2864.1	3250.7	3509.6	2496.7	2533.7	2526.2	2479.5	2404.8	2311.1	2205.3	2092.9	1977.8	1862.7	1749.8	1640.2	21863.3
1953	350.6	981.6	1679.8	2310.4	2815.4	3178.9	3414.3	3545.8	2452.2	2437.1	2392.1	2320.0	2229.6	2127.5	2019.1	1908.0	1797.0	1688.1	1582.4	21092.1
1954	350.5	980.3	1668.8	2286.2	2766.0	3106.7	3319.5	3429.5	3462.4	2345.0	2294.3	2225.1	2138.4	2040.5	1936.5	1830.0	1723.6	1619.1	1517.7	20229.8
1955	350.4	978.5	1651.2	2250.1	2711.6	3023.8	3214.0	3303.3	3317.8	3280.3	2187.1	2114.4	2032.0	1938.9	1840.1	1738.9	1637.8	1538.5	1442.1	19222.7
1956	350.2	977.2	1640.0	2215.5	2655.8	2949.8	3112.9	3182.6	3180.0	3127.8	3044.4	2005.7	1921.3	1833.4	1739.9	1644.2	1548.6	1454.7	1363.6	18176.0
1957	350.0	975.5	1626.4	2185.0	2596.5	2868.7	3015.4	3060.8	3042.2	2976.8	2882.5	2772.2	1809.7	1721.3	1633.6	1543.8	1454.0	1365.8	1280.3	17065.5
1958	349.7	972.3	1598.6	2133.5	2521.3	2761.6	2887.3	2919.3	2880.8	2804.1	2701.1	2584.4	2462.9	1596.4	1510.2	1427.1	1344.1	1262.6	1183.6	15776.2
1959	349.3	970.7	1585.6	2086.9	2450.1	2668.6	2766.1	2781.8	2734.3	2642.4	2532.0	2410.1	2284.9	2162.1	1393.8	1312.9	1236.6	1161.6	1088.9	14513.8
1960	348.9	967.7	1564.2	2045.5	2368.1	2562.5	2641.3	2633.4	2574.7	2478.4	2357.9	2232.5	2105.6	1982.1	1865.4	1197.4	1124.2	1056.0	989.9	13194.4
1961	348.3	964.2	1538.7	1991.1	2290.4	2444.0	2502.7	2481.4	2405.1	2302.8	2182.2	2051.4	1924.6	1802.4	1687.5	1581.3	1011.7	947.3	888.0	11836.2
1962	347.7	962.8	1533.5	1958.9	2229.9	2364.1	2387.3	2351.5	2266.6	2151.4	2027.9	1898.8	1768.7	1647.7	1534.7	1430.7	1336.2	852.6	796.7	10619.2
1963	347.2	962.7	1546.1	1971.4	2215.3	2324.2	2331.9	2265.1	2169.0	2047.4	1913.2	1781.9	1653.3	1529.1	1416.7	1313.9	1220.8	1137.2	724.1	9620.8
1964	346.7	963.0	1563.3	2009.8	2254.3	2334.8	2318.1	2237.2	2112.5	1981.1	1840.9	1699.8	1568.7	1445.2	1329.4	1226.4	1133.6	1050.5	976.5	8815.3
1965	346.4	963.2	1576.5	2048.7	2316.9	2395.2	2347.6	2242.0	2103.5	1945.3	1795.8	1648.9	1508.6	1382.4	1266.7	1160.2	1066.8	983.5	909.5	8413.8
1966	346.3	963.8	1590.2	2083.7	2381.9	2482.8	2428.9	2289.9	2126.1	1953.5	1778.4	1622.2	1476.0	1340.8	1222.0	1114.9	1017.8	933.4	858.7	8079.3
1967	346.0	959.1	1551.5	2049.4	2362.1	2488.7	2454.9	2310.1	2117.3	1925.2	1741.3	1566.4	1415.9	1279.1	1155.7	1048.8	953.6	868.3	794.6	7552.1
1968	345.5	952.9	1493.3	1933.8	2246.9	2387.0	2379.9	2258.2	2065.8	1854.3	1659.7	1483.4	1322.2	1186.7	1066.2	959.2	867.6	786.8	714.9	6820.8
1969	344.6	945.2	1427.8	1791.1	2040.3	2185.1	2196.7	2106.8	1943.3	1741.0	1538.4	1360.6	1205.0	1066.5	952.0	851.7	763.7	688.9	623.5	5926.3
1970	343.1	937.0	1367.4	1653.6	1824.6	1915.8	1941.5	1877.5	1750.5	1581.3	1394.7	1217.7	1067.2	938.4	826.0	734.2	654.7	585.5	527.0	4973.2
1971	340.9	923.0	1272.9	1487.1	1581.9	1608.8	1598.5	1558.3	1465.0	1337.6	1189.5	1036.6	896.9	780.4	682.5	598.2	529.9	471.3	420.6	3921.8
1972	337.7	913.1	1223.4	1350.6	1388.0	1360.8	1309.7	1251.8	1186.3	1092.2	981.7	862.7	744.9	639.9	553.8	482.3	421.3	372.2	330.4	3021.0
1973	333.7	900.2	1177.1	1262.5	1226.0	1161.3	1077.5	997.5	926.8	860.2	779.6	692.4	602.9	516.9	441.7	380.6	330.3	287.8	253.8	2267.5
1974	230.7	885.3	1128.4	1181.1	1114.3	997.4	894.1	797.9	718.1	653.4	597.0	534.7	470.6	406.8	346.9	295.1	253.5	219.4	190.8	1658.8
1975	199.6	605.9	1046.4	1067.7	983.0	854.8	724.1	624.3	541.7	477.4	427.7	386.1	342.6	299.4	257.4	218.6	185.3	158.8	137.2	1147.5
1976	233.9	517.1	660.9	913.8	820.2	696.0	572.8	466.7	391.2	332.4	288.4	255.3	228.3	201.2	174.9	149.7	126.7	107.1	91.6	735.6
1977	304.9	595.9	512.4	524.3	637.7	527.5	423.6	335.3	265.6	218.0	182.4	156.4	137.1	121.8	106.7	92.4	78.8	66.5	56.2	430.3
1978	334.1	753.7	496.2	341.6	307.5	344.7	269.8	208.4	160.4	124.4	100.5	83.1	70.6	61.5	54.3	47.4	40.9	34.8	29.3	212.6
1979	189.7	795.8	505.4	266.4	161.3	133.8	141.9	106.9	80.3	60.5	46.2	36.9	30.2	25.5	22.1	19.4	16.9	14.5	12.3	85.2
1980	351.8	443.4	479.0	243.5	112.9	63.0	49.5	50.5	36.9	27.2	20.2	15.2	12.0	9.8	8.2	7.1	6.2	5.4	4.6	30.8
1981	77.0	808.9	242.4	209.6	93.7	40.1	21.2	16.0	15.8	11.4	8.2	6.0	4.5	3.5	2.9	2.4	2.1	1.8	1.6	10.2
1982	155.2	190.9	686.0	164.6	125.2	51.6	20.9	10.6	7.8	7.6	5.3	3.8	2.8	2.1	1.6	1.3	1.1	0.9	0.8	5.2
1983	278.5	387.0	166.9	480.1	101.3	71.0	27.7	10.8	5.3	3.8	3.7	2.6	1.8	1.3	1.0	0.7	0.6	0.5	0.4	2.8
1984	376.5	682.3	306.0	105.7	267.4	52.0	34.5	12.9	4.9	2.4	1.7	1.6	1.1	0.8	0.6	0.4	0.3	0.3	0.2	1.3
1985	106.5	820.7	529.5	164.5	49.9	116.2	21.4	13.7	5.0	1.8	0.9	0.6	0.6	0.4	0.3	0.2	0.1	0.1	0.1	0.5
1986	140.6	233.1	637.3	294.7	80.2	22.4	49.4	8.7	5.4	1.9	0.7	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.2
1987	176.1	298.6	183.6	405.0	164.7	41.3	10.9	23.2	4.0	2.4	0.9	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1
1988	140.5	405.3	276.9	134.7	261.4	97.9	23.2	5.9	12.2	2.1	1.2	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1
1989	141.9	323.8	360.5	193.4	82.8	148.0	52.5	12.0	3.0	6.0	1.0	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1990	123.9	335.0	301.3	219.1	103.3	40.7	68.9	23.5	5.2	1.3	2.5	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1991	167.1	272.5	274.8	192.1	122.6	53.2	19.9	32.3	10.7	2.3	0.6	1.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1992	84.6	408.0	289.3	211.6	129.1	75.8	31.1	11.2	17.7	5.7	1.2	0.3	0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0
1993	65.2	220.4	503.7	245.5	140.4	78.4	43.6	17.2	6.0	9.3	3.0	0.6	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0
1994	63.8	161.8	249.1	378.9	129.6	67.5	35.7	19.1	7.3	2.5	3.8	1.2	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0
1995	64.6	149.2	178.6	205.7	252.1	78.9	38.9	19.8	10.3	3.9	1.3	2.0	0.6	0.1	0.0	0.1	0.0	0.0	0.0	0.0
1996	88.9	150.0	161.2	142.8	132.9	149.0	44.1	20.9	10.3	5.3	2.0	0.7	1.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0
1997	92.3	215.5	173.0	133.0	91.5	77.9	82.6	23.5	10.8	5.3	2.7	1.0	0.3	0.5	0.2	0.0	0.0	0.0	0.0	0.0
1998	197.1	232.8	269.6	149.7	86.3	54.3	43.7	44.6	12.4	5.6	2.7	1.4	0.5	0.2	0.3	0.1	0.0	0.0	0.0	0.0
1999	227.2	495.5	270.1	220.2	98.5	52.0	31.0	24.0	23.8	6.5	2.9	1.4	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0
2000	182.8	569.0	556.5	208.7	136.8	56.1	28.0	16.1	12.1	11.7	3.2	1.4	0.7	0.3	0.1	0.0	0.1	0.0	0.0	0.0
2001	126.9	447.2	612.9	425.8	133.9	80.6	31.3	15.0	8.4	6.2	6.0	1.6	0.7	0.3	0.2	0.1	0.0	0.0	0.0	0.0
2002	151.2	298.1	451.1	443.4	254.6	73.4	41.8	15.6	7.3	4.0	2.9	2.9	0.8	0.3	0.2	0.1	0.0	0.0	0.0	0.0
2003	106.4	354.7	307.1	343.5	290.8	153.3	41.8	22.9	8.3	3.8	2.1	1.5	1.5	0.4	0.2	0.1	0.0	0.0	0.0	0.0
2004	129.8	250.2	367.3	245.0	251.7	196.2	97.9	25.7	13.7	4.9	2.2	1.2	0.9	0.9	0.2	0.1	0.0	0.0	0.0	0.0
2005	137.1	299.0	249.4	273.6	161.3	152.3	112.4	53.9	13.7	7.2	2.5	1.2	0.6	0.5	0.4	0.1	0.1	0.0	0.0	0.0
2006	139.9	321.9	303.8	189.3	186.4	101.2	90.4	64.1	29.9	7.5	3.9	1.4	0.6	0.3	0.2	0.2	0.1	0.0	0.0	0.0
2007	143.0	339.4	350.6	248.3	140.1	127.1	65.3	56.1	38.7	17.7	4.4	2.2	0.8	0.4	0.2	0.1	0.1	0.0	0.0	0.0

Table 1.6. Red snapper: Estimated time series and status indicators. Fishing mortality rate is full F, which includes discard mortalities. Total biomass (B) is at the start of the year, and spawning biomass (SSB) at the midpoint; B and SSB are in units mt. $F_{40\%}$ and $SSB_{F_{40\%}}$ are used as proxies for MSY *reference points. The* MSST *is defined by* $\mathrm{MSST} = (1 - M)\mathrm{SSB}_{F_{40\%}}$*, with constant* $M = 0.078$*. SPR is static spawning potential ratio.*

Year	F	$F/F_{40\%}$	B	B/B_{unfished}	SSB	$SSB/SSB_{F_{40\%}}$	SSB/MSST	SPR
1945	0.00389	0.0374	29352	0.7500	13985	2.0424	2.2152	0.64548
1946	0.00426	0.0409	29290	0.7484	13907	2.0310	2.2028	0.64305
1947	0.00937	0.0900	29312	0.7490	13856	2.0235	2.1947	0.61029
1948	0.01452	0.1395	29298	0.7486	13801	2.0155	2.1860	0.57936
1949	0.01973	0.1896	29247	0.7473	13736	2.0060	2.1757	0.55004
1950	0.02504	0.2405	29141	0.7446	13647	1.9930	2.1616	0.52208
1951	0.03263	0.3135	28963	0.7401	13510	1.9730	2.1399	0.48505
1952	0.03591	0.3450	28634	0.7316	13332	1.9470	2.1117	0.47012
1953	0.04174	0.4010	28269	0.7223	13120	1.9161	2.0782	0.44496
1954	0.05107	0.4905	27792	0.7101	12836	1.8746	2.0331	0.40817
1955	0.05599	0.5379	27113	0.6928	12487	1.8236	1.9779	0.39031
1956	0.06304	0.6056	26364	0.6737	12095	1.7663	1.9158	0.36646
1957	0.07856	0.7546	25504	0.6517	11604	1.6947	1.8380	0.32030
1958	0.08340	0.8012	24348	0.6221	11044	1.6128	1.7493	0.30745
1959	0.09531	0.9155	23193	0.5926	10449	1.5261	1.6552	0.27866
1960	0.10863	1.0435	21904	0.5597	9794	1.4303	1.5513	0.25055
1961	0.10850	1.0423	20494	0.5237	9153	1.3367	1.4498	0.25080
1962	0.09873	0.9484	19263	0.4922	8634	1.2610	1.3676	0.27105
1963	0.08766	0.8421	18367	0.4693	8269	1.2076	1.3098	0.29672
1964	0.07953	0.7640	17784	0.4544	8032	1.1730	1.2723	0.31765
1965	0.07105	0.6825	17428	0.4453	7900	1.1537	1.2513	0.34162
1966	0.09630	0.9251	17277	0.4415	7731	1.1290	1.2245	0.27642
1967	0.12972	1.2461	16756	0.4281	7369	1.0761	1.1672	0.21335
1968	0.16809	1.6147	15778	0.4032	6799	0.9930	1.0770	0.16283
1969	0.20318	1.9518	14378	0.3674	6076	0.8874	0.9624	0.13010
1970	0.26607	2.5559	12751	0.3258	5207	0.7604	0.8247	0.09114
1971	0.29068	2.7924	10751	0.2747	4316	0.6304	0.6837	0.08040
1972	0.31850	3.0595	8992	0.2298	3539	0.5168	0.5606	0.07034
1973	0.34654	3.3290	7474	0.1910	2879	0.4205	0.4560	0.06195
1974	0.40527	3.8931	6157	0.1573	2296	0.3352	0.3636	0.04856
1975	0.48547	4.6635	4847	0.1238	1736	0.2535	0.2749	0.03624
1976	0.58151	5.5861	3612	0.0923	1220	0.1782	0.1933	0.02677
1977	0.75546	7.2570	2619	0.0669	785	0.1146	0.1243	0.01702
1978	0.97213	9.3384	1849	0.0472	469	0.0684	0.0742	0.01091
1979	1.08018	10.3764	1248	0.0319	287	0.0419	0.0454	0.00905
1980	1.17629	11.2997	897	0.0229	184	0.0269	0.0292	0.00778
1981	0.73730	7.0826	716	0.0183	178	0.0261	0.0283	0.01776
1982	0.70673	6.7889	656	0.0167	181	0.0264	0.0287	0.01912
1983	0.80713	7.7534	702	0.0179	171	0.0249	0.0271	0.01515
1984	1.07205	10.2982	840	0.0215	178	0.0260	0.0282	0.01122
1985	1.03330	9.9261	831	0.0212	193	0.0281	0.0305	0.01164
1986	0.98506	9.4627	669	0.0171	176	0.0257	0.0279	0.01319
1987	0.82464	7.9216	595	0.0152	163	0.0237	0.0257	0.01998
1988	0.84583	8.1252	618	0.0158	164	0.0239	0.0260	0.01790
1989	0.90349	8.6791	601	0.0154	154	0.0225	0.0244	0.01593
1990	1.00768	9.6800	556	0.0142	142	0.0207	0.0225	0.01415
1991	0.67271	6.4622	521	0.0133	144	0.0210	0.0227	0.02561
1992	0.77002	7.3970	574	0.0147	169	0.0247	0.0267	0.03283
1993	1.10288	10.5944	605	0.0155	174	0.0253	0.0275	0.02206
1994	0.99546	9.5626	508	0.0130	157	0.0230	0.0249	0.02629
1995	1.04026	9.9929	456	0.0117	139	0.0203	0.0220	0.02428
1996	0.95771	9.1999	413	0.0105	122	0.0179	0.0194	0.02720
1997	0.86656	8.3243	413	0.0105	121	0.0177	0.0192	0.03185
1998	0.84933	8.1588	499	0.0128	137	0.0199	0.0216	0.02895
1999	0.91163	8.7572	660	0.0169	172	0.0251	0.0272	0.02555
2000	0.92516	8.8872	809	0.0207	220	0.0322	0.0349	0.02466
2001	1.08069	10.3813	861	0.0220	241	0.0352	0.0382	0.02028
2002	0.99186	9.5280	793	0.0203	233	0.0340	0.0368	0.02317
2003	0.87289	8.3851	743	0.0190	229	0.0334	0.0362	0.02748
2004	1.02364	9.8333	720	0.0184	214	0.0312	0.0339	0.02190
2005	0.94855	9.1119	665	0.0170	196	0.0286	0.0310	0.02382
2006	0.79722	7.6582	654	0.0167	197	0.0288	0.0312	0.03061
2007	.	.	696	0.0178	.	.	.	.

Table 1.7. Red snapper: Selectivity at age for commercial handline (c.hal), commercial diving (c.dv), headboat (hb), general recreational (rec), commercial handline discard mortalities (D.c.hal), headboat discard mortalities (D.hb), general recreational discard mortalities (D.rec), selectivity of landings averaged across fisheries (L.avg), and selectivity of discard mortalities averaged across fisheries (D.avg).

Age	Length (mm)	Length (in)	c.hal	c.dv	hb	rec	D.c.hal	D.hb	D.rec	L.avg	D.avg	L.avg+D.avg
1	262.8	10.3	0.0001	0.0020	0.0000	0.0369	0.5000	0.5000	0.5000	0.0122	0.1803	0.1925
2	395.2	15.6	0.0051	0.0306	0.0002	0.6852	1.0000	1.0000	1.0000	0.2269	0.3606	0.5876
3	499.8	19.7	0.2839	0.3279	0.5410	0.9920	0.6014	0.6814	0.5967	0.4397	0.2205	0.6602
4	582.5	22.9	0.9685	0.8827	0.9998	0.9999	0.0188	0.0004	0.0249	0.6311	0.0072	0.6383
5	647.9	25.5	0.9996	0.9915	1.0000	1.0000	0.0002	0.0000	0.0004	0.6391	0.0001	0.6393
6	699.6	27.5	1.0000	0.9994	1.0000	1.0000	0.0000	0.0000	0.0000	0.6394	0.0000	0.6394
7	740.4	29.2	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6394	0.0000	0.6394
8	772.7	30.4	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6394	0.0000	0.6394
9	798.3	31.4	1.0000	0.9998	1.0000	1.0000	0.0000	0.0000	0.0000	0.6394	0.0000	0.6394
10	818.5	32.2	1.0000	0.4576	1.0000	1.0000	0.0000	0.0000	0.0000	0.6304	0.0000	0.6304
11	834.4	32.9	1.0000	0.0001	1.0000	1.0000	0.0000	0.0000	0.0000	0.6229	0.0000	0.6229
12	847.1	33.3	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6228	0.0000	0.6228
13	857.0	33.7	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6228	0.0000	0.6228
14	864.9	34.1	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6228	0.0000	0.6228
15	871.2	34.3	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6228	0.0000	0.6228
16	876.1	34.5	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6228	0.0000	0.6228
17	880.0	34.6	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6228	0.0000	0.6228
18	883.1	34.8	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6228	0.0000	0.6228
19	885.5	34.9	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6228	0.0000	0.6228
20	887.4	34.9	1.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.6228	0.0000	0.6228

Table 1.8. Red snapper: Estimated time series of fishing mortality rate for commercial handline (F.c.hal), commercial diving (F.c.dv), headboat (F.hb), general recreational (F.rec), commercial handline discard mortalities (F.c.hal.D), headboat discard mortalities (F.hb.D), general recreational discard mortalities (F.mrfss.D), and full F (F.full).

Year	F.c.hal	F.c.dv	F.hb	F.rec	F.c.hal.D	F.hb.D	F.rec.D	F.full
1945	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.004
1946	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.004
1947	0.005	0.000	0.000	0.005	0.000	0.000	0.000	0.009
1948	0.005	0.000	0.000	0.010	0.000	0.000	0.000	0.015
1949	0.005	0.000	0.000	0.014	0.000	0.000	0.000	0.020
1950	0.006	0.000	0.000	0.019	0.000	0.000	0.000	0.025
1951	0.008	0.000	0.000	0.024	0.000	0.000	0.000	0.033
1952	0.006	0.000	0.000	0.030	0.000	0.000	0.000	0.036
1953	0.007	0.000	0.000	0.035	0.000	0.000	0.000	0.042
1954	0.010	0.000	0.000	0.041	0.000	0.000	0.000	0.051
1955	0.009	0.000	0.000	0.047	0.000	0.000	0.000	0.056
1956	0.009	0.000	0.000	0.054	0.000	0.000	0.000	0.063
1957	0.016	0.000	0.000	0.062	0.000	0.000	0.000	0.079
1958	0.012	0.000	0.000	0.071	0.000	0.000	0.000	0.083
1959	0.014	0.000	0.000	0.082	0.000	0.000	0.000	0.095
1960	0.015	0.000	0.000	0.094	0.000	0.000	0.000	0.109
1961	0.019	0.000	0.000	0.090	0.000	0.000	0.000	0.108
1962	0.015	0.000	0.000	0.084	0.000	0.000	0.000	0.099
1963	0.012	0.000	0.000	0.076	0.000	0.000	0.000	0.088
1964	0.014	0.000	0.000	0.066	0.000	0.000	0.000	0.080
1965	0.016	0.000	0.000	0.055	0.000	0.000	0.000	0.071
1966	0.019	0.000	0.000	0.078	0.000	0.000	0.000	0.096
1967	0.026	0.000	0.000	0.104	0.000	0.000	0.000	0.130
1968	0.031	0.000	0.000	0.137	0.000	0.000	0.000	0.168
1969	0.022	0.000	0.000	0.181	0.000	0.000	0.000	0.203
1970	0.024	0.000	0.000	0.242	0.000	0.000	0.000	0.266
1971	0.025	0.000	0.000	0.266	0.000	0.000	0.000	0.291
1972	0.026	0.000	0.006	0.287	0.000	0.000	0.000	0.318
1973	0.026	0.000	0.009	0.312	0.000	0.000	0.000	0.347
1974	0.053	0.000	0.007	0.345	0.000	0.000	0.000	0.405
1975	0.081	0.000	0.010	0.394	0.000	0.000	0.000	0.485
1976	0.097	0.000	0.019	0.465	0.000	0.000	0.000	0.582
1977	0.156	0.000	0.016	0.584	0.000	0.000	0.000	0.755
1978	0.233	0.000	0.027	0.712	0.000	0.000	0.000	0.972
1979	0.250	0.000	0.036	0.794	0.000	0.000	0.000	1.080
1980	0.368	0.000	0.057	0.752	0.000	0.000	0.000	1.176
1981	0.342	0.000	0.115	0.280	0.000	0.000	0.000	0.737
1982	0.318	0.000	0.109	0.280	0.000	0.000	0.000	0.707
1983	0.335	0.000	0.085	0.387	0.000	0.000	0.000	0.807
1984	0.365	0.003	0.087	0.517	0.012	0.006	0.080	1.072
1985	0.303	0.007	0.122	0.509	0.009	0.007	0.077	1.033
1986	0.260	0.001	0.062	0.481	0.033	0.012	0.136	0.985
1987	0.265	0.001	0.103	0.292	0.053	0.032	0.080	0.825
1988	0.234	0.001	0.155	0.319	0.025	0.025	0.087	0.846
1989	0.386	0.003	0.091	0.370	0.010	0.006	0.038	0.903
1990	0.350	0.005	0.090	0.358	0.124	0.047	0.034	1.008
1991	0.219	0.015	0.101	0.285	0.015	0.009	0.029	0.673
1992	0.218	0.023	0.063	0.334	0.057	0.004	0.069	0.770
1993	0.463	0.013	0.079	0.317	0.078	0.046	0.106	1.103
1994	0.350	0.027	0.096	0.163	0.146	0.048	0.164	0.995
1995	0.355	0.022	0.115	0.174	0.160	0.082	0.132	1.040
1996	0.336	0.016	0.110	0.211	0.184	0.027	0.072	0.958
1997	0.294	0.023	0.138	0.207	0.156	0.007	0.042	0.867
1998	0.234	0.024	0.069	0.320	0.077	0.027	0.099	0.849
1999	0.214	0.027	0.103	0.359	0.048	0.017	0.144	0.912
2000	0.202	0.025	0.091	0.351	0.043	0.021	0.191	0.925
2001	0.287	0.034	0.096	0.325	0.060	0.052	0.226	1.081
2002	0.234	0.035	0.092	0.287	0.067	0.053	0.224	0.992
2003	0.167	0.025	0.054	0.287	0.064	0.038	0.238	0.873
2004	0.223	0.029	0.110	0.281	0.057	0.069	0.254	1.024
2005	0.190	0.016	0.090	0.311	0.052	0.060	0.229	0.949
2006	0.140	0.007	0.066	0.308	0.053	0.039	0.182	0.797

Table 1.9. Red snapper: Estimated instantaneous fishing mortality rate (per yr) at age, including discard mortality

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1945	0.001	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1946	0.001	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1947	0.002	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
1948	0.003	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1949	0.003	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
1950	0.004	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
1951	0.006	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
1952	0.006	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
1953	0.007	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
1954	0.009	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
1955	0.010	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
1956	0.011	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
1957	0.014	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
1958	0.014	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
1959	0.016	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
1960	0.019	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
1961	0.019	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
1962	0.017	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099
1963	0.015	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088
1964	0.014	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
1965	0.012	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
1966	0.017	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096
1967	0.022	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
1968	0.029	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168
1969	0.035	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203
1970	0.046	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266
1971	0.050	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291
1972	0.055	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318
1973	0.060	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347
1974	0.070	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405
1975	0.084	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485
1976	0.100	0.581	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582
1977	0.130	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755
1978	0.168	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972
1979	0.186	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080	1.080
1980	0.203	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176
1981	0.127	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737	0.737
1982	0.122	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707	0.707
1983	0.139	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807
1984	0.256	0.826	0.971	0.973	0.973	0.973	0.973	0.973	0.973	0.971	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970

Table 1.9. (continued)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1985	0.252	0.825	0.936	0.940	0.940	0.940	0.940	0.940	0.940	0.937	0.934	0.934	0.934	0.934	0.934	0.934	0.934	0.934	0.934	0.934
1986	0.282	0.811	0.803	0.804	0.804	0.804	0.804	0.804	0.804	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803
1987	0.201	0.648	0.659	0.660	0.660	0.660	0.660	0.660	0.660	0.659	0.659	0.659	0.659	0.659	0.659	0.659	0.659	0.659	0.659	0.659
1988	0.201	0.690	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709	0.709
1989	0.176	0.644	0.848	0.849	0.850	0.850	0.850	0.850	0.850	0.848	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847
1990	0.247	0.771	0.800	0.803	0.803	0.803	0.803	0.803	0.803	0.801	0.798	0.798	0.798	0.798	0.798	0.798	0.798	0.798	0.798	0.798
1991	0.143	0.513	0.611	0.619	0.621	0.621	0.621	0.621	0.621	0.613	0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606	0.606
1992	0.078	0.362	0.514	0.632	0.639	0.639	0.639	0.639	0.639	0.626	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
1993	0.127	0.450	0.635	0.861	0.872	0.873	0.873	0.873	0.873	0.866	0.860	0.860	0.860	0.860	0.860	0.860	0.860	0.860	0.860	0.860
1994	0.186	0.474	0.541	0.629	0.636	0.636	0.636	0.636	0.636	0.622	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610
1995	0.193	0.495	0.573	0.659	0.666	0.666	0.666	0.666	0.666	0.654	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
1996	0.149	0.430	0.542	0.667	0.674	0.674	0.674	0.674	0.674	0.666	0.658	0.658	0.658	0.658	0.658	0.658	0.658	0.658	0.658	0.658
1997	0.110	0.349	0.494	0.654	0.662	0.662	0.662	0.662	0.662	0.650	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640	0.640
1998	0.113	0.424	0.553	0.640	0.646	0.646	0.646	0.646	0.646	0.634	0.623	0.623	0.623	0.623	0.623	0.623	0.623	0.623	0.623	0.623
1999	0.117	0.456	0.608	0.698	0.703	0.703	0.703	0.703	0.703	0.689	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676
2000	0.141	0.498	0.618	0.666	0.669	0.669	0.670	0.670	0.670	0.656	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
2001	0.181	0.564	0.674	0.736	0.742	0.742	0.742	0.742	0.742	0.724	0.708	0.708	0.708	0.708	0.708	0.708	0.708	0.708	0.708	0.708
2002	0.183	0.543	0.623	0.644	0.648	0.648	0.648	0.648	0.648	0.629	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614
2003	0.180	0.538	0.576	0.532	0.533	0.534	0.534	0.534	0.534	0.520	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508
2004	0.201	0.576	0.644	0.640	0.642	0.643	0.643	0.643	0.643	0.627	0.613	0.613	0.613	0.613	0.613	0.613	0.613	0.613	0.613	0.613
2005	0.182	0.556	0.626	0.606	0.607	0.607	0.607	0.607	0.607	0.598	0.591	0.591	0.591	0.591	0.591	0.591	0.591	0.591	0.591	0.591
2006	0.149	0.487	0.552	0.523	0.523	0.523	0.523	0.523	0.523	0.519	0.515	0.515	0.515	0.515	0.515	0.515	0.515	0.515	0.515	0.515

Table 1.10. Red snapper: Estimated total landings at age (1000 fish)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1945	0.3	1.4	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3	4.2
1946	0.5	1.5	1.3	1.2	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3	4.6
1947	1.0	4.8	2.8	2.5	2.3	2.1	1.9	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.9	0.8	0.8	10.0
1948	1.6	7.4	6.4	3.9	3.5	3.2	2.9	2.7	2.4	2.3	2.1	1.9	1.8	1.7	1.5	1.4	1.3	1.2	1.2	15.3
1949	2.1	10.1	8.6	7.6	4.7	4.2	3.9	3.5	3.3	3.0	2.8	2.6	2.4	2.2	2.1	1.9	1.8	1.7	1.5	20.4
1950	2.7	12.7	10.8	9.5	8.5	5.3	4.8	4.4	4.1	3.7	3.5	3.2	3.0	2.8	2.6	2.4	2.2	2.1	1.9	25.3
1951	3.5	16.5	14.0	12.2	10.9	9.8	6.1	5.6	5.1	4.7	4.4	4.1	3.8	3.5	3.2	3.0	2.8	2.6	2.4	32.0
1952	3.9	18.1	15.2	13.2	11.7	10.5	9.5	5.9	5.5	5.0	4.7	4.3	4.0	3.7	3.4	3.2	3.0	2.8	2.6	34.0
1953	4.5	21.0	17.6	15.1	13.3	11.9	10.7	9.8	6.1	5.6	5.2	4.8	4.5	4.2	3.9	3.6	3.3	3.1	2.9	38.1
1954	5.5	25.5	21.2	18.2	15.9	14.2	12.7	11.5	10.5	6.6	6.1	5.6	5.2	4.9	4.5	4.2	3.9	3.6	3.4	44.5
1955	6.0	27.8	23.0	19.6	17.1	15.1	13.5	12.1	11.0	10.1	6.4	5.9	5.4	5.0	4.7	4.3	4.0	3.8	3.5	46.2
1956	6.8	31.2	25.6	21.7	18.8	16.5	14.6	13.1	11.9	10.8	9.9	6.2	5.8	5.4	5.0	4.6	4.3	4.0	3.7	49.0
1957	8.4	38.5	31.4	26.5	22.7	19.8	17.5	15.6	14.0	12.7	11.6	10.7	6.7	6.2	5.8	5.4	5.0	4.6	4.3	56.9
1958	8.9	40.7	32.7	27.4	23.4	20.2	17.8	15.8	14.1	12.7	11.5	10.5	9.7	6.1	5.6	5.2	4.9	4.5	4.2	55.8
1959	10.2	46.1	36.9	30.4	25.8	22.2	19.4	17.1	15.2	13.6	12.3	11.2	10.2	9.4	5.9	5.5	5.1	4.7	4.4	58.3
1960	11.6	52.1	41.2	33.8	28.2	24.2	20.9	18.3	16.2	14.4	13.0	11.7	10.7	9.8	9.0	5.7	5.2	4.9	4.5	60.0
1961	11.5	51.8	40.5	32.8	27.3	23.0	19.8	17.2	15.1	13.4	12.0	10.7	9.7	8.9	8.1	7.5	4.7	4.4	4.1	53.8
1962	10.5	47.3	36.9	29.5	24.3	20.4	17.3	14.9	13.0	11.5	10.2	9.1	8.2	7.4	6.7	6.2	5.7	3.6	3.3	44.1
1963	9.3	42.2	33.2	26.5	21.5	17.9	15.1	12.8	11.1	9.7	8.6	7.6	6.8	6.1	5.6	5.1	4.6	4.3	2.7	35.7
1964	8.4	38.5	30.6	24.6	20.0	16.3	13.6	11.5	9.9	8.6	7.5	6.6	5.9	5.3	4.8	4.3	3.9	3.6	3.3	29.8
1965	7.5	34.5	27.7	22.5	18.4	15.0	12.4	10.4	8.8	7.6	6.6	5.8	5.1	4.5	4.1	3.7	3.3	3.0	2.8	25.5
1966	10.2	46.2	37.4	30.7	25.3	20.9	17.2	14.2	11.9	10.2	8.7	7.6	6.7	5.9	5.2	4.7	4.2	3.8	3.5	32.8
1967	13.7	61.0	48.3	40.0	33.3	27.7	23.0	19.0	15.7	13.3	11.3	9.7	8.5	7.4	6.6	5.9	5.3	4.7	4.3	40.6
1968	17.6	77.1	59.2	48.0	40.3	33.8	28.4	23.6	19.5	16.2	13.7	11.7	10.1	8.8	7.7	6.8	6.1	5.5	4.9	46.6
1969	21.2	91.0	67.3	52.9	43.5	36.8	31.1	26.2	21.9	18.1	15.1	12.8	10.9	9.4	8.2	7.2	6.4	5.7	5.1	48.2
1970	27.5	114.6	81.9	62.1	49.5	41.0	35.0	29.7	25.0	20.9	17.4	14.5	12.3	10.5	9.0	7.9	6.9	6.1	5.5	51.4
1971	29.8	122.0	82.3	60.3	46.3	37.2	31.1	26.6	22.6	19.1	16.0	13.3	11.1	9.4	8.1	6.9	6.1	5.3	4.7	43.7
1972	32.3	130.5	85.6	59.2	43.9	34.1	27.5	23.1	19.8	16.9	14.3	12.0	10.0	8.4	7.1	6.1	5.2	4.6	4.0	36.4
1973	34.6	138.2	88.4	59.4	41.7	31.2	24.3	19.8	16.6	14.3	12.2	10.3	8.7	7.2	6.1	5.1	4.4	3.8	3.3	29.4
1974	27.8	154.8	96.5	63.3	43.1	30.5	23.0	18.0	14.7	12.4	10.6	9.1	7.7	6.5	5.4	4.5	3.8	3.3	2.8	24.5
1975	28.7	122.4	103.4	66.1	43.9	30.2	21.5	16.3	12.8	10.4	8.8	7.6	6.5	5.5	4.6	3.9	3.2	2.7	2.4	19.5
1976	39.9	119.9	75.0	64.9	42.1	28.2	19.5	13.9	10.6	8.3	6.8	5.8	5.0	4.3	3.6	3.0	2.5	2.1	1.8	14.4
1977	66.7	166.5	70.0	44.8	39.4	25.7	17.4	12.1	8.6	6.6	5.2	4.2	3.6	3.1	2.7	2.3	1.9	1.6	1.3	10.1
1978	92.4	247.6	79.7	34.3	22.3	19.8	13.0	8.8	6.1	4.4	3.4	2.6	2.2	1.8	1.6	1.4	1.2	1.0	0.8	5.9
1979	57.8	278.1	86.3	28.5	12.4	8.2	7.3	4.8	3.3	2.3	1.6	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.4	2.5
1980	115.8	162.5	85.7	27.3	9.1	4.0	2.7	2.4	1.6	1.1	0.7	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.9
1981	16.4	222.3	32.6	17.6	5.7	1.9	0.9	0.6	0.5	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.2
1982	31.9	51.0	89.5	13.4	7.4	2.4	0.8	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1
1983	64.8	113.0	23.8	42.9	6.5	3.6	1.2	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
1984	123.4	178.2	49.1	10.6	19.4	3.0	1.7	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 1.10. (continued)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1985	34.7	215.9	83.1	16.2	3.5	6.5	1.0	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	42.1	53.1	90.7	26.3	5.2	1.1	2.1	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	34.0	55.9	22.8	31.5	9.3	1.8	0.4	0.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	30.2	85.3	36.2	11.0	15.5	4.6	0.9	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	34.8	74.2	53.1	17.9	5.5	7.8	2.3	0.5	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	28.5	69.7	42.8	19.5	6.6	2.1	2.9	0.9	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	32.5	51.6	32.3	14.3	6.6	2.3	0.7	1.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	1.8	41.4	25.3	15.9	7.1	3.3	1.1	0.4	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	1.3	20.5	47.3	22.8	9.5	4.2	2.0	0.7	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.6	7.8	15.9	28.2	7.1	2.9	1.3	0.6	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.7	7.5	12.0	15.8	14.3	3.5	1.5	0.7	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	1.2	9.4	11.8	11.1	7.6	6.7	1.7	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	1.2	13.8	13.0	10.2	5.2	3.5	3.1	0.8	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	4.0	22.0	22.8	11.3	4.8	2.4	1.6	1.4	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	5.1	51.8	25.1	17.7	5.8	2.4	1.2	0.8	0.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	4.0	57.1	49.5	16.2	7.8	2.5	1.1	0.5	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	2.5	40.5	53.6	35.4	8.2	3.9	1.3	0.5	0.3	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2002	2.6	24.1	35.7	33.6	14.1	3.2	1.5	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2003	1.9	28.6	22.2	22.5	14.0	5.8	1.3	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2004	2.2	19.5	28.6	18.4	13.9	8.6	3.6	0.8	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2005	2.6	25.9	19.9	19.8	8.5	6.4	3.9	1.7	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	2.7	28.4	23.1	12.3	8.8	3.8	2.8	1.8	0.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 1.11. Red snapper: Estimated total landings at age (mt)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1945	0.1	1.1	2.0	2.8	3.6	4.1	4.5	4.7	4.8	4.8	4.7	4.6	4.4	4.2	4.0	3.7	3.5	3.3	3.1	41.4
1946	0.1	1.2	2.2	3.1	3.9	4.5	4.9	5.1	5.2	5.2	5.1	5.0	4.8	4.6	4.3	4.1	3.8	3.6	3.4	45.2
1947	0.2	3.9	4.7	6.7	8.5	9.8	10.7	11.2	11.4	11.4	11.2	10.8	10.4	10.0	9.4	8.9	8.4	7.9	7.4	98.7
1948	0.4	6.0	10.7	10.4	13.0	15.0	16.3	17.1	17.5	17.4	17.1	16.6	16.0	15.2	14.5	13.7	12.9	12.1	11.3	151.2
1949	0.5	8.1	14.4	20.4	17.4	20.0	21.8	22.9	23.3	23.3	22.9	22.2	21.3	20.4	19.3	18.3	17.2	16.2	15.1	202.0
1950	0.6	10.2	18.1	25.5	31.7	24.9	27.1	28.4	28.9	28.9	28.4	27.5	26.5	25.3	24.0	22.7	21.3	20.0	18.8	250.6
1951	0.8	13.3	23.3	32.7	40.5	46.4	34.4	35.9	36.6	36.6	35.9	34.9	33.5	32.0	30.4	28.7	27.0	25.4	23.8	317.4
1952	0.9	14.6	25.4	35.5	43.7	49.7	53.8	38.3	39.0	38.9	38.2	37.1	35.6	34.0	32.3	30.5	28.7	27.0	25.3	337.5
1953	1.0	16.9	29.3	40.6	49.7	56.4	60.7	63.1	43.7	43.5	42.7	41.4	39.8	38.0	36.1	34.1	32.1	30.2	28.3	377.3
1954	1.2	20.5	35.4	48.9	59.5	67.1	71.8	74.3	75.1	50.9	49.9	48.4	46.5	44.4	42.2	39.9	37.5	35.3	33.1	440.7
1955	1.4	22.4	38.4	52.7	63.8	71.4	76.1	78.3	78.8	77.9	52.0	50.3	48.4	46.2	43.8	41.4	39.0	36.7	34.4	458.1
1956	1.5	25.1	42.7	58.2	70.1	78.2	82.7	84.7	84.7	83.4	81.2	53.5	51.3	49.0	46.5	43.9	41.4	38.9	36.5	486.0
1957	1.9	31.0	52.4	71.0	84.8	94.0	99.1	100.7	100.2	98.2	95.1	91.5	59.8	56.9	54.0	51.0	48.1	45.2	42.3	564.3
1958	2.0	32.7	54.6	73.4	87.2	95.9	100.5	101.7	100.5	97.9	94.4	90.4	86.2	55.9	52.9	50.0	47.1	44.2	41.5	552.6
1959	2.3	37.1	61.5	81.6	96.3	105.2	109.3	110.1	108.4	104.9	100.5	95.7	90.8	86.0	55.4	52.2	49.2	46.2	43.3	577.5
1960	2.6	41.9	68.7	90.6	105.4	114.4	118.2	118.1	115.6	111.4	106.0	100.4	94.8	89.2	84.0	53.9	50.6	47.6	44.6	594.6
1961	2.6	41.7	67.5	88.1	101.8	109.0	111.9	111.1	107.9	103.4	98.0	92.2	86.5	81.1	75.9	71.1	45.5	42.6	40.0	532.8
1962	2.4	38.1	61.5	79.2	90.6	96.4	97.6	96.3	92.9	88.3	83.3	78.0	72.7	67.7	63.1	58.9	55.0	35.1	32.8	437.0
1963	2.1	34.0	55.4	71.2	80.4	84.6	85.1	82.8	79.4	75.0	70.1	65.4	60.7	56.1	52.0	48.2	44.8	41.8	26.6	353.4
1964	1.9	30.9	51.0	66.1	74.5	77.4	77.1	74.5	70.4	66.1	61.5	56.8	52.4	48.3	44.5	41.0	37.9	35.1	32.7	295.0
1965	1.7	27.8	46.1	60.4	68.7	71.3	70.0	67.0	62.9	58.2	53.8	49.4	45.2	41.5	38.0	34.8	32.0	29.5	27.3	252.6
1966	2.3	37.2	62.3	82.3	94.6	98.9	97.0	91.6	85.1	78.3	71.3	65.1	59.2	53.8	49.1	44.8	40.9	37.5	34.5	324.7
1967	3.1	49.1	80.6	107.3	124.3	131.4	129.9	122.4	112.4	102.3	92.6	83.3	75.3	68.1	61.5	55.8	50.8	46.2	42.3	402.3
1968	4.0	62.0	98.7	128.8	150.4	160.3	160.2	152.3	139.5	125.3	112.2	100.3	89.5	80.3	72.2	65.0	58.8	53.3	48.4	462.1
1969	4.8	73.2	112.2	141.8	162.4	174.4	175.8	168.9	155.9	139.8	123.6	109.4	96.9	85.8	76.6	68.6	61.5	55.5	50.2	477.3
1970	6.2	92.2	136.6	166.5	184.6	194.4	197.5	191.3	178.5	161.4	142.5	124.5	109.1	96.0	84.5	75.1	67.0	59.9	53.9	509.1
1971	6.8	98.1	137.3	161.7	172.8	176.3	175.6	171.4	161.4	147.5	131.2	114.4	99.0	86.2	75.4	66.1	58.6	52.1	46.5	433.5
1972	7.3	105.0	142.7	158.8	164.0	161.3	155.6	148.9	141.3	130.2	117.1	103.0	89.0	76.4	66.2	57.6	50.4	44.5	39.5	361.2
1973	7.8	111.2	147.5	159.4	155.6	147.8	137.5	127.5	118.6	110.1	99.9	88.8	77.3	66.3	56.7	48.8	42.4	36.9	32.6	291.1
1974	6.3	124.5	161.0	169.8	161.0	144.5	129.8	116.1	104.6	95.2	87.1	78.0	68.7	59.4	50.7	43.1	37.0	32.1	27.9	242.4
1975	6.5	98.4	172.4	177.3	164.0	143.1	121.4	104.9	91.1	80.4	72.0	65.1	57.7	50.5	43.4	36.9	31.3	26.8	23.1	193.6
1976	9.1	96.5	125.0	174.1	157.0	133.6	110.2	89.9	75.5	64.2	55.7	49.3	44.2	38.9	33.8	29.0	24.5	20.7	17.7	142.4
1977	15.1	133.9	116.7	120.3	147.0	121.9	98.1	77.8	61.7	50.7	42.4	36.4	31.9	28.4	24.9	21.5	18.4	15.5	13.1	100.3
1978	21.0	199.2	132.8	92.1	83.2	93.6	73.4	56.8	43.7	34.0	27.5	22.7	19.3	16.8	14.8	13.0	11.2	9.5	8.0	58.2
1979	13.1	223.7	143.9	76.3	46.4	38.6	41.1	31.0	23.3	17.5	13.4	10.7	8.8	7.4	6.4	5.6	4.9	4.2	3.6	24.8
1980	26.3	130.7	142.9	73.1	34.0	19.1	15.0	15.3	11.2	8.3	6.1	4.6	3.7	3.0	2.5	2.2	1.9	1.6	1.4	9.4
1981	3.7	178.8	54.3	47.3	21.3	9.1	4.8	3.6	3.6	2.6	1.9	1.4	1.0	0.8	0.7	0.5	0.5	0.4	0.4	2.3
1982	7.2	41.0	149.3	36.1	27.6	11.4	4.6	2.3	1.7	1.7	1.2	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.2	1.2
1983	14.7	90.9	39.7	115.1	24.4	17.2	6.7	2.6	1.3	0.9	0.9	0.6	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.7
1984	28.0	143.3	81.9	28.5	72.4	14.1	9.4	3.5	1.3	0.6	0.5	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.4

Table 1.11. (continued)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1985	7.9	173.7	138.5	43.4	13.2	30.9	5.7	3.6	1.3	0.5	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.1
1986	9.6	42.7	151.2	70.5	19.3	5.4	11.9	2.1	1.3	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1
1987	7.7	45.0	38.0	84.6	34.5	8.7	2.3	4.9	0.8	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	6.9	68.6	60.4	29.6	57.7	21.7	5.2	1.3	2.7	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	7.9	59.7	88.6	47.9	20.6	37.0	13.1	3.0	0.7	1.5	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	6.5	56.1	71.3	52.4	24.8	9.8	16.6	5.7	1.3	0.3	0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	7.4	41.5	53.9	38.3	24.6	10.7	4.0	6.5	2.2	0.5	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.4	33.3	42.2	42.7	26.5	15.6	6.4	2.3	3.7	1.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.3	16.5	78.9	61.1	35.5	19.9	11.1	4.4	1.5	2.4	0.8	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.1	6.2	26.6	75.6	26.5	13.8	7.3	3.9	1.5	0.5	0.8	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.2	6.0	20.0	42.5	53.2	16.7	8.3	4.2	2.2	0.8	0.3	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.3	7.6	19.7	29.8	28.3	31.8	9.5	4.5	2.2	1.1	0.4	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.3	11.1	21.7	27.4	19.2	16.4	17.5	5.0	2.3	1.1	0.5	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.9	17.7	38.1	30.4	17.8	11.3	9.1	9.3	2.6	1.1	0.5	0.3	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
1999	1.2	41.7	41.8	47.5	21.6	11.5	6.8	5.3	5.3	1.4	0.6	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.9	45.9	82.5	43.5	29.0	11.9	6.0	3.4	2.6	2.5	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.6	32.6	89.4	95.1	30.5	18.4	7.2	3.4	1.9	1.4	1.3	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.6	19.4	59.5	90.0	52.7	15.2	8.7	3.3	1.5	0.8	0.6	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2003	0.4	23.0	37.0	60.4	52.2	27.6	7.5	4.1	1.5	0.7	0.4	0.3	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2004	0.5	15.7	47.8	49.5	51.8	40.5	20.3	5.3	2.8	1.0	0.4	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
2005	0.6	20.8	33.1	53.1	31.9	30.2	22.3	10.7	2.7	1.4	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
2006	0.6	22.8	38.5	32.9	32.9	17.9	16.0	11.4	5.3	1.3	0.7	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Table 1.12. Red snapper: Estimated total landings at age (1000 lb)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1945	0.1	2.4	4.4	6.2	7.8	9.0	9.9	10.3	10.5	10.5	10.3	10.0	9.6	9.2	8.7	8.3	7.8	7.3	6.9	91.4
1946	0.2	2.6	4.8	6.8	8.5	9.9	10.8	11.3	11.5	11.5	11.3	10.9	10.5	10.0	9.5	9.0	8.5	8.0	7.5	99.6
1947	0.5	8.5	10.4	14.9	18.7	21.5	23.5	24.7	25.1	25.1	24.6	23.9	23.0	21.9	20.8	19.7	18.5	17.4	16.3	217.7
1948	0.8	13.2	23.5	22.8	28.6	33.0	36.0	37.8	38.5	38.4	37.7	36.6	35.2	33.6	31.9	30.1	28.4	26.7	25.0	333.3
1949	1.1	17.8	31.7	44.9	38.3	44.0	48.1	50.4	51.4	51.3	50.4	48.9	47.0	44.9	42.6	40.3	37.9	35.6	33.4	445.2
1950	1.3	22.5	39.8	56.2	69.9	54.8	59.6	62.6	63.8	63.6	62.5	60.7	58.3	55.7	52.8	49.9	47.1	44.2	41.4	552.4
1951	1.8	29.2	51.4	72.2	89.3	102.2	75.8	79.2	80.8	80.6	79.2	76.8	73.9	70.5	66.9	63.3	59.6	56.0	52.5	699.6
1952	1.9	32.1	56.0	78.2	96.3	109.6	118.6	84.5	85.9	85.7	84.2	81.7	78.5	75.0	71.2	67.3	63.4	59.5	55.8	744.0
1953	2.2	37.2	64.6	89.5	109.7	124.2	133.8	139.1	96.3	95.8	94.1	91.3	87.8	83.8	79.6	75.2	70.9	66.6	62.4	831.8
1954	2.7	45.2	78.1	107.9	131.2	147.9	158.4	163.9	165.7	112.3	110.0	106.7	102.6	97.9	93.0	87.9	82.8	77.7	72.9	971.6
1955	3.0	49.4	84.6	116.2	140.7	157.4	167.7	172.7	173.6	171.8	114.7	110.9	106.6	101.8	96.6	91.3	86.0	80.8	75.8	1009.9
1956	3.4	55.3	94.2	128.3	154.6	172.3	182.3	186.7	186.7	183.9	179.1	118.0	113.1	108.0	102.5	96.9	91.3	85.7	80.4	1071.4
1957	4.2	68.3	115.6	156.5	187.0	207.3	218.4	222.0	220.9	216.4	209.7	201.8	131.8	125.4	119.0	112.5	106.0	99.5	93.3	1244.1
1958	4.5	72.1	120.3	161.9	192.3	211.3	221.5	224.3	221.6	215.9	208.1	199.2	189.9	123.2	116.5	110.1	103.8	97.5	91.4	1218.2
1959	5.1	81.8	135.6	179.9	212.3	232.0	241.1	242.8	239.0	231.2	221.7	211.1	200.2	189.5	122.2	115.1	108.4	101.9	95.5	1273.3
1960	5.8	92.3	151.5	199.7	232.4	252.3	260.7	260.3	254.8	245.5	233.7	221.4	208.9	196.7	185.2	118.9	111.6	104.9	98.3	1310.8
1961	5.8	91.9	148.9	194.2	224.5	240.4	246.7	245.0	237.8	227.9	216.1	203.2	190.8	178.7	167.3	156.8	100.4	94.0	88.1	1174.5
1962	5.2	83.9	135.6	174.7	199.8	212.6	215.2	212.3	204.9	194.6	183.6	172.0	160.3	149.4	139.2	129.7	121.2	77.3	72.3	963.5
1963	4.7	74.9	122.1	156.9	177.2	186.6	187.6	182.5	175.0	165.3	154.6	144.1	133.7	123.7	114.7	106.4	98.8	92.1	58.6	779.2
1964	4.2	68.2	112.4	145.7	164.3	170.7	169.9	164.2	155.3	145.7	135.5	125.2	115.6	106.5	98.0	90.4	83.6	77.5	72.0	650.3
1965	3.8	61.2	101.7	133.2	151.5	157.1	154.3	147.6	138.7	128.4	118.6	108.9	99.7	91.4	83.8	76.7	70.6	65.1	60.2	556.8
1966	5.1	82.0	137.4	181.4	208.5	218.0	213.8	201.9	187.7	172.6	157.2	143.5	130.6	118.7	108.2	98.7	90.1	82.7	76.1	715.8
1967	6.8	108.2	177.6	236.5	274.0	289.7	286.4	269.9	247.7	225.4	204.0	183.6	166.1	150.1	135.6	123.1	111.9	101.9	93.3	886.8
1968	8.8	136.8	217.5	284.0	331.6	353.4	353.2	335.7	307.4	276.2	247.4	221.2	197.3	177.1	159.2	143.2	129.6	117.5	106.8	1018.8
1969	10.6	161.3	247.3	312.7	357.9	384.6	387.5	372.3	343.8	308.3	272.6	241.2	213.7	189.2	168.9	151.2	135.6	122.3	110.7	1052.2
1970	13.8	203.3	301.1	367.0	406.9	428.6	435.4	421.7	393.6	355.9	314.1	274.4	240.6	211.6	186.3	165.6	147.7	132.1	118.9	1122.3
1971	14.9	216.3	302.7	356.4	381.0	388.7	387.1	378.0	355.7	325.1	289.3	252.3	218.3	190.0	166.2	145.7	129.1	114.8	102.5	955.8
1972	16.1	231.5	314.7	350.1	361.5	355.6	343.0	328.4	311.6	287.1	258.2	227.0	196.1	168.5	145.9	127.1	111.0	98.1	87.1	796.2
1973	17.3	245.1	325.2	351.5	343.0	325.9	303.1	281.0	261.4	242.8	220.2	195.7	170.5	146.2	124.9	107.7	93.5	81.5	71.8	641.8
1974	13.9	274.5	354.9	374.3	354.8	318.6	286.2	255.8	230.5	209.9	191.9	172.0	151.4	130.9	111.7	95.0	81.6	70.7	61.5	534.4
1975	14.3	217.0	380.1	390.8	361.5	315.4	267.7	231.2	200.8	177.1	158.8	143.4	127.3	111.3	95.7	81.3	68.9	59.1	51.0	426.9
1976	20.0	212.6	275.6	383.8	346.1	294.6	243.0	198.3	166.4	141.5	122.8	108.8	97.3	85.8	74.6	63.9	54.1	45.7	39.1	313.9
1977	33.3	295.3	257.3	265.2	324.0	268.8	216.3	171.5	136.0	111.7	93.5	80.2	70.4	62.5	54.8	47.4	40.5	34.2	28.8	221.0
1978	46.2	439.2	292.9	203.0	183.5	206.3	161.8	125.2	96.4	74.9	60.5	50.0	42.5	37.1	32.7	28.6	24.6	21.0	17.7	128.2
1979	28.9	493.3	317.2	168.3	102.4	85.1	90.5	68.2	51.3	38.7	29.6	23.6	19.3	16.3	14.1	12.4	10.8	9.3	7.9	54.6
1980	57.9	288.1	315.1	161.3	75.1	42.0	33.0	33.8	24.7	18.2	13.5	10.2	8.1	6.6	5.5	4.8	4.2	3.6	3.1	20.7
1981	8.2	394.3	119.8	104.3	46.9	20.1	10.6	8.0	8.0	5.7	4.1	3.0	2.3	1.8	1.4	1.2	1.0	0.9	0.8	5.1
1982	15.9	90.4	329.1	79.5	60.8	25.1	10.2	5.2	3.8	3.7	2.6	1.9	1.4	1.0	0.8	0.6	0.5	0.5	0.4	2.6
1983	32.4	200.5	87.6	253.8	53.8	37.8	14.8	5.8	2.8	2.0	2.0	1.4	1.0	0.7	0.5	0.4	0.3	0.3	0.2	1.5
1984	61.7	316.0	180.5	62.8	159.7	31.2	20.7	7.8	2.9	1.4	1.0	1.0	0.7	0.5	0.3	0.2	0.2	0.2	0.1	0.8

Table 1.12. (continued)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1985	17.3	382.9	305.4	95.7	29.2	68.2	12.6	8.0	2.9	1.1	0.5	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.3
1986	21.1	94.1	333.4	155.4	42.5	11.9	26.3	4.7	2.9	1.0	0.4	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1
1987	17.0	99.1	83.9	186.5	76.2	19.2	5.1	10.8	1.9	1.1	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
1988	15.1	151.2	133.1	65.3	127.2	47.8	11.4	2.9	6.0	1.0	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	17.4	131.5	195.3	105.7	45.4	81.5	28.9	6.6	1.6	3.3	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	14.3	123.6	157.2	115.4	54.7	21.6	36.6	12.5	2.8	0.7	1.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	16.3	91.6	118.8	84.5	54.3	23.6	8.8	14.4	4.8	1.0	0.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.9	73.5	93.0	94.1	58.4	34.4	14.2	5.1	8.1	2.6	0.5	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.6	36.4	174.0	134.6	78.4	43.9	24.5	9.7	3.4	5.2	1.7	0.4	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.3	13.8	58.6	166.7	58.4	30.5	16.2	8.7	3.3	1.1	1.7	0.5	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
1995	0.3	13.3	44.0	93.7	117.4	36.9	18.2	9.3	4.8	1.8	0.6	0.9	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.6	16.7	43.5	65.8	62.4	70.2	20.8	9.9	4.9	2.5	0.9	0.3	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.6	24.4	47.8	60.5	42.4	36.2	38.5	11.0	5.1	2.4	1.2	0.5	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0
1998	2.0	39.1	84.0	67.0	39.3	24.8	20.0	20.5	5.7	2.5	1.2	0.6	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
1999	2.6	91.9	92.2	104.8	47.6	25.2	15.1	11.7	11.6	3.1	1.4	0.7	0.3	0.1	0.0	0.1	0.0	0.0	0.0	0.0
2000	2.0	101.2	181.9	95.9	63.9	26.3	13.2	7.6	5.7	5.5	1.5	0.7	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0
2001	1.3	71.8	197.1	209.6	67.2	40.6	15.8	7.6	4.2	3.1	2.9	0.8	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0
2002	1.3	42.7	131.1	198.4	116.3	33.6	19.2	7.2	3.4	1.8	1.3	1.3	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0
2003	0.9	50.7	81.6	133.2	115.0	60.8	16.6	9.1	3.3	1.5	0.8	0.6	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0
2004	1.1	34.5	105.3	109.0	114.2	89.4	44.7	11.7	6.2	2.2	1.0	0.5	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0
2005	1.3	45.9	73.0	117.1	70.2	66.5	49.2	23.6	6.0	3.1	1.1	0.5	0.3	0.2	0.2	0.1	0.0	0.0	0.0	0.0
2006	1.3	50.4	84.8	72.6	72.5	39.5	35.4	25.1	11.7	2.9	1.5	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0

Table 1.13. Red snapper: Base run: Estimated status indicators, benchmarks, and related quantities from the catch-at-age model, conditional on estimated current selectivities averaged across fisheries. Values are those associated with $F_{40\%}$, the recommended proxy for F_{MSY}. They are presented for the base estimate of R_0, and also for $\pm 25\% R_0$. Estimates of yield (Y) do not include discard mortalities (D); equilibrium recruitment (R) includes bias correction. The MSST *is defined by* $\mathrm{MSST} = (1 - M)\mathrm{SSB}_{F_{40\%}}$*, with constant* $M = 0.078$*. Rate estimates (F) are in units of per year; status indicators are dimensionless; and biomass estimates are in units of mt or pounds, as indicated. SPR is spawning potential ratio and YPR is yield per recruit.*

Quantity	Units	Base estimate	$+25\% R_0$	$-25\% R_0$
$F_{40\%}$	y^{-1}	0.104	–	–
$85\% F_{40\%}$	y^{-1}	0.089	–	–
$75\% F_{40\%}$	y^{-1}	0.078	–	–
$65\% F_{40\%}$	y^{-1}	0.068	–	–
SSB/R at $F = 0$	lb/fish	64.42	–	–
SPR at $F_{40\%}$	–	40.0%	–	–
SPR at $85\% F_{40\%}$	–	44.7%	–	–
SPR at $75\% F_{40\%}$	–	48.4%	–	–
SPR at $65\% F_{40\%}$	–	52.5%	–	–
YPR at $F_{40\%}$	lb	3.33	–	–
YPR at $85\% F_{40\%}$	lb	3.17	–	–
YPR at $75\% F_{40\%}$	lb	3.02	–	–
YPR at $65\% F_{40\%}$	lb	2.84	–	–
Y at $F_{40\%}$	1000 lb	1949	2436	1462
Y at $85\% F_{40\%}$	1000 lb	1926	2408	1445
Y at $75\% F_{40\%}$	1000 lb	1883	2353	1412
Y at $65\% F_{40\%}$	1000 lb	1811	2264	1358
Y at $F_{40\%}$	1000 fish	157	196	117
Y at $85\% F_{40\%}$	1000 fish	150	187	112
Y at $75\% F_{40\%}$	1000 fish	143	179	108
Y at $65\% F_{40\%}$	1000 fish	135	169	101
D at $F_{40\%}$	1000 lb	62	77	46
D at $85\% F_{40\%}$	1000 lb	55	69	41
D at $75\% F_{40\%}$	1000 lb	50	63	38
D at $65\% F_{40\%}$	1000 lb	45	56	34
D at $F_{40\%}$	1000 fish	33	41	25
D at $85\% F_{40\%}$	1000 fish	29	37	22
D at $75\% F_{40\%}$	1000 fish	27	33	20
D at $65\% F_{40\%}$	1000 fish	24	30	18
R bias correction	–	1.104	–	–
R at $F = 0$ (R_0)	1000 fish	638	798	479
R at $F_{40\%}$	1000 fish	586	732	439
R at $85\% F_{40\%}$	1000 fish	608	761	456
R at $75\% F_{40\%}$	1000 fish	623	779	467
R at $65\% F_{40\%}$	1000 fish	637	796	477
$\mathrm{B}_{F_{40\%}}$	mt	15063	18829	11297
$\mathrm{SSB}_{F_{40\%}}$	mt	6847	8559	5136
MSST	mt	6313	7892	4735
$F_{2006}/F_{40\%}$	–	7.658	–	–
$\mathrm{SSB}_{2006}/\mathrm{SSB}_{F_{40\%}}$	–	0.029	0.023	0.038
$\mathrm{SSB}_{2006}/\mathrm{MSST}$	–	0.031	0.025	0.042

*Table 1.14. Red snapper: Projection results under scenario R1—fishing mortality rate fixed at $F = 0$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $SSB_{F_{40\%}} = 6847$, $R_{F_{40\%}} = 586$, $MSY_{F_{40\%}} = 1949$, and $D_{F_{40\%}} = 33$, each in the same units as the relevant time series.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2007	0.918	0	204	286	450	450	98
2008	0.918	0	201	61	454	904	68
2009	0	0	175	60	0	904	0
2010	0	0	323	53	0	904	0
2011	0	0	410	92	0	904	0
2012	0	0	501	113	0	904	0
2013	0	0	602	134	0	904	0
2014	0	0	718	156	0	904	0
2015	0	0	853	179	0	904	0
2016	0	0	1010	204	0	904	0
2017	0	0	1190	231	0	904	0
2018	0	0	1397	259	0	904	0
2019	0	0	1631	287	0	904	0
2020	0	0	1895	316	0	904	0
2021	0	0	2190	346	0	904	0
2022	0	0	2515	374	0	904	0
2023	0	0	2870	402	0	904	0
2024	0	0	3255	428	0	904	0
2025	0	0	3668	453	0	904	0
2026	0	0	4106	476	0	904	0
2027	0	0	4567	497	0	904	0
2028	0	0.01	5049	517	0	904	0
2029	0	0.04	5547	535	0	904	0
2030	0	0.08	6060	552	0	904	0
2031	0	0.14	6582	566	0	904	0
2032	0	0.24	7111	580	0	904	0
2033	0	0.35	7643	592	0	904	0
2034	0	0.48	8175	603	0	904	0
2035	0	0.61	8704	612	0	904	0
2036	0	0.73	9228	621	0	904	0
2037	0	0.82	9744	629	0	904	0
2038	0	0.9	10,251	636	0	904	0
2039	0	0.94	10,746	643	0	904	0
2040	0	0.96	11,228	649	0	904	0
2041	0	0.98	11,696	654	0	904	0
2042	0	0.99	12,149	659	0	904	0
2043	0	1	12,587	663	0	904	0
2044	0	1	13,009	667	0	904	0
2045	0	1	13,414	671	0	904	0
2046	0	1	13,803	674	0	904	0
2047	0	1	14,176	677	0	904	0
2048	0	1	14,532	680	0	904	0
2049	0	1	14,872	682	0	904	0
2050	0	1	15,196	684	0	904	0

*Table 1.15. Red snapper: Projection results under scenario R2—fishing mortality rate fixed at $F = F_{40\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). For reference, estimated proxy reference points are $F_{40\%}$ = 0.104, $SSB_{F_{40\%}}$ = 6847, $R_{F_{40\%}}$ = 586, $MSY_{F_{40\%}}$ = 1949, and $D_{F_{40\%}}$ = 33, each in the same units as the relevant time series.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2007	0.918	0	204	286	450	450	98
2008	0.918	0	201	61	454	904	68
2009	0.104	0	175	60	60	964	4
2010	0.104	0	293	53	83	1047	3
2011	0.104	0	350	84	99	1146	4
2012	0.104	0	403	98	114	1259	5
2013	0.104	0	457	111	128	1388	6
2014	0.104	0	517	124	145	1533	6
2015	0.104	0	583	138	163	1696	7
2016	0.104	0	656	152	183	1879	8
2017	0.104	0	736	167	205	2084	9
2018	0.104	0	824	182	230	2315	9
2019	0.104	0	921	199	258	2572	10
2020	0.104	0	1026	216	287	2860	11
2021	0.104	0	1139	233	319	3179	12
2022	0.104	0	1260	251	353	3532	13
2023	0.104	0	1389	269	390	3922	14
2024	0.104	0	1527	286	429	4351	15
2025	0.104	0	1671	304	470	4821	16
2026	0.104	0	1823	321	513	5334	17
2027	0.104	0	1981	338	558	5891	18
2028	0.104	0	2144	354	604	6495	19
2029	0.104	0	2311	370	652	7147	20
2030	0.104	0	2483	385	700	7847	21
2031	0.104	0	2657	399	750	8597	22
2032	0.104	0	2833	413	800	9397	22
2033	0.104	0	3009	425	850	10,247	23
2034	0.104	0	3186	437	901	11,148	24
2035	0.104	0	3361	449	951	12,099	25
2036	0.104	0	3534	459	1000	13,099	25
2037	0.104	0	3705	469	1049	14,147	26
2038	0.104	0	3872	478	1096	15,244	26
2039	0.104	0	4035	486	1143	16,387	27
2040	0.104	0	4193	494	1188	17,575	27
2041	0.104	0	4346	501	1232	18,807	28
2042	0.104	0.01	4494	508	1274	20,081	28
2043	0.104	0.01	4637	514	1315	21,396	29
2044	0.104	0.01	4773	520	1354	22,750	29
2045	0.104	0.02	4903	525	1391	24,141	29
2046	0.104	0.03	5028	530	1427	25,568	30
2047	0.104	0.04	5146	534	1461	27,029	30
2048	0.104	0.05	5258	539	1493	28,521	30
2049	0.104	0.06	5364	542	1523	30,044	30
2050	0.104	0.07	5465	546	1552	31,596	31
2051	0.104	0.09	5559	549	1579	33,174	31
2052	0.104	0.1	5648	552	1604	34,778	31
2053	0.104	0.11	5732	555	1628	36,406	31
2054	0.104	0.12	5811	557	1650	38,057	31
2055	0.104	0.13	5884	559	1672	39,729	31

*Table 1.16. Red snapper: Projection results under scenario R3—fishing mortality rate fixed at F = 65%$F_{40\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). For reference, estimated proxy reference points are $F_{40\%}$ = 0.104, $SSB_{F_{40\%}}$ = 6847, $R_{F_{40\%}}$ = 586, $MSY_{F_{40\%}}$ = 1949, and $D_{F_{40\%}}$ = 33, each in the same units as the relevant time series.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2007	0.918	0	204	286	450	450	98
2008	0.918	0	201	61	454	904	68
2009	0.068	0	175	60	40	943	3
2010	0.068	0	303	53	56	999	2
2011	0.068	0	370	87	68	1067	2
2012	0.068	0	434	103	80	1147	3
2013	0.068	0	504	119	92	1239	4
2014	0.068	0	580	135	106	1345	4
2015	0.068	0	666	151	121	1466	5
2016	0.068	0	763	169	139	1604	6
2017	0.068	0	871	187	158	1762	6
2018	0.068	0	992	207	180	1943	7
2019	0.068	0	1125	228	205	2148	8
2020	0.068	0	1272	249	232	2380	9
2021	0.068	0	1433	270	262	2641	9
2022	0.068	0	1607	292	294	2935	10
2023	0.068	0	1794	314	328	3263	11
2024	0.068	0	1995	335	365	3628	12
2025	0.068	0	2207	356	404	4032	12
2026	0.068	0	2430	376	446	4478	13
2027	0.068	0	2664	395	489	4967	14
2028	0.068	0	2906	413	534	5500	15
2029	0.068	0	3155	430	580	6080	15
2030	0.068	0	3410	447	627	6707	16
2031	0.068	0	3669	462	675	7382	17
2032	0.068	0	3931	476	724	8106	17
2033	0.068	0	4193	489	772	8878	18
2034	0.068	0	4455	501	821	9699	18
2035	0.068	0.01	4714	513	869	10,569	19
2036	0.068	0.02	4970	523	917	11,485	19
2037	0.068	0.03	5221	532	963	12,449	19
2038	0.068	0.05	5466	541	1009	13,458	20
2039	0.068	0.07	5705	549	1053	14,511	20
2040	0.068	0.1	5936	556	1096	15,608	20
2041	0.068	0.14	6160	563	1138	16,746	21
2042	0.068	0.18	6375	569	1178	17,923	21
2043	0.068	0.23	6581	575	1216	19,140	21
2044	0.068	0.28	6779	580	1253	20,393	21
2045	0.068	0.35	6967	584	1288	21,681	22
2046	0.068	0.4	7146	589	1321	23,002	22
2047	0.068	0.46	7316	593	1353	24,355	22
2048	0.068	0.51	7477	596	1383	25,738	22
2049	0.068	0.56	7629	599	1411	27,149	22
2050	0.068	0.61	7773	602	1438	28,587	22
2051	0.068	0.66	7908	605	1463	30,050	22
2052	0.068	0.7	8036	608	1487	31,536	23
2053	0.068	0.74	8155	610	1509	33,045	23
2054	0.068	0.76	8268	612	1530	34,575	23
2055	0.068	0.79	8373	614	1549	36,124	23

*Table 1.17. Red snapper: Projection results under scenario R4—fishing mortality rate fixed at F = 75%$F_{40\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). For reference, estimated proxy reference points are $F_{40\%}$ = 0.104, $SSB_{F_{40\%}}$ = 6847, $R_{F_{40\%}}$ = 586, $MSY_{F_{40\%}}$ = 1949, and $D_{F_{40\%}}$ = 33, each in the same units as the relevant time series.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2007	0.918	0	204	286	450	450	98
2008	0.918	0	201	61	454	904	68
2009	0.078	0	175	60	46	949	3
2010	0.078	0	300	53	63	1013	2
2011	0.078	0	364	86	77	1090	3
2012	0.078	0	425	102	90	1180	4
2013	0.078	0	490	117	103	1283	4
2014	0.078	0	561	131	118	1401	5
2015	0.078	0	641	147	135	1536	6
2016	0.078	0	730	164	153	1689	6
2017	0.078	0	830	181	174	1863	7
2018	0.078	0	941	200	197	2060	8
2019	0.078	0	1063	219	223	2284	9
2020	0.078	0	1196	239	252	2535	9
2021	0.078	0	1342	259	282	2818	10
2022	0.078	0	1499	280	316	3133	11
2023	0.078	0	1668	300	352	3485	12
2024	0.078	0	1849	321	390	3875	13
2025	0.078	0	2039	341	431	4306	14
2026	0.078	0	2240	360	473	4779	15
2027	0.078	0	2449	379	518	5297	15
2028	0.078	0	2666	396	564	5862	16
2029	0.078	0	2889	413	612	6474	17
2030	0.078	0	3117	429	661	7134	18
2031	0.078	0	3349	444	710	7845	18
2032	0.078	0	3583	458	760	8605	19
2033	0.078	0	3817	471	811	9416	20
2034	0.078	0	4051	484	861	10,277	20
2035	0.078	0	4283	495	911	11,187	21
2036	0.078	0.01	4513	505	960	12,147	21
2037	0.078	0.01	4738	515	1008	13,155	22
2038	0.078	0.02	4958	524	1055	14,210	22
2039	0.078	0.03	5172	532	1101	15,311	22
2040	0.078	0.04	5380	539	1146	16,457	23
2041	0.078	0.06	5580	546	1189	17,646	23
2042	0.078	0.09	5773	553	1230	18,876	23
2043	0.078	0.12	5959	558	1270	20,145	24
2044	0.078	0.15	6136	564	1308	21,453	24
2045	0.078	0.18	6305	568	1344	22,797	24
2046	0.078	0.22	6466	573	1379	24,176	24
2047	0.078	0.27	6619	577	1411	25,587	24
2048	0.078	0.31	6764	581	1442	27,030	25
2049	0.078	0.35	6900	584	1472	28,501	25
2050	0.078	0.4	7030	587	1499	30,001	25
2051	0.078	0.43	7151	590	1526	31,526	25
2052	0.078	0.48	7266	593	1550	33,076	25
2053	0.078	0.52	7373	595	1573	34,650	25
2054	0.078	0.56	7474	597	1595	36,244	25
2055	0.078	0.59	7568	599	1615	37,859	26

*Table 1.18. Red snapper: Projection results under scenario R5—fishing mortality rate fixed at F = 85%$F_{40\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). For reference, estimated proxy reference points are $F_{40\%}$ = 0.104, $SSB_{F_{40\%}}$ = 6847, $R_{F_{40\%}}$ = 586, $MSY_{F_{40\%}}$ = 1949, and $D_{F_{40\%}}$ = 33, each in the same units as the relevant time series.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2007	0.918	0	204	286	450	450	98
2008	0.918	0	201	61	454	904	68
2009	0.088	0	175	60	52	955	4
2010	0.088	0	297	53	71	1026	3
2011	0.088	0	358	85	86	1113	3
2012	0.088	0	416	101	100	1213	4
2013	0.088	0	477	114	114	1326	5
2014	0.088	0	543	128	129	1456	6
2015	0.088	0	617	143	147	1603	6
2016	0.088	0	700	159	166	1769	7
2017	0.088	0	791	175	188	1956	8
2018	0.088	0	892	193	212	2169	9
2019	0.088	0	1004	211	239	2407	9
2020	0.088	0	1125	230	268	2675	10
2021	0.088	0	1257	249	300	2975	11
2022	0.088	0	1399	268	334	3309	12
2023	0.088	0	1551	288	370	3679	13
2024	0.088	0	1713	307	409	4088	14
2025	0.088	0	1884	326	451	4539	15
2026	0.088	0	2063	344	494	5033	16
2027	0.088	0	2250	362	539	5572	17
2028	0.088	0	2444	379	586	6158	17
2029	0.088	0	2643	396	634	6792	18
2030	0.088	0	2847	412	684	7475	19
2031	0.088	0	3054	426	734	8209	20
2032	0.088	0	3263	440	784	8993	21
2033	0.088	0	3473	453	835	9829	21
2034	0.088	0	3682	465	886	10,715	22
2035	0.088	0	3890	477	936	11,651	22
2036	0.088	0	4095	487	986	12,637	23
2037	0.088	0	4296	497	1035	13,672	23
2038	0.088	0.01	4494	506	1083	14,755	24
2039	0.088	0.01	4686	514	1130	15,885	24
2040	0.088	0.01	4872	522	1175	17,060	25
2041	0.088	0.02	5052	529	1219	18,279	25
2042	0.088	0.04	5226	535	1261	19,540	25
2043	0.088	0.05	5393	541	1301	20,841	26
2044	0.088	0.07	5552	547	1340	22,181	26
2045	0.088	0.09	5704	552	1377	23,558	26
2046	0.088	0.12	5849	556	1412	24,971	27
2047	0.088	0.14	5987	560	1446	26,417	27
2048	0.088	0.17	6117	564	1478	27,894	27
2049	0.088	0.2	6241	568	1508	29,402	27
2050	0.088	0.23	6357	571	1536	30,938	27
2051	0.088	0.25	6467	574	1563	32,500	28
2052	0.088	0.28	6570	577	1588	34,088	28
2053	0.088	0.32	6667	579	1611	35,699	28
2054	0.088	0.35	6758	582	1633	37,332	28
2055	0.088	0.38	6843	584	1654	38,986	28

*Table 1.19. Red snapper: Projection results under scenario R6—Discard-only projection with fishing rate fixed at $F = F_{\text{current}}$ minus commercial diving, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. F = fishing rate (per year), Fmort = fishing rate leading to discard mortality (a portion of F), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb*), D = discard mortalities (1000 fish), D.wgt = discard mortalities in weight (1000 lb). For reference, the target for rebuilding is* $\text{SSB}_{F_{40\%}} = 6847$.

Year	F(per yr)	Fmort(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	D(1000)	D.wgt(1000 lb)
2007	0.918	0.918	0	204	286	450	98	152
2008	0.918	0.918	0	201	61	454	68	136
2009	0.903	0.651	0	175	60	0	74	323
2010	0.903	0.651	0	195	53	0	57	298
2011	0.903	0.651	0	181	58	0	50	276
2012	0.903	0.651	0	163	54	0	45	251
2013	0.903	0.651	0	146	49	0	41	226
2014	0.903	0.651	0	130	44	0	37	202
2015	0.903	0.651	0	116	40	0	33	180
2016	0.903	0.651	0	104	36	0	30	161
2017	0.903	0.651	0	93	32	0	27	144
2018	0.903	0.651	0	83	29	0	24	129
2019	0.903	0.651	0	74	26	0	21	116
2020	0.903	0.651	0	67	23	0	19	104
2021	0.903	0.651	0	60	21	0	17	93
2022	0.903	0.651	0	54	19	0	16	84
2023	0.903	0.651	0	48	17	0	14	75
2024	0.903	0.651	0	43	15	0	13	68
2025	0.903	0.651	0	39	14	0	11	61
2026	0.903	0.651	0	35	12	0	10	55
2027	0.903	0.651	0	32	11	0	9	49
2028	0.903	0.651	0	28	10	0	8	44
2029	0.903	0.651	0	25	9	0	7	40
2030	0.903	0.651	0	23	8	0	7	36
2031	0.903	0.651	0	21	7	0	6	32
2032	0.903	0.651	0	19	7	0	5	29
2033	0.903	0.651	0	17	6	0	5	26
2034	0.903	0.651	0	15	5	0	4	23
2035	0.903	0.651	0	14	5	0	4	21
2036	0.903	0.651	0	12	4	0	4	19
2037	0.903	0.651	0	11	4	0	3	17
2038	0.903	0.651	0	10	4	0	3	15
2039	0.903	0.651	0	9	3	0	3	14
2040	0.903	0.651	0	8	3	0	2	13
2041	0.903	0.651	0	7	3	0	2	11
2042	0.903	0.651	0	7	2	0	2	10
2043	0.903	0.651	0	6	2	0	2	9
2044	0.903	0.651	0	5	2	0	2	8
2045	0.903	0.651	0	5	2	0	1	7
2046	0.903	0.651	0	4	2	0	1	7
2047	0.903	0.651	0	4	1	0	1	6
2048	0.903	0.651	0	3	1	0	1	5
2049	0.903	0.651	0	3	1	0	1	5
2050	0.903	0.651	0	3	1	0	1	4
2051	0.903	0.651	0	3	1	0	1	4
2052	0.903	0.651	0	2	1	0	1	4
2053	0.903	0.651	0	2	1	0	1	3
2054	0.903	0.651	0	2	1	0	1	3
2055	0.903	0.651	0	2	1	0	0	3

*Table 1.20. Red snapper: Projection results under scenario R7—Discard-only projection with fishing rate fixed at F = $F_{40\%}$ minus commercial diving, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. F = fishing rate (per year), Fmort = fishing rate leading to discard mortality (a portion of F), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb*), D = discard mortalities (1000 fish), D.wgt = discard mortalities in weight (1000 lb). For reference, the target for rebuilding is* $SSB_{F_{40\%}}$ = 6847.

Year	F(per yr)	Fmort(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	D(1000)	D.wgt(1000 lb)
2007	0.918	0.918	0	204	286	450	98	152
2008	0.918	0.918	0	201	61	454	68	136
2009	0.104	0.075	0	175	60	0	10	43
2010	0.104	0.075	0	304	53	0	10	53
2011	0.104	0.075	0	373	87	0	11	64
2012	0.104	0.075	0	440	104	0	12	76
2013	0.104	0.075	0	511	120	0	14	89
2014	0.104	0.075	0	590	136	0	16	103
2015	0.104	0.075	0	678	153	0	19	118
2016	0.104	0.075	0	778	171	0	21	135
2017	0.104	0.075	0	889	190	0	24	155
2018	0.104	0.075	0	1014	210	0	27	176
2019	0.104	0.075	0	1152	231	0	30	200
2020	0.104	0.075	0	1305	253	0	34	226
2021	0.104	0.075	0	1471	275	0	37	254
2022	0.104	0.075	0	1652	297	0	41	285
2023	0.104	0.075	0	1847	319	0	45	318
2024	0.104	0.075	0	2056	340	0	49	353
2025	0.104	0.075	0	2277	361	0	53	391
2026	0.104	0.075	0	2510	382	0	58	430
2027	0.104	0.075	0	2754	401	0	62	471
2028	0.104	0.075	0	3007	420	0	66	513
2029	0.104	0.075	0	3269	437	0	71	557
2030	0.104	0.075	0	3536	454	0	75	601
2031	0.104	0.075	0	3808	469	0	79	646
2032	0.104	0.075	0	4082	483	0	83	692
2033	0.104	0.075	0	4358	496	0	87	738
2034	0.104	0.075	0.01	4633	509	0	91	783
2035	0.104	0.075	0.01	4907	520	0	95	829
2036	0.104	0.075	0.03	5177	530	0	98	873
2037	0.104	0.075	0.04	5442	540	0	102	917
2038	0.104	0.075	0.07	5701	548	0	105	960
2039	0.104	0.075	0.1	5954	556	0	108	1001
2040	0.104	0.075	0.14	6200	563	0	111	1042
2041	0.104	0.075	0.19	6437	570	0	114	1081
2042	0.104	0.075	0.24	6665	576	0	117	1118
2043	0.104	0.075	0.3	6885	582	0	119	1155
2044	0.104	0.075	0.37	7095	587	0	122	1189
2045	0.104	0.075	0.44	7296	591	0	124	1222
2046	0.104	0.075	0.5	7488	596	0	126	1253
2047	0.104	0.075	0.56	7670	600	0	128	1283
2048	0.104	0.075	0.61	7842	603	0	130	1312
2049	0.104	0.075	0.66	8006	606	0	131	1338
2050	0.104	0.075	0.7	8160	609	0	133	1364
2051	0.104	0.075	0.75	8306	612	0	135	1388
2052	0.104	0.075	0.79	8443	615	0	136	1410
2053	0.104	0.075	0.82	8573	617	0	137	1431
2054	0.104	0.075	0.84	8694	619	0	139	1451
2055	0.104	0.075	0.87	8808	621	0	140	1470

*Table 1.21. Red snapper: Projection results under scenario R8—Discard-only projection with fishing rate fixed at $F = 65\%F_{40\%}$, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. F = fishing rate (per year), Fmort = fishing rate leading to discard mortality (a portion of F), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb*), D = discard mortalities (1000 fish), D.wgt = discard mortalities in weight (1000 lb). For reference, the target for rebuilding is* $\mathrm{SSB}_{F_{40\%}} = 6847$.

Year	F(per yr)	Fmort(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	D(1000)	D.wgt(1000 lb)
2007	0.918	0.918	0	204	286	450	98	152
2008	0.918	0.918	0	201	61	454	68	136
2009	0.068	0.049	0	175	60	0	6	28
2010	0.068	0.049	0	311	53	0	6	35
2011	0.068	0.049	0	385	89	0	7	43
2012	0.068	0.049	0	460	107	0	8	52
2013	0.068	0.049	0	541	125	0	10	61
2014	0.068	0.049	0	632	143	0	11	72
2015	0.068	0.049	0	735	162	0	13	83
2016	0.068	0.049	0	852	182	0	15	96
2017	0.068	0.049	0	985	204	0	17	111
2018	0.068	0.049	0	1135	227	0	19	128
2019	0.068	0.049	0	1302	250	0	22	146
2020	0.068	0.049	0	1487	274	0	24	167
2021	0.068	0.049	0	1692	299	0	27	190
2022	0.068	0.049	0	1915	323	0	30	214
2023	0.068	0.049	0	2157	348	0	33	241
2024	0.068	0.049	0	2417	371	0	36	269
2025	0.068	0.049	0	2694	394	0	40	299
2026	0.068	0.049	0	2987	415	0	43	331
2027	0.068	0.049	0	3293	436	0	46	365
2028	0.068	0.049	0	3612	455	0	50	399
2029	0.068	0.049	0	3941	473	0	53	435
2030	0.068	0.049	0	4279	490	0	56	471
2031	0.068	0.049	0.01	4622	505	0	59	508
2032	0.068	0.049	0.01	4968	519	0	62	545
2033	0.068	0.049	0.03	5316	532	0	66	583
2034	0.068	0.049	0.05	5664	544	0	68	620
2035	0.068	0.049	0.1	6008	555	0	71	657
2036	0.068	0.049	0.14	6349	565	0	74	693
2037	0.068	0.049	0.2	6683	574	0	77	729
2038	0.068	0.049	0.27	7010	582	0	79	764
2039	0.068	0.049	0.37	7329	590	0	81	798
2040	0.068	0.049	0.46	7638	596	0	84	831
2041	0.068	0.049	0.54	7937	603	0	86	863
2042	0.068	0.049	0.62	8225	608	0	88	894
2043	0.068	0.049	0.7	8502	613	0	90	923
2044	0.068	0.049	0.76	8768	618	0	92	951
2045	0.068	0.049	0.82	9021	622	0	93	978
2046	0.068	0.049	0.86	9263	626	0	95	1004
2047	0.068	0.049	0.9	9494	630	0	96	1029
2048	0.068	0.049	0.92	9712	633	0	98	1052
2049	0.068	0.049	0.94	9920	636	0	99	1074
2050	0.068	0.049	0.95	10,116	639	0	100	1095
2051	0.068	0.049	0.97	10,302	641	0	102	1115
2052	0.068	0.049	0.98	10,477	643	0	103	1133
2053	0.068	0.049	0.99	10,642	646	0	104	1151
2054	0.068	0.049	0.99	10,798	647	0	105	1167
2055	0.068	0.049	0.99	10,944	649	0	106	1183

*Table 1.22. Red snapper: Projection results under scenario R9—Discard-only projection with fishing rate fixed at F = 75%$F_{40\%}$, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. F = fishing rate (per year), Fmort = fishing rate leading to discard mortality (a portion of F), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb*), D = discard mortalities (1000 fish), D.wgt = discard mortalities in weight (1000 lb). For reference, the target for rebuilding is* $SSB_{F_{40\%}} = 6847$.

Year	F(per yr)	Fmort(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	D(1000)	D.wgt(1000 lb)
2007	0.918	0.918	0	204	286	450	98	152
2008	0.918	0.918	0	201	61	454	68	136
2009	0.078	0.056	0	175	60	0	7	32
2010	0.078	0.056	0	309	53	0	7	40
2011	0.078	0.056	0	382	88	0	8	49
2012	0.078	0.056	0	454	106	0	9	59
2013	0.078	0.056	0	532	123	0	11	69
2014	0.078	0.056	0	620	141	0	13	81
2015	0.078	0.056	0	718	159	0	15	94
2016	0.078	0.056	0	830	179	0	17	108
2017	0.078	0.056	0	957	200	0	19	125
2018	0.078	0.056	0	1099	222	0	22	143
2019	0.078	0.056	0	1257	245	0	24	163
2020	0.078	0.056	0	1433	268	0	27	186
2021	0.078	0.056	0	1626	292	0	30	210
2022	0.078	0.056	0	1836	316	0	34	237
2023	0.078	0.056	0	2064	339	0	37	266
2024	0.078	0.056	0	2308	362	0	41	297
2025	0.078	0.056	0	2568	385	0	44	330
2026	0.078	0.056	0	2843	406	0	48	364
2027	0.078	0.056	0	3130	426	0	51	400
2028	0.078	0.056	0	3429	445	0	55	438
2029	0.078	0.056	0	3737	463	0	59	476
2030	0.078	0.056	0	4053	480	0	62	515
2031	0.078	0.056	0	4374	495	0	66	555
2032	0.078	0.056	0.01	4699	509	0	69	596
2033	0.078	0.056	0.02	5024	522	0	73	636
2034	0.078	0.056	0.03	5349	534	0	76	676
2035	0.078	0.056	0.06	5672	545	0	79	716
2036	0.078	0.056	0.1	5991	555	0	82	756
2037	0.078	0.056	0.14	6304	564	0	85	794
2038	0.078	0.056	0.2	6610	573	0	88	832
2039	0.078	0.056	0.26	6908	580	0	90	869
2040	0.078	0.056	0.35	7197	587	0	93	905
2041	0.078	0.056	0.43	7477	594	0	95	939
2042	0.078	0.056	0.51	7747	599	0	97	972
2043	0.078	0.056	0.59	8006	605	0	99	1004
2044	0.078	0.056	0.66	8254	609	0	101	1034
2045	0.078	0.056	0.72	8491	614	0	103	1064
2046	0.078	0.056	0.78	8717	618	0	105	1091
2047	0.078	0.056	0.82	8932	621	0	107	1118
2048	0.078	0.056	0.86	9136	625	0	108	1143
2049	0.078	0.056	0.9	9329	628	0	110	1167
2050	0.078	0.056	0.92	9512	631	0	111	1189
2051	0.078	0.056	0.93	9685	633	0	112	1210
2052	0.078	0.056	0.95	9848	636	0	113	1230
2053	0.078	0.056	0.96	10,002	638	0	115	1249
2054	0.078	0.056	0.97	10,147	640	0	116	1267
2055	0.078	0.056	0.98	10,283	642	0	117	1284

*Table 1.23. Red snapper: Projection results under scenario R10—Discard-only projection with fishing rate fixed at $F = 85\%F_{40\%}$, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. F = fishing rate (per year), Fmort = fishing rate leading to discard mortality (a portion of F), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb*), D = discard mortalities (1000 fish), D.wgt = discard mortalities in weight (1000 lb). For reference, the target for rebuilding is* $\mathrm{SSB}_{F_{40\%}} = 6847$.

Year	F(per yr)	Fmort(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	D(1000)	D.wgt(1000 lb)
2007	0.918	0.918	0	204	286	450	98	152
2008	0.918	0.918	0	201	61	454	68	136
2009	0.088	0.064	0	175	60	0	8	37
2010	0.088	0.064	0	307	53	0	8	46
2011	0.088	0.064	0	378	88	0	9	55
2012	0.088	0.064	0	448	105	0	11	66
2013	0.088	0.064	0	524	122	0	12	77
2014	0.088	0.064	0	607	139	0	14	90
2015	0.088	0.064	0	702	157	0	16	104
2016	0.088	0.064	0	809	176	0	19	120
2017	0.088	0.064	0	929	196	0	21	137
2018	0.088	0.064	0	1064	217	0	24	157
2019	0.088	0.064	0	1214	239	0	27	179
2020	0.088	0.064	0	1380	262	0	30	203
2021	0.088	0.064	0	1562	285	0	33	229
2022	0.088	0.064	0	1760	308	0	37	258
2023	0.088	0.064	0	1974	331	0	40	289
2024	0.088	0.064	0	2204	354	0	44	321
2025	0.088	0.064	0	2448	375	0	48	356
2026	0.088	0.064	0	2705	396	0	52	393
2027	0.088	0.064	0	2974	416	0	56	431
2028	0.088	0.064	0	3254	435	0	60	471
2029	0.088	0.064	0	3543	453	0	64	512
2030	0.088	0.064	0	3838	469	0	68	554
2031	0.088	0.064	0	4139	485	0	72	596
2032	0.088	0.064	0	4442	499	0	75	639
2033	0.088	0.064	0.01	4747	512	0	79	682
2034	0.088	0.064	0.02	5052	524	0	82	725
2035	0.088	0.064	0.03	5354	535	0	86	767
2036	0.088	0.064	0.06	5652	545	0	89	809
2037	0.088	0.064	0.1	5945	555	0	92	850
2038	0.088	0.064	0.14	6231	563	0	95	890
2039	0.088	0.064	0.19	6510	571	0	98	929
2040	0.088	0.064	0.25	6781	578	0	101	967
2041	0.088	0.064	0.32	7043	584	0	103	1004
2042	0.088	0.064	0.4	7295	590	0	106	1039
2043	0.088	0.064	0.47	7538	596	0	108	1073
2044	0.088	0.064	0.55	7770	601	0	110	1105
2045	0.088	0.064	0.62	7991	605	0	112	1136
2046	0.088	0.064	0.67	8203	609	0	114	1165
2047	0.088	0.064	0.72	8404	613	0	116	1193
2048	0.088	0.064	0.77	8594	616	0	117	1220
2049	0.088	0.064	0.82	8775	619	0	119	1245
2050	0.088	0.064	0.85	8946	622	0	121	1269
2051	0.088	0.064	0.88	9107	625	0	122	1291
2052	0.088	0.064	0.9	9259	627	0	123	1312
2053	0.088	0.064	0.92	9403	630	0	124	1332
2054	0.088	0.064	0.94	9537	632	0	126	1351
2055	0.088	0.064	0.95	9664	634	0	127	1369

1.3.6 Figures

Figure 1.1. Red snapper: Comparison of previous and corrected recreational landings. Headboat landings are separated from these general recreational landings starting in 1972, but are assumed included prior. The large solid circles in 1960, 1965, and 1970 represent values from Salt-Water Angling Surveys and served as anchor points for linear interpolations, as documented in the Assessment Workshop report.

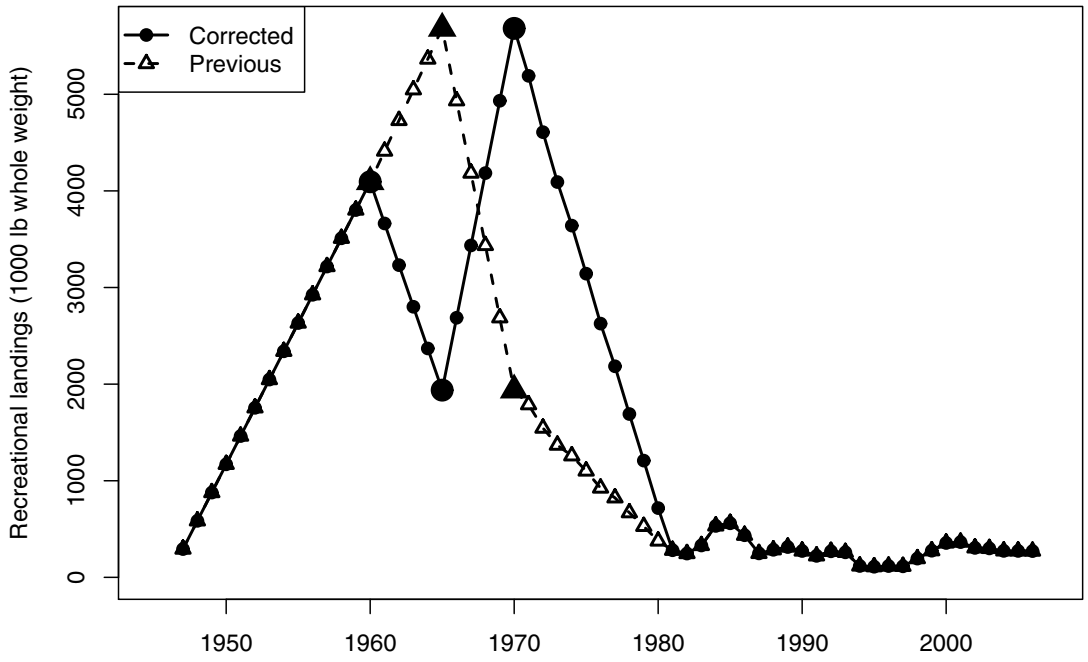


Figure 1.2. Red snapper: Comparison of predicted time series from the base assessment model using the previous and corrected recreational landings from the Salt-Water Angling reports.

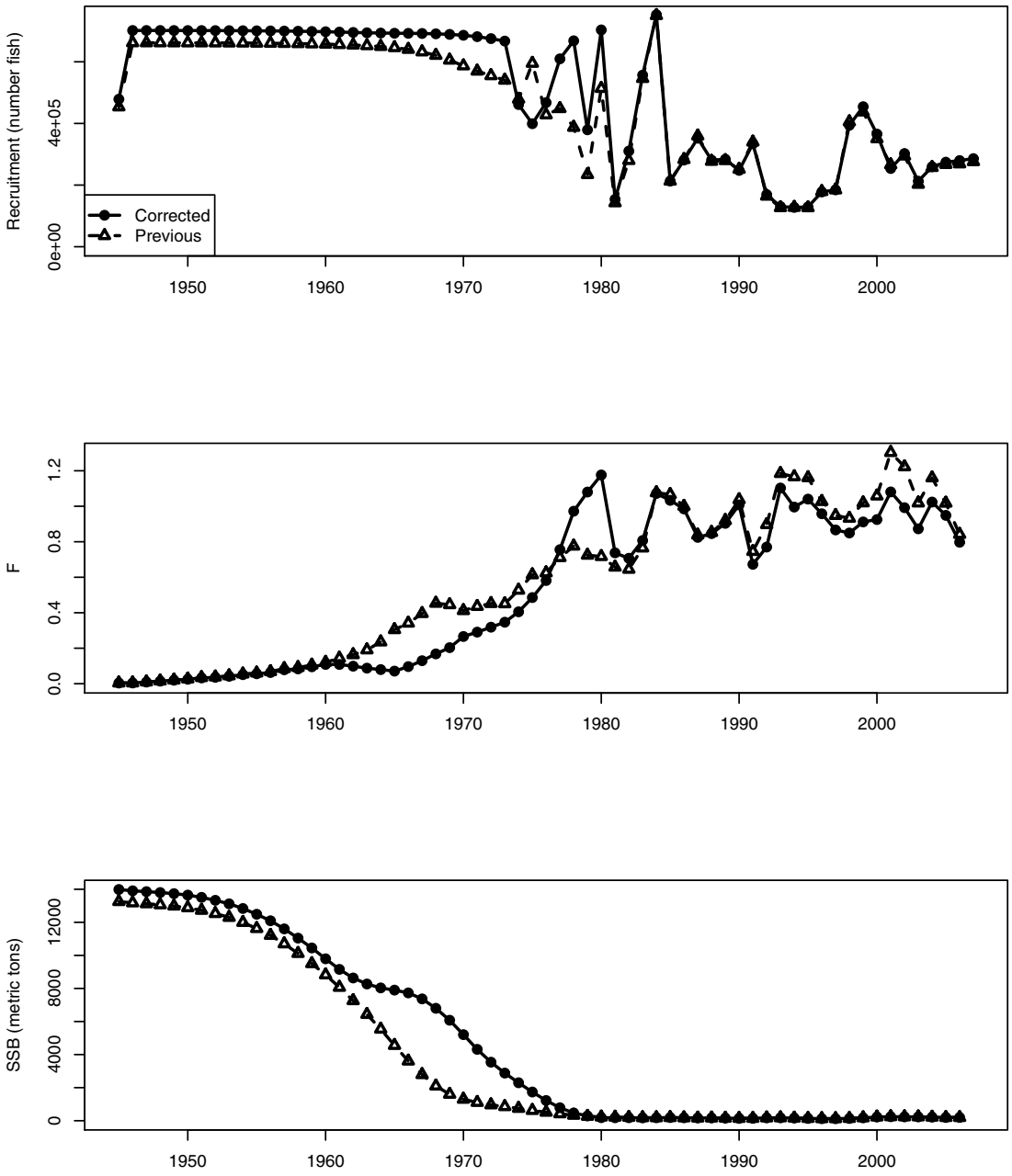


Figure 1.3. Red snapper: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, c.hal to commercial handline, c.dv to commercial diving, hb to headboat, and rec to general recreational (MRFSS).

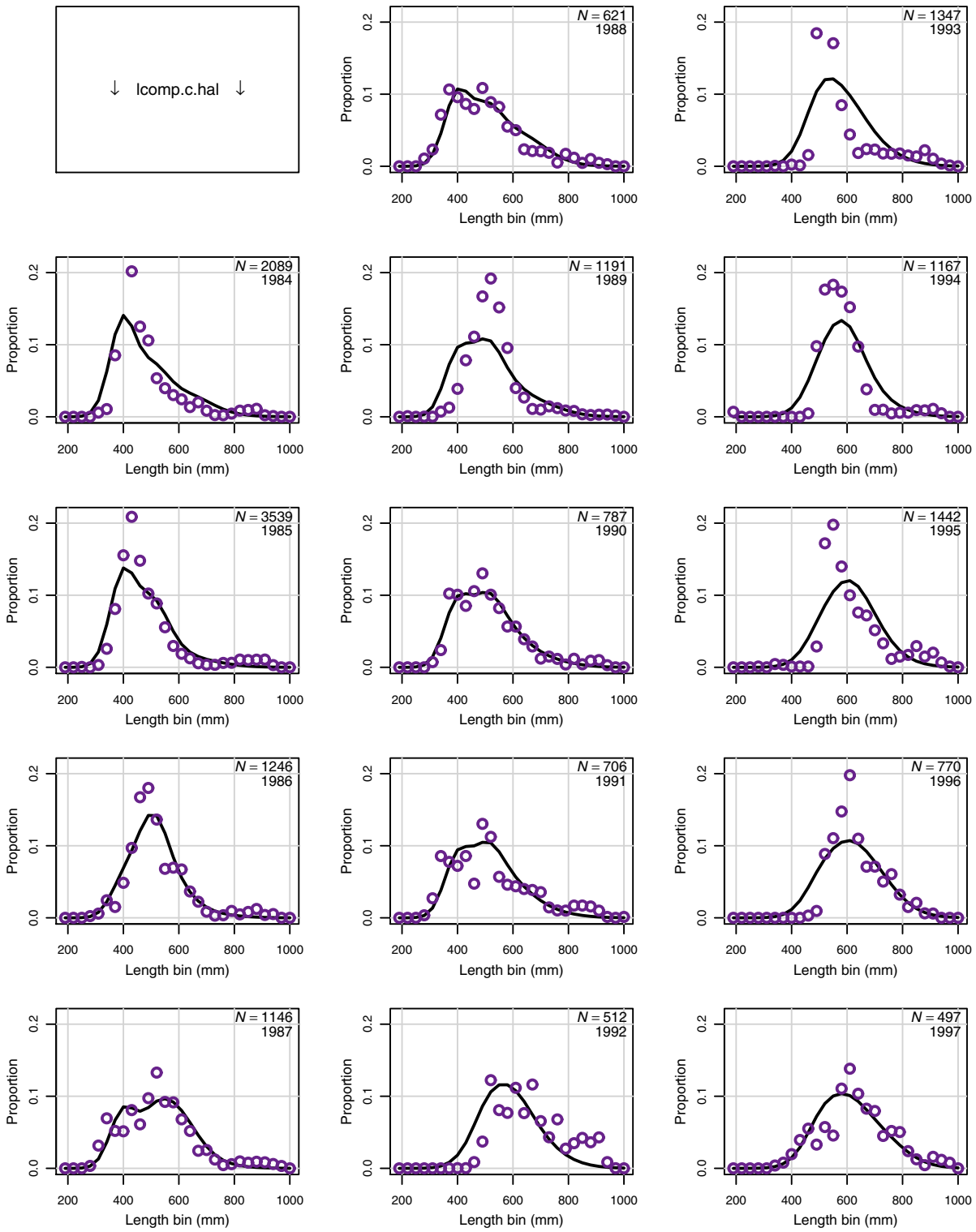


Figure 1.3. (cont.) Red snapper: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

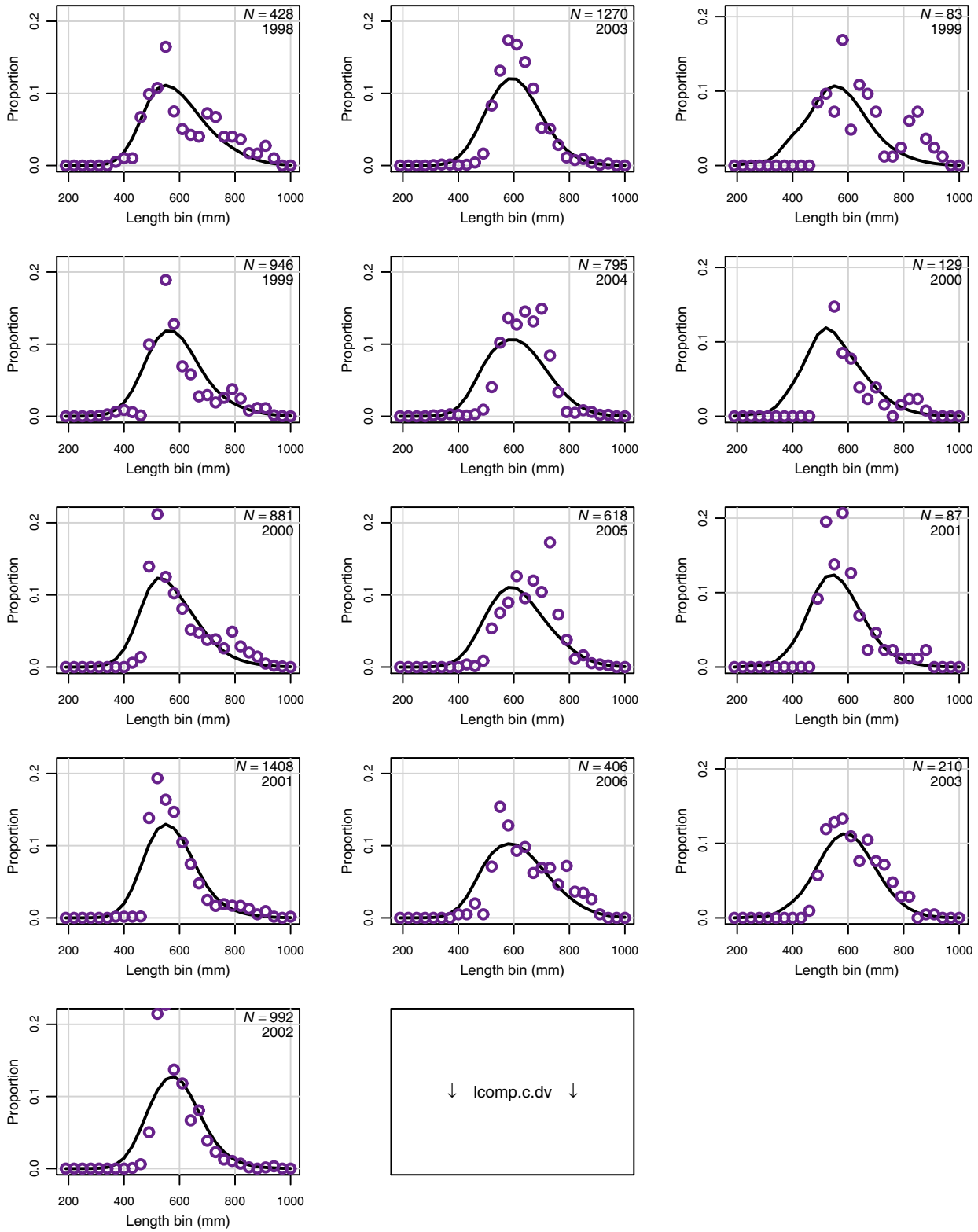


Figure 1.3. (cont.) Red snapper: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

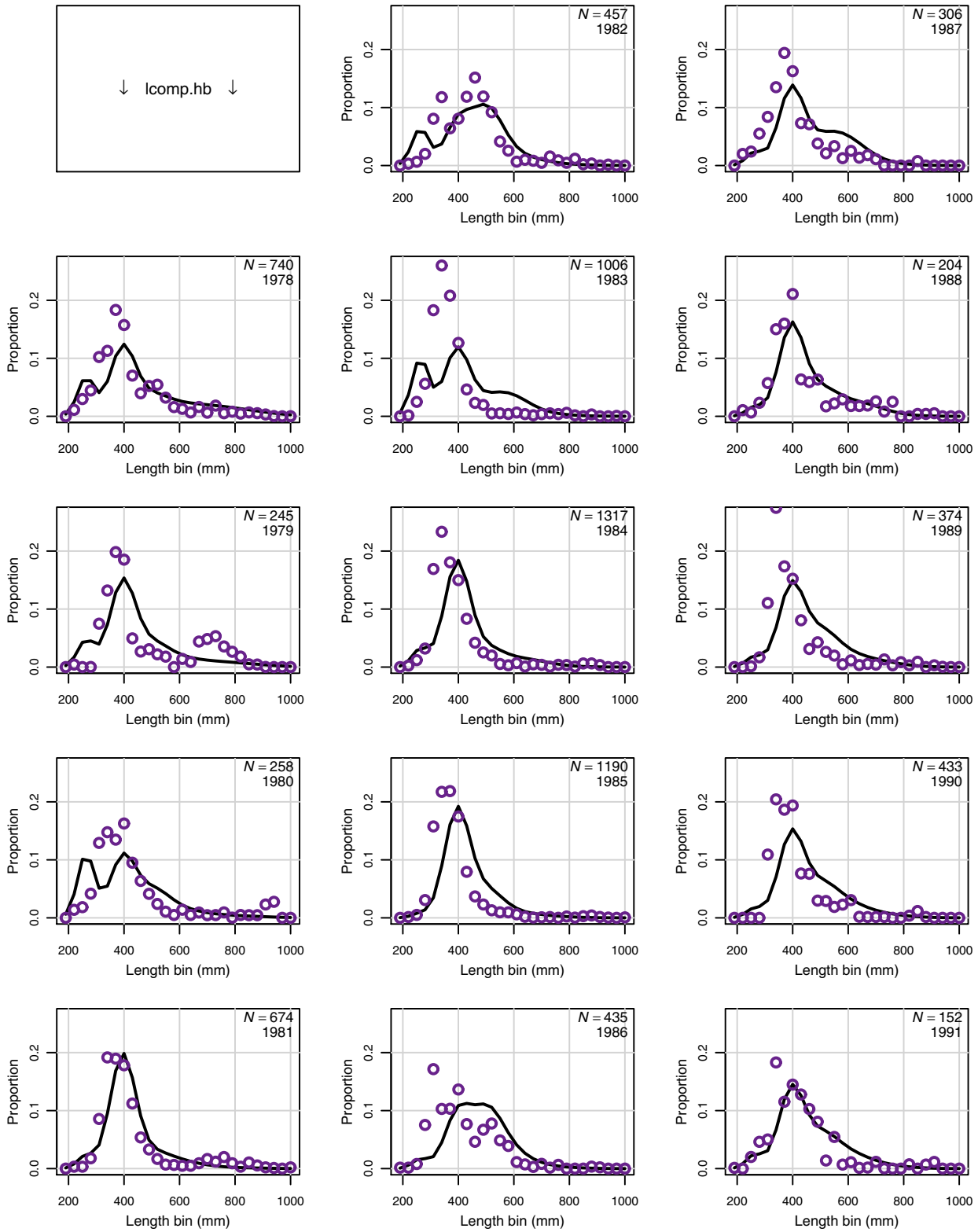


Figure 1.3. (cont.) Red snapper: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

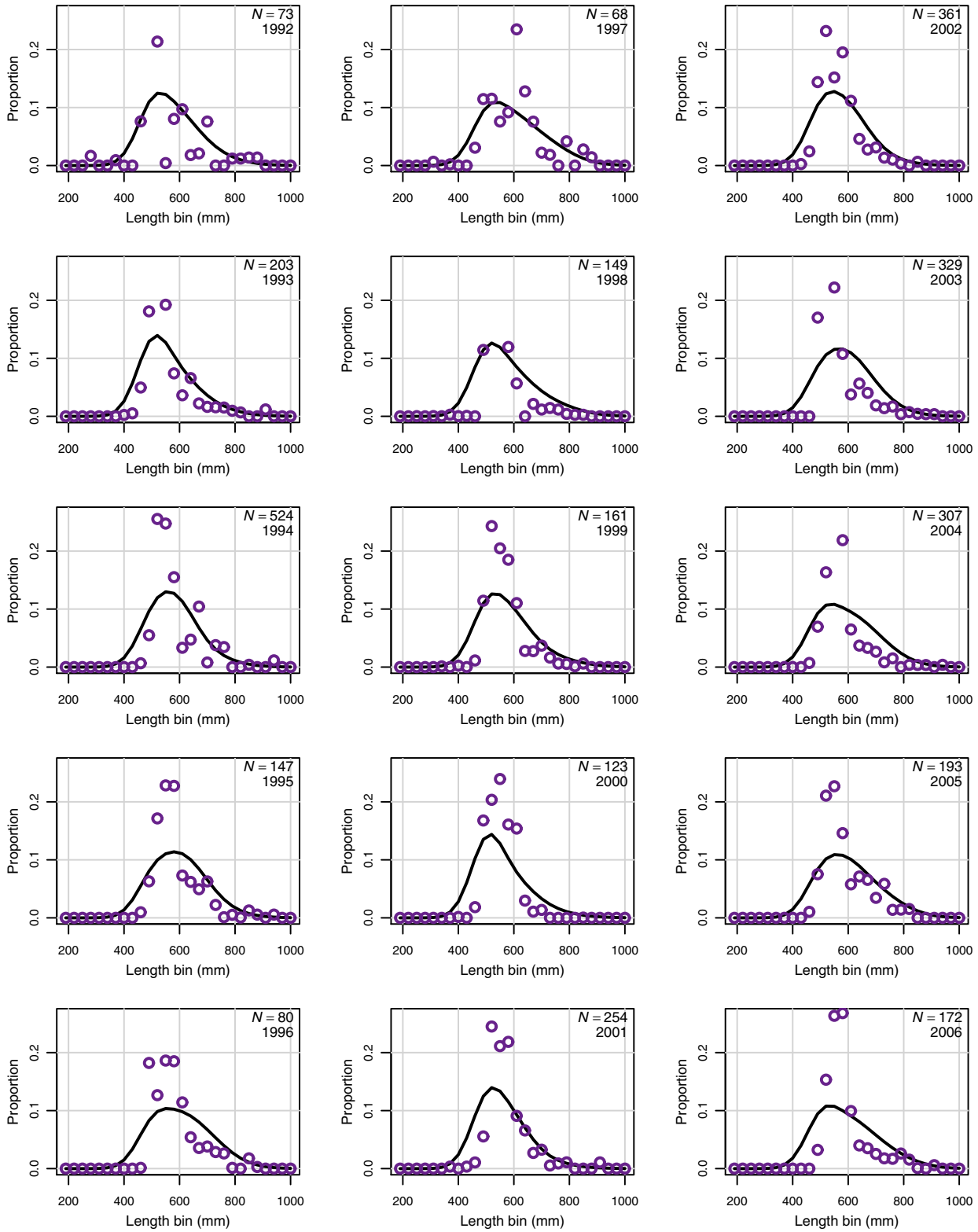


Figure 1.3. (cont.) Red snapper: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

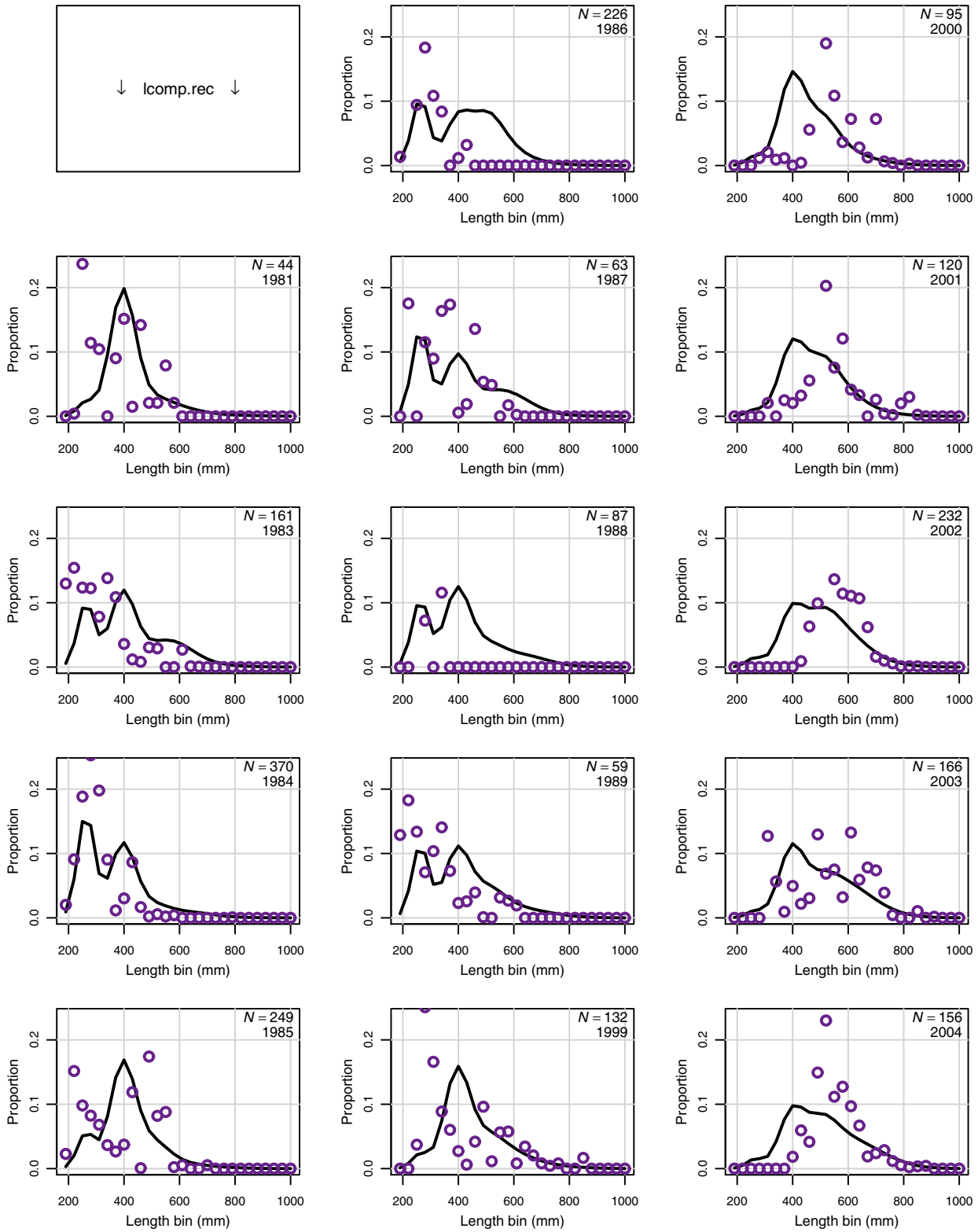


Figure 1.3. (cont.) Red snapper: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

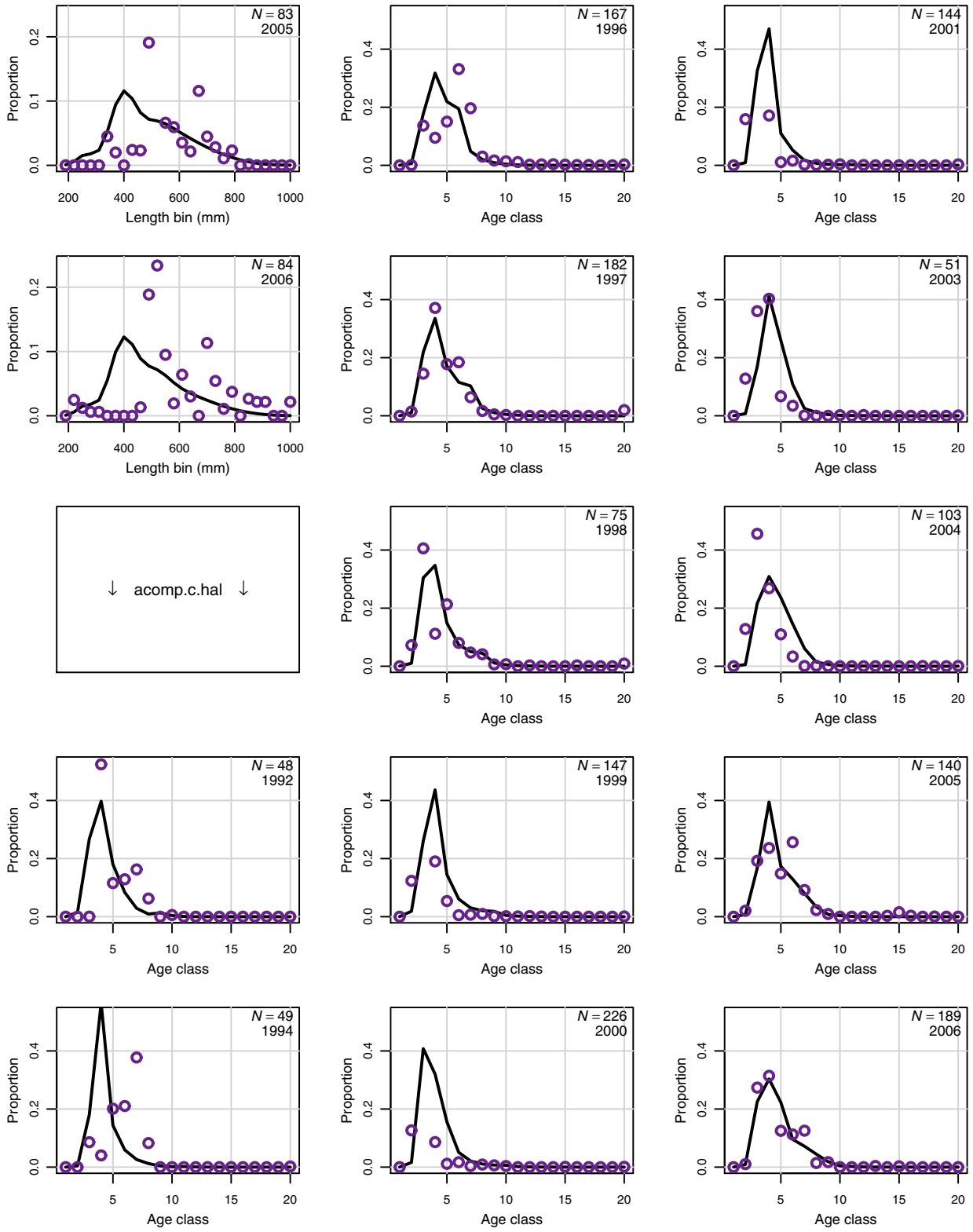


Figure 1.3. (cont.) Red snapper: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

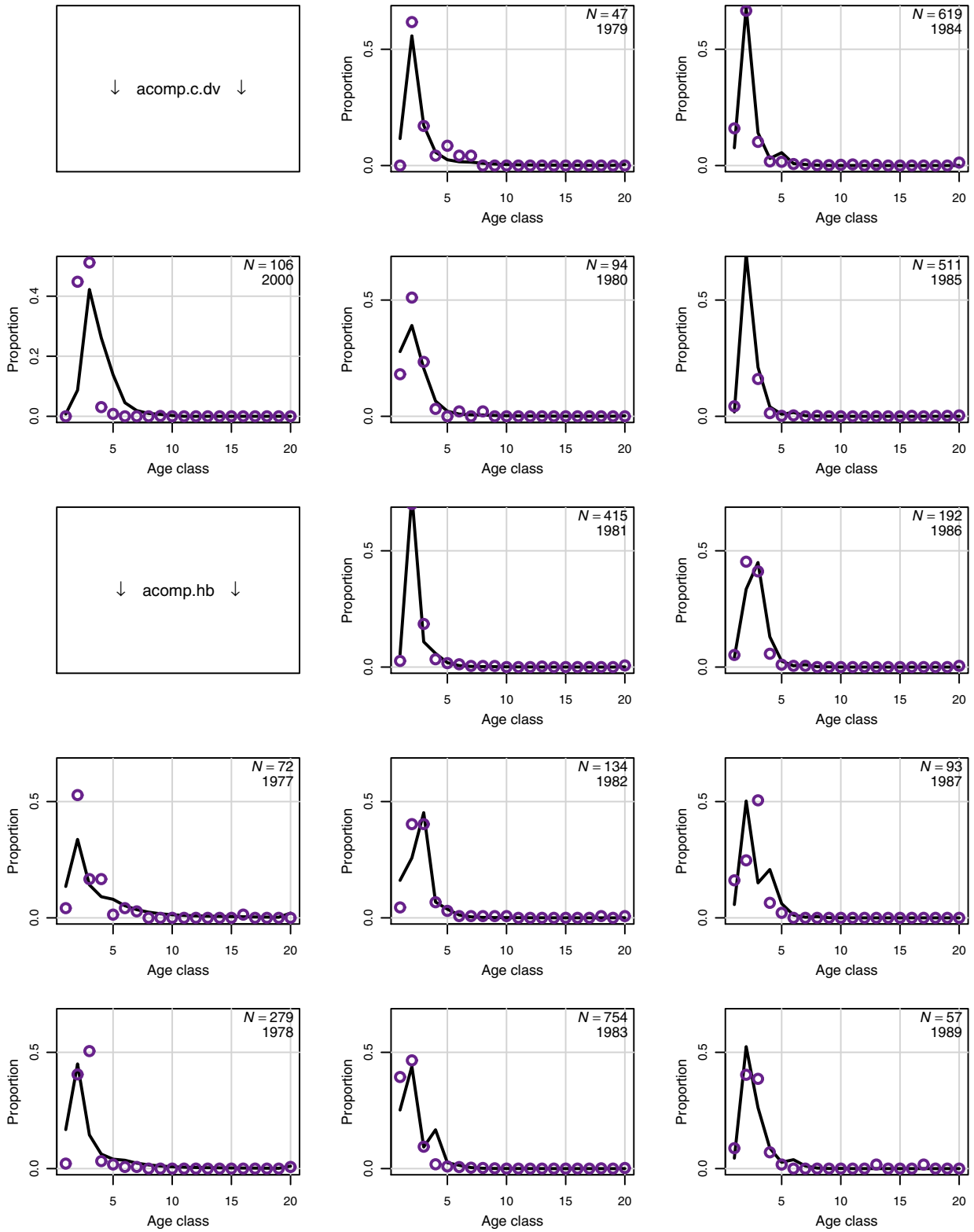


Figure 1.3. (cont.) Red snapper: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

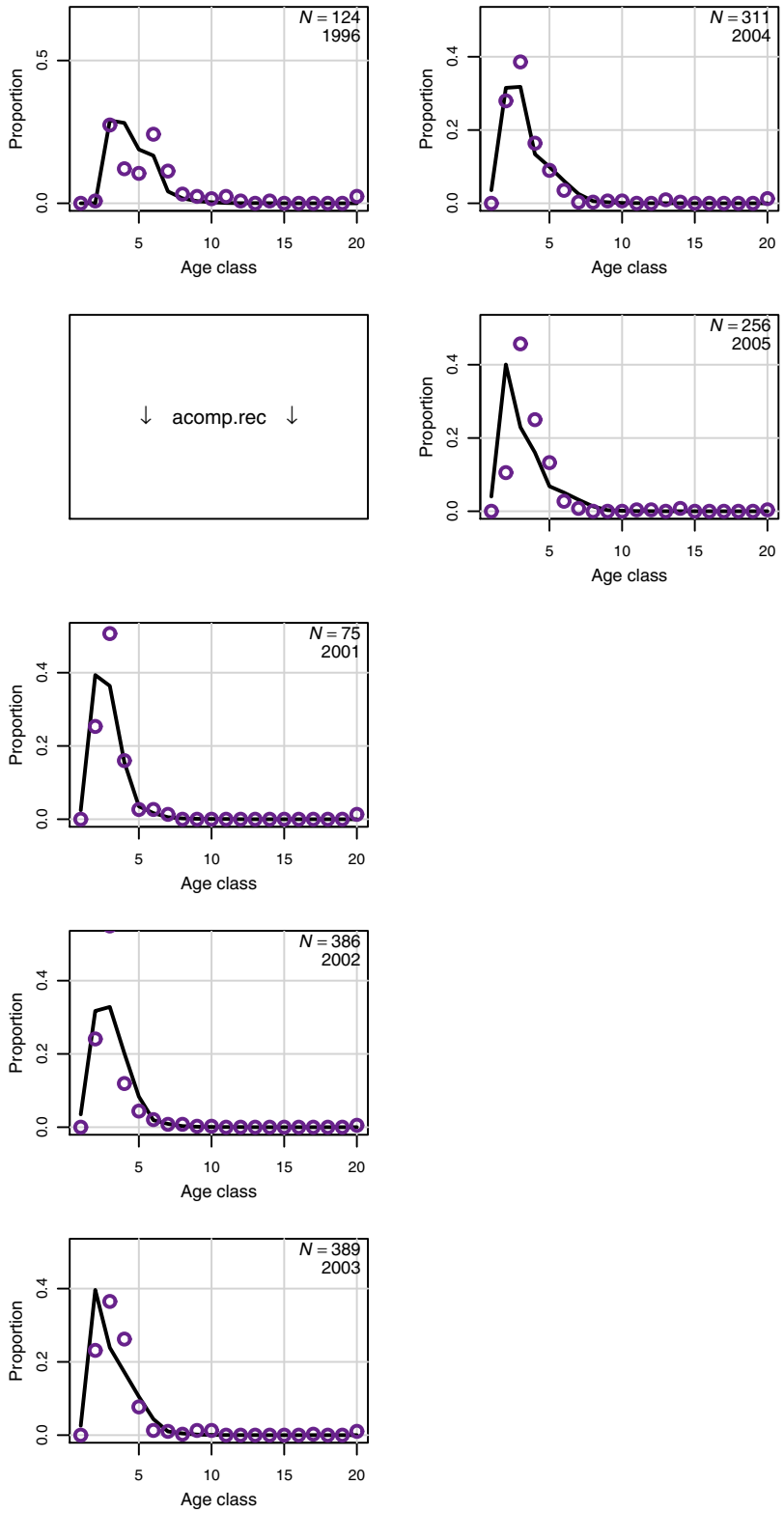


Figure 1.4. Red snapper: Top panel is a bubble plot of length composition residuals from the commercial hand-line fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

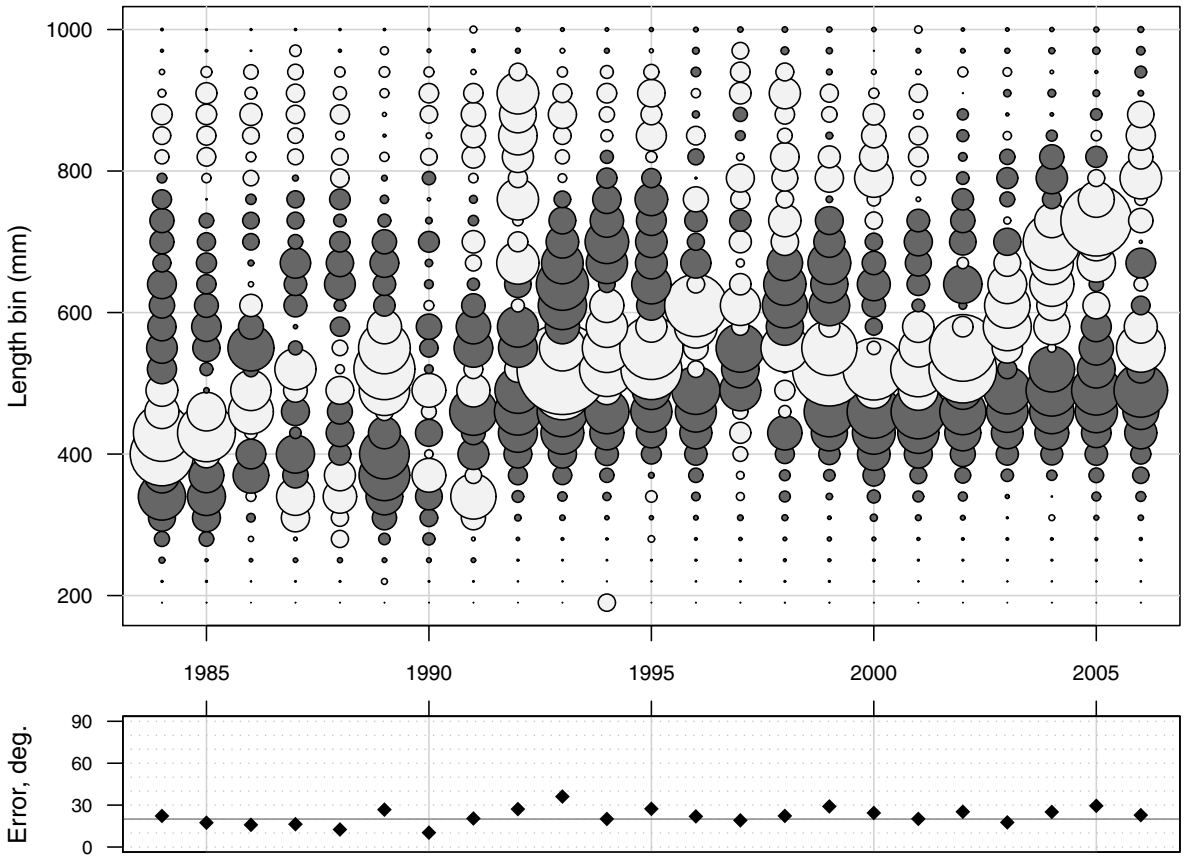


Figure 1.5. Red snapper: Top panel is a bubble plot of length composition residuals from the commercial diving fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

Figure 1.6. Red snapper: Top panel is a bubble plot of length composition residuals from the headboat fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

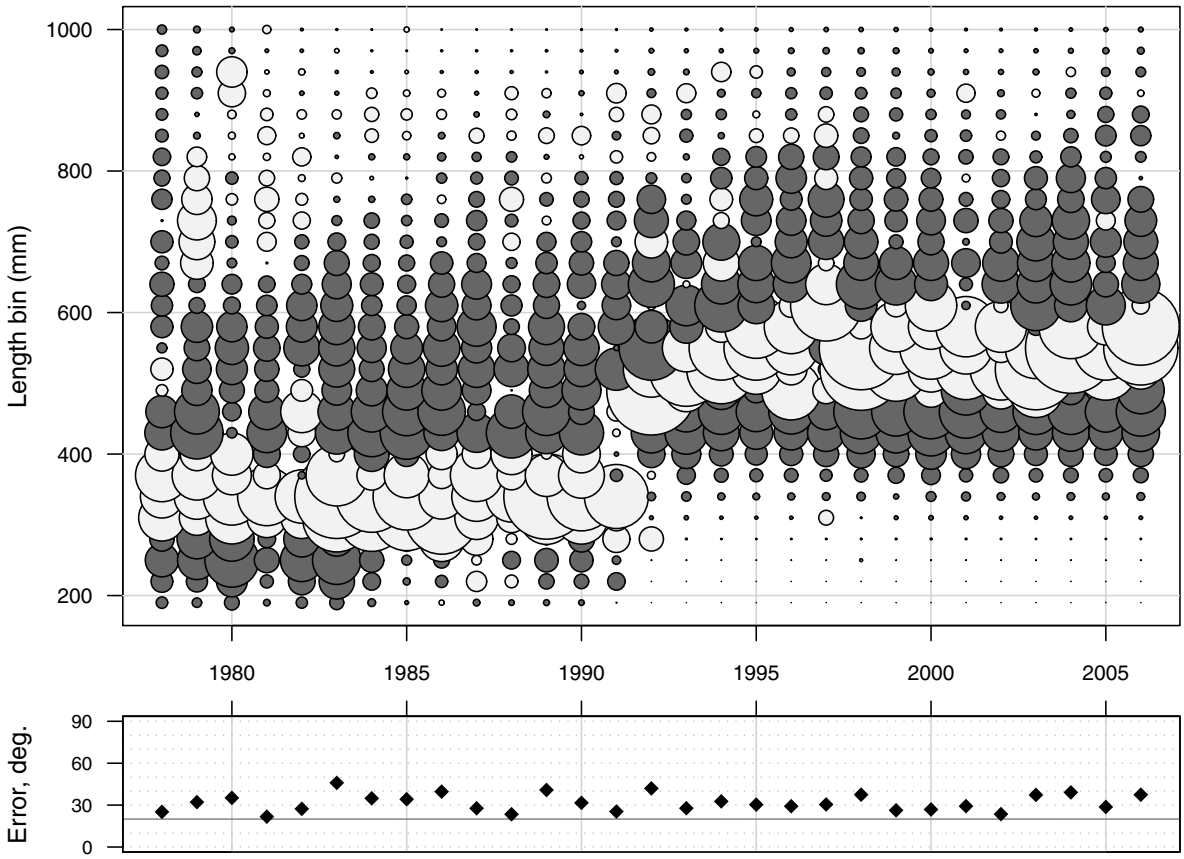


Figure 1.7. Red snapper: Top panel is a bubble plot of length composition residuals from the recreational fishery (MRFSS); Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

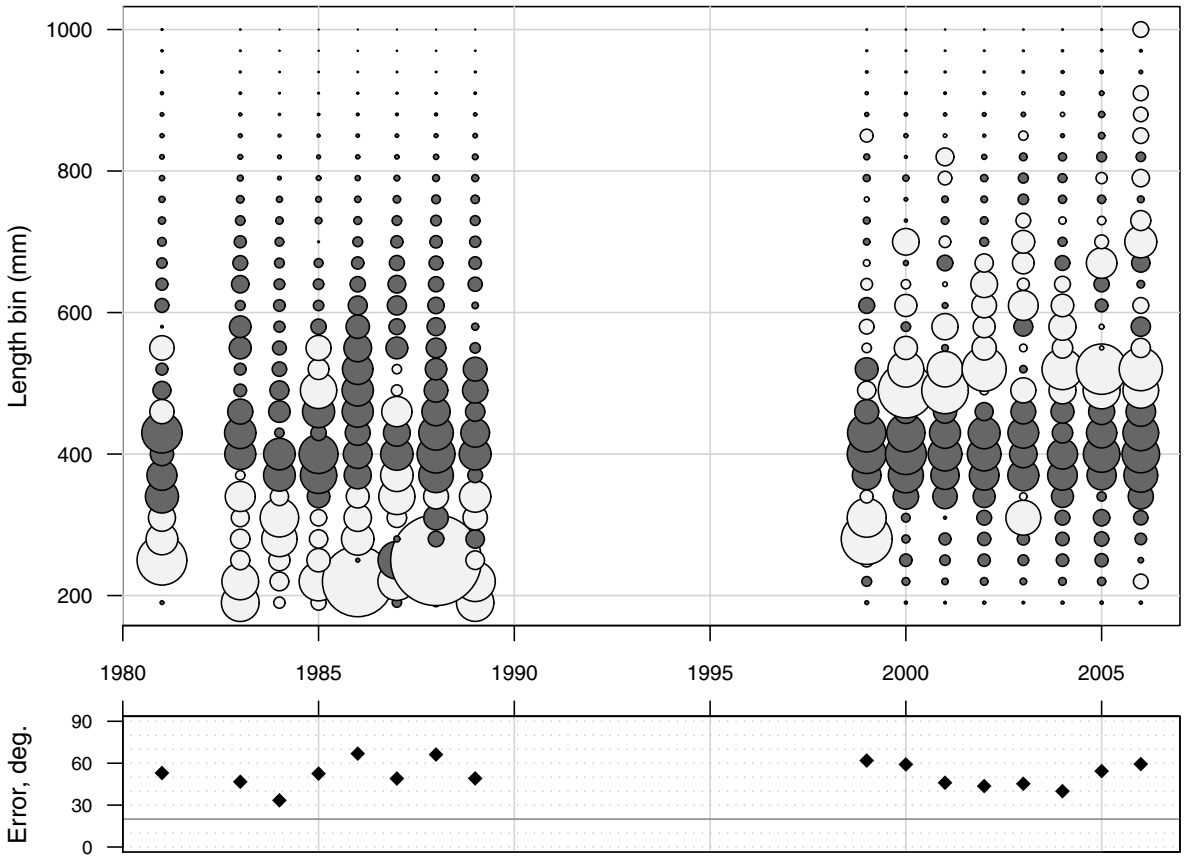


Figure 1.8. Red snapper: Top panel is a bubble plot of age composition residuals from the commercial handline fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

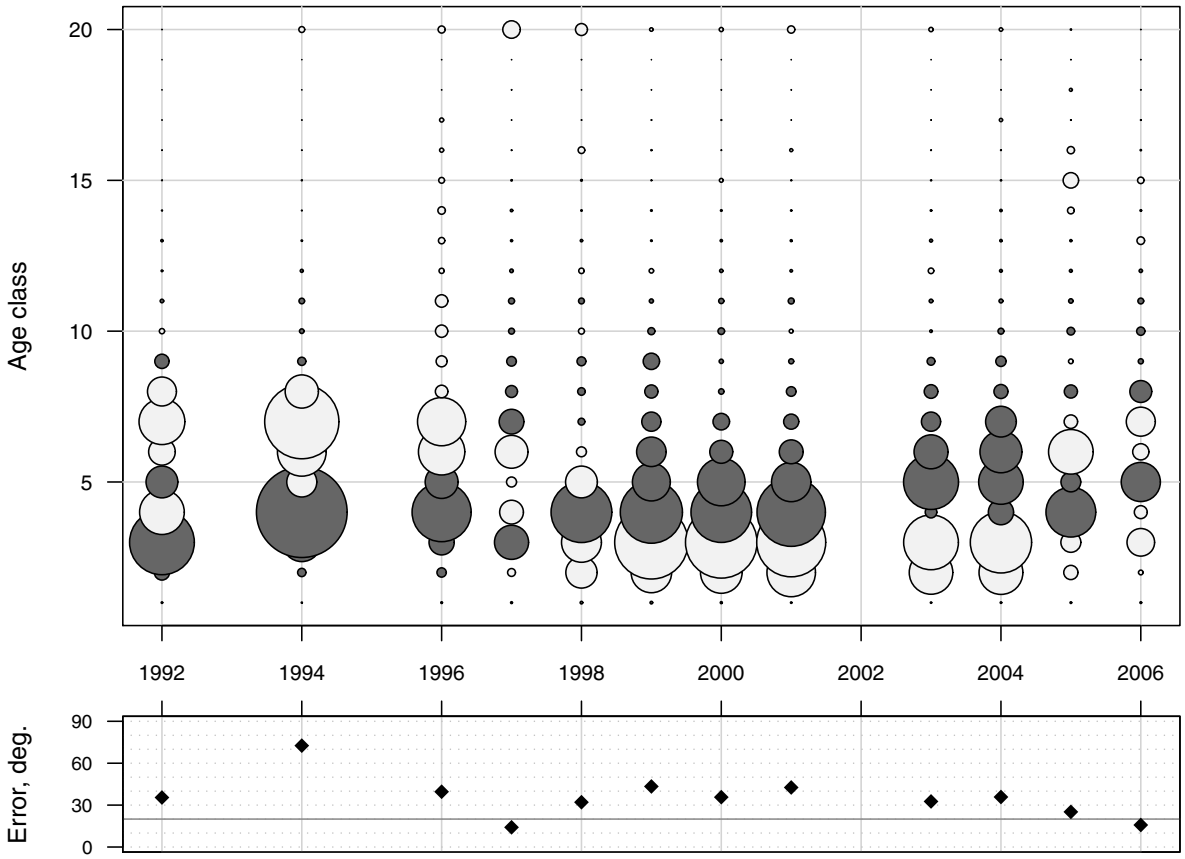


Figure 1.9. Red snapper: Top panel is a bubble plot of age composition residuals from the commercial diving fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

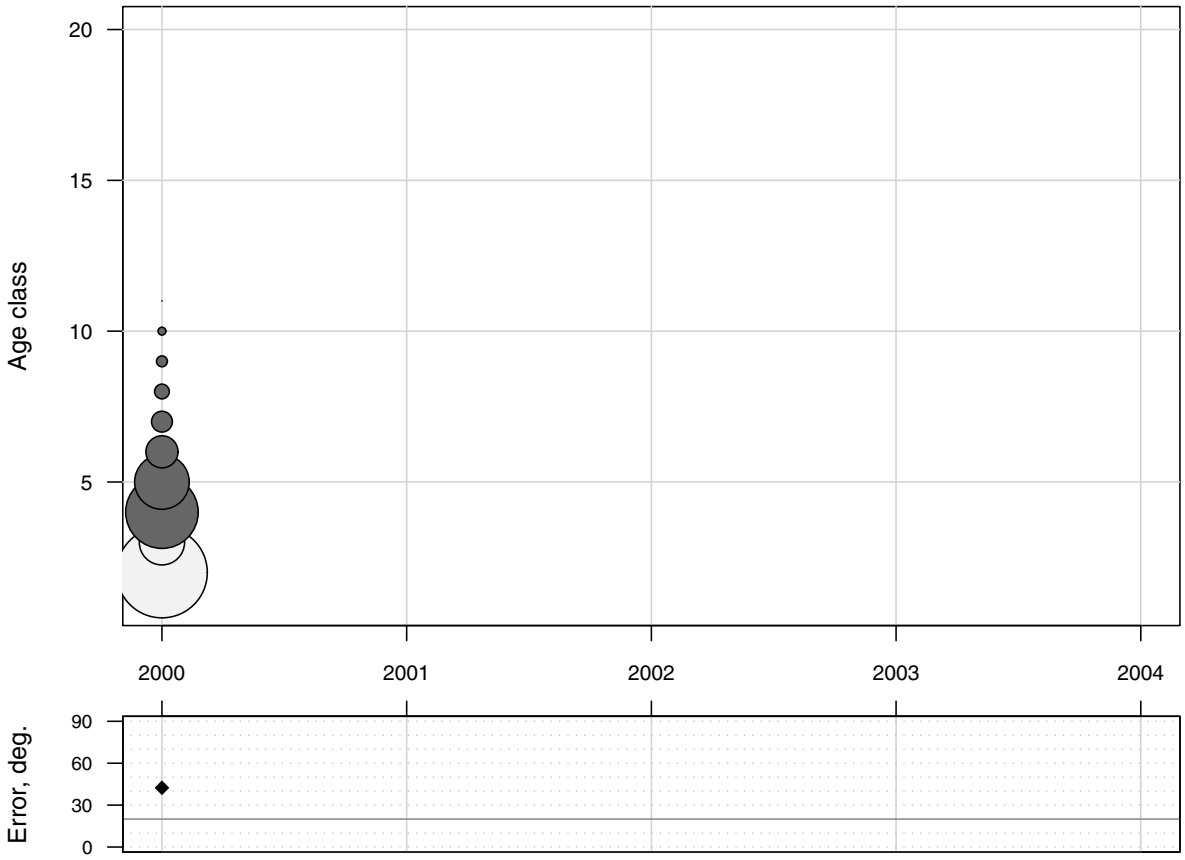


Figure 1.10. Red snapper: Top panel is a bubble plot of age composition residuals from the headboat fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

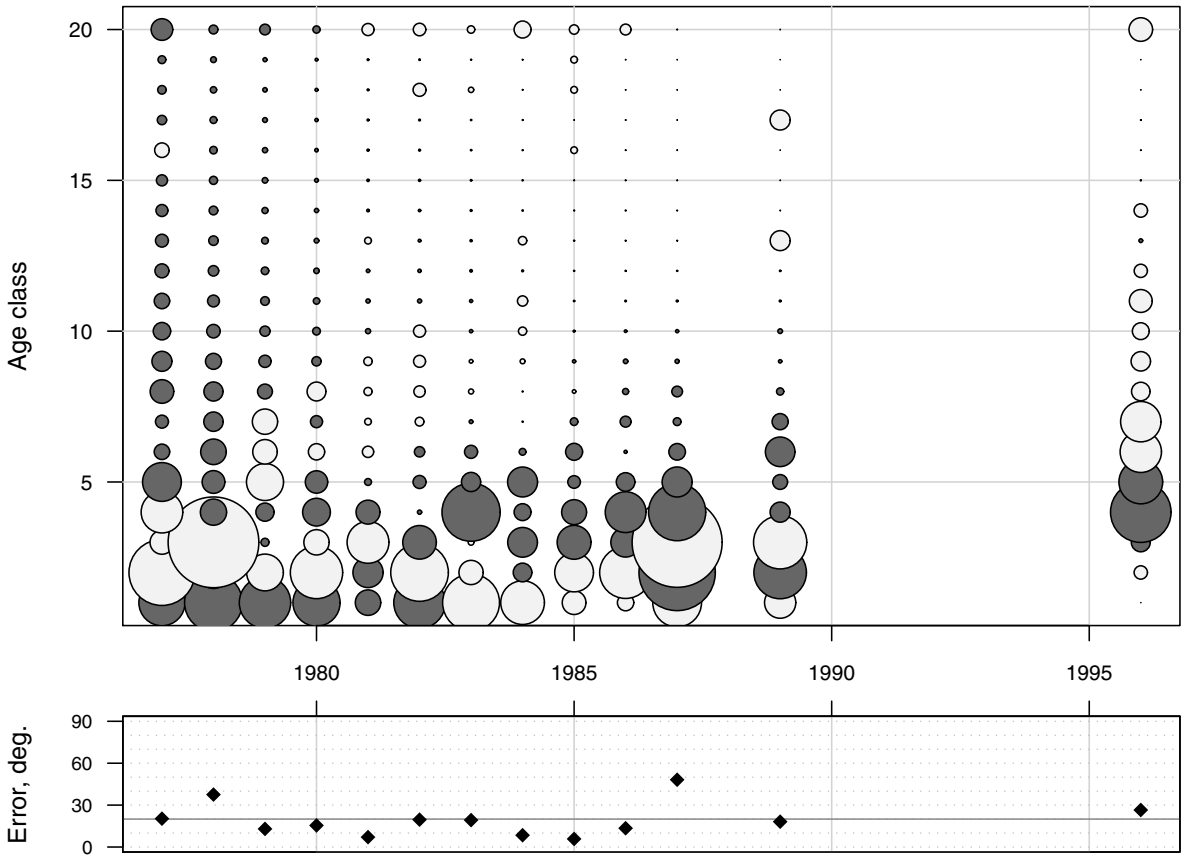


Figure 1.11. Red snapper: Top panel is a bubble plot of age composition residuals from the recreational fishery (MRFSS); Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

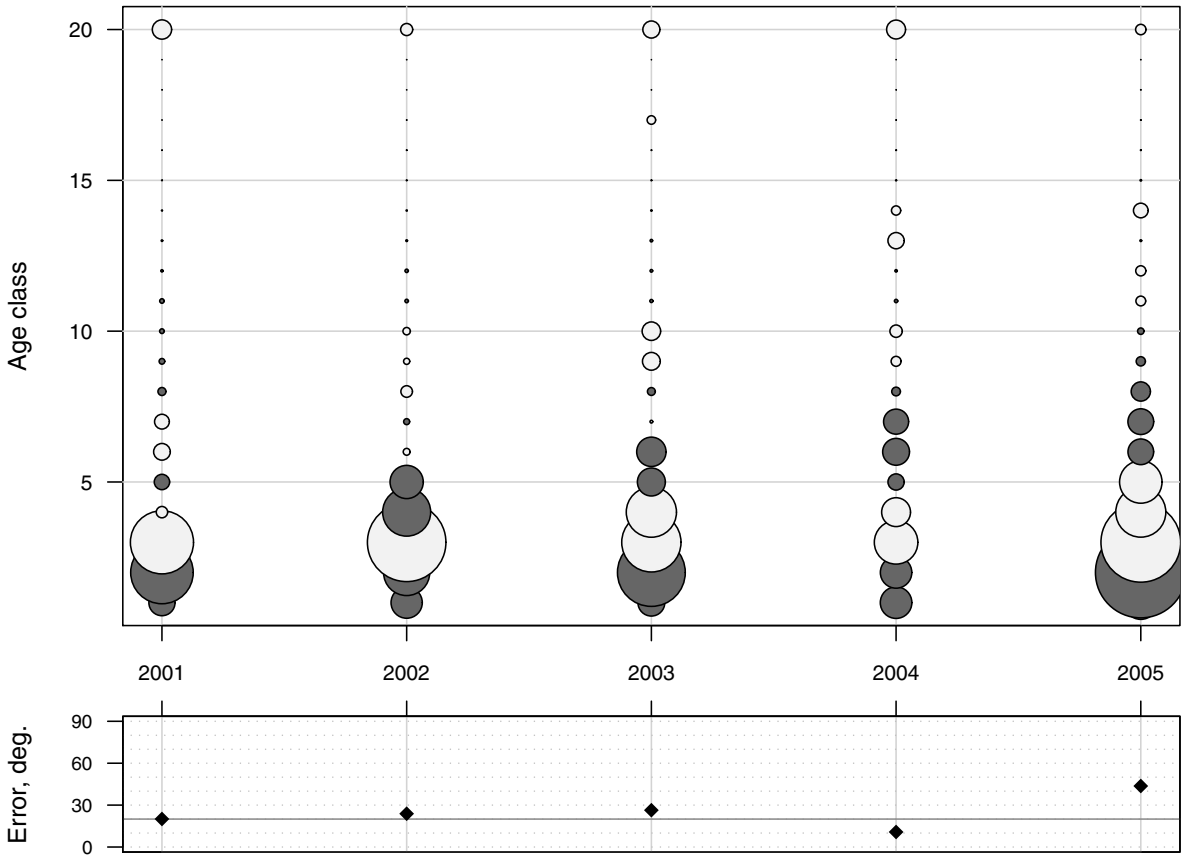


Figure 1.12. Red snapper: Observed (open circles) and estimated (solid line, circles) commercial handline landings (whole weight). Open and closed circles are indistinguishable.

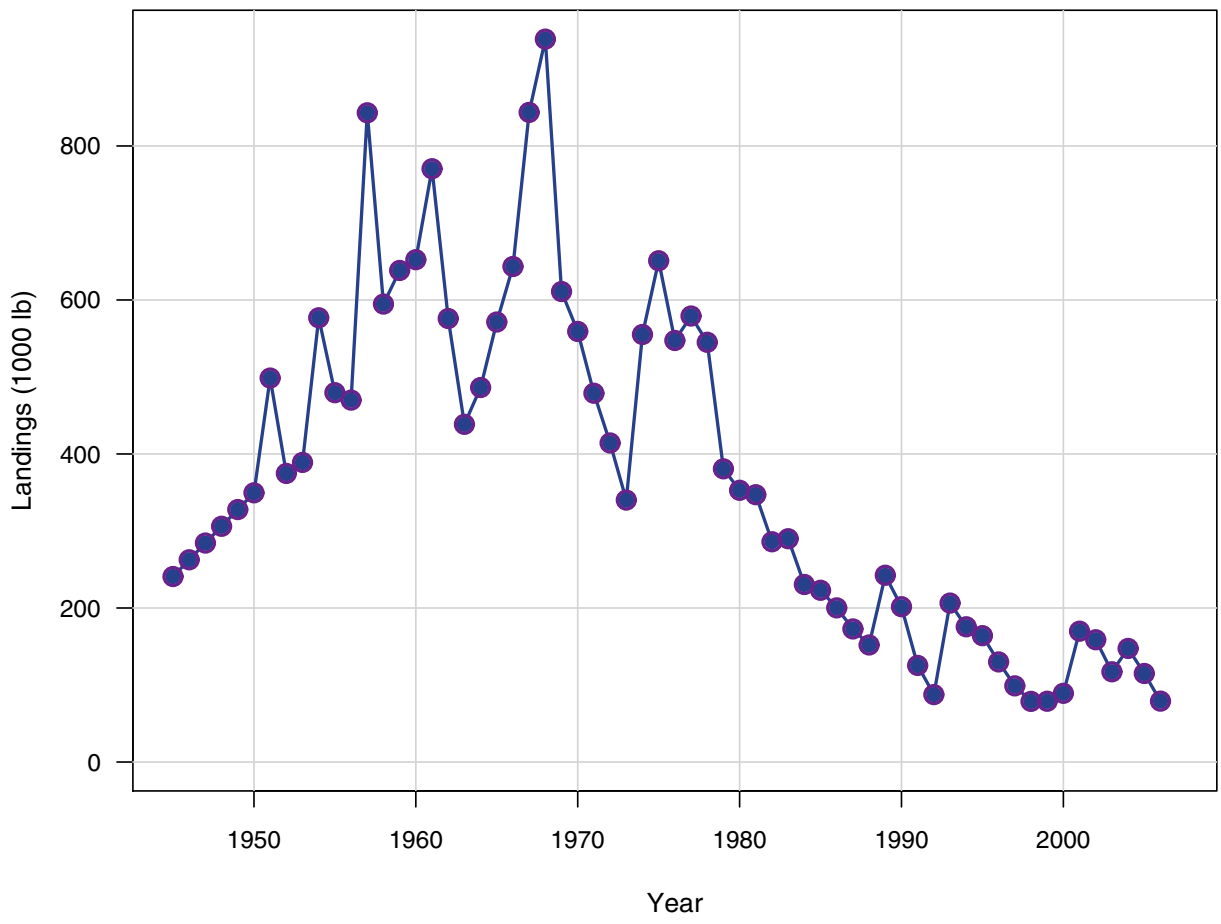


Figure 1.13. Red snapper: Observed (open circles) and estimated (solid line, circles) commercial diving landings (whole weight). Open and closed circles are indistinguishable.

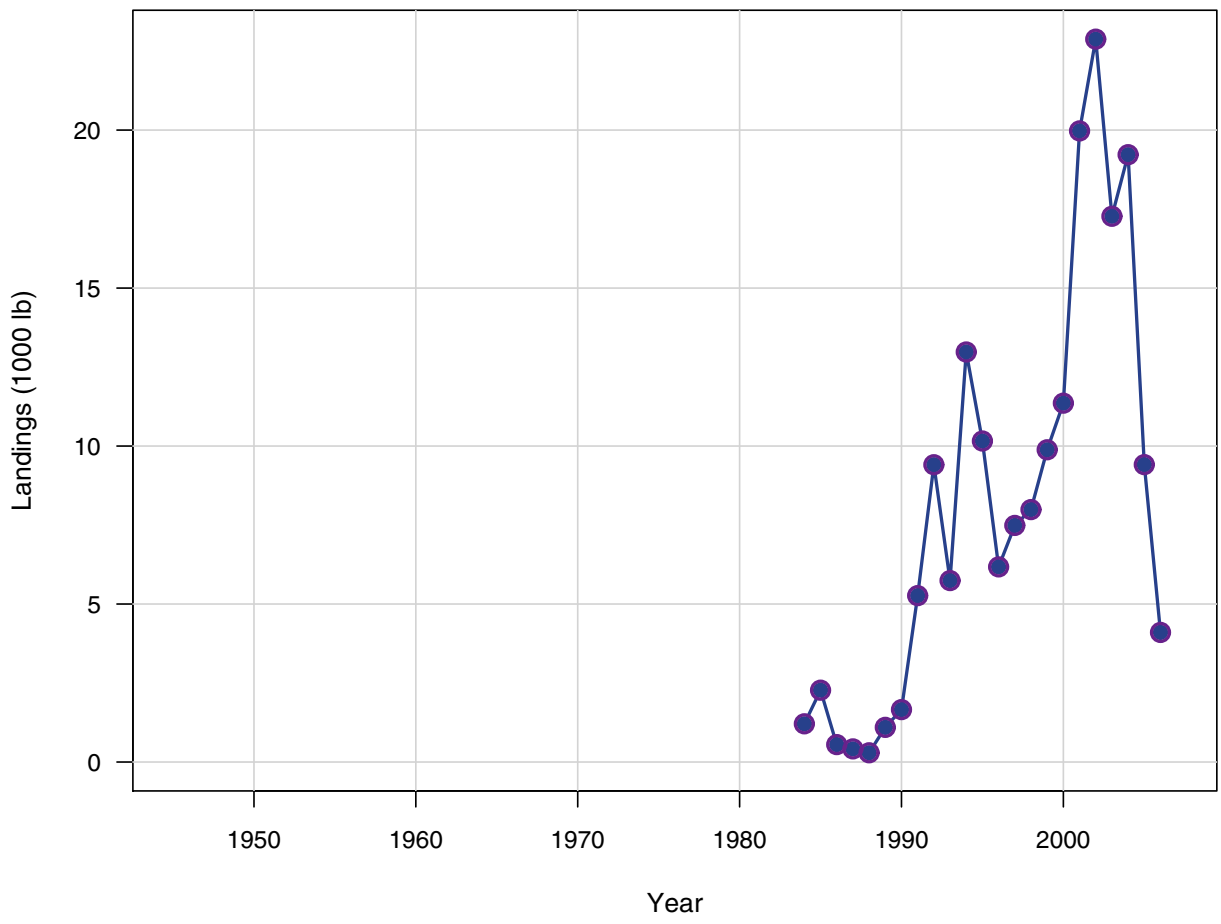


Figure 1.14. Red snapper: Observed (open circles) and estimated (solid line, circles) headboat landings (whole weight). Open and closed circles are indistinguishable.

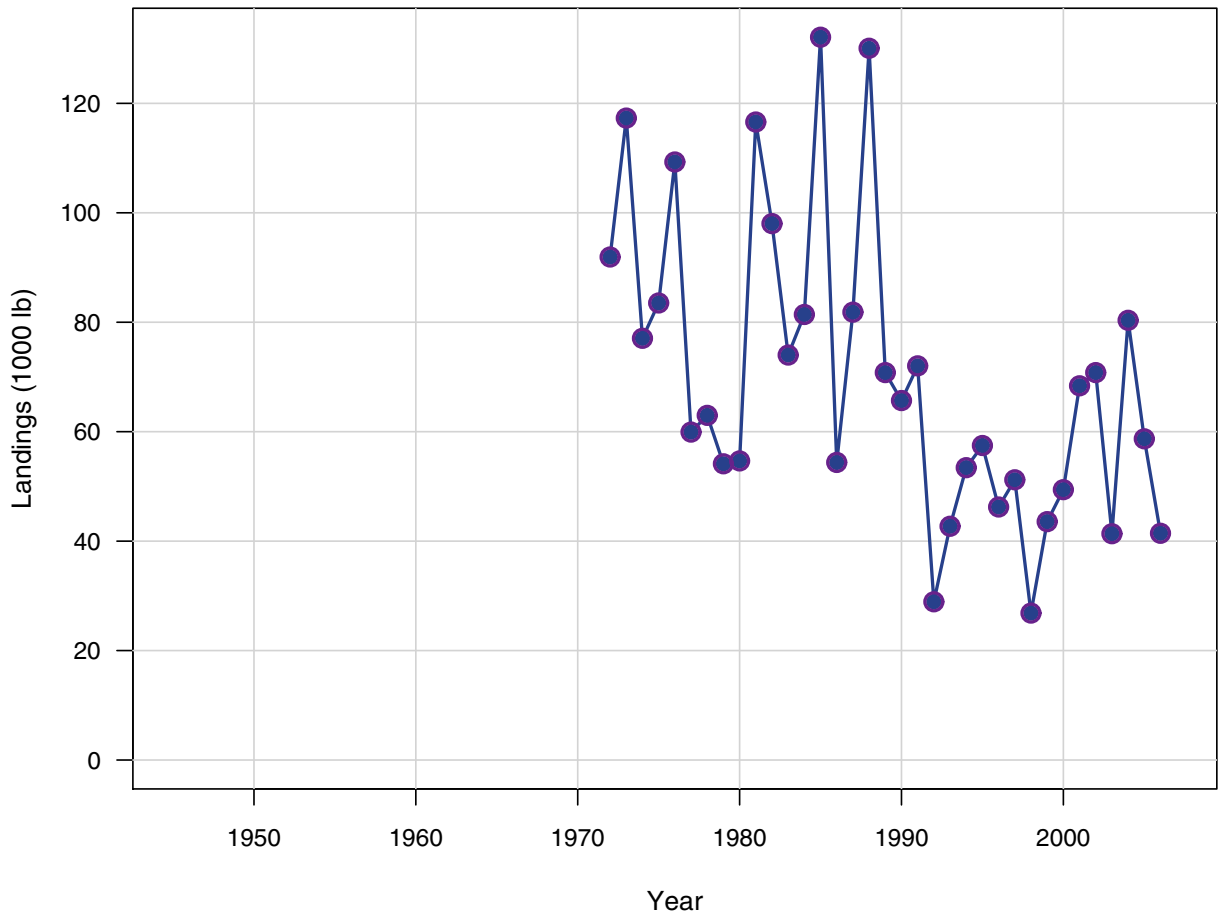


Figure 1.15. Red snapper: Observed (open circles) and estimated (solid line, circles) general recreational landings (whole weight). Open and closed circles are indistinguishable.

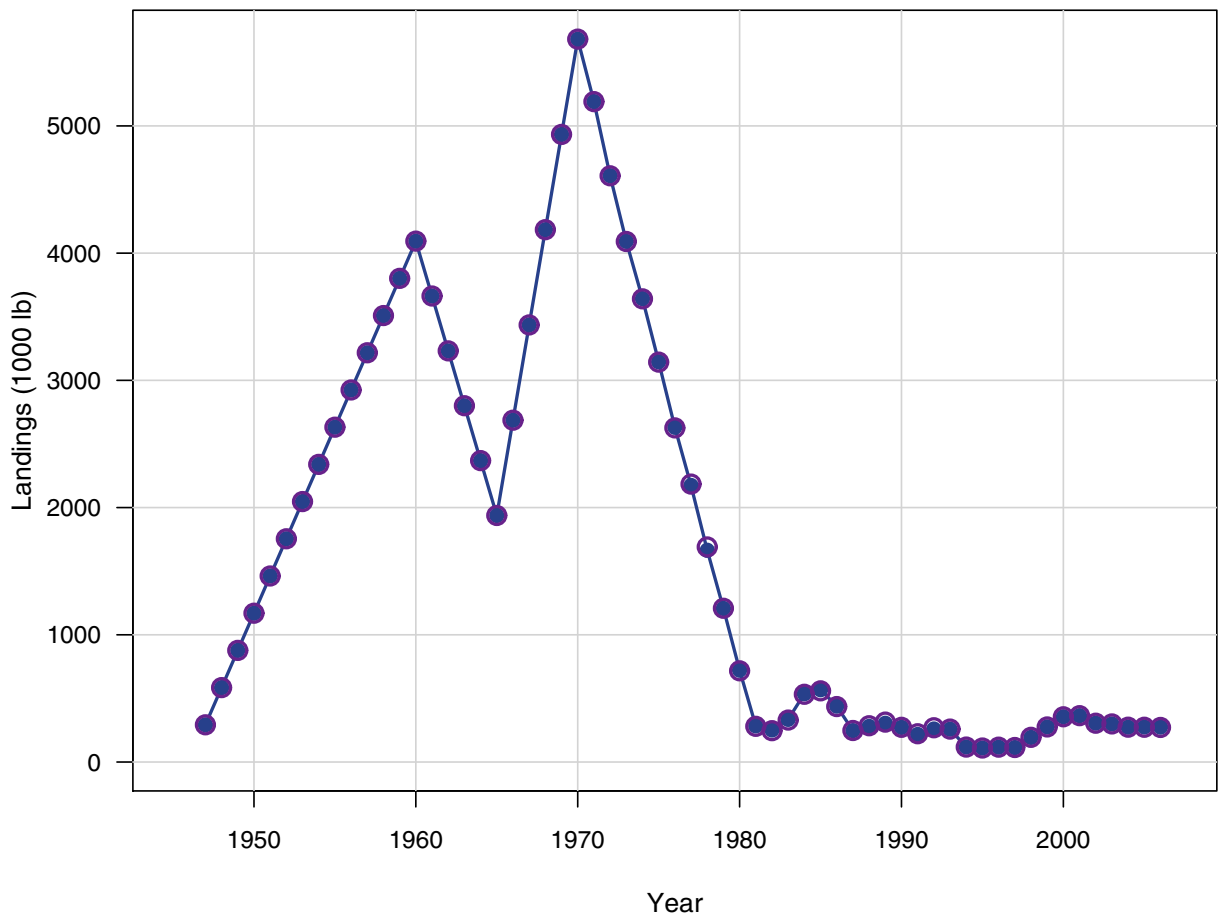


Figure 1.16. Red snapper: Observed (open circles) and estimated (solid line, circles) commercial handline discard mortalities. Open and closed circles are indistinguishable.

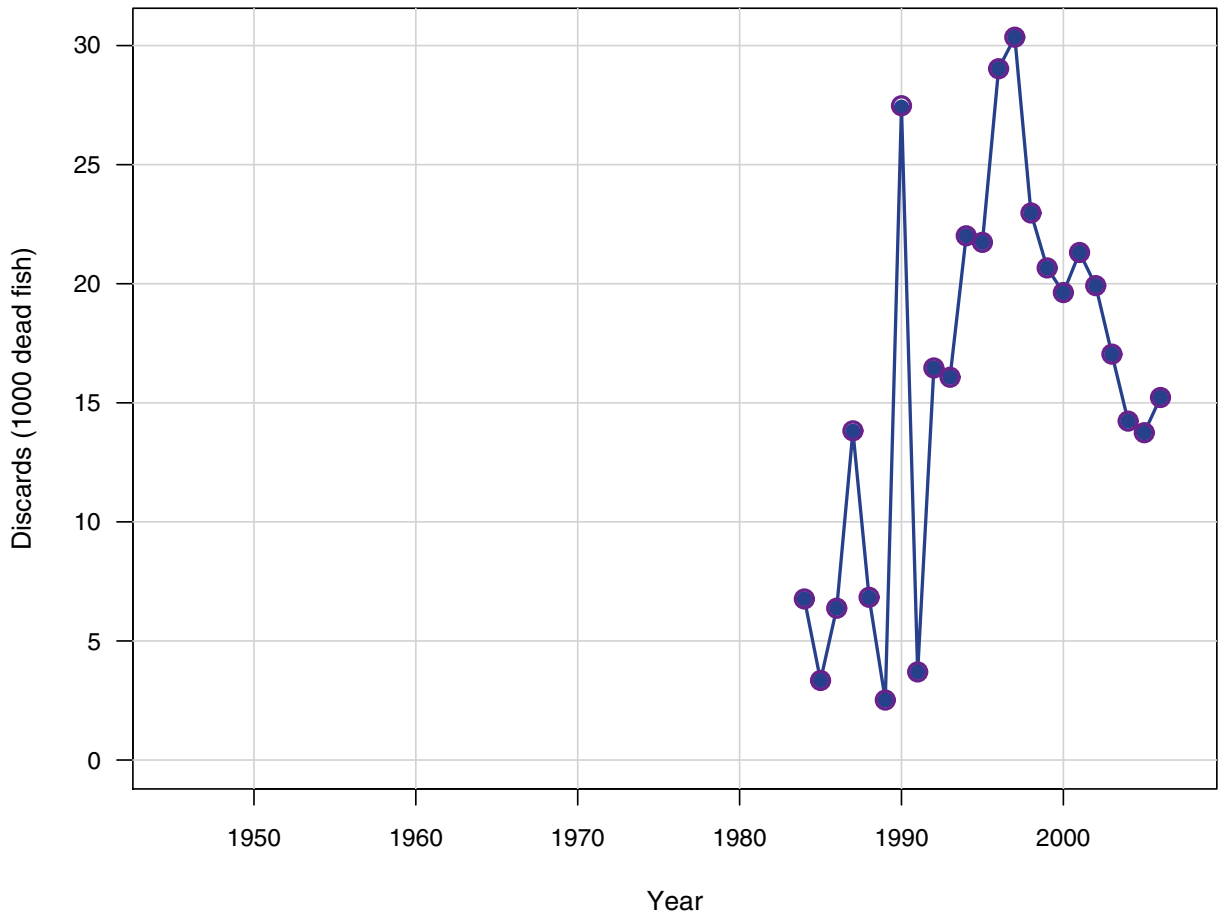


Figure 1.17. Red snapper: Observed (open circles) and estimated (solid line, circles) headboat discard mortalities. Open and closed circles are indistinguishable.

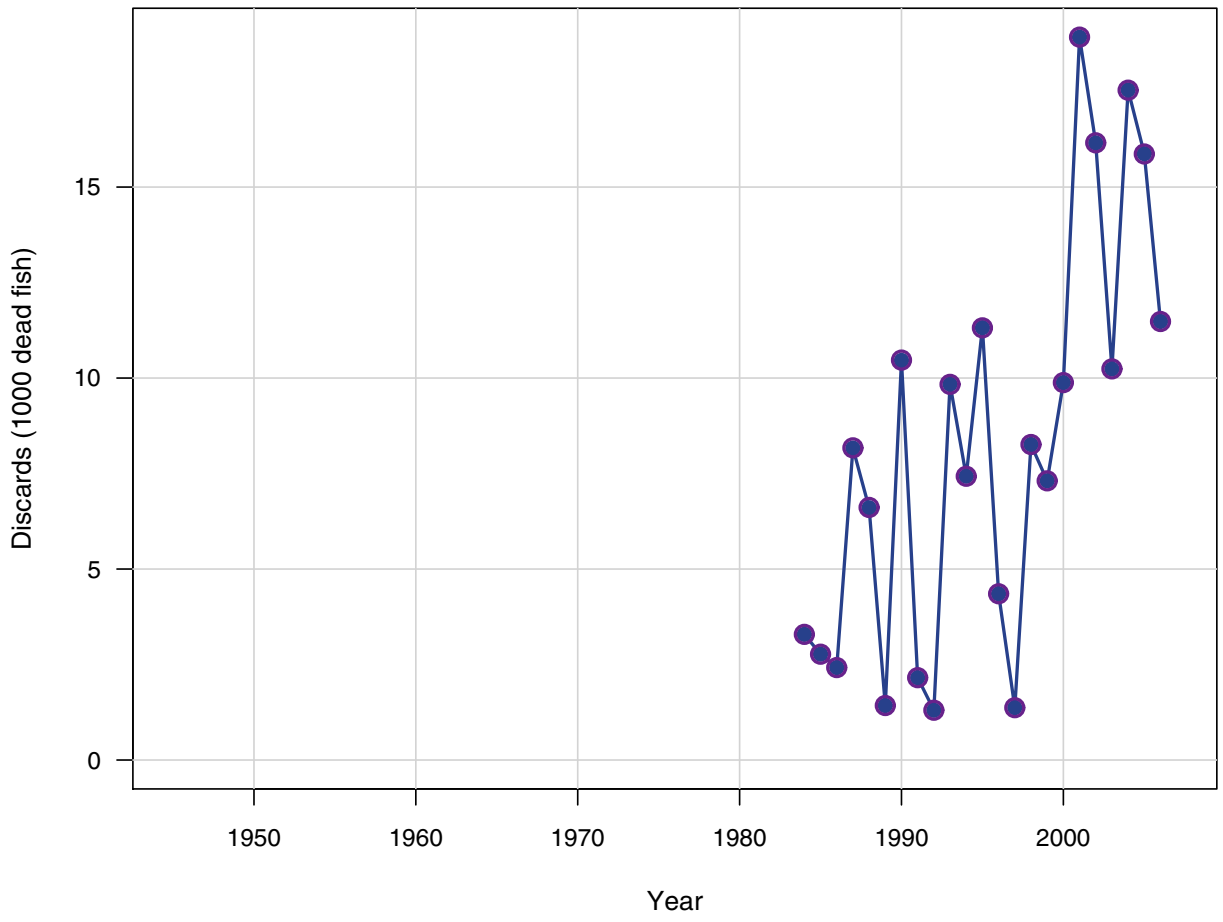


Figure 1.18. Red snapper: Observed (open circles) and estimated (solid line, circles) general recreational discard mortalities. Open and closed circles are indistinguishable.

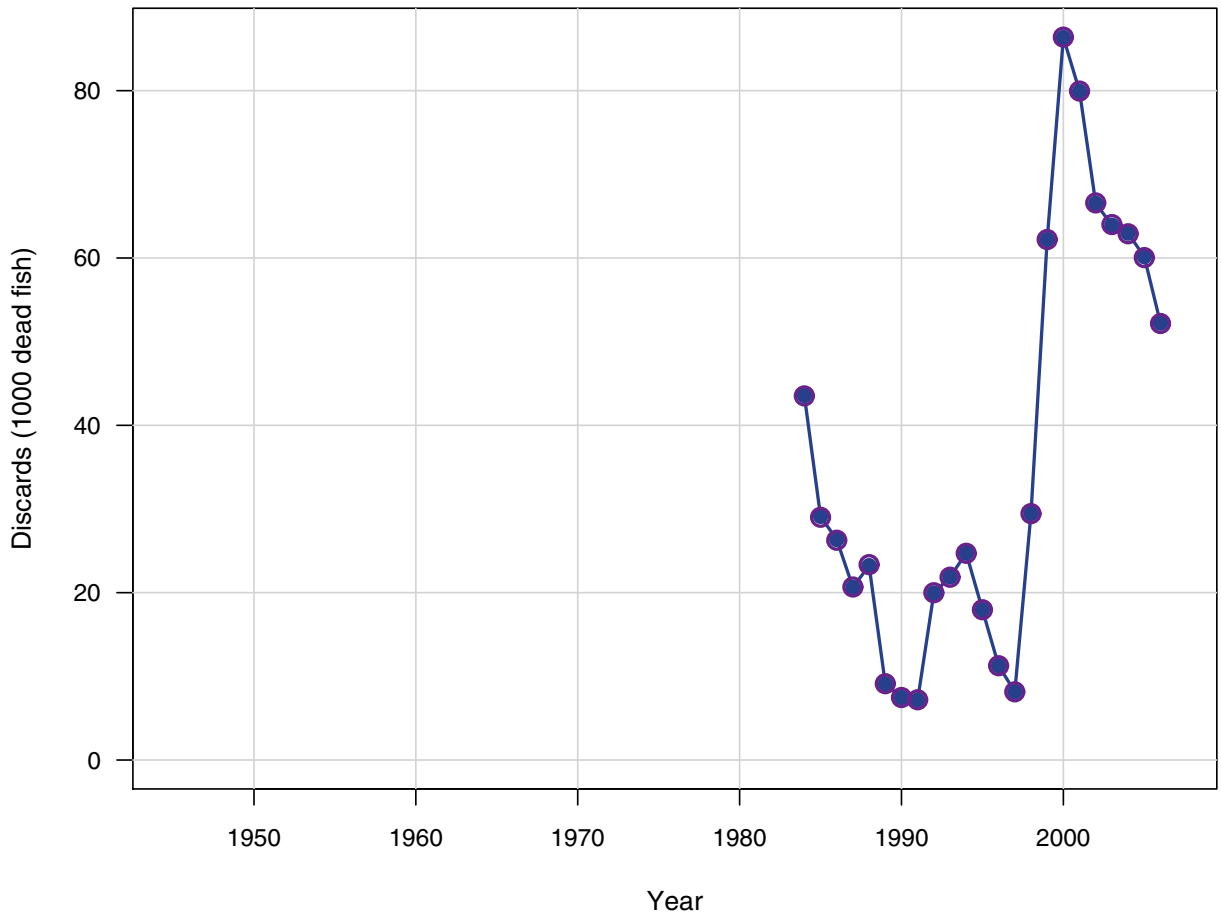


Figure 1.19. Red snapper: Fit of index of abundance from commercial handline; Observed (open circles) and estimated (solid line, circles).

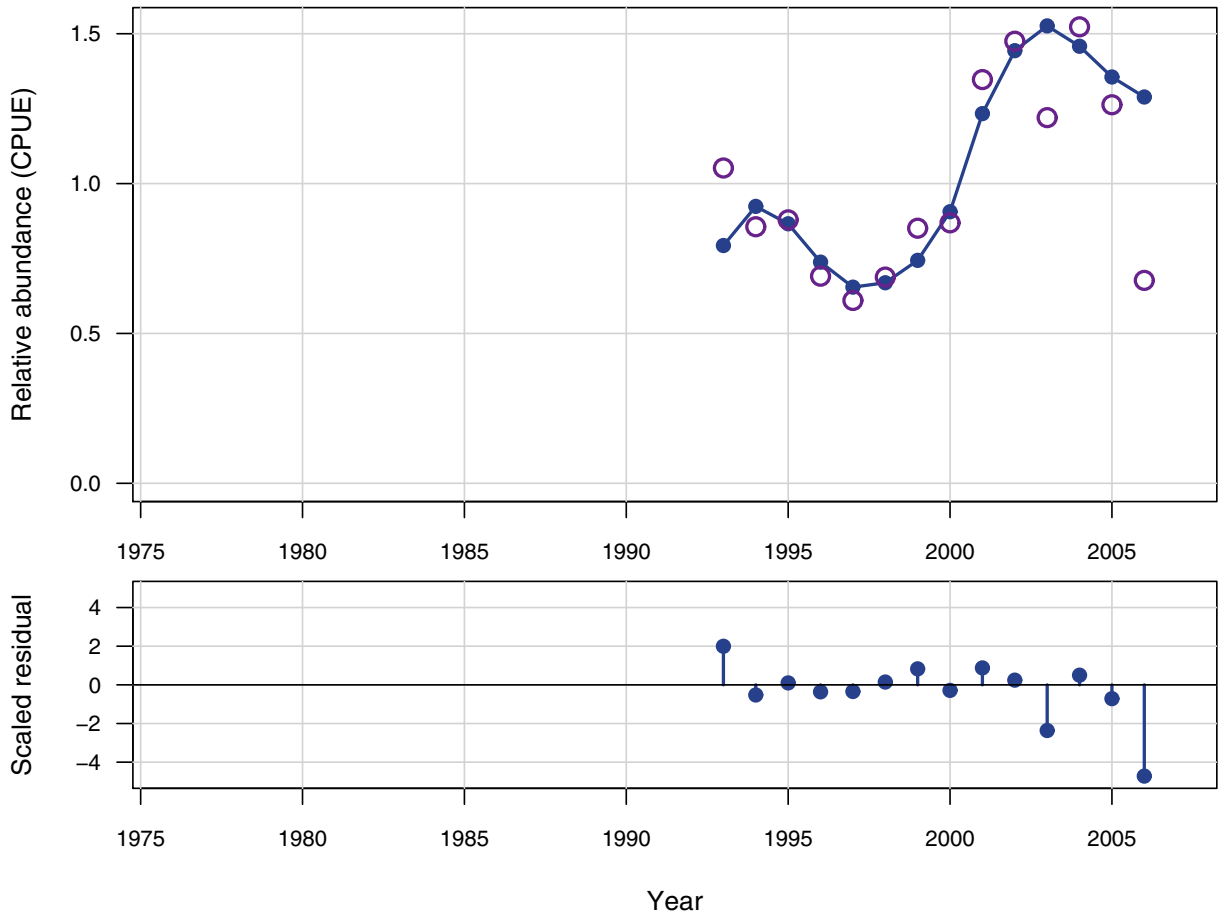


Figure 1.20. Red snapper: Fit of index of abundance from headboat; Observed (open circles) and estimated (solid line, circles).

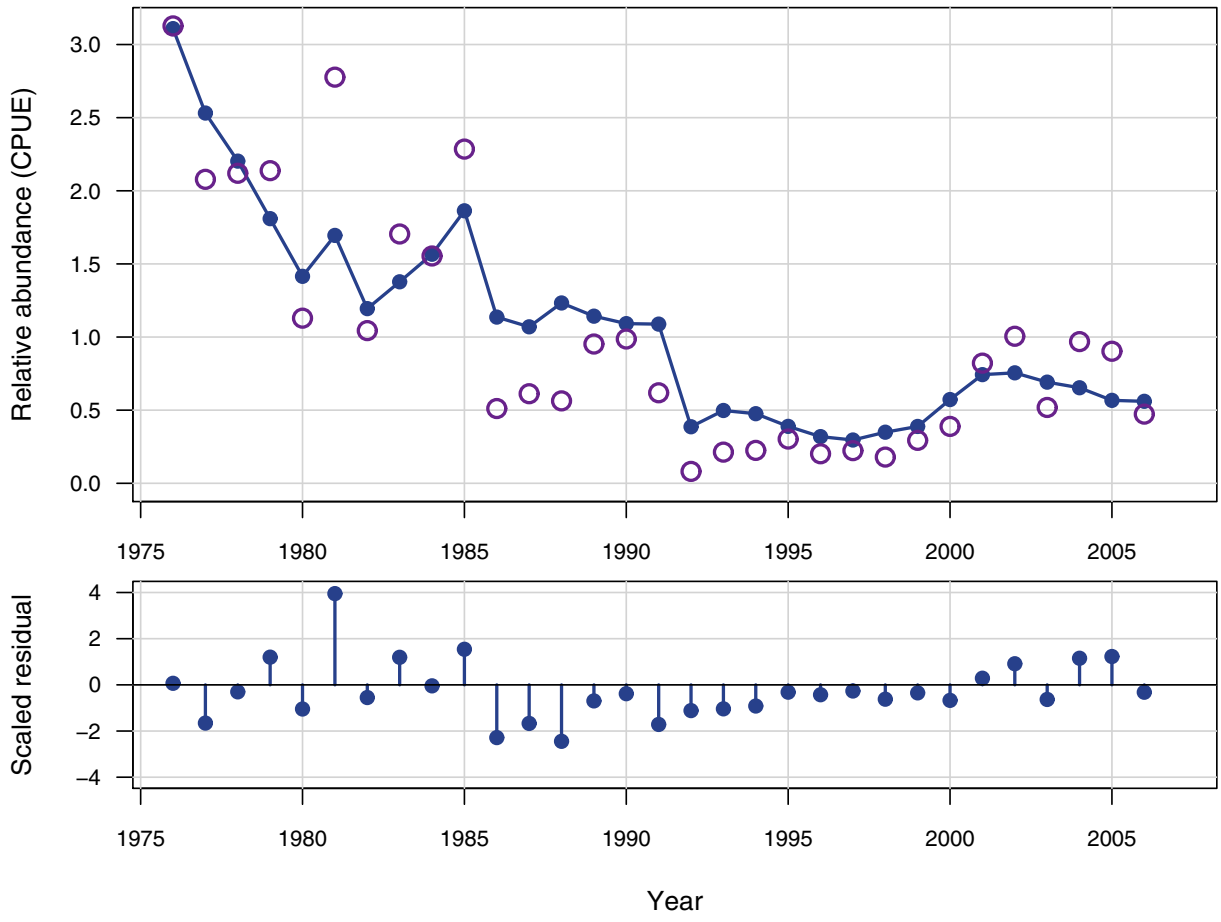


Figure 1.21. Red snapper: Fit of index of abundance from general recreational (MRFSS); Observed (open circles) and estimated (solid line, circles).

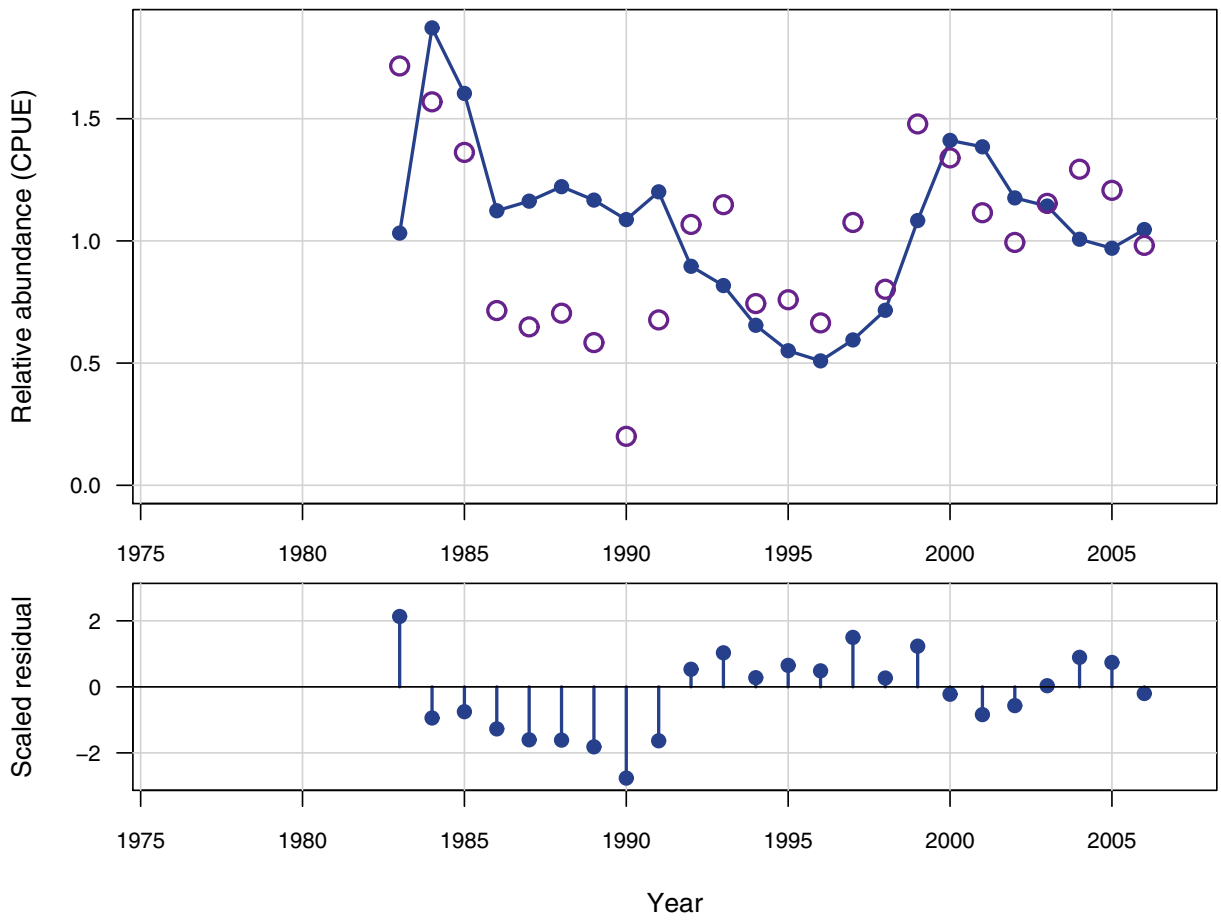


Figure 1.22. Red snapper: Mean length at age (mm) and estimated 95% confidence interval.

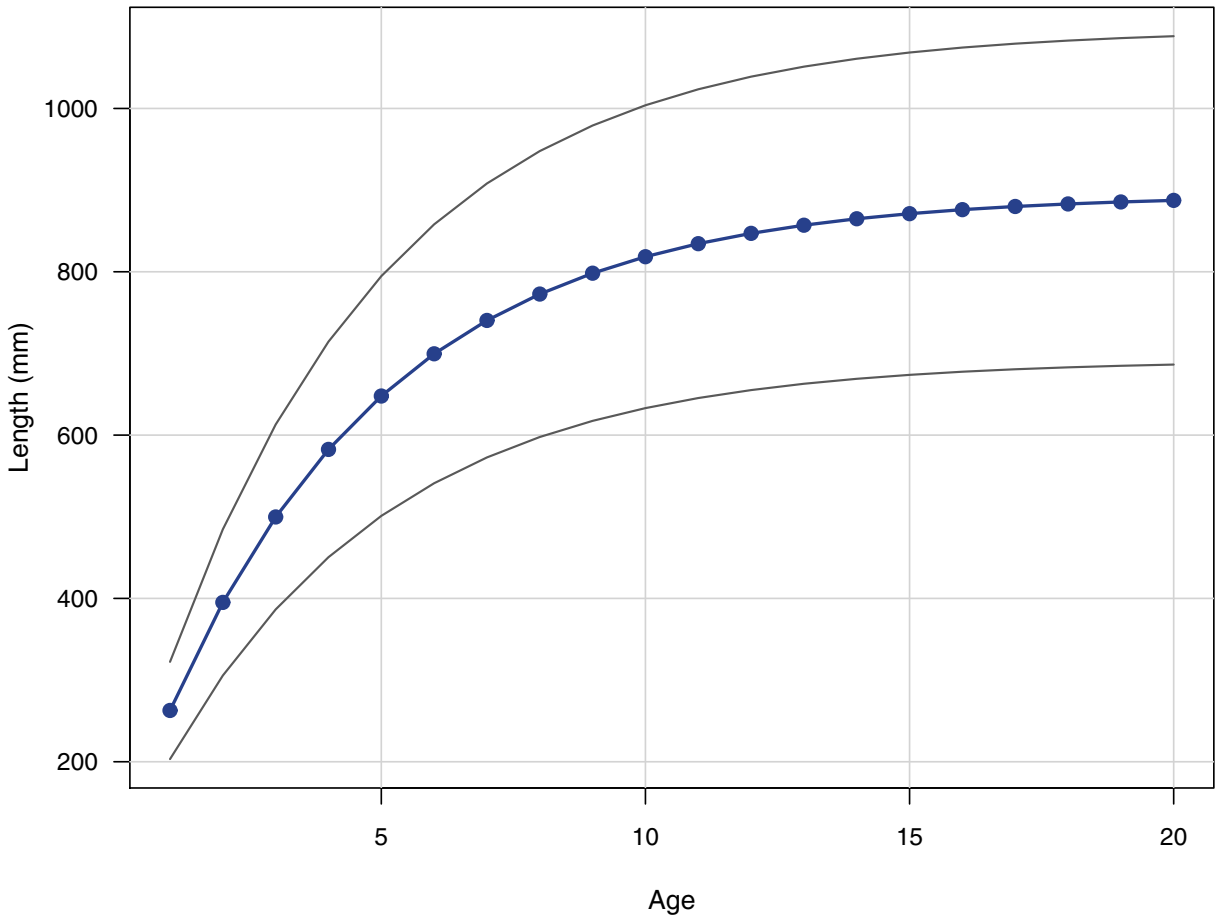


Figure 1.23. Red snapper: Top panel – Estimated recruitment of age-1 fish. Bottom panel – log recruitment residuals.

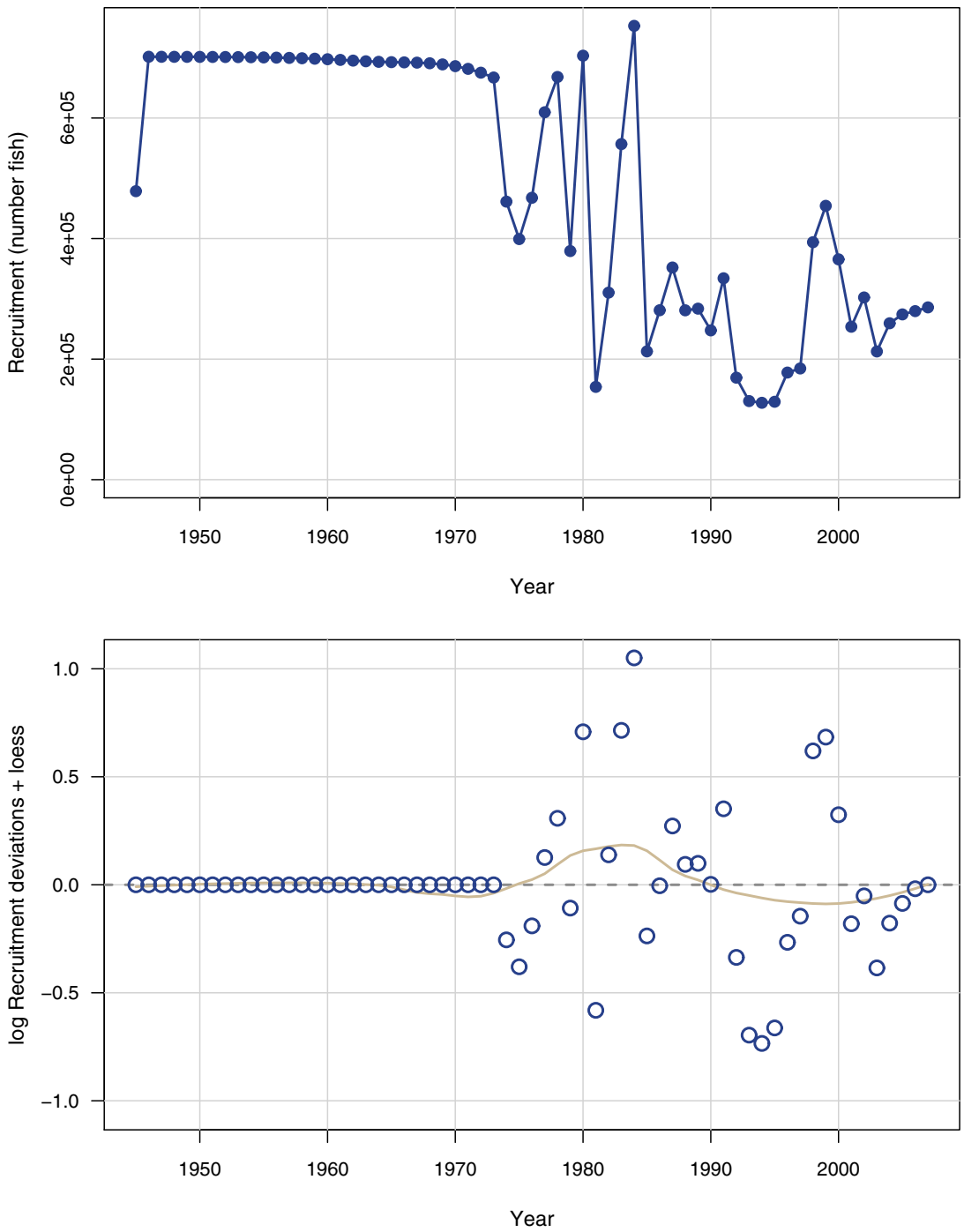


Figure 1.24. Red snapper: Top panel – Estimated total biomass (metric tons) at start of year. Bottom panel – Estimated spawning biomass (metric tons) at midpoint of year.

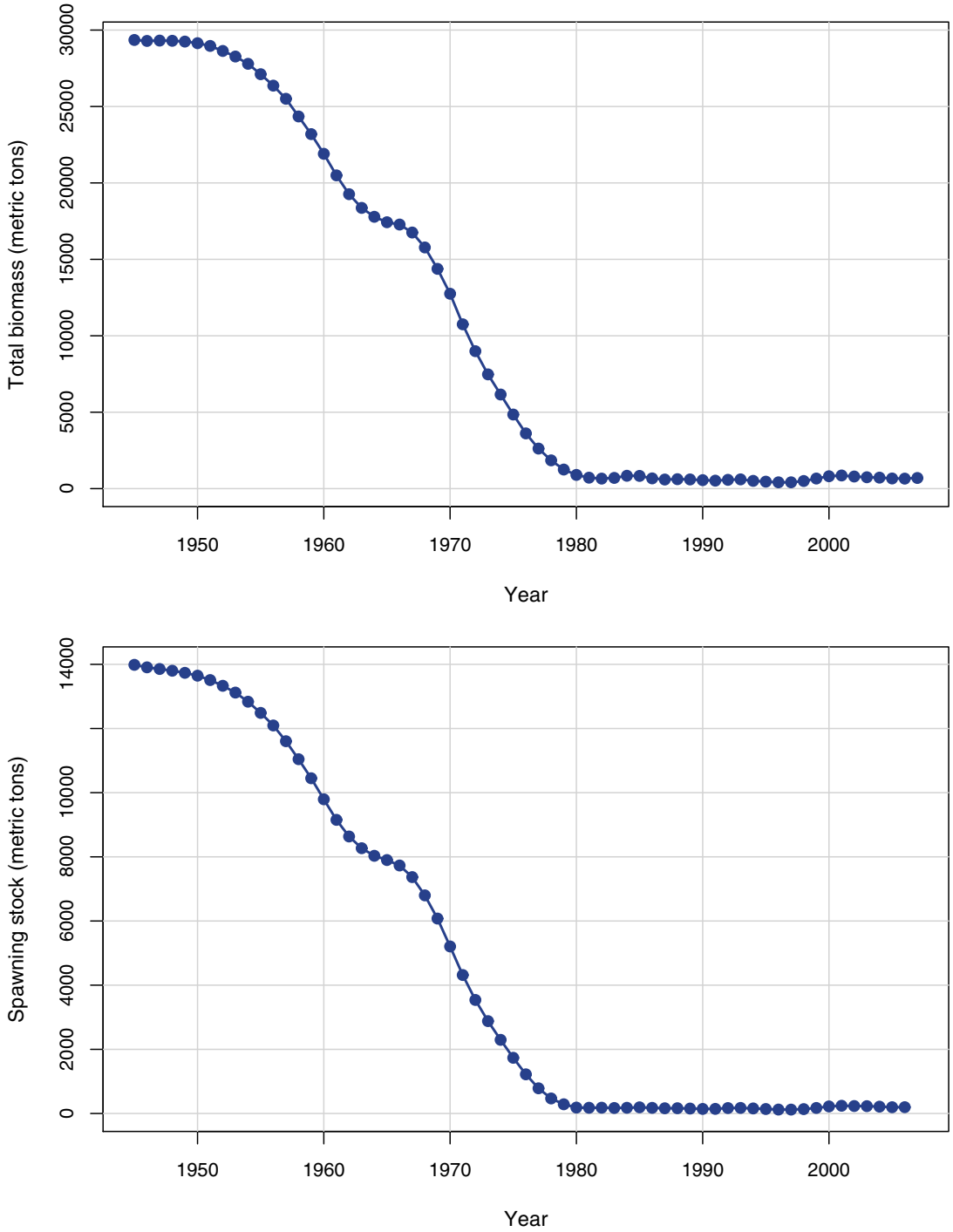


Figure 1.25. Red snapper: Estimated selectivities of commercial handline. Top panel – period 1 (prior to 1984, no regulations). Middle panel – period 2 (1984–1991, 12-inch limit). Bottom panel – period 3 (1992–2006, 20-inch limit).

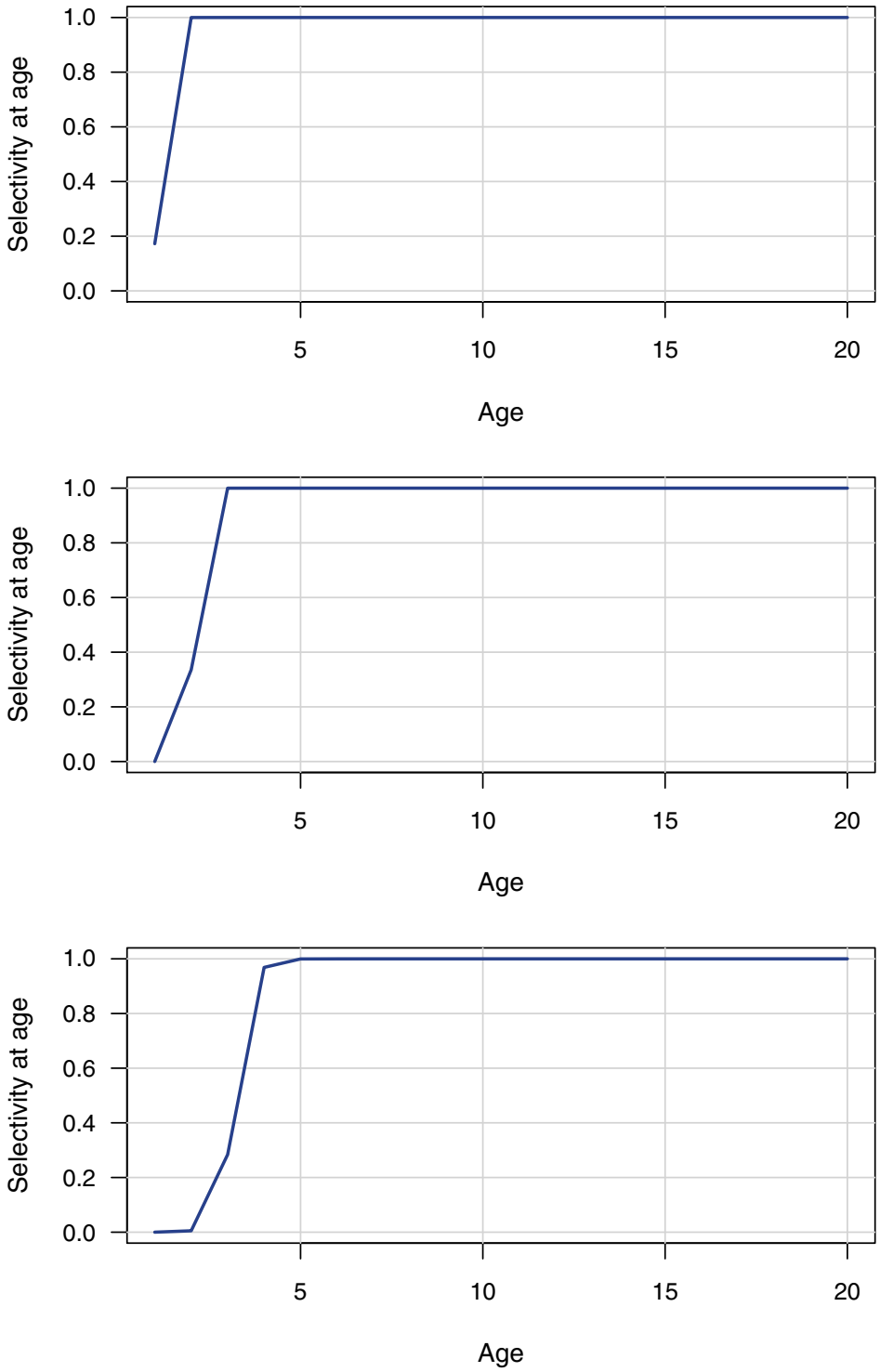


Figure 1.26. Red snapper: Estimated selectivity of commercial diving, assumed constant through time.

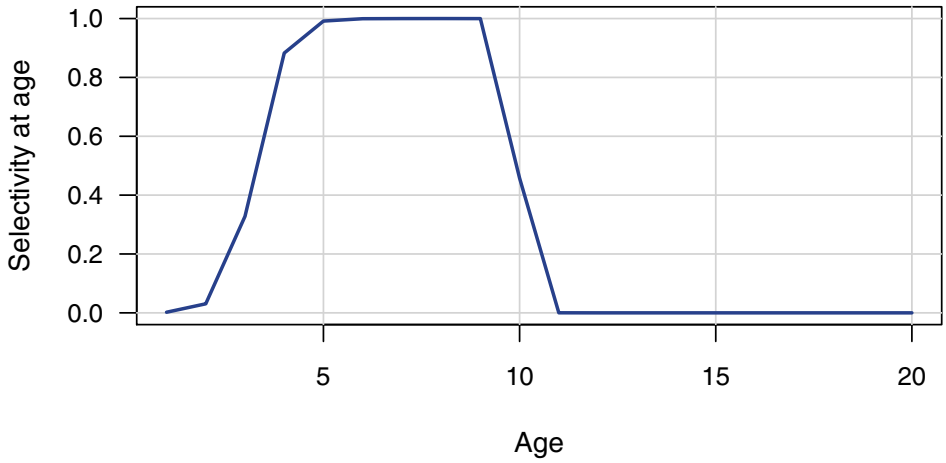


Figure 1.27. Red snapper: Estimated selectivities of the headboat fishery. Top panel – period 1 (prior to 1984, no regulations). Middle panel – period 2 (1984–1991, 12-inch limit). Bottom panel – period 3 (1992–2006, 20-inch limit).

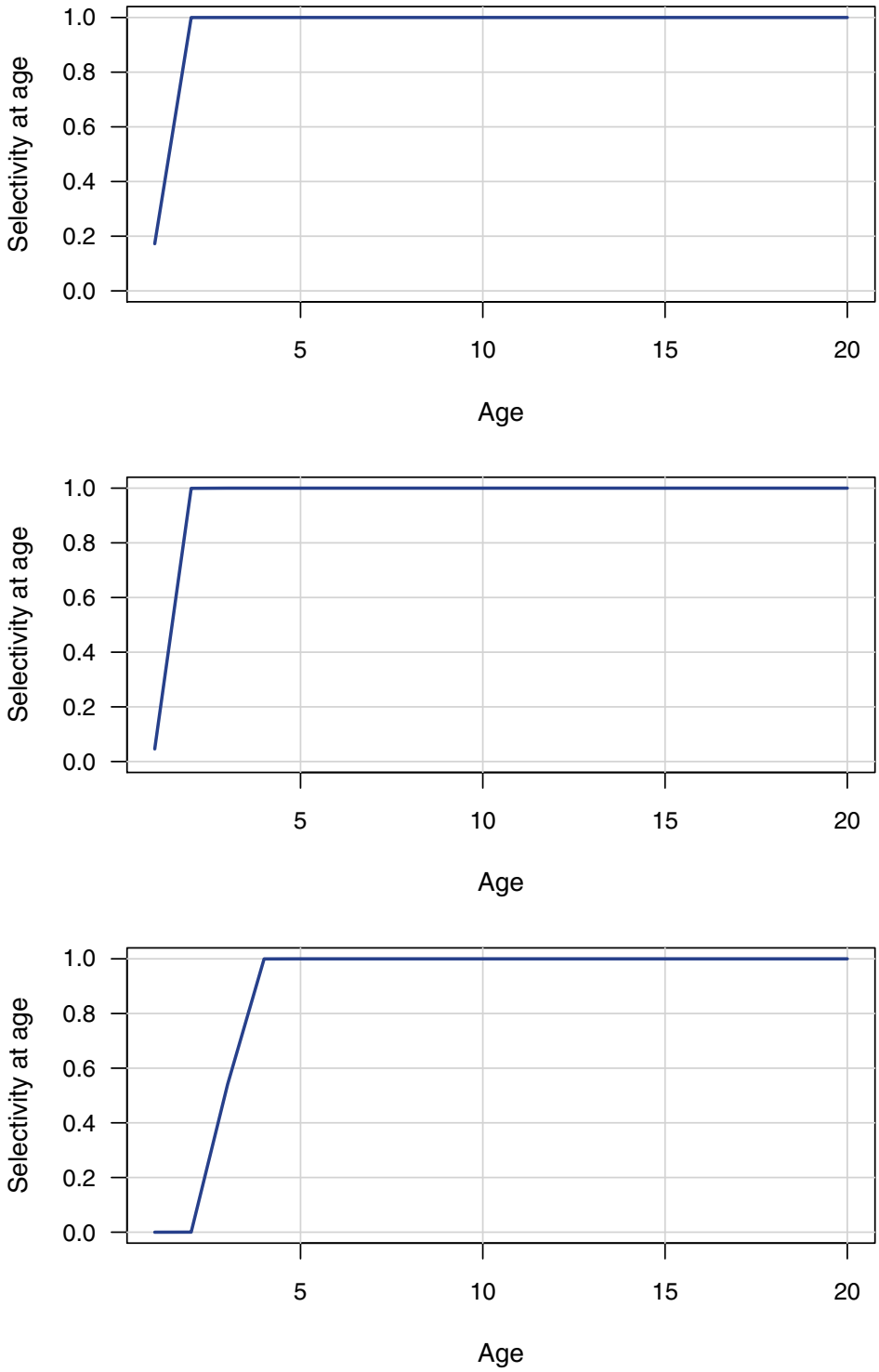


Figure 1.28. Red snapper: Estimated selectivities of the general recreational fishery. Top panel – period 1 (prior to 1984, no regulations). Middle panel – period 2 (1984–1991, 12-inch limit). Bottom panel – period 3 (1992–2006, 20-inch limit).

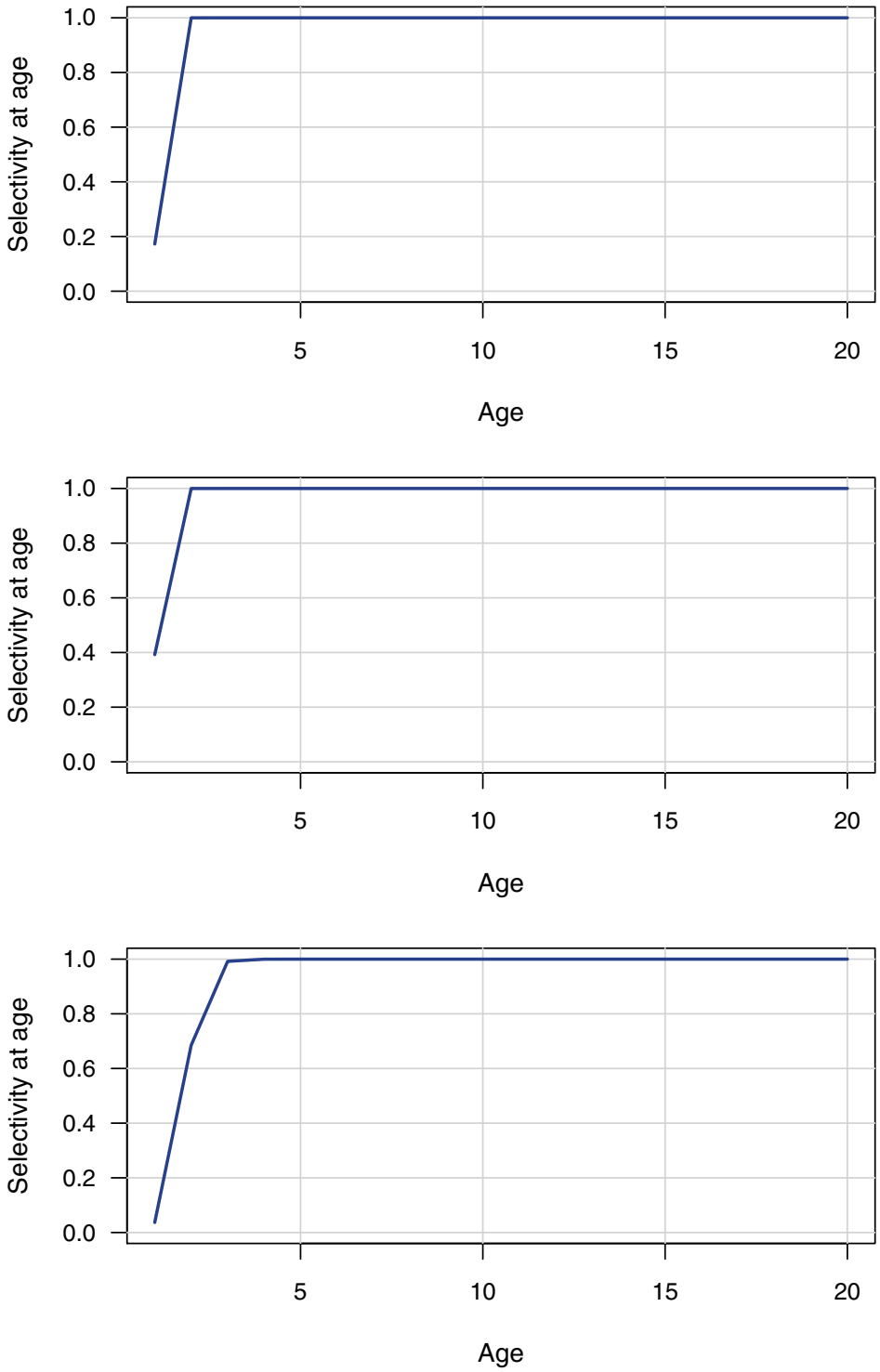


Figure 1.29. Red snapper: Estimated selectivities of discard mortalities from commercial handline. Discards were assumed negligible in period 1, the years prior to implementation of regulations. Top panel – period 2 (1984–1991, 12-inch limit). Bottom panel – period 3 (1992–2006, 20-inch limit).

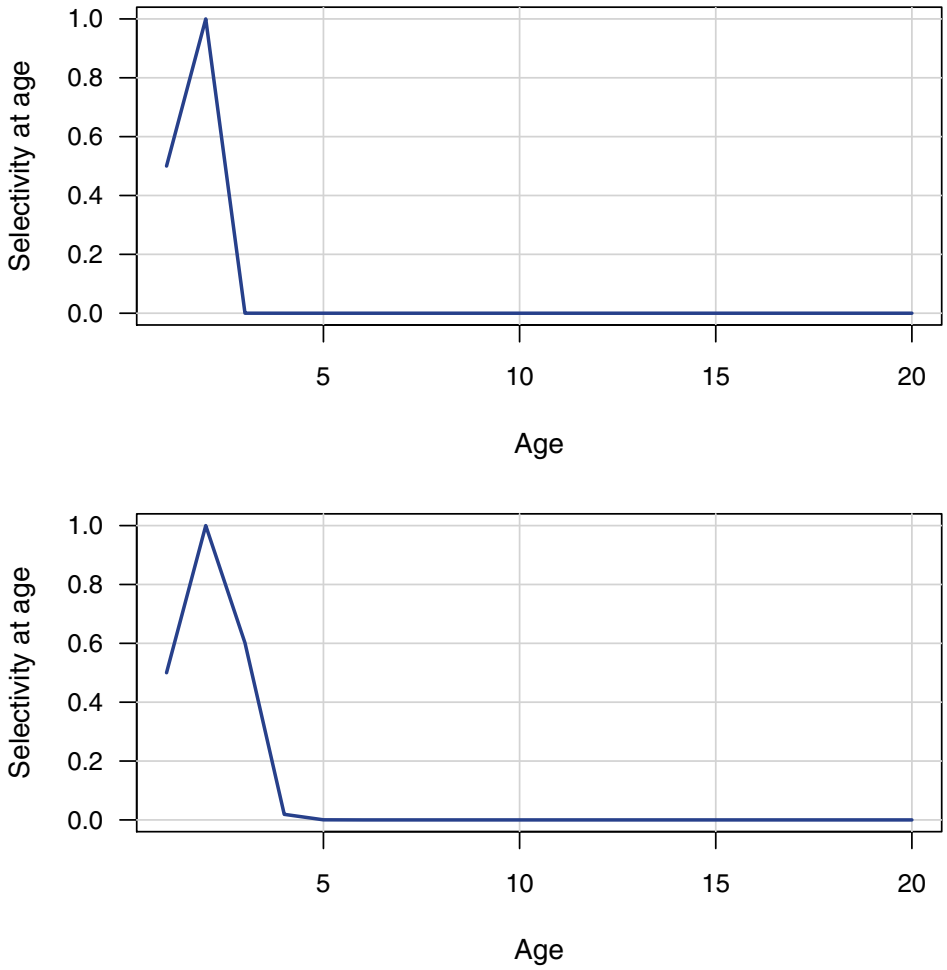


Figure 1.30. Red snapper: Estimated selectivities of discard mortalities from the headboat fishery. Discards were assumed negligible in period 1, the years prior to implementation of regulations. Top panel – period 2 (1984–1991, 12-inch limit). Bottom panel – period 3 (1992–2006, 20-inch limit).

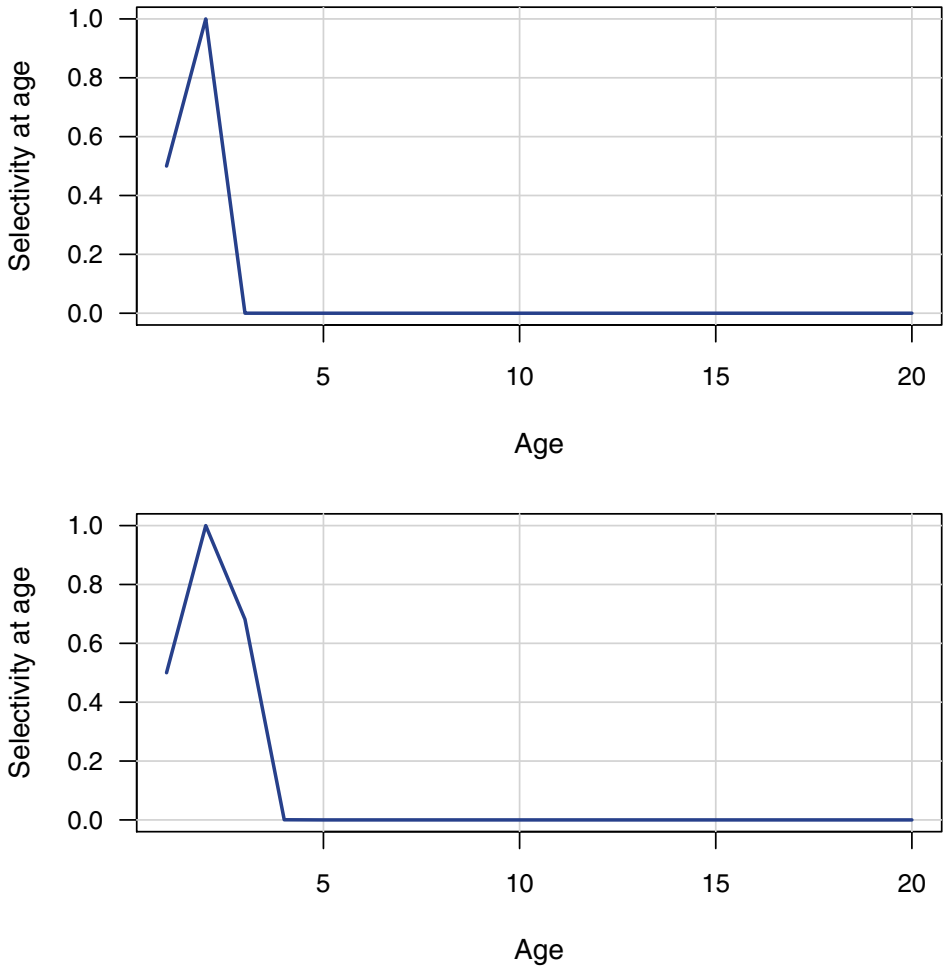


Figure 1.31. Red snapper: Estimated selectivities of discard mortalities from the general recreational fishery. Discards were assumed negligible in period 1, the years prior to implementation of regulations. Top panel – period 2 (1984–1991, 12-inch limit). Bottom panel – period 3 (1992–2006, 20-inch limit).

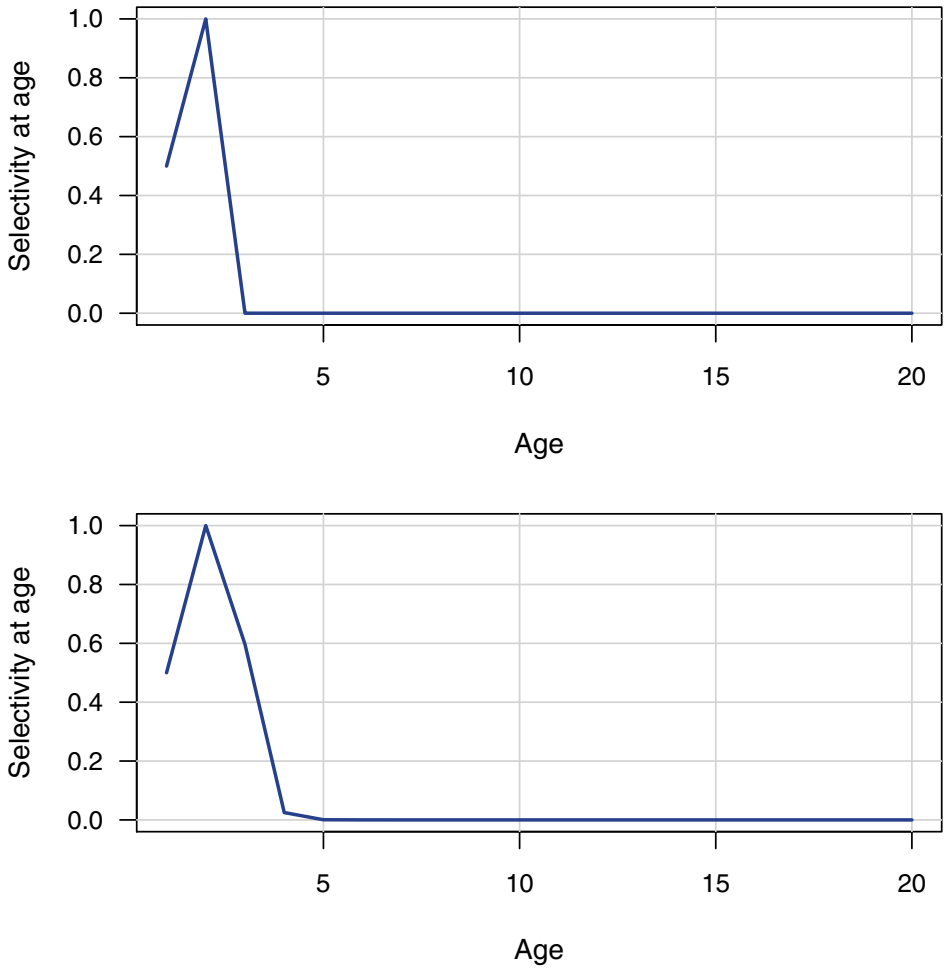


Figure 1.32. Red snapper: Average selectivities from period 3 (1992–2006, 20-inch limit), weighted by geometric mean Fs from the last three assessment years. and used in computation of benchmarks and projections. Top panel – Average selectivity applied to landings. Middle panel – Average selectivity applied to discard mortalities. Bottom panel – Total average selectivity.

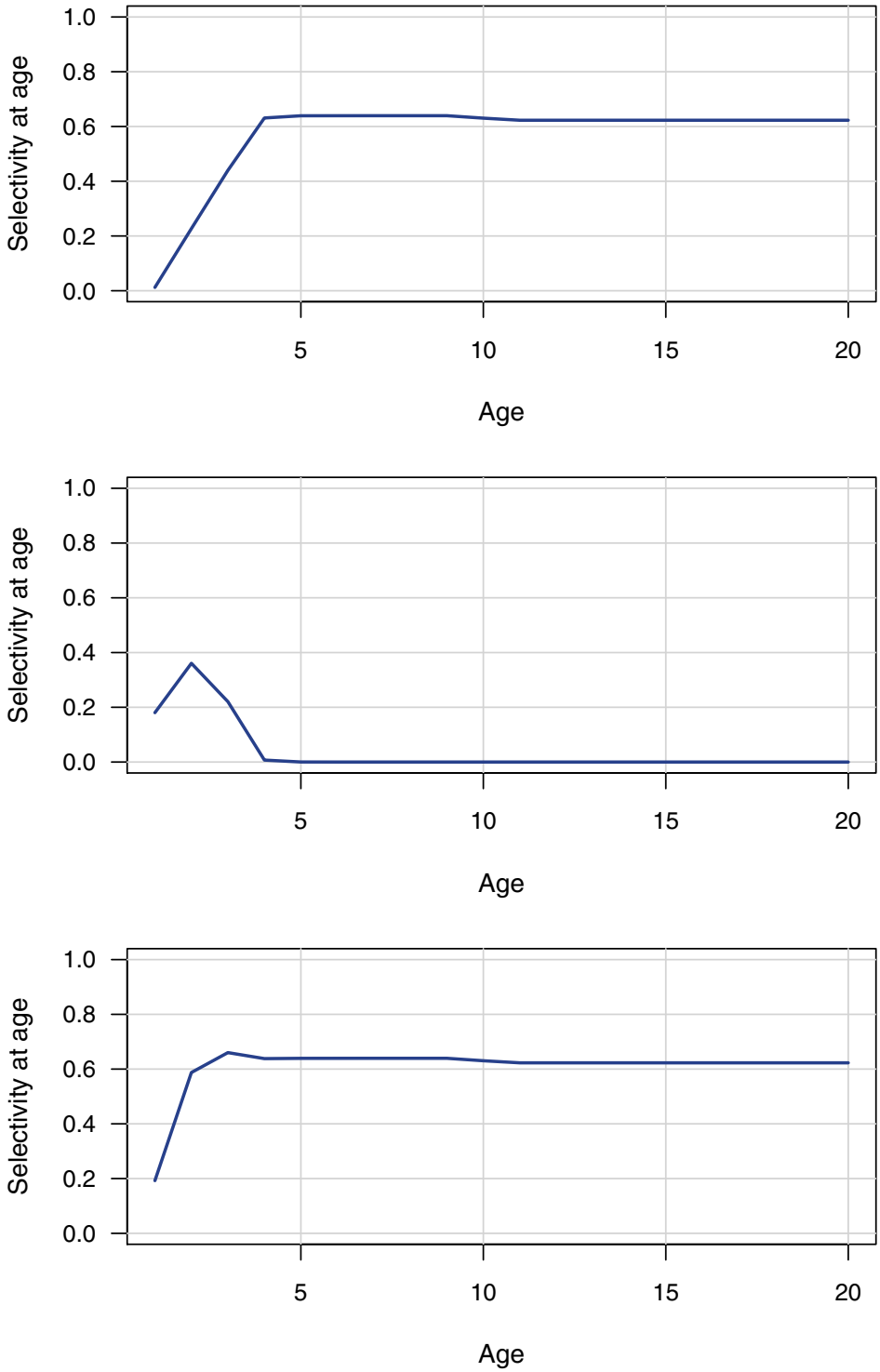


Figure 1.33. Red snapper: Estimated instantaneous fishing mortality rate (per year) by fishery. c.hal refers to commercial handline, c.dv to commercial diving, hb to headboat, rec to general recreational, c.hal.D to commercial discard mortalities, c.hb.D to headboat discard mortalities, and rec.D to general recreational discard mortalities.

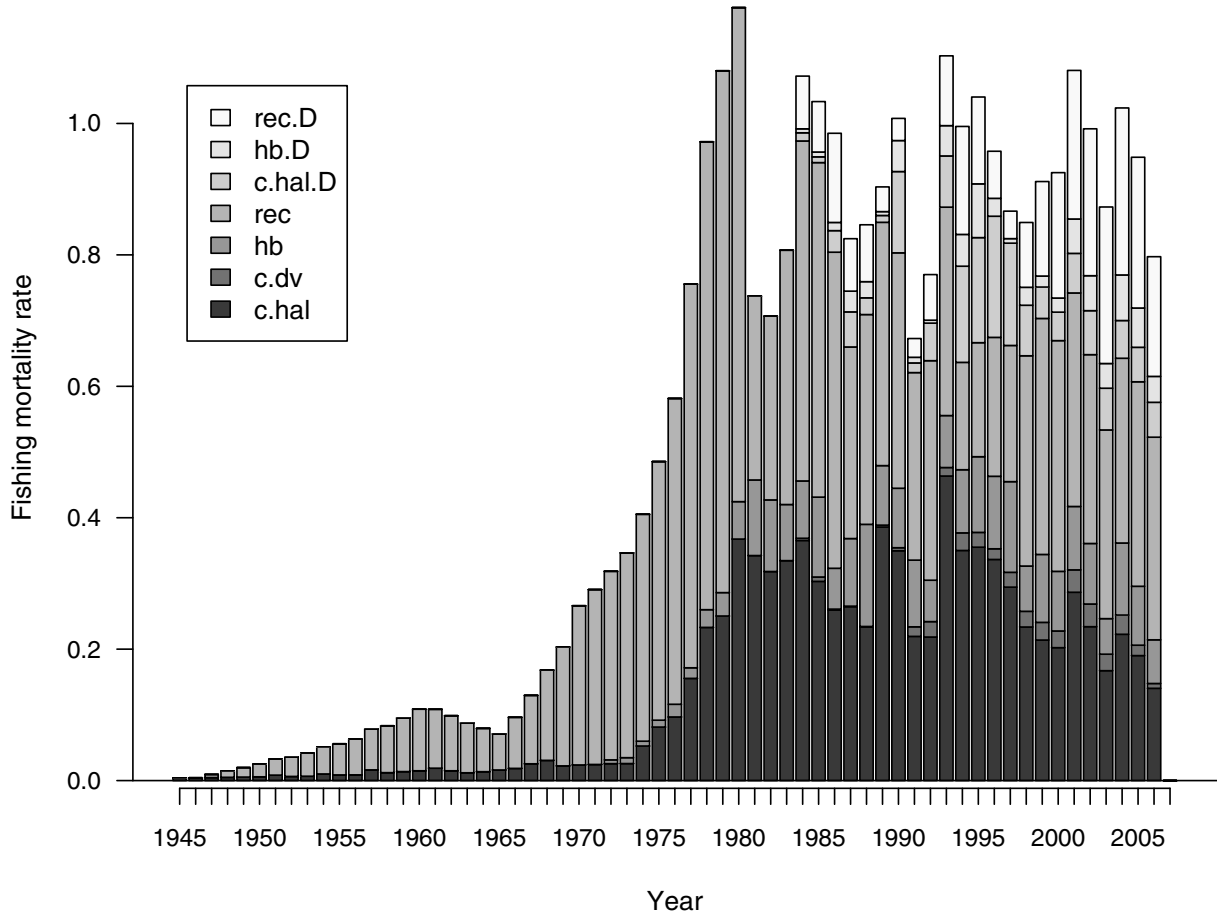


Figure 1.34. Red snapper: Estimated landings by fishery from the catch-at-age model. c.hal refers to commercial handline, c.dv to commercial diving, hb to headboat, rec to general recreational.

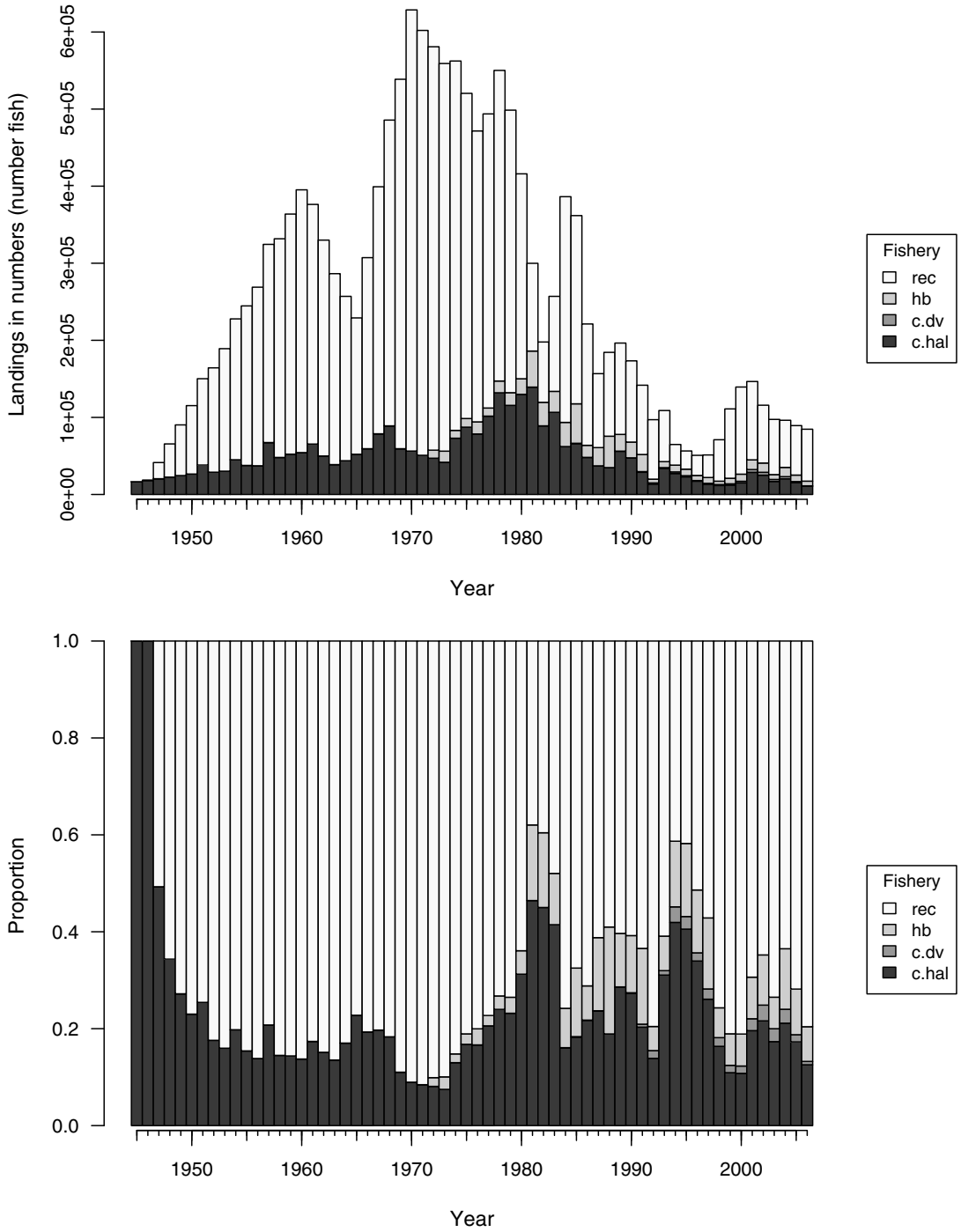


Figure 1.35. Red snapper: Estimated discard mortalities by fishery from the catch-at-age model. c.hal refers discard mortalities from commercial handline, hb from headboat, rec from general recreational.

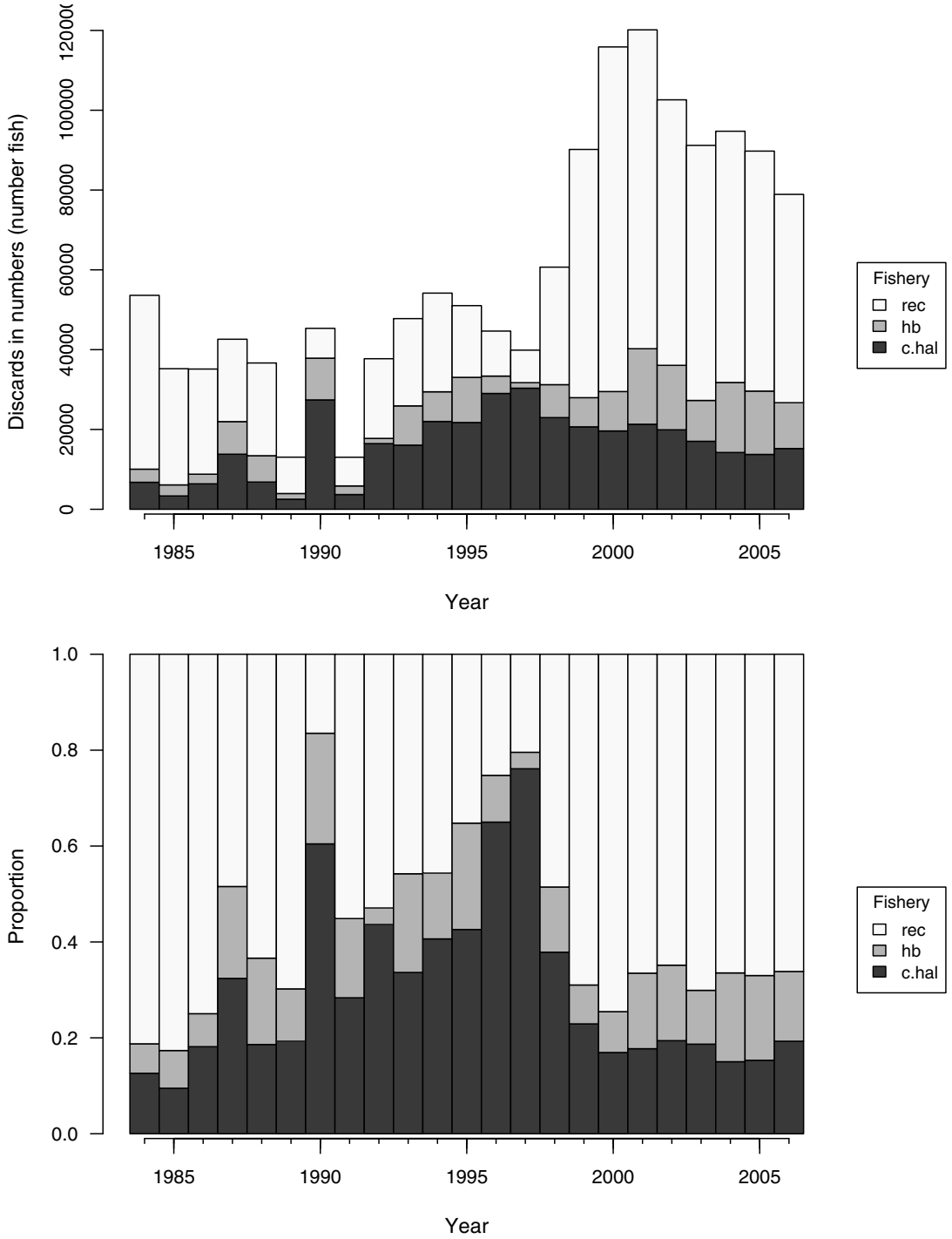


Figure 1.36. Red snapper: Estimated Beverton–Holt spawner-recruit curves, with and without lognormal bias correction.

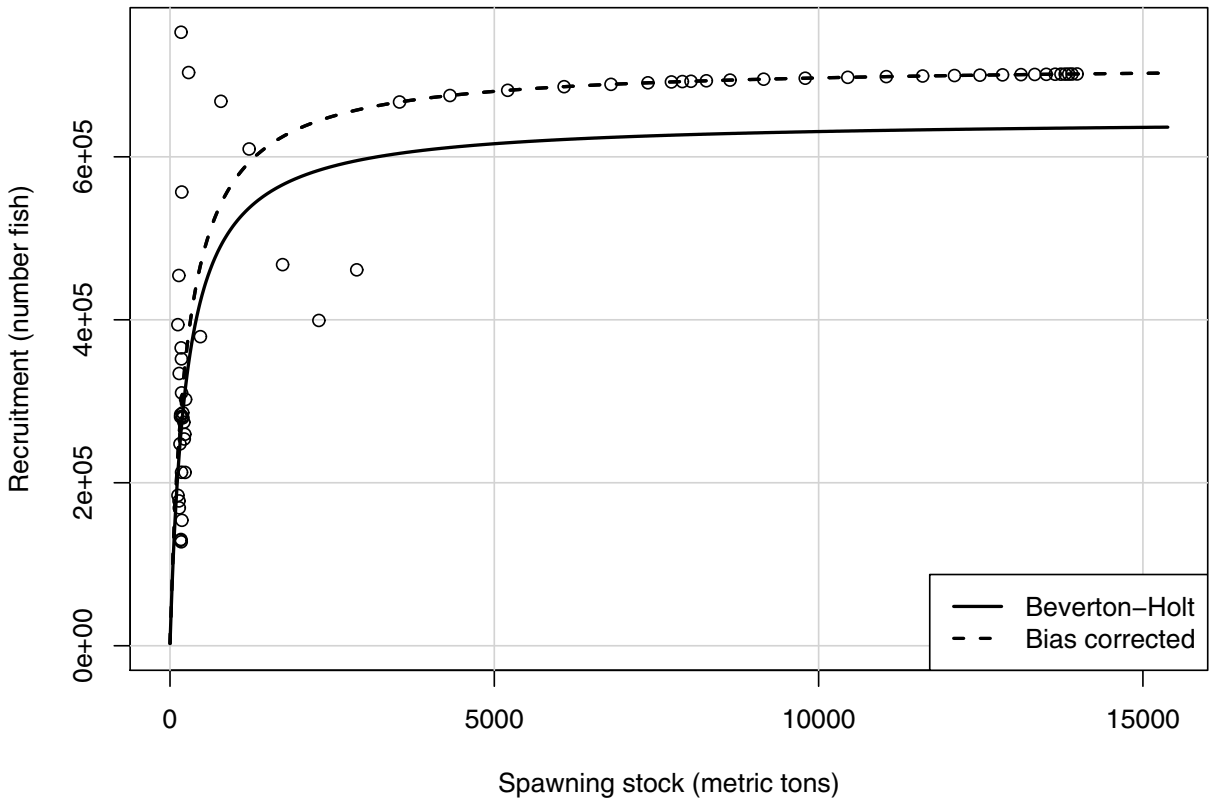


Figure 1.37. Red snapper: Relationship between %SPR and implied steepness (h), given that $F_{X\%} = F_{\mathrm{MSY}}$. SPR of $X = 40\%$ corresponds to $h = 0.68$.

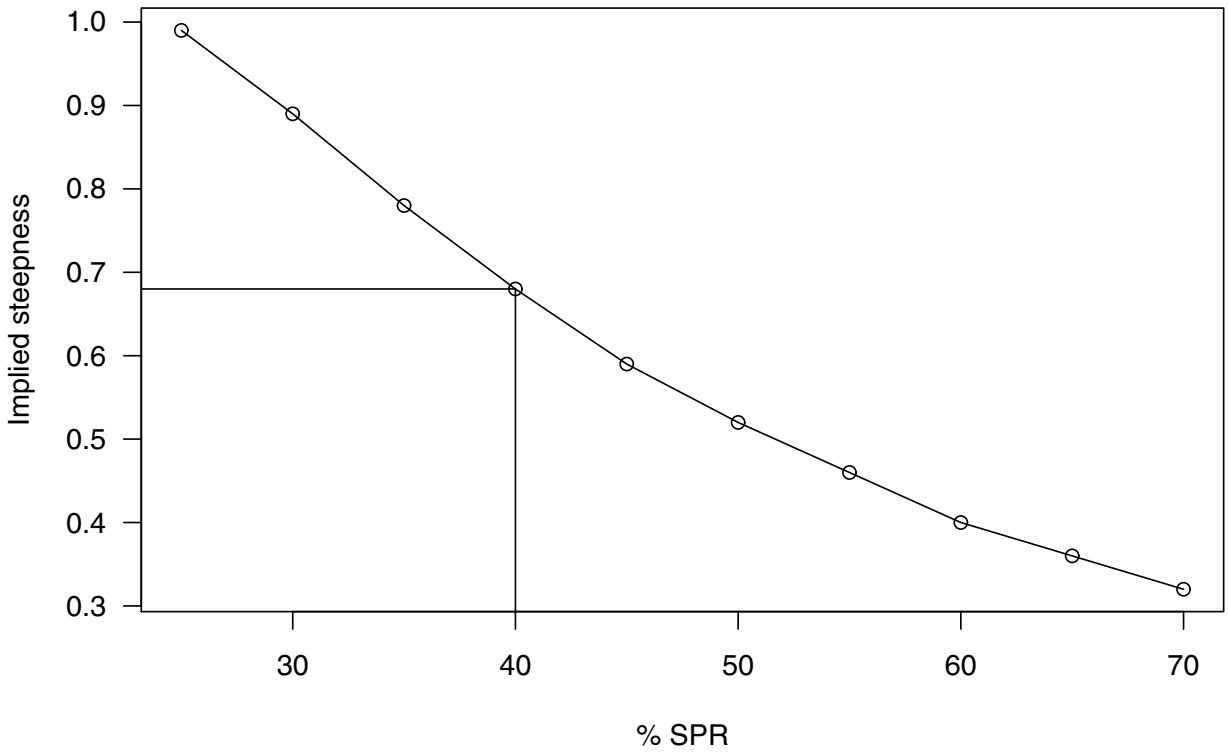


Figure 1.38. Red snapper: Estimated time series of static spawning potential ratio, the annual equilibrium spawners per recruit relative to that at the unfished level.

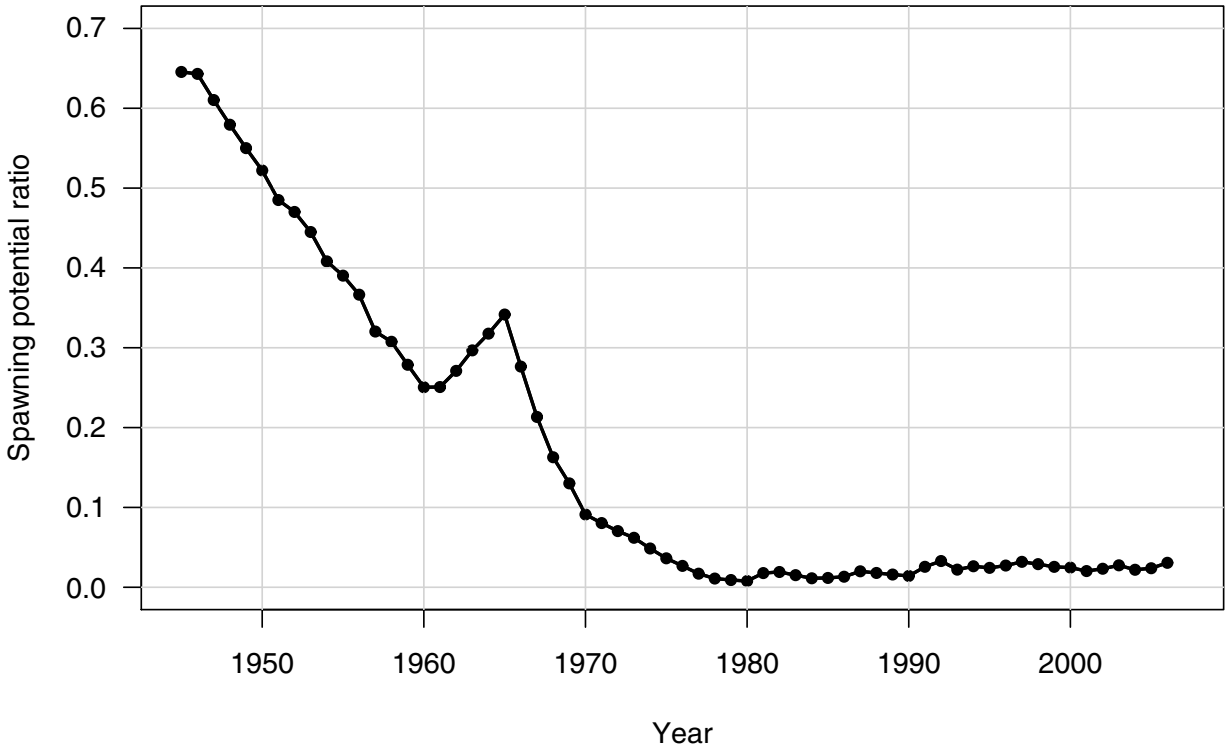


Figure 1.39. Red snapper: Top panel – Yield per recruit. Bottom panel – Spawning potential ratio (spawners per recruit relative to that at the unfished level), from which the 40% level provides $F_{40\%}$, the recommended proxy for F_{MSY}. Both curves are based on average selectivity from the end of the assessment period.

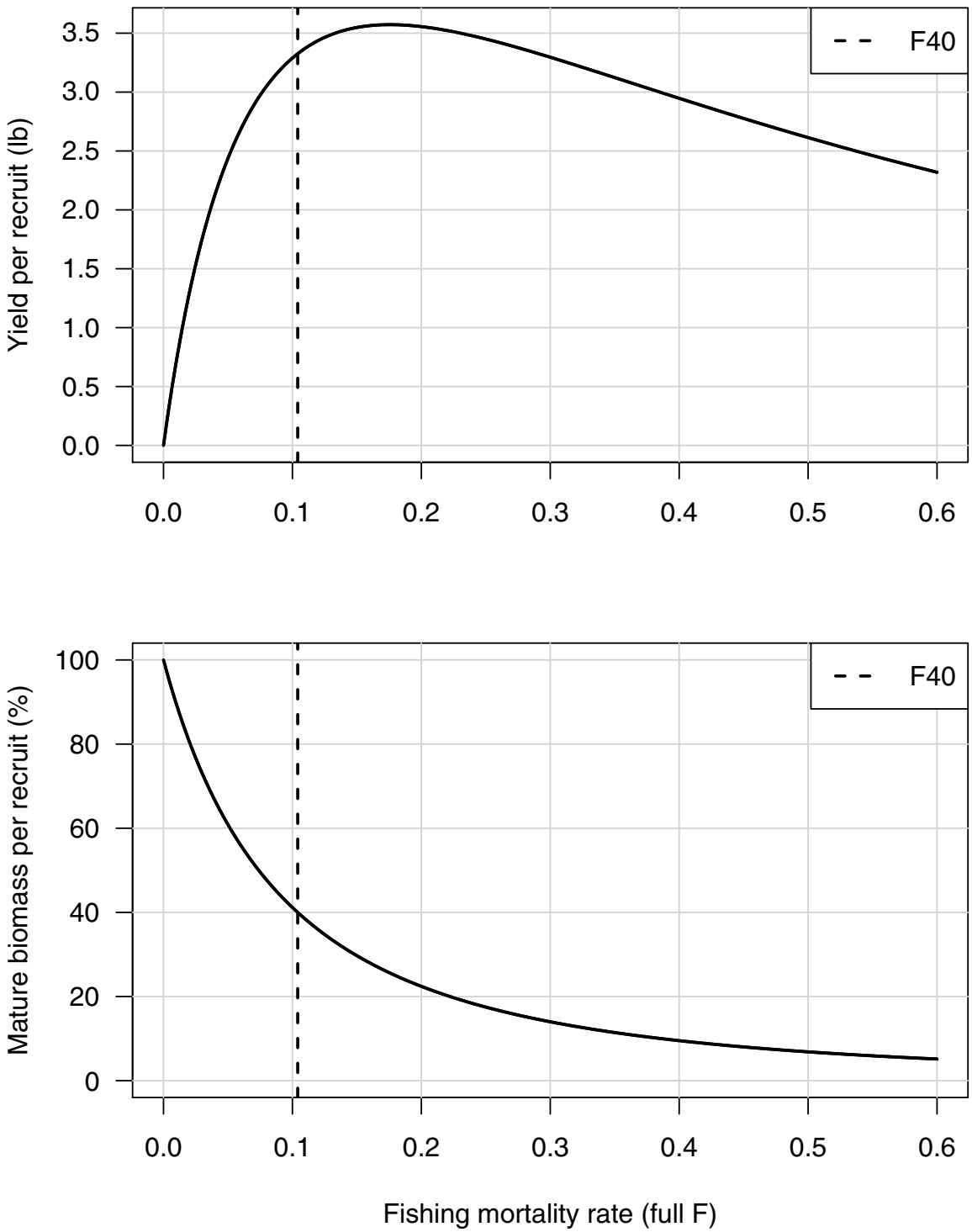


Figure 1.40. Red snapper: Top panel – Equilibrium landings. Bottom panel – Equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.

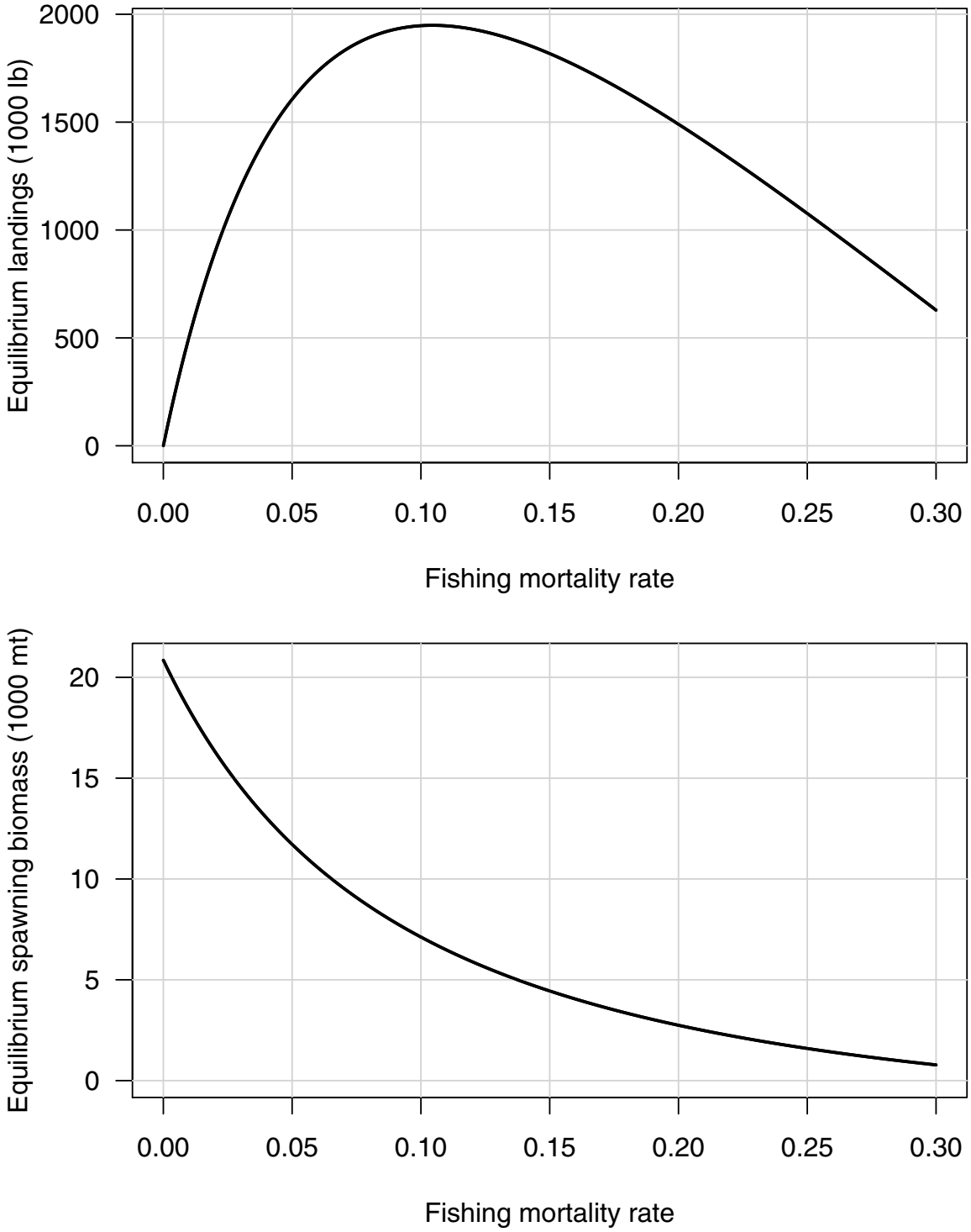


Figure 1.41. Red snapper: Top panel – Equilibrium landings as a function of equilibrium biomass, which itself is a function of fishing mortality rate. The peak occurs where equilibrium biomass is $B = 15.06$ 1000 *mt and equilibrium landings are 1949* 1000 *lb. Bottom panel – Equilibrium discard mortality as a function of equilibrium biomass.*

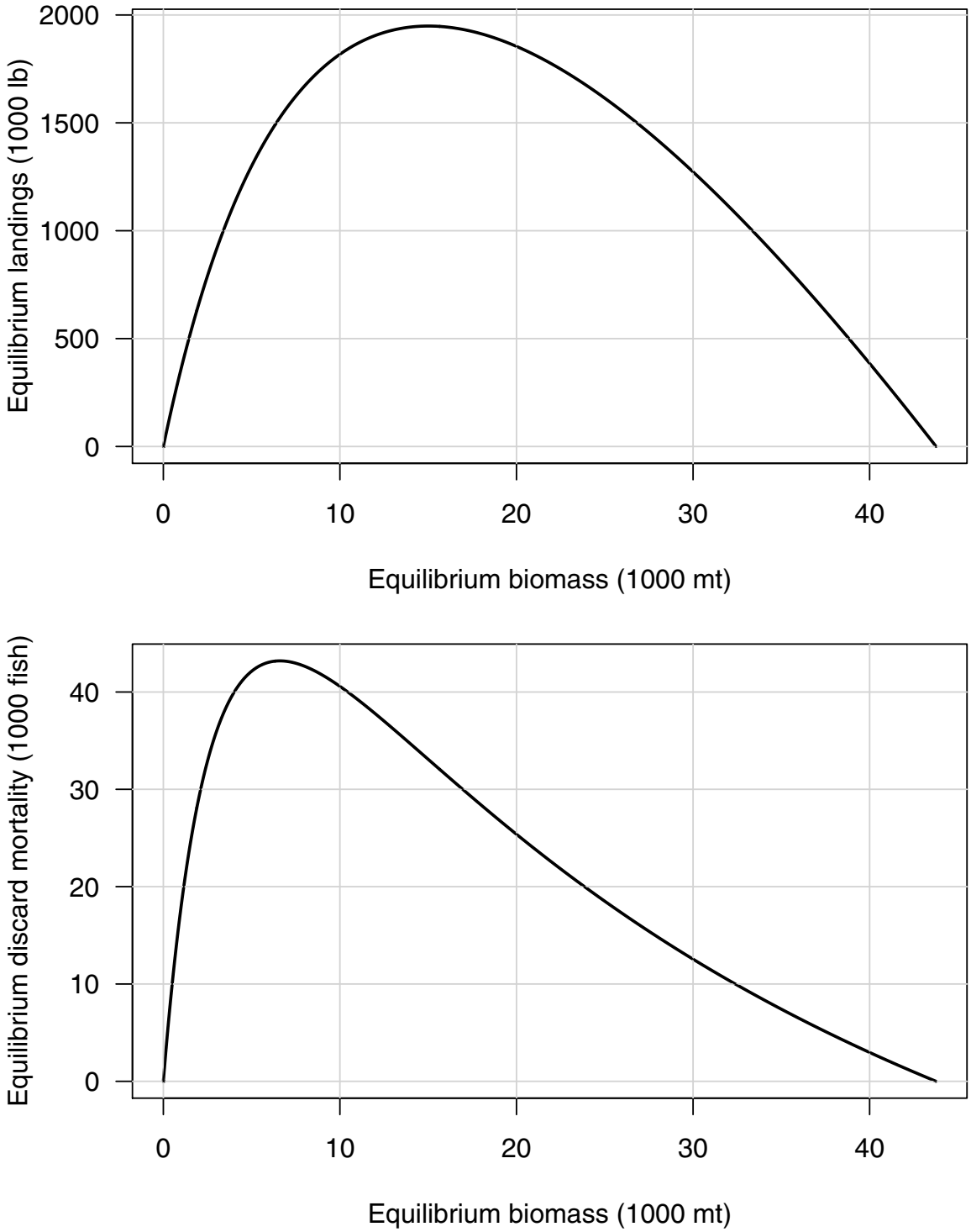


Figure 1.42. Red snapper: Estimated time series of biomass relative to reference points. Top panel – B relative to B_{MSY} *proxy. Bottom panel –* SSB *relative to* SSB_{MSY} *proxy. Proxies are based on* $F_{40\%}$.

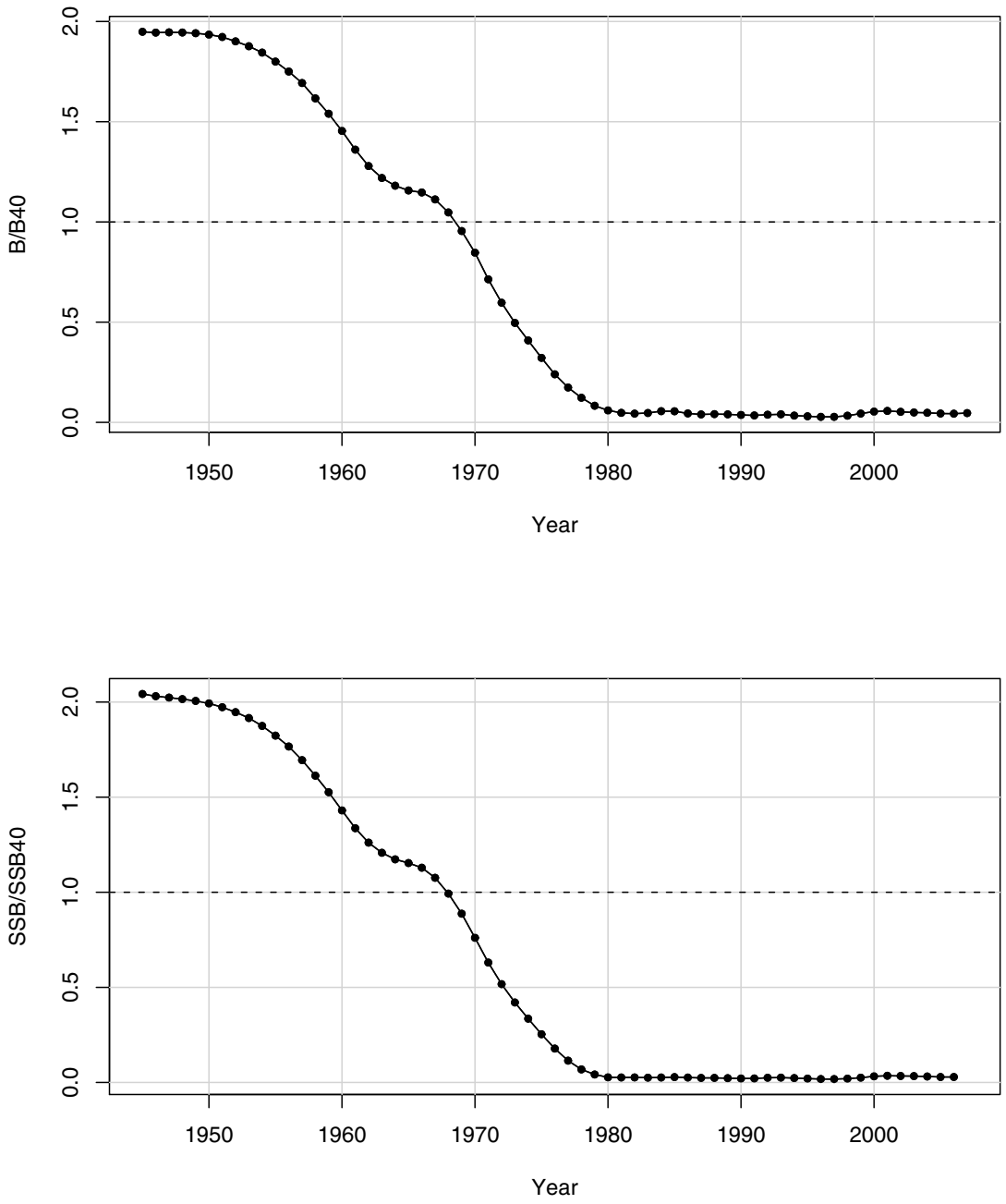


Figure 1.43. Red snapper: Estimated time series of full F relative to the F_{MSY} proxy, $F_{40\%}$.

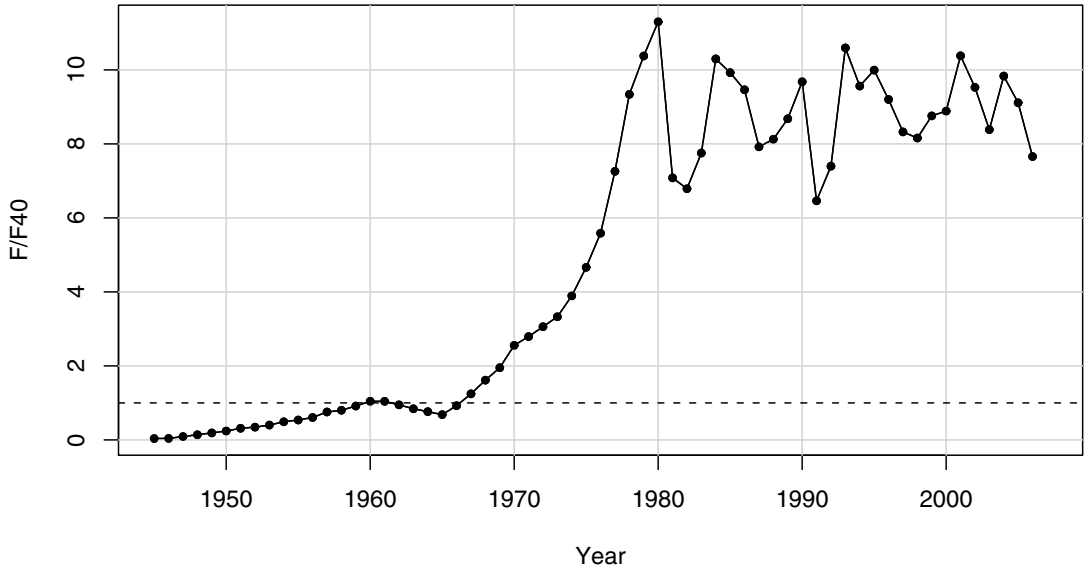


Figure 1.44. Red snapper: Projection results under scenario R1—fishing mortality rate fixed at $F = 0$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Horizontal lines mark proxy reference points. Spawning stock biomass (SSB) is at mid-year.

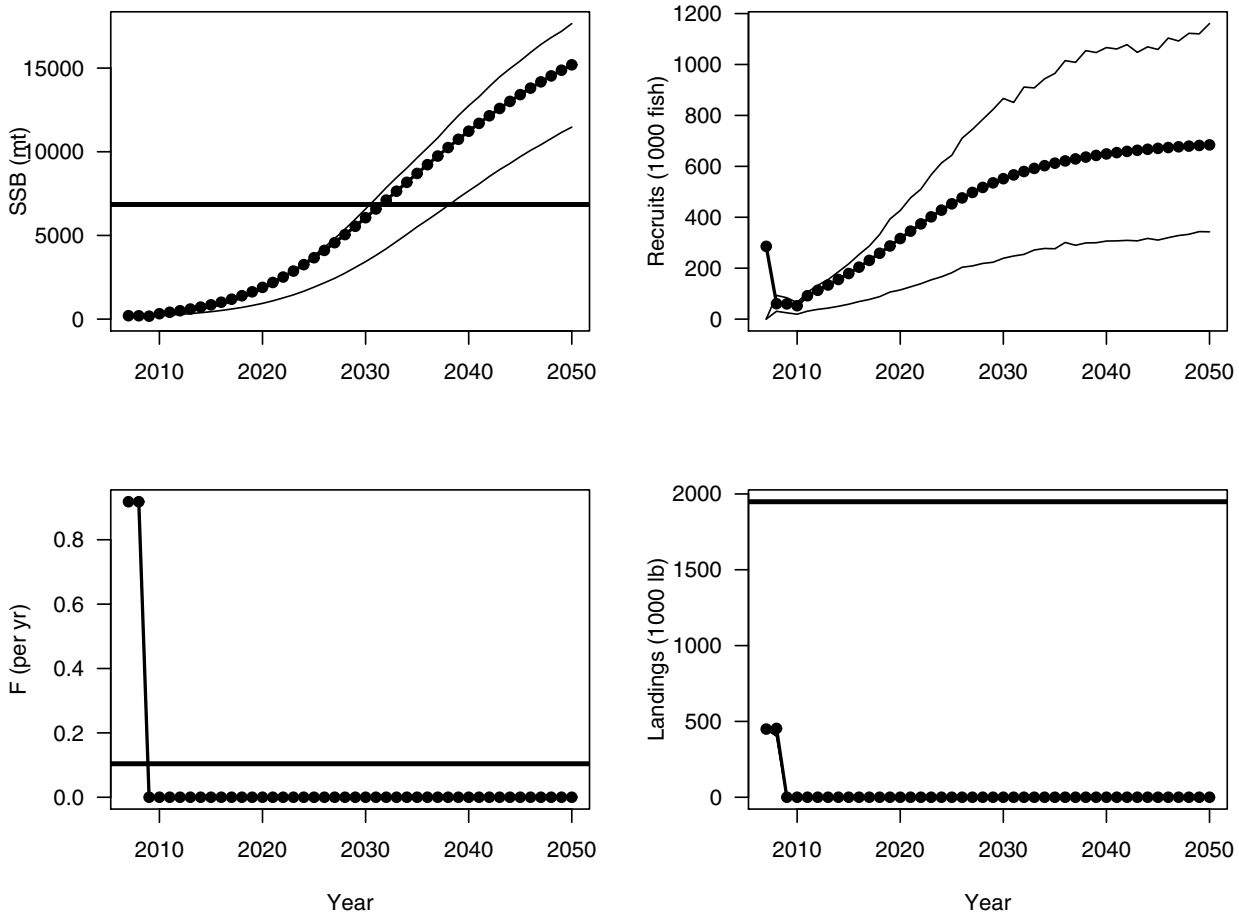


Figure 1.45. Red snapper: Projection results under scenario R2—fishing mortality rate fixed at $F = F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Horizontal lines mark proxy reference points. Spawning stock biomass (SSB) is at mid-year.

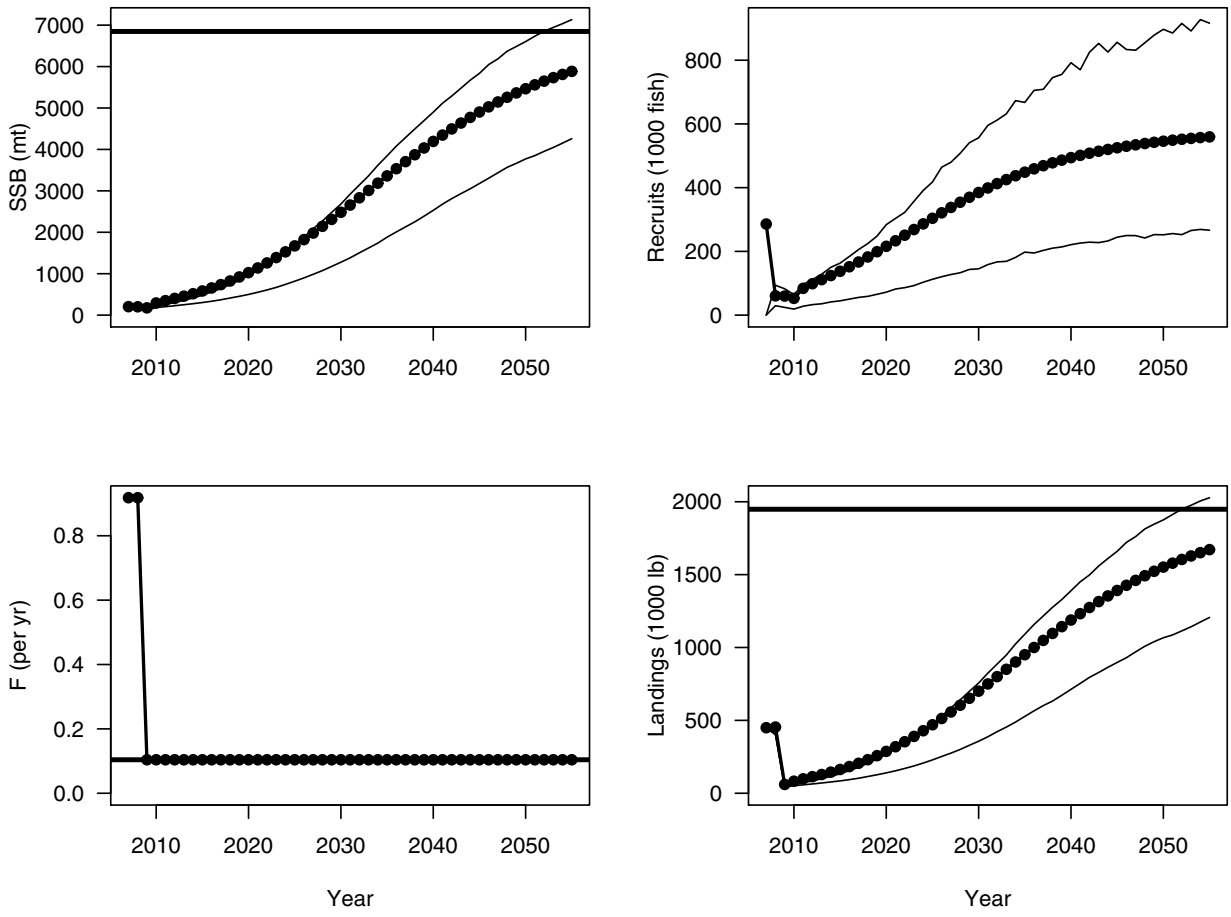


Figure 1.46. Red snapper: Projection results under scenario R3—fishing mortality rate fixed at $F = 65\%F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Horizontal lines mark proxy reference points. Spawning stock biomass (SSB) is at mid-year.

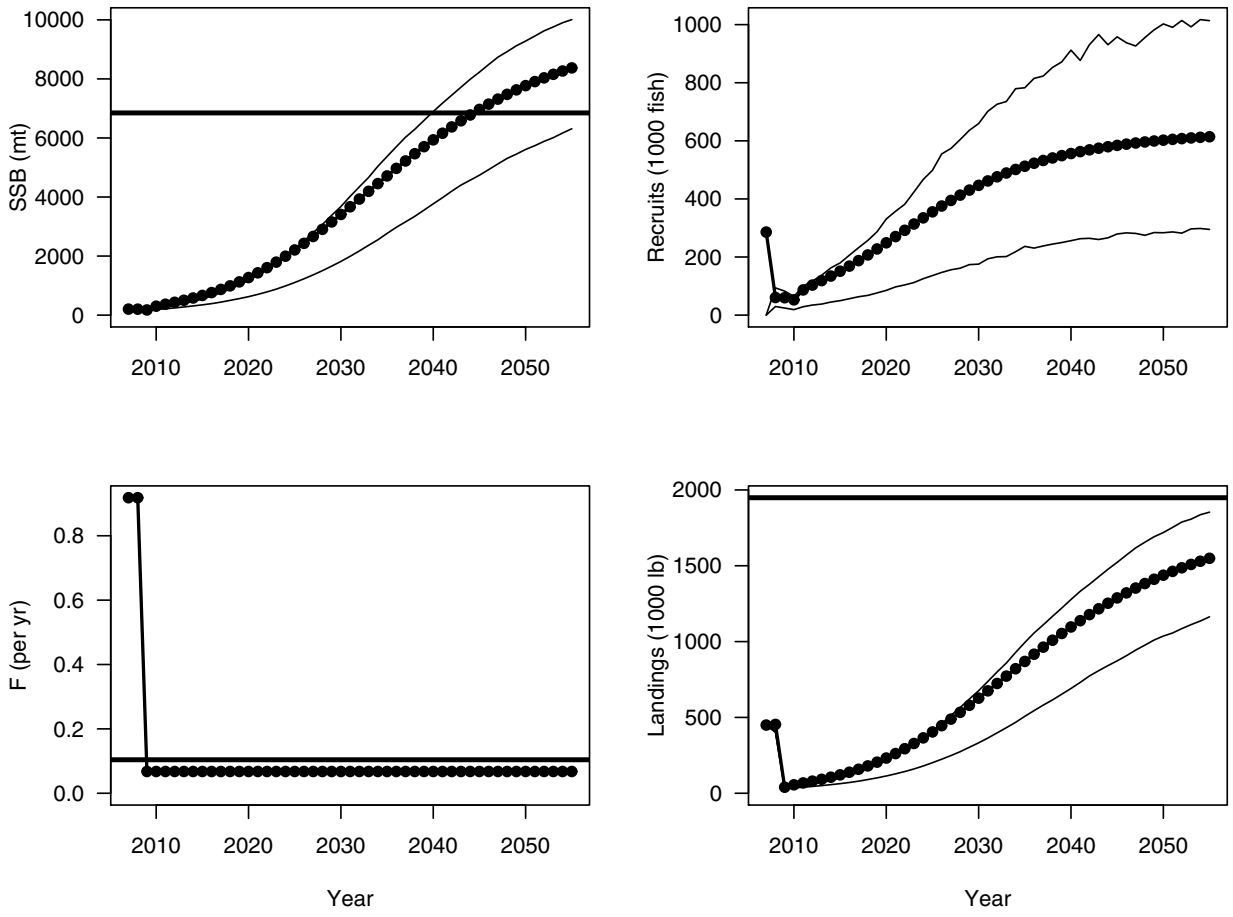


Figure 1.47. Red snapper: Projection results under scenario R4—fishing mortality rate fixed at $F = 75\%F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Horizontal lines mark proxy reference points. Spawning stock biomass (SSB) is at mid-year.

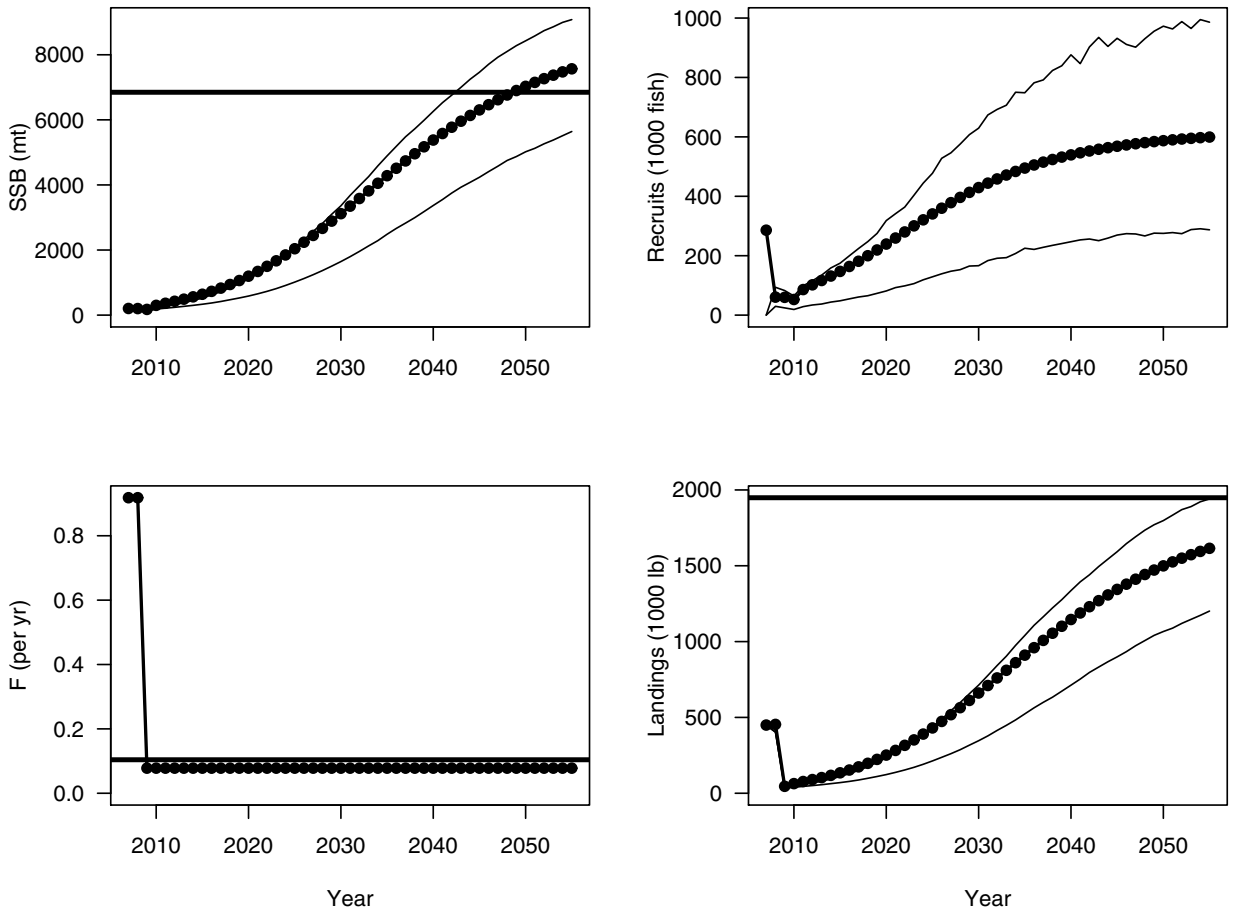


Figure 1.48. Red snapper: Projection results under scenario R5—fishing mortality rate fixed at $F = 85\%F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Horizontal lines mark proxy reference points. Spawning stock biomass (SSB) is at mid-year.

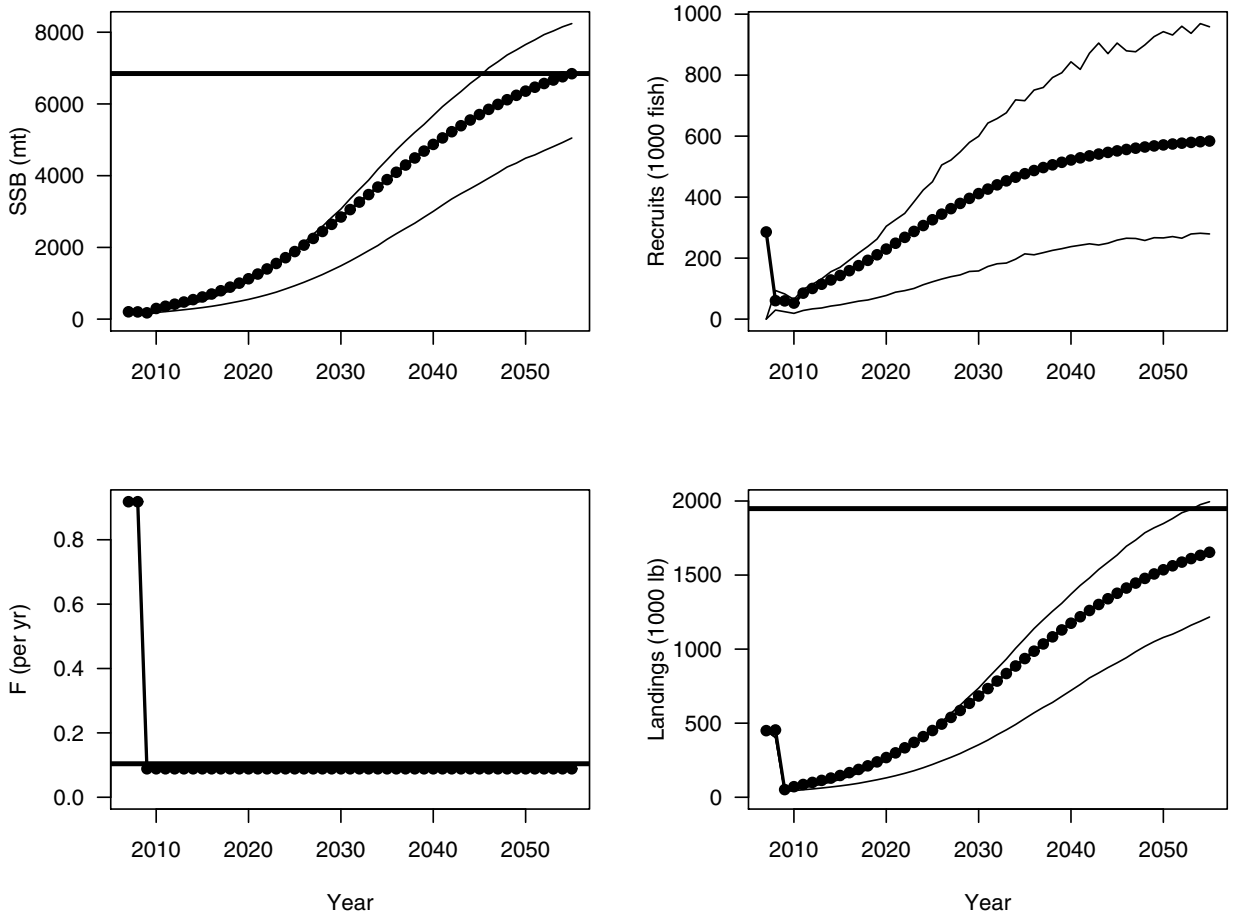


Figure 1.49. Red snapper: Projection results under scenario R6—Discard-only projection with fishing mortality rate fixed at $F = F_{\text{current}}$ minus that of commercial diving, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Spawning stock biomass (SSB) is at mid-year. In the SSB panel, solid horizontal line marks $\text{SSB}_{F_{40\%}}$, the rebuilding target. In the F panel, the dashed horizontal line marks the fishing rate applied, of which only a portion (dotted solid line) leads to discard mortality.

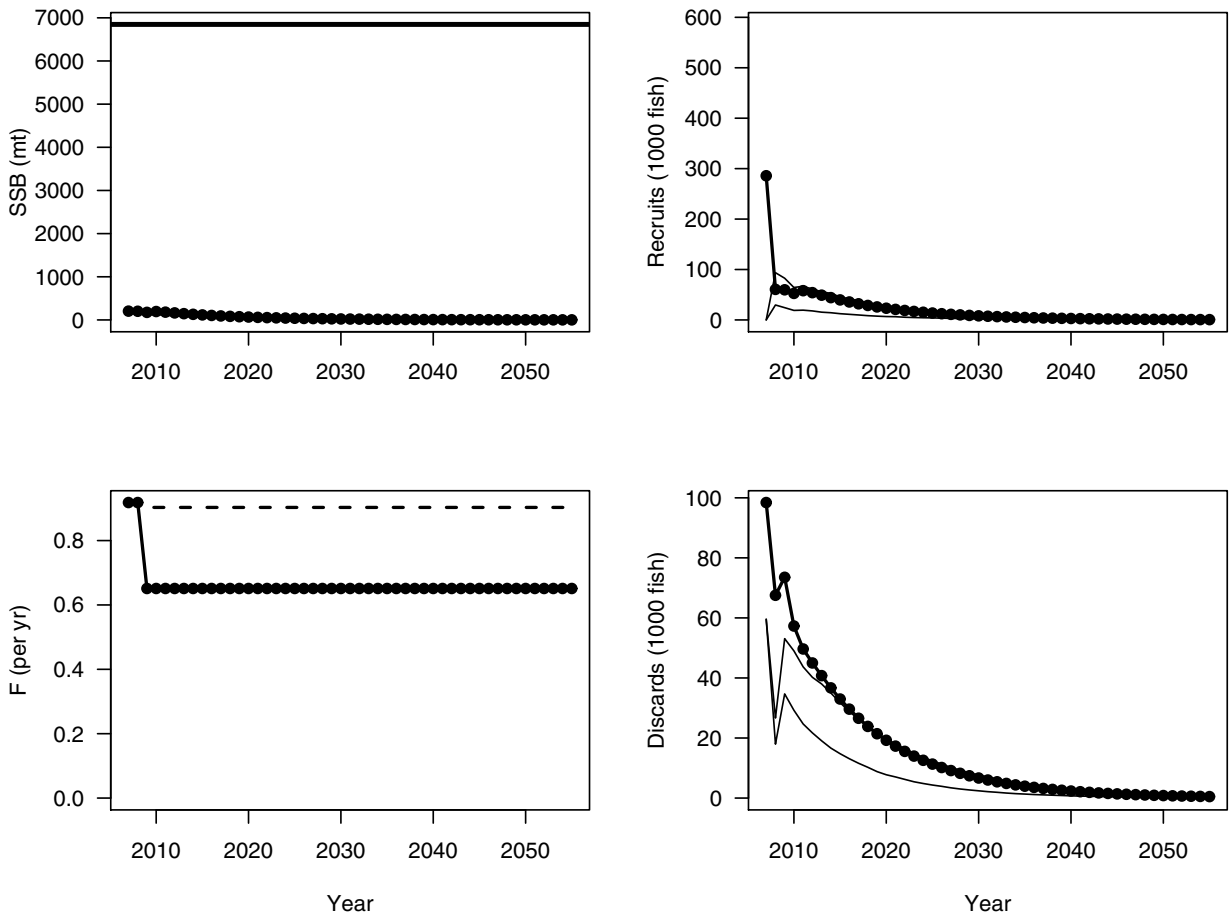


Figure 1.50. Red snapper: Projection results under scenario R7—Discard-only projection with fishing mortality rate fixed at $F = F_{40\%}$, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Spawning stock biomass (SSB) is at mid-year. In the SSB *panel, solid horizontal line marks* $\mathrm{SSB}_{F_{40\%}}$*, the rebuilding target. In the F panel, the dashed horizontal line marks the fishing rate applied, of which only a portion (dotted solid line) leads to discard mortality.*

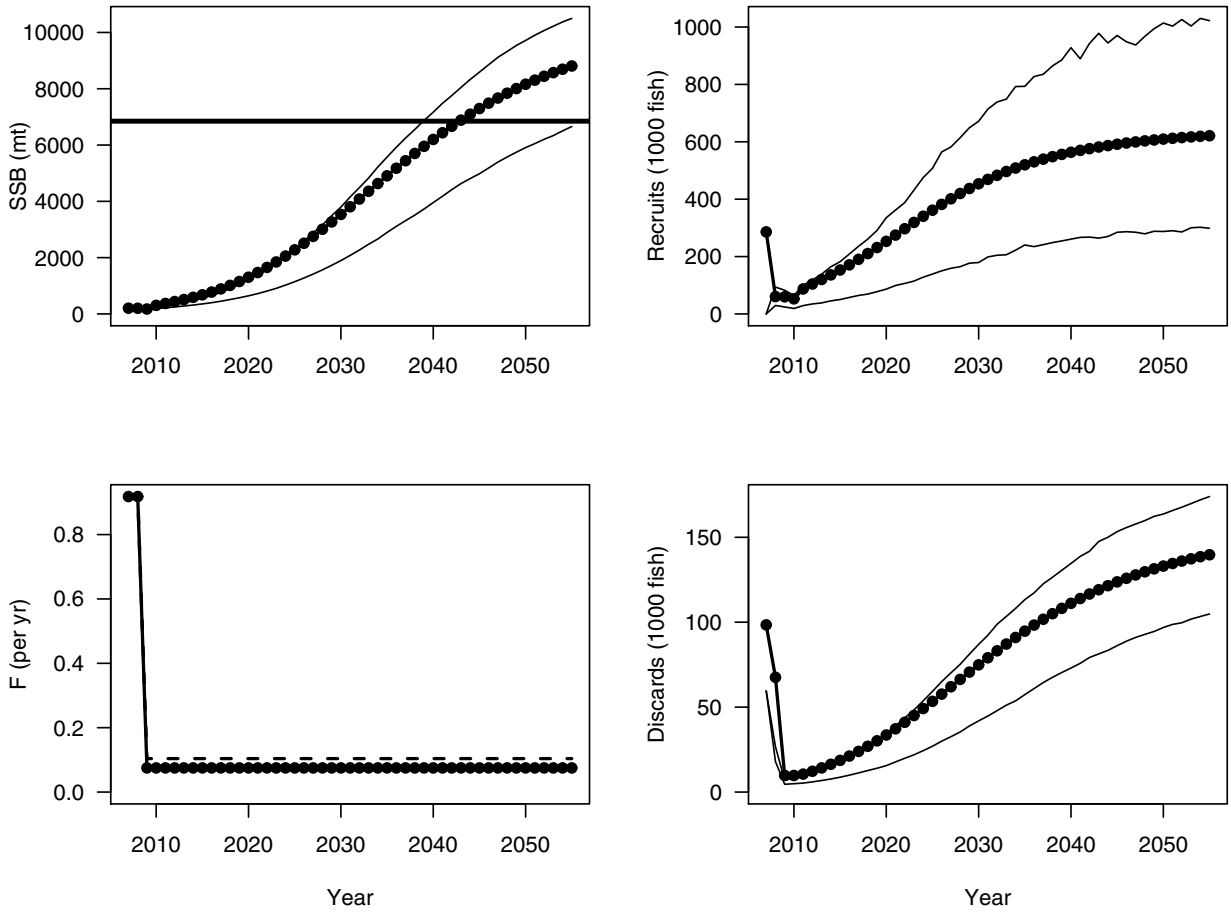


Figure 1.51. Red snapper: Projection results under scenario R8—Discard-only projection with fishing mortality rate fixed at $F = 65\%F_{40\%}$, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Spawning stock biomass (SSB) is at mid-year. In the SSB *panel, solid horizontal line marks* $\mathrm{SSB}_{F_{40\%}}$*, the rebuilding target. In the F panel, the dashed horizontal line marks the fishing rate applied, of which only a portion (dotted solid line) leads to discard mortality.*

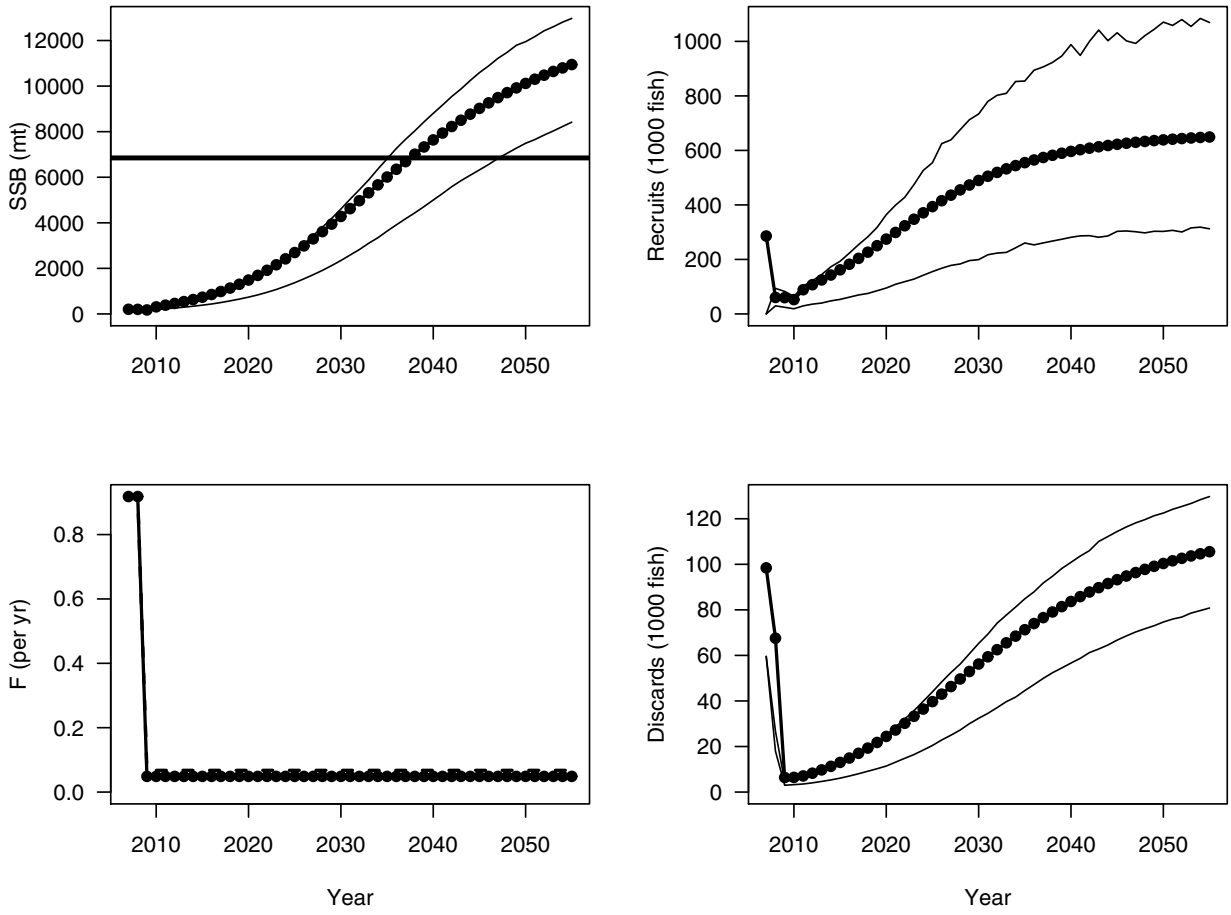


Figure 1.52. Red snapper: Projection results under scenario R9—Discard-only projection with fishing mortality rate fixed at $F = 75\%F_{40\%}$, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Spawning stock biomass (SSB) is at mid-year. In the SSB *panel, solid horizontal line marks* $\mathrm{SSB}_{F_{40\%}}$*, the rebuilding target. In the F panel, the dashed horizontal line marks the fishing rate applied, of which only a portion (dotted solid line) leads to discard mortality.*

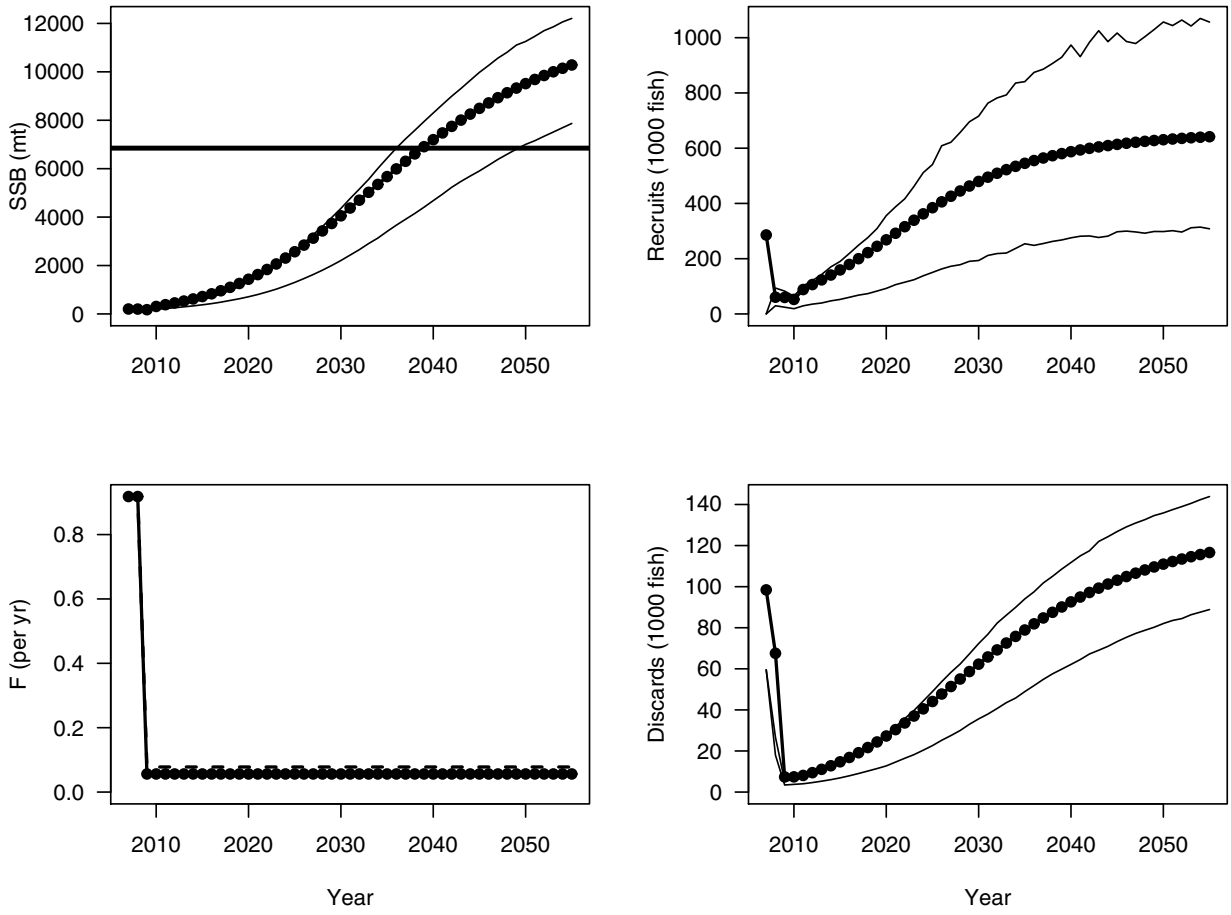
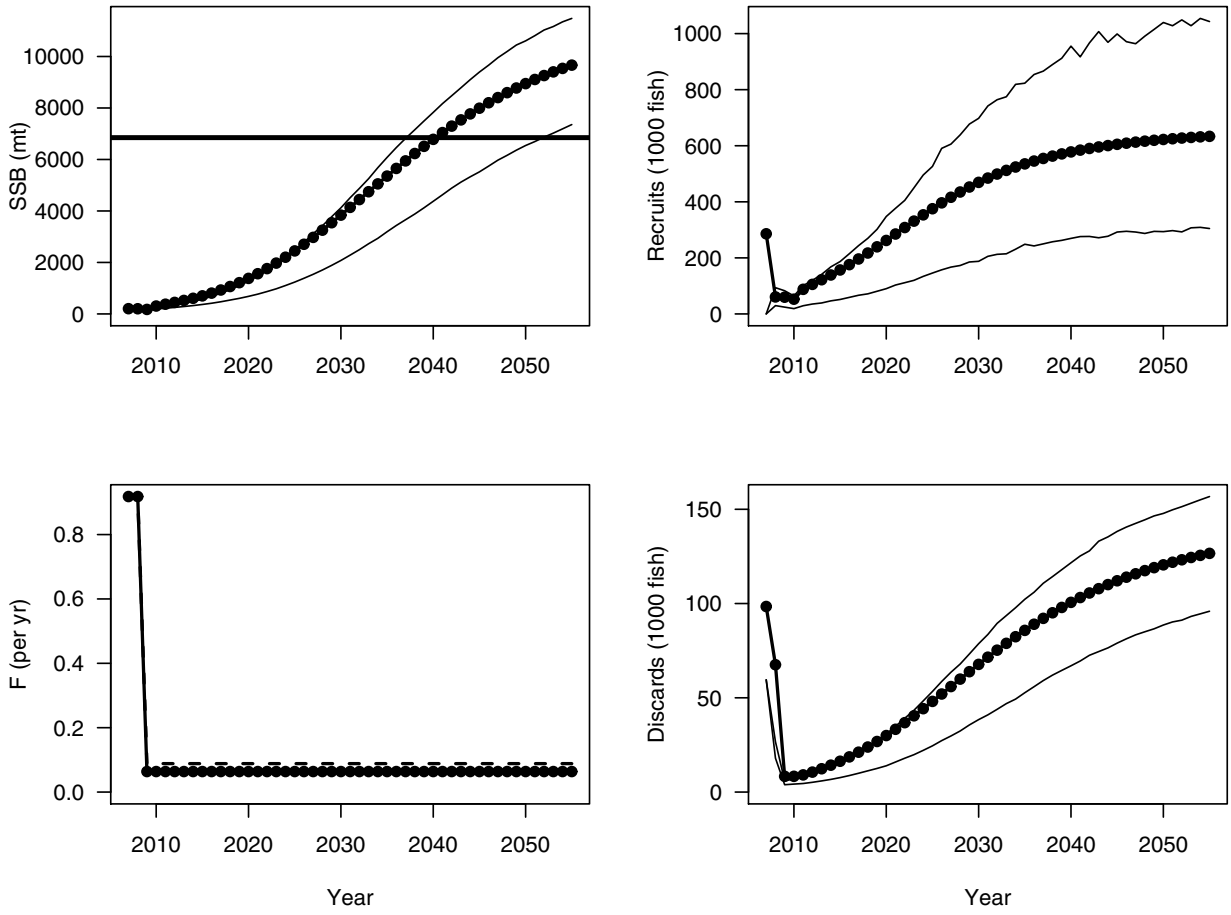


Figure 1.53. Red snapper: Projection results under scenario R10—Discard-only projection with fishing mortality rate fixed at $F = 85\%F_{40\%}$, and with release mortality rates of 0.9 in the commercial sector and 0.4 in the headboat and general recreational sectors. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 replicate projections. Spawning stock biomass (SSB) is at mid-year. In the SSB *panel, solid horizontal line marks* $\mathrm{SSB}_{F_{40\%}}$*, the rebuilding target. In the F panel, the dashed horizontal line marks the fishing rate applied, of which only a portion (dotted solid line) leads to discard mortality.*



Appendix A Parameter estimates from AD Model Builder implementation of catch-at-age assessment model

```
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# log_dev_N_rec:
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# selpar_L50_commHAL2:
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# selpar_slope_MRFSS3:
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# selpar_L50_MRFSS3:
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# log_F_dev_commHAL_2:
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# log_F_dev_commDV:
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# log_F_dev_HB:
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 0.290203851827 0.484468711448 0.665993475287 0.622868715367 0.846562379817 0.152024777047 0.557894724710
 0.427257469431 0.488812764329 0.442468046121 -0.0894885178072 0.616539293286
0.415216573592 0.116407250062
# log_avg_F_MRFSS:
-1.82889351083
# log_F_dev_MRFSS:
 -3.52039459292 -2.82405838140 -2.41408074868 -2.12002525383 -1.88688574352 -1.69138509951 -1.52141363557
 -1.36616247166 -1.22107346737 -1.08408758540 -0.947805187885 -0.811721397585 -0.676970953948 -0.538767735985
 -0.583019232799 -0.650446031321 -0.750874885589 -0.889387641294 -1.07386267968 -0.726080686875 -0.433107621276
 -0.156801479478 0.118471254121 0.411049192371 0.505140871659 0.580542631655 0.663188333222 0.765647177093
 0.896411604441 1.06396830492 1.29074013187 1.48928328334 1.59836210033
1.54363855647 0.555426488660 0.554588122376 0.879692131031 1.16983330676 1.15372321037 1.09696204095
0.596345365132 0.687089560507 0.835343981490 0.802372192310 0.574986139233 0.732422689915 0.680345828427
0.0173439208595 0.0775096379101 0.274978650539 0.254908326554 0.689452737265 0.804832165374 0.782249966097
0.704681864492 0.581922198694 0.581073360883 0.560035420655 0.661608329103 0.652241436507
# log_avg_F_commHAL_D:
-2.97766946971
# log_F_dev_commHAL_D:
 -1.40799150290 -1.75393513444 -0.438016834779 0.0475354005347 -0.694119847577 -1.58857016133 0.887738654068
 -1.24217113320 0.116428308146 0.426033672012 1.05579387997 1.14435639249 1.28676017512 1.11763655257
 0.412607871207 -0.0636658858339 -0.160840330972 0.168480635658 0.273231321681 0.220979040550 0.120397038286
 0.0294730546582 0.0418588340895
# log_avg_F_HB_D:
-3.76205178550
# log_F_dev_HB_D:
 -1.34427300878 -1.15664037253 -0.622937576792 0.306825074975 0.0574146729436 -1.37222653188 0.708786741310
 -0.997642455486 -1.64935214038 0.685274183198 0.733508528824 1.25887062791 0.159497679203 -1.20897113992
 0.161081183140 -0.327045719536 -0.0806251549870 0.810843461433 0.828437051591 0.480988296661 1.09363868581
 0.945466060770 0.529081852536
# log_avg_F_MRFSS_D:
-2.24840044056
# log_F_dev_MRFSS_D:
 -0.274705088622 -0.318487255963 0.251044389592 -0.279523416978 -0.198113186553 -1.03163945821 -1.14209736530
 -1.30654699330 -0.419437899856 0.00621333153448 0.442348823577 0.224773881023 -0.387693966462 -0.926095479756
 -0.0676756530221 0.309334664641 0.592219487605 0.761635177641 0.750368985493 0.813816000570 0.878699170244
 0.776132936240 0.545428915863
```

Red Snapper Projections V – Addendum

10 April 2009

1 Description of Addendum

This addendum provides one additional projection scenario to those described in the document titled, "Red Snapper Projections V." That earlier document included a projection labeled Scenario D5, a discard-only projection with $F = F_{40\%}$, which used regression-estimated 2008 MRFSS landings. The additional projection of this addendum is identical to Scenario D5, except that it uses the preliminary estimate of 2008 recreational landings from MRFSS, rather than the regression-estimated value. This new projeciton is labeled:

- Scenario D5-alt: $F = F_{40\%}$

The discard-only projections differ from the harvest projections in two main ways: first, dive fishing was not included, and second, all fish caught were assumed released and were subjected to the release mortality rates used in the assessment (0.9 in the commercial sector and 0.4 in the headboat and recreational sectors). Thus, not all of the applied fishing rate contributes to mortality; tables of results report both the applied rate (e.g., F_{current}or $F_{40\%}$) and the rate that actually contributes to mortality (labeled as Fmort). When interpreting the discard-only projections, one should bear in mind that the distribution of full F among the various fisheries is different from that in the assessment, which leads to inconsistency between projections and benchmarks (e.g., fishing at $F_{40\%}$ leads to an equilibrium stock size other than $\text{SSB}_{F_{40\%}}$).

The period between the end of the assessment (2006) and the start of new management (2010) was projected using values of F_{2007}, F_{2008}, and F_{2009}. The 2007 and 2008 values of F were those that, in the deterministic projections, provided the 2007 and 2008 estimates of landings. The 2009 value of F was assumed to be F_{current}, defined as the geometric mean of F from 2004–2008.

2 Results of Scenario D5-alt

Results are shown in Table 4.1.

3 Comments on Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- Initial abundance at age of the projections were based on estimates from the last year of the assessment. If those estimates are inaccurate, rebuilding will likely be affected.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect rebuilding.

- The projections assumed no change in the selectivity applied to discards. As recovery generally begins with the smallest size classes, management action may be needed to meet that assumption.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If changes in environmental or ecological conditions affect recruitment or life-history characteristics, rebuilding may be affected.
- The projections used a spawner-recruit relationship with steepness of $h = 0.95$, the value estimated in the assessment but with considerable uncertainty. Such a high value implies that the stock, at its currently low abundance, spawns nearly as many recruits as it would at high abundance. That is, productivity is nearly independent of spawning biomass. If productivity depends on spawning biomass, stock recovery would take longer than projected.
- The preliminary estimates of 2008 MRFSS landings, as used in this addendum, were much higher than in recent years. These preliminary high values, if real, could reflect recruitment to the fishery of a strong year-class. The projection model, however, would be unaware of such a year-class, and instead interprets the high landings to be a consequence of high F. If a strong year-class is indeed pulsing through the population, and if it is protected by management regulations, stock recovery could occur more quickly than projected.
- Discard-only projections tacitly assumed that any individual fish would be caught only once per year. To the extent that this assumption is violated, discard-only projections may overestimate the velocity of recovery.
- Discard-only projections allocated sources of mortality in different proportions than those used in computing reference points. Thus discard-only projections are not consistent with reference points, in the sense that fishing at $F_{40\%}$ may lead to an equilibrium stock size other than $\mathrm{SSB}_{F_{40\%}}$.

4 Tables

Table 4.1. Red snapper: Projection results under scenario D5-alt—fishing mortality rate $F = F_{40\%}$. This scenario differs from D5 by using preliminary estiamtes of 2008 recreational landings from MRFSS. F = fishing rate (per year), Fmort = fishing rate (per year) as the portion of F that leads to (discard) mortality, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Fmort	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.930	0.930	0.00	203	286	454	454	95	153	99
2008	4.980	4.980	0.00	205	321	1000	1454	218	383	304
2009	1.291	1.291	0.00	14	322	75	1529	29	89	91
2010	0.104	0.075	0.00	58	37	0	1529	0	23	11
2011	0.104	0.075	0.00	175	136	0	1529	0	36	12
2012	0.104	0.075	0.00	278	295	0	1529	0	52	17
2013	0.104	0.075	0.00	421	377	0	1529	0	83	26
2014	0.104	0.075	0.00	630	449	0	1529	0	123	36
2015	0.104	0.075	0.00	910	512	0	1529	0	174	46
2016	0.104	0.075	0.00	1262	561	0	1529	0	235	56
2017	0.104	0.075	0.00	1678	597	0	1529	0	306	66
2018	0.104	0.075	0.00	2146	622	0	1529	0	385	76
2019	0.104	0.075	0.00	2654	640	0	1529	0	469	84
2020	0.104	0.075	0.00	3187	653	0	1529	0	557	92
2021	0.104	0.075	0.00	3730	662	0	1529	0	646	100
2022	0.104	0.075	0.01	4274	670	0	1529	0	735	106
2023	0.104	0.075	0.01	4807	675	0	1529	0	822	112
2024	0.104	0.075	0.03	5322	679	0	1529	0	907	118
2025	0.104	0.075	0.06	5815	682	0	1529	0	987	123
2026	0.104	0.075	0.10	6281	685	0	1529	0	1063	127
2027	0.104	0.075	0.16	6718	687	0	1529	0	1134	131
2028	0.104	0.075	0.22	7126	689	0	1529	0	1201	135
2029	0.104	0.075	0.32	7503	690	0	1529	0	1262	138
2030	0.104	0.075	0.40	7851	691	0	1529	0	1319	141
2031	0.104	0.075	0.49	8171	692	0	1529	0	1371	144
2032	0.104	0.075	0.58	8463	693	0	1529	0	1418	146
2033	0.104	0.075	0.65	8730	694	0	1529	0	1462	148
2034	0.104	0.075	0.72	8973	694	0	1529	0	1501	150
2035	0.104	0.075	0.76	9194	695	0	1529	0	1537	152
2036	0.104	0.075	0.82	9394	695	0	1529	0	1570	154
2037	0.104	0.075	0.85	9575	696	0	1529	0	1599	155
2038	0.104	0.075	0.88	9739	696	0	1529	0	1626	156
2039	0.104	0.075	0.90	9887	696	0	1529	0	1650	158
2040	0.104	0.075	0.91	10,021	697	0	1529	0	1672	159
2041	0.104	0.075	0.92	10,142	697	0	1529	0	1692	160
2042	0.104	0.075	0.94	10,251	697	0	1529	0	1709	160
2043	0.104	0.075	0.95	10,350	697	0	1529	0	1725	161
2044	0.104	0.075	0.96	10,439	697	0	1529	0	1740	162
2045	0.104	0.075	0.97	10,519	698	0	1529	0	1753	162
2046	0.104	0.075	0.97	10,591	698	0	1529	0	1765	163
2047	0.104	0.075	0.97	10,656	698	0	1529	0	1775	163
2048	0.104	0.075	0.97	10,714	698	0	1529	0	1785	164
2049	0.104	0.075	0.98	10,767	698	0	1529	0	1793	164
2050	0.104	0.075	0.98	10,815	698	0	1529	0	1801	165

Red Snapper Projections V

19 March 2009

1 Introduction

Projections of red snapper in the U.S. South Atlantic were completed as part of SEDAR-15 and were described in the SEDAR-15 assessment report. Following the SEDAR-15 Review Workshop, those projections were revised according to an SAFMC memorandum (dated August 12, 2008) from Bob Mahood to Dr. Bonnie Ponwith; the revised projections were described in the SEDAR-15 "Addenda and updates." Additional projections were computed for consideration of the SAFMC SSC at their December, 2008 meeting, as described in a report titled "Red snapper: Estimation of biomass benchmarks and projections." During that meeting, the SSC requested more projections, which were computed and described in a follow-up report to the SSC titled, "Red Snapper Projections: the SSC Alternative (1 December 2008)."

A SERO memorandum (dated February 13, 2009), from Dr. Roy Crabtree to Dr. Bonnie Ponwith, requested additional red snapper projections. This report describes those projections. A synopsis of the request follows:

1. Provide the time frame for rebuilding in the absence of fishing mortality (Tmin).
2. Provide the time frame for rebuilding in the absence of fishing mortality plus one mean generation time (Tmax).
3. Provide projections of spawning stock biomass, recruitment, landings, discards, and probability of stock recovery, from 2007 to Tmax for the fishing mortality rates F_{current}, $F_{40\%}$, 65%$F_{40\%}$, 75%$F_{40\%}$, and 85% $F_{40\%}$.
4. Provide similar projections as in #3 above, but assume no directed harvest and discards correspond to the yield associated with fishing mortality rates F_{current}, $F_{40\%}$, 65%$F_{40\%}$, 75%$F_{40\%}$, and 85% $F_{40\%}$.

It was requested that the above projections be based on the MFMT $F_{40\%} = 0.104$ and steepness $h = 0.95$. It was also requested that reductions in F begin in 2010 (rather than the previous beginning of 2009), and that available landings data for 2007 and 2008 be examined, if possible, to determine appropriate levels of F in 2007–2009.

To compute the time frame for rebuilding (i.e., item #1), a biomass benchmark is required. Here that value was taken as $\text{SSB}_{F_{40\%}}$, the equilibrium spawning biomass achieved when fishing at $F_{40\%}$ =0.104. The value of $\text{SSB}_{F_{40\%}}$(and other biomass benchmarks) was computed through long-term, deterministic projections with bias correction, providing consistency between benchmarks and harvest projections. For comparison to $F_{40\%}$ benchmarks, $F_{30\%}$ benchmarks were also computed in the same manner.

2 Projection scenarios

To accomplish item #1, projections were run with $F = 0$. This projection is labeled "Scenario P0." In this scenario, the minimum time frame for rebuilding (Tmin) was defined by when the probability of stock recovery achieved at least 0.5.

To accomplish item #3, several projection scenarios allowing harvest were considered:

- Scenario H1: $F = F_{\text{current}}$
- Scenario H2: $F = 65\% F_{40\%}$
- Scenario H3: $F = 75\% F_{40\%}$
- Scenario H4: $F = 85\% F_{40\%}$
- Scenario H5: $F = F_{40\%}$

To accomplish item #4, several discard-only projections were considered:

- Scenario D1: $F = F_{\text{current}}$
- Scenario D2: $F = 65\% F_{40\%}$
- Scenario D3: $F = 75\% F_{40\%}$
- Scenario D4: $F = 85\% F_{40\%}$
- Scenario D5: $F = F_{40\%}$

The discard-only projections differ from the harvest projections in two main ways: first, dive fishing was not included, and second, all fish caught were assumed released and were subjected to the release mortality rates used in the assessment (0.9 in the commercial sector and 0.4 in the headboat and recreational sectors). Thus, not all of the applied fishing rate contributes to mortality; tables of results report both the applied rate (e.g., F_{current}or $F_{40\%}$) and the rate that actually contributes to mortality (labeled as Fmort). When interpreting the discard-only projections, one should bear in mind that the distribution of full F among the various fisheries is different from that in the assessment, which leads to inconsistency between projections and benchmarks (e.g., fishing at $F_{40\%}$ leads to an equilibrium stock size other than $\text{SSB}_{F_{40\%}}$).

The period between the end of the assessment (2006) and the start of new management (2010) was projected using values of F_{2007}, F_{2008}, and F_{2009}. The 2007 and 2008 values of F were those that, in the deterministic projections, provided the 2007 and 2008 estimates of landings. The 2009 value of F was assumed to be F_{current}, defined as the geometric mean of F from 2004–2008.

2.1 Landings in 2007 and 2008

The 2007 and 2008 landings were examined by sector. The estimates of commercial landings were available in the Accumulated Landings System and were provided by D. Gloeckner (NMFS-Beaufort). Handline landings were 108,076 lb in 2007 and 160,101 lb in 2008; commercial dive landings were 7605 lb in 2007 and 4343 lb in 2008. The estimate of 2007 headboat landings—37,460 lb, a relatively low value—was available from the Headboat Survey and provided by K. Brennan (NMFS-Beaufort). Finalized headboat landings in 2008 were not available in the survey and were thus estimated by linear regression of 1999–2007 headboat landings on commercial handline landings, which yielded a value of 70,080 lb (Figure 5.1). The estimate of 2007 MRFSS landings was available from the MRFSS website (http://www.st.nmfs.noaa.gov/mrip/), which was queried on March 3, 2009 for South Atlantic A+B1 landings in numbers (total minus headboat) and multiplied by the 2007 mean weight. This query provided a 2007 estimate of MRFSS landings of 300,902 lb. Finalized MRFSS landings in 2008 were not available from the MRFSS website and were thus estimated by linear regression of 1999–2007 MRFSS landings on commercial handline landings, which yielded a value of 318,361 lb (Figure 5.1). Combined across sectors, 2007 landings were $\sim 454,000$ lb and 2008 landings were $\sim 553,000$ lb.

2.2 Alternative landings in 2008

Although the MRFSS website did not provide final landings data for 2008, it did provide preliminary estimates. Based on the same method described above to compute MRFSS landings in weight, preliminary 2008 MRFSS landings were 765,443 lb. This value, in combination with other sectors, resulted in 2008 landings of $\sim 1,000,000$ lb.

Sensitivity of projections to this alternative 2008 estimate of landings were examined in two cases. The first case was the $F = 0$ projection used to define the rebuilding time; it is labeled here as "Scenario P0-alt." The second case was the $F = 75\% F_{40\%}$ projection with harvest; it is labeled here as "Scenario H3-alt."

These sensitivity runs should be interpreted with caution for at least two reasons. First, the 2008 MRFSS estimate is preliminary, and its value is higher than any other since the sampling program began in 1981. Second, recruitment estimates near the end of the assessment period were necessarily constrained, and thus, projections can only match such a high level of 2008 landings by imposing very high F. If the high landings were included in the assessment model itself, they might alternatively be explained by higher than expected recruitment.

3 Results

3.1 Benchmarks

Benchmarks computed by projection using $F_{40\%} = 0.104$ were $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, $\mathrm{D}_{F_{40\%}} = 72,717$ lb (38,966 fish), and $\mathrm{R}_{F_{40\%}} = 692,864$ fish (Table 4.1). Thus, the value of $\mathrm{SSB}_{F_{40\%}} = 8102.5$ was used when computing the probability of rebuilding, which in turn was used to compute the rebuilding time frame Tmin.

Analogous benchmarks based on $F_{30\%}$ were also computed. The value of $F_{30\%}$ was $F_{30\%} = 0.148$, and corresponding benchmarks were $\mathrm{SSB}_{F_{30\%}} = 6025.1$ mt, $\mathrm{Y}_{F_{30\%}} = 2,430,792$ lb, $\mathrm{D}_{F_{30\%}} = 99,092$ lb (53,666 fish), and $\mathrm{R}_{F_{30\%}} = 685,824$ fish. These $F_{30\%}$ benchmarks were not used in the projection scenarios, but are reported here simply for comparison with $F_{40\%}$ benchmarks.

3.2 Rebuilding time frame

In the projection with $F = 0$, the probability of stock recovery is expected to exceed 0.5 during the year 2024 (Table 4.2, Fig. 5.2). Thus, with stock recovery expected by the beginning of 2025, Tmin is 15 years (2010–2024). The mean generation time is 20 years (SEDAR-15), and thus Tmax is 35 years. This value would imply that stock recovery should occur by the beginning of 2045, at the latest.

3.3 Projection results

Results of projections with allowable harvest are tabulated in Tables 4.3–4.7, and are presented graphically in Figs. 5.3–5.7.

Results of projections with no allowable harvest (discards only) are tabulated in Tables 4.8–4.12, and are presented graphically in Figs. 5.8–5.12.

Sensitivity projections showed that results were sensitive to the preliminary estimates of 2008 MRFSS landings. In the $F = 0$ sensitivity projection (Scenario P0-alt), the probability of stock recovery is expected to exceed 0.5 during the year 2026 (Table 4.13, Fig. 5.13), two years after the prediction of Scenario P0. In the $F = 75\%F_{40\%}$ sensitivity projection (Scenario H3-alt), projected landings were lower than in Scenario H3 (Table 4.14, Fig. 5.14), because a very high 2008 F decimated the stock.

3.4 Comments on Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- Initial abundance at age of the projections were based on estimates from the last year of the assessment. If those estimates are inaccurate, rebuilding will likely be affected.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect rebuilding.
- The projections assumed no change in the selectivity applied to discards. As recovery generally begins with the smallest size classes, management action may be needed to meet that assumption.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If changes in environmental or ecological conditions affect recruitment or life-history characteristics, rebuilding may be affected.
- The projections used a spawner-recruit relationship with steepness of $h = 0.95$, the value estimated in the assessment but with considerable uncertainty. Such a high value implies that the stock, at its currently low abundance, spawns nearly as many recruits as it would at high abundance. That is, productivity is nearly independent of spawning biomass. If productivity depends on spawning biomass, stock recovery would take longer than projected.

- The preliminary estimates of 2008 MRFSS landings, as used in Scenarios P0-alt and H3-alt, were much higher than in recent years. These preliminary high values, if real, could reflect recruitment to the fishery of a strong year-class. The projection model, however, would be unaware of such a year-class, and instead interprets the high landings to be a consequence of high F. If a strong year-class is indeed pulsing through the population, and if it is protected by management regulations, stock recovery could occur more quickly than projected.
- Discard-only projections tacitly assumed that any individual fish would be caught only once per year. To the extent that this assumption is violated, discard-only projections may overestimate the velocity of recovery.
- Discard-only projections allocated sources of mortality in different proportions than those used in computing reference points. Thus discard-only projections are not consistent with reference points, in the sense that fishing at $F_{40\%}$ may lead to an equilibrium stock size other than $\mathrm{SSB}_{F_{40\%}}$.

4 Tables

Table 4.1. Estimated status indicators, benchmarks, and related quantities, conditional on estimated current selectivities averaged across fisheries. Values are MSY*-based proxies associated with* $F_{40\%}$*, the recommended proxy for* F_{MSY}*, and also* $F_{30\%}$*. Biomass-based and number-based quantities were computed as equilibrium values from projections with fishing rate* $F_{30\%}$ *or* $F_{40\%}$ *(or X% of those rates), as indicated. Estimates of yield (Y) do not include discard mortalities (D). The* MSST *is defined by* $\mathrm{MSST} = (1 - M)\mathrm{SSB}_{\mathrm{MSY}}$*, with constant* $M = 0.078$*.*

Quantity	Units	$F_{40\%}$ Proxy	$F_{30\%}$ Proxy
F_{MSY}	y^{-1}	0.104	0.148
$\mathrm{SSB}_{\mathrm{MSY}}$	mt	8102.5	6025.1
$\mathrm{D}_{\mathrm{MSY}}$	1000 fish	39	54
Recruits at F_{MSY}	1000 fish	693	686
Y at 65% F_{MSY}	1000 lb	1984	2257
Y at 75% F_{MSY}	1000 lb	2104	2338
Y at 85% F_{MSY}	1000 lb	2199	2391
Y at F_{MSY}	1000 lb	2304	2431
MSST	mt	7470.5	5555.1
$F_{2006}/F_{\mathrm{MSY}}$	–	7.67	5.39
$\mathrm{SSB}_{2006}/\mathrm{SSB}_{\mathrm{MSY}}$	–	0.02	0.03
$\mathrm{SSB}_{2006}/\mathrm{MSST}$	–	0.03	0.04

*Table 4.2. Red snapper: Projection results under scenario P0—fishing mortality rate F = 0. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0	0	187	285	0	1414	0	0	0
2011	0	0	444	306	0	1414	0	0	0
2012	0	0	703	458	0	1414	0	0	0
2013	0	0	1041	527	0	1414	0	0	0
2014	0	0	1474	576	0	1414	0	0	0
2015	0	0	2001	611	0	1414	0	0	0
2016	0	0	2611	635	0	1414	0	0	0
2017	0	0	3290	652	0	1414	0	0	0
2018	0	0	4020	664	0	1414	0	0	0
2019	0	0.01	4786	673	0	1414	0	0	0
2020	0	0.05	5571	679	0	1414	0	0	0
2021	0	0.13	6364	684	0	1414	0	0	0
2022	0	0.28	7151	687	0	1414	0	0	0
2023	0	0.46	7926	690	0	1414	0	0	0
2024	0	0.62	8680	692	0	1414	0	0	0
2025	0	0.76	9409	694	0	1414	0	0	0
2026	0	0.86	10,108	696	0	1414	0	0	0

*Table 4.3. Red snapper: Projection results under scenario H1—fishing mortality rate $F = F_{\text{current}}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\text{SSB}_{F_{40\%}} = 8102.5$ mt, $\text{R}_{F_{40\%}} = 692,864$ fish, $\text{Y}_{F_{40\%}} = 2,303,676$ lb, and $\text{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.974	0	187	285	425	1839	97	169	109
2011	0.974	0	192	306	443	2282	98	163	106
2012	0.974	0	195	311	453	2735	100	163	109
2013	0.974	0	199	314	459	3194	101	168	111
2014	0.974	0	202	317	467	3661	103	170	112
2015	0.974	0	205	320	474	4135	104	172	113
2016	0.974	0	207	322	481	4616	105	173	114
2017	0.974	0	210	325	486	5102	106	175	115
2018	0.974	0	212	327	491	5593	107	176	116
2019	0.974	0	213	328	495	6088	108	177	116
2020	0.974	0	215	330	499	6587	109	178	117
2021	0.974	0	216	331	502	7089	109	179	118
2022	0.974	0	217	332	505	7594	110	179	118
2023	0.974	0	218	333	507	8101	110	180	118
2024	0.974	0	219	334	510	8611	111	181	119
2025	0.974	0	220	335	511	9122	111	181	119
2026	0.974	0	221	335	513	9635	111	181	119
2027	0.974	0	221	336	515	10,150	112	182	119
2028	0.974	0	222	336	516	10,665	112	182	120
2029	0.974	0	222	337	517	11,182	112	182	120
2030	0.974	0	222	337	518	11,700	112	183	120
2031	0.974	0	223	337	519	12,219	112	183	120
2032	0.974	0	223	337	519	12,738	112	183	120
2033	0.974	0	223	338	520	13,258	113	183	120
2034	0.974	0	224	338	520	13,778	113	183	120
2035	0.974	0	224	338	521	14,299	113	183	120
2036	0.974	0	224	338	521	14,820	113	183	120
2037	0.974	0	224	338	522	15,341	113	183	120
2038	0.974	0	224	338	522	15,863	113	184	121
2039	0.974	0	224	339	522	16,385	113	184	121
2040	0.974	0	224	339	522	16,908	113	184	121
2041	0.974	0	224	339	522	17,430	113	184	121
2042	0.974	0	224	339	523	17,953	113	184	121
2043	0.974	0	225	339	523	18,475	113	184	121
2044	0.974	0	225	339	523	18,998	113	184	121
2045	0.974	0	225	339	523	19,521	113	184	121
2046	0.974	0	225	339	523	20,044	113	184	121
2047	0.974	0	225	339	523	20,568	113	184	121
2048	0.974	0	225	339	523	21,091	113	184	121
2049	0.974	0	225	339	523	21,614	113	184	121
2050	0.974	0	225	339	523	22,137	113	184	121

*Table 4.4. Red snapper: Projection results under scenario H2—fishing mortality rate $F = 65\% F_{40\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $SSB_{F_{40\%}} = 8102.5$ mt, $R_{F_{40\%}} = 692,864$ fish, $Y_{F_{40\%}} = 2,303,676$ lb, and $D_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.068	0	187	285	39	1452	9	15	9
2011	0.068	0	418	306	68	1521	14	19	11
2012	0.068	0	640	448	109	1630	20	21	13
2013	0.068	0	920	514	160	1790	26	27	16
2014	0.068	0	1269	562	222	2012	34	34	19
2015	0.068	0	1681	597	299	2311	43	38	21
2016	0.068	0	2145	622	385	2696	52	41	22
2017	0.068	0	2647	640	479	3175	61	43	23
2018	0.068	0	3171	653	577	3753	69	44	24
2019	0.068	0	3703	662	677	4430	76	45	24
2020	0.068	0	4234	669	777	5207	83	46	25
2021	0.068	0.01	4752	675	874	6082	90	47	25
2022	0.068	0.02	5251	679	967	7049	96	47	25
2023	0.068	0.05	5725	682	1056	8105	101	47	25
2024	0.068	0.1	6172	684	1139	9244	106	48	25
2025	0.068	0.14	6590	686	1217	10,462	110	48	25
2026	0.068	0.21	6977	688	1289	11,751	114	48	26
2027	0.068	0.28	7335	690	1356	13,107	117	48	26
2028	0.068	0.37	7663	691	1417	14,523	120	48	26
2029	0.068	0.44	7963	692	1472	15,996	123	48	26
2030	0.068	0.53	8236	693	1523	17,519	126	48	26
2031	0.068	0.6	8484	693	1569	19,088	128	49	26
2032	0.068	0.66	8709	694	1611	20,700	130	49	26
2033	0.068	0.72	8912	694	1649	22,349	132	49	26
2034	0.068	0.76	9096	695	1683	24,032	133	49	26
2035	0.068	0.79	9261	695	1714	25,745	135	49	26
2036	0.068	0.83	9410	695	1741	27,487	136	49	26
2037	0.068	0.85	9544	696	1766	29,253	137	49	26
2038	0.068	0.88	9664	696	1789	31,042	139	49	26
2039	0.068	0.9	9772	696	1809	32,851	139	49	26
2040	0.068	0.91	9870	696	1827	34,677	140	49	26
2041	0.068	0.91	9957	697	1843	36,520	141	49	26
2042	0.068	0.92	10,035	697	1858	38,378	142	49	26
2043	0.068	0.93	10,106	697	1871	40,249	142	49	26
2044	0.068	0.94	10,169	697	1882	42,131	143	49	26
2045	0.068	0.94	10,226	697	1893	44,024	143	49	26
2046	0.068	0.95	10,276	697	1902	45,927	144	49	26
2047	0.068	0.95	10,322	697	1911	47,838	144	49	26
2048	0.068	0.95	10,363	697	1918	49,756	145	49	26
2049	0.068	0.96	10,399	697	1925	51,681	145	49	26
2050	0.068	0.97	10,432	697	1931	53,613	145	49	26

*Table 4.5. Red snapper: Projection results under scenario H3—fishing mortality rate $F = 75\%F_{40\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $SSB_{F_{40\%}} = 8102.5$ mt, $R_{F_{40\%}} = 692,864$ fish, $Y_{F_{40\%}} = 2,303,676$ lb, and $D_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.078	0	187	285	44	1458	10	17	11
2011	0.078	0	414	306	78	1536	16	22	12
2012	0.078	0	631	446	124	1661	22	25	15
2013	0.078	0	903	512	181	1842	30	31	18
2014	0.078	0	1240	560	250	2092	39	39	22
2015	0.078	0	1637	595	335	2427	49	43	24
2016	0.078	0	2082	620	431	2858	58	46	25
2017	0.078	0	2561	638	534	3393	68	49	26
2018	0.078	0	3059	651	642	4035	77	51	27
2019	0.078	0	3563	660	751	4786	85	52	28
2020	0.078	0	4062	668	860	5646	93	53	28
2021	0.078	0.01	4548	673	965	6610	100	53	29
2022	0.078	0.02	5014	677	1065	7676	106	54	29
2023	0.078	0.03	5455	680	1160	8836	112	54	29
2024	0.078	0.06	5868	683	1249	10,085	117	55	29
2025	0.078	0.1	6252	685	1331	11,416	122	55	29
2026	0.078	0.14	6607	687	1408	12,824	126	55	29
2027	0.078	0.19	6932	688	1478	14,301	130	55	29
2028	0.078	0.25	7229	689	1541	15,843	133	55	29
2029	0.078	0.32	7499	690	1599	17,442	136	55	29
2030	0.078	0.38	7744	691	1652	19,094	138	55	30
2031	0.078	0.44	7966	692	1699	20,793	141	55	30
2032	0.078	0.5	8165	693	1742	22,535	143	56	30
2033	0.078	0.56	8344	693	1780	24,315	145	56	30
2034	0.078	0.61	8505	693	1815	26,130	146	56	30
2035	0.078	0.65	8650	694	1846	27,976	148	56	30
2036	0.078	0.69	8779	694	1874	29,850	149	56	30
2037	0.078	0.73	8895	694	1898	31,748	150	56	30
2038	0.078	0.75	8998	695	1921	33,669	151	56	30
2039	0.078	0.78	9091	695	1940	35,610	152	56	30
2040	0.078	0.79	9173	695	1958	37,568	153	56	30
2041	0.078	0.8	9247	695	1974	39,542	154	56	30
2042	0.078	0.82	9313	695	1988	41,530	155	56	30
2043	0.078	0.83	9372	696	2001	43,531	155	56	30
2044	0.078	0.84	9424	696	2012	45,543	156	56	30
2045	0.078	0.84	9471	696	2022	47,565	156	56	30
2046	0.078	0.86	9513	696	2031	49,596	157	56	30
2047	0.078	0.87	9550	696	2039	51,634	157	56	30
2048	0.078	0.87	9583	696	2046	53,681	157	56	30
2049	0.078	0.87	9613	696	2052	55,733	158	56	30
2050	0.078	0.87	9639	696	2058	57,791	158	56	30

*Table 4.6. Red snapper: Projection results under scenario H4—fishing mortality rate $F = 85\%F_{40\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $SSB_{F_{40\%}} = 8102.5$ mt, $R_{F_{40\%}} = 692,864$ fish, $Y_{F_{40\%}} = 2,303,676$ lb, and $D_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.088	0	187	285	50	1464	11	19	12
2011	0.088	0	411	306	88	1552	18	25	14
2012	0.088	0	622	445	139	1691	25	28	16
2013	0.088	0	886	510	201	1892	33	35	21
2014	0.088	0	1212	558	277	2169	43	43	24
2015	0.088	0	1595	593	369	2538	54	48	27
2016	0.088	0	2021	618	474	3012	65	52	28
2017	0.088	0	2478	636	586	3597	75	55	30
2018	0.088	0	2951	649	702	4299	85	57	31
2019	0.088	0	3429	659	819	5118	94	58	31
2020	0.088	0	3899	666	934	6052	102	59	32
2021	0.088	0	4355	671	1046	7098	110	60	32
2022	0.088	0.01	4790	676	1152	8250	116	60	32
2023	0.088	0.02	5199	679	1252	9502	122	61	33
2024	0.088	0.04	5581	682	1345	10,848	128	61	33
2025	0.088	0.07	5935	684	1431	12,279	133	61	33
2026	0.088	0.09	6259	685	1511	13,790	137	62	33
2027	0.088	0.13	6556	687	1583	15,372	141	62	33
2028	0.088	0.17	6825	688	1648	17,020	144	62	33
2029	0.088	0.21	7069	689	1707	18,728	147	62	33
2030	0.088	0.27	7289	690	1761	20,489	150	62	33
2031	0.088	0.32	7486	691	1809	22,298	152	62	33
2032	0.088	0.37	7663	691	1852	24,150	154	62	33
2033	0.088	0.41	7822	692	1890	26,040	156	62	33
2034	0.088	0.46	7963	692	1925	27,965	158	62	33
2035	0.088	0.51	8089	693	1956	29,921	159	62	33
2036	0.088	0.53	8202	693	1983	31,903	161	62	33
2037	0.088	0.56	8302	693	2007	33,911	162	63	33
2038	0.088	0.59	8391	693	2029	35,939	163	63	33
2039	0.088	0.62	8470	694	2048	37,987	164	63	33
2040	0.088	0.64	8540	694	2065	40,052	165	63	33
2041	0.088	0.66	8603	694	2080	42,133	165	63	33
2042	0.088	0.67	8658	694	2094	44,226	166	63	33
2043	0.088	0.68	8707	694	2106	46,332	167	63	33
2044	0.088	0.69	8751	694	2116	48,448	167	63	33
2045	0.088	0.71	8790	694	2126	50,574	168	63	33
2046	0.088	0.71	8824	694	2134	52,708	168	63	33
2047	0.088	0.72	8855	695	2141	54,850	168	63	33
2048	0.088	0.73	8882	695	2148	56,998	169	63	33
2049	0.088	0.74	8906	695	2154	59,152	169	63	33
2050	0.088	0.74	8927	695	2159	61,311	169	63	33

*Table 4.7. Red snapper: Projection results under scenario H5—fishing mortality rate $F = F_{40\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $SSB_{F_{40\%}} = 8102.5$ mt, $R_{F_{40\%}} = 692,864$ fish, $Y_{F_{40\%}} = 2,303,676$ lb, and $D_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.104	0	187	285	59	1473	13	23	14
2011	0.104	0	405	306	102	1574	21	29	16
2012	0.104	0	609	442	160	1734	29	32	19
2013	0.104	0	861	507	230	1964	38	40	24
2014	0.104	0	1172	554	315	2278	49	50	28
2015	0.104	0	1533	589	417	2696	61	56	31
2016	0.104	0	1933	614	532	3228	73	60	33
2017	0.104	0	2359	633	655	3882	85	63	35
2018	0.104	0	2798	646	781	4664	96	66	36
2019	0.104	0	3238	656	908	5572	106	67	36
2020	0.104	0	3668	663	1033	6604	115	68	37
2021	0.104	0	4082	669	1152	7757	123	69	37
2022	0.104	0	4475	673	1265	9021	130	70	38
2023	0.104	0.01	4842	677	1370	10,392	136	70	38
2024	0.104	0.02	5182	679	1468	11,860	142	71	38
2025	0.104	0.03	5494	681	1557	13,417	147	71	38
2026	0.104	0.05	5779	683	1639	15,056	152	71	38
2027	0.104	0.07	6037	685	1713	16,769	156	72	38
2028	0.104	0.09	6270	686	1780	18,549	159	72	39
2029	0.104	0.11	6479	687	1839	20,388	162	72	39
2030	0.104	0.14	6666	688	1893	22,281	165	72	39
2031	0.104	0.17	6833	688	1941	24,222	167	72	39
2032	0.104	0.19	6982	689	1983	26,206	169	72	39
2033	0.104	0.21	7114	690	2021	28,227	171	72	39
2034	0.104	0.24	7231	690	2054	30,281	173	72	39
2035	0.104	0.27	7334	690	2084	32,365	174	72	39
2036	0.104	0.3	7426	691	2110	34,475	176	72	39
2037	0.104	0.32	7506	691	2133	36,608	177	72	39
2038	0.104	0.33	7578	691	2154	38,762	178	73	39
2039	0.104	0.35	7640	691	2172	40,933	179	73	39
2040	0.104	0.37	7696	692	2187	43,121	179	73	39
2041	0.104	0.4	7745	692	2201	45,322	180	73	39
2042	0.104	0.42	7788	692	2214	47,536	181	73	39
2043	0.104	0.43	7826	692	2224	49,760	181	73	39
2044	0.104	0.44	7859	692	2234	51,994	182	73	39
2045	0.104	0.44	7888	692	2242	54,237	182	73	39
2046	0.104	0.45	7914	692	2250	56,487	182	73	39
2047	0.104	0.45	7937	692	2256	58,743	183	73	39
2048	0.104	0.45	7957	692	2262	61,005	183	73	39
2049	0.104	0.45	7974	692	2267	63,272	183	73	39
2050	0.104	0.45	7990	693	2271	65,543	183	73	39

*Table 4.8. Red snapper: Projection results under scenario D1—fishing mortality rate $F = F_{\text{current}}$ (minus F associated with commercial diving). F = fishing rate (per year), Fmort = fishing rate (per year) as the portion of F that leads to (discard) mortality, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\text{SSB}_{F_{40\%}} = 8102.5$ mt, $\text{R}_{F_{40\%}} = 692,864$ fish, $\text{Y}_{F_{40\%}} = 2,303,676$ lb, and $\text{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Fmort	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.930	0.930	0	203	286	454	454	95	153	99
2008	1.220	1.220	0	205	321	553	1007	117	190	129
2009	0.974	0.974	0	165	322	407	1414	91	157	109
2010	0.958	0.691	0	187	285	0	1414	0	421	163
2011	0.958	0.691	0	258	306	0	1414	0	495	174
2012	0.958	0.691	0	302	364	0	1414	0	563	191
2013	0.958	0.691	0	345	391	0	1414	0	643	214
2014	0.958	0.691	0	388	415	0	1414	0	722	234
2015	0.958	0.691	0	431	435	0	1414	0	796	251
2016	0.958	0.691	0	473	453	0	1414	0	865	266
2017	0.958	0.691	0	511	468	0	1414	0	929	279
2018	0.958	0.691	0	546	480	0	1414	0	988	291
2019	0.958	0.691	0	578	491	0	1414	0	1040	301
2020	0.958	0.691	0	605	499	0	1414	0	1086	309
2021	0.958	0.691	0	630	506	0	1414	0	1126	316
2022	0.958	0.691	0	651	512	0	1414	0	1161	322
2023	0.958	0.691	0	669	517	0	1414	0	1191	327
2024	0.958	0.691	0	685	521	0	1414	0	1216	331
2025	0.958	0.691	0	698	524	0	1414	0	1237	334
2026	0.958	0.691	0	709	527	0	1414	0	1255	337
2027	0.958	0.691	0	719	529	0	1414	0	1270	340
2028	0.958	0.691	0	726	531	0	1414	0	1283	341
2029	0.958	0.691	0	733	532	0	1414	0	1293	343
2030	0.958	0.691	0	738	533	0	1414	0	1302	344
2031	0.958	0.691	0	743	534	0	1414	0	1309	345
2032	0.958	0.691	0	746	535	0	1414	0	1315	346
2033	0.958	0.691	0	749	536	0	1414	0	1320	347
2034	0.958	0.691	0	752	536	0	1414	0	1324	348
2035	0.958	0.691	0	754	537	0	1414	0	1327	348
2036	0.958	0.691	0	756	537	0	1414	0	1330	348
2037	0.958	0.691	0	757	537	0	1414	0	1332	349
2038	0.958	0.691	0	758	538	0	1414	0	1334	349
2039	0.958	0.691	0	759	538	0	1414	0	1335	349
2040	0.958	0.691	0	760	538	0	1414	0	1337	349
2041	0.958	0.691	0	760	538	0	1414	0	1338	350
2042	0.958	0.691	0	761	538	0	1414	0	1338	350
2043	0.958	0.691	0	761	538	0	1414	0	1339	350
2044	0.958	0.691	0	762	538	0	1414	0	1340	350
2045	0.958	0.691	0	762	538	0	1414	0	1340	350
2046	0.958	0.691	0	762	538	0	1414	0	1341	350
2047	0.958	0.691	0	762	538	0	1414	0	1341	350
2048	0.958	0.691	0	763	539	0	1414	0	1341	350
2049	0.958	0.691	0	763	539	0	1414	0	1341	350
2050	0.958	0.691	0	763	539	0	1414	0	1341	350

*Table 4.9. Red snapper: Projection results under scenario D2—fishing mortality rate $F = 65\%F_{40\%}$. F = fishing rate (per year), Fmort = fishing rate (per year) as the portion of F that leads to (discard) mortality, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Fmort	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.930	0.930	0.00	203	286	454	454	95	153	99
2008	1.220	1.220	0.00	205	321	553	1007	117	190	129
2009	0.974	0.974	0.00	165	322	407	1414	91	157	109
2010	0.068	0.049	0.00	187	285	0	1414	0	35	13
2011	0.068	0.049	0.00	427	306	0	1414	0	56	18
2012	0.068	0.049	0.00	661	451	0	1414	0	82	23
2013	0.068	0.049	0.00	961	519	0	1414	0	118	30
2014	0.068	0.049	0.00	1338	567	0	1414	0	161	38
2015	0.068	0.049	0.00	1789	602	0	1414	0	211	45
2016	0.068	0.049	0.00	2302	627	0	1414	0	267	51
2017	0.068	0.049	0.00	2864	645	0	1414	0	328	57
2018	0.068	0.049	0.00	3458	657	0	1414	0	391	63
2019	0.068	0.049	0.00	4070	666	0	1414	0	457	68
2020	0.068	0.049	0.01	4688	673	0	1414	0	522	73
2021	0.068	0.049	0.03	5299	678	0	1414	0	587	78
2022	0.068	0.049	0.07	5896	682	0	1414	0	651	82
2023	0.068	0.049	0.14	6473	685	0	1414	0	712	85
2024	0.068	0.049	0.22	7023	688	0	1414	0	770	89
2025	0.068	0.049	0.34	7545	690	0	1414	0	825	92
2026	0.068	0.049	0.46	8036	691	0	1414	0	877	94
2027	0.068	0.049	0.58	8496	693	0	1414	0	926	97
2028	0.068	0.049	0.69	8924	694	0	1414	0	971	99
2029	0.068	0.049	0.77	9322	695	0	1414	0	1013	101
2030	0.068	0.049	0.85	9690	696	0	1414	0	1052	103
2031	0.068	0.049	0.89	10,029	696	0	1414	0	1088	105
2032	0.068	0.049	0.93	10,341	697	0	1414	0	1121	107
2033	0.068	0.049	0.95	10,627	697	0	1414	0	1151	108
2034	0.068	0.049	0.97	10,890	698	0	1414	0	1179	110
2035	0.068	0.049	0.98	11,131	698	0	1414	0	1205	111
2036	0.068	0.049	0.99	11,350	699	0	1414	0	1228	112
2037	0.068	0.049	0.99	11,552	699	0	1414	0	1249	113
2038	0.068	0.049	0.99	11,735	699	0	1414	0	1268	114
2039	0.068	0.049	1.00	11,903	699	0	1414	0	1286	115
2040	0.068	0.049	1.00	12,056	700	0	1414	0	1302	115
2041	0.068	0.049	1.00	12,196	700	0	1414	0	1317	116
2042	0.068	0.049	1.00	12,323	700	0	1414	0	1331	117
2043	0.068	0.049	1.00	12,440	700	0	1414	0	1343	117
2044	0.068	0.049	1.00	12,545	700	0	1414	0	1354	118
2045	0.068	0.049	1.00	12,642	700	0	1414	0	1364	118
2046	0.068	0.049	1.00	12,730	700	0	1414	0	1374	119
2047	0.068	0.049	1.00	12,811	700	0	1414	0	1382	119
2048	0.068	0.049	1.00	12,884	701	0	1414	0	1390	120
2049	0.068	0.049	1.00	12,950	701	0	1414	0	1397	120
2050	0.068	0.049	1.00	13,011	701	0	1414	0	1403	120

*Table 4.10. Red snapper: Projection results under scenario D3—fishing mortality rate $F = 75\%F_{40\%}$. F = fishing rate (per year), Fmort = fishing rate (per year) as the portion of F that leads to (discard) mortality, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Fmort	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.930	0.930	0.00	203	286	454	454	95	153	99
2008	1.220	1.220	0.00	205	321	553	1007	117	190	129
2009	0.974	0.974	0.00	165	322	407	1414	91	157	109
2010	0.078	0.056	0.00	187	285	0	1414	0	40	16
2011	0.078	0.056	0.00	424	306	0	1414	0	65	20
2012	0.078	0.056	0.00	655	450	0	1414	0	94	27
2013	0.078	0.056	0.00	949	518	0	1414	0	134	35
2014	0.078	0.056	0.00	1318	566	0	1414	0	183	43
2015	0.078	0.056	0.00	1759	601	0	1414	0	240	51
2016	0.078	0.056	0.00	2258	626	0	1414	0	303	59
2017	0.078	0.056	0.00	2804	643	0	1414	0	371	65
2018	0.078	0.056	0.00	3379	656	0	1414	0	442	72
2019	0.078	0.056	0.00	3971	665	0	1414	0	515	78
2020	0.078	0.056	0.01	4566	672	0	1414	0	588	83
2021	0.078	0.056	0.02	5154	677	0	1414	0	660	88
2022	0.078	0.056	0.06	5726	681	0	1414	0	730	92
2023	0.078	0.056	0.11	6277	684	0	1414	0	797	97
2024	0.078	0.056	0.18	6802	687	0	1414	0	861	100
2025	0.078	0.056	0.28	7298	689	0	1414	0	922	104
2026	0.078	0.056	0.39	7763	691	0	1414	0	979	107
2027	0.078	0.056	0.51	8198	692	0	1414	0	1032	109
2028	0.078	0.056	0.61	8601	693	0	1414	0	1081	112
2029	0.078	0.056	0.70	8975	694	0	1414	0	1127	114
2030	0.078	0.056	0.79	9319	695	0	1414	0	1169	116
2031	0.078	0.056	0.85	9636	696	0	1414	0	1207	118
2032	0.078	0.056	0.89	9926	696	0	1414	0	1243	120
2033	0.078	0.056	0.92	10,192	697	0	1414	0	1275	122
2034	0.078	0.056	0.94	10,435	697	0	1414	0	1305	123
2035	0.078	0.056	0.96	10,656	698	0	1414	0	1332	124
2036	0.078	0.056	0.97	10,858	698	0	1414	0	1356	126
2037	0.078	0.056	0.98	11,043	698	0	1414	0	1379	127
2038	0.078	0.056	0.98	11,210	698	0	1414	0	1399	128
2039	0.078	0.056	0.99	11,363	699	0	1414	0	1418	128
2040	0.078	0.056	0.99	11,502	699	0	1414	0	1435	129
2041	0.078	0.056	0.99	11,628	699	0	1414	0	1450	130
2042	0.078	0.056	1.00	11,743	699	0	1414	0	1464	131
2043	0.078	0.056	1.00	11,847	699	0	1414	0	1477	131
2044	0.078	0.056	1.00	11,942	699	0	1414	0	1489	132
2045	0.078	0.056	1.00	12,028	700	0	1414	0	1499	132
2046	0.078	0.056	1.00	12,107	700	0	1414	0	1509	133
2047	0.078	0.056	1.00	12,178	700	0	1414	0	1517	133
2048	0.078	0.056	1.00	12,243	700	0	1414	0	1525	134
2049	0.078	0.056	1.00	12,301	700	0	1414	0	1533	134
2050	0.078	0.056	1.00	12,355	700	0	1414	0	1539	134

*Table 4.11. Red snapper: Projection results under scenario D4—fishing mortality rate $F = 85\%F_{40\%}$. F = fishing rate (per year), Fmort = fishing rate (per year) as the portion of F that leads to (discard) mortality, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Fmort	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.930	0.930	0.00	203	286	454	454	95	153	99
2008	1.220	1.220	0.00	205	321	553	1007	117	190	129
2009	0.974	0.974	0.00	165	322	407	1414	91	157	109
2010	0.088	0.064	0.00	187	285	0	1414	0	46	18
2011	0.088	0.064	0.00	422	306	0	1414	0	73	23
2012	0.088	0.064	0.00	649	449	0	1414	0	106	30
2013	0.088	0.064	0.00	938	516	0	1414	0	150	39
2014	0.088	0.064	0.00	1299	564	0	1414	0	205	48
2015	0.088	0.064	0.00	1729	599	0	1414	0	267	57
2016	0.088	0.064	0.00	2215	624	0	1414	0	337	66
2017	0.088	0.064	0.00	2745	642	0	1414	0	412	73
2018	0.088	0.064	0.00	3302	655	0	1414	0	490	80
2019	0.088	0.064	0.00	3874	664	0	1414	0	570	87
2020	0.088	0.064	0.01	4448	671	0	1414	0	649	93
2021	0.088	0.064	0.02	5013	676	0	1414	0	728	98
2022	0.088	0.064	0.05	5562	680	0	1414	0	804	103
2023	0.088	0.064	0.09	6088	684	0	1414	0	877	107
2024	0.088	0.064	0.15	6588	686	0	1414	0	946	111
2025	0.088	0.064	0.23	7060	688	0	1414	0	1012	115
2026	0.088	0.064	0.32	7501	690	0	1414	0	1073	118
2027	0.088	0.064	0.43	7912	691	0	1414	0	1130	121
2028	0.088	0.064	0.54	8292	692	0	1414	0	1182	124
2029	0.088	0.064	0.63	8643	693	0	1414	0	1231	127
2030	0.088	0.064	0.71	8965	694	0	1414	0	1275	129
2031	0.088	0.064	0.78	9261	695	0	1414	0	1316	131
2032	0.088	0.064	0.84	9531	695	0	1414	0	1354	133
2033	0.088	0.064	0.87	9778	696	0	1414	0	1388	134
2034	0.088	0.064	0.91	10,002	696	0	1414	0	1419	136
2035	0.088	0.064	0.93	10,207	697	0	1414	0	1447	137
2036	0.088	0.064	0.94	10,393	697	0	1414	0	1473	138
2037	0.088	0.064	0.96	10,561	697	0	1414	0	1496	140
2038	0.088	0.064	0.97	10,714	698	0	1414	0	1517	141
2039	0.088	0.064	0.98	10,853	698	0	1414	0	1537	141
2040	0.088	0.064	0.98	10,979	698	0	1414	0	1554	142
2041	0.088	0.064	0.98	11,094	698	0	1414	0	1570	143
2042	0.088	0.064	0.99	11,197	698	0	1414	0	1584	144
2043	0.088	0.064	0.99	11,291	699	0	1414	0	1597	144
2044	0.088	0.064	0.99	11,376	699	0	1414	0	1609	145
2045	0.088	0.064	0.99	11,453	699	0	1414	0	1619	145
2046	0.088	0.064	0.99	11,523	699	0	1414	0	1629	146
2047	0.088	0.064	0.99	11,586	699	0	1414	0	1638	146
2048	0.088	0.064	1.00	11,643	699	0	1414	0	1646	147
2049	0.088	0.064	1.00	11,695	699	0	1414	0	1653	147
2050	0.088	0.064	1.00	11,742	699	0	1414	0	1659	147

*Table 4.12. Red snapper: Projection results under scenario D5—fishing mortality rate $F = F_{40\%}$. F = fishing rate (per year), Fmort = fishing rate (per year) as the portion of F that leads to (discard) mortality, Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Fmort	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.930	0.930	0.00	203	286	454	454	95	153	99
2008	1.220	1.220	0.00	205	321	553	1007	117	190	129
2009	0.974	0.974	0.00	165	322	407	1414	91	157	109
2010	0.104	0.075	0.00	187	285	0	1414	0	54	21
2011	0.104	0.075	0.00	418	306	0	1414	0	85	27
2012	0.104	0.075	0.00	640	448	0	1414	0	123	35
2013	0.104	0.075	0.00	921	514	0	1414	0	174	45
2014	0.104	0.075	0.00	1270	562	0	1414	0	236	56
2015	0.104	0.075	0.00	1685	597	0	1414	0	307	66
2016	0.104	0.075	0.00	2152	622	0	1414	0	386	76
2017	0.104	0.075	0.00	2659	640	0	1414	0	470	84
2018	0.104	0.075	0.00	3191	653	0	1414	0	558	92
2019	0.104	0.075	0.00	3734	663	0	1414	0	647	100
2020	0.104	0.075	0.00	4277	670	0	1414	0	736	106
2021	0.104	0.075	0.01	4809	675	0	1414	0	823	112
2022	0.104	0.075	0.03	5325	679	0	1414	0	907	118
2023	0.104	0.075	0.06	5817	682	0	1414	0	987	123
2024	0.104	0.075	0.11	6283	685	0	1414	0	1063	127
2025	0.104	0.075	0.16	6720	687	0	1414	0	1134	131
2026	0.104	0.075	0.24	7127	689	0	1414	0	1201	135
2027	0.104	0.075	0.32	7504	690	0	1414	0	1262	138
2028	0.104	0.075	0.42	7852	691	0	1414	0	1319	141
2029	0.104	0.075	0.50	8172	692	0	1414	0	1371	144
2030	0.104	0.075	0.59	8464	693	0	1414	0	1419	146
2031	0.104	0.075	0.66	8731	694	0	1414	0	1462	148
2032	0.104	0.075	0.73	8974	694	0	1414	0	1502	150
2033	0.104	0.075	0.78	9195	695	0	1414	0	1537	152
2034	0.104	0.075	0.83	9395	695	0	1414	0	1570	154
2035	0.104	0.075	0.86	9576	696	0	1414	0	1600	155
2036	0.104	0.075	0.88	9740	696	0	1414	0	1626	156
2037	0.104	0.075	0.90	9888	696	0	1414	0	1650	158
2038	0.104	0.075	0.92	10,022	697	0	1414	0	1672	159
2039	0.104	0.075	0.93	10,143	697	0	1414	0	1692	160
2040	0.104	0.075	0.94	10,252	697	0	1414	0	1709	160
2041	0.104	0.075	0.95	10,350	697	0	1414	0	1725	161
2042	0.104	0.075	0.96	10,439	697	0	1414	0	1740	162
2043	0.104	0.075	0.96	10,519	698	0	1414	0	1753	162
2044	0.104	0.075	0.97	10,591	698	0	1414	0	1765	163
2045	0.104	0.075	0.97	10,656	698	0	1414	0	1775	163
2046	0.104	0.075	0.98	10,715	698	0	1414	0	1785	164
2047	0.104	0.075	0.98	10,767	698	0	1414	0	1793	164
2048	0.104	0.075	0.98	10,815	698	0	1414	0	1801	165
2049	0.104	0.075	0.98	10,858	698	0	1414	0	1808	165
2050	0.104	0.075	0.98	10,896	698	0	1414	0	1814	165

*Table 4.13. Red snapper: Projection results under scenario P0-alt—fishing mortality rate $F = 0$. This scenario differs from P0 by using preliminary estimates of 2008 recreational landings from MRFSS. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	4.98	0	205	321	1000	1454	218	383	304
2009	1.291	0	14	322	75	1529	29	89	91
2010	0	0	58	37	0	1529	0	0	0
2011	0	0	187	136	0	1529	0	0	0
2012	0	0	307	307	0	1529	0	0	0
2013	0	0	478	395	0	1529	0	0	0
2014	0	0	732	470	0	1529	0	0	0
2015	0	0	1082	533	0	1529	0	0	0
2016	0	0	1530	581	0	1529	0	0	0
2017	0	0	2070	614	0	1529	0	0	0
2018	0	0	2691	638	0	1529	0	0	0
2019	0	0	3379	654	0	1529	0	0	0
2020	0	0	4116	665	0	1529	0	0	0
2021	0	0.02	4886	673	0	1529	0	0	0
2022	0	0.06	5674	680	0	1529	0	0	0
2023	0	0.15	6467	684	0	1529	0	0	0
2024	0	0.29	7254	688	0	1529	0	0	0
2025	0	0.46	8026	690	0	1529	0	0	0
2026	0	0.63	8778	693	0	1529	0	0	0

*Table 4.14. Red snapper: Projection results under scenario H3-alt—fishing mortality rate $F = 75\%F_{40\%}$. This scenario differs from H3 by using preliminary estimates of 2008 recreational landings from MRFSS. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $SSB_{F_{40\%}} = 8102.5$ mt, $R_{F_{40\%}} = 692,864$ fish, $Y_{F_{40\%}} = 2,303,676$ lb, and $D_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	4.98	0	205	321	1000	1454	218	383	304
2009	1.291	0	14	322	75	1529	29	89	91
2010	0.078	0	58	37	12	1541	5	12	6
2011	0.078	0	174	136	31	1572	7	12	5
2012	0.078	0	275	294	56	1628	10	8	7
2013	0.078	0	414	375	81	1709	14	18	12
2014	0.078	0	616	446	120	1828	21	27	16
2015	0.078	0	888	509	176	2005	29	33	19
2016	0.078	0	1227	558	248	2252	39	39	22
2017	0.078	0	1625	594	333	2585	48	43	24
2018	0.078	0	2071	619	428	3013	58	46	25
2019	0.078	0	2550	638	532	3545	68	49	26
2020	0.078	0	3048	651	640	4185	77	51	27
2021	0.078	0	3553	660	750	4934	85	52	28
2022	0.078	0	4053	667	858	5792	93	53	28
2023	0.078	0.01	4540	673	963	6755	100	53	29
2024	0.078	0.02	5006	677	1063	7818	106	54	29
2025	0.078	0.03	5447	680	1158	8977	112	54	29
2026	0.078	0.06	5861	683	1247	10,224	117	55	29
2027	0.078	0.09	6246	685	1330	11,554	122	55	29
2028	0.078	0.13	6601	687	1406	12,961	126	55	29
2029	0.078	0.19	6927	688	1476	14,437	129	55	29
2030	0.078	0.25	7224	689	1540	15,977	133	55	29
2031	0.078	0.32	7495	690	1598	17,576	136	55	29
2032	0.078	0.38	7740	691	1651	19,227	138	55	30
2033	0.078	0.44	7962	692	1699	20,925	141	55	30
2034	0.078	0.51	8162	693	1741	22,666	143	56	30
2035	0.078	0.56	8342	693	1780	24,446	145	56	30
2036	0.078	0.6	8503	693	1814	26,261	146	56	30
2037	0.078	0.66	8647	694	1845	28,106	148	56	30
2038	0.078	0.69	8777	694	1873	29,980	149	56	30
2039	0.078	0.73	8893	694	1898	31,878	150	56	30
2040	0.078	0.75	8996	695	1920	33,798	151	56	30
2041	0.078	0.77	9089	695	1940	35,738	152	56	30
2042	0.078	0.79	9172	695	1958	37,696	153	56	30
2043	0.078	0.8	9246	695	1974	39,670	154	56	30
2044	0.078	0.82	9312	695	1988	41,658	155	56	30
2045	0.078	0.82	9371	696	2001	43,658	155	56	30
2046	0.078	0.83	9423	696	2012	45,670	156	56	30
2047	0.078	0.85	9470	696	2022	47,692	156	56	30
2048	0.078	0.86	9512	696	2031	49,723	157	56	30
2049	0.078	0.86	9549	696	2039	51,761	157	56	30
2050	0.078	0.86	9582	696	2046	53,807	157	56	30

5 Figures

Figure 5.1. Regressions used to estimate 2008 headboat (top panel) and general recreational (bottom panel) landings, as used in the projections. The 2007 data (indicated) were not available in the assessment but were used in this regression. Predicted landings for 2008 are shown as filled circles.

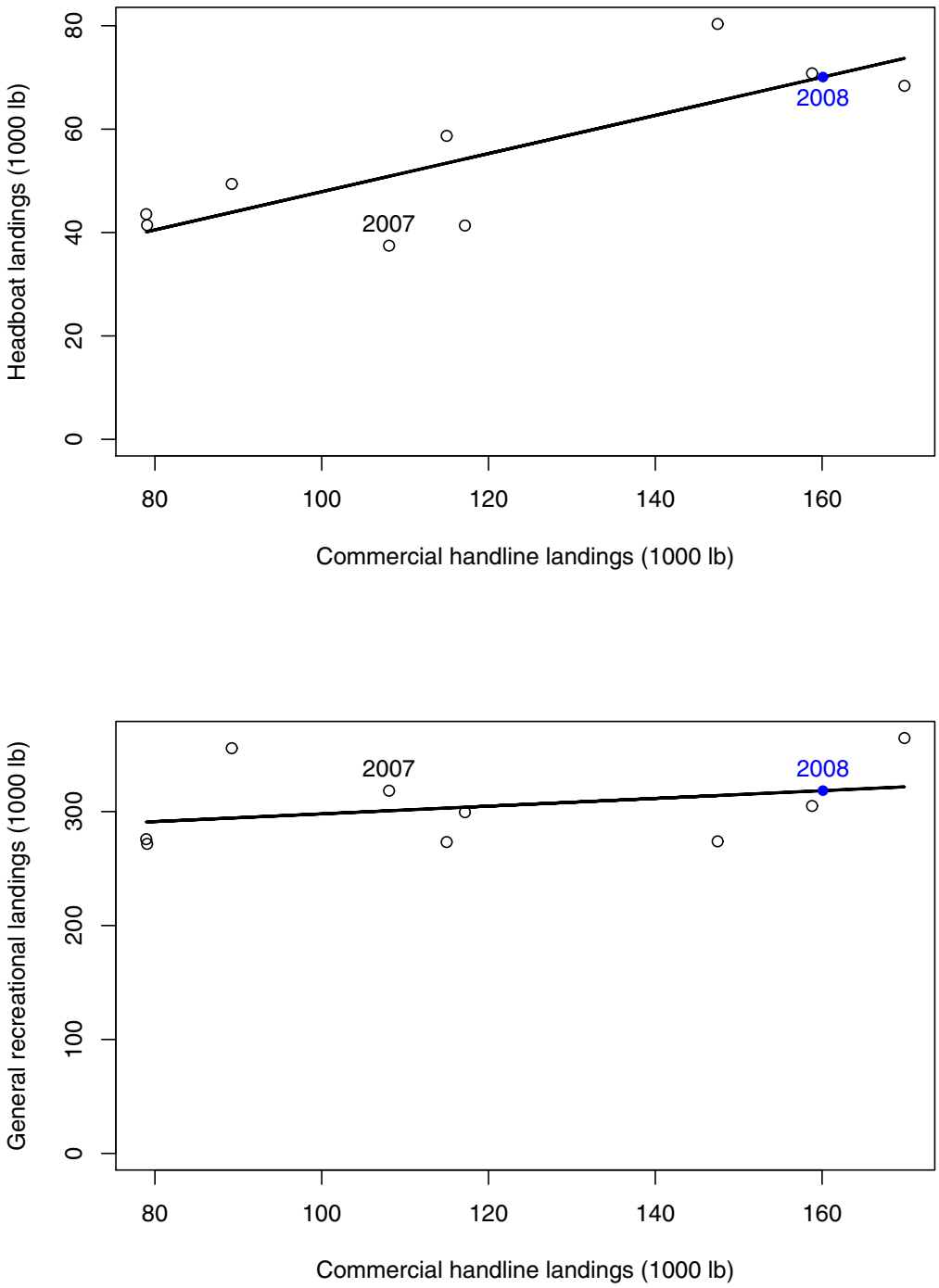


Figure 5.2. Projection results under scenario P0—fishing mortality rate fixed at $F = 0$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks.

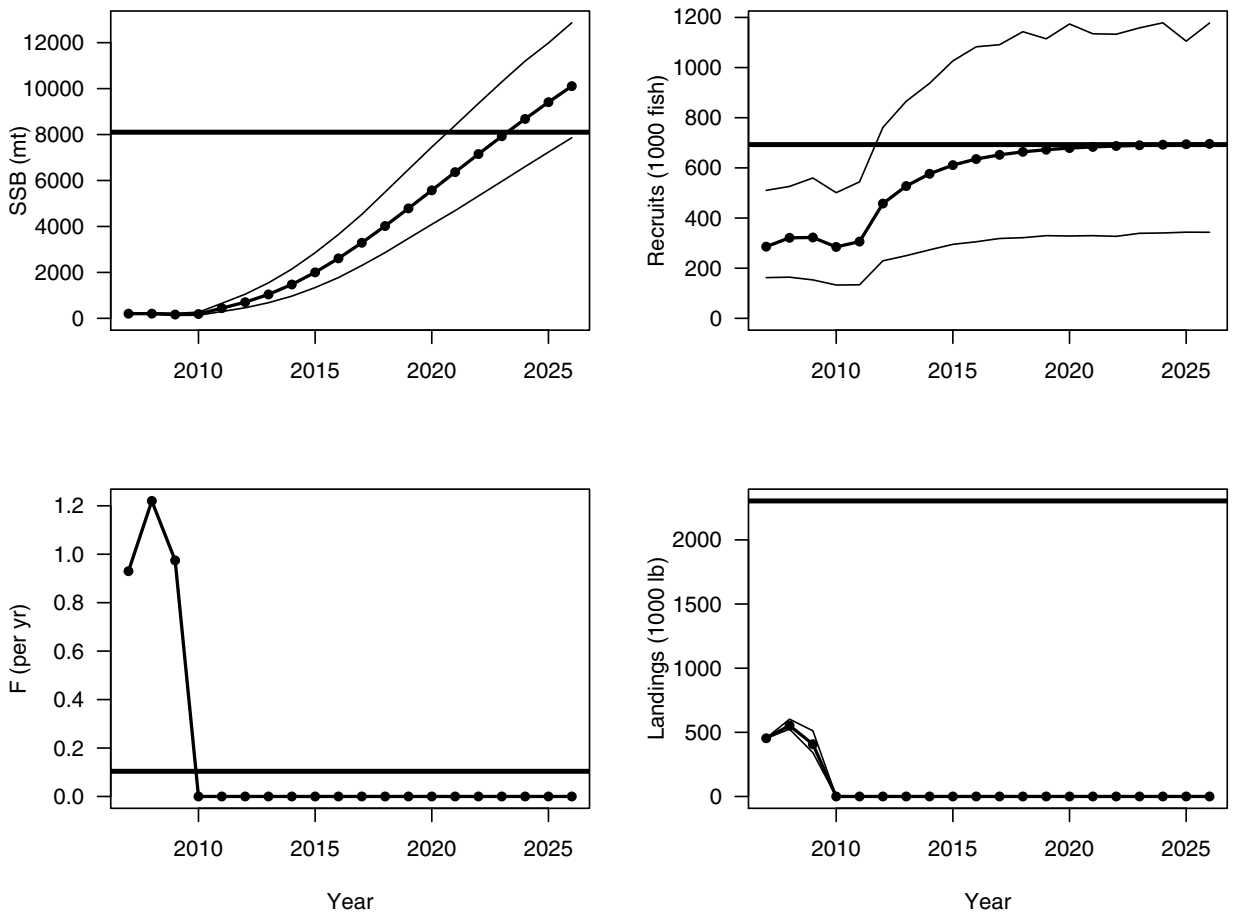


Figure 5.3. Projection results under scenario H1—fishing mortality rate fixed at $F = F_{\text{current}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks.

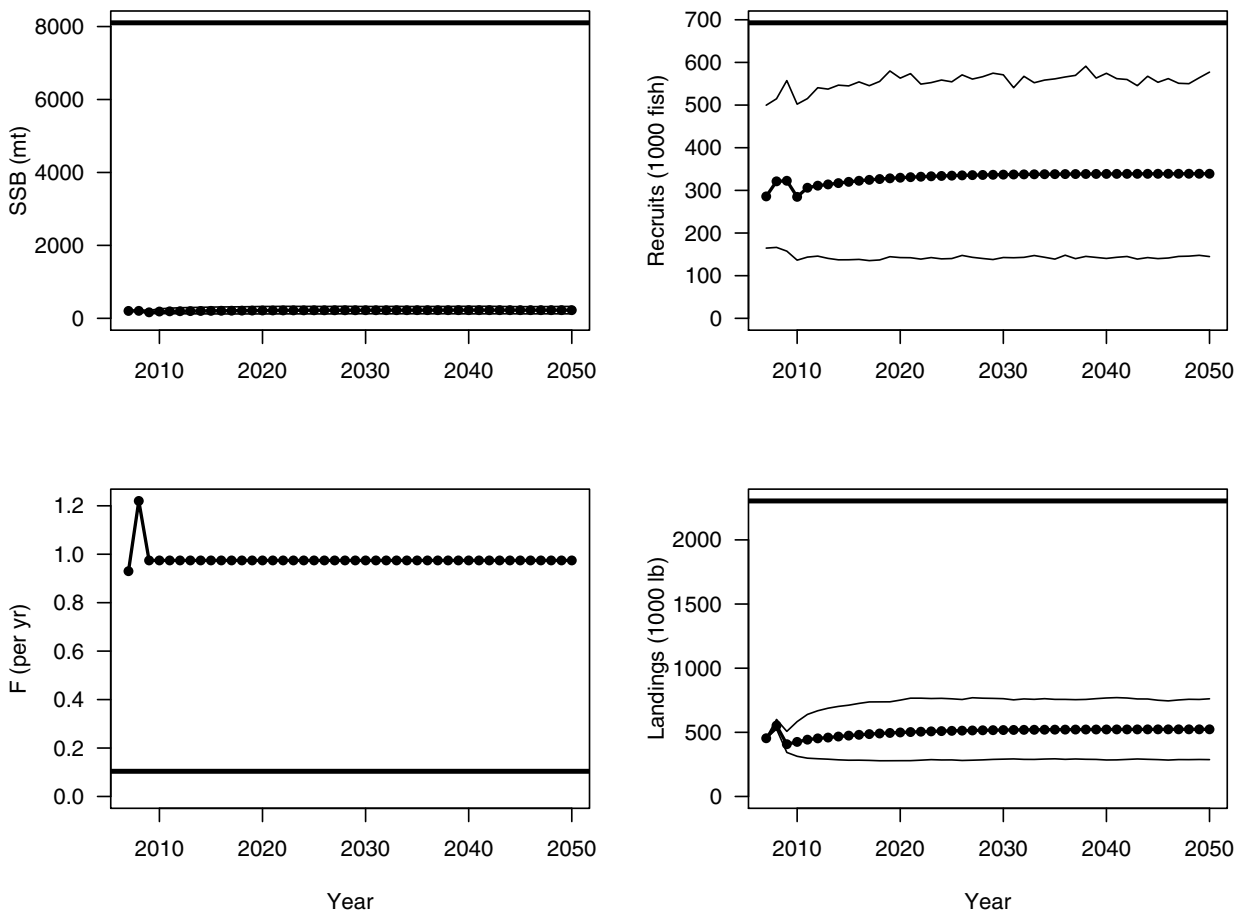


Figure 5.4. Projection results under scenario H2—fishing mortality rate fixed at $F = 65\% F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks.

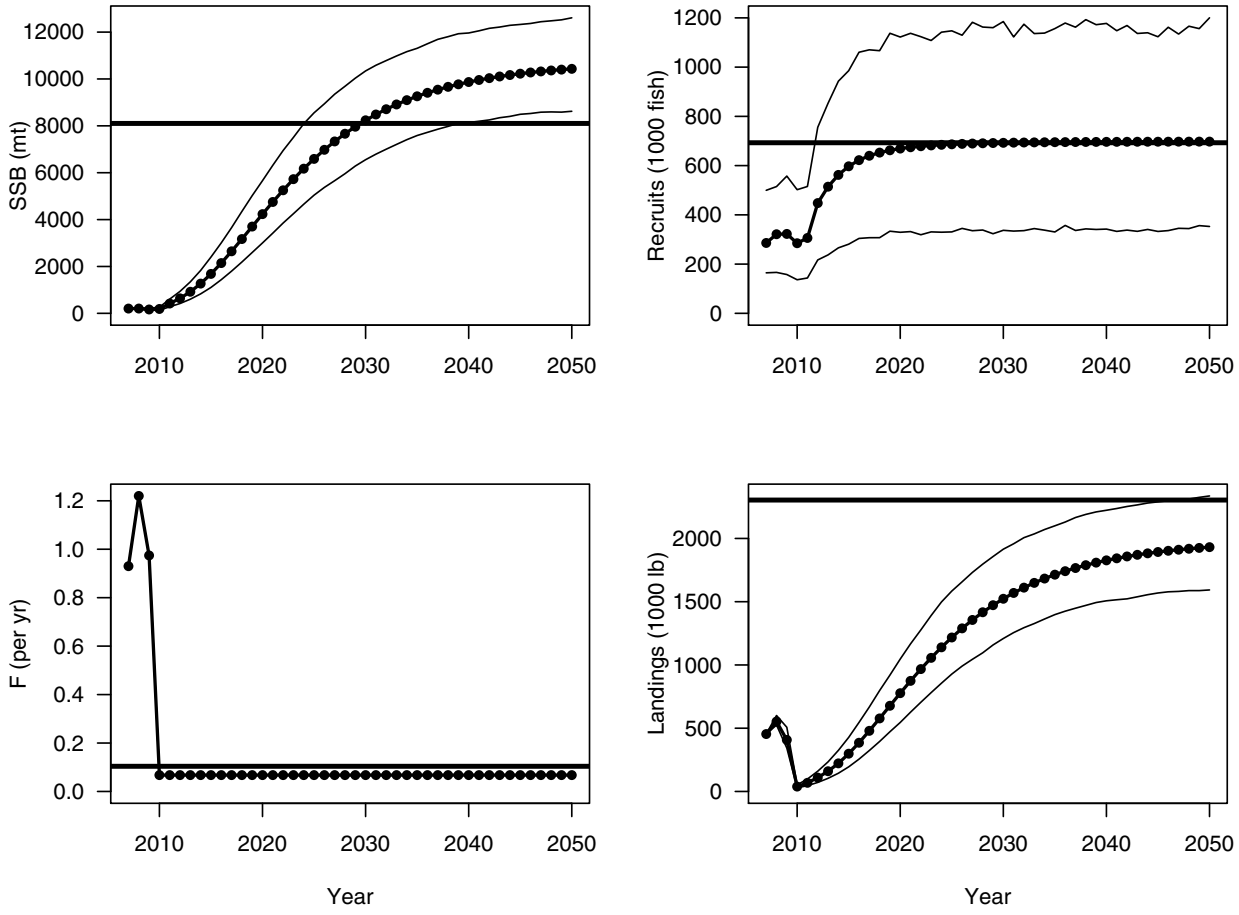


Figure 5.5. Projection results under scenario H3—fishing mortality rate fixed at $F = 75\% F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks.

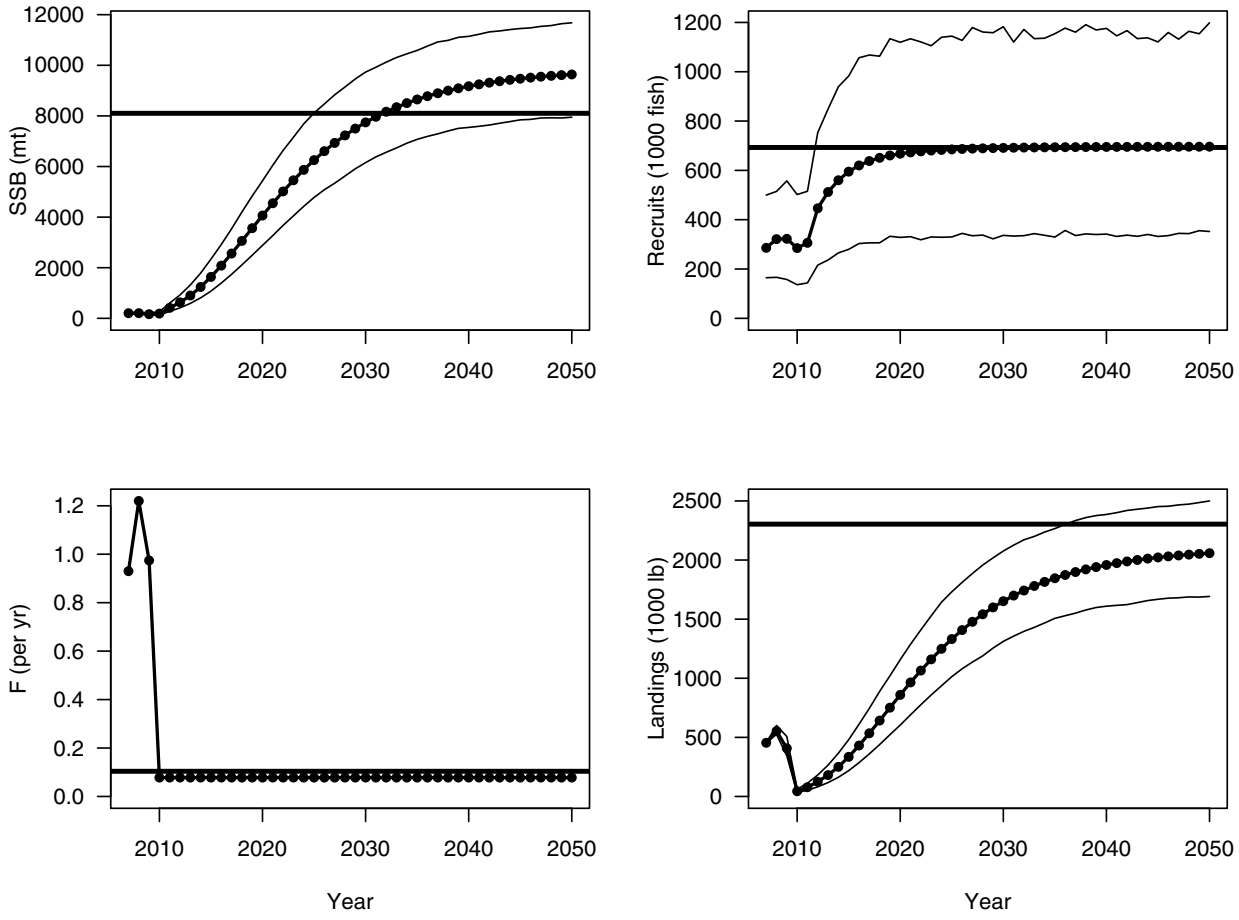


Figure 5.6. Projection results under scenario H4—fishing mortality rate fixed at $F = 85\% F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks.

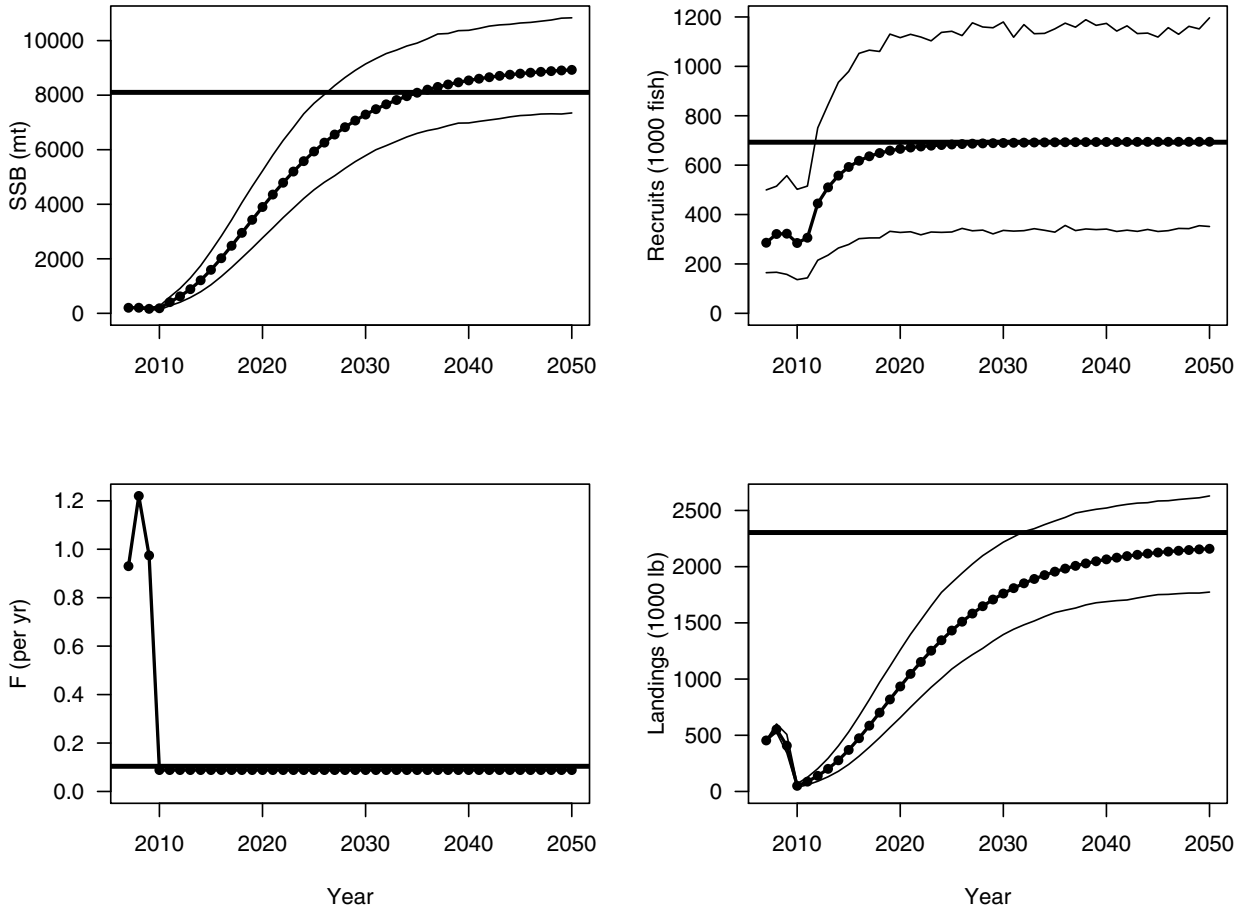


Figure 5.7. Projection results under scenario H5—fishing mortality rate fixed at $F = F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks.

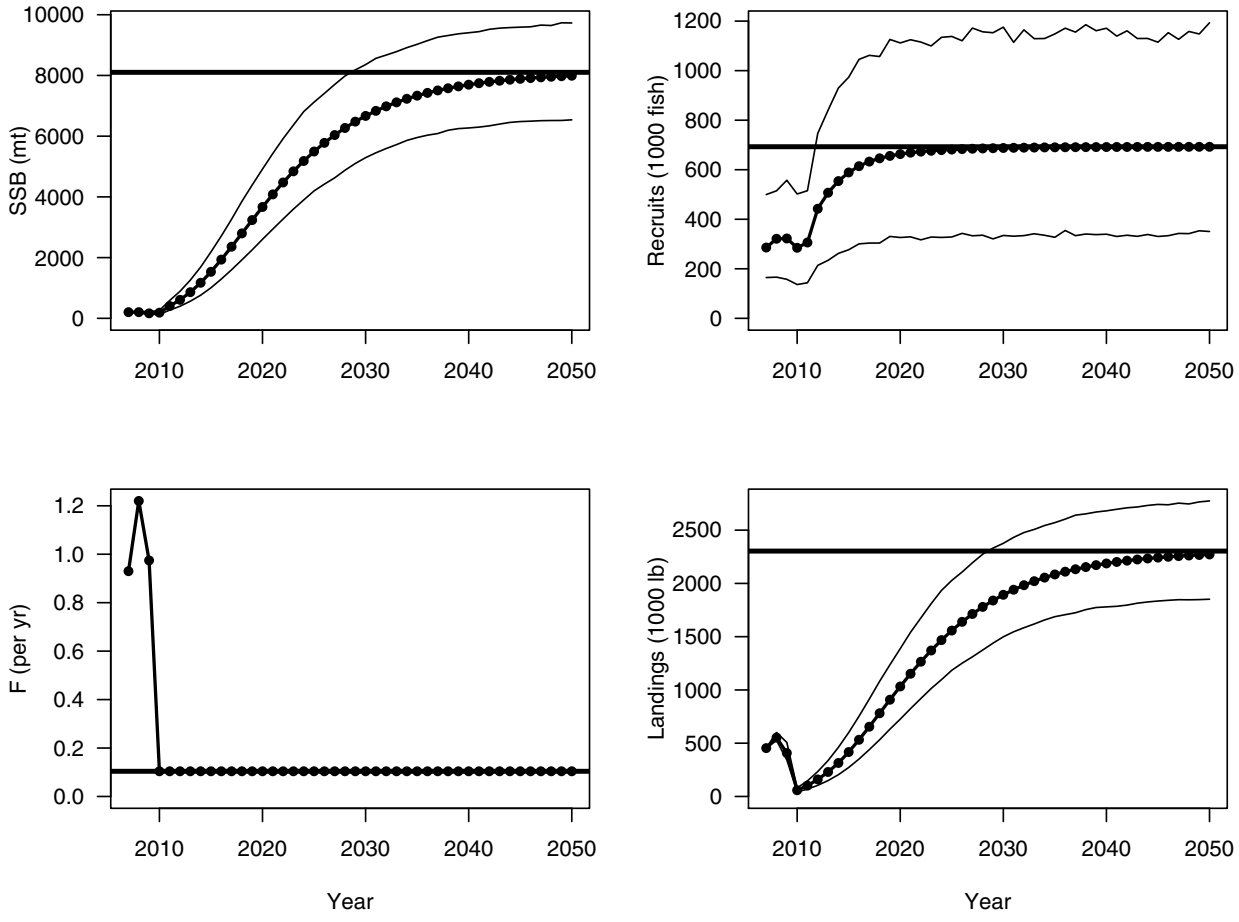


Figure 5.8. Projection results under scenario D1—Discard-only projection with fishing mortality rate fixed at $F = F_{\text{current}}$ (minus current F associated with commercial diving). Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks. In the F panel, the dashed horizontal line represents the fishing rate applied, of which only a portion, represented by the dotted solid line, contributes to (discard) mortality.

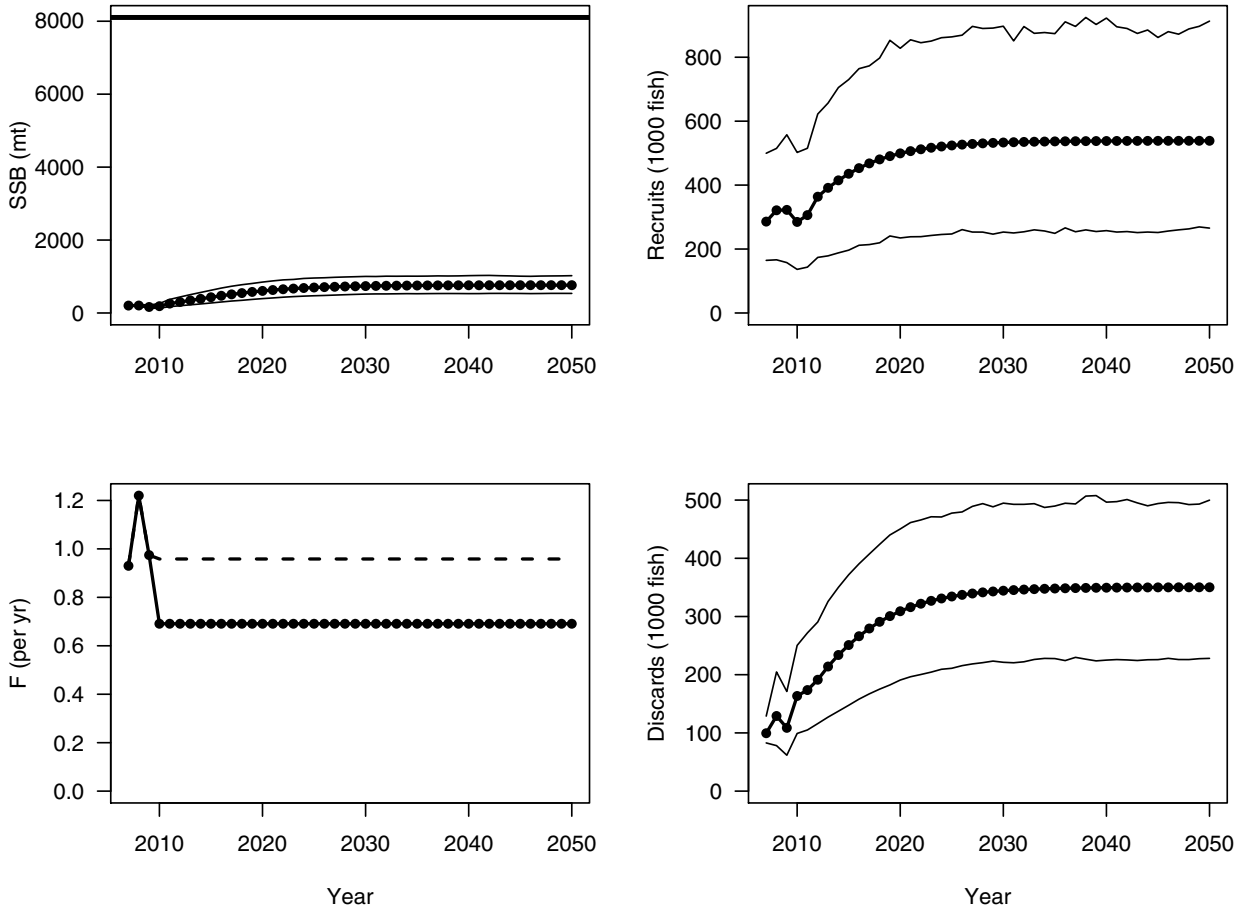


Figure 5.9. Projection results under scenario D2—Discard-only projection with fishing mortality rate fixed at $F = 65\%F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks. In the F panel, the dashed horizontal line represents the fishing rate applied, of which only a portion, represented by the dotted solid line, contributes to (discard) mortality.

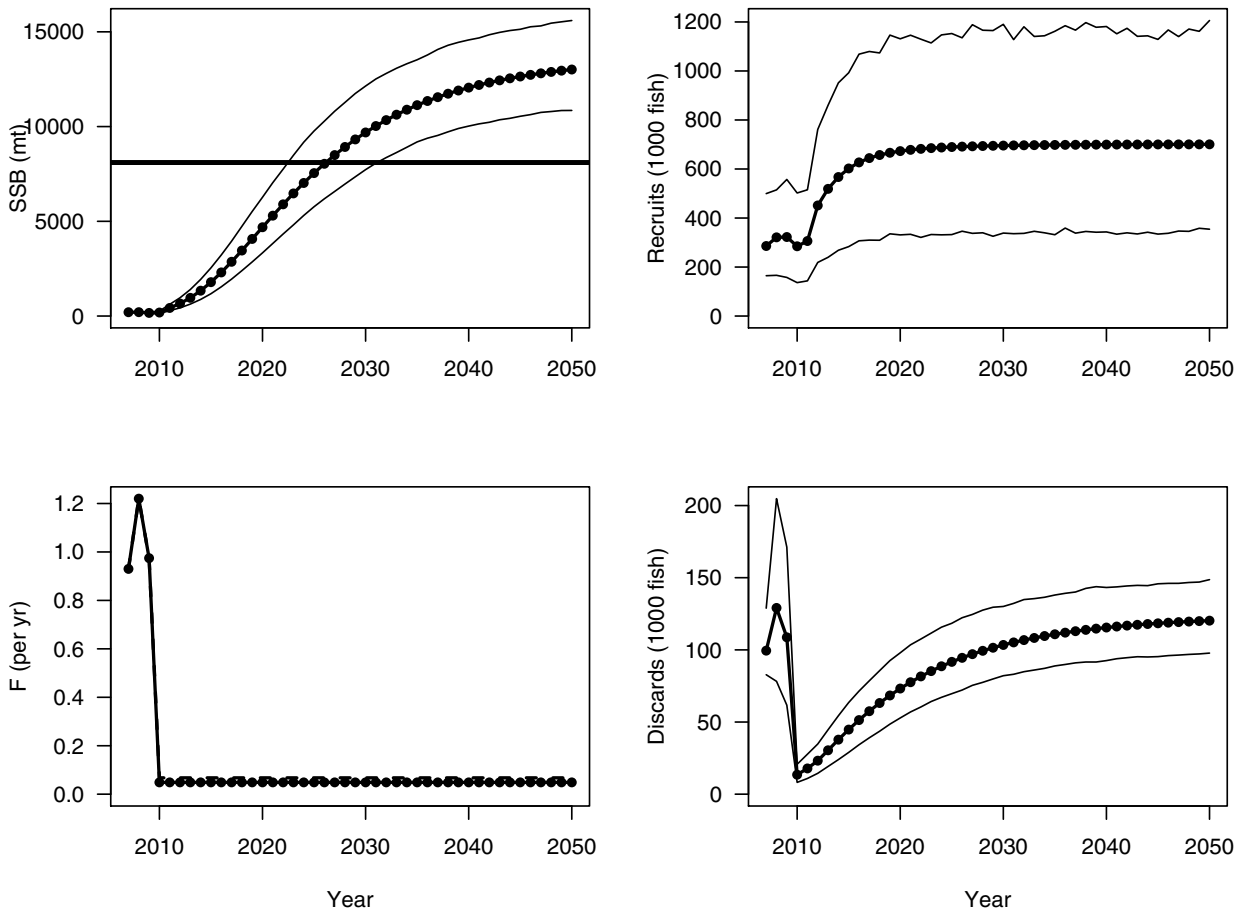


Figure 5.10. Projection results under scenario D3—Discard-only projection with fishing mortality rate fixed at $F = 75\%F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks. In the F panel, the dashed horizontal line represents the fishing rate applied, of which only a portion, represented by the dotted solid line, contributes to (discard) mortality.

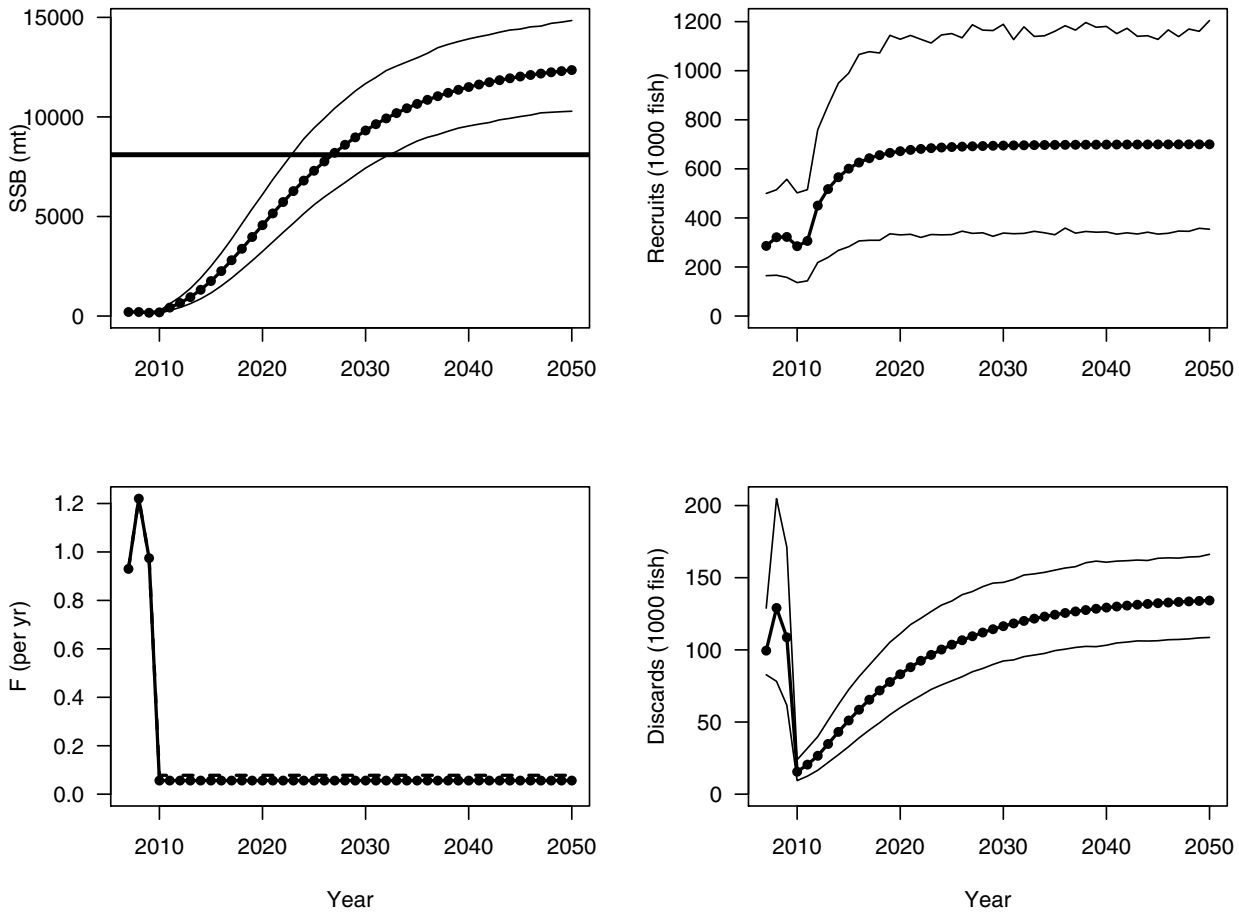


Figure 5.11. Projection results under scenario D4—Discard-only projection with fishing mortality rate fixed at $F = 85\% F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks. In the F panel, the dashed horizontal line represents the fishing rate applied, of which only a portion, represented by the dotted solid line, contributes to (discard) mortality.

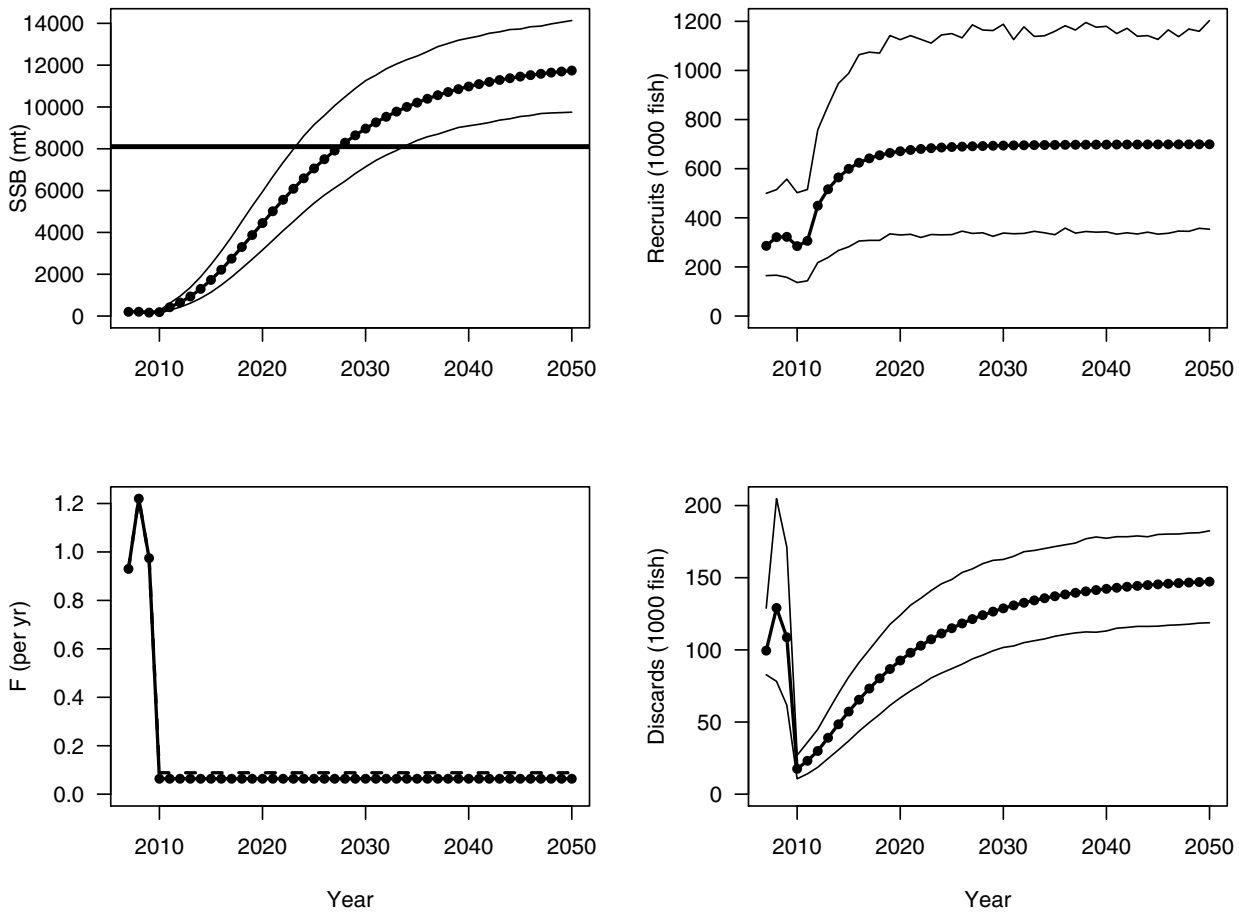


Figure 5.12. Projection results under scenario D5—Discard-only projection with fishing mortality rate fixed at $F = F_{40\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks. In the F panel, the dashed horizontal line represents the fishing rate applied, of which only a portion, represented by the dotted solid line, contributes to (discard) mortality.

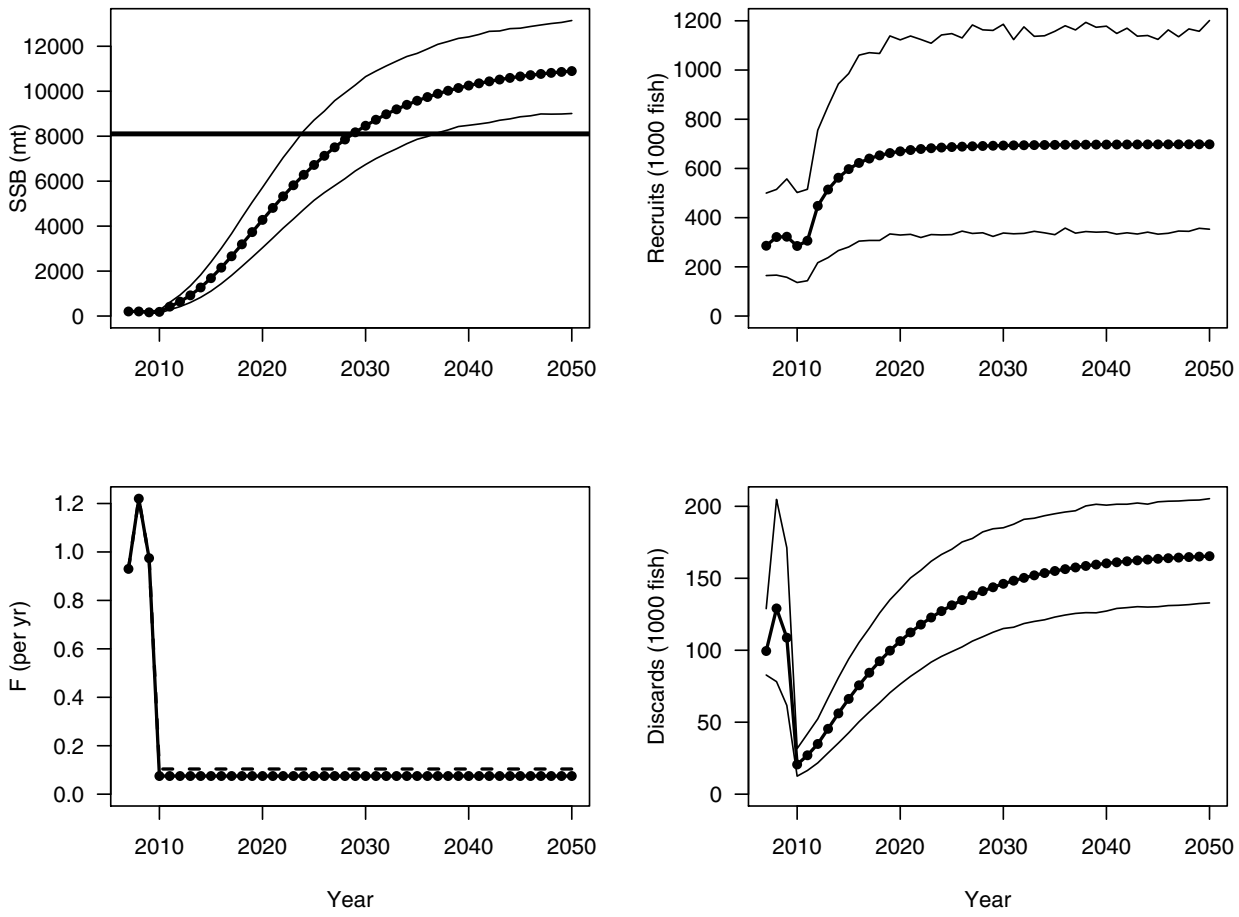


Figure 5.13. Projection results under scenario P0-alt—fishing mortality rate fixed at $F = 0$. This scenario differs from P0 by using preliminary estimates of 2008 recreational landings from MRFSS. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks.

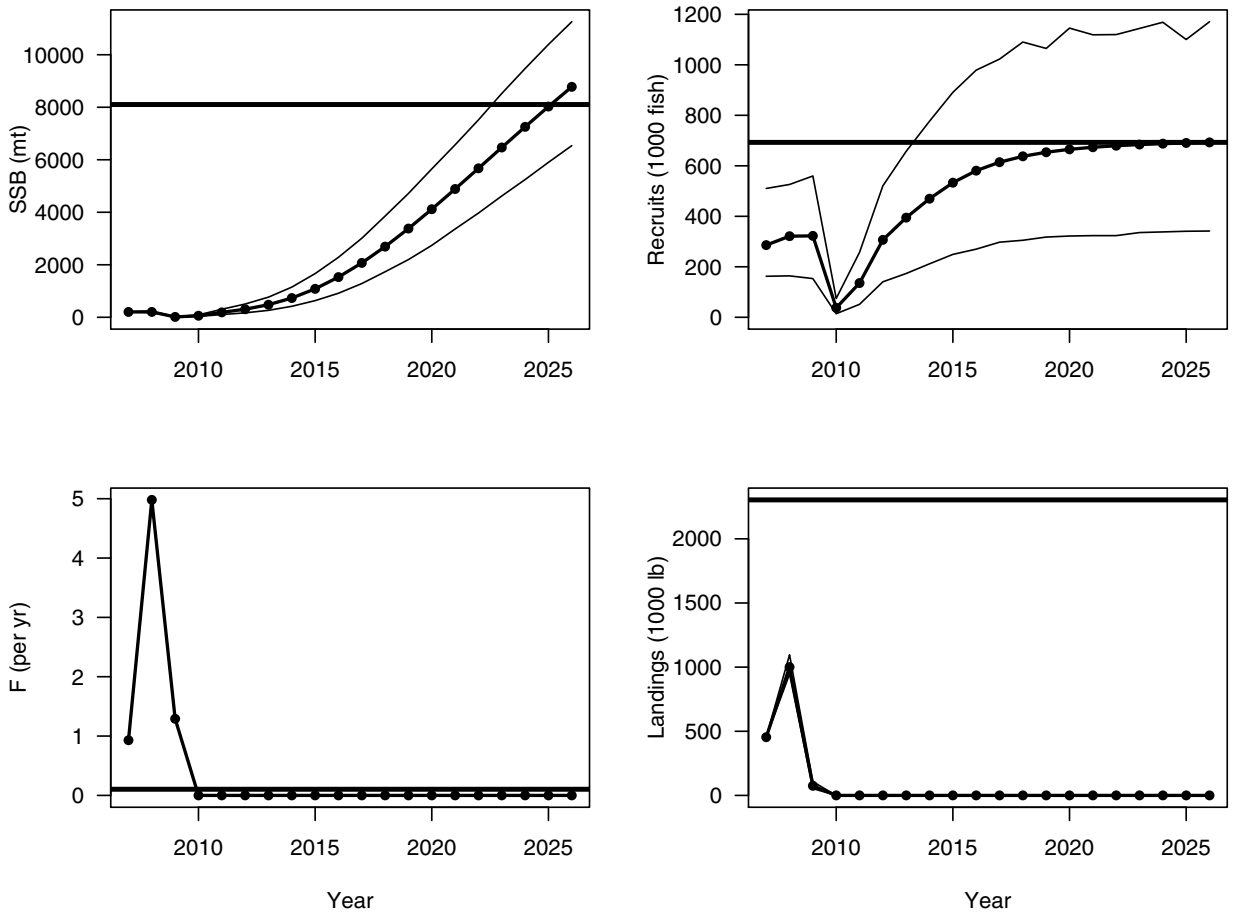
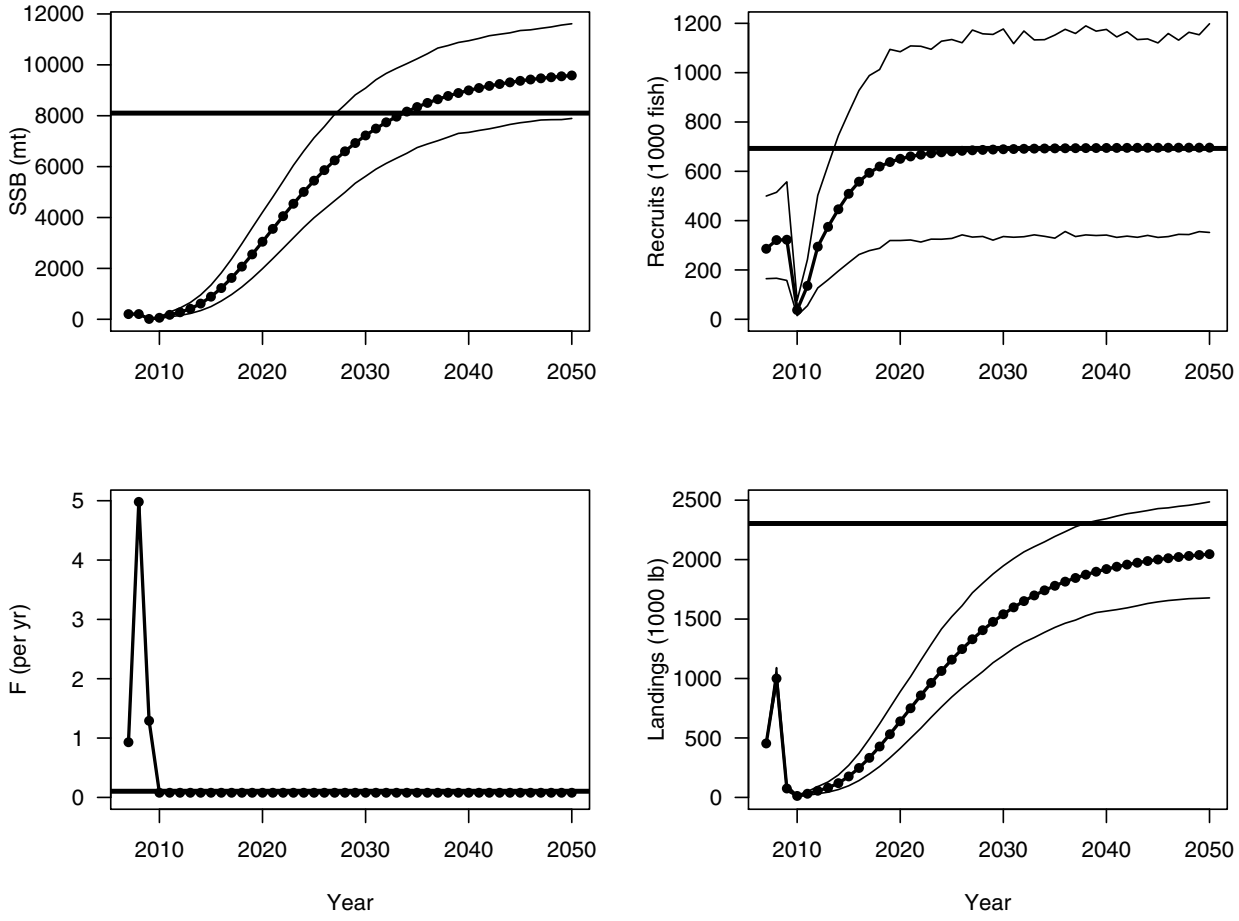


Figure 5.14. Projection results under scenario H3-alt—fishing mortality rate fixed at $F = 75\%F_{40\%}$. This scenario differs from H3 by using preliminary estimates of 2008 recreational landings from MRFSS. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent benchmarks.



UNITED STATES DEPARTMENT OF COMMERCE
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Southeast Fisheries Science Center
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August 12, 2009 F/SEC2: TJ

MEMORANDUM TO: Roy Crabtree, Ph.D.
Regional Administrator, Southeast Regional Office

FROM: Bonnie Ponwith, Ph.D. Theo R. Brainerd
Science Director, Southeast Fisheries Science Center

SUBJECT: Data Analyses for Amendment 17A and 17B to the South Atlantic Snapper Grouper Fishery Management Plan

Enclosed are the Southeast Fisheries Science Center data analyses for actions being considered in Amendments 17A and 17B of the South Atlantic Fishery Management Council.

For Amendment 17A, the following red snapper analyses were conducted and contained in the attached files, "**Red Snapper Projections Revised VI**" and "**Red Snapper Projections VII**":

(1) Suite of projections with "high" recruitment in 2005-2006;
(2) Projection that rebuilds in 35 years;
(3) Suite of projections using F30%;
(4) Yield at F45%.

For Amendment 17B, the following analyses were conducted and contained in the attached files, "**Average Weight of tilefish (*Lopholatilus chamaeleonticeps*) in recreational landings**" and "**P* Tables for Gag, *Mycteroperca microlepis*, off the Southeastern United States**":

(5) Identify conversion factor for landings of tilefish;
(6) Gag grouper P* tables.

You may contact Erik Williams at (252) 728-8603 or Erik.Williams@noaa.gov if you have any questions or clarifications.

Cc: F/SEC – Theo Brainerd
F/SEC – Peter Thompson
F/SEC – Tom Jamir
F/SEC – Sophia Howard
F/SER – Andy Strelcheck
F/SER – Jack McGovern

Average weight of tilefish (*Lopholatilus chamaeleonticeps*) in recreational landings

Sustainable Fisheries Branch, SEFSC-Beaufort
31 July 2009

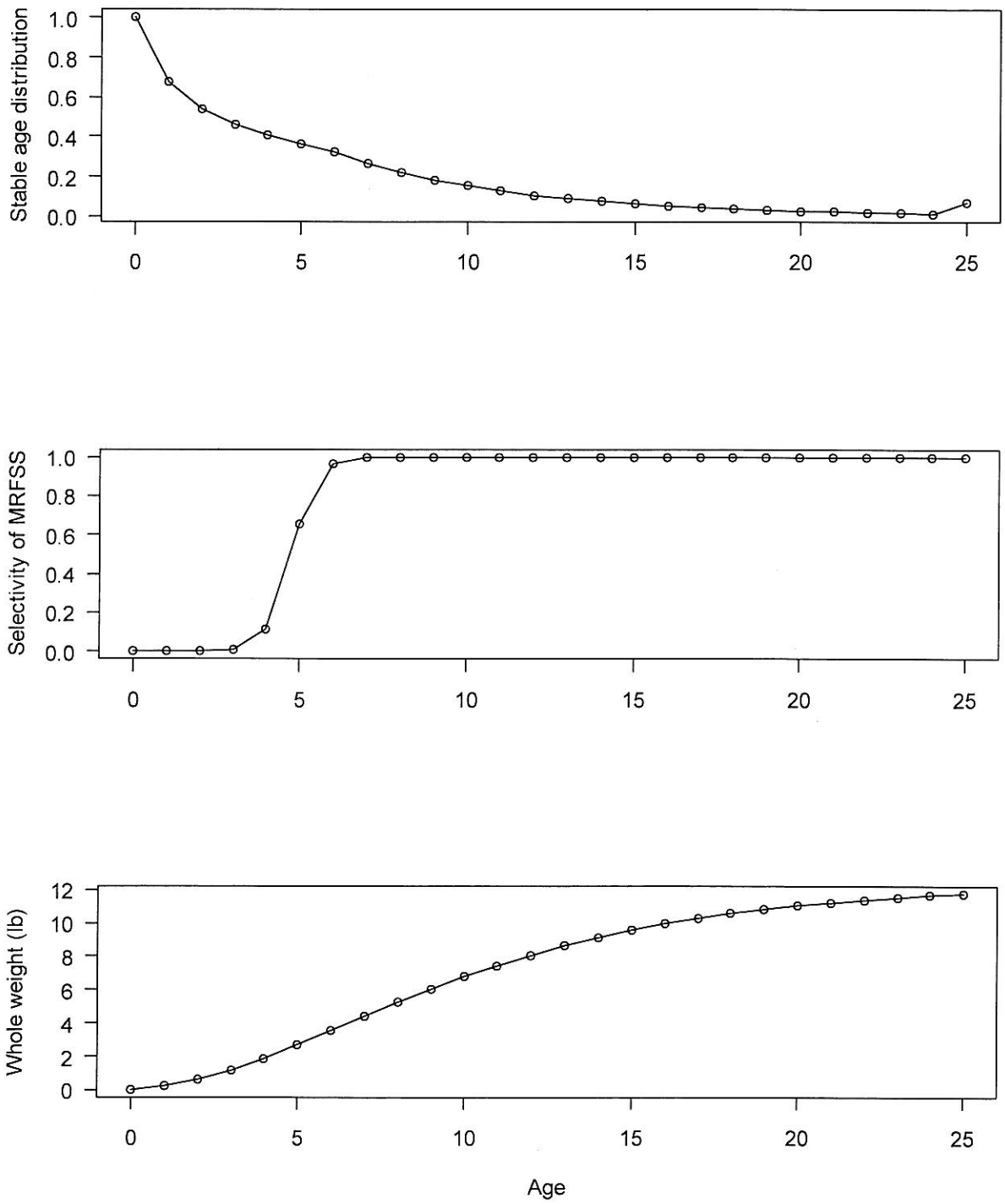
In a memorandum dated 10 July 2009, from Dr. Crabtree to Dr. Ponwith, SERO requested that the SEFSC provide a conversion factor for tilefish to convert recreational landings in weight to landings in numbers. This document provides that conversion factor and describes the methods used to compute it.

The conversion factor was computed using results from the SEDAR-4 benchmark assessment of tilefish. That assessment applied a mixed Monte Carlo and bootstrap procedure, which included many model runs. The run used here was the primary run (labeled "initial run" in the assessment report). From the initial run, we applied the stable age distribution (N_a), selectivity at age of MRFSS (s_a), and average whole weight at age (w_a) (Figure 1). The stable age distribution was computed using the total mortality at age averaged over the last five years of the assessment (1998–2002), and it treated the oldest age as a plus-group. The mean weight (μ_L) of fish landed by MRFSS was then calculated as,

$$\mu_L = \frac{\sum_a (N_a s_a w_a)}{\sum_a (N_a s_a)}$$

This resulted in an average weight of 6.21 lb whole weight per fish. Thus, to convert landings in pounds of whole weight to landings in numbers, one should divide landings (pounds whole weight) by 6.21.

Figure 1. Tilefish stable age distribution (top), selectivity of MRFSS (middle), and mean weight at age (bottom).



P* Tables for
Gag, *Mycteroperca microlepis*, off the Southeastern United States

Last modified: August 14, 2009

Southeast Fisheries Science Center
NOAA Center for Coastal Fisheries and Habitat Research
101 Pivers Island Road
Beaufort, NC 28516

1. Introduction

To help guide management decisions, this preliminary report offers a method to compute annual catch limits (ACLs) of gag off the southeastern United States. Because ACLs are a new requirement under the reauthorized Magnuson–Stevens Fishery Conservation and Management Act (MSFCMA), a body of practice does not yet exist on implementation. We describe a probability-based approach to compute ACLs that maintains a low probability of overfishing, which is the intent of the new requirement, and accommodates uncertainty in both stock dynamics and assessment results. The method is based on the REPAST approach to setting target reference points (Prager et al. 2003), but considerably revised to (1) establish reference points in catch, not fishing mortality rate, and (2) add a stock-projection component, which is needed to set catch for more than one year following a stock assessment.

As of the date of this report, ACLs are not clearly defined. In fact, they have yet to be specified as either a target or a limit. In this report, they are treated as a target. However, the methods could still apply if ACLs were specified as a limit simply by changing terminology.

This preliminary report is not intended to propose actual ACLs of any stock, although the method is illustrated with an application to gag grouper. The purpose of this preliminary report is to provide the SSC a chance to review the method and application. If the method is found acceptable, suggested improvements could be incorporated into a subsequent report, which would be made available for review at a future SSC meeting. The subsequent report would propose actual ACLs for management of gag.

2. Methods

Given the uncertainties in fishery management and science, it is arguably impossible to fish without at least some risk of overfishing. Rather than attempt to achieve zero probability of overfishing, we describe a method whose goal is to keep the probability of overfishing in any year below a preset value (e.g., 0.1), thus satisfying the new requirement of the MSFCMA. The method is general, but can incorporate details of almost any stock previously subjected to assessment, in this case, gag off the southeastern US.

2.1 A probability-based approach to setting catch limits (PASCL)

Our proposed method is a probability-based approach to setting catch limits (PASCL). It acts as a control rule, incorporating uncertainties in assessment results and in future stock dynamics. Given these uncertainties, PASCL sets annual levels of catch consistent with the risk of overfishing considered acceptable by managers.

Uncertainty in assessment results is standard output of most stock assessments, for example, through Bayesian or bootstrap approaches. For use in PASCL, the key assessment result is uncertainty in the limit reference point (LRP) of fishing mortality rate (F). Characterizing such uncertainty is quite flexible in PASCL; it can be described by any appropriate probability density function, whether parametric (e.g., normal, lognormal) or nonparametric (e.g., empirical, kernel density estimate). Where a distribution is unavailable, PASCL could utilize a single point estimate; however, we do not recommend this approach as it ignores uncertainty in assessment results.

Uncertainty in stock dynamics is described by a stochastic projection model. The projection not only allows setting ACLs for more than a single year, but also accounts for the inevitable lag between final year of assessment data and first year of ACL implementation. The projection model can include any source of uncertainty deemed appropriate, no different from other projection models used currently for fishery management. Sources often considered are recruitment dynamics and initial number at age.

In PASCL, as in REPAST (Prager et al. 2003), the level of risk acceptable to managers is quantified and transparent. Here we define *risk* as the probability (P^*) that F in any given year exceeds its LRP. A small value of P^* would imply risk-averse management, and a large value would imply risk-prone management. Either way, P^* should be less than 0.5, as $P^*=0.5$ would, in effect, treat the limit as a target, with overfishing expected in half of all years.

If the LRP is fixed (i.e., a point estimate), P^* in year t depends only on the probability density function (ϕ_{F_t}) of F_t:

$$P^* = \Pr(F_t > F_{LRP}) = \int_{F_{LRP}}^{\infty} \phi_{F_t}(F)dF = 1 - \Phi_{F_t}(F_{LRP}) \qquad (1)$$

where $\Phi_{F_t}(F_{LRP})$ is the cumulative density function of F_t evaluated at the limit F_{LRP}. If the LRP is uncertain, described by its own probability density function ($\phi_{F_{LRP}}$), P^* is computed from the following:

$$P^* = \Pr(F_t > F_{LRP}) = \int_{0}^{\infty} \left[1 - \Phi_{F_t}(F)\right] \phi_{F_{LRP}}(F)dF \qquad (2)$$

In essence, Equation 2 is the weighted sum of probabilities computed through Equation 1, for all possible values of F_{LRP}. Because P^* is defined as an annual probability, the risk of overfishing in at least one year grows as the time horizon is extended (Figure 1).

The goal of PASCL is to set the ACL such that the realized P^* equals the desired P^*. This can be achieved through projection (Figure 2):

1) For each of N replicates of the stock, compute F_t that yields a fixed catch C. This will produce N values of F_t, which can be used to define its probability density (ϕ_{F_t}).

2) Given ϕ_{F_t} and the probability density of F_{LRP} ($\phi_{F_{LRP}}$), compute the realized P^* according to Equation 2.

3) Adjust C until the realized P^* equals the desired P^*, which could be accomplished with an optimization routine. This C is the ACL.

4) Project each replicate one year forward with its F_t that provides the ACL.

5) Repeat for T years.

The needed duration (T) of the projection will vary from stock to stock, but should extend at least until ACLs based on the next scheduled assessment could be implemented.

2.2 Application to gag

Gag was most recently assessed in 2006 using data through 2004 (SEDAR 2006). The assessment had two base models that differed regarding their assumptions about catchability in fishery-dependent indices of abundance. One model assumed that catchability has remained constant over the past several decades; the other assumed that catchability has increased with improved technology and gear. In this application, we used the model with constant catchability to remain consistent with the recommendation of the SEDAR review panel. Although that panel acknowledged a likely increase in catchability over time, the rate of increase remains an open question, and thus the panel recommended adopting the status quo of constant catchability.

Implementation of PASCL requires probability densities of the limit reference point and of the fishing rates that achieve ACLs. The LRP of F was based on F_{MSY}, the fishing rate at maximum sustainable yield (*MSY*). In this application, as in the assessment, the probability density of F_{MSY} ($\phi_{F_{MSY}}$) was estimated from values that were generated by empirical bootstrap of the Beverton–Holt spawner-recruit curve (Figure 3). The probability density of F_t (ϕ_{F_t}) was estimated from values that were generated by a stochastic projection model with $n=2000$ replicates. Both densities ($\phi_{F_{MSY}}$, ϕ_{F_t}) were quantified nonparametrically using kernel density estimation with a Gaussian kernel and bandwidth equal to that kernel's standard deviation (Venables and Ripley 2002).

The projection model was identical to the age-structured assessment model, and parameter values were those used or estimated in the assessment (SEDAR 2006). The projection included two sources of uncertainty in stock dynamics. One was uncertainty in recruitment, which was assumed to follow the lognormal distribution of error estimated in the assessment. The other was uncertainty in initial number at age. The assessment provided only point estimates of number at age in 2005, the first year of projection; to add uncertainty, we assumed the initial number at each age followed a lognormal distribution with standard deviation equal to that of recruitment and mean equal to the point estimate. This approach accounts for uncertainty in the initial conditions, while maintaining any strong year classes estimated in the last year of the assessment.

The projection started in 2005, yet ACLs would not likely be implemented until 2008. To project the stock through this initialization period (2005–2007), we applied a fixed F set at the geometric mean of values estimated by the assessment for 2002–2004. The duration of projection was set to 10 years, which included three years of initialization followed by seven years of ACLs.

PASCL requires as input the quantified risk of overfishing. This allows managers to acknowledge such risk explicitly and to decide on a level considered acceptable. To help guide that decision, we present ACLs computed from six values of P^*: 0.10–0.35, in increments of 0.05.

3. Results

For any level of catch, the $n=2000$ projection replicates produced $n=2000$ values of F_t, because stock structure (number at age) varied stochastically among the replicates. The ACLs were set by adjusting catch until the values of F_t provided the desired P^* (example in Figure 4).

By definition, P^* quantifies the acceptable risk of overfishing. In general, a higher P^* led to larger ACLs (Tables 1–6). It also led to more dead discards and smaller spawning stock biomass (SSB). Ultimately, the choice of P^* is a management decision.

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Table 1. Projection with annual probability of overfishing $P^*=0.10$.

Yr	SSB (1000 lb)	Recruits (1000s)	F(/yr)	Landings (1000 lb)	Dead Discards (1000s)	Dead Discards (1000 lb)
2005	8033	455	0.31	1574	23	114
2006	7356	457	0.31	1542	21	88
2007	6472	459	0.31	1387	25	98
2008	5928	446	0.15	628	14	56
2009	6475	453	0.15	651	15	64
2010	7092	450	0.15	686	15	65
2011	7680	452	0.14	737	14	64
2012	8234	448	0.14	797	14	64
2013	8759	457	0.14	852	14	63
2014	9208	465	0.14	898	14	63

Table 2. Projection with annual probability of overfishing $P^*=0.15$.

Yr	SSB (1000 lb)	Recruits (1000s)	F(/yr)	Landings (1000 lb)	Dead Discards (1000s)	Dead Discards (1000 lb)
2005	8033	455	0.31	1574	23	114
2006	7356	457	0.31	1542	21	88
2007	6472	459	0.31	1387	25	98
2008	5928	446	0.16	676	15	61
2009	6420	453	0.16	693	16	68
2010	6984	450	0.16	725	16	70
2011	7531	452	0.15	775	15	69
2012	8033	448	0.15	835	15	68
2013	8511	456	0.15	888	15	68
2014	8923	464	0.15	932	15	68

Table 3. Projection with annual probability of overfishing $P^*=0.20$.

Yr	SSB (1000 lb)	Recruits (1000s)	F(/yr)	Landings (1000 lb)	Dead Discards (1000s)	Dead Discards (1000 lb)
2005	8033	455	0.31	1574	23	114
2006	7356	457	0.31	1542	21	88
2007	6472	459	0.31	1387	25	98
2008	5928	446	0.17	715	16	64
2009	6375	453	0.17	727	17	72
2010	6898	449	0.17	755	17	74
2011	7410	452	0.16	804	16	73
2012	7873	447	0.16	863	16	72
2013	8319	456	0.16	916	16	72
2014	8696	464	0.16	957	16	71

Table 4. Projection with annual probability of overfishing $P^*=0.25$.

Yr	SSB (1000 lb)	Recruits (1000s)	F(/yr)	Landings (1000 lb)	Dead Discards (1000s)	Dead Discards (1000 lb)
2005	8033	455	0.31	1574	23	114
2006	7356	457	0.31	1542	21	88
2007	6472	459	0.31	1387	25	98
2008	5928	446	0.18	749	17	68
2009	6336	453	0.18	755	17	76
2010	6828	449	0.18	782	17	77
2011	7306	452	0.17	830	17	76
2012	7739	447	0.17	889	17	76
2013	8147	455	0.17	940	17	75
2014	8493	463	0.17	980	17	75

Table 5. Projection with annual probability of overfishing $P^*=0.30$.

Yr	SSB (1000 lb)	Recruits (1000s)	F(/yr)	Landings (1000 lb)	Dead Discards (1000s)	Dead Discards (1000 lb)
2005	8033	455	0.31	1574	23	114
2006	7356	457	0.31	1542	21	88
2007	6472	459	0.31	1387	25	98
2008	5928	446	0.19	778	17	70
2009	6302	453	0.19	781	18	79
2010	6762	449	0.18	805	18	80
2011	7213	451	0.18	854	18	79
2012	7615	447	0.18	914	18	79
2013	7996	455	0.18	963	18	79
2014	8308	463	0.18	1002	18	78

Table 6. Projection with annual probability of overfishing $P^*=0.35$.

Yr	SSB (1000 lb)	Recruits (1000s)	F(/yr)	Landings (1000 lb)	Dead Discards (1000s)	Dead Discards (1000 lb)
2005	8033	455	0.31	1574	23	114
2006	7356	457	0.31	1542	21	88
2007	6472	459	0.31	1387	25	98
2008	5928	446	0.20	805	18	73
2009	6272	453	0.19	804	19	82
2010	6704	449	0.19	827	19	83
2011	7127	451	0.19	876	19	82
2012	7501	446	0.19	937	19	82
2013	7856	455	0.19	985	18	82
2014	8140	462	0.19	1022	18	81

Figure 1. Risk of overfishing extended across years, calculated as the probability of overfishing in at least one year as a function of the annual risk P^*, assuming independence among years.

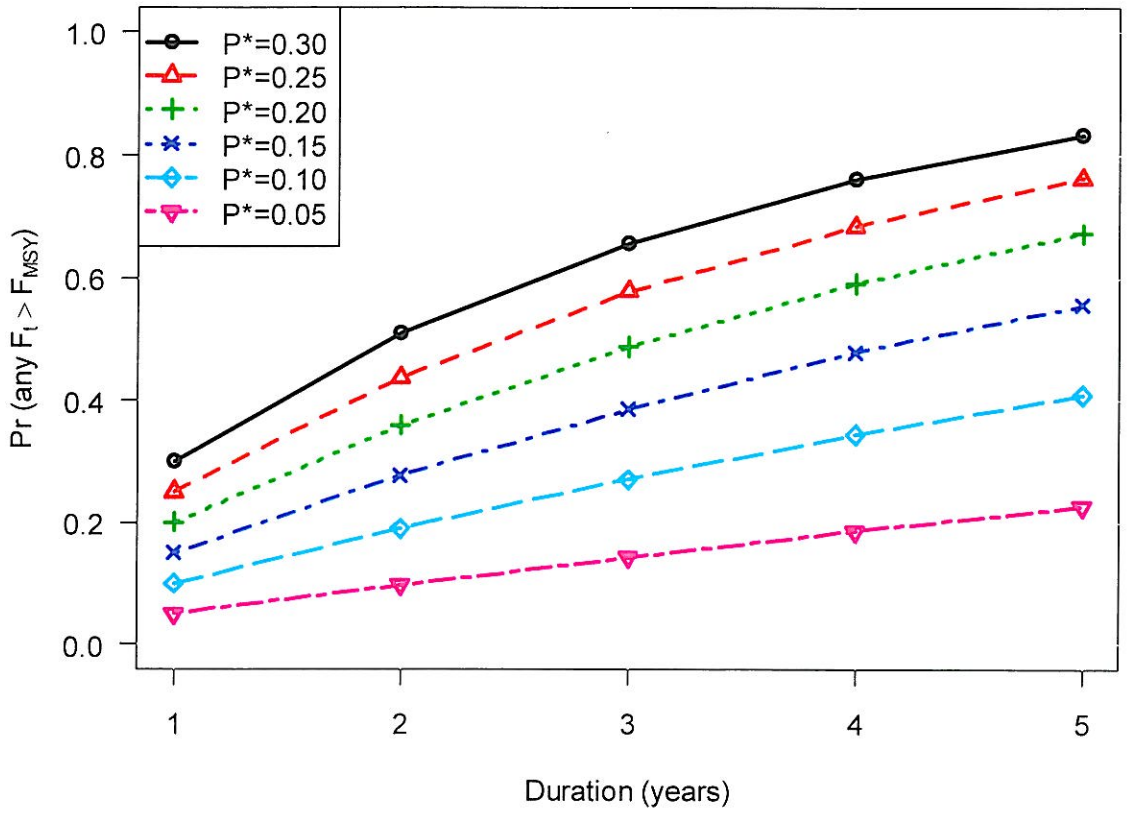


Figure 2. Flowchart of method to compute ACLs.

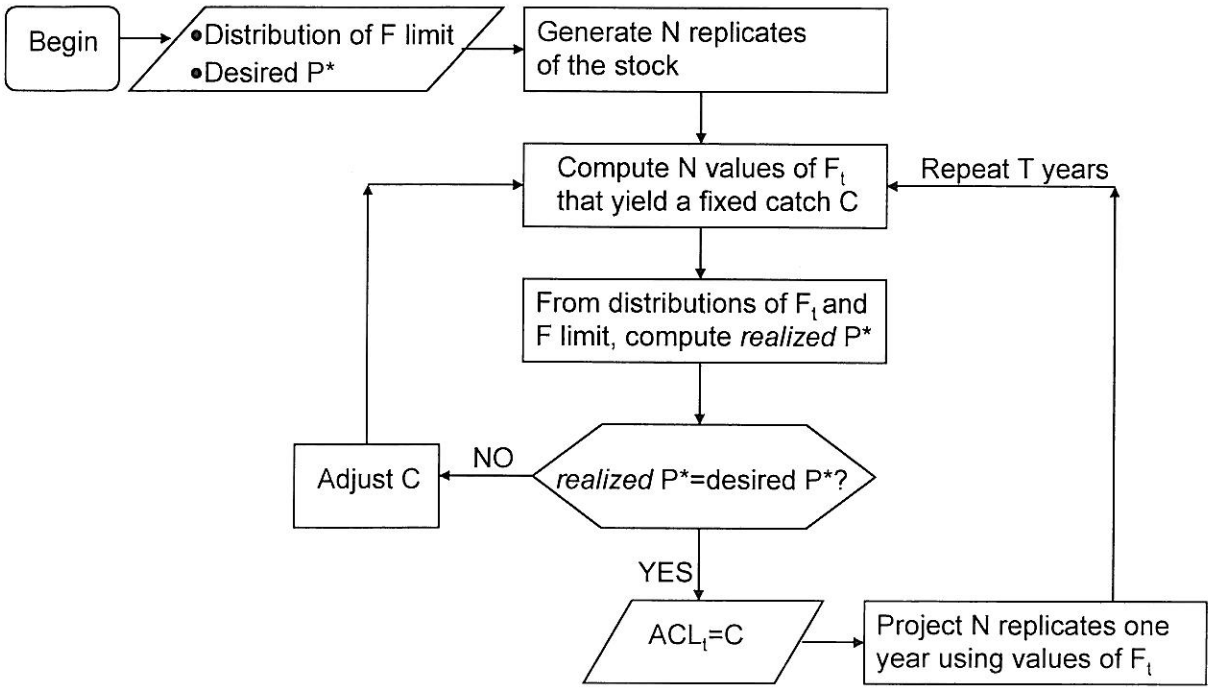


Figure 3. Probability density of F_{MSY}, estimated from the SEDAR 10 assessment and used as input for PASCL.

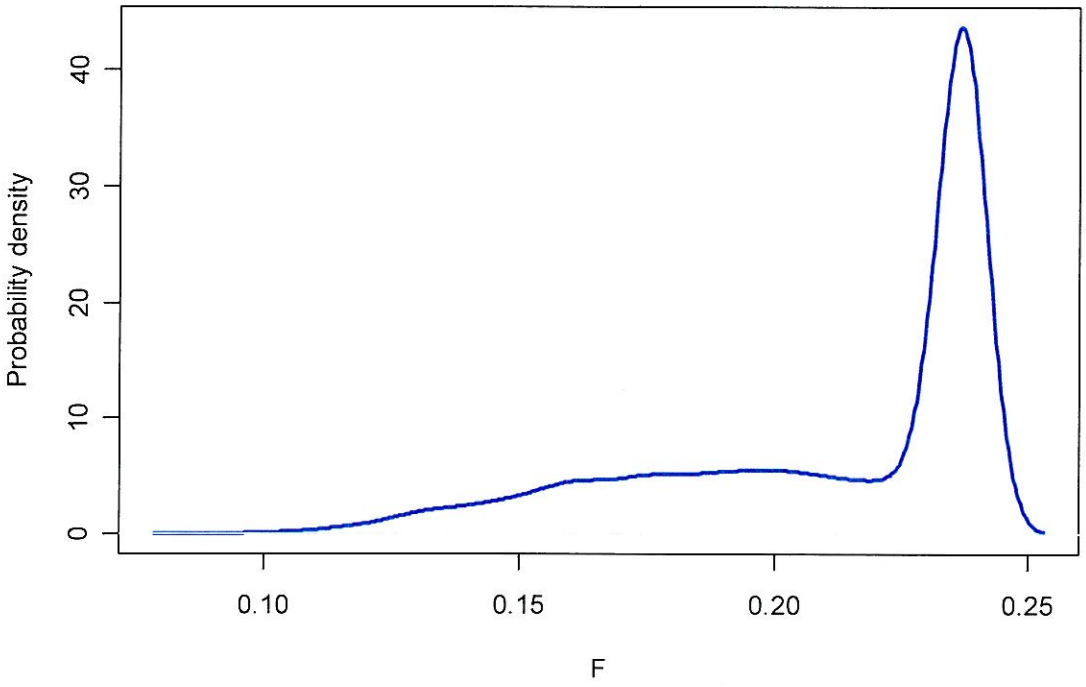
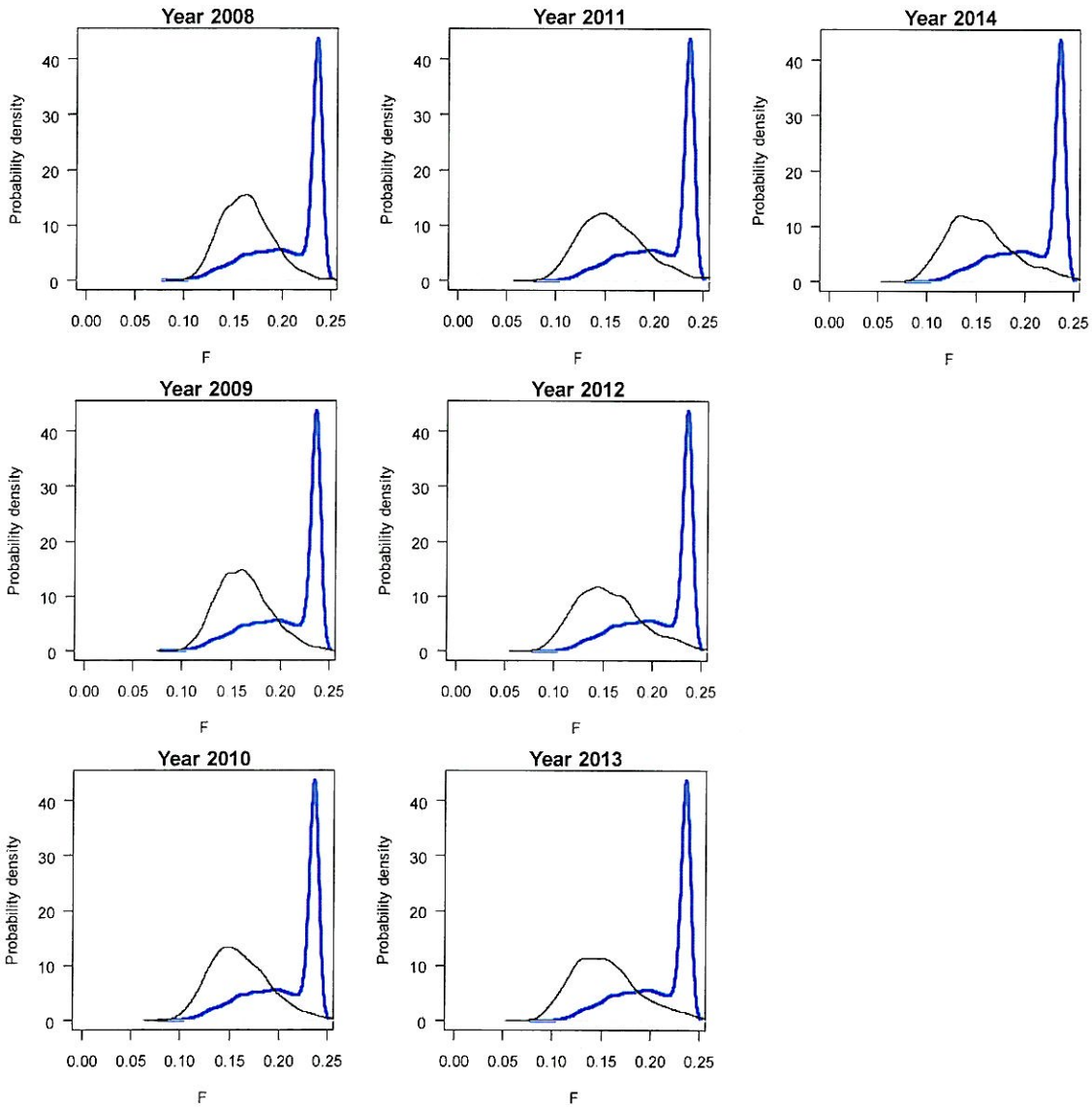


Figure 4. Example distributions: Probability density of F_{MSY} (thick, blue line) and of F_t (thin, black line) that achieve $P^*=0.15$. For lower P^* (less risk), the probability densities of F_t would shift to the left; for higher P^* (more risk), to the right.



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August 13, 2009 F/SEC2: TJ

MEMORANDUM TO: Roy E. Crabtree, Ph.D.
Regional Administrator, Southeast Regional Office

FROM: Bonnie Ponwith, Ph.D. Theo R. Brainerd
Science Director, Southeast Fisheries Science Center

SUBJECT: SEFSC Revised Report on Red Snapper in the U.S. Atlantic: Sensitivity Analyses Using Dome-Shaped Selectivity for Recreational Sectors

As per request by the South Atlantic Fishery Management Council (SAFMC) and the NMFS Southeast Regional Office (SERO), the Southeast Fisheries Science Center (SEFSC) completed a sensitivity analyses on Dr. Frank Hester's query. These analyses were contained in the earlier SEFSC memo to SERO dated August 5, 2009.

The SEFSC submits the following revised report containing the results of the sensitivity analyses to the Southeast Regional Office for transmission to the SAFMC:

- ***Red Snapper in the U.S. Atlantic: Sensitivity analyses using dome-shaped selectivity for recreational sectors (12 August 2009).***

Please contact Erik Williams (erik.williams@noaa.gov) if you have any questions.

Encl.

CC: F/SEC - Theo Brainerd
F/SEC - Peter Thompson
F/SEC - Tom Jamir
F/SEC - Sophia Howard
F/SER - Heather Blough
F/SER - Jack McGovern

Red snapper in the U.S. Atlantic: Sensitivity analyses using dome-shaped selectivity for recreational sectors

Prepared by Southeast Fisheries Science Center
12 August 2009

1 Executive summary

Although the SEDAR-15 red snapper stock assessment for the U.S. South Atlantic has been through exhaustive review, concern remains within the fishing community. Dr. Frank Hester, a consultant hired by the fishing industry, conducted his own review of the stock assessment and issued his report on May 8, 2009. Most of Dr. Hester's concerns have already been addressed by the South Atlantic Fishery Management Council or by previous work conducted through the SEDAR process. For example, Dr. Hester questioned the use of historical Fish and Wildlife Service (FWS) recreational catch data. Those data were already considered by SEDAR to be a source of uncertainty, and sensitivity analyses had previously addressed the issue: Assessment results are qualitatively insensitive to those historical FWS recreational catch data. The primary subject of this report is the effect of a dome-shaped selectivity curve for the recreational sector, as hypothesized by Dr. Hester. Here, three additional sensitivity runs were conducted using various combinations of estimated dome-shaped selectivity curves and a curve proposed by Dr. Hester in his report. Dr. Hester's selectivity curve assumes no fish over age 10 are caught in the fishery, an assertion that is demonstrated here to be incorrect (samples of recreational catches do include fish over 10 years old, including a 50 and 53 year old fish). More realistic dome-shaped selectivity curves yield results very similar to the base stock assessment model run. Nonetheless, the nature of the fisheries and analyses in this report do not support the use of a dome-shaped selectivity function for commercial handline or recreational sectors. Nearly forty different sensitivity analyses of the red snapper model have been conducted, and although results vary quantitatively, they are all in strong qualitative agreement pointing to a stock that is depleted and experiencing overfishing. This red snapper stock demonstrates hallmarks of stock depletion: truncated age structure and constricted spatial range.

2 Background

The SEDAR-15 stock assessment of red snapper in the U.S. Atlantic has been through exhaustive review, first by internationally esteemed independent experts within the SEDAR process, and then through multiple reviews conducted by scientists of the South Atlantic Fishery Management Council's own Scientific and Statistical Committee. Following those scientific reviews, the Southeastern Fisheries Association, Inc. hired a consultant, Dr. Frank Hester, to conduct a review on behalf of the fishing industry. In his report dated 8 May 2009, Dr. Hester raised several questions about the stock assessment. The Council has already addressed those questions in a previous document (attached here as an Appendix). One question left unanswered, however, was whether selectivity of recreational sectors might have been dome-shaped (i.e., excluded older fish) rather than flat-topped (i.e., included older fish, as in the SEDAR assessment). This report explores such an assumption for its effects on assessment results.

3 Sensitivity analyses

In his report, Dr. Hester guessed at a possible shape of recreational dome-shaped selectivity (reproduced in Fig. 6.1—top panel). Here, the hypothesis of dome-shaped selectivity was applied to the red snapper assessment in three different ways. In the first application, Dr. Hester's assumed shape was applied to both headboat and general recreational fishing throughout the entire assessment time frame (1945–2006). In the second application, his assumed shape was applied to both headboat and general recreational fishing in the early time period (1945–1983), and in later periods (1984–1991 and 1992–2006), dome-shaped selectivities were estimated (separately for each period). The third application was similar to the second, but differed by applying the estimated selectivity of the middle time period to the early time period, rather than applying Dr. Hester's assumed shape. The three different approaches are labeled S37, S38, S39 (36 sensitivity analyses have been conducted previously as part of the assessment and review workshops):

- S37: Hypothesized dome-shaped selectivity (Fig. 6.1—top panel) applied to headboat and general recreational sectors throughout the entire assessment time frame.
- S38: Hypothesized dome-shaped selectivity (Fig. 6.1—top panel) applied to headboat and general recreational sectors in the early time period, and estimated dome-shaped selectivities used in subsequent periods.
- S39: Estimated dome-shaped selectivities (Fig. 6.1-bottom panel) applied to headboat and general recreational sectors throughout the full assessment time frame.

Initial runs of these analyses fitted the age and length composition data poorly. Thus, the likelihood weighting on those components were increased by a factor of ten (relative to the weights used in the base assessment) to give these hypotheses a chance to achieve reasonable fits to data. Weights on other data components (e.g., landings, CPUE) remained the same.

For each sensitivity run, management benchmarks were based on the proxy of $F_{40\%}$. The equilibrium spawning biomass and yield corresponding to $F_{40\%}$ were computed through long-term projections.

4 Results

As expected, sensitivity runs with dome-shaped recreational selectivities estimated somewhat different time series of fishing rate and spawning biomass than those of the base assessment model (Fig. 6.2). In the early years, sensitivity runs had higher estimates of full fishing mortality rates, and different absolute levels of spawning biomass (although similar trends). However, since about 1980, estimates of full F have been similar among the four models (base, S37, S38, and S39), as have been estimates of spawning biomass.

Management benchmarks differed among the four models (Table 6.1). This result is expected, because benchmarks are conditional on selectivity. However, stock and fishery status in the terminal assessment year were qualitatively the same across these models and other sensitivity runs: the stock is experiencing overfishing and is depleted relative to the benchmark level (Fig. 6.3).

5 Discussion

5.1 Sensitivity runs using dome-shaped selectivity

Of the three sensitivity runs described in this report, S37 (which applies Dr. Hester's selectivity) is the most questionable, for at least three reasons. First, S37 does not account for changes in size limits. Second, one cannot reliably guess the shape of selectivity simply by visual inspection of data (as Dr. Hester attempted), for reasons detailed in the subsequent section §5.2. Third, Dr. Hester's assumed selectivity does not include fish older than age 10 (Fig. 6.1—top panel), which is demonstrably wrong (Fig. 6.4). Runs S38 and S39 do not suffer from those same problems, and their results were quite similar to those of the base run.

Although S38 and S39 are clearly preferable to S37, all three should be viewed with strong skepticism. By objective criteria (discussed in subsequent sections), the assumption of dome-shaped selectivity for red snapper in the Atlantic does not appear to be realistic. Evidence suggests flat-topped selectivity, and therefore sensitivity runs using dome-shaped selectivity (S37, S38, S39) do not deserve equal footing as other sensitivity runs (although results were qualitatively the same).

5.2 Selectivity (general)

The commonly used term "selectivity" in stock assessment modeling refers to an age-specific (or length-specific) schedule composed of spatial/temporal availability and fishing gear selectivity. The concepts of availability and selectivity should not be confused with vulnerability and catchability, which relate primarily to a unit of effort. Because selectivity includes both gear characteristics and population availability components, it unfortunately cannot be surmised simply by visual inspection of catch-at-age or average-weight data. In many fisheries around the world, the tendency is to target the largest and oldest individuals, simply because they tend to be more valuable. Red snapper is one of the U.S. South Atlantic's more valuable snapper-grouper species.

When modeling selectivity, stock assessments tend to use functional curves to describe selectivity-at-age. One reason for doing this is to use fewer parameters in the model, thus increasing the statistical degrees of freedom. Often a model can achieve the same fit to the data with fewer parameters being estimated, a property referred to as parsimony.

Stock assessment models used in the U.S. South Atlantic have primarily used one of two functional forms for selectivity-at-age, the logistic and double-logistic equations. The two-parameter logistic function results in a flat-topped selectivity curve and assumes that the oldest and largest fish are fully available to the fishery. The four parameter double-logistic function can assume either a flat-topped or dome-shaped selection curve. A dome-shaped curve implies that the oldest and largest fish are not fully available to the fishery. Dome-shaped selectivity can result from factors such as 1) the oldest fish move to areas that are not fished, 2) fish outgrow the gear being used for capture, or 3) regulations inhibit the ability to capture the oldest fish.

The primary data that stock assessment models draw upon for the estimation of selectivity are the age and length composition data from the fishery. The slope of the decline of the oldest or largest fish in the age and length composition data is a function of both mortality and age-specific selectivity. Separating mortality and selectivity can be difficult, especially when dome-shaped selectivity is suspected in a given fishery. Fortunately, for most fisheries, there is at least one sector that tends to target the oldest largest fish (flat-topped selectivity). The establishment of at least one sector as having flat-topped selectivity tends to anchor the other sectors,

enabling the estimation of dome-shaped selectivity functions. If a fishery is suspected of being composed entirely of dome-shaped selectivity functions, the estimation can be difficult and often gets confounded with mortality estimates.

5.3 Selectivity (red snapper)

It has been demonstrated for some snapper-grouper species in the U.S. South Atlantic that older larger individuals tend to occur in deeper water, although the patterns differ across species. For example, in the case of red grouper, the pattern suggests that shallower waters contain both big and small fish, and that as depth increases the smaller fish disappear. In this case the largest fish are available across both shallow and deep depths. For many species, relationships between size and depth are weak or nonexistent. Unfortunately, the U.S. South Atlantic has very little depth or detailed spatial data to definitively describe depth-size relationships for our snapper-grouper species. To complicate the issue, seasonal shifts in species distributions can occur as well. Anecdotal reports from fishermen off the coast of northeast Florida have suggested that the largest red snapper tend to move inshore during June–September to depths as shallow as 60–90 feet. Such a pattern of seasonal shift would support using a flat-topped selectivity curve.

Commercial fishermen often have economic incentive to catch large fish, and thus if possible, will rationally do so. Indeed, evidence suggests that the commercial sector does fish in depths and areas where the oldest and largest red snapper exist. For example, vessels with bandit rigs, a type of hook-and-line gear, fish in depths that are likely beyond where red snapper occur (e.g., when fishing for snowy grouper and tilefish). This strongly suggests that the full depth range is covered by commercial vessels. Furthermore, in areas off northeast Florida where red snapper are most abundant, the shelf edge is relatively close to shore, suggesting that travel distance is not likely an impediment to fishing in the deeper waters for large red snapper. It is difficult to imagine a plausible scenario in which selectivity for the commercial handline fishery is anything but flat-topped. (However, for the commercial diving sector, the SEDAR-15 red snapper stock assessment did assume a dome-shaped selectivity function; the clear reason being that divers are depth limited.)

In the recreational fishery the sectors include private/shore fishermen, charter boats, and headboats. These recreational sectors can fish quite differently in some cases. The charter and headboats tend to fish snapper-grouper species in similar areas, using similar gear. A common pattern for charter boats in the Carolinas is to troll in the Gulf Stream for pelagic species and then bottomfish for snapper-grouper species. In those cases, the vessels are fishing deep enough depths where the largest red snapper are likely to occur. Headboats may be constrained in the distance they can travel offshore because they are typically slower and may only fish half-day trips. Unfortunately, the ability to know fishing locations is lacking in the U.S. South Atlantic. The implementation of Vessel Monitoring Systems (VMS), as applied in other regions of the United States, would help resolve such data needs.

Although precise data on fishing locations are unavailable, it is possible to explore the hypothesis of dome-shaped selectivity by comparing age composition data from different sectors. In the case of red snapper, recreational age composition data can be compared to those of the commercial handline fishery, which is believed to have flat-topped selectivity (for reasons described above). For evidence of dome-shaped selectivity in the recreational sector, one should expect the descending limbs of recreational age compositions to decline more quickly than those of the commercial sector. For red snapper in the U.S. South Atlantic, no such evidence exists (Figs. 6.4, 6.5), which supports using flat-topped selectivity for the recreational sector.

5.4 Early recreational landings

The base assessment model used recreational landings from the U.S. Fish and Wildlife Service (FWS) Salt-Water Angling Reports. As explained in the Council's response (Appendix of this report) to Dr. Hester's questions, those survey landings were used because 1) the surveys collected legitimate data, 2) they were preferable to any available alternatives (e.g., linear interpolation), and 3) they improved the model by helping to explain the already reduced population when age/size sampling began. Furthermore, angling effort in those surveys was corroborated by other data. Nonetheless, the FWS surveys were considered to be a source of uncertainty, and consequently several sensitivity analyses were run to address this issue (Runs S0, S7, S8, S32 and S33 in Table 6.1). Although use of FWS landings provided better fidelity to other data sources (age/length compositions), the qualitative results of current stock status were insensitive to the early recreational landings.

5.5 Stock status

In addition to applying multiple models, nearly forty different sensitivity analyses of the base model have been conducted on the red snapper assessment (as part of the assessment workshop, as part of the review workshop, and now in response to Dr. Hester's report). Although results vary quantitatively among the multiple assessment models and nearly forty sensitivity analyses, results are all in strong qualitative agreement. The base model and each sensitivity run show that overfishing is occurring and the red snapper stock is depleted to levels much lower than the spawning biomass benchmark (Table 6.1, Fig. 6.3).

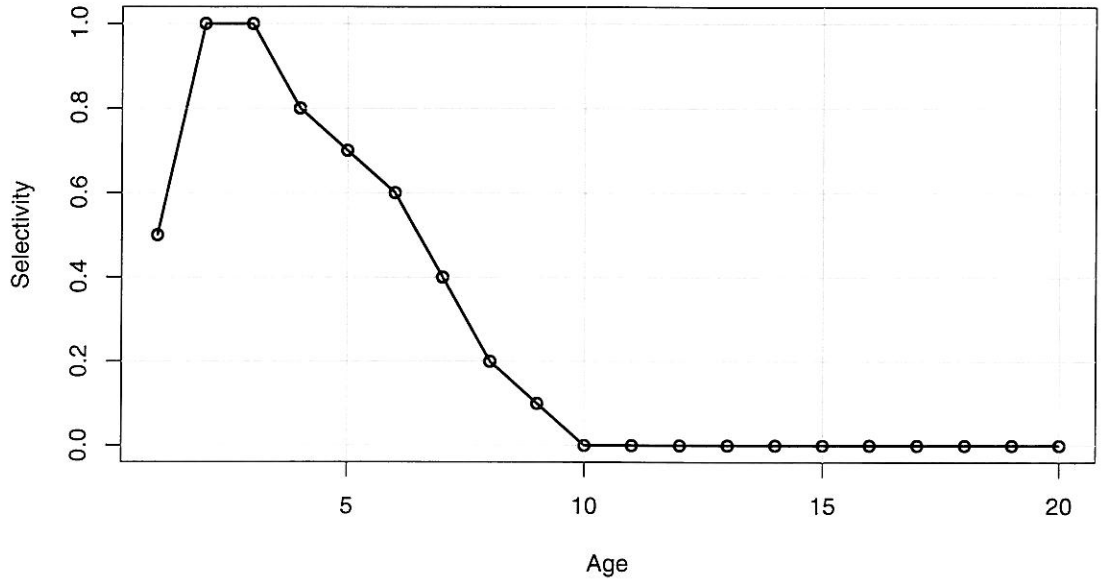
The overfished status is consistent with two strong lines of evidence. First, red snapper can live more than 50 years, yet fish older than 10 years are rarely caught by fishermen. Such a severely truncated age structure typically signals that the exploitation rate does not allow many fish to reach older ages. Although some large fish are caught, they are not necessarily old fish, because of the variability of size at age. Second, red snapper were once abundant along the southeast U.S. coast, but now are primarily caught off northeast Florida, apparently the center of this stock's range. Relative to earlier decades, few red snapper are now caught, for example, off North Carolina's coast. The constriction of a fish population's range typically signals reduced abundance.

6 Tables and Figures

Table 6.1. Results from sensitivity runs of the red snapper catch-age assessment model. Runs S0–S31 were previously reported in the original Assessment Workshop Report (Table 3.13; S0 was then called base). Runs S32–S36 were previously reported in the Review Workshop Report (Table 2). Runs S37–S39 are new, described in this report. Note that S37–S39, as well as the base model, use $F_{40\%}$ proxies for MSY-based reference points.

Run	Description	F_{MSY}	SSB_{MSY} (mt)	MSY (1000 lb)	F_{2006}/F_{MSY}	SSB_{2006}/SSB_{MSY}	steep	R0(1000)
Base	—	0.104	8103	2304	7.67	0.02	0.95	638
S0	Recr L transposed	0.112	5184	2319	7.51	0.04	0.95	605
S1	Low M	0.097	6112	1977	10.36	0.03	0.95	377
S2	High M	0.112	5089	2362	7.25	0.04	0.95	673
S3	q slope 0.0	0.111	5304	2226	5.72	0.05	0.95	603
S4	q slope 0.04	0.107	5174	2355	9.20	0.03	0.95	606
S5	Rec dev 1972	0.106	5203	2299	7.82	0.04	0.95	608
S6	Rec dev 1976	0.106	5209	2302	7.79	0.04	0.95	602
S7	Low early recr L	0.143	1729	559	11.09	0.11	0.95	152
S8	Bias early recr L	0.104	9024	3927	7.72	0.02	0.94	1034
S9	Comm D mort 0.7	0.105	5180	2316	7.72	0.04	0.95	603
S10	Comm D mort 0.8	0.106	5186	2302	7.70	0.04	0.95	604
S11	Comm D mort 1.0	0.106	5238	2289	7.79	0.04	0.95	606
S12	Recr D mort 0.2	0.115	4978	2424	6.01	0.04	0.95	601
S13	Recr D mort 0.6	0.113	5417	2176	8.51	0.04	0.95	607
S14	D sel age 1 0.25	0.113	5201	2295	7.94	0.04	0.95	605
S15	D sel age 1 0.75	0.128	5157	2381	6.65	0.04	0.95	605
S16	steep=0.8	0.131	7648	2056	9.59	0.03	0.80	562
S17	steep=0.6	0.118	10554	1624	7.09	0.05	0.60	441
S18	Retro 2005	0.107	4812	2107	7.74	0.04	0.95	559
S19	Retro 2004	0.106	4936	2150	7.80	0.04	0.95	569
S20	Retro 2003	0.106	5020	2194	7.78	0.04	0.95	581
S21	Retro 2002	0.106	5109	2241	7.76	0.04	0.95	592
S22	Retro 2001	0.105	5367	2333	7.82	0.04	0.95	619
S23	B1/K=0.95	0.105	5463	2401	7.79	0.04	0.95	633
S24	B1/K=0.90	0.109	5588	2492	7.64	0.03	0.95	649
S25	B1/K=0.85	0.105	5706	2528	7.75	0.03	0.95	664
S26	B1/K=0.80	0.105	5851	2600	7.74	0.03	0.95	682
S27	B1/K=0.70	0.104	5211	2326	7.34	0.05	0.95	606
S28	B1/K=0.65	0.106	5197	2325	8.05	0.05	0.95	605
S29	B1/K=0.60	0.132	5070	2415	8.23	0.04	0.95	604
S30	B1/K=0.55	0.104	5239	2325	9.21	0.05	0.95	600
S31	B1/K=0.50	0.176	4870	2571	12.84	0.04	0.94	601
S32	0.5 Early recr L	0.112	3189	1314	8.3	0.06	0.95	356
S33	1.5 Early recr L	0.104	7419	3283	7.73	0.03	0.94	858
S34	Finit=0.05	0.106	5431	2416	7.71	0.06	0.95	635
S35	Finit=0.1	0.105	6069	2696	7.74	0.03	0.95	706
S36	Finit=0.15	0.104	6600	2912	7.83	0.03	0.95	764
S37	Dome recr sel 1	0.263	13110	1336	2.04	0.09	0.95	528
S38	Dome recr sel 2	0.156	12882	3129	6.16	0.02	0.92	595
S39	Dome recr sel 3	0.184	9846	2274	5.93	0.02	0.93	778

Figure 6.1. Dome-shaped selectivity for recreational sectors as considered in sensitivity runs of this report (see text for details). Top panel) Selectivity hypothesized by Dr. Hester (reproduced from Dr. Hester's report dated 8 May 2009) and applied in sensitivity runs S37 and S38 (full assessment period in S37; early time period only in S38). Bottom panel) Dome-shaped selectivities estimated in sensitivity run S39.



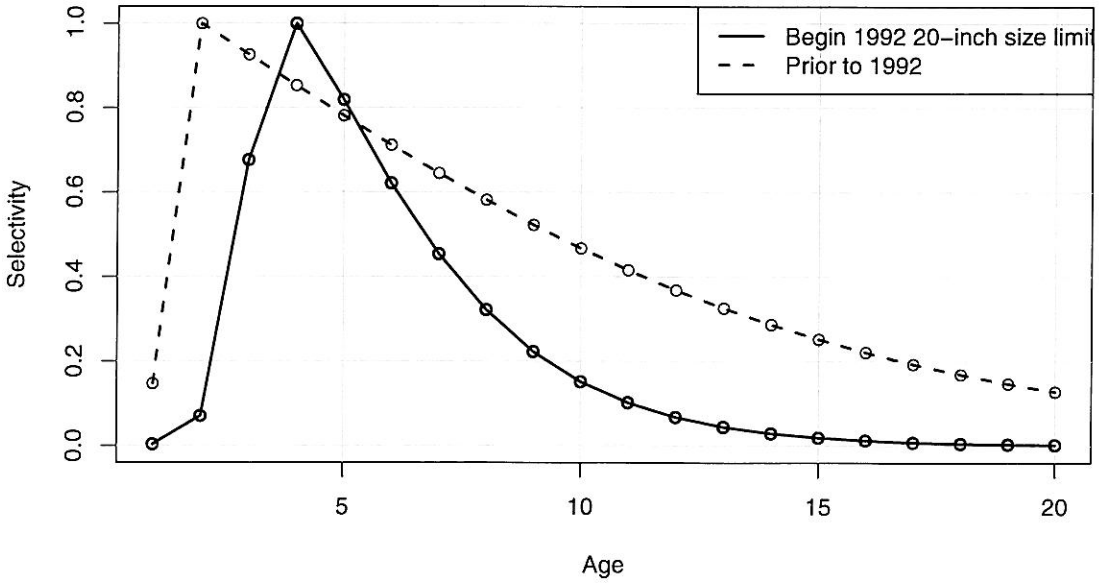
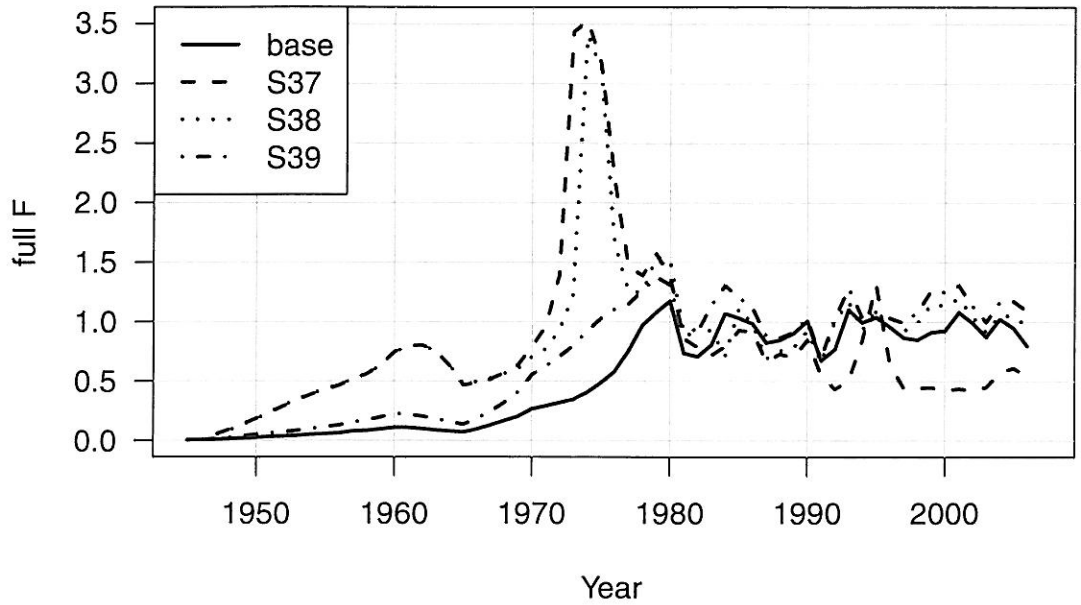


Figure 6.2. Comparison of full F (top) and spawning biomass (bottom) from the base assessment model (base) and three sensitivity runs (S37, S38, S39) with dome-shaped selectivity for recreational sectors (see text for details).



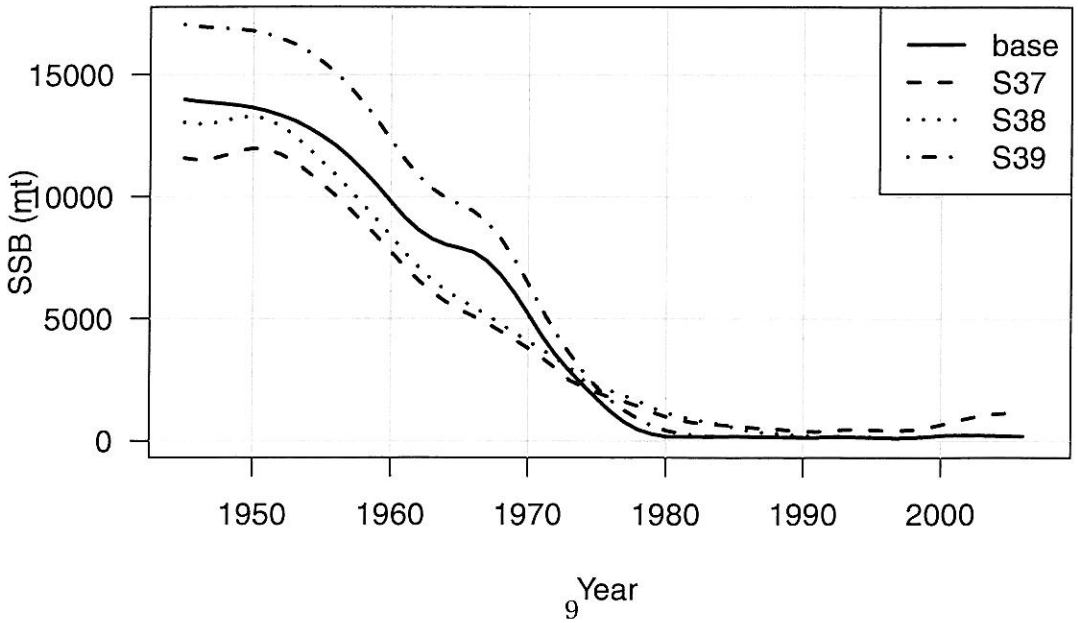


Figure 6.3. Stock and fishery status of base run (solid circle) and 40 sensitivity runs (open circles). Values have been jittered (small noise added) to improve distinction of overlapping circles. Note that sensitivity runs S37–S39, as well as the base model, use $F_{40\%}$ proxies for MSY-*based reference points.*

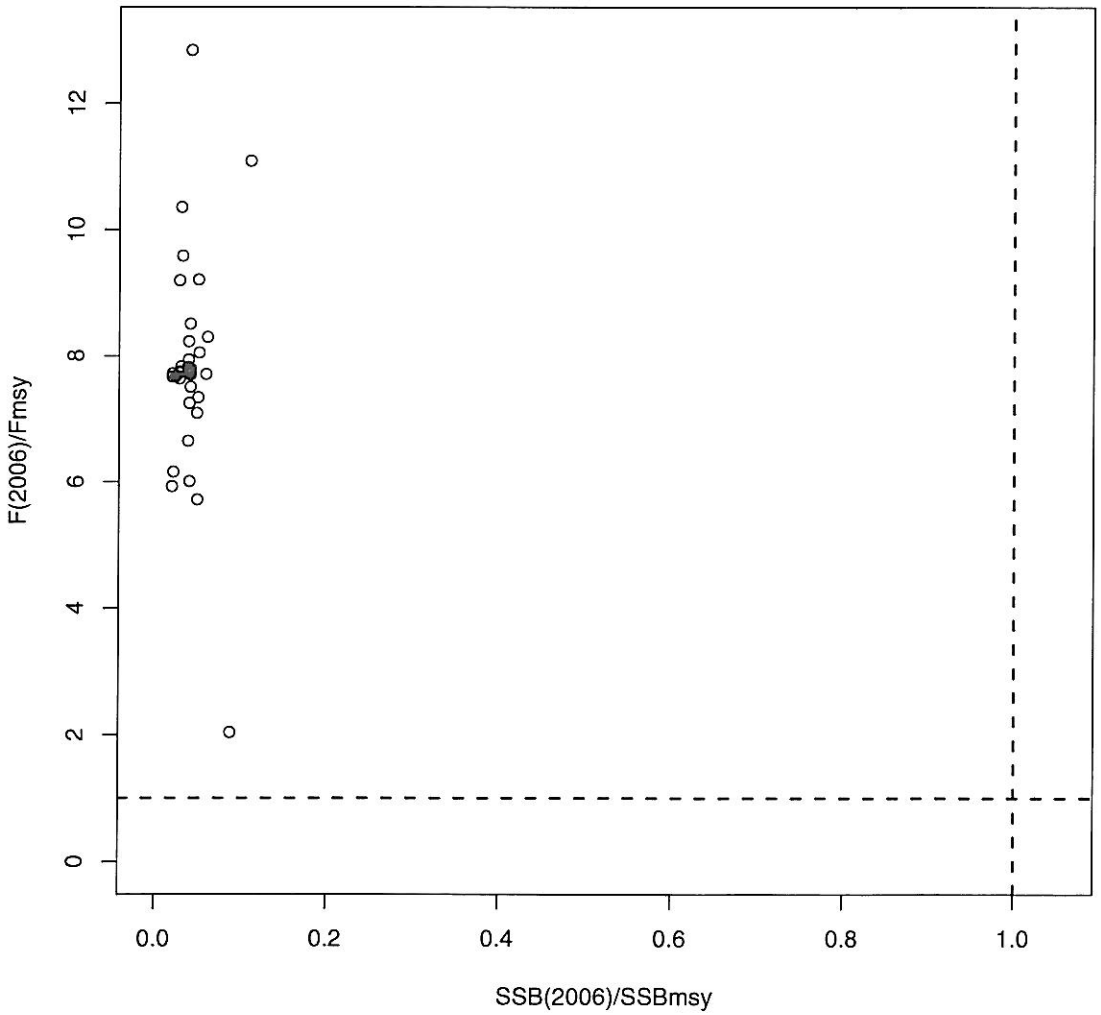


Figure 6.4. Comparison of catch-at-age data from recreational and commercial sectors. Y-axis is on log scale. Age 20 was pooled.

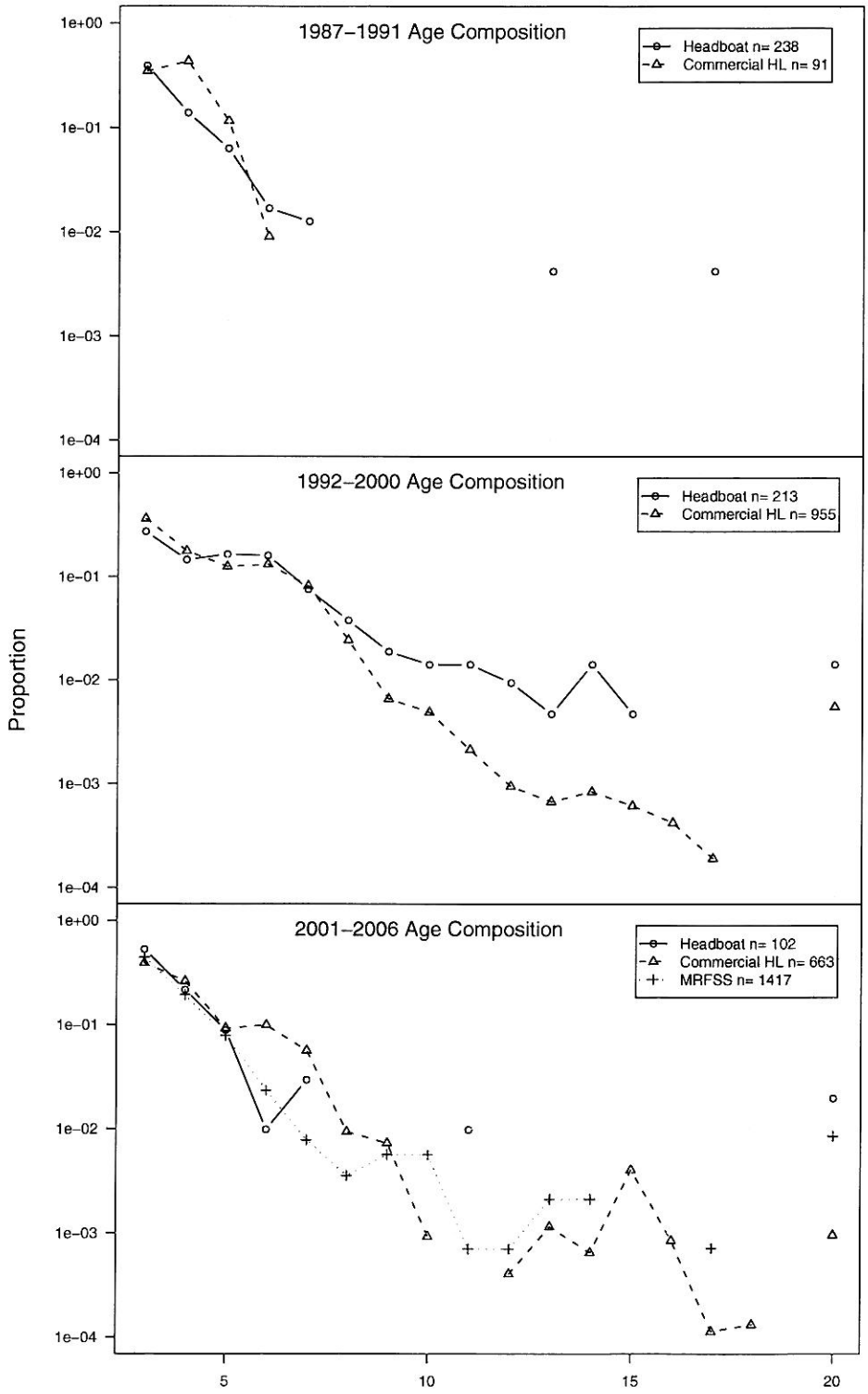
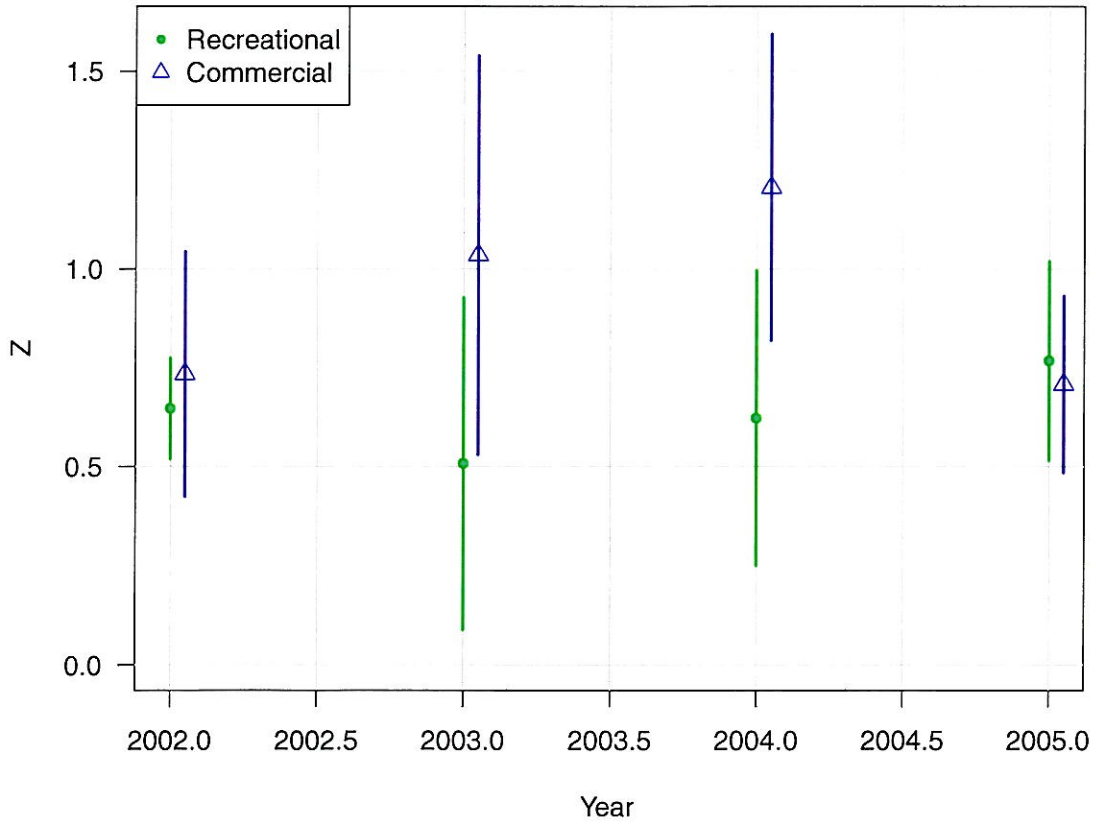


Figure 6.5. Estimates of total mortality (Z) from catch curve analysis using recreational or commercial catch-at-age data. Lines represent 95% confidence intervals. A higher estimate of Z indicates that the right-hand limb of age composition data descends more quickly, which could occur because mortality is higher or because of dome-shaped selectivity. Thus, assuming that selectivity of the commercial sector is flat-topped, one can compare estimates of Z for evidence of dome-shaped selectivity in the recreational sector. A much higher value of Z could indicate dome-shaped selectivity. This analysis reveals no evidence for dome-shaped selectivity of the recreational sector.



7 Appendix

SAFMC Staff Review of Comments Submitted by Dr. Frank Hester Regarding the Red Snapper Assessment

Upon review of the comments on the red snapper assessment submitted by Dr. Hester, there may be a need to further evaluate the selectivity assumption, its impact on the disparity between historical mean catch weight estimates and observations, and any potential impacts on recent SSB estimates. The underlying question is with selectivity, and whether a dome or flat top pattern is more appropriate for the recreational fishery. Potential evidence that the flat top assumption may bias some results is provided through Dr. Hester's comparison of the model produced mean catch weight (from total estimated catch in numbers and in weight) and the mean catch weight from the FWS reports in 1965 and 1970.

1. Dr. Hester criticizes the DW for information not provided. The observations are correct, but criticisms are somewhat unfounded as the DW report fully acknowledges these and several other data concerns.

- The DW provided the life history information that was available. Fecundity is seldom available for SG stocks, and this criticism would only be warranted if he cited some information that was overlooked. He does not.
- Very few species have available 'observations based estimates of natural mortality'. In fact, I cannot think of a single wild stock where such information is available.
- The DW provided one approach to estimating pre 1981 recreational catches – a linear interpolation that has little justification and is soundly disputed by the observations that area available in the FWS reports.
- No issues requiring additional analyses are raised in this section.

2. Comparison of VPA and forward projecting catch-age

- That VPA is more 'familiar' than catch-age is the opinion of the author. My opinion is that SEDAR participants are much more familiar with the model framework used for red snapper as it has been in use since the first SEDAR.
- It is true that both models suffer from poor data. Extensive comparisons of the various model classes in use today prove that all models suffer from poor and missing data, and that some models are better than others at dealing with particular data holes. SEDAR assessments seldom use VPA because VPA models require a complete catch-age input and apply an assumption that the catch is measured without error. Most stocks managed by the SAFMC have only a short time series of age observations adequate for constructing catch at age, and it is widely accepted that key catch sectors have considerable error in their catch estimates. In fact, determining the level of uncertainty in historic catch records is usually a topic of extensive discussion. The model used for red snapper is state of the art and has been extensively reviewed by independent peer review panels.
- Both models suffer from terminal year uncertainty and provide more accurate estimates farther back in time. This is a simple fact of all age structured assessments that essentially rely on tracking a cohort as it progress through its life.
- No issues requiring additional analyses are raised in this section.

3. It is stated that use of the FWS reports causes a major problem

- I disagree with this statement. As Dr Hester states in quotations from the AW report, initial model runs without the FWS observations suggested that pre-1981 catches were significantly higher than those estimated by the simple linear interpolation provided by the DW group. The fact is that age and length composition information suggest that the population was already reduced by the time sampling began, and observations of catch post-1981 were inadequate to drive the population down to accommodate the age composition observed when actual age composition observations became available. The model was looking for a way to remove fish, and since recreational catches are specified to have greater uncertainty than commercial catches, in terms of minimizing error the appropriate way for the model to do this was to increase early recreational catches. When reviewed further at the AW, the panel recognized that the FWS reports corroborated the path the model was determined to take, and therefore including those observations and developing an alternative historical catch series improved overall model performance, in terms of fit and residual patterns.
- The FWS observations are legitimate observations and deserved further consideration at the AW. They are based on survey results and recall, and their precision may be difficult to ascertain, but they are believed to provide better information than the linear interpolation put forth by the DW. Historical catch records are important to inferring long-term productivity, and this debate underscores the need to refine methods for estimating pre-1981 recreational landings and other historical removals

4. Conversion of catch in weight to catch in numbers. This section indicates that perhaps Dr. Hester believes that the problem with the assessment is more in how the FWS observations are incorporated than in the fact that they were incorporated at all.

- I am not familiar enough with the internal workings of the model to know all the steps it takes to go from an overall annual weight to the annual estimates of abundance and then catches at age, but I am fairly certain it involves more than just the selectivity curve. We could request further clarification, but I don't think this is critical to the potentially relevant point that emerges later.
- It is stated "The fact that these are averages implies that half the landings are less than 3 pounds" . This is not always true. It is true, however, that the preferred statistic to describe the center value of a distribution is the median, and if the median were 3 pounds then half of the observations would be less than 3 pounds. However, the same cannot be said of the average. Consider a simple example with 3 observations: 25, 50, and 225. The average is 100 and the value of the median observation is 50, so in this example one-third of the values are less than the median and two-thirds have values less than the average. All of this is really beside, and unfortunately detracts from, the fundamental observation that is identified later— that there is a discrepancy between the mean weight from the FWS reports, which provide the bulk of the landings in the early years, and the mean weight from the overall, model-estimated catch at age.
- I don't see adequate information provided to support the statement that the catch at age should heavily favor fish less than three years old. I'm also confused by the switch from an argument based on pounds to an argument based on age. If the population was indeed lightly exploited in the earliest years, and retained reasonable numbers of older fish, it

should not be surprising that the sum total of catches across the oldest 17+ ages would be more than the total across the youngest 3 ages. Even more so when less than full selectivity is applied to age 1, a model feature that is not disputed.

5. Selectivity Issues

- The model does incorporate a flat selectivity curve for the recreational fisheries. I am not clear whether this was a specification or whether the shape of the selectivity curve was something the model was free to determine. It is not apparent in the assessment report whether an alternative selectivity was forced in a sensitivity analysis and I can't recall that being explored at the AW.
- Concerns over the use of the flat selectivity curve were raised by Roy Crabtree some time ago. The Gulf red snapper assessment used a dome curve, and while this alone is not ample reason to apply a dome shaped selectivity pattern to Atlantic red snapper, it does provide some justification to consider a sensitivity incorporating a similar pattern.
- Some anecdotal reports suggest that species like red snapper which inhabit bottom substrates and can grow to very large size may have domed selectivity patterns by size because the largest fish are more difficult to land. There is some confounding though when selectivity is considered by age, especially for a stock such as this where the life history observations reveal that length is not informative of age. In other words, while the biggest fish may be harder to land, the biggest fish are not always and necessarily the oldest fish. Again, though, since this perception exists the domed selectivity pattern should be explored if it has not already.
- The selectivity issue may somewhat alter the model estimates of overall annual catch mean weight.

6. Conclusions

- Concerns are raised with the early catch records and the selectivity. To me, the issues go hand in hand as the selectivity assumption will influence the estimated catch age distribution and hence the back calculated average weight of the catch.
- Given Dr. Hester's submission and prior concerns raised regarding selectivity, I would like to know more about how the selectivity curve was modeled. I would also like to see a sensitivity analysis fixing a dome shaped selectivity curve in the recreational fisheries, at least in the early years when there are substantial numbers of older fish in the estimated population.
- I believe the issue of selectivity should be explored. I will be surprised if specifying a dome shaped selectivity curve will substantially change stock status estimates, but the issue requires attention so that the process can move ahead.
- It is within reason to hypothesize that a domed shaped selectivity would increase the estimated abundance of older fish, impact SSB, and ultimately influence the Stock-Recruit relationship and steepness.
- It is also within reason to hypothesize that switching to a dome shaped selectivity pattern will increase the overall F. The model needs to account for a certain number of dead fish, and if you specify that a certain segment of the population is 'off limits' or receives a smaller portion of the overall F, the model will likely be forced to increase the overall removal rate. Considering beyond the scientific ramifications, given this outcome, actions applied to the portion of the population that is exploited might need to be more severe.

- Hypothesizing even further along these lines, increased abundance of older fish would increase SSB and potentially decrease the extent to which the stock is overfished, but keep in mind that all estimates suggest the stock is severely overfished and current SSB is on the order of 3% of the desired level.

7. Discussion Items

- Dr. Hester's concluding discussion largely reflects the opinions stated by the Review Panel, namely that while the stock appears to be at a point of equilibrium, the relation of this point of equilibrium to desirable conditions and long term maximization of yields is uncertain.
- While current F may be sustainable over a short time, there is considerable evidence to suggest that yield is well below MSY. Also, evidence suggests the fishery is highly susceptible to fluctuations in correlation with year class strength which is risky and a classic sign of excessive exploitation.
- There is well noted uncertainty in the biological reference for exploitation, but it should be acknowledged that estimates of current F are well above any of the proposed values for MFMT.
- I am skeptical that new data sources will be found at this point, largely because none have surfaced over the last year as controversies regarding this assessment arose and because Dr. Hester, who clearly devoted considerable time and effort to reviewing the assessment, fails to point out any even potential sources of information to shed light on the uncertainties in the assessment.
- I am skeptical that increased sampling of the current population in the short term will resolve the problems with estimating long-term productivity. Improving estimates of productivity can only be achieved through reducing exploitation so the age structure can expand and ensuring adequate monitoring as the population recovers.
- Increased sampling may shed some light on the current age composition, and should at least provide greater confidence in the age composition estimates. Such endeavors should not be short lived however, as the assessment considerably suffers from a lack of both age and length sampling. Commercial age samples range from 7 to 332 annually, and only 1820 are available over nearly 20 years. That is less than 100 per year on average, which is pretty poor for a fish with a life span over 50 years.
- I agree the Council needs to take action, and all the available evidence indicates that fishing mortality must be reduced substantially.
- I strongly and completely disagree with the characterization that all assessment scientists presuppose a stock is depleted. This is one of several unfortunate opinion statements that detract from the potentially legitimate concerns raised regarding the selectivity pattern, and the questions raised regarding the differences in observed and estimated overall mean weight.

Red Snapper Projections VII

31 July 2009

1 Introduction

Projections of red snapper in the U.S. South Atlantic were completed as part of SEDAR-15 and were described in the SEDAR-15 assessment report. Following the SEDAR-15 Review Workshop, those projections were revised according to an SAFMC memorandum (dated August 12, 2008) from Bob Mahood to Dr. Bonnie Ponwith; the revised projections were described in the SEDAR-15 "Addenda and updates." Additional projections were computed for consideration of the SAFMC SSC at their December, 2008 meeting, as described in a report titled "Red snapper: Estimation of biomass benchmarks and projections." During that meeting, the SSC requested more projections, which were computed and described in a follow-up report to the SSC titled, "Red Snapper Projections: the SSC Alternative (1 December 2008)."

A SERO memorandum (dated February 13, 2009), from Dr. Roy Crabtree to Dr. Bonnie Ponwith, requested additional red snapper projections. Those projections were described in the report titled, "Red Snapper Projections V". Following that report, the Council requested an additional projection, which was described in "Red Snapper Projections V – Addendum". In preparation for the June 2009 Council meeting, further projections were run to explore the potential effects of strong recruitment in 2006. Those projections were described in "Red Snapper Projections VI."

A SERO memorandum (dated July 10, 2009), from Dr. Roy Crabtree to Dr. Bonnie Ponwith, requested more red snapper projections. This report, along with the report titled, "Red Snapper Projections VI—Revised," documents these projections. A synopsis of the request follows:

1. New constant fishing mortality projections similar to those provided on March 9, 2009, which incorporates high recruitment that appears to have occurred in 2005 or 2006
2. An additional constant fishing mortality projection that would rebuild the stock in 35 years, which is the maximum allowable rebuilding time
3. A suite of projections using $F_{30\%}$
4. Provide the value of the yield at $F_{45\%}$

Item one regarding high recent recruitment is described in a companion report, titled "Red Snapper Projections VI—Revised." Items two through four are covered in this report.

To accomplish the fourth item, biomass benchmarks associated with $F_{45\%}$ were computed through long-term, deterministic projections with bias correction, as was done with $F_{30\%}$ and $F_{40\%}$. Similar long-term projections were run to compute the yield associated with 65%, 75%, and 85% of $F_{45\%}$. Benchmarks are shown in Table 5.1.

2 Projection scenarios

To accomplish the second and third items, several projection scenarios with constant F were considered:

- Scenario A: $F = F_{\text{rebuild}}$, defined as the maximum F that allows rebuilding by the start of 2045
- Scenario B: $F = 65\% F_{30\%}$
- Scenario C: $F = 75\% F_{30\%}$
- Scenario D: $F = 85\% F_{30\%}$
- Scenario E: $F = F_{30\%}$

Methods are described more fully in "Red Snapper Projections V."

3 Projection Results

Results of projections with $F = F_{\text{rebuild}}$ are tabulated in Table 5.2 and are presented graphically in Fig. 6.1. The maximum F that allowed rebuilding was $F_{\text{rebuild}} = 0.1$.

Results of the projections associated with $F_{30\%}$ are tabulated in Table 5.3–5.6, and are presented graphically in Figs. 6.2–6.5.

4 Comments on Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- Initial abundance at age of the projections were based on estimates from the last year of the assessment. If those estimates are inaccurate, rebuilding will likely be affected.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect rebuilding.
- The projections assumed no change in the selectivity applied to discards. As recovery generally begins with the smallest size classes, management action may be needed to meet that assumption.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If changes in environmental or ecological conditions affect recruitment or life-history characteristics, rebuilding may be affected.
- The projections used a spawner-recruit relationship with steepness of $h = 0.95$, the value estimated in the assessment but with considerable uncertainty. Such a high value implies that the stock, at its currently low abundance, spawns nearly as many recruits as it would at high abundance. That is, productivity is nearly independent of spawning biomass. If productivity depends on spawning biomass, stock recovery would take longer than projected.

5 Tables

Table 5.1. Estimated status indicators, benchmarks, and related quantities, conditional on estimated current selectivities averaged across fisheries. Values are MSY*-based proxies associated with* $F_{40\%}$*, the recommended proxy for* F_{MSY}*, and also* $F_{35\%}$ *and* $F_{30\%}$*. Biomass-based and number-based quantities were computed as equilibrium values from projections with fishing rate* $F_{30\%}$*,* $F_{40\%}$*, or* $F_{45\%}$ *(or X% of those rates), as indicated. Estimates of yield (Y) do not include discard mortalities (D). The* MSST *is defined by* $\mathrm{MSST} = (1 - M)\mathrm{SSB}_{\mathrm{MSY}}$*, with constant* $M = 0.078$*.*

Quantity	Units	$F_{45\%}$ Proxy	$F_{40\%}$ Proxy	$F_{30\%}$ Proxy
F_{MSY}	y^{-1}	0.088	0.104	0.148
$\mathrm{SSB}_{\mathrm{MSY}}$	mt	9120.6	8102.5	6025.1
$\mathrm{D}_{\mathrm{MSY}}$	1000 fish	33	39	54
Recruits at F_{MSY}	1000 fish	695	693	686
Y at 65% F_{MSY}	1000 lb	1833	1984	2257
Y at 75% F_{MSY}	1000 lb	1963	2104	2338
Y at 85% F_{MSY}	1000 lb	2070	2199	2391
Y at F_{MSY}	1000 lb	2196	2304	2431
MSST	mt	8409.2	7470.5	5555.1
$F_{2006}/F_{\mathrm{MSY}}$	–	9.06	7.67	5.39
$\mathrm{SSB}_{2006}/\mathrm{SSB}_{\mathrm{MSY}}$	–	0.02	0.02	0.03
$\mathrm{SSB}_{2006}/\mathrm{MSST}$	–	0.02	0.03	0.04

*Table 5.2. Red snapper: Projection results under scenario A—fishing mortality rate $F = F_{\text{rebuild}}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\text{SSB}_{F_{40\%}} = 8102.5$ mt, $\text{R}_{F_{40\%}} = 692,864$ fish, $\text{Y}_{F_{40\%}} = 2,303,676$ lb, and $\text{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.1	0	187	285	56	1470	13	22	13
2011	0.1	0	406	306	98	1568	20	28	16
2012	0.1	0	612	443	155	1723	28	31	18
2013	0.1	0	868	508	223	1946	37	39	23
2014	0.1	0	1182	555	305	2251	48	48	27
2015	0.1	0	1548	590	405	2656	59	54	30
2016	0.1	0	1955	615	518	3174	71	58	32
2017	0.1	0	2389	634	638	3812	82	61	33
2018	0.1	0	2837	647	762	4574	93	63	34
2019	0.1	0	3285	657	886	5460	103	65	35
2020	0.1	0	3726	664	1009	6469	112	66	36
2021	0.1	0	4150	669	1127	7595	119	67	36
2022	0.1	0.01	4553	674	1238	8833	127	68	36
2023	0.1	0.01	4931	677	1342	10,176	133	68	37
2024	0.1	0.02	5281	680	1439	11,615	139	68	37
2025	0.1	0.04	5603	682	1528	13,142	144	69	37
2026	0.1	0.06	5898	684	1609	14,751	148	69	37
2027	0.1	0.08	6165	685	1682	16,434	152	69	37
2028	0.1	0.1	6407	686	1749	18,183	155	69	37
2029	0.1	0.13	6625	687	1809	19,991	159	69	37
2030	0.1	0.16	6819	688	1862	21,854	161	70	37
2031	0.1	0.2	6994	689	1910	23,764	164	70	37
2032	0.1	0.23	7149	690	1953	25,717	166	70	37
2033	0.1	0.26	7287	690	1991	27,708	168	70	37
2034	0.1	0.29	7410	691	2025	29,733	169	70	37
2035	0.1	0.32	7519	691	2055	31,788	171	70	37
2036	0.1	0.35	7615	691	2081	33,869	172	70	37
2037	0.1	0.37	7700	692	2105	35,974	173	70	37
2038	0.1	0.4	7776	692	2125	38,099	174	70	37
2039	0.1	0.42	7842	692	2144	40,243	175	70	37
2040	0.1	0.44	7901	692	2160	42,403	176	70	37
2041	0.1	0.47	7953	692	2174	44,577	177	70	38
2042	0.1	0.48	7999	692	2187	46,764	177	70	38
2043	0.1	0.5	8040	693	2198	48,962	178	70	38
2044	0.1	0.51	8075	693	2208	51,170	178	70	38
2045	0.1	0.52	8107	693	2216	53,386	179	70	38
2046	0.1	0.52	8135	693	2224	55,610	179	70	38
2047	0.1	0.53	8159	693	2231	57,841	179	70	38
2048	0.1	0.52	8181	693	2237	60,078	180	70	38
2049	0.1	0.53	8200	693	2242	62,320	180	70	38
2050	0.1	0.53	8217	693	2247	64,566	180	70	38

*Table 5.3. Red snapper: Projection results under scenario B—fishing mortality rate $F = 65\% F_{30\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{30\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $\mathrm{SSB}_{F_{30\%}} = 6025.1$ mt, $\mathrm{R}_{F_{30\%}} = 685,824$ fish, $\mathrm{Y}_{F_{30\%}} = 2,430,792$ lb, and $\mathrm{D}_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.096	0	187	285	54	1468	12	21	13
2011	0.096	0	408	306	95	1563	19	27	15
2012	0.096	0	615	444	150	1713	27	30	18
2013	0.096	0	874	509	216	1928	36	37	22
2014	0.096	0	1192	556	296	2224	46	47	26
2015	0.096	0	1563	591	394	2618	58	52	29
2016	0.096	0	1977	616	504	3122	69	56	31
2017	0.096	0	2418	634	621	3743	80	59	32
2018	0.096	0	2874	648	743	4486	90	61	33
2019	0.096	0.01	3332	657	865	5351	100	63	34
2020	0.096	0.03	3782	665	985	6336	109	64	34
2021	0.096	0.06	4216	670	1101	7438	116	65	35
2022	0.096	0.11	4629	674	1211	8649	123	65	35
2023	0.096	0.18	5017	678	1314	9963	130	66	35
2024	0.096	0.27	5377	680	1410	11,373	135	66	35
2025	0.096	0.37	5709	683	1498	12,870	140	66	36
2026	0.096	0.47	6013	684	1578	14,449	145	67	36
2027	0.096	0.58	6290	686	1652	16,101	148	67	36
2028	0.096	0.65	6541	687	1718	17,819	152	67	36
2029	0.096	0.72	6766	688	1778	19,596	155	67	36
2030	0.096	0.78	6969	689	1831	21,428	158	67	36
2031	0.096	0.84	7150	690	1879	23,307	160	67	36
2032	0.096	0.87	7313	690	1922	25,229	162	67	36
2033	0.096	0.9	7457	691	1961	27,190	164	67	36
2034	0.096	0.92	7586	691	1995	29,184	166	67	36
2035	0.096	0.93	7700	691	2025	31,209	167	67	36
2036	0.096	0.95	7801	692	2052	33,260	169	68	36
2037	0.096	0.96	7891	692	2075	35,336	170	68	36
2038	0.096	0.97	7971	692	2096	37,432	171	68	36
2039	0.096	0.97	8041	693	2115	39,547	172	68	36
2040	0.096	0.97	8103	693	2131	41,678	172	68	36
2041	0.096	0.98	8159	693	2146	43,824	173	68	36
2042	0.096	0.98	8207	693	2159	45,983	174	68	36
2043	0.096	0.98	8251	693	2170	48,154	174	68	36
2044	0.096	0.98	8289	693	2180	50,334	175	68	36
2045	0.096	0.99	8322	693	2189	52,524	175	68	36
2046	0.096	0.99	8352	693	2197	54,721	176	68	36
2047	0.096	0.99	8378	693	2204	56,925	176	68	36
2048	0.096	0.99	8402	694	2210	59,135	176	68	36
2049	0.096	0.99	8422	694	2216	61,351	176	68	36
2050	0.096	0.99	8440	694	2221	63,572	177	68	36

*Table 5.4. Red snapper: Projection results under scenario C—fishing mortality rate $F = 75\% F_{30\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{30\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $SSB_{F_{30\%}} = 6025.1$ mt, $R_{F_{30\%}} = 685,824$ fish, $Y_{F_{30\%}} = 2,430,792$ lb, and $D_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.111	0	187	285	62	1476	14	24	15
2011	0.111	0	402	306	108	1584	22	31	17
2012	0.111	0	603	441	169	1753	30	34	20
2013	0.111	0	851	506	242	1995	40	43	26
2014	0.111	0	1154	553	330	2325	52	53	30
2015	0.111	0	1506	588	437	2763	64	59	33
2016	0.111	0	1895	613	556	3319	77	64	35
2017	0.111	0	2308	631	683	4002	89	67	37
2018	0.111	0	2732	645	814	4816	100	69	38
2019	0.111	0.01	3156	655	944	5760	110	71	39
2020	0.111	0.01	3570	662	1072	6832	120	72	39
2021	0.111	0.03	3967	668	1194	8026	128	73	40
2022	0.111	0.07	4341	672	1309	9335	135	74	40
2023	0.111	0.12	4691	675	1416	10,751	142	75	40
2024	0.111	0.18	5014	678	1515	12,266	148	75	40
2025	0.111	0.24	5310	680	1606	13,872	153	75	41
2026	0.111	0.32	5578	682	1688	15,560	158	76	41
2027	0.111	0.41	5821	684	1762	17,322	162	76	41
2028	0.111	0.48	6039	685	1829	19,151	165	76	41
2029	0.111	0.56	6235	686	1888	21,039	168	76	41
2030	0.111	0.62	6409	687	1942	22,980	171	76	41
2031	0.111	0.68	6564	687	1989	24,969	173	76	41
2032	0.111	0.73	6701	688	2031	27,000	175	77	41
2033	0.111	0.76	6823	689	2068	29,068	177	77	41
2034	0.111	0.79	6930	689	2101	31,169	179	77	41
2035	0.111	0.82	7025	689	2130	33,298	180	77	41
2036	0.111	0.84	7108	690	2155	35,453	182	77	41
2037	0.111	0.86	7182	690	2177	37,631	183	77	41
2038	0.111	0.88	7246	690	2197	39,828	184	77	41
2039	0.111	0.89	7303	690	2215	42,043	184	77	41
2040	0.111	0.89	7353	691	2230	44,272	185	77	41
2041	0.111	0.9	7397	691	2243	46,515	186	77	41
2042	0.111	0.9	7435	691	2255	48,770	186	77	41
2043	0.111	0.91	7469	691	2265	51,035	187	77	41
2044	0.111	0.92	7499	691	2274	53,310	187	77	41
2045	0.111	0.93	7525	691	2282	55,592	188	77	41
2046	0.111	0.92	7547	691	2289	57,881	188	77	41
2047	0.111	0.93	7567	691	2295	60,176	188	77	41
2048	0.111	0.93	7585	691	2300	62,476	189	77	41
2049	0.111	0.93	7600	691	2305	64,781	189	77	41
2050	0.111	0.94	7614	692	2309	67,090	189	77	41

*Table 5.5. Red snapper: Projection results under scenario D—fishing mortality rate $F = 85\% F_{30\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{30\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $\mathrm{SSB}_{F_{30\%}} = 6025.1$ mt, $\mathrm{R}_{F_{30\%}} = 685,824$ fish, $\mathrm{Y}_{F_{30\%}} = 2,430,792$ lb, and $\mathrm{D}_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.126	0	187	285	70	1484	16	27	17
2011	0.126	0	397	306	121	1605	25	35	19
2012	0.126	0	591	439	187	1792	34	38	23
2013	0.126	0	828	503	267	2059	45	48	29
2014	0.126	0	1117	549	362	2421	57	59	34
2015	0.126	0	1451	584	477	2898	71	66	37
2016	0.126	0	1817	610	604	3501	84	71	39
2017	0.126	0	2204	628	738	4240	97	75	41
2018	0.126	0	2599	642	876	5115	109	77	42
2019	0.126	0	2991	652	1013	6128	120	79	43
2020	0.126	0.01	3371	659	1146	7274	130	81	44
2021	0.126	0.02	3734	665	1272	8546	138	82	44
2022	0.126	0.04	4075	670	1391	9937	146	83	45
2023	0.126	0.07	4390	673	1500	11,437	153	83	45
2024	0.126	0.11	4680	676	1601	13,038	159	84	45
2025	0.126	0.15	4943	678	1692	14,730	164	84	45
2026	0.126	0.2	5181	680	1775	16,505	169	85	46
2027	0.126	0.26	5395	681	1849	18,354	173	85	46
2028	0.126	0.32	5585	683	1915	20,268	176	85	46
2029	0.126	0.38	5755	684	1973	22,242	180	85	46
2030	0.126	0.43	5905	685	2025	24,267	182	85	46
2031	0.126	0.48	6037	685	2071	26,338	185	85	46
2032	0.126	0.53	6154	686	2112	28,450	187	86	46
2033	0.126	0.58	6257	686	2147	30,597	188	86	46
2034	0.126	0.61	6346	687	2178	32,775	190	86	46
2035	0.126	0.64	6425	687	2205	34,980	191	86	46
2036	0.126	0.67	6494	688	2229	37,210	193	86	46
2037	0.126	0.69	6554	688	2250	39,460	194	86	46
2038	0.126	0.71	6607	688	2268	41,728	194	86	46
2039	0.126	0.73	6653	688	2284	44,012	195	86	46
2040	0.126	0.74	6693	688	2298	46,310	196	86	46
2041	0.126	0.75	6728	689	2310	48,620	197	86	46
2042	0.126	0.76	6758	689	2321	50,941	197	86	46
2043	0.126	0.76	6785	689	2330	53,271	197	86	46
2044	0.126	0.77	6808	689	2338	55,608	198	86	46
2045	0.126	0.78	6828	689	2345	57,953	198	86	46
2046	0.126	0.78	6845	689	2351	60,304	198	86	46
2047	0.126	0.78	6861	689	2356	62,660	199	86	46
2048	0.126	0.79	6874	689	2361	65,021	199	86	46
2049	0.126	0.79	6885	689	2365	67,385	199	86	46
2050	0.126	0.79	6895	689	2368	69,753	199	86	46

*Table 5.6. Red snapper: Projection results under scenario E—fishing mortality rate $F = F_{30\%}$. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{30\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $SSB_{F_{30\%}} = 6025.1$ mt, $R_{F_{30\%}} = 685,824$ fish, $Y_{F_{30\%}} = 2,430,792$ lb, and $D_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	203	286	454	454	95	153	99
2008	1.22	0	205	321	553	1007	117	190	129
2009	0.974	0	165	322	407	1414	91	157	109
2010	0.148	0	187	285	82	1496	19	32	20
2011	0.148	0	390	306	139	1635	28	40	23
2012	0.148	0	573	436	214	1849	39	44	27
2013	0.148	0	796	498	301	2150	51	55	33
2014	0.148	0	1064	544	405	2555	64	68	39
2015	0.148	0	1372	579	529	3084	79	76	43
2016	0.148	0	1707	605	666	3749	94	81	45
2017	0.148	0	2058	623	809	4558	108	86	47
2018	0.148	0	2412	637	954	5513	121	89	49
2019	0.148	0	2761	647	1097	6610	132	91	50
2020	0.148	0	3097	655	1236	7846	143	93	51
2021	0.148	0.01	3415	661	1366	9212	152	94	51
2022	0.148	0.02	3710	666	1487	10,698	160	95	52
2023	0.148	0.03	3981	669	1598	12,296	167	96	52
2024	0.148	0.05	4227	672	1698	13,994	173	96	52
2025	0.148	0.07	4449	674	1789	15,783	179	97	53
2026	0.148	0.1	4648	676	1870	17,653	183	97	53
2027	0.148	0.12	4824	678	1942	19,595	187	98	53
2028	0.148	0.15	4980	679	2005	21,600	191	98	53
2029	0.148	0.18	5118	680	2061	23,662	194	98	53
2030	0.148	0.22	5238	681	2110	25,772	196	98	53
2031	0.148	0.25	5344	682	2153	27,925	198	98	53
2032	0.148	0.28	5436	682	2191	30,116	200	98	53
2033	0.148	0.3	5515	683	2223	32,339	202	99	53
2034	0.148	0.32	5585	683	2252	34,591	204	99	53
2035	0.148	0.35	5645	684	2276	36,867	205	99	53
2036	0.148	0.37	5697	684	2297	39,164	206	99	53
2037	0.148	0.38	5742	684	2316	41,480	207	99	54
2038	0.148	0.4	5781	684	2331	43,811	208	99	54
2039	0.148	0.41	5815	685	2345	46,157	208	99	54
2040	0.148	0.43	5844	685	2357	48,514	209	99	54
2041	0.148	0.45	5869	685	2367	50,881	209	99	54
2042	0.148	0.46	5890	685	2376	53,257	210	99	54
2043	0.148	0.46	5909	685	2384	55,640	210	99	54
2044	0.148	0.47	5925	685	2390	58,031	210	99	54
2045	0.148	0.48	5939	685	2396	60,426	211	99	54
2046	0.148	0.47	5951	685	2401	62,827	211	99	54
2047	0.148	0.47	5961	685	2405	65,232	211	99	54
2048	0.148	0.47	5970	686	2408	67,640	211	99	54
2049	0.148	0.47	5978	686	2412	70,052	212	99	54
2050	0.148	0.47	5984	686	2414	72,466	212	99	54

6 Figures

Figure 6.1. Projection results under scenario A—fishing mortality rate fixed at F_{rebuild}, the maximum F that allows rebuilding by the start of 2045. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent $F_{40\%}$ benchmarks.

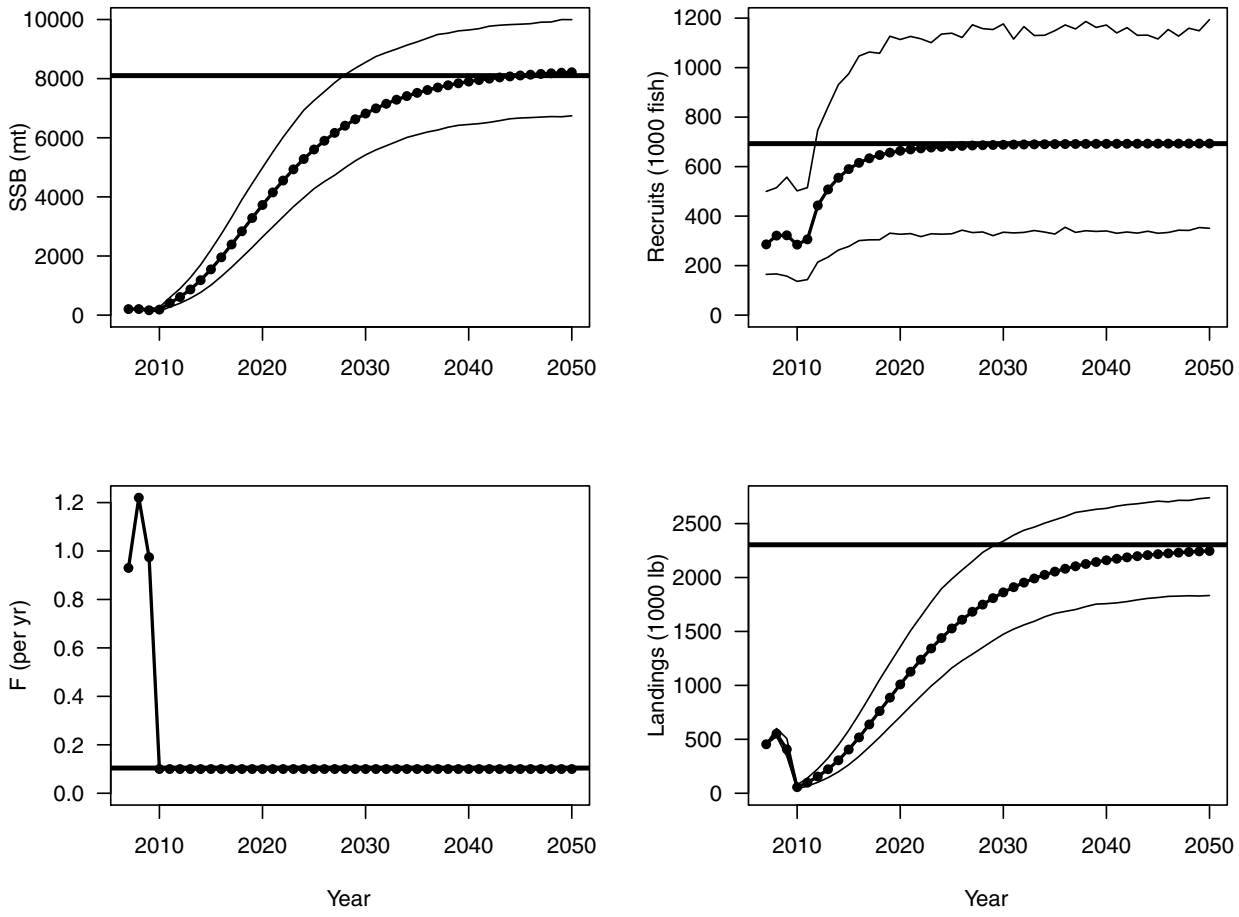


Figure 6.2. Projection results under scenario B—fishing mortality rate fixed at $F = 65\% F_{30\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent $F_{30\%}$ benchmarks.

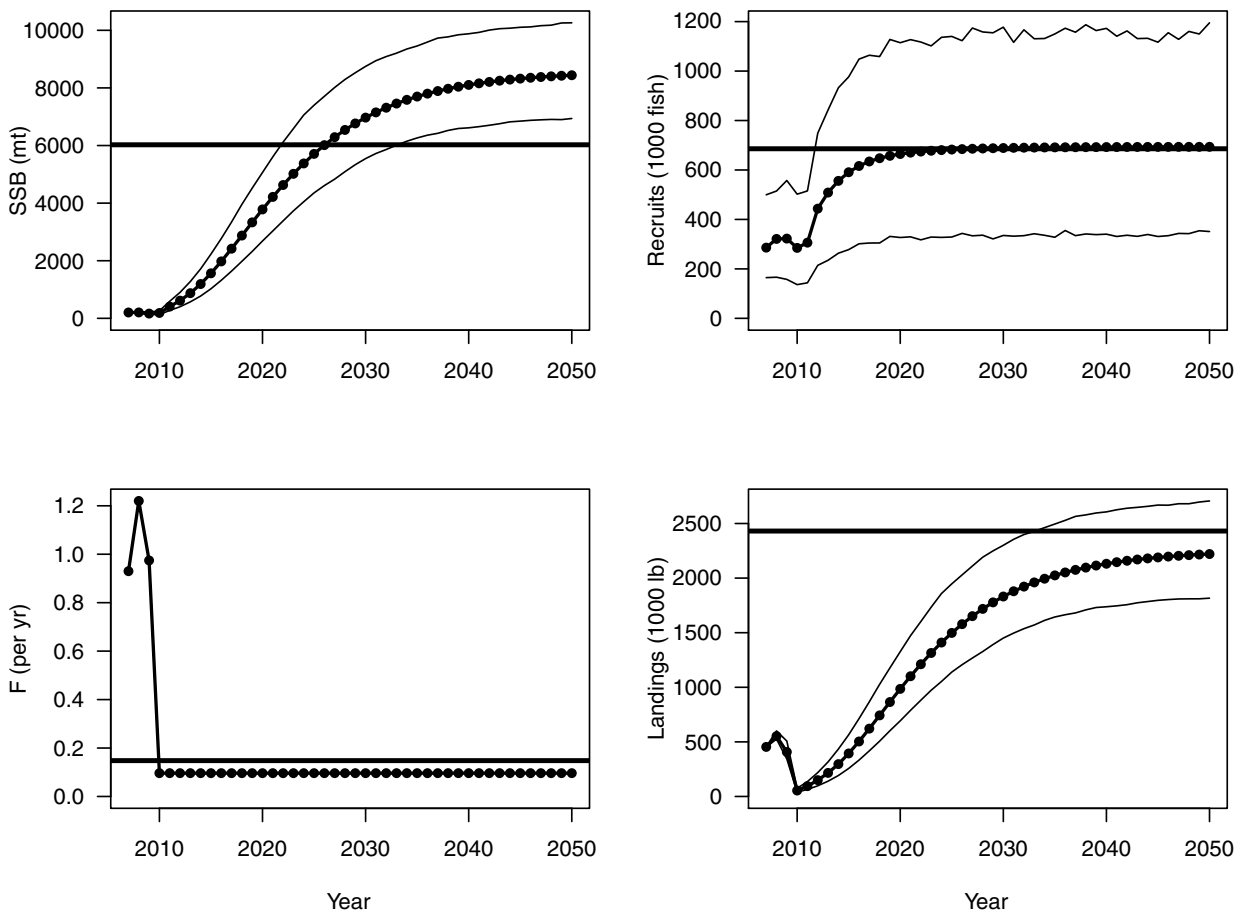


Figure 6.3. Projection results under scenario C—fishing mortality rate fixed at $F = 75\%F_{30\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent $F_{30\%}$ benchmarks.

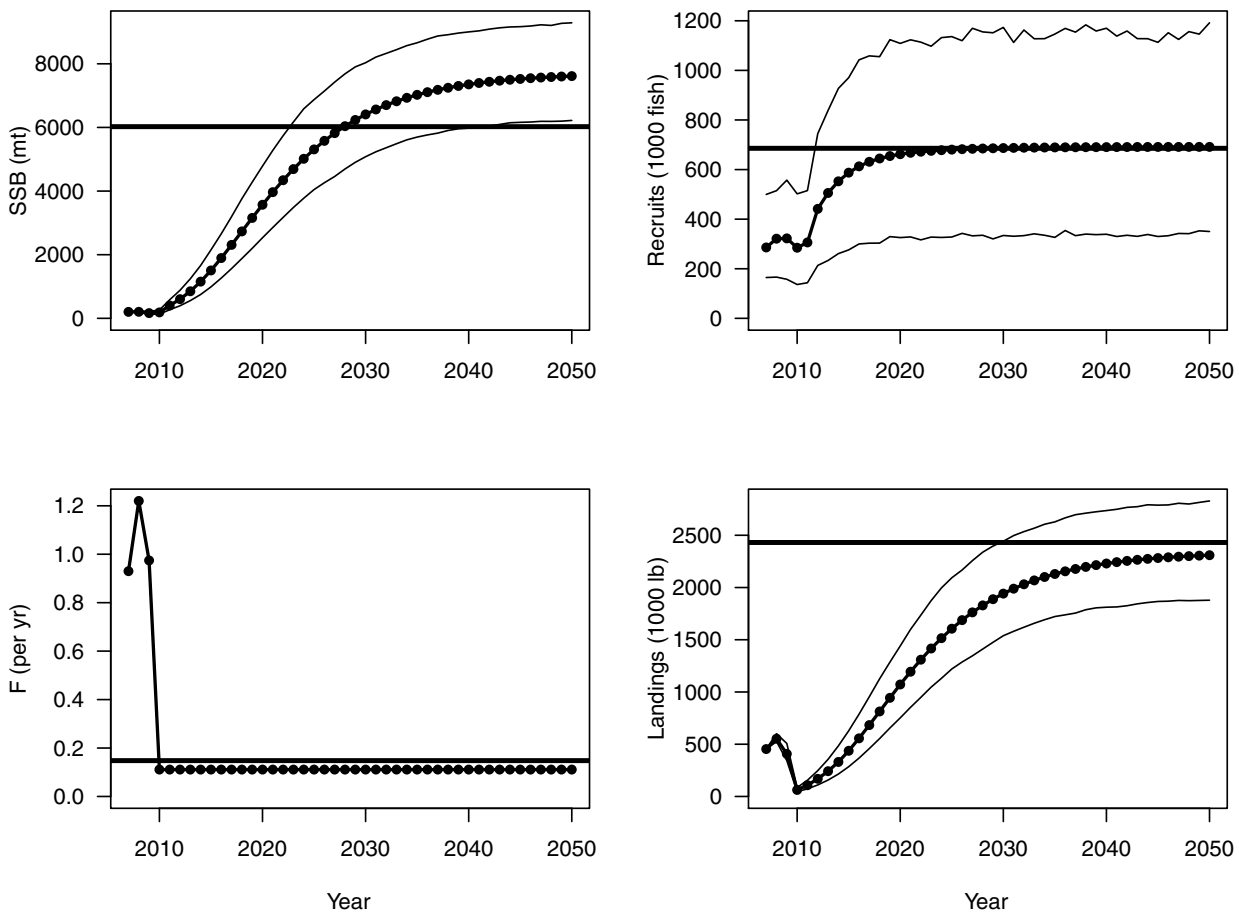


Figure 6.4. Projection results under scenario D—fishing mortality rate fixed at $F = 85\% F_{30\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent $F_{30\%}$ benchmarks.

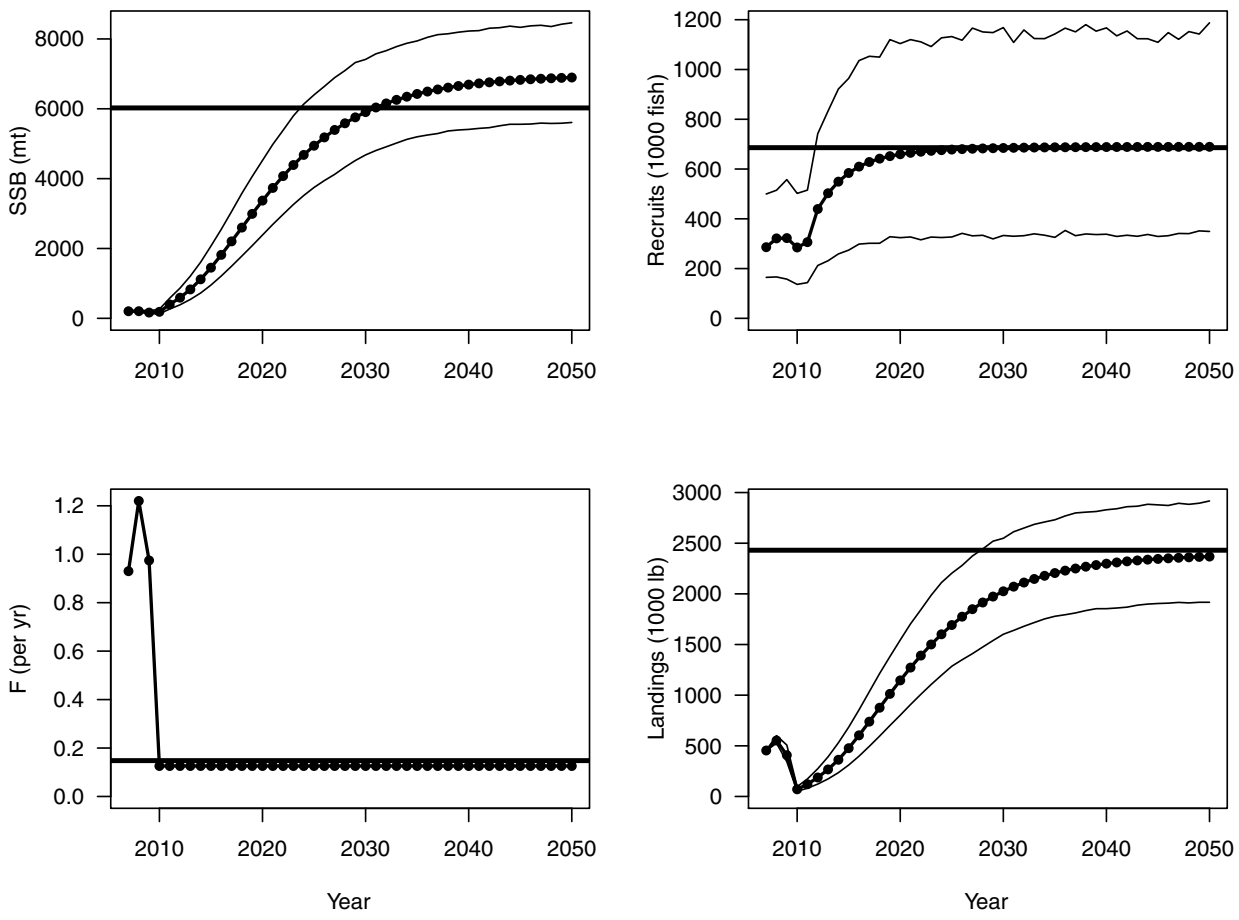
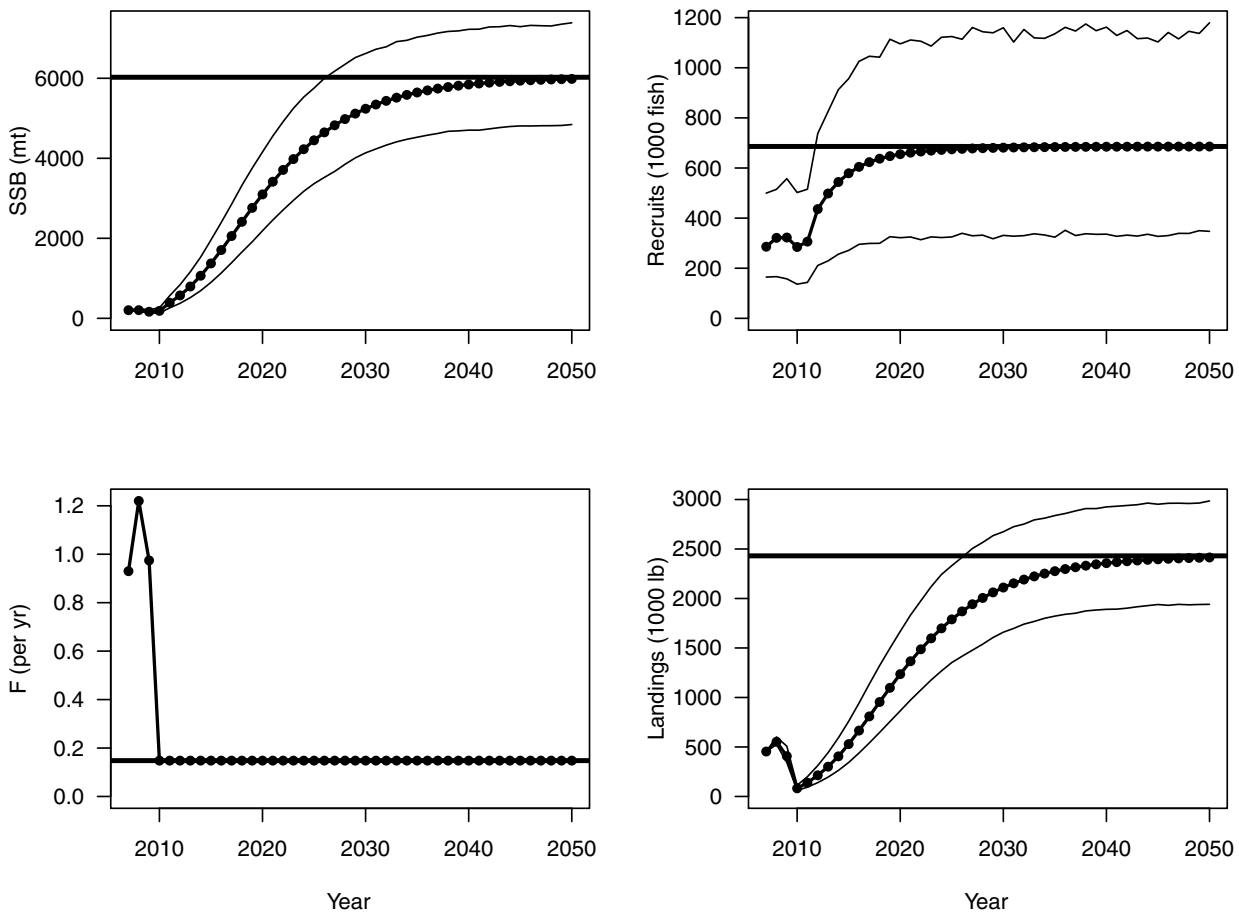


Figure 6.5. Projection results under scenario D—fishing mortality rate fixed at $F = F_{30\%}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 2000 replicate projections. Thick horizontal lines represent $F_{30\%}$ benchmarks.



Red Snapper Projections VI—Revised

Issued: 29 May 2009

Revised: 23 July 2009

Revision notes: This report was issued originally on 19 May 2009, in response to informal requests. In a memorandum dated 10 July 2009, from Dr. Crabtree to Dr. Ponwith, the projections were formally requested. This revision has the same analyses as the original, but includes tables of output.

1 Description of projections

The 2008 recreational landings of red snapper in the U.S. South Atlantic were much higher than have been observed in recent years, and the 2008 commercial landings were on the high end of their recent range. Preliminary reports of 2009 landings also indicate higher than typical values. The majority of fish being landed are near the legal limit of 20 inches. This suggests that the high landings are being driven by a particularly strong year-class entering the fishery. This document examines effects of such a strong year-class on recovery projections.

The estimated selectivity curve of the general recreational fishery indicates that fish are nearly fully selected by age 3. Average growth of red snapper suggests that age-3 fish would be near the legal size limit (Fig. 5.1). This suggests that the pulse of red snapper entering the fishery in 2008 were age-3, or equivalently, were recruited to the population in 2006 as age-1 fish. To examine effects of such a pulse on projections, the 2006 year-class was inflated to one of three levels, corresponding to 50%, 100%, and 150% of the maximum recruitment event observed in the assessment over the years 1974–2006. This maximum recruitment event occurred in 1984 and was about 753,000 age-1 fish. The assessment-estimated value for 2006 was approximately 280,000 age-1 fish, and thus the three values used in these projections—$\sim 376,000$, $\sim 753,000$, and $\sim 1,129,000$—are labelled as high, very high, and extremely high, respectively. Results are compared graphically to those of earlier projections that used the assessment-estimated value.

For each of the three levels of 2006 recruitment, two levels of fishing rate were considered: $F = F_{\text{current}}$ and $F = 0.75F_{40\%}$. These new projections are labeled:

- Scenario P1: $F = F_{\text{current}}$, high 2006 recruitment (50% the observed maximum)
- Scenario P2: $F = F_{\text{current}}$, very high 2006 recruitment (100% the observed maximum)
- Scenario P3: $F = F_{\text{current}}$, extremely high 2006 recruitment (150% the observed maximum)
- Scenario P4: $F = 0.75F_{40\%}$, high 2006 recruitment
- Scenario P5: $F = 0.75F_{40\%}$, very high 2006 recruitment
- Scenario P6: $F = 0.75F_{40\%}$, extremely high 2006 recruitment

Projected fishing mortality rates in 2007–2009, prior to new management, assumed the regression levels used in the report titled, Red Snapper Projections V. These rates do not reflect any increase in fishing effort that may be associated with the very high landings reported by MRFSS in 2008. If effort has actually increased along with the high landings, these projections could be considered overly optimistic in terms of spawning biomass, recruitment, and landing in subsequent years.

2 Results

In scenarios with fishing at the current level, an unusually strong year class in 2006 was projected to boost spawning biomass, recruits, and landings, relative to estimates from the base projections (Tables 4.1–4.3, Figure 5.2). Over time, expected values were projected to converge back to the current low levels, as the strong year class disappeared from the population. In scenarios with fishing at $0.75F_{40\%}$, an unusually strong year class in 2006 was projected to have little effect on the trajectory of stock recovery (Tables 4.4–4.6, Figure 5.3). In both fishing scenarios, the 2006 recruitment class affected short-term transient dynamics, but not the long-term trends.

3 Comments on Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- These projections reflect a belief that the 2006 year-class was strong. However, the recruitment values applied are based on guesswork. Thus, results of these projections should be interpretted in a qualitative light.
- Initial abundance at age of the projections, other than 2006 age-1 recruits, were based on estimates from the last year of the assessment. If those estimates are inaccurate, rebuilding will likely be affected.
- The 2008 recreational landings reported by MRFSS indicate very high levels of landings, which could be due to a very strong 2006 year-class, as explored in these projections. The high landings could also be due, at least in part, to increased fishing effort, which is not accounted for here. If effort has actually increased along with the high landings, these projections could be considered overly optimistic in terms of spawning biomass, recruitment, and landing in subsequent years.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect rebuilding.
- The projections assumed no change in the selectivity applied to discards. As recovery generally begins with the smallest size classes, management action may be needed to meet that assumption.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If changes in environmental or ecological conditions affect recruitment or life-history characteristics, rebuilding may be affected.
- The projections used a spawner-recruit relationship with steepness of $h = 0.95$, the value estimated in the assessment but with considerable uncertainty. Such a high value implies that the stock, at its currently low abundance, spawns nearly as many recruits as it would at high abundance. That is, productivity is nearly independent of spawning biomass. If productivity depends on spawning biomass, stock recovery would take longer than projected.

4 Tables

*Table 4.1. Red snapper: Projection results under scenario P1—fishing mortality rate $F = F_{\text{current}}$, with high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\text{SSB}_{F_{40\%}} = 8102.5$ mt, $\text{R}_{F_{40\%}} = 692,864$ fish, $\text{Y}_{F_{40\%}} = 2,303,676$ lb, and $\text{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	215	286	472	472	105	182	115
2008	1.22	0	222	331	595	1066	129	212	137
2009	0.974	0	177	337	443	1509	98	161	112
2010	0.974	0	198	297	454	1963	102	176	113
2011	0.974	0	202	317	468	2431	103	170	111
2012	0.974	0	204	320	475	2906	104	169	112
2013	0.974	0	207	322	479	3386	105	173	114
2014	0.974	0	209	324	485	3871	106	175	115
2015	0.974	0	211	326	490	4361	107	176	116
2016	0.974	0	213	328	494	4855	108	177	116
2017	0.974	0	215	329	498	5353	109	178	117
2018	0.974	0	216	331	502	5855	109	179	117
2019	0.974	0	217	332	504	6359	110	179	118
2020	0.974	0	218	333	507	6866	110	180	118
2021	0.974	0	219	334	509	7376	111	180	119
2022	0.974	0	220	334	511	7887	111	181	119
2023	0.974	0	220	335	513	8400	111	181	119
2024	0.974	0	221	336	514	8914	112	182	119
2025	0.974	0	222	336	516	9429	112	182	120
2026	0.974	0	222	337	517	9946	112	182	120
2027	0.974	0	222	337	518	10,464	112	183	120
2028	0.974	0	223	337	518	10,982	112	183	120
2029	0.974	0	223	337	519	11,501	112	183	120
2030	0.974	0	223	338	520	12,021	113	183	120

*Table 4.2. Red snapper: Projection results under scenario P2—fishing mortality rate $F = F_{\text{current}}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\text{SSB}_{F_{40\%}} = 8102.5$ mt, $\text{R}_{F_{40\%}} = 692,864$ fish, $\text{Y}_{F_{40\%}} = 2,303,676$ lb, and $\text{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.974	0	242	339	563	2442	122	199	129
2011	0.974	0	240	352	560	3001	120	193	125
2012	0.974	0	237	351	555	3557	119	189	125
2013	0.974	0	235	349	549	4105	118	190	125
2014	0.974	0	234	347	545	4651	117	189	124
2015	0.974	0	232	346	542	5193	117	189	124
2016	0.974	0	231	345	540	5733	116	188	123
2017	0.974	0	230	344	537	6270	116	187	123
2018	0.974	0	230	344	536	6806	115	187	123
2019	0.974	0	229	343	534	7340	115	186	122
2020	0.974	0	228	342	533	7872	115	186	122
2021	0.974	0	228	342	531	8403	115	186	122
2022	0.974	0	228	342	530	8934	114	186	122
2023	0.974	0	227	341	529	9463	114	185	122
2024	0.974	0	227	341	529	9992	114	185	122
2025	0.974	0	227	341	528	10,519	114	185	121
2026	0.974	0	226	341	527	11,047	114	185	121
2027	0.974	0	226	340	527	11,574	114	185	121
2028	0.974	0	226	340	526	12,100	114	185	121
2029	0.974	0	226	340	526	12,626	114	185	121
2030	0.974	0	226	340	526	13,152	114	184	121

*Table 4.3. Red snapper: Projection results under scenario P3—fishing mortality rate $F = F_{\text{current}}$, with extremely high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\text{SSB}_{F_{40\%}} = 8102.5$ mt, $\text{R}_{F_{40\%}} = 692,864$ fish, $\text{Y}_{F_{40\%}} = 2,303,676$ lb, and $\text{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	309	286	610	610	183	402	240
2008	1.22	0	358	396	923	1533	218	382	193
2009	0.974	0	271	421	714	2247	149	188	135
2010	0.974	0	283	372	668	2915	139	217	141
2011	0.974	0	274	380	644	3559	134	211	136
2012	0.974	0	265	374	625	4185	131	205	134
2013	0.974	0	259	369	608	4792	128	204	133
2014	0.974	0	254	364	595	5387	126	201	131
2015	0.974	0	249	361	584	5972	124	198	129
2016	0.974	0	246	358	575	6547	122	196	128
2017	0.974	0	243	355	568	7115	121	194	127
2018	0.974	0	240	353	561	7676	120	193	126
2019	0.974	0	238	351	556	8232	119	192	126
2020	0.974	0	236	349	551	8784	118	191	125
2021	0.974	0	235	348	548	9331	118	190	124
2022	0.974	0	233	347	544	9875	117	189	124
2023	0.974	0	232	346	541	10,417	116	188	123
2024	0.974	0	231	345	539	10,956	116	188	123
2025	0.974	0	230	344	537	11,492	116	187	123
2026	0.974	0	229	343	535	12,027	115	187	122
2027	0.974	0	229	343	533	12,561	115	186	122
2028	0.974	0	228	342	532	13,093	115	186	122
2029	0.974	0	228	342	531	13,623	115	186	122
2030	0.974	0	227	341	530	14,153	114	186	122

*Table 4.4. Red snapper: Projection results under scenario P4—fishing mortality rate $F = 75\% F_{40\%}$, with high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	215	286	472	472	105	182	115
2008	1.22	0	222	331	595	1066	129	212	137
2009	0.974	0	177	337	443	1509	98	161	112
2010	0.078	0	198	297	47	1556	11	18	11
2011	0.078	0	437	317	83	1639	17	23	13
2012	0.078	0	663	455	131	1770	23	26	15
2013	0.078	0	944	519	190	1959	31	32	19
2014	0.078	0	1289	565	261	2220	40	39	22
2015	0.078	0	1693	599	347	2567	50	44	24
2016	0.078	0	2143	623	444	3012	60	47	26
2017	0.078	0	2625	640	548	3560	69	49	27
2018	0.078	0	3125	652	656	4216	78	51	27
2019	0.078	0	3629	661	766	4982	86	52	28
2020	0.078	0	4127	668	874	5856	94	53	28
2021	0.078	0.01	4610	674	978	6834	101	53	29
2022	0.078	0.01	5073	678	1078	7912	107	54	29
2023	0.078	0.03	5510	681	1172	9084	113	54	29
2024	0.078	0.06	5920	683	1260	10,344	118	55	29
2025	0.078	0.09	6300	685	1342	11,685	122	55	29
2026	0.078	0.14	6651	687	1417	13,103	126	55	29
2027	0.078	0.19	6972	688	1486	14,589	130	55	29
2028	0.078	0.25	7266	690	1549	16,138	133	55	29
2029	0.078	0.33	7533	690	1606	17,744	136	55	29
2030	0.078	0.39	7774	691	1658	19,403	139	55	30

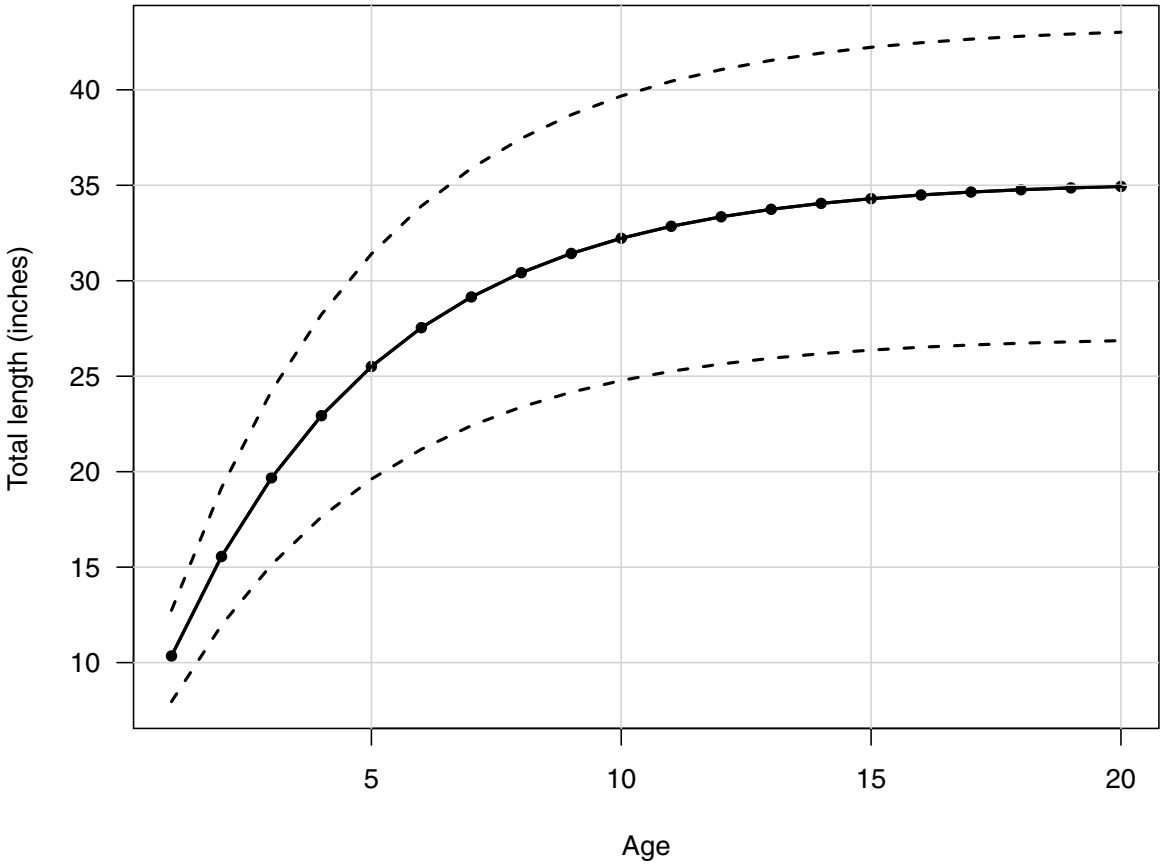
*Table 4.5. Red snapper: Projection results under scenario P5—fishing mortality rate $F = 75\% F_{40\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish*).* For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.078	0	242	339	59	1937	13	20	12
2011	0.078	0	520	352	99	2036	19	26	14
2012	0.078	0	776	483	154	2190	27	29	17
2013	0.078	0	1086	541	219	2410	35	34	20
2014	0.078	0	1458	581	297	2706	44	41	23
2015	0.078	0	1884	610	388	3094	54	45	25
2016	0.078	0	2349	631	489	3583	64	48	26
2017	0.078	0	2840	646	595	4178	73	50	27
2018	0.078	0	3343	657	704	4882	82	51	28
2019	0.078	0	3845	665	812	5694	90	52	28
2020	0.078	0	4338	671	919	6613	97	53	28
2021	0.078	0.01	4813	675	1022	7635	104	54	29
2022	0.078	0.02	5265	679	1119	8754	110	54	29
2023	0.078	0.04	5690	682	1211	9965	115	54	29
2024	0.078	0.07	6087	684	1296	11,261	120	55	29
2025	0.078	0.11	6455	686	1375	12,636	124	55	29
2026	0.078	0.16	6793	688	1448	14,084	128	55	29
2027	0.078	0.21	7102	689	1514	15,598	131	55	29
2028	0.078	0.28	7384	690	1575	17,172	135	55	29
2029	0.078	0.36	7640	691	1629	18,802	137	55	29
2030	0.078	0.42	7871	692	1679	20,481	140	55	30

*Table 4.6. Red snapper: Projection results under scenario P6—fishing mortality rate $F = 75\% F_{40\%}$, with extremely high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	309	286	610	610	183	402	240
2008	1.22	0	358	396	923	1533	218	382	193
2009	0.974	0	271	421	714	2247	149	188	135
2010	0.078	0	283	372	70	2316	14	22	14
2011	0.078	0	596	380	114	2430	22	29	16
2012	0.078	0	875	504	175	2605	30	31	18
2013	0.078	0	1209	556	245	2850	38	36	21
2014	0.078	0	1601	592	328	3178	48	43	24
2015	0.078	0	2042	618	422	3600	57	46	25
2016	0.078	0	2518	637	525	4125	67	49	26
2017	0.078	0	3014	650	633	4758	76	50	27
2018	0.078	0	3518	660	742	5500	85	52	28
2019	0.078	0	4018	667	850	6349	92	53	28
2020	0.078	0	4505	673	955	7305	99	53	29
2021	0.078	0.01	4973	677	1056	8361	106	54	29
2022	0.078	0.02	5416	680	1152	9513	112	54	29
2023	0.078	0.05	5831	683	1241	10,754	117	54	29
2024	0.078	0.08	6218	685	1324	12,078	121	55	29
2025	0.078	0.13	6575	687	1401	13,479	125	55	29
2026	0.078	0.18	6903	688	1471	14,950	129	55	29
2027	0.078	0.24	7203	689	1536	16,486	133	55	29
2028	0.078	0.31	7476	690	1594	18,080	136	55	29
2029	0.078	0.38	7723	691	1647	19,727	138	55	30
2030	0.078	0.44	7946	692	1695	21,423	141	55	30

Figure 5.1. Average length at age (solid line) with plus/minus two standard deviations (dashed lines).



5 Figures

Figure 5.2. Projection results under scenarios with fishing mortality rate fixed at $F = F_{\text{current}}$. For reference, the proxy reference point used to define stock recovery is $\text{SSB}_{\text{MSY}} = 8102.5$ mt, which corresponds to a yield of about 2.3 million lb.

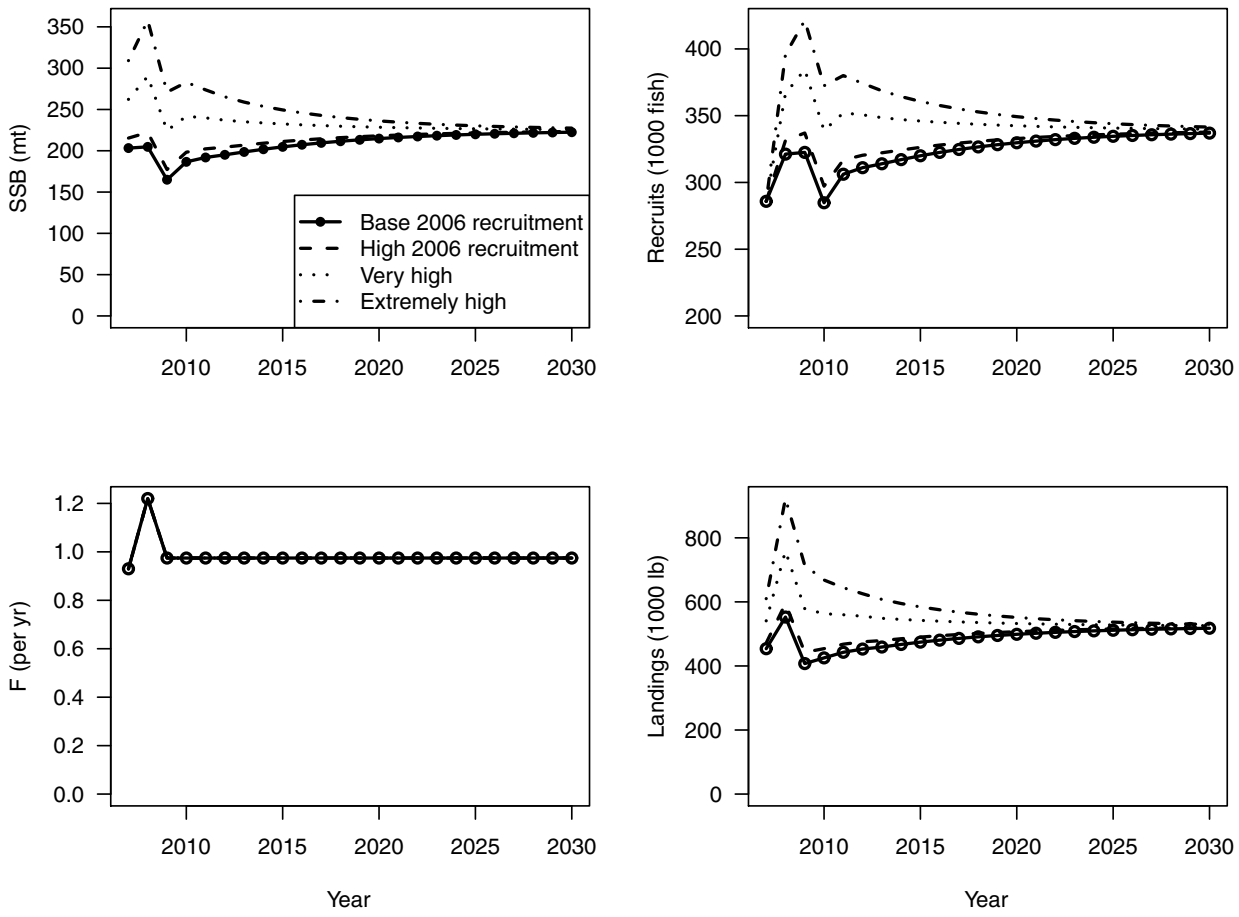
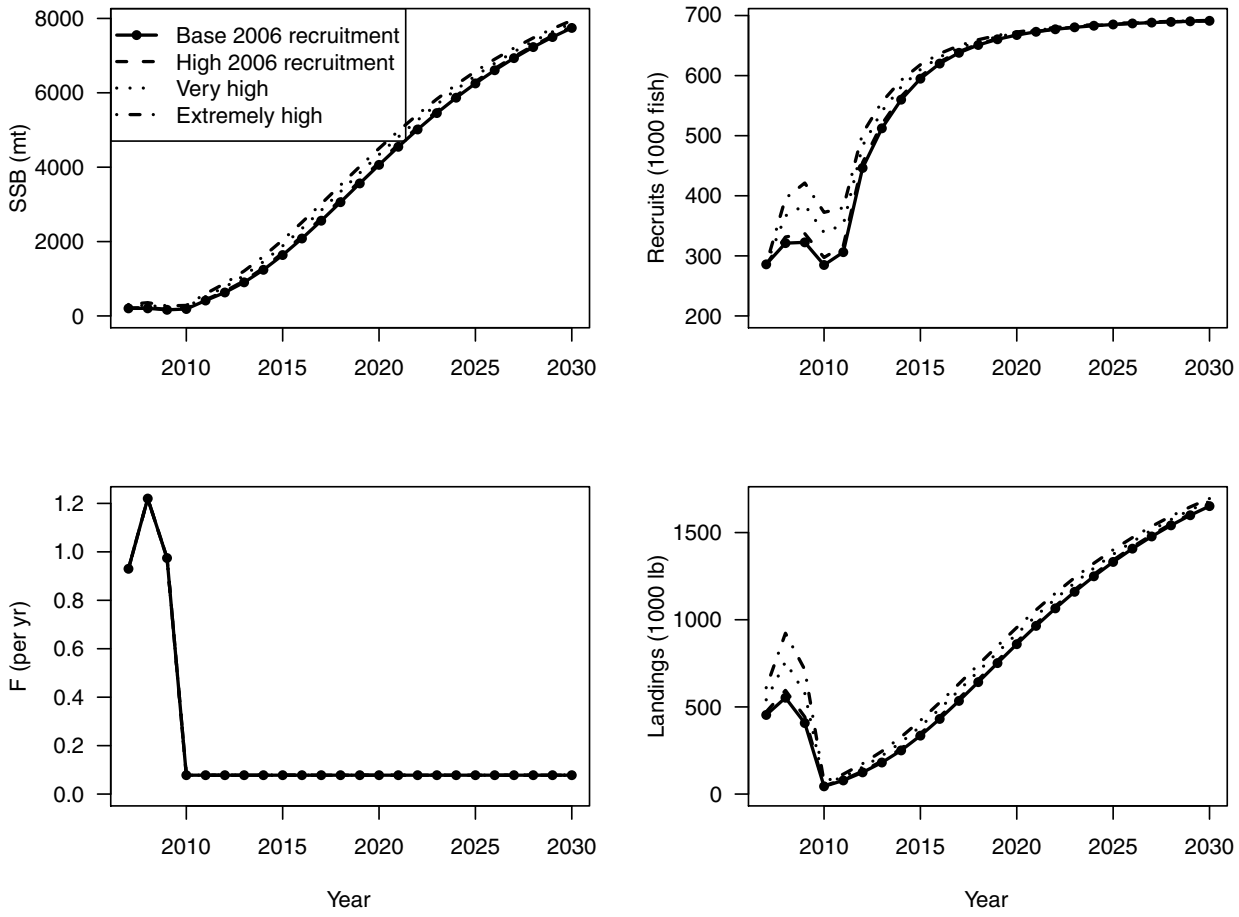


Figure 5.3. Projection results under scenarios with fishing mortality rate fixed at $F = 0.75F_{40\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 8102.5$ mt, which corresponds to a yield of about 2.3 million lb.



Red Snapper Projections VII

Prepared by the NOAA/NMFS Southeast Fisheries Science Center
Issued: 6 November 2009

1 Description of projections

This report describes a suite of projections requested in a memorandum, dated 8 October 2009, from Dr. Crabtree to Dr. Ponwith. In addition to projections, the memorandum requested a table of status indicators and related quantities associated with very high 2006 recruitment, similar to Table 4.1 in the document titled Red Snapper Projections V (dated March 19, 2009). However, because such quantities are based on longterm equilibrium values, they would not be affected by any one year of high, or low, recruitment. Thus, values of that previous table would not change. The table is repeated here for ease of reference (Table 4.1).

The projections assume that recruitment in 2006 was equal to the maximum level predicted by the stock assessment during the years 1974–2006. This maximum occurred in 1984 and was about 753,000 age-1 fish.

Several levels of fishing mortality rate were projected:

- Scenario P1: $F = F_{\text{rebuild}}$, the maximum fishing rate that allows rebuilding by the start of 2045
- Scenario P2: $F = 0.65F_{40\%}$
- Scenario P3: $F = 0.75F_{40\%}$
- Scenario P4: $F = 0.85F_{40\%}$
- Scenario P5: $F = F_{40\%}$

Projected fishing mortality rates in 2007–2009, prior to new management, assumed the regression levels used in the report titled, Red Snapper Projections V. These rates do not reflect any increase in fishing effort that may be associated with the very high landings reported by MRFSS in 2008.

2 Results

Results of the five projection scenarios are tabulated in Tables 4.2–4.6, and are shown graphically in Figures 5.1–5.5. The longterm equilibrium yield associated with F_{rebuild} is 2,287,000 lb.

3 Comments on Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- These projections reflect a belief that the 2006 year-class was strong. However, for now, the actual strength can only be guessed, and thus the scientific merit of these projections is questionable. The real value of these projections may be more qualitative than quantitative.
- The projections used a spawner-recruit relationship with steepness of $h = 0.95$, the value estimated in the assessment but with considerable uncertainty. On this topic, the SEDAR-15 Review Workshop Report stated, "One of the principal difficulties with the SCA model estimate of stock recruitment parameters is that the steepness estimate appears unrealistically high." Such a high value implies that the stock, at its currently low abundance, spawns nearly as many recruits as it would at high abundance. That is, productivity is nearly independent of spawning biomass. If productivity depends on spawning biomass, stock recovery would take longer than projected.
- The 2008 recreational landings reported by MRFSS indicate very high levels of landings, which could be due to a very strong 2006 year-class, as explored in these projections. The high landings could also be due, at least in part, to increased fishing effort, which is not accounted for here. If effort has actually increased along with the high landings, these projections could be considered overly optimistic in terms of spawning biomass, recruitment, and landing in subsequent years.
- The rebuilding time frame was computed without high 2006 recuitment. If it were recomputed using the high recruitment of these current projections, the rebuilding time frame may be shorter, which would lead to lower estimates of F_{rebuild}. Nonetheless, longterm stock projections, on which F_{rebuild} depends, are highly uncertain. (See last paragraph of this report.)
- Initial abundance at age of the projections, other than 2006 age-1 recruits, were based on estimates from the last year of the assessment. If those estimates are inaccurate, rebuilding will likely be affected.
- Fleets were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect rebuilding.
- The projections assumed no change in the selectivity applied to discards. As recovery generally begins with the smallest size classes, management action may be needed to meet that assumption.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If changes in environmental or ecological conditions affect recruitment or life-history characteristics, rebuilding may be affected.

On the topic of uncertainty in projections, the SEDAR-15 Review Workshop Report stated in January of 2008, "The panel discussed the value of projections made beyond 5–10 years. Clearly the uncertainty increases rapidly with time as the currently measured stock is replaced by model values into the future. Realistically, the projections beyond the range of the predominant age groups in the stock are highly uncertain. In this assessment, the best that can be concluded is that rebuilding times will be very long." The assessment team concurs with that statement, and would add that uncertainty is even greater now because of the increased duration between the terminal year of the assessment (2006) and any new implementation of management (Shertzer and Prager. 2007. Delay in fishery management: diminished yield, longer rebuilding, and increased probability of stock collapse. ICES Journal of Marine Science 64:149–159.).

4 Tables

Table 4.1. Estimated status indicators, benchmarks, and related quantities, conditional on estimated current selectivities averaged across fisheries. Values are MSY*-based proxies associated with* $F_{40\%}$*, the recommended proxy for* F_{MSY}*, and also* $F_{30\%}$*. Biomass-based and number-based quantities were computed as equilibrium values from projections with fishing rate* $F_{30\%}$ *or* $F_{40\%}$ *(or X% of those rates), as indicated. Estimates of yield (Y) do not include discard mortalities (D). The* MSST *is defined by* $\mathrm{MSST} = (1 - M)\mathrm{SSB}_{\mathrm{MSY}}$*, with constant* $M = 0.078$*. This table is repeated from the report titled Red Snapper Projections V of 19 March 2009.*

Quantity	Units	$F_{40\%}$ Proxy	$F_{30\%}$ Proxy
F_{MSY}	y^{-1}	0.104	0.148
$\mathrm{SSB}_{\mathrm{MSY}}$	mt	8102.5	6025.1
$\mathrm{D}_{\mathrm{MSY}}$	1000 fish	39	54
Recruits at F_{MSY}	1000 fish	693	686
Y at 65% F_{MSY}	1000 lb	1984	2257
Y at 75% F_{MSY}	1000 lb	2104	2338
Y at 85% F_{MSY}	1000 lb	2199	2391
Y at F_{MSY}	1000 lb	2304	2431
MSST	mt	7470.5	5555.1
$F_{2006}/F_{\mathrm{MSY}}$	–	7.67	5.39
$\mathrm{SSB}_{2006}/\mathrm{SSB}_{\mathrm{MSY}}$	–	0.02	0.03
$\mathrm{SSB}_{2006}/\mathrm{MSST}$	–	0.03	0.04

*Table 4.2. Red snapper: Projection results under scenario P1—fishing mortality rate $F = F_{\text{rebuild}}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\text{SSB}_{F_{40\%}} = 8102.5$ mt, $\text{R}_{F_{40\%}} = 692,864$ fish, $\text{Y}_{F_{40\%}} = 2,303,676$ lb, and $\text{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.101	0	242	339	75	1954	16	26	16
2011	0.101	0	510	352	126	2079	25	34	19
2012	0.101	0	751	480	193	2272	34	36	21
2013	0.101	0	1041	537	272	2544	44	43	25
2014	0.101	0	1386	576	365	2909	55	52	29
2015	0.101	0	1775	605	472	3381	67	57	31
2016	0.101	0	2197	626	590	3972	78	61	33
2017	0.101	0	2638	642	714	4686	89	63	34
2018	0.101	0	3085	653	839	5525	99	65	35
2019	0.101	0	3528	661	963	6488	109	66	36
2020	0.101	0	3957	667	1084	7572	117	67	36
2021	0.101	0	4367	672	1198	8770	124	68	36
2022	0.101	0.01	4753	676	1306	10,076	131	68	37
2023	0.101	0.01	5112	679	1406	11,482	137	69	37
2024	0.101	0.03	5444	681	1499	12,981	142	69	37
2025	0.101	0.05	5747	683	1583	14,564	147	69	37
2026	0.101	0.07	6024	685	1660	16,224	151	70	37
2027	0.101	0.09	6274	686	1729	17,953	155	70	37
2028	0.101	0.11	6499	687	1792	19,745	158	70	38
2029	0.101	0.14	6702	688	1848	21,594	161	70	38
2030	0.101	0.18	6882	689	1899	23,492	164	70	38
2031	0.101	0.21	7044	689	1943	25,435	166	70	38
2032	0.101	0.24	7187	690	1983	27,419	168	70	38
2033	0.101	0.26	7315	690	2019	29,437	170	70	38
2034	0.101	0.29	7428	691	2050	31,487	171	70	38
2035	0.101	0.33	7528	691	2078	33,565	172	71	38
2036	0.101	0.35	7617	691	2102	35,668	174	71	38
2037	0.101	0.37	7695	692	2124	37,792	175	71	38
2038	0.101	0.39	7764	692	2143	39,935	176	71	38
2039	0.101	0.41	7826	692	2160	42,096	176	71	38
2040	0.101	0.44	7879	692	2175	44,271	177	71	38
2041	0.101	0.46	7927	692	2189	46,460	178	71	38
2042	0.101	0.47	7969	692	2200	48,660	178	71	38
2043	0.101	0.48	8006	693	2211	50,871	179	71	38
2044	0.101	0.5	8039	693	2220	53,090	179	71	38
2045	0.101	0.51	8068	693	2228	55,318	180	71	38
2046	0.101	0.51	8093	693	2235	57,553	180	71	38
2047	0.101	0.51	8115	693	2241	59,794	180	71	38
2048	0.101	0.51	8135	693	2246	62,040	181	71	38
2049	0.101	0.51	8152	693	2251	64,291	181	71	38
2050	0.101	0.52	8168	693	2255	66,547	181	71	38

*Table 4.3. Red snapper: Projection results under scenario P2—fishing mortality rate $F = 65\% F_{40\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.068	0	242	339	51	1929	11	17	11
2011	0.068	0	525	352	87	2016	17	23	13
2012	0.068	0	787	485	135	2152	24	25	14
2013	0.068	0	1107	543	194	2346	31	30	17
2014	0.068	0	1492	583	264	2609	39	36	20
2015	0.068	0	1935	612	346	2955	48	40	22
2016	0.068	0	2421	633	437	3392	57	42	23
2017	0.068	0	2937	648	534	3926	65	44	24
2018	0.068	0	3467	658	633	4559	73	45	24
2019	0.068	0	3999	666	733	5292	80	46	25
2020	0.068	0.01	4524	672	831	6123	87	46	25
2021	0.068	0.01	5032	677	927	7050	93	47	25
2022	0.068	0.04	5518	680	1017	8067	99	47	25
2023	0.068	0.08	5977	683	1103	9170	104	48	25
2024	0.068	0.12	6408	686	1183	10,353	108	48	25
2025	0.068	0.18	6809	687	1258	11,611	112	48	26
2026	0.068	0.25	7179	689	1327	12,938	116	48	26
2027	0.068	0.33	7521	690	1390	14,328	119	48	26
2028	0.068	0.41	7833	691	1448	15,776	122	48	26
2029	0.068	0.49	8118	692	1501	17,278	125	48	26
2030	0.068	0.57	8377	693	1549	18,827	127	49	26
2031	0.068	0.64	8612	694	1593	20,420	129	49	26
2032	0.068	0.7	8824	694	1633	22,053	131	49	26
2033	0.068	0.75	9016	695	1668	23,721	133	49	26
2034	0.068	0.78	9189	695	1700	25,422	134	49	26
2035	0.068	0.81	9345	695	1729	27,151	136	49	26
2036	0.068	0.84	9486	696	1756	28,907	137	49	26
2037	0.068	0.86	9612	696	1779	30,686	138	49	26
2038	0.068	0.89	9726	696	1800	32,486	139	49	26
2039	0.068	0.91	9828	696	1819	34,305	140	49	26
2040	0.068	0.91	9919	697	1836	36,141	141	49	26
2041	0.068	0.91	10,002	697	1851	37,992	141	49	26
2042	0.068	0.93	10,075	697	1865	39,857	142	49	26
2043	0.068	0.94	10,142	697	1877	41,735	143	49	26
2044	0.068	0.94	10,201	697	1888	43,623	143	49	26
2045	0.068	0.94	10,254	697	1898	45,521	144	49	26
2046	0.068	0.95	10,302	697	1907	47,429	144	49	26
2047	0.068	0.96	10,345	697	1915	49,344	145	49	26
2048	0.068	0.95	10,384	697	1922	51,266	145	49	26
2049	0.068	0.96	10,418	697	1929	53,195	145	49	26
2050	0.068	0.97	10,449	697	1934	55,129	145	49	26

*Table 4.4. Red snapper: Projection results under scenario P3—fishing mortality rate $F = 75\% F_{40\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish*).* For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.078	0	242	339	59	1937	13	20	12
2011	0.078	0	520	352	99	2036	19	26	14
2012	0.078	0	776	483	154	2190	27	29	17
2013	0.078	0	1086	541	219	2410	35	34	20
2014	0.078	0	1458	581	297	2706	44	41	23
2015	0.078	0	1884	610	388	3094	54	45	25
2016	0.078	0	2349	631	489	3583	64	48	26
2017	0.078	0	2840	646	595	4178	73	50	27
2018	0.078	0	3343	657	704	4882	82	51	28
2019	0.078	0	3845	665	812	5694	90	52	28
2020	0.078	0	4338	671	919	6613	97	53	28
2021	0.078	0.01	4813	675	1022	7635	104	54	29
2022	0.078	0.02	5265	679	1119	8754	110	54	29
2023	0.078	0.05	5690	682	1211	9965	115	54	29
2024	0.078	0.08	6087	684	1296	11,261	120	55	29
2025	0.078	0.12	6455	686	1375	12,636	124	55	29
2026	0.078	0.17	6793	688	1448	14,084	128	55	29
2027	0.078	0.22	7102	689	1514	15,598	131	55	29
2028	0.078	0.29	7384	690	1575	17,172	135	55	29
2029	0.078	0.35	7640	691	1629	18,802	137	55	29
2030	0.078	0.41	7871	692	1679	20,481	140	55	30
2031	0.078	0.47	8080	692	1724	22,204	142	55	30
2032	0.078	0.54	8268	693	1764	23,969	144	56	30
2033	0.078	0.59	8437	693	1800	25,769	146	56	30
2034	0.078	0.63	8588	694	1833	27,602	147	56	30
2035	0.078	0.68	8724	694	1862	29,464	149	56	30
2036	0.078	0.71	8845	694	1888	31,351	150	56	30
2037	0.078	0.74	8954	695	1911	33,263	151	56	30
2038	0.078	0.76	9051	695	1932	35,195	152	56	30
2039	0.078	0.79	9138	695	1951	37,145	153	56	30
2040	0.078	0.8	9216	695	1967	39,113	154	56	30
2041	0.078	0.81	9285	695	1982	41,095	154	56	30
2042	0.078	0.82	9347	696	1995	43,090	155	56	30
2043	0.078	0.83	9402	696	2007	45,097	156	56	30
2044	0.078	0.84	9451	696	2018	47,115	156	56	30
2045	0.078	0.85	9495	696	2027	49,142	157	56	30
2046	0.078	0.86	9534	696	2036	51,178	157	56	30
2047	0.078	0.88	9569	696	2043	53,221	157	56	30
2048	0.078	0.87	9600	696	2050	55,270	158	56	30
2049	0.078	0.87	9628	696	2056	57,326	158	56	30
2050	0.078	0.87	9652	696	2061	59,387	158	56	30

*Table 4.5. Red snapper: Projection results under scenario P4—fishing mortality rate $F = 85\% F_{40\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.088	0	242	339	66	1945	14	23	14
2011	0.088	0	516	352	111	2056	22	30	16
2012	0.088	0	764	482	172	2228	30	32	19
2013	0.088	0	1066	539	244	2472	39	38	23
2014	0.088	0	1425	579	328	2800	49	46	26
2015	0.088	0	1834	608	428	3228	60	51	28
2016	0.088	0	2279	629	537	3764	71	54	29
2017	0.088	0	2747	644	651	4416	81	56	30
2018	0.088	0	3223	655	768	5184	90	58	31
2019	0.088	0	3698	663	885	6069	99	59	32
2020	0.088	0	4161	669	998	7067	106	60	32
2021	0.088	0.01	4605	674	1107	8174	114	60	32
2022	0.088	0.01	5026	678	1210	9384	120	61	32
2023	0.088	0.03	5420	680	1306	10,690	126	61	33
2024	0.088	0.05	5786	683	1395	12,085	131	61	33
2025	0.088	0.08	6123	685	1477	13,562	135	62	33
2026	0.088	0.11	6431	686	1552	15,115	139	62	33
2027	0.088	0.15	6712	688	1621	16,735	143	62	33
2028	0.088	0.19	6967	689	1683	18,418	146	62	33
2029	0.088	0.25	7197	690	1738	20,156	149	62	33
2030	0.088	0.29	7403	690	1789	21,945	151	62	33
2031	0.088	0.35	7589	691	1834	23,779	153	62	33
2032	0.088	0.38	7755	691	1874	25,654	155	62	33
2033	0.088	0.43	7904	692	1910	27,564	157	62	33
2034	0.088	0.48	8037	692	1943	29,507	159	62	33
2035	0.088	0.52	8155	693	1971	31,478	160	62	33
2036	0.088	0.55	8260	693	1997	33,475	161	63	33
2037	0.088	0.58	8354	693	2020	35,495	163	63	33
2038	0.088	0.6	8437	693	2040	37,535	164	63	33
2039	0.088	0.63	8511	694	2058	39,593	164	63	33
2040	0.088	0.65	8577	694	2074	41,667	165	63	33
2041	0.088	0.67	8635	694	2088	43,755	166	63	33
2042	0.088	0.68	8687	694	2101	45,856	166	63	33
2043	0.088	0.69	8733	694	2112	47,967	167	63	33
2044	0.088	0.7	8774	694	2122	50,089	167	63	33
2045	0.088	0.71	8810	694	2131	52,220	168	63	33
2046	0.088	0.72	8842	695	2138	54,358	168	63	33
2047	0.088	0.73	8871	695	2145	56,504	169	63	33
2048	0.088	0.73	8896	695	2151	58,655	169	63	33
2049	0.088	0.74	8918	695	2157	60,812	169	63	33
2050	0.088	0.74	8938	695	2162	62,974	169	63	33

*Table 4.6. Red snapper: Projection results under scenario P5—fishing mortality rate $F = F_{40\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish*).* For reference, estimated proxy reference points are $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ mt, $\mathrm{R}_{F_{40\%}} = 692,864$ fish, $\mathrm{Y}_{F_{40\%}} = 2,303,676$ lb, and $\mathrm{D}_{F_{40\%}} = 72,717$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.104	0	242	339	78	1956	17	27	16
2011	0.104	0	509	352	129	2085	25	35	19
2012	0.104	0	748	480	198	2283	35	37	22
2013	0.104	0	1036	536	278	2561	45	44	26
2014	0.104	0	1376	576	373	2934	56	53	30
2015	0.104	0	1762	605	483	3417	68	59	32
2016	0.104	0	2178	626	603	4019	80	62	34
2017	0.104	0	2613	641	728	4747	91	65	35
2018	0.104	0	3053	652	855	5602	101	67	36
2019	0.104	0	3488	660	981	6583	111	68	37
2020	0.104	0	3910	667	1102	7685	119	69	37
2021	0.104	0	4312	671	1218	8903	127	70	37
2022	0.104	0.01	4690	675	1327	10,230	134	70	38
2023	0.104	0.01	5042	678	1428	11,658	140	71	38
2024	0.104	0.02	5366	681	1521	13,178	145	71	38
2025	0.104	0.04	5662	683	1606	14,784	150	71	38
2026	0.104	0.06	5931	684	1683	16,467	154	72	38
2027	0.104	0.08	6175	685	1752	18,219	158	72	38
2028	0.104	0.1	6394	686	1815	20,034	161	72	39
2029	0.104	0.12	6590	687	1871	21,905	164	72	39
2030	0.104	0.15	6765	688	1921	23,826	166	72	39
2031	0.104	0.18	6921	689	1966	25,792	169	72	39
2032	0.104	0.21	7060	689	2006	27,798	171	72	39
2033	0.104	0.23	7183	690	2041	29,839	172	72	39
2034	0.104	0.26	7292	690	2072	31,911	174	72	39
2035	0.104	0.28	7388	691	2099	34,010	175	72	39
2036	0.104	0.31	7473	691	2124	36,134	176	72	39
2037	0.104	0.33	7549	691	2145	38,279	177	72	39
2038	0.104	0.34	7615	691	2164	40,444	178	73	39
2039	0.104	0.36	7673	692	2181	42,625	179	73	39
2040	0.104	0.38	7725	692	2196	44,820	180	73	39
2041	0.104	0.41	7770	692	2209	47,029	180	73	39
2042	0.104	0.42	7810	692	2220	49,249	181	73	39
2043	0.104	0.43	7845	692	2230	51,479	181	73	39
2044	0.104	0.44	7876	692	2239	53,718	182	73	39
2045	0.104	0.45	7904	692	2247	55,965	182	73	39
2046	0.104	0.46	7928	692	2254	58,218	183	73	39
2047	0.104	0.46	7949	692	2260	60,478	183	73	39
2048	0.104	0.46	7967	692	2265	62,743	183	73	39
2049	0.104	0.45	7984	693	2270	65,013	183	73	39
2050	0.104	0.45	7998	693	2274	67,287	184	73	39

5 Figures

Figure 5.1. Projection results under scenarios with fishing mortality rate fixed at $F = F_{\text{rebuild}}$. For reference, the proxy reference point used to define stock recovery is $\text{SSB}_{\text{MSY}} = 8102.5$ mt, which corresponds to a yield of about 2.3 million lb.

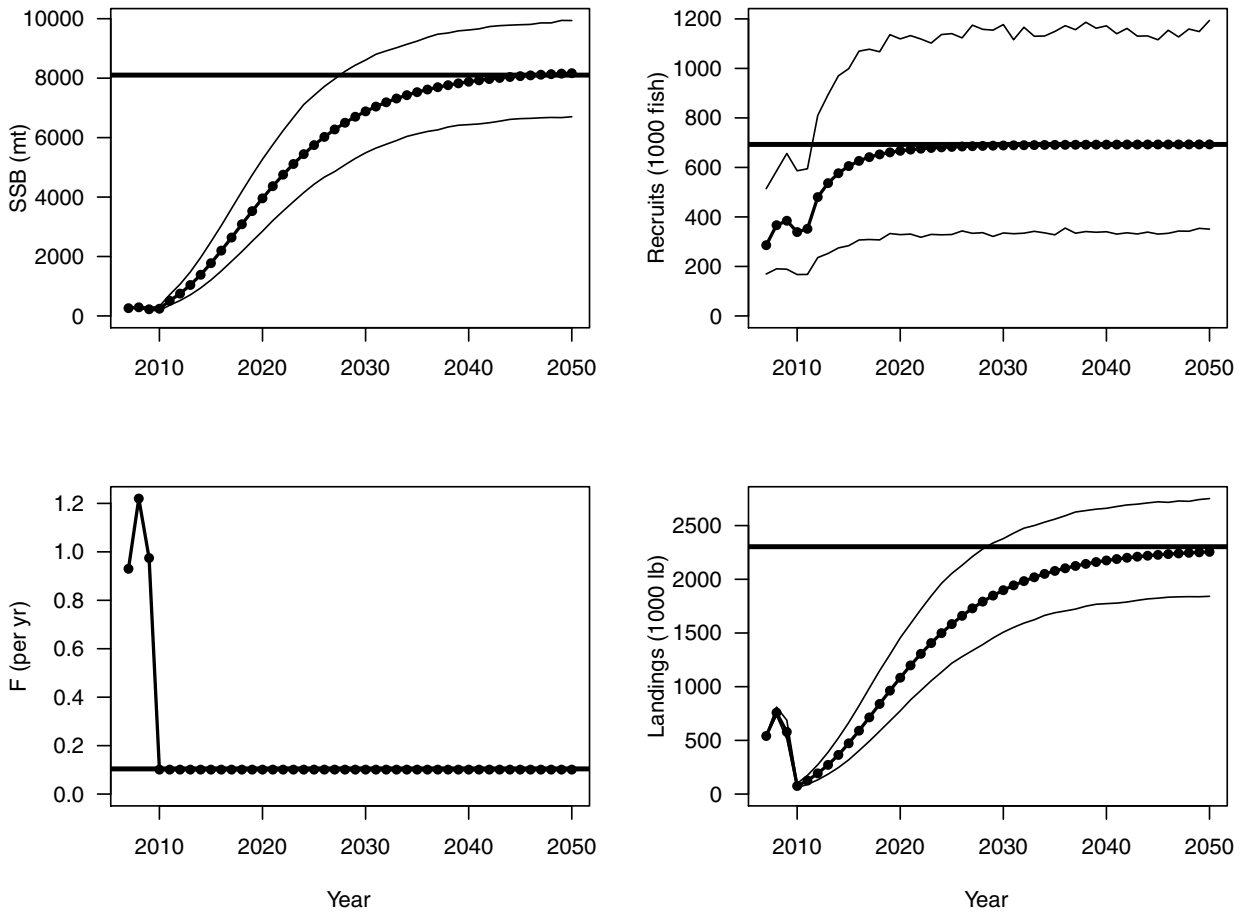


Figure 5.2. Projection results under scenarios with fishing mortality rate fixed at $F = 0.65F_{40\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 8102.5$ mt, which corresponds to a yield of about 2.3 million lb.

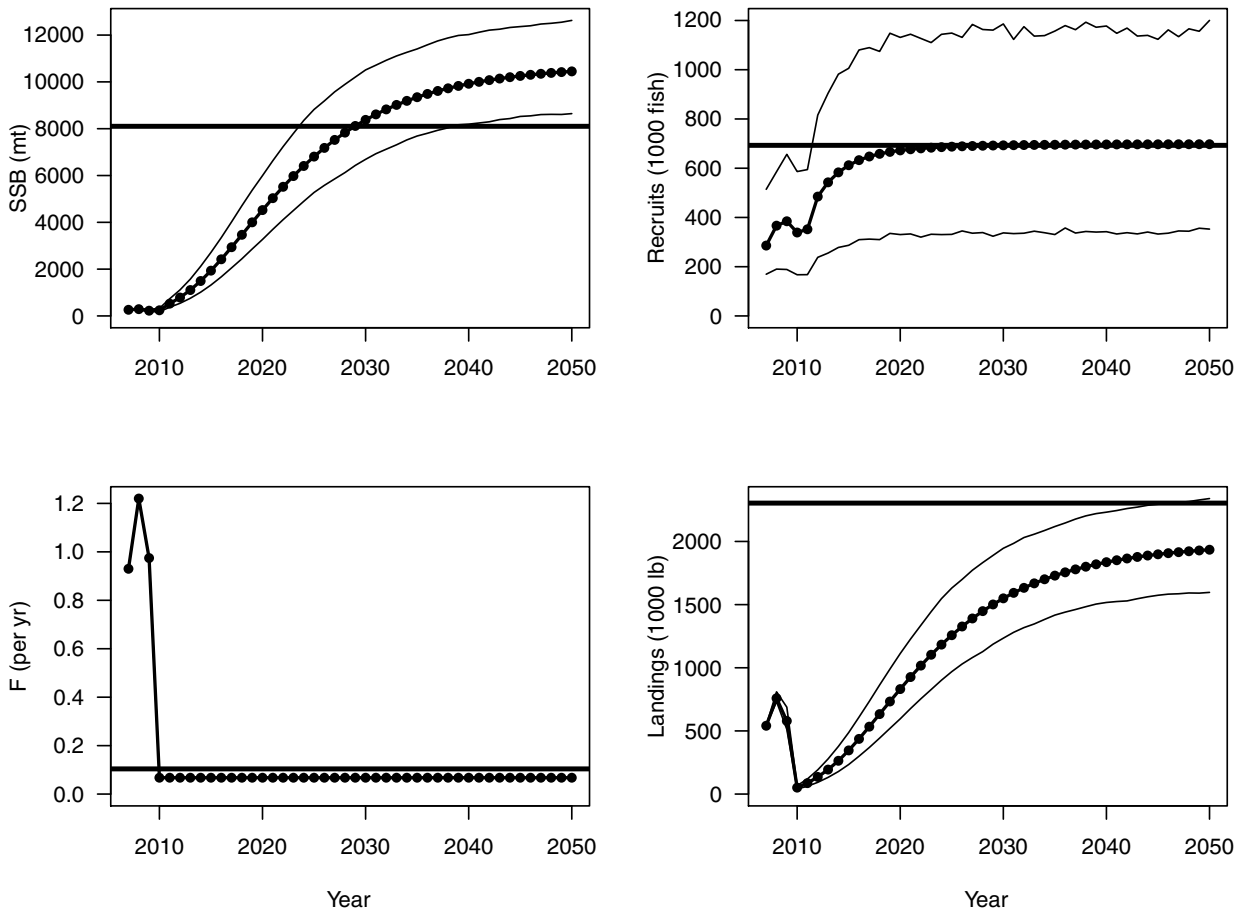


Figure 5.3. Projection results under scenarios with fishing mortality rate fixed at $F = 0.75F_{40\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 8102.5$ mt, which corresponds to a yield of about 2.3 million lb.

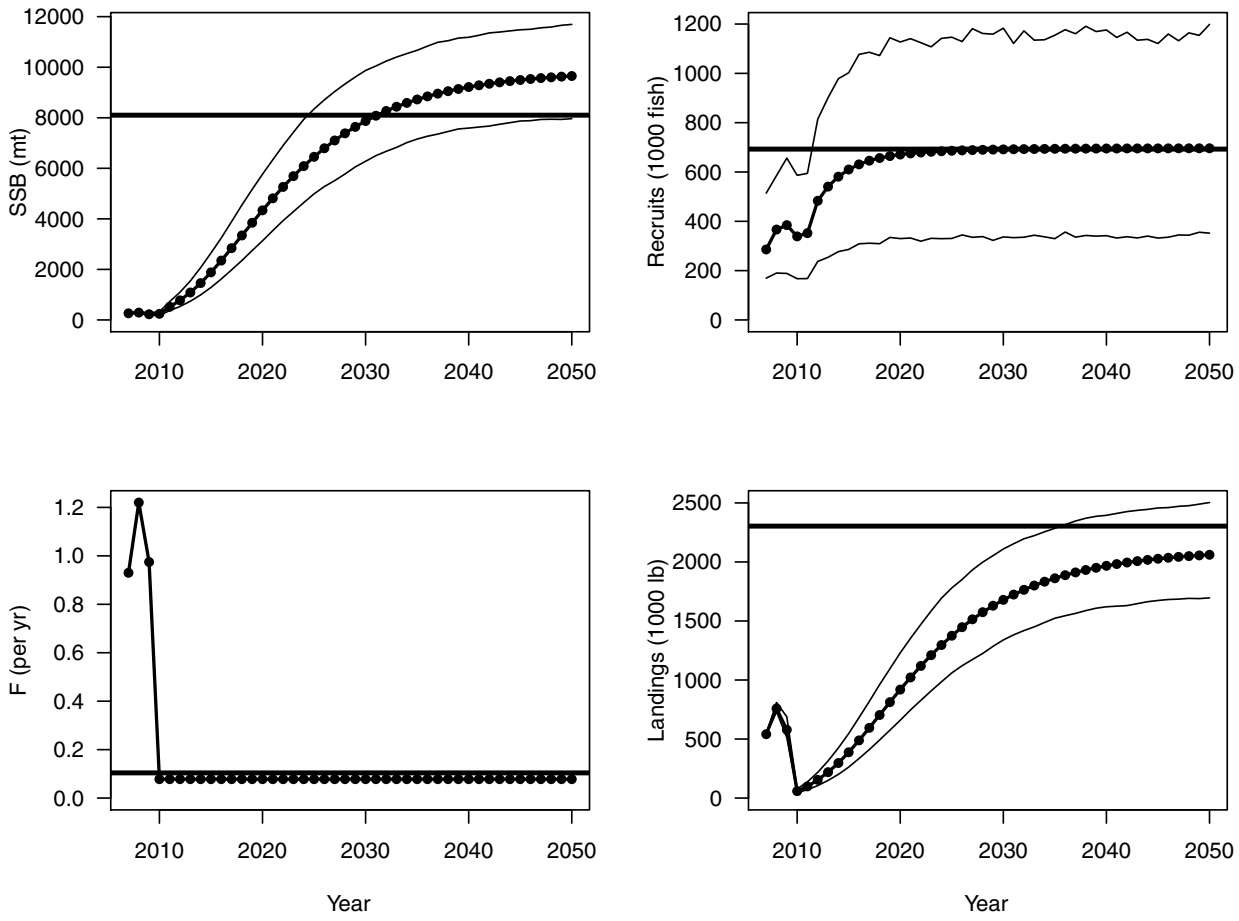


Figure 5.4. Projection results under scenarios with fishing mortality rate fixed at $F = 0.85F_{40\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 8102.5$ mt, which corresponds to a yield of about 2.3 million lb.

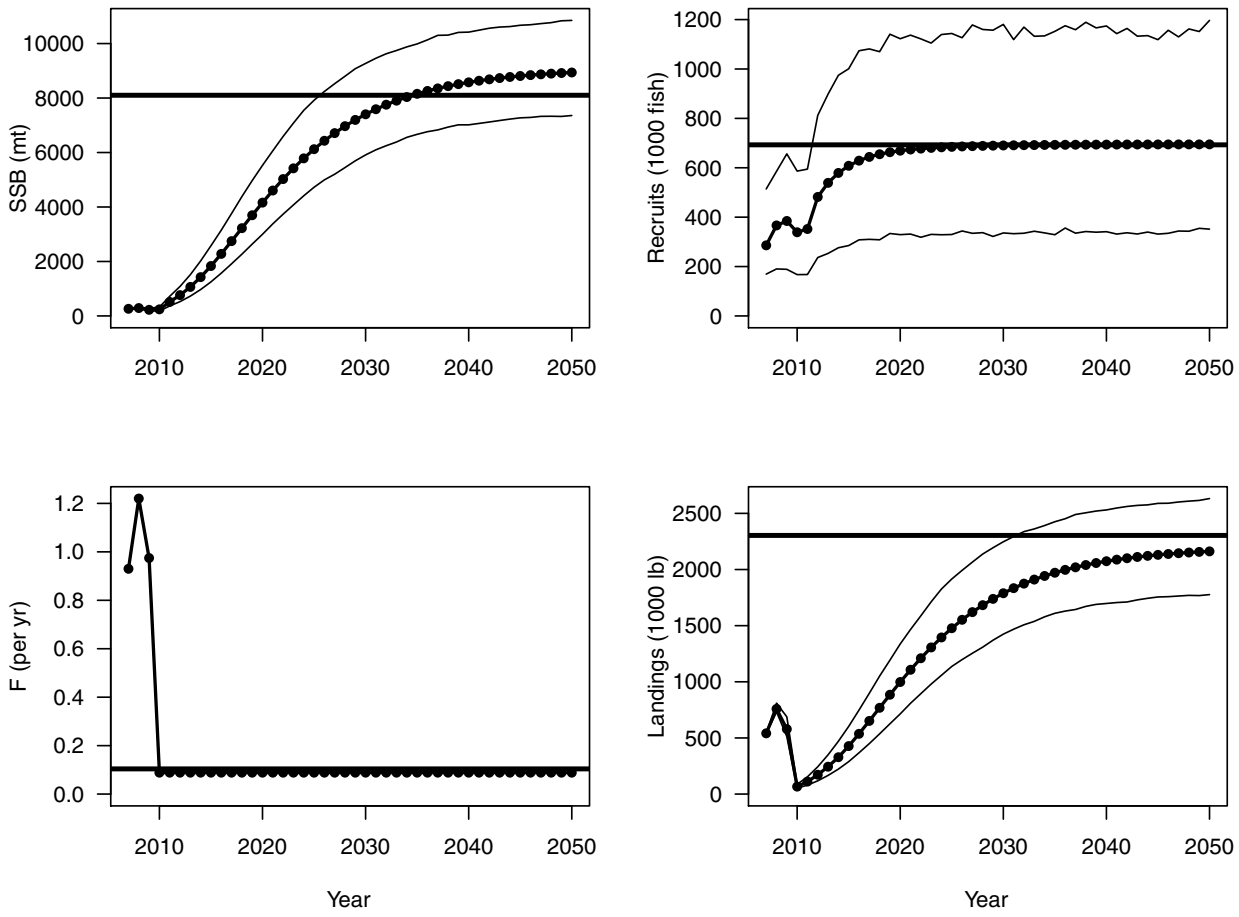
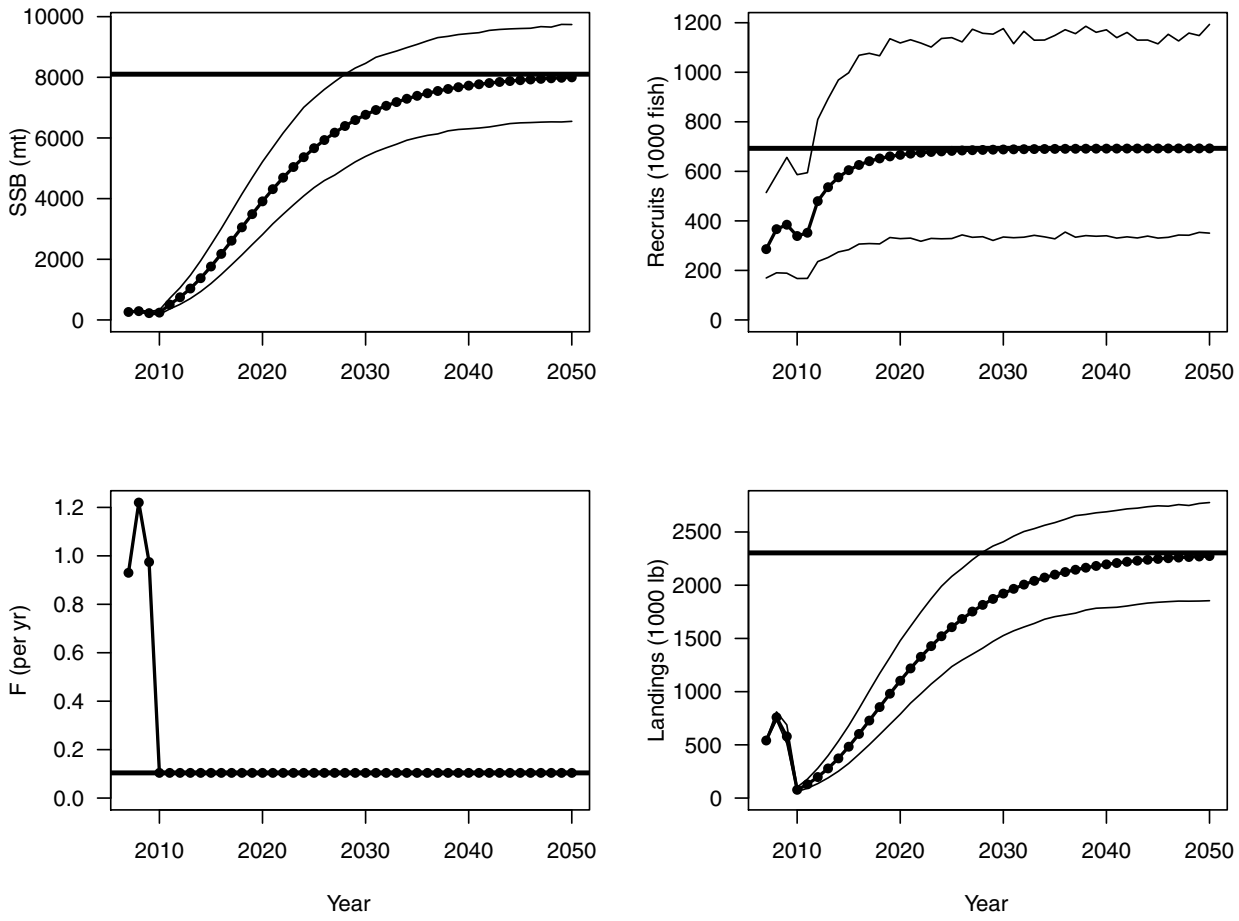


Figure 5.5. Projection results under scenarios with fishing mortality rate fixed at $F = F_{40\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 8102.5$ *mt, which corresponds to a yield of about 2.3 million lb.*



Red Snapper Projections VIII

Prepared by the NOAA/NMFS Southeast Fisheries Science Center
Issued: 8 January 2010

1 Description of projections

This report describes a suite of projections requested in a memorandum, dated 18 December 2010, from Dr. Crabtree to Dr. Ponwith. Specifically, that memorandum requested projections of spawning stock biomass, recruitment, landings, discards, and probability of stock recovery from 2007 to T_{MAX} that considers very high recruitment for fishing mortality rates $F_{45\%}$, $F_{30\%}$, F_{rebuild}, $85\%F_{30\%}$, $75\%F_{30\%}$, and $65\%F_{30\%}$. As before, the table of proxies for F_{MSY} benchmarks is repeated here for ease of reference (Table 5.1).

The projections assume that recruitment in 2006 was equal to the maximum level predicted by the stock assessment during the years 1974–2006. This maximum occurred in 1984 and was about 753,000 age-1 fish.

Several levels of fishing mortality rate were projected:

- Scenario P1: $F = F_{\mathrm{rebuild}}$, the maximum fishing rate that allows 0.5 probability of rebuilding to the $F_{30\%}$ proxy for $\mathrm{SSB}_{\mathrm{MSY}}$ by the start of 2042
- Scenario P2: $F = 0.65F_{30\%}$
- Scenario P3: $F = 0.75F_{30\%}$
- Scenario P4: $F = 0.85F_{30\%}$
- Scenario P5: $F = F_{30\%}$
- Scenario P6: $F = F_{45\%}$

Projected fishing mortality rates in 2007–2009, prior to new management, assumed the regression levels used in the report titled, Red Snapper Projections V. These rates do not reflect any increase in fishing effort that may be associated with the very high landings reported by MRFSS in 2008.

2 Rebuilding time frame

In a projection with $F = 0$, the probability of stock recovery to the $F_{30\%}$ proxy is expected to exceed 0.5 during the year 2021 (Table 5.2, Fig. 6.1). Thus, with stock recovery expected by the beginning of 2022, Tmin is 11 years (2010–2021). The mean generation time is 20 years (SEDAR-15), and thus Tmax is 31 years. This value would imply that stock recovery should occur by the beginning of 2042, at the latest.

3 Results

Results of the six projection scenarios are tabulated in Tables 5.3–5.8, and are shown graphically in Figures 6.2–6.7.

4 Comments on Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- These projections reflect a belief that the 2006 year-class was strong. However, for now, the actual strength can only be guessed, and thus the scientific merit of these projections is questionable. The real value of these projections may be more qualitative than quantitative.
- The projections used a spawner-recruit relationship with steepness of $h = 0.95$, the value estimated in the assessment but with considerable uncertainty. On this topic, the SEDAR-15 Review Workshop Report stated, "One of the principal difficulties with the SCA model estimate of stock recruitment parameters is that the steepness estimate appears unrealistically high." Such a high value implies that the stock, at its currently low abundance, spawns nearly as many recruits as it would at high abundance. That is, productivity is nearly independent of spawning biomass. If productivity depends on spawning biomass, stock recovery would take longer than projected.
- The 2008 recreational landings reported by MRFSS indicate very high levels of landings, which could be due to a very strong 2006 year-class, as explored in these projections. The high landings could also be due, at least in part, to increased fishing effort, which is not accounted for here. If effort has actually increased along with the high landings, these projections could be considered overly optimistic in terms of spawning biomass, recruitment, and landing in subsequent years.
- Longterm stock projections, on which Tmax and F_{rebuild}depend, are highly uncertain. (See last paragraph of this report.)
- Initial abundance at age of the projections, other than 2006 age-1 recruits, were based on estimates from the last year of the assessment. If those estimates are inaccurate, rebuilding will likely be affected.
- Fleets were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect rebuilding.
- The projections assumed no change in the selectivity applied to discards. As recovery generally begins with the smallest size classes, management action may be needed to meet that assumption.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If changes in environmental or ecological conditions affect recruitment or life-history characteristics, rebuilding may be affected.

Most of the projections in this report are based on using $F_{30\%}$ as a proxy for F_{MSY}. Scientific literature indicates that $F_{30\%}$ generally exceeds F_{MSY} (Clark 1993; Mace 1994; Clark 2002; Dorn 2002; Ralston 2002; Williams and Shertzer 2003; Brooks et al. 2009). For this reason, $F_{30\%}$ may be considered a risk-prone proxy for red snapper.

On the topic of uncertainty in projections, the SEDAR-15 Review Workshop Report stated in January of 2008, "The panel discussed the value of projections made beyond 5–10 years. Clearly the uncertainty increases rapidly with time as the currently measured stock is replaced by model values into the future. Realistically, the projections beyond the range of the predominant age groups in the stock are highly uncertain. In this assessment, the best that can be concluded is that rebuilding times will be very long." The assessment team concurs with that statement, and would add that uncertainty is even greater now because of the increased duration between the terminal year of the assessment (2006) and any new implementation of management (Shertzer and Prager 2007).

4.1 References

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5 Tables

Table 5.1. Estimated status indicators, benchmarks, and related quantities, conditional on estimated current selectivities averaged across fisheries. Values are MSY*-based proxies associated with* $F_{40\%}$*, the recommended proxy for* F_{MSY}*, and also* $F_{30\%}$*. Biomass-based and number-based quantities were computed as equilibrium values from projections with fishing rate* $F_{30\%}$ *or* $F_{40\%}$ *(or X% of those rates), as indicated. Estimates of yield (Y) do not include discard mortalities (D). The* MSST *is defined by* $\mathrm{MSST} = (1 - M)\mathrm{SSB}_{\mathrm{MSY}}$*, with constant* $M = 0.078$*. This table is repeated from the report titled Red Snapper Projections V of 19 March 2009.*

Quantity	Units	$F_{40\%}$ Proxy	$F_{30\%}$ Proxy
F_{MSY}	y^{-1}	0.104	0.148
$\mathrm{SSB}_{\mathrm{MSY}}$	mt	8102.5	6025.1
$\mathrm{D}_{\mathrm{MSY}}$	1000 fish	39	54
Recruits at F_{MSY}	1000 fish	693	686
Y at 65% F_{MSY}	1000 lb	1984	2257
Y at 75% F_{MSY}	1000 lb	2104	2338
Y at 85% F_{MSY}	1000 lb	2199	2391
Y at F_{MSY}	1000 lb	2304	2431
MSST	mt	7470.5	5555.1
$F_{2006}/F_{\mathrm{MSY}}$	–	7.67	5.39
$\mathrm{SSB}_{2006}/\mathrm{SSB}_{\mathrm{MSY}}$	–	0.02	0.03
$\mathrm{SSB}_{2006}/\mathrm{MSST}$	–	0.03	0.04

*Table 5.2. Red snapper: Projection results under fishing mortality rate $F = 0$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $\mathrm{SSB}_{F_{30\%}} = 6025.1$ mt, $\mathrm{R}_{F_{30\%}} = 685,824$ fish, $\mathrm{Y}_{F_{30\%}} = 2,430,792$ lb, and $\mathrm{D}_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0	0	242	339	0	1878	0	0	0
2011	0	0	558	352	0	1878	0	0	0
2012	0	0	865	494	0	1878	0	0	0
2013	0	0	1254	555	0	1878	0	0	0
2014	0	0	1737	596	0	1878	0	0	0
2015	0	0	2309	625	0	1878	0	0	0
2016	0	0	2957	645	0	1878	0	0	0
2017	0	0.03	3664	659	0	1878	0	0	0
2018	0	0.1	4414	669	0	1878	0	0	0
2019	0	0.25	5192	676	0	1878	0	0	0
2020	0	0.47	5982	681	0	1878	0	0	0
2021	0	0.68	6773	686	0	1878	0	0	0
2022	0	0.85	7555	689	0	1878	0	0	0
2023	0	0.94	8320	691	0	1878	0	0	0
2024	0	0.98	9061	693	0	1878	0	0	0
2025	0	0.99	9775	695	0	1878	0	0	0
2026	0	1	10,458	696	0	1878	0	0	0

*Table 5.3. Red snapper: Projection results under scenario P1—fishing mortality rate $F = F_{\text{rebuild}}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish*).* For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $\text{SSB}_{F_{30\%}} = 6025.1$ mt, $\text{R}_{F_{30\%}} = 685,824$ fish, $\text{Y}_{F_{30\%}} = 2,430,792$ lb, and $\text{D}_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.145	0	242	339	107	1985	23	37	23
2011	0.145	0	491	352	173	2158	34	47	26
2012	0.145	0	707	474	259	2417	46	50	30
2013	0.145	0	962	528	358	2776	58	60	35
2014	0.145	0	1258	567	472	3248	72	71	40
2015	0.145	0	1588	596	603	3850	87	78	43
2016	0.145	0	1939	617	743	4593	101	83	46
2017	0.145	0	2298	633	887	5480	114	86	47
2018	0.145	0	2656	644	1030	6510	126	89	48
2019	0.145	0	3005	653	1170	7680	137	90	49
2020	0.145	0.01	3336	660	1303	8983	147	92	50
2021	0.145	0.01	3647	665	1427	10,410	155	93	51
2022	0.145	0.02	3934	669	1542	11,952	162	94	51
2023	0.145	0.04	4196	672	1647	13,599	169	94	51
2024	0.145	0.07	4434	674	1742	15,341	175	95	51
2025	0.145	0.1	4647	676	1827	17,168	179	95	52
2026	0.145	0.12	4838	678	1903	19,070	184	96	52
2027	0.145	0.16	5006	679	1970	21,040	187	96	52
2028	0.145	0.19	5156	680	2029	23,069	191	96	52
2029	0.145	0.23	5287	681	2081	25,150	193	96	52
2030	0.145	0.27	5402	682	2127	27,278	196	96	52
2031	0.145	0.3	5502	683	2167	29,445	198	96	52
2032	0.145	0.33	5590	683	2202	31,647	200	97	52
2033	0.145	0.36	5666	684	2232	33,879	201	97	52
2034	0.145	0.38	5732	684	2259	36,138	202	97	52
2035	0.145	0.4	5790	684	2282	38,419	204	97	52
2036	0.145	0.42	5840	685	2301	40,721	205	97	52
2037	0.145	0.44	5883	685	2319	43,039	205	97	52
2038	0.145	0.46	5920	685	2333	45,372	206	97	52
2039	0.145	0.47	5953	685	2346	47,719	207	97	52
2040	0.145	0.5	5980	685	2357	50,076	207	97	52
2041	0.145	0.5	6005	686	2367	52,443	208	97	52
2042	0.145	0.51	6025	686	2375	54,818	208	97	53
2043	0.145	0.52	6043	686	2382	57,201	209	97	53
2044	0.145	0.53	6059	686	2389	59,589	209	97	53
2045	0.145	0.53	6072	686	2394	61,983	209	97	53
2046	0.145	0.53	6084	686	2398	64,381	209	97	53
2047	0.145	0.53	6094	686	2402	66,784	210	97	53
2048	0.145	0.53	6103	686	2406	69,190	210	97	53
2049	0.145	0.53	6110	686	2409	71,599	210	97	53
2050	0.145	0.53	6116	686	2411	74,010	210	97	53

*Table 5.4. Red snapper: Projection results under scenario P2—fishing mortality rate $F = 65\% F_{30\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $\mathrm{SSB}_{F_{30\%}} = 6025.1$ mt, $\mathrm{R}_{F_{30\%}} = 685,824$ fish, $\mathrm{Y}_{F_{30\%}} = 2,430,792$ lb, and $\mathrm{D}_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.096	0	242	339	72	1950	15	25	15
2011	0.096	0	512	352	120	2071	24	32	18
2012	0.096	0	756	481	185	2256	32	35	20
2013	0.096	0	1051	537	261	2517	42	41	24
2014	0.096	0	1400	577	351	2868	53	50	28
2015	0.096	0	1797	606	456	3324	64	55	30
2016	0.096	0	2228	627	571	3894	75	58	32
2017	0.096	0	2679	642	691	4585	86	60	33
2018	0.096	0.01	3137	653	813	5398	96	62	34
2019	0.096	0.01	3591	662	934	6333	105	63	34
2020	0.096	0.04	4033	668	1052	7385	113	64	35
2021	0.096	0.08	4456	673	1165	8550	120	65	35
2022	0.096	0.16	4854	676	1271	9821	127	65	35
2023	0.096	0.23	5227	679	1370	11,191	133	66	35
2024	0.096	0.33	5571	682	1461	12,652	138	66	35
2025	0.096	0.43	5887	684	1545	14,197	143	66	36
2026	0.096	0.53	6175	685	1621	15,818	147	67	36
2027	0.096	0.62	6437	686	1690	17,509	150	67	36
2028	0.096	0.7	6673	688	1753	19,262	154	67	36
2029	0.096	0.76	6885	688	1809	21,071	157	67	36
2030	0.096	0.81	7075	689	1859	22,931	159	67	36
2031	0.096	0.86	7246	690	1905	24,835	161	67	36
2032	0.096	0.88	7397	690	1945	26,780	163	67	36
2033	0.096	0.91	7533	691	1980	28,760	165	67	36
2034	0.096	0.93	7653	691	2012	30,772	167	67	36
2035	0.096	0.94	7759	692	2040	32,813	168	67	36
2036	0.096	0.95	7854	692	2065	34,878	169	68	36
2037	0.096	0.96	7938	692	2088	36,966	170	68	36
2038	0.096	0.97	8012	692	2107	39,073	171	68	36
2039	0.096	0.97	8078	693	2125	41,198	172	68	36
2040	0.096	0.98	8136	693	2140	43,338	173	68	36
2041	0.096	0.98	8187	693	2154	45,491	173	68	36
2042	0.096	0.98	8233	693	2166	47,657	174	68	36
2043	0.096	0.98	8273	693	2176	49,833	175	68	36
2044	0.096	0.98	8308	693	2186	52,019	175	68	36
2045	0.096	0.99	8340	693	2194	54,213	175	68	36
2046	0.096	0.99	8368	693	2201	56,414	176	68	36
2047	0.096	0.99	8392	694	2208	58,622	176	68	36
2048	0.096	0.99	8414	694	2214	60,836	176	68	36
2049	0.096	0.99	8433	694	2219	63,054	177	68	36
2050	0.096	0.99	8450	694	2223	65,277	177	68	36

*Table 5.5. Red snapper: Projection results under scenario P3—fishing mortality rate $F = 75\% F_{30\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish*).* For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $\mathrm{SSB}_{F_{30\%}} = 6025.1$ mt, $\mathrm{R}_{F_{30\%}} = 685,824$ fish, $\mathrm{Y}_{F_{30\%}} = 2,430,792$ lb, and $\mathrm{D}_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.111	0	242	339	83	1961	18	28	18
2011	0.111	0	506	352	137	2098	27	37	20
2012	0.111	0	741	479	209	2307	37	40	23
2013	0.111	0	1023	535	293	2600	47	47	28
2014	0.111	0	1355	574	391	2992	59	57	32
2015	0.111	0	1730	603	506	3497	72	62	34
2016	0.111	0	2135	624	630	4127	84	66	36
2017	0.111	0	2555	640	759	4886	96	69	37
2018	0.111	0	2980	651	890	5777	106	71	38
2019	0.111	0.01	3399	659	1019	6796	116	72	39
2020	0.111	0.02	3804	665	1144	7939	125	73	39
2021	0.111	0.05	4188	670	1262	9201	132	74	40
2022	0.111	0.09	4548	674	1373	10,574	139	74	40
2023	0.111	0.15	4882	677	1475	12,049	146	75	40
2024	0.111	0.22	5189	680	1569	13,618	151	75	40
2025	0.111	0.29	5469	681	1654	15,272	156	76	41
2026	0.111	0.38	5723	683	1732	17,004	160	76	41
2027	0.111	0.46	5951	684	1802	18,806	164	76	41
2028	0.111	0.53	6156	685	1864	20,670	167	76	41
2029	0.111	0.6	6339	686	1920	22,590	170	76	41
2030	0.111	0.66	6501	687	1970	24,560	172	76	41
2031	0.111	0.71	6646	688	2014	26,574	175	77	41
2032	0.111	0.76	6774	688	2053	28,627	177	77	41
2033	0.111	0.79	6887	689	2088	30,714	178	77	41
2034	0.111	0.81	6987	689	2118	32,832	180	77	41
2035	0.111	0.83	7075	690	2145	34,977	181	77	41
2036	0.111	0.85	7152	690	2168	37,145	182	77	41
2037	0.111	0.87	7220	690	2189	39,335	183	77	41
2038	0.111	0.88	7280	690	2208	41,542	184	77	41
2039	0.111	0.89	7333	691	2224	43,766	185	77	41
2040	0.111	0.9	7379	691	2238	46,004	186	77	41
2041	0.111	0.9	7420	691	2250	48,254	186	77	41
2042	0.111	0.91	7455	691	2261	50,515	187	77	41
2043	0.111	0.92	7487	691	2271	52,785	187	77	41
2044	0.111	0.92	7514	691	2279	55,064	188	77	41
2045	0.111	0.93	7538	691	2286	57,350	188	77	41
2046	0.111	0.92	7559	691	2293	59,643	188	77	41
2047	0.111	0.93	7578	691	2298	61,941	189	77	41
2048	0.111	0.94	7594	691	2303	64,244	189	77	41
2049	0.111	0.94	7608	691	2308	66,552	189	77	41
2050	0.111	0.94	7621	692	2311	68,863	189	77	41

*Table 5.6. Red snapper: Projection results under scenario P4—fishing mortality rate $F = 85\% F_{30\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish*).* For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $\mathrm{SSB}_{F_{30\%}} = 6025.1$ mt, $\mathrm{R}_{F_{30\%}} = 685,824$ fish, $\mathrm{Y}_{F_{30\%}} = 2,430,792$ lb, and $\mathrm{D}_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.126	0	242	339	93	1972	20	32	20
2011	0.126	0	499	352	153	2125	30	41	23
2012	0.126	0	726	477	232	2356	41	44	26
2013	0.126	0	995	532	323	2680	52	53	31
2014	0.126	0	1312	571	429	3108	65	63	36
2015	0.126	0	1666	600	551	3659	79	69	38
2016	0.126	0	2046	621	683	4342	92	73	40
2017	0.126	0	2438	637	820	5163	104	76	42
2018	0.126	0	2832	648	957	6120	116	79	43
2019	0.126	0.01	3218	656	1092	7212	126	80	44
2020	0.126	0.01	3589	663	1221	8434	135	82	44
2021	0.126	0.03	3939	668	1343	9777	143	82	45
2022	0.126	0.06	4265	672	1457	11,234	150	83	45
2023	0.126	0.1	4565	675	1561	12,795	157	84	45
2024	0.126	0.14	4839	677	1656	14,451	162	84	45
2025	0.126	0.19	5087	679	1742	16,193	167	84	46
2026	0.126	0.24	5310	681	1819	18,013	171	85	46
2027	0.126	0.3	5510	682	1889	19,901	175	85	46
2028	0.126	0.36	5688	683	1950	21,851	178	85	46
2029	0.126	0.41	5846	684	2005	23,856	181	85	46
2030	0.126	0.46	5985	685	2053	25,909	184	85	46
2031	0.126	0.51	6108	686	2096	28,005	186	85	46
2032	0.126	0.56	6216	686	2133	30,138	188	86	46
2033	0.126	0.6	6311	687	2166	32,304	189	86	46
2034	0.126	0.63	6394	687	2195	34,499	191	86	46
2035	0.126	0.66	6467	687	2220	36,719	192	86	46
2036	0.126	0.69	6531	688	2242	38,961	193	86	46
2037	0.126	0.71	6586	688	2261	41,222	194	86	46
2038	0.126	0.72	6635	688	2278	43,500	195	86	46
2039	0.126	0.74	6677	688	2293	45,792	196	86	46
2040	0.126	0.75	6714	688	2305	48,098	196	86	46
2041	0.126	0.76	6746	689	2316	50,414	197	86	46
2042	0.126	0.76	6774	689	2326	52,740	197	86	46
2043	0.126	0.77	6799	689	2335	55,075	198	86	46
2044	0.126	0.78	6820	689	2342	57,417	198	86	46
2045	0.126	0.78	6839	689	2348	59,765	198	86	46
2046	0.126	0.79	6855	689	2354	62,119	199	86	46
2047	0.126	0.79	6869	689	2359	64,478	199	86	46
2048	0.126	0.79	6881	689	2363	66,841	199	86	46
2049	0.126	0.8	6892	689	2367	69,208	199	86	46
2050	0.126	0.79	6901	689	2370	71,578	199	86	46

*Table 5.7. Red snapper: Projection results under scenario P5—fishing mortality rate $F = F_{30\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish*).* For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $\mathrm{SSB}_{F_{30\%}} = 6025.1$ mt, $\mathrm{R}_{F_{30\%}} = 685,824$ fish, $\mathrm{Y}_{F_{30\%}} = 2,430,792$ lb, and $\mathrm{D}_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.148	0	242	339	109	1987	23	37	23
2011	0.148	0	489	352	176	2164	35	48	27
2012	0.148	0	704	474	264	2428	47	51	30
2013	0.148	0	956	528	364	2792	59	61	36
2014	0.148	0	1249	567	480	3272	73	73	41
2015	0.148	0	1574	596	611	3883	88	79	44
2016	0.148	0	1920	617	752	4636	103	84	47
2017	0.148	0	2274	632	898	5533	116	88	48
2018	0.148	0	2626	644	1042	6575	128	90	49
2019	0.148	0	2968	652	1182	7758	139	92	50
2020	0.148	0	3293	659	1316	9073	149	94	51
2021	0.148	0.01	3597	664	1441	10,514	157	95	52
2022	0.148	0.02	3878	668	1555	12,069	164	96	52
2023	0.148	0.04	4134	671	1660	13,729	171	96	52
2024	0.148	0.06	4365	674	1754	15,484	177	97	53
2025	0.148	0.09	4573	676	1839	17,323	181	97	53
2026	0.148	0.11	4758	677	1915	19,237	186	97	53
2027	0.148	0.14	4922	679	1981	21,219	189	98	53
2028	0.148	0.17	5066	680	2040	23,259	192	98	53
2029	0.148	0.2	5193	681	2092	25,351	195	98	53
2030	0.148	0.23	5304	681	2137	27,488	198	98	53
2031	0.148	0.26	5401	682	2177	29,665	200	98	53
2032	0.148	0.29	5485	683	2211	31,876	201	99	53
2033	0.148	0.31	5559	683	2241	34,117	203	99	53
2034	0.148	0.34	5622	684	2267	36,384	204	99	53
2035	0.148	0.36	5678	684	2289	38,673	205	99	53
2036	0.148	0.38	5725	684	2309	40,982	206	99	54
2037	0.148	0.38	5766	684	2326	43,307	207	99	54
2038	0.148	0.4	5802	685	2340	45,647	208	99	54
2039	0.148	0.42	5833	685	2353	48,000	209	99	54
2040	0.148	0.44	5859	685	2363	50,363	209	99	54
2041	0.148	0.46	5882	685	2373	52,736	210	99	54
2042	0.148	0.46	5902	685	2381	55,117	210	99	54
2043	0.148	0.47	5919	685	2388	57,504	210	99	54
2044	0.148	0.47	5934	685	2394	59,898	211	99	54
2045	0.148	0.48	5947	685	2399	62,297	211	99	54
2046	0.148	0.48	5957	685	2403	64,700	211	99	54
2047	0.148	0.48	5967	686	2407	67,107	211	99	54
2048	0.148	0.48	5975	686	2410	69,518	211	99	54
2049	0.148	0.47	5982	686	2413	71,931	212	99	54
2050	0.148	0.47	5988	686	2416	74,346	212	99	54

*Table 5.8. Red snapper: Projection results under scenario P6—fishing mortality rate $F = F_{45\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (*mt*), R = recruits (1000 fish), L = landings (1000* lb *whole weight or fish), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000* lb or fish). For reference, estimated proxy reference points are $F_{30\%} = 0.148$, $\mathrm{SSB}_{F_{30\%}} = 6025.1$ mt, $\mathrm{R}_{F_{30\%}} = 685,824$ fish, $\mathrm{Y}_{F_{30\%}} = 2,430,792$ lb, and $\mathrm{D}_{F_{30\%}} = 99,092$ lb.

Year	F	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	L(1000)	D(1000 lb)	D(1000)
2007	0.93	0	262	286	541	541	144	292	177
2008	1.22	0	290	367	759	1300	174	297	165
2009	0.974	0	225	385	579	1878	124	176	125
2010	0.088	0	242	339	66	1944	14	23	14
2011	0.088	0	516	352	111	2055	22	30	16
2012	0.088	0	765	482	171	2226	30	32	19
2013	0.088	0	1066	539	243	2469	39	38	22
2014	0.088	0	1426	579	327	2797	49	46	26
2015	0.088	0	1836	608	426	3223	60	50	28
2016	0.088	0	2282	629	535	3758	70	53	29
2017	0.088	0	2750	644	649	4407	80	56	30
2018	0.088	0.01	3228	655	766	5173	90	57	31
2019	0.088	0.02	3703	663	882	6055	98	58	31
2020	0.088	0.05	4167	669	995	7050	106	59	32
2021	0.088	0.11	4613	674	1104	8154	113	60	32
2022	0.088	0.2	5034	678	1207	9361	119	60	32
2023	0.088	0.29	5430	681	1303	10,663	125	61	33
2024	0.088	0.4	5797	683	1392	12,055	130	61	33
2025	0.088	0.51	6135	685	1474	13,529	135	61	33
2026	0.088	0.62	6445	686	1549	15,077	139	61	33
2027	0.088	0.71	6727	688	1617	16,694	142	62	33
2028	0.088	0.78	6982	689	1679	18,373	145	62	33
2029	0.088	0.84	7213	690	1735	20,107	148	62	33
2030	0.088	0.89	7421	690	1785	21,892	151	62	33
2031	0.088	0.91	7607	691	1830	23,722	153	62	33
2032	0.088	0.93	7774	692	1870	25,593	155	62	33
2033	0.088	0.95	7924	692	1907	27,499	157	62	33
2034	0.088	0.96	8057	692	1939	29,438	158	62	33
2035	0.088	0.97	8176	693	1968	31,406	160	62	33
2036	0.088	0.98	8282	693	1993	33,399	161	62	33
2037	0.088	0.98	8376	693	2016	35,415	162	62	33
2038	0.088	0.99	8460	694	2036	37,451	163	62	33
2039	0.088	0.99	8534	694	2054	39,505	164	62	33
2040	0.088	0.99	8600	694	2070	41,576	165	62	33
2041	0.088	0.99	8659	694	2084	43,660	165	62	33
2042	0.088	0.99	8711	694	2097	45,757	166	62	33
2043	0.088	0.99	8757	694	2108	47,865	167	62	33
2044	0.088	0.99	8798	694	2118	49,984	167	62	33
2045	0.088	1	8835	694	2127	52,111	167	62	33
2046	0.088	1	8867	695	2135	54,245	168	62	33
2047	0.088	1	8896	695	2142	56,387	168	62	33
2048	0.088	1	8922	695	2148	58,535	168	62	33
2049	0.088	1	8944	695	2153	60,689	169	62	33
2050	0.088	1	8964	695	2158	62,847	169	62	33

6 Figures

Figure 6.1. Probability that spawning biomass achieves the $F_{30\%}$ proxy for $\mathrm{SSB}_{\mathrm{MSY}}$ *(i.e.,* 6025.1 *mt) in a projection with* $F = 0$.

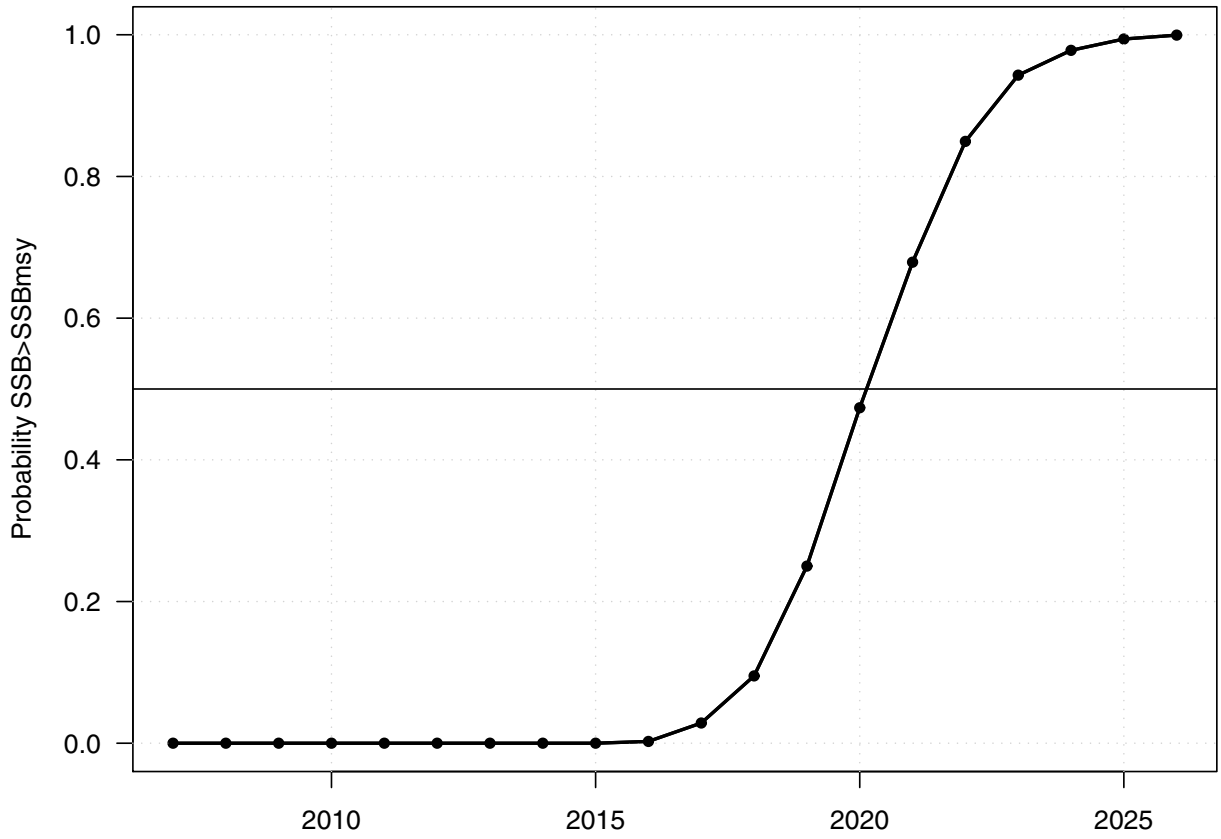

Figure 6.2. Projection results under scenario with fishing mortality rate fixed at $F = F_{\text{rebuild}}$. For reference, the proxy reference point used to define stock recovery is $\text{SSB}_{\text{MSY}} = 6025.1$ mt, which corresponds to a yield of about 2.4 million lb.

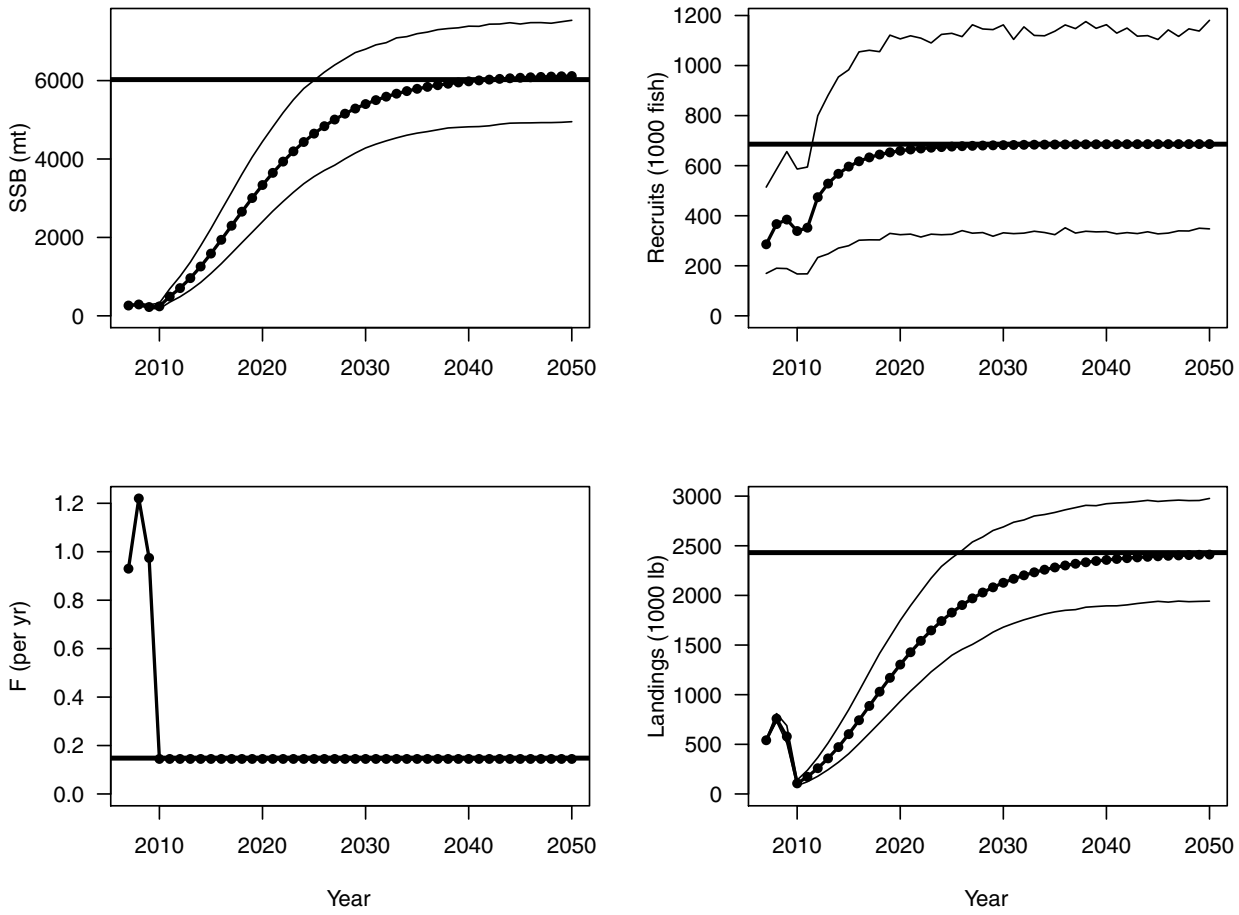

Figure 6.3. Projection results under scenario with fishing mortality rate fixed at $F = 0.65F_{30\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 6025.1$ mt, which corresponds to a yield of about 2.4 million lb.

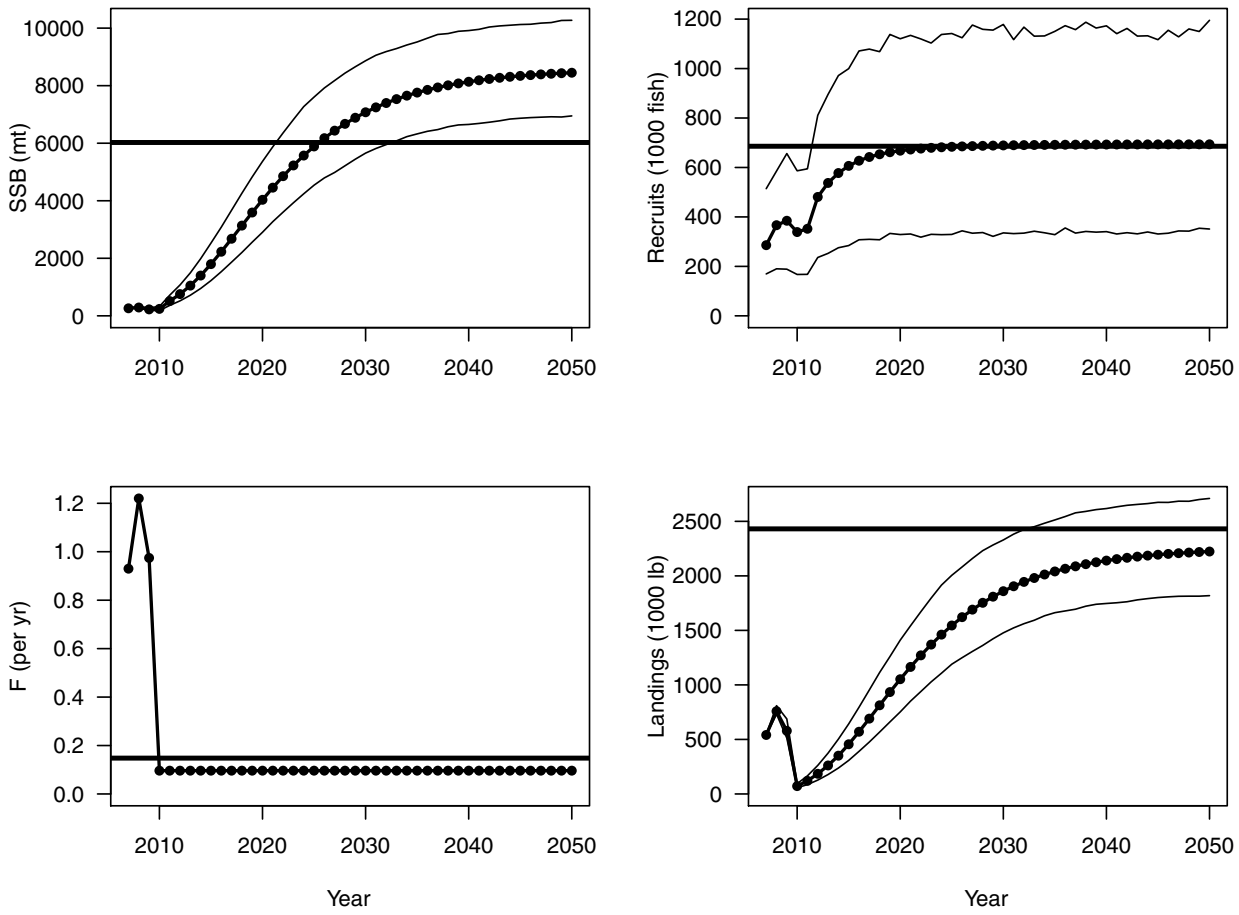

Figure 6.4. Projection results under scenario with fishing mortality rate fixed at $F = 0.75F_{30\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 6025.1$ mt, which corresponds to a yield of about 2.4 million lb.

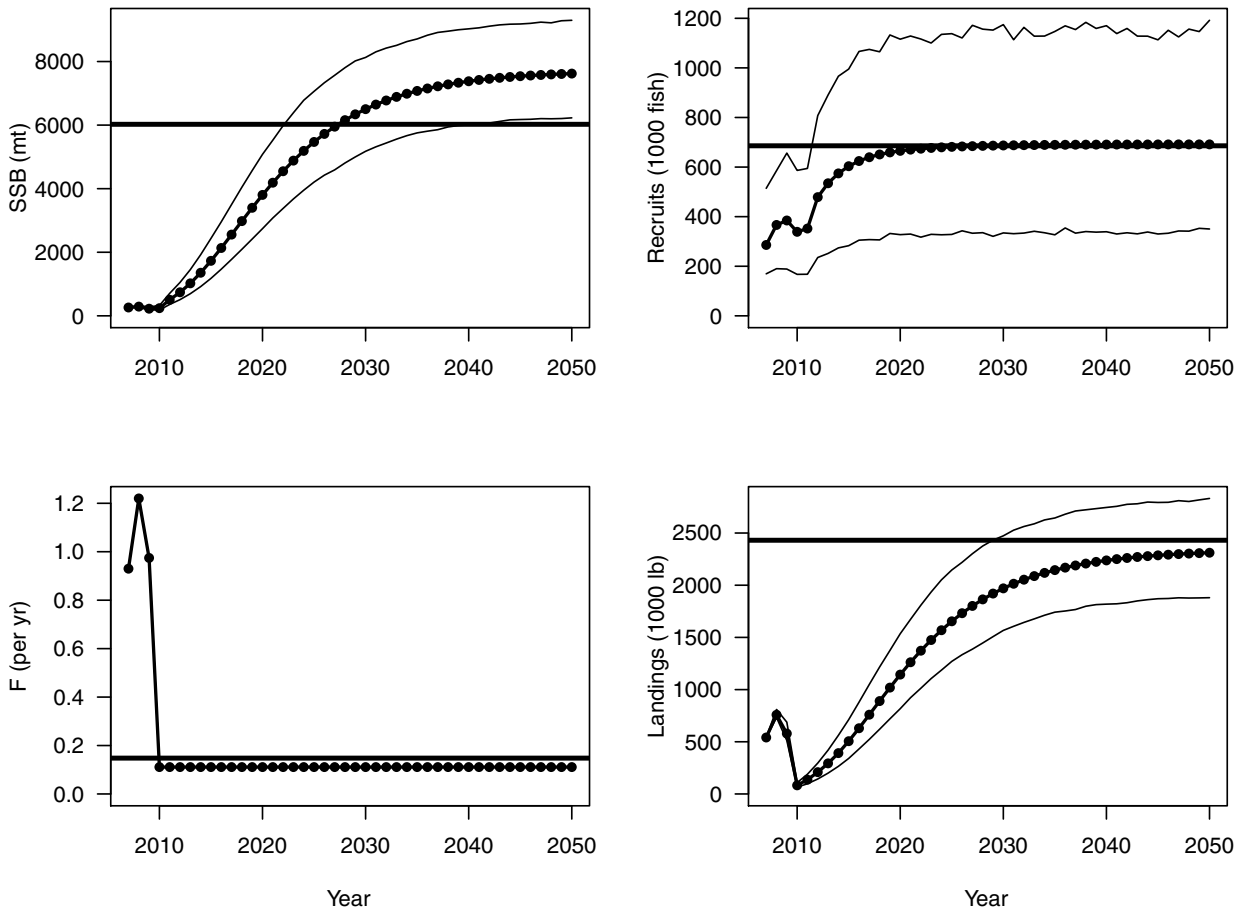

Figure 6.5. Projection results under scenario with fishing mortality rate fixed at $F = 0.85F_{30\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 6025.1$ mt, which corresponds to a yield of about 2.4 million lb.

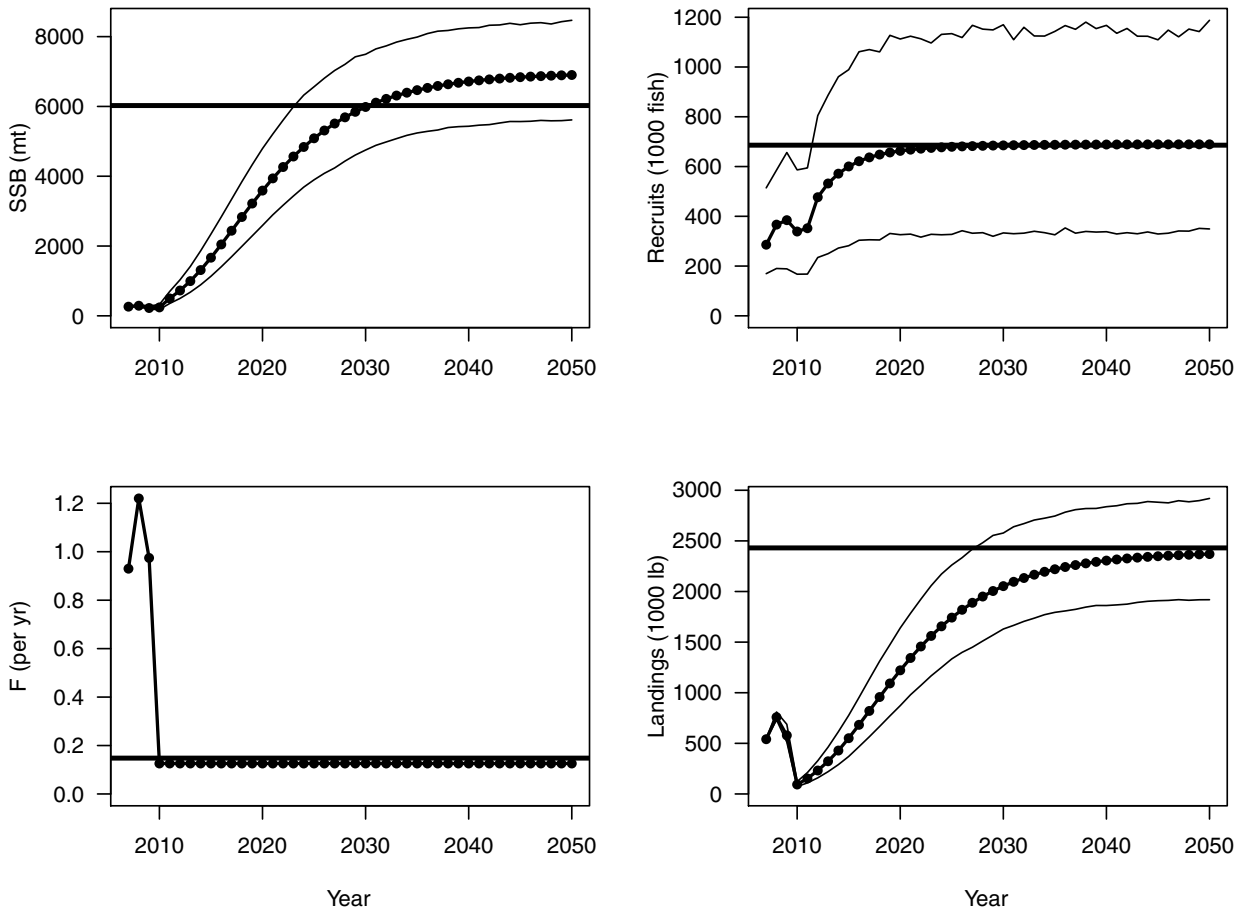

Figure 6.6. Projection results under scenario with fishing mortality rate fixed at $F = F_{30\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 6025.1$ *mt, which corresponds to a yield of about 2.4 million lb.*

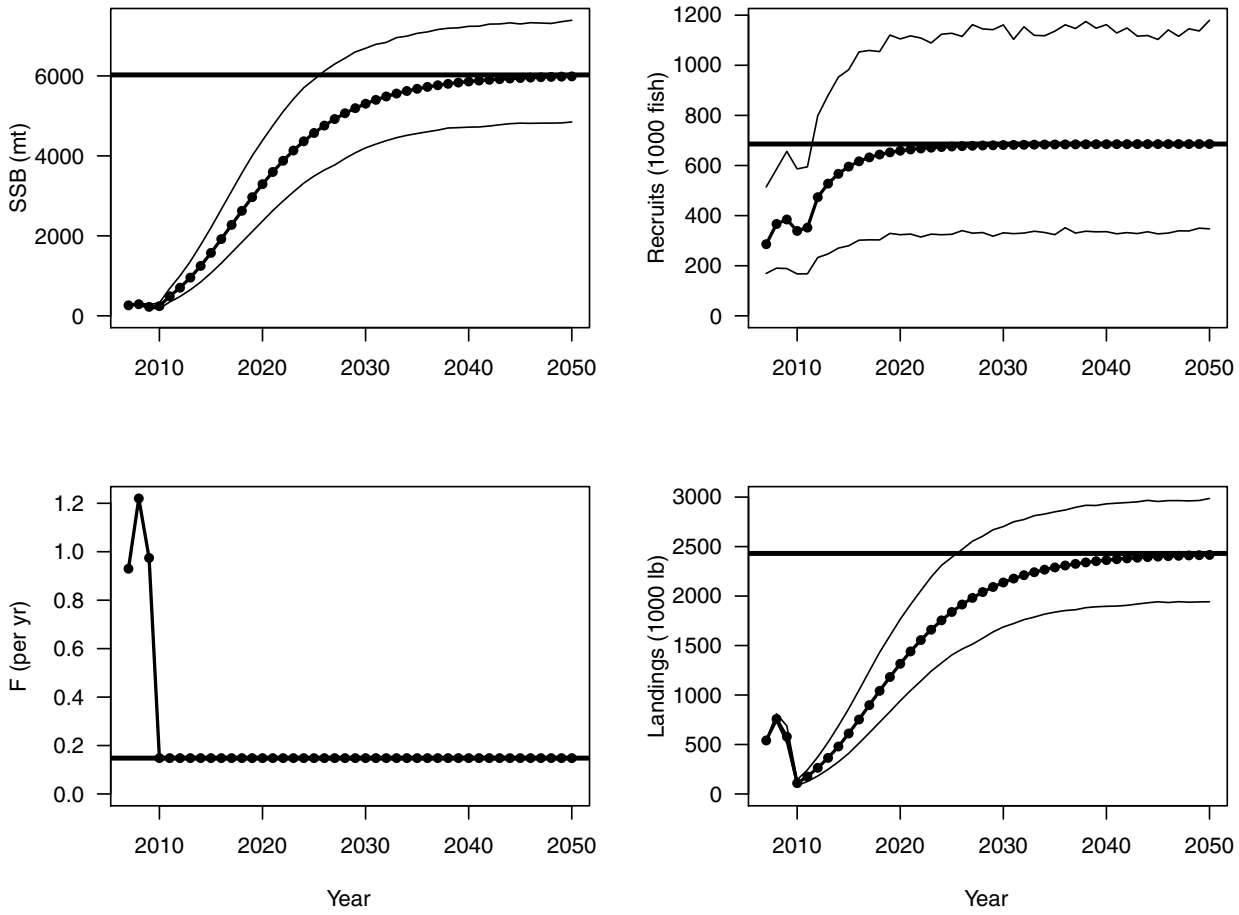
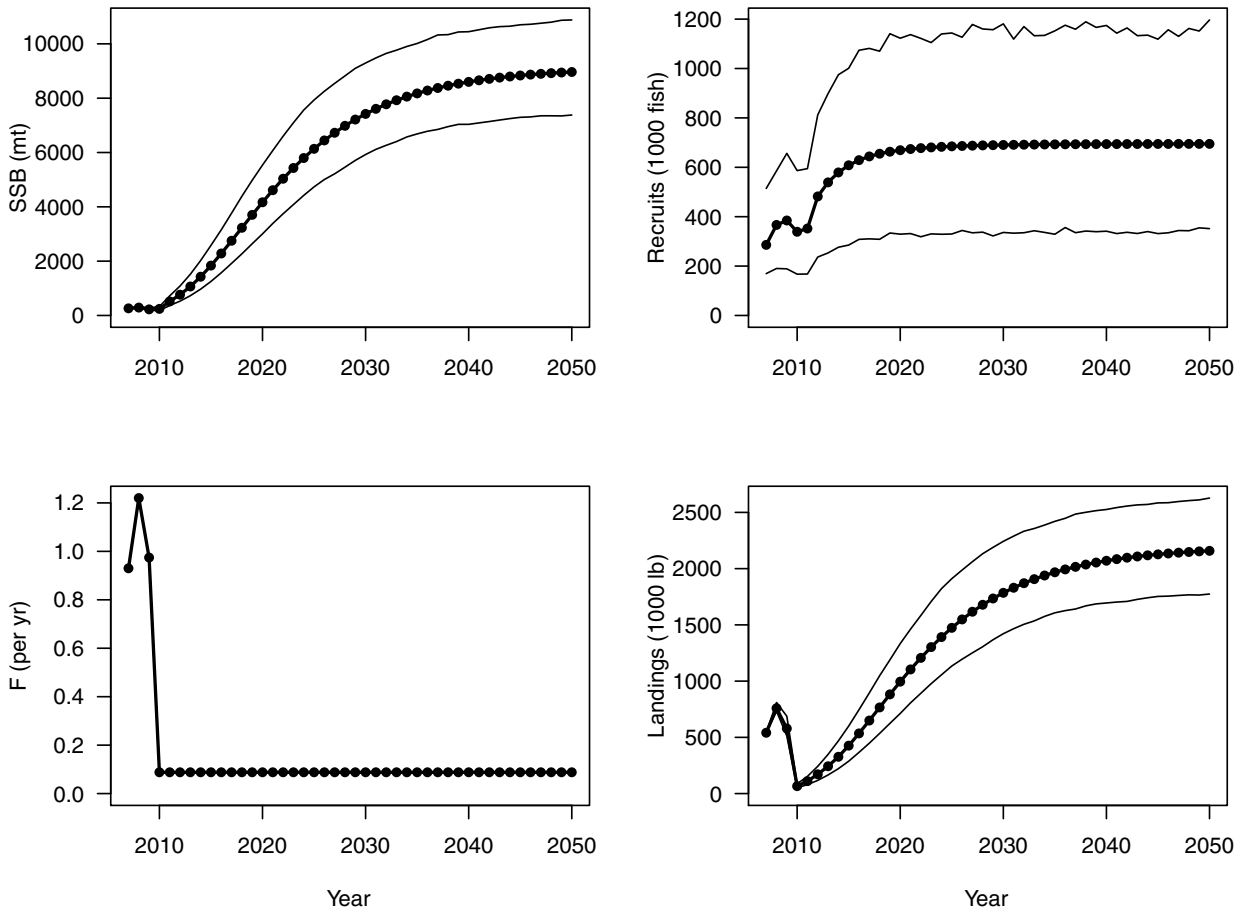
Figure 6.7. Projection results under scenario with fishing mortality rate fixed at $F = F_{45\%}$.