Red Snapper Projections VIII

Prepared by the NOAA/NMFS Southeast Fisheries Science Center
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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: $F = F_{rebuild}$, the maximum fishing rate that allows 0.5 probability of rebuilding to the $F_{30\%}$ proxy for SSB_{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

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 $SSB_{F40\%}$, 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	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 $F_{30\%} = 0.148$, $\text{SSB}_{F_{30\%}} = 6025.1$ 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	0.096	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 $F_{30\%} = 0.148$, $\text{SSB}_{F_{30\%}} = 6025.1$ 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	0.111	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 $F_{30\%} = 0.148$, $\text{SSB}_{F_{30\%}} = 6025.1$ 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)
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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 SSB_{MSY} *(i.e.,* 6025.1 *mt) in a projection with $F = 0$.*

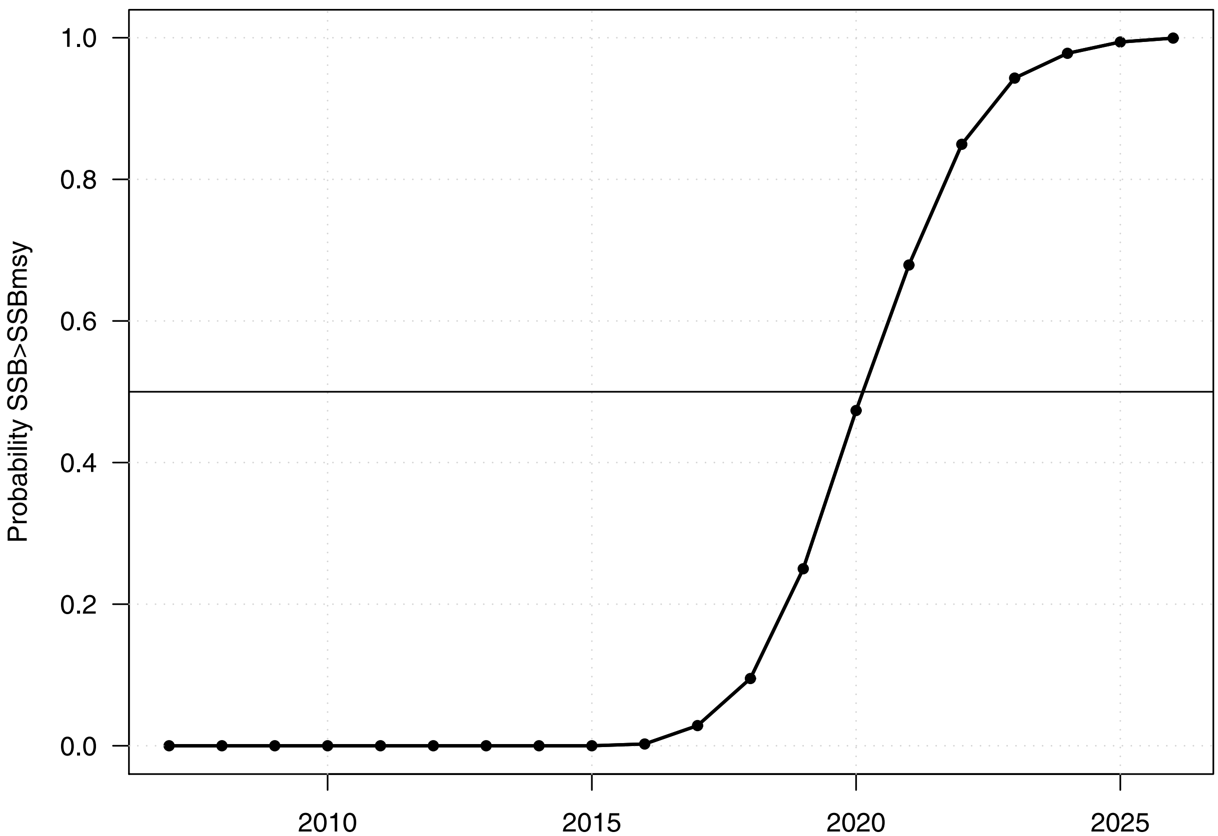

Figure 6.2. Projection results under scenario with fishing mortality rate fixed at $F = F_{\text{rebuild}}$. For reference, the proxy reference point used to define stock recovery is $\text{SSB}_{\text{MSY}} = 6025.1$ *mt, which corresponds to a yield of about 2.4 million lb.*

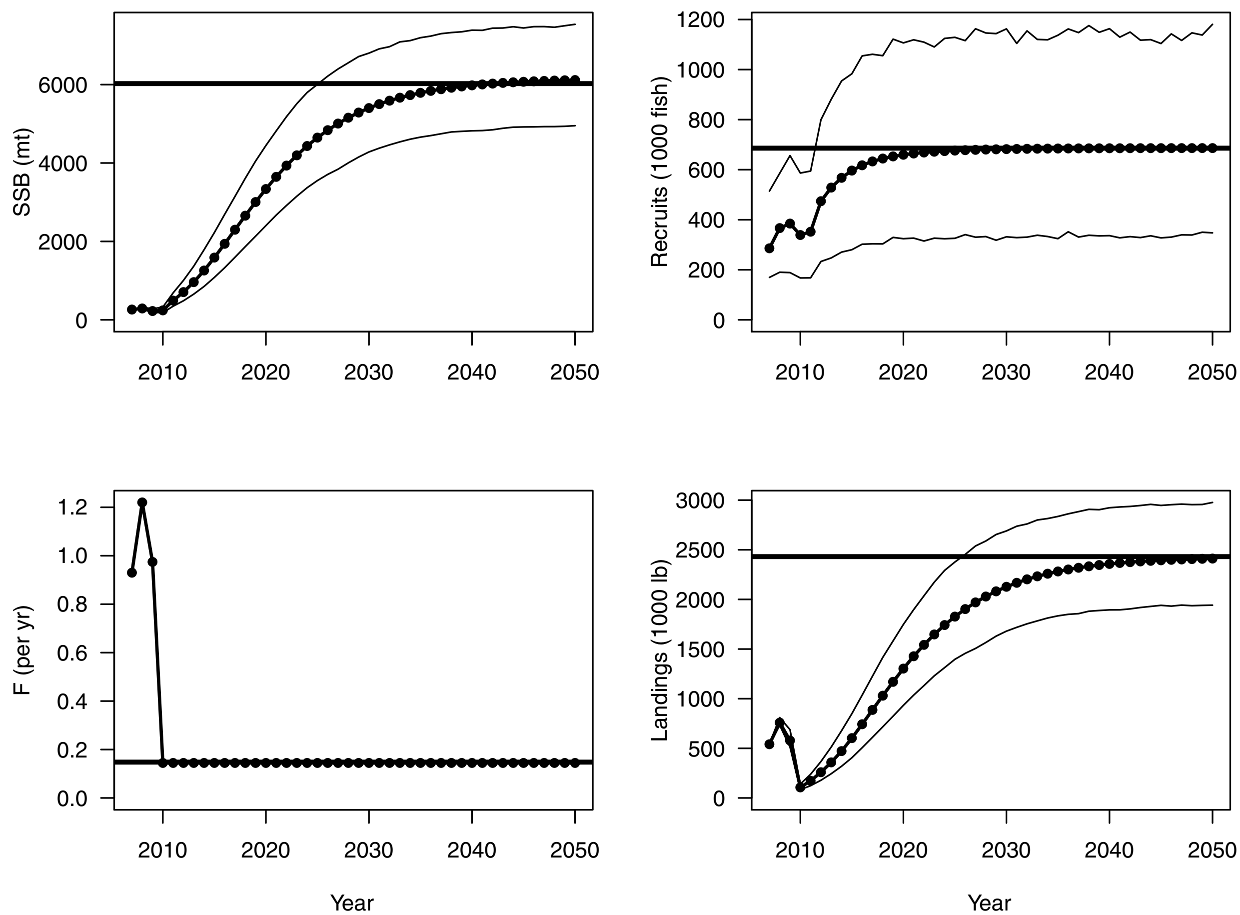

Figure 6.3. Projection results under scenario with fishing mortality rate fixed at $F = 0.65F_{30\%}$. *For reference, the proxy reference point used to define stock recovery is* $\mathrm{SSB}_{\mathrm{MSY}} = 6025.1$ *mt, which corresponds to a yield of about 2.4 million lb.*

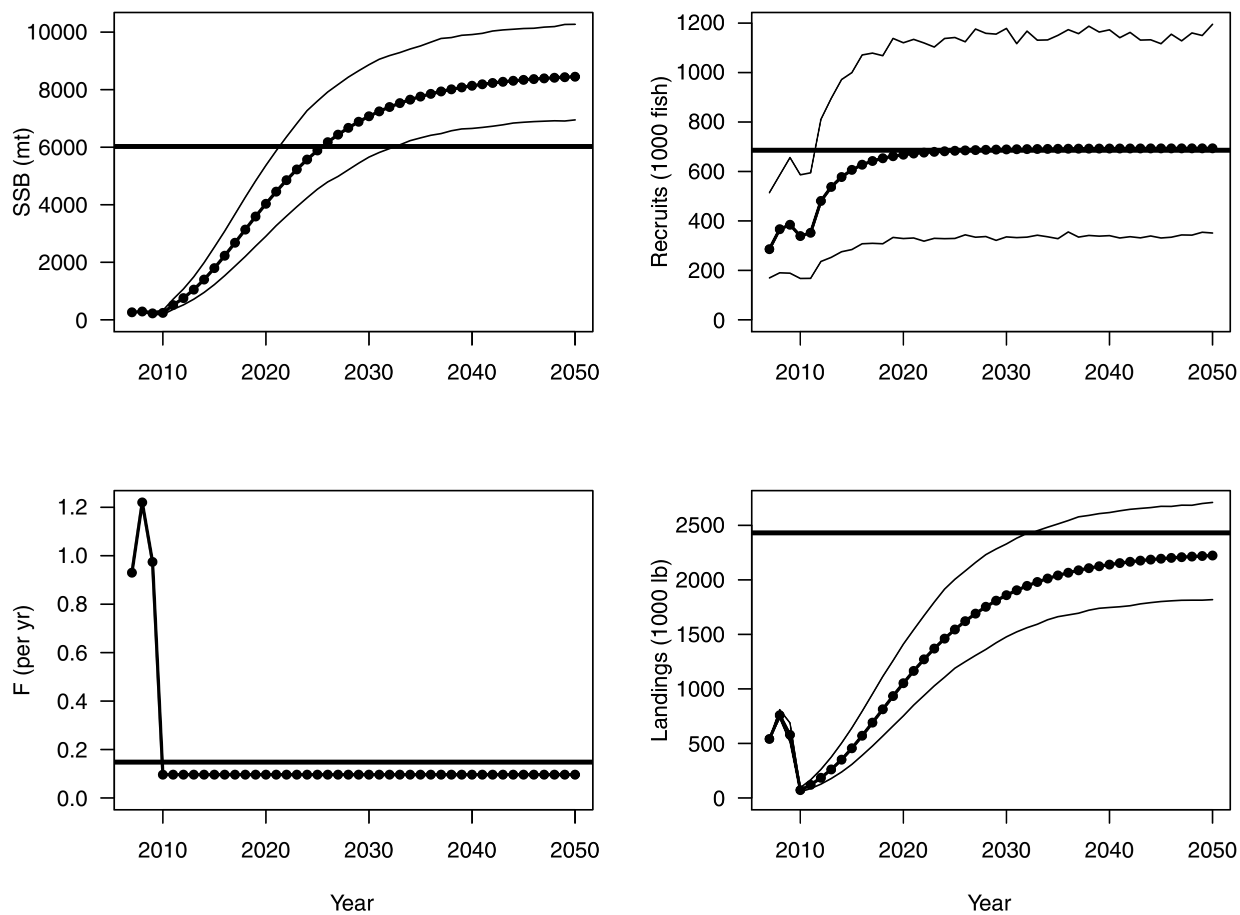

Figure 6.4. Projection results under scenario with fishing mortality rate fixed at $F = 0.75F_{30\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB_{MSY}} = 6025.1$ mt, which corresponds to a yield of about 2.4 million lb.

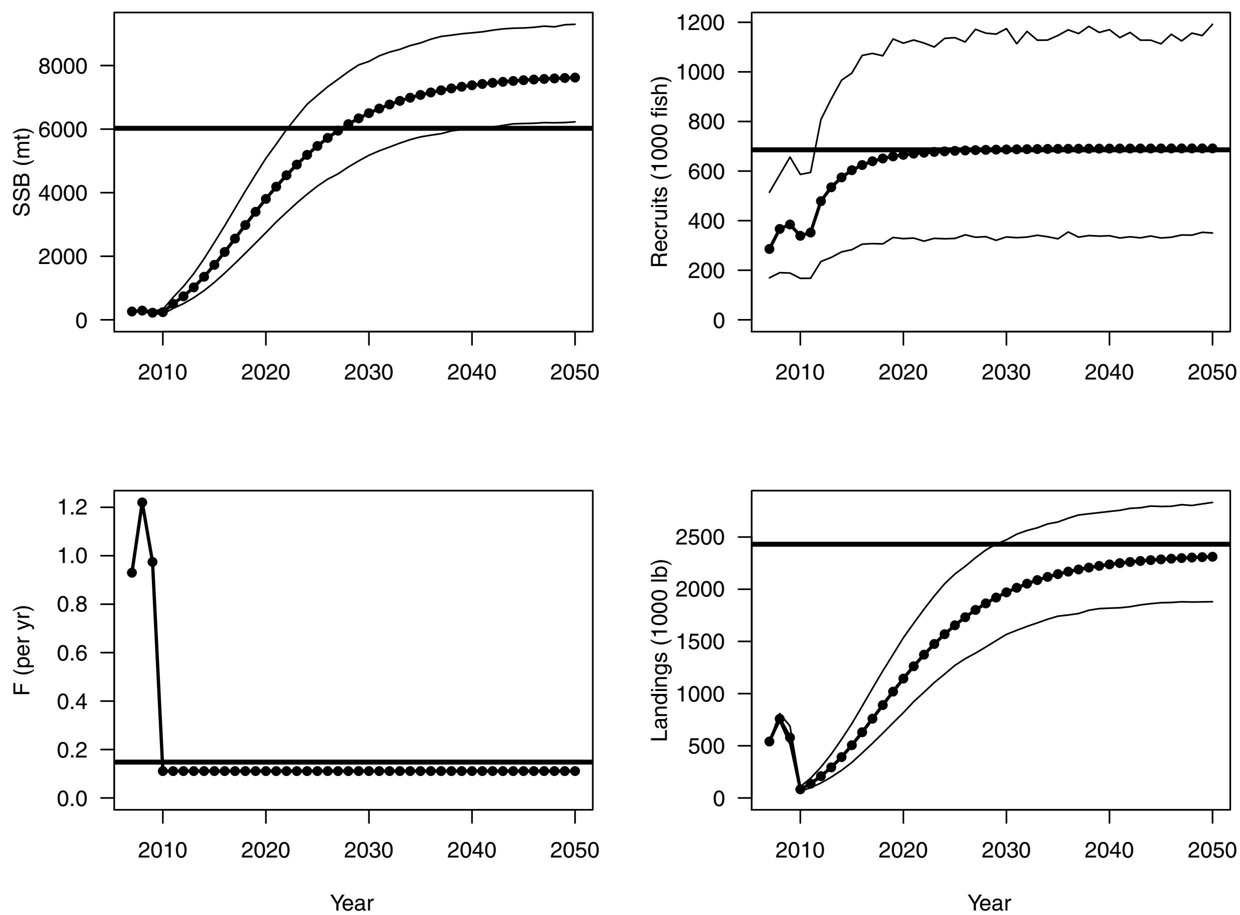

Figure 6.5. Projection results under scenario with fishing mortality rate fixed at $F = 0.85F_{30\%}$*. For reference, the proxy reference point used to define stock recovery is* $\mathrm{SSB_{MSY}} = 6025.1$ *mt, which corresponds to a yield of about 2.4 million lb.*

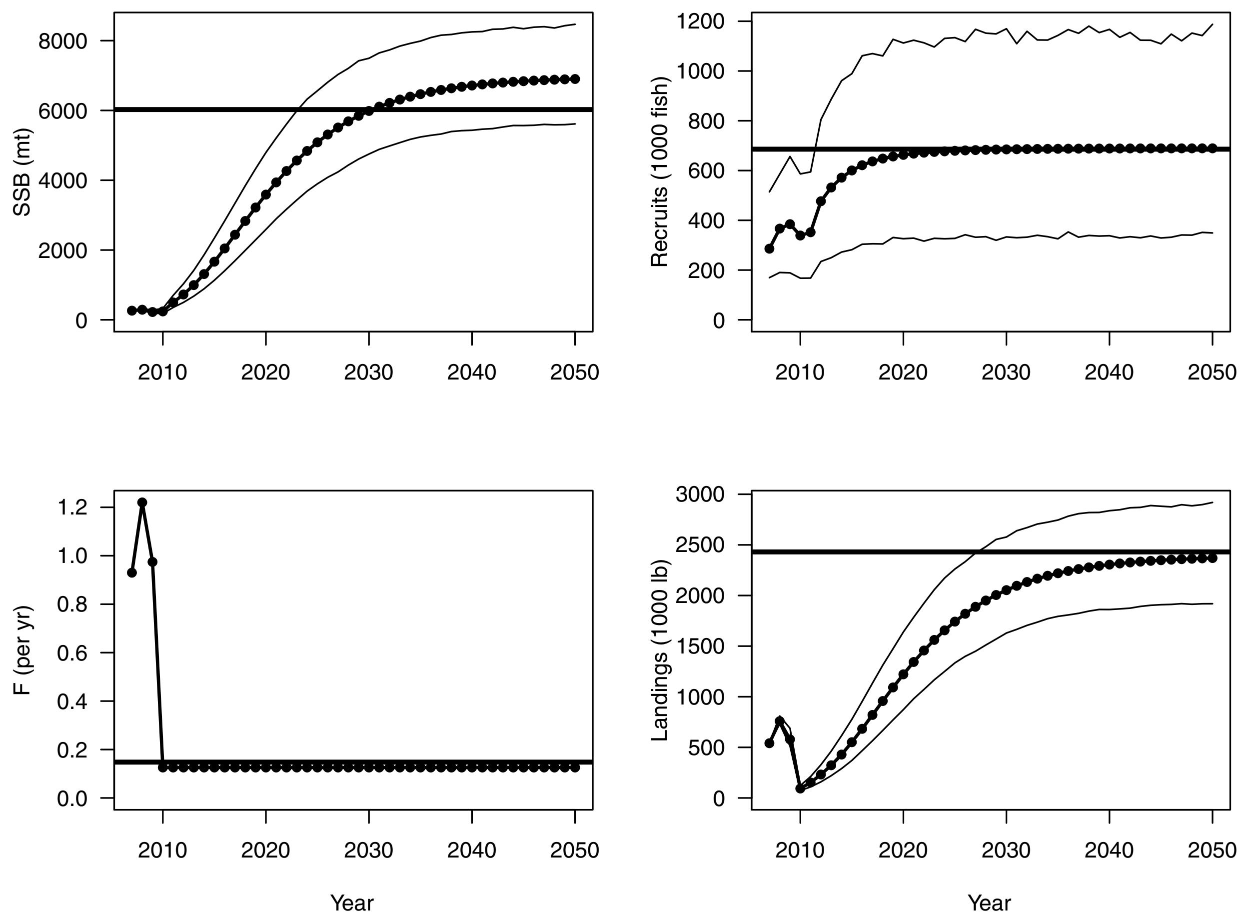

Figure 6.6. Projection results under scenario with fishing mortality rate fixed at $F = F_{30\%}$. For reference, the proxy reference point used to define stock recovery is $SSB_{MSY} = 6025.1$ *mt, which corresponds to a yield of about 2.4 million lb.*

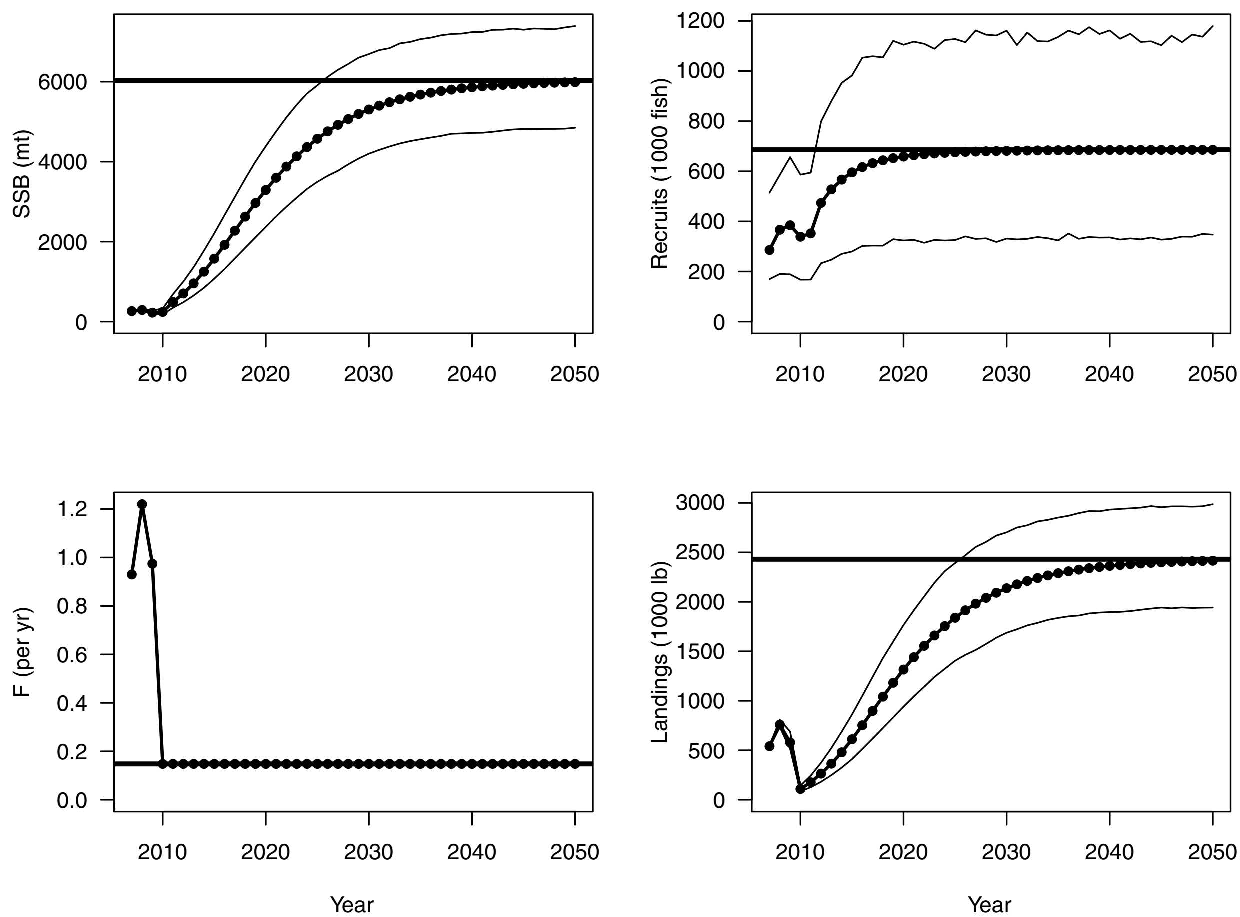

Figure 6.7. Projection results under scenario with fishing mortality rate fixed at $F = F_{45\%}$.