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_{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 $F = F_{\mathrm{current}}$, 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 $F_{40\%} = 0.104$, $\mathrm{SSB}_{F_{40\%}} = 8102.5$ 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	0.974	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

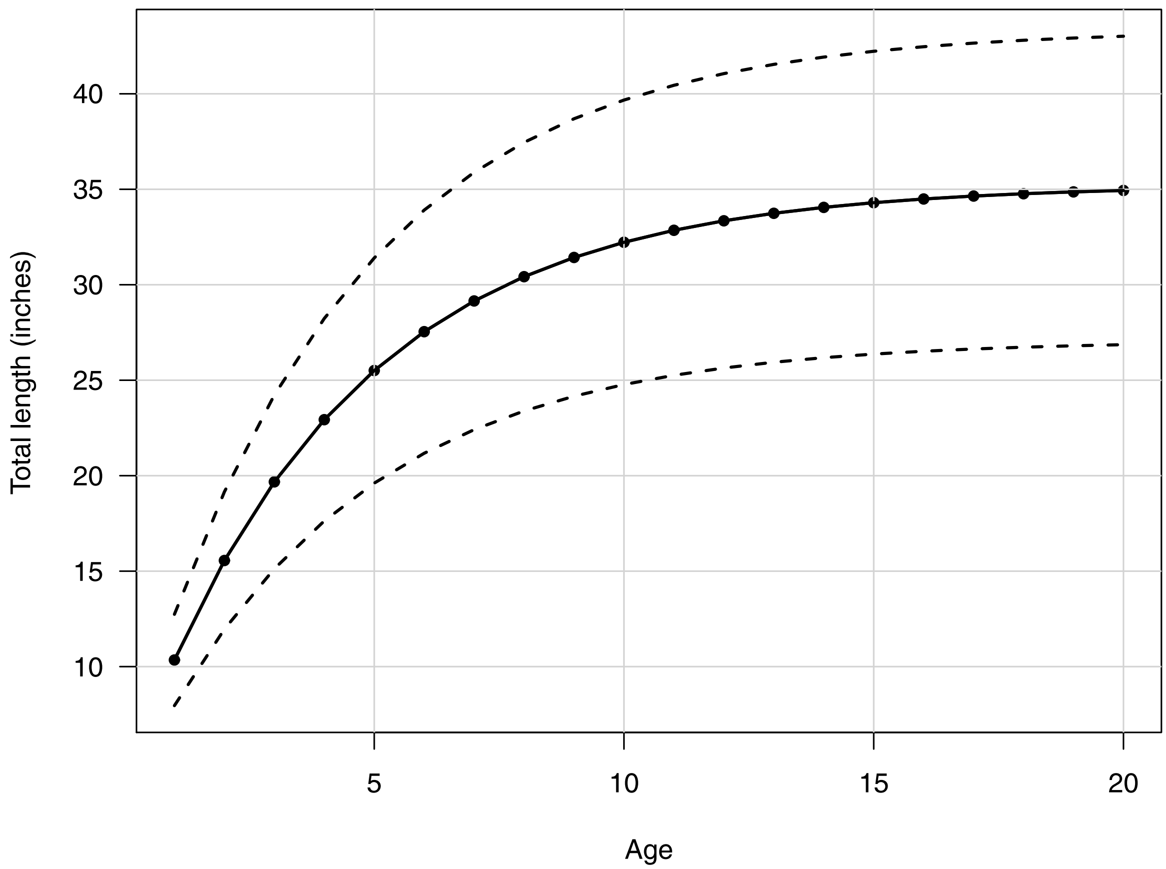
Table 4.5. Red snapper: Projection results under scenario P5—fishing mortality rate $F = 75\% F_{40\%}$, with very high 2006 recruitment. F = fishing mortality rate (per year), Pr(recover) = proportion of replicates reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning biomass (mt)*, R = recruits (1000 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.*

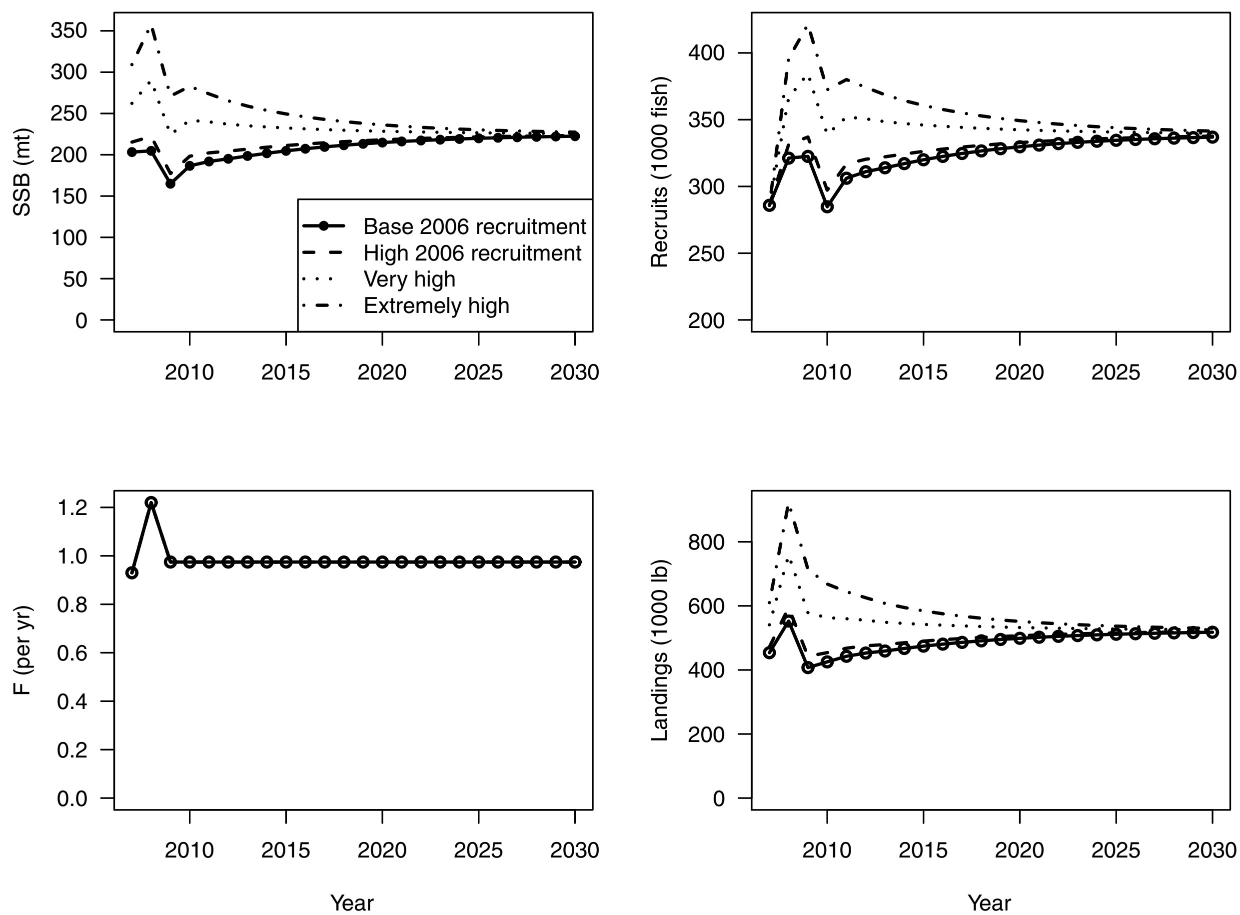


Figure 5.3. Projection results under scenarios with fishing mortality rate fixed at $F = 0.75F_{40\%}$. For reference, the proxy reference point used to define stock recovery is $\mathrm{SSB}_{\mathrm{MSY}} = 8102.5$ mt, which corresponds to a yield of about 2.3 million lb.