Executive Summary

Stock

This is the second assessment of the population status of cabezon (*Scorpaenichthys marmoratus* [Ayres]) off the west coast of the United States. The first assessment was for a coastwide California cabezon stock in the year 2003 (Cope *et al.* 2004). Two substocks (the northern California substock (NCS) and the southern California substock (SCS)) are delineated for the purposes of this assessment at Point Conception, CA. This delineation is based on differences in how the fishery has operated spatially (the NCS has been the primary area from which removals have occurred), the ecology of nearshore groundfish species, and current management needs.

Catches

Cabezon removals were assigned to six fleets (two commercial and four recreational; Figures E-1–E-3; Table E-1) for each substock because each of these fleets targets a different component of the population. Recreational removals were reconstructed for each of the four fleets back to 1916, when the commercial fishery began. The recreational fishery for cabezon did not begin in earnest until the late 1920s when the California CPFV fleet started. Historically, the CPFV fleet has been the primary source of removals of cabezon. The commercial catch of California was reconstructed back to 1916 for each substock and has become a major source of removals in the last 10 years because of the developing live-fish fishery. The sensitivity of the assessment results to the magnitude of historical recreational catch is explored as part of the assessment. Discard mortality is assumed to be negligible because cabezon can generally survive catch and release in the commercial nearshore fishery and cabezon have not been commonly recorded in the West Coast Observer Program.

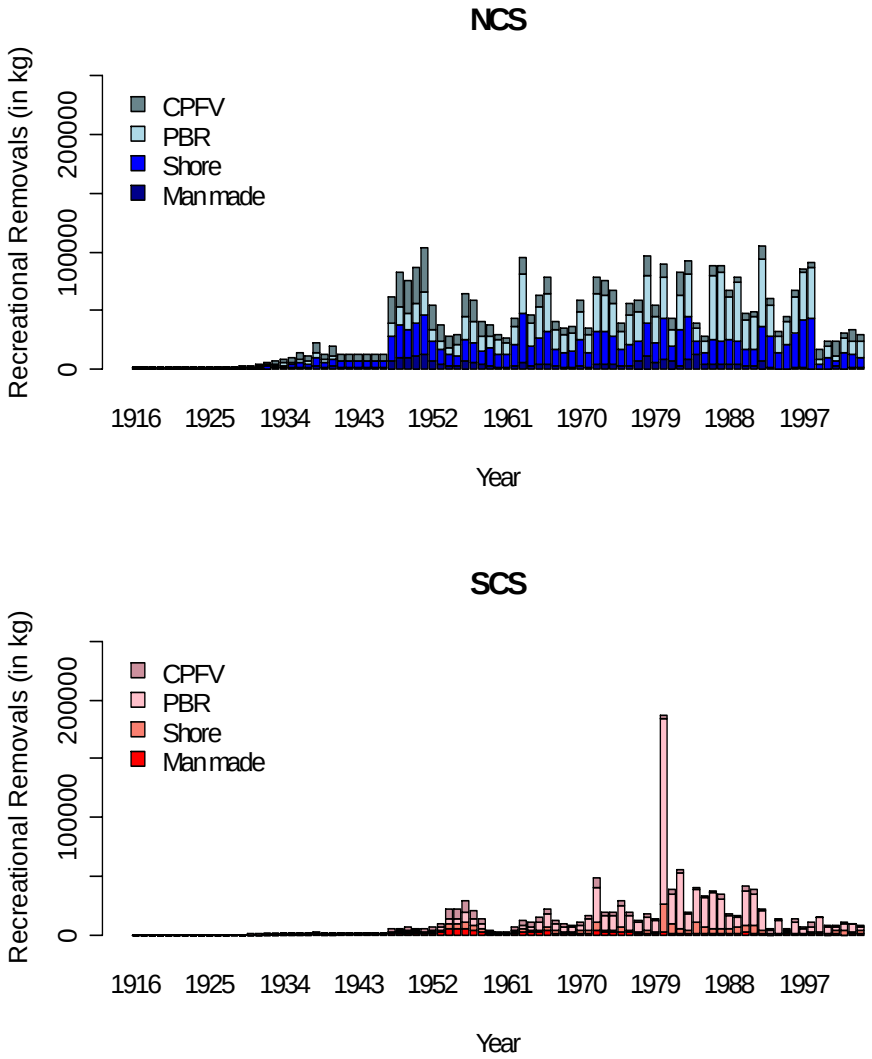

Figure E-1. Recreational fishery cabezon removals (in kg) by fleet and substock.

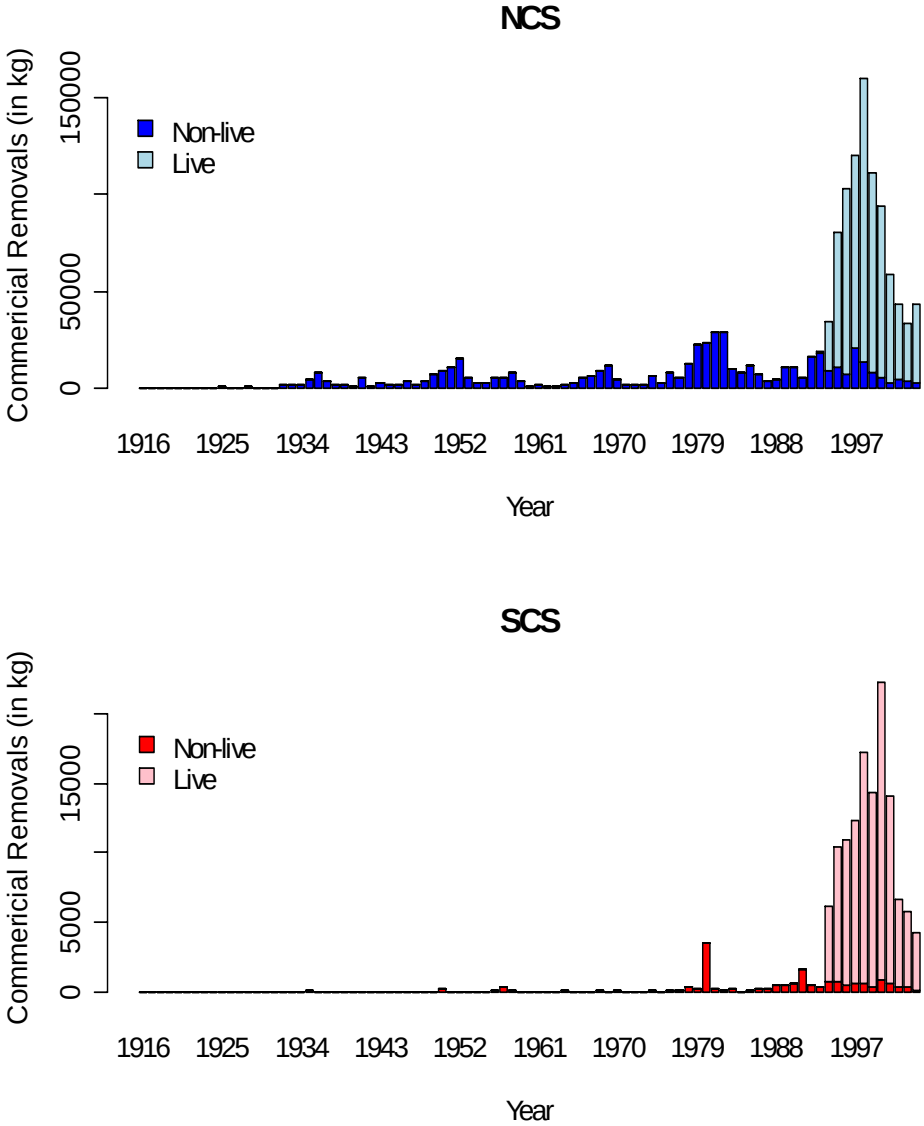

Figure E-2. Commercial fishery cabezon removals (in kg) by fleet and substock.

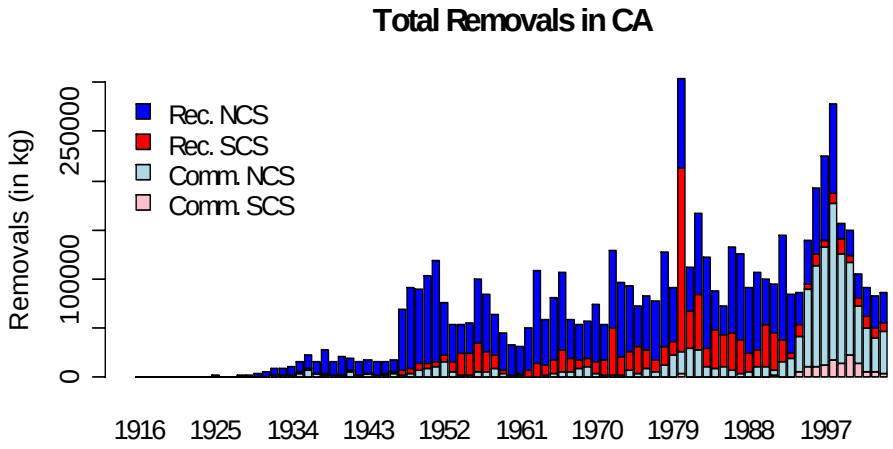

Figure E-3. Removals of cabezon (in kg) by sector and substock.

Table E-1. Removals (in kg) of cabezon by substock, sector, and fleet.

	NCS						SCS					
	Commercial		Recreational				Commercial		Recreational			
Year	Non-live	Live	Man-Made	Shore	PBR	CPFV	Non-live	Live	Man-Made	Shore	PBR	CPFV
1916	32	0	330	707	0	0	0	0	0	23	20	0
1917	151	0	330	707	0	0	0	0	0	23	20	0
1918	76	0	330	707	0	0	0	0	0	23	20	0
1919	0	0	330	707	0	0	0	0	0	23	20	0
1920	0	0	330	707	0	0	0	0	0	23	20	0
1921	0	0	330	707	0	0	0	0	0	23	20	0
1922	0	0	330	707	0	0	0	0	0	23	20	0
1923	0	0	330	707	0	0	0	0	0	23	20	0
1924	0	0	330	707	0	0	0	0	0	23	20	0
1925	1520	0	330	707	0	0	0	0	0	23	20	0
1926	0	0	330	707	0	0	0	0	0	23	20	0
1927	341	0	330	707	0	0	0	0	0	23	20	0
1928	1192	0	330	707	0	0	0	0	39	23	20	16
1929	542	0	330	707	490	980	0	0	78	45	41	31
1930	474	0	494	1059	734	1467	0	0	117	68	61	47
1931	505	0	658	1411	977	1955	0	0	157	91	82	63
1932	2121	0	822	1761	1220	2440	1	0	196	114	102	78
1933	1901	0	986	2113	1464	2928	33	0	235	136	122	94
1934	2370	0	1150	2465	1708	3416	0	0	274	159	143	110
1935	4712	0	1314	2817	1952	3903	67	0	314	182	163	126
1936	8334	0	1847	3958	2742	5484	6	0	441	256	229	176
1937	3713	0	1595	3420	2369	4738	1	0	292	169	152	117
1938	2460	0	3050	6538	4529	9058	0	0	825	479	429	330
1939	1823	0	1735	3719	2576	5153	1	0	309	179	161	124
1940	1512	0	2534	5432	3763	7525	27	0	291	169	151	116
1941	6018	0	1927	5165	0	5724	35	0	613	356	319	245
1942	1040	0	1927	5165	0	5724	4	0	613	356	319	245
1943	3411	0	1927	5165	0	5724	0	0	613	356	319	245
1944	1754	0	1927	5165	0	5724	15	0	613	356	319	245
1945	1952	0	1927	5165	0	5724	0	0	613	356	319	245
1946	3542	0	1927	5165	0	5724	0	0	613	356	319	245
1947	2047	0	7649	20498	11359	22718	6	0	1885	1094	980	754
1948	3714	0	10246	27456	15215	30429	6	0	2122	1232	1104	849
1949	7273	0	9376	25125	13923	27846	5	0	2763	1604	1437	1105
1950	9544	0	10769	28858	15991	31983	289	0	2153	1250	1120	861
1951	10802	0	12757	34184	18943	37886	19	0	1976	1147	1028	790
1952	15595	0	6649	17818	9874	19747	51	0	2659	1543	1383	1064
1953	6021	0	4679	12538	6948	13896	15	0	3954	2295	2057	1582
1954	2816	0	3483	9333	5172	10344	1	0	9036	5244	4700	3614
1955	3141	0	3096	8296	9194	9194	9	0	8713	5057	4532	3485
1956	5566	0	6780	18167	20135	20135	58	0	9882	5735	5140	8051
1957	5627	0	6064	16250	18010	18010	363	0	7220	4190	3755	5882
1958	8787	0	4178	11480	12408	12408	67	0	4868	2825	2532	3966
1959	4297	0	3325	14968	9875	9875	7	0	1246	723	648	1015
1960	1385	0	1559	11480	12235	4929	3	0	597	346	311	486
1961	2236	0	1527	11480	9928	4000	10	0	706	410	367	575
1962	1120	0	2393	18948	15553	6266	2	0	2171	1260	1129	1769
1963	1271	0	5290	41894	34387	13854	5	0	4368	2535	2272	3559
1964	2326	0	2978	16848	19361	7800	70	0	3475	2017	1807	2831
1965	3357	0	4005	22658	26037	10490	16	0	3602	2090	1874	7204
1966	5664	0	4942	27955	32124	12942	51	0	5507	3196	2864	11014
1967	6441	0	2580	14593	16769	6756	38	0	2849	1653	2422	5698
1968	9059	0	2219	12554	14426	5812	61	0	2029	1178	1725	4058
1969	11677	0	2347	13275	15255	6146	43	0	1939	1125	1648	3878
1970	4762	0	3752	21224	24389	9826	90	0	2473	1435	2102	4946
1971	2026	0	2231	12619	14501	5842	24	0	2558	1485	2174	10232
1972	2618	0	4935	27920	32084	12926	37	0	7459	4329	6340	29836
1973	2051	0	4784	27065	31101	12530	15	0	2986	1733	2538	11944
1974	6694	0	4231	23933	27502	11080	65	0	3044	1767	2587	12176
1975	3299	0	2517	14239	16362	6592	27	0	4521	2624	3843	18084
1976	8604	0	3745	17654	24345	9808	89	0	2995	1738	2546	11980
1977	5404	0	6761	17896	24677	9942	107	0	1936	1124	1646	7744
1978	12569	0	10956	29002	39992	16112	320	0	2858	1659	2429	11432
1979	22612	0	6221	16466	22706	9148	214	0	2138	1241	1817	8552
1980	23658	0	9349	34458	34458	11518	3572	0	3043	2287	24283	156824
1981	28946	0	7519	12970	12970	10055	260	0	3465	309	9316	25511
1982	28787	0	3167	30039	30039	19196	153	0	2062	400	4123	48486
1983	10517	0	8314	36160	36160	11569	186	0	1740	1004	3382	12738
1984	8420	0	12692	11610	11610	3560	53	0	631	1434	10017	27356
1985	11656	0	4342	10195	10195	3015	115	0	456	813	5595	25783
1986	7176	0	4494	20272	55278	7848	185	0	1697	1026	3722	30759
1987	3722	0	4317	19475	58646	5645	290	0	3478	1014	3678	25983
1988	5288	0	4709	21245	36011	5862	493	0	1404	1084	3930	11985
1989	10888	0	4331	19537	50886	3450	458	0	2322	1465	5311	7835
1990	11171	0	3014	13596	26050	4834	606	0	4421	1749	6344	29047
1991	5794	0	3147	14196	27200	5047	1596	0	4120	1630	5912	27067
1992	16211	0	6667	30075	57623	10692	461	0	2385	944	3422	15666
1993	18723	390	1941	26469	26469	5027	387	4	1495	68	373	3615
1994	9095	25873	942	13569	13569	3682	704	5482	1194	382	717	10589
1995	11322	68877	573	20109	20109	3564	787	9655	839	673	1314	1751
1996	7898	94700	1879	29744	29744	5606	455	10470	2724	1336	265	8610
1997	21149	99163	1854	40373	40373	3225	630	11719	1620	949	630	2939
1998	13988	145361	557	43044	43044	3800	668	16570	3185	651	1819	4730
1999	8554	102158	439	4456	4456	7264	320	14006	1041	818	2189	11594
2000	5343	88835	317	9608	9608	5182	851	21441	1818	140	435	5506
2001	3210	55305	3674	3901	3901	12766	606	13510	1094	1014	2399	3465
2002	5035	38652	943	13256	13256	2942	357	6360	1823	173	3455	5723
2003	3666	30303	1874	11280	11280	9538	361	5407	1317	506	1859	6364
2004	3058	40219	1522	8845	13955	5310	167	4084	2266	391	3592	2296

Data and assessment

Three potential indices of abundance are formally considered for the NCS: 1) California CPFV Logbook, 2) Monterey nearshore reef adult survey, and 3) TENERA nearshore reef benthic adult survey. There are also three potential indices of abundance for the SCS: 1) California CPFV Logbook index, 2) CalCOFI larval index, and 3) Southern California Power Plant impingement (recruitment) index. Each index is developed by fitting generalized linear models to the proportion of non-zero records and the catch-rate (or whatever quantity is being measured) given that the catch was non-zero, and taking the product of the resultant year effects. Only the CPFV index is used in the base model for the NCS because of its area-wide coverage and the potential bias in SCUBA surveys for cryptic species like cabezon. The results for the NCS assessment are sensitive to the inclusion (or otherwise) of the TENERA survey (Fig. E-4). The TENERA index was not included because SCUBA surveys may not be appropriate for cryptic species and the trend contradicted the CPUE trend for Morro Bay (the spatially closest port). The base model for the SCS uses all three indices. Fishery mean weight and catch length composition data are also used to fit the model. The assessment is based on the program Stock Synthesis 2, developed specifically to use age-and length-structured data.

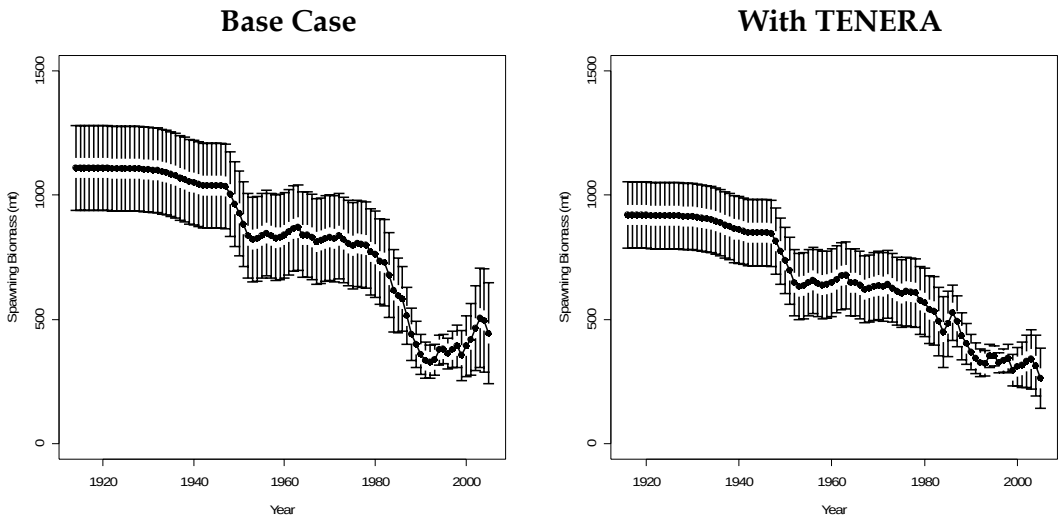

Figure E-4. Spawning biomass trajectories without and with the inclusion of the TENERA adult survey.

Unresolved problems and major uncertainties

Several sources of uncertainty were recognized and explored using sensitivity analyses. Inclusion and exclusion of data sources generally made little difference to the outputs for the NCS or the SCS, except in one major case. The exclusion of the mean weight value for the recreational man-made fleet for 2000 led to a major reduction in the status of the SCS (to 5.8% of virgin biomass in 2005; Fig. E-5). The use of this one data point is perhaps the most important uncertainty of the SCS assessment. Other major uncertainties relate to the values assumed for natural mortality (*M*) for each sex, the extent of variation in recruitment (σ_R), the values for stock-recruitment parameters such as steepness (*h*), the number of years for which recruitment residuals are estimated, the size of the historical recreational catch, the

effective sample size assigned to the catch length composition data, and the length–at-age CVs. The catch by the PBR fleet in 1980 based on RecFIN is very large, but does not seem to influence the results for the SCS substantially.

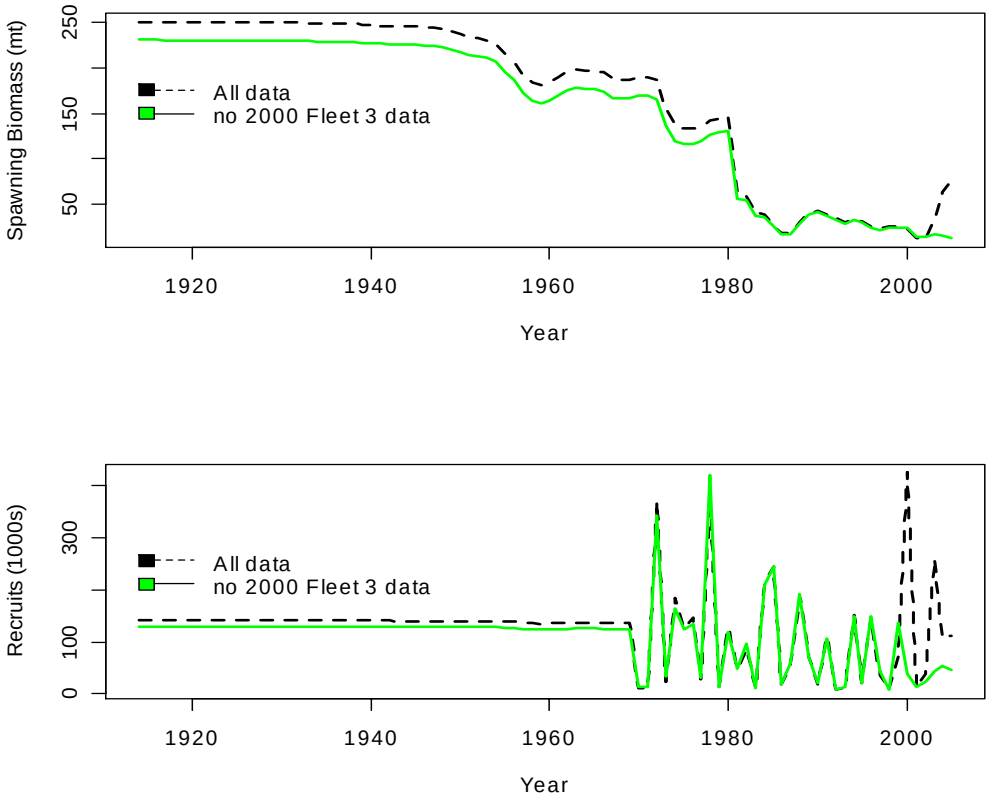

Figure E-5. MPD time-trajectories of reproductive output (upper panel) and recruitment (lower panel) for the SCS, including and excluding the mean weight datum for 2000 for the man-made fleet.

Reference points

Substock-specific reference points for each base case are provided in Table E-2. Figure E-6 includes reference points based on federal (the 40-10 control rule with a $F_{45\%}$ F_{MSY} proxy) and state (the 60-20 control rule with a $F_{50\%}$ F_{MSY} proxy) guidelines for each substock.

Table E-2. Reference points for each cabezon substock.

	Substock					
	NCS			SCS		
	Low *M*	Base Case	High *M*	Low SB_{2005}	Base Case	High SB_{2005}
Unfished Spawning Stock Biomass (SB_0)	1066	1110	1296	247	251	252
Unfished Summary (2+) Age Biomass (B_0)	1659	1858	2357	426	433	436
Unfished Recruitment (R_0)	366	627	1135	139	141	142
SPR_{msy} or F_{msy}	F_{MSY}	F_{MSY}	F_{MSY}	F_{MSY}	F_{MSY}	F_{MSY}
Basis for F_{msy}	$F_{45\%}$	$F_{45\%}$	$F_{45\%}$	$F_{45\%}$	$F_{45\%}$	$F_{45\%}$
Spawning Stock Biomass at MSY proxy ($F_{45\%}$)	409	426	498	95	96	97
MSY ($F_{45\%}$)	87	119	173	26	26	26
Exploitation Rate corresponding to $F_{45\%}$	0.11	0.13	0.15	0.13	0.13	0.13
Basis for F_{msy}	$F_{50\%}$	$F_{50\%}$	$F_{50\%}$	$F_{50\%}$	$F_{50\%}$	$F_{50\%}$
Spawning Stock Biomass at MSY proxy ($F_{50\%}$)	469	489	570	108	110	111
MSY ($F_{50\%}$)	83	112	164	24	25	25
Exploitation Rate corresponding to $F_{50\%}$	0.10	0.11	0.13	0.11	0.11	0.11

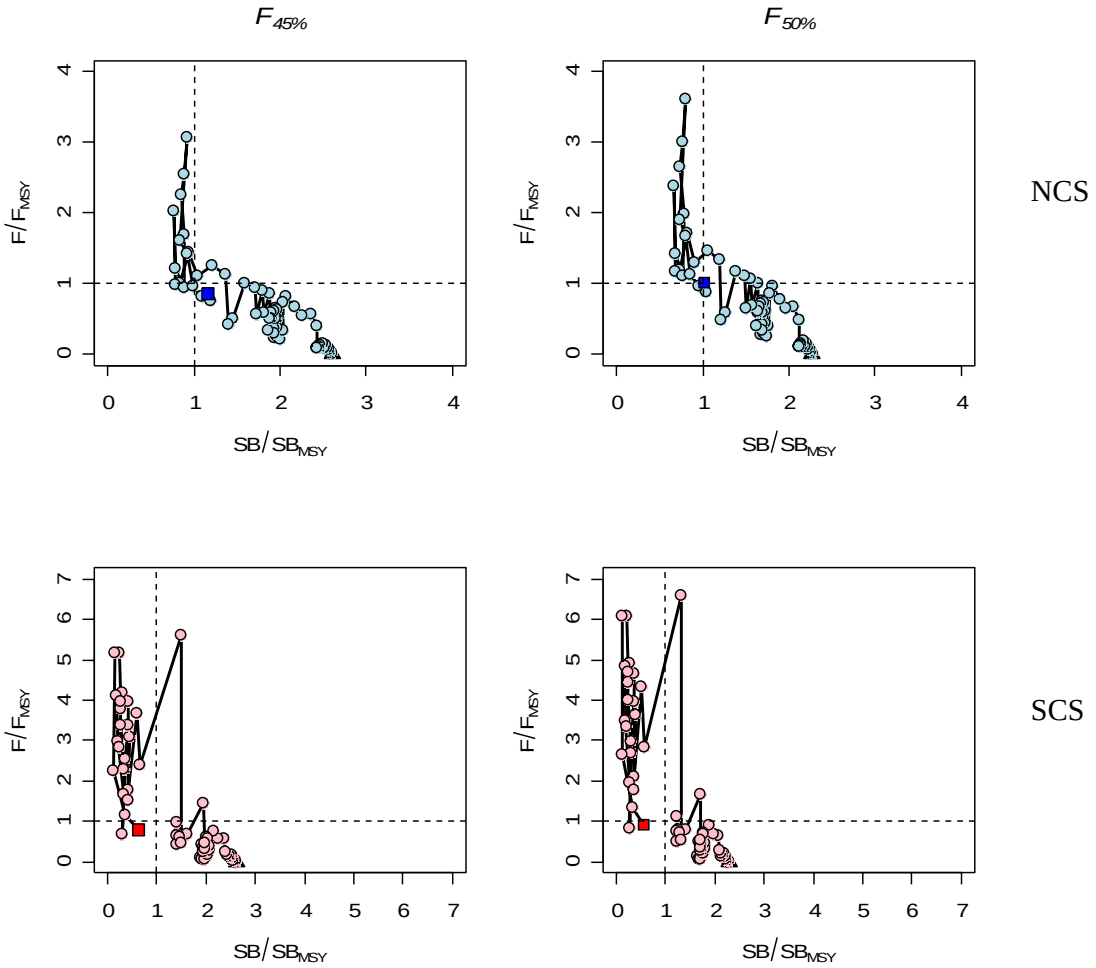

Figure E-6. Spawning biomass and exploitation rates relative to the target levels (at MSY) for each substock (NCS top row; SCS bottom row) for each F_{MSY} proxy (columns). Solid triangles represent the start of the time period; solid squares represent the end of the time period.

Stock biomass

The unfished reproductive outputs of the California cabezon substocks are estimated to be 1110 (NCS) and 251 (SCS) mt, respectively, with estimated reproductive outputs of 445 (NCS) and 71 (SCS) mt in 2005 (Figure E-7). This leads to an estimated depletion level of 40.1% and 28.3% for each substock. Total unfished cabezon reproductive output is estimated at 1316 mt compared to 1268 for a one stock model (Table E-3). Current total cabezon reproductive output for the two substock model is 516 mt, compared with 634 mt for the one stock model. The previous assessment estimated a depletion rate for 2003 intermediate between those for the one and two stock models for 2003 (Table E-3).

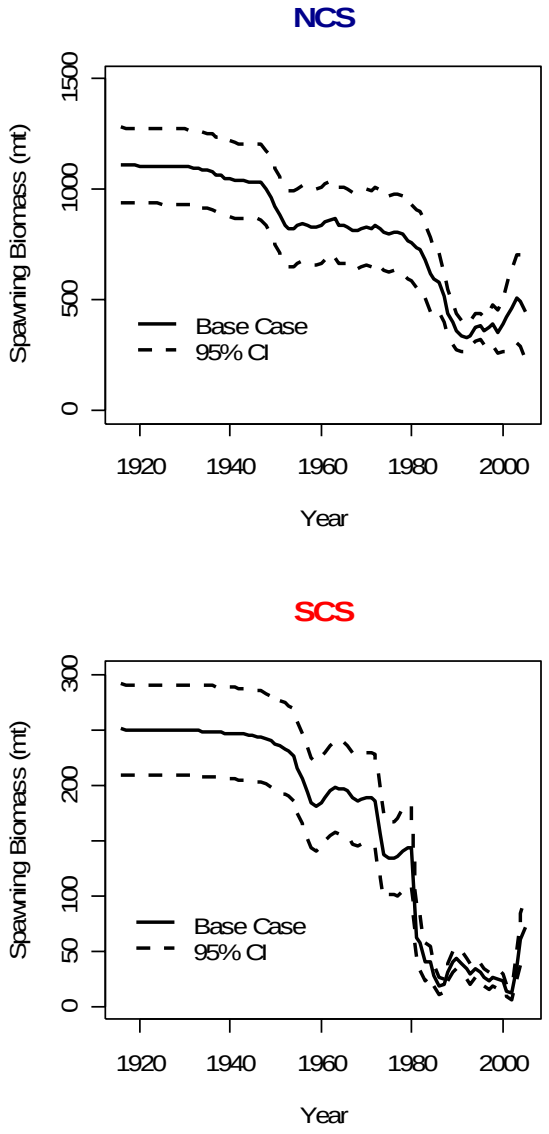

Figure E-7. Time-trajectories of reproductive output (measured in spawning biomass) for the NCS and the SCS.

Table E-3. Total cabezon reproductive output and depletion rates in California.

Model	Total California Cabezon Spawning Biomass (mt)					
	SB_{1916}	SB_{1930}	SB_{2003}	SB_{2005}	SB_{2003}/SB_{1930}	SB_{2005}/SB_{1916}
2005 Assessment						
two substock model	1361	1353	542	516	40.0%	37.9%
one stock model	1268	1260	353	634	28.0%	50.0%
2003 Assessment		902	313		34.7%	

Recruitment

A Beverton-Holt equation with lognormal process error is used to characterize the spawner-recruitment relationship of cabezon. The steepness parameter is set to 0.7 for the base model. Recruitment residuals are estimated for 1980–2003 (NCS) and 1970–2003 (SCS). There are several major recruitment events for the NCS after 1980, but only two for the SCS: one in 2000 and another in 2003, both about twice the historical average (Figure E-8). Actual recruitment patterns are unclear because of a lack of age-composition data.

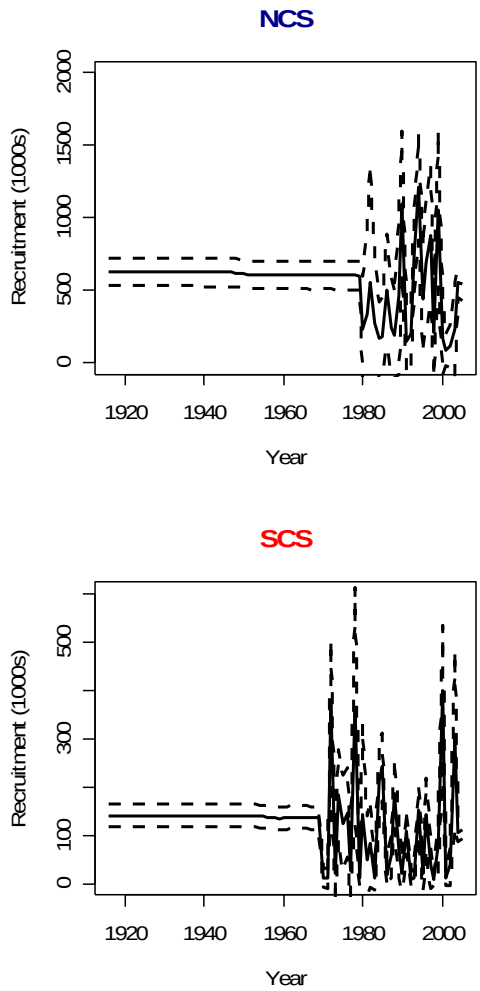

Figure E-8. Time-trajectories of recruitment (1000s) for the NCS and the SCS. Bold lines are point estimates; broken lines represent the approximate 95% confidence intervals.

Table E-4. Ten year summary of catches, biomass, recruitment and depletion levels for each of the cabezon substocks. Parenthetic values are asymptotic standard deviations.

NCS								
Year	Statewide OY ($F_{50\%}$)	Total Catch	Exploitation Rate	Spawning Potential Ratio (SPR)	Summary Age (2+) Biomass	Spawning Stock Biomass	Recruitment	Depletion level
1995	--	125	13%	40%	779	382 (30)	437 (185)	34%
1996	--	170	17%	33%	917	362 (32)	687 (226)	33%
1997	--	206	20%	29%	909	380 (37)	876 (245)	34%
1998	--	250	25%	25%	895	393 (44)	206 (154)	35%
1999	--	127	14%	41%	876	356 (51)	1059 (274)	32%
2000	72	119	12%	45%	849	393 (63)	171 (129)	35%
2001	72	83	8%	56%	963	420 (74)	86 (56)	38%
2002	81	74	8%	61%	959	466 (87)	118 (76)	42%
2003	88	68	7%	63%	900	507 (101)	232 (165)	46%
2004	69	73	9%	60%	815	496 (105)	554 (54)	45% (8%)
2005	69	--	--		731	445 (103)	541 (56)	40% (8%)

SCS								
Year	Statewide OY ($F_{50\%}$)	Total Catch	Exploitation Rate	Spawning Potential Ratio (SPR)	Summary Age (2+) Biomass	Spawning Stock Biomass	Recruitment	Depletion level
1995	--	15	19%	29%	57	31 (4)	21 (17)	12%
1996	--	24	29%	17%	75	26 (4)	144 (37)	10%
1997	--	18	22%	23%	64	23 (4)	38 (25)	9%
1998	--	28	32%	16%	82	26 (4)	8 (7)	10%
1999	--	30	39%	14%	74	25 (4)	80 (29)	10%
2000	72	30	39%	12%	52	23 (3)	398 (69)	9%
2001	72	22	24%	12%	43	14 (3)	10 (7)	5%
2002	81	18	15%	29%	116	12 (3)	38 (21)	5%
2003	88	16	11%	47%	130	35 (7)	298 (93)	14%
2004	69	13	7%	59%	135	60 (12)	105 (10)	24% (5%)
2005	69	--	--		191	71 (15)	111 (10)	28% (6%)

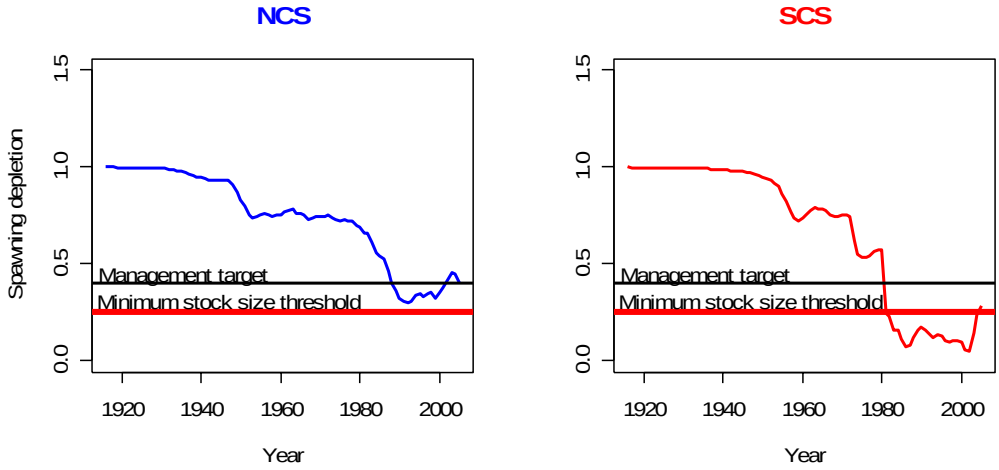

Figure E-9. Time-trajectory (1916-2005) of spawning depletion for each substock in relation to management targets.

Exploitation status
The current (2005) reproductive output of the cabezon resource off California is estimated to be about 40.1% and 28.3% of the unfished level based on the base models (Table E-4). The NCS, the major fished substock off California, seems healthy at this time, and is just above its target level (Fig. E-9). The status of the SCS is much more uncertain and sensitive to the exact specifications of the assessment, but its reproductive output is estimated to be more than 25% of the unfished level at present (Fig. E-9).

Management performance
No management regulations existed for cabezon before 1982 when a size limit (12-inches) was set for recreationally caught cabezon off California. This limit was raised to 14-inches in 2000, and extended to include commercially retained fish. It was increased further to 15-inches in 2001. Recreational bag limits have been 10fish/day in California since 2000. Cabezon are currently included in the California recreational regulatory complex Rockfish, Cabezon, and Greenlings (the RCG complex) and subject to seasonal closures for recreational fishers. Oregon imposed a 16-inch commercial size limit and a 15-inch recreational size limit for cabezon in 2001. Oregon has a 10fish/day bag limit for cabezon and greenling combined. California and Oregon are proposing slot limits for cabezon; cabezon must be between 15–22 inches in California and 15–19 inches in Oregon to be retained. There is no size limit in Washington and recreational fishers are limited to 15 bottom-type fishes daily.

Historically, commercial landings of cabezon were monitored as part of a mixed group called "Other Fish". This group of species includes sharks, skates, rays, grenadiers and other groundfish. This group has been defined historically as groundfish species that do not have directed or economically important fisheries. The coastwise ABC for this entire group of species was 14,700mt during 1999–2002 (5,200mt for the Eureka, Monterey and Conception INPFC areas and 9,500mt for the Columbia and Vancouver INPFC areas). In California, the cabezon fishery is independently monitored and regulated by analyzing two-month cumulative trip limits. In 2004, the season closed on 4 September when the annual commercial allocation of 75,600 pounds was reached before ends year.

Regional Management
The cabezon has thus far been managed on a coastwide basis in California. The results of this two substock assessment provide the scientific basis for cabezon to be managed regionally using the California Department of Fish and Game northern/central and southern California management areas. More work and sampling effort is needed to evaluate whether cabezon in these two areas differ biologically (growth, maturity, etc.), but the results of this assessment indicate that the biomass of cabezon in the southern management area may be smaller than that of conspecifics north of Point Conception. Regional management is an important consideration in relatively sedentary nearshore reef species such as cabezon and future assessments should continue to provide scientific analyses on increasingly finer spatial scales.

Forecasts
Twelve-year yield forward projections are conducted for each substock under two alternative ABC control rules (based on F_{MSY} proxies of $F_{45\%}$ and $F_{50\%}$) and two OY

threshold control rules (40-10 or 60-20). The standard PFMC OY control rule for groundfish such as cabezon is based on $F_{45\%}$ with a 40-10 adjustment for stocks below the target level of 40% of the unfished reproductive output. The California Nearshore Fishery Management Plan proposes the use of a F_{MSY} proxy of $F_{50\%}$ and a 60-20 adjustment for stocks below 60% of the unfished reproductive output. The relative proportion of the six fleets in future harvests is assumed to be the same as the last year (2004) in the model. Results of the projections are given in Table E-5.

Table E-5. Summary of forecast outputs for the A) NCS and B) SCS.

A) NCS

	40-10/$F_{45\%}$					60-20/$F_{50\%}$				
Year	OY	ABC	SB_{2+}	SB	Depletion	OY	ABC	SB_{2+}	SB	Depletion
2005	59	107	727	440	40%	59	90	727	440	40%
2006	59	90	684	393	35%	59	78	684	393	35%
2007	84	81	655	360	32%	44	71	655	360	32%
2008	76	78	655	327	29%	43	70	691	351	32%
2009	77	81	684	321	29%	48	73	746	363	33%
2010	84	86	721	335	30%	58	78	805	390	35%
2011	91	92	755	354	32%	68	83	857	420	38%
2012	97	96	782	370	33%	77	88	900	445	40%
2013	102	100	803	383	34%	84	91	934	465	42%
2014	105	103	821	392	35%	89	95	960	481	43%
2015	108	105	834	400	36%	93	97	981	494	44%
2016	110	107	845	406	37%	96	100	997	503	45%

B) SCS

	40-10/$F_{45\%}$					60-20/$F_{50\%}$				
Year	OY	ABC	SB_{2+}	SB	Depletion	OY	ABC	SB	SB_{2+}	Depletion
2005	10	24	197	72	29%	10	21	197	72	29%
2006	10	27	217	90	36%	10	23	217	90	36%
2007	30	26	226	112	45%	22	23	226	112	45%
2008	29	25	219	111	45%	22	23	227	116	46%
2009	28	25	214	106	43%	21	23	228	115	46%
2010	27	25	211	103	41%	21	23	230	115	46%
2011	27	25	209	101	40%	22	23	232	116	46%
2012	27	25	207	100	40%	22	23	234	117	47%
2013	27	25	206	100	40%	22	24	235	118	47%
2014	26	26	205	99	40%	23	24	237	118	47%
2015	26	26	204	99	39%	23	24	237	119	48%
2016	26	26	204	98	39%	23	24	238	120	48%

Decision table

Projections based on alternative states of nature for each substock were explored to capture uncertainty in population conditions. For the NCS, the low and high *M* scenarios refer to different assumptions about sex-specific natural mortality and were selected to represent the 95% confidence intervals for terminal spawning biomass based on the Hessian approximation. The low scenario assumes $M = 0.2\text{yr}^{-1}$ and 0.25 yr^{-1} for females and males respectively, while the high scenario assumes 0.3 yr^{-1} and 0.35 yr^{-1} respectively. For the SCS, the low and high scenarios are based on altering the CV on the mean weight avalue in the year 2000 for the man-made fleet. These states of nature attempt to capture the uncertainty in current depletion based on the uncertainty in the magnitude of the 2000 recruitment. Results from each of the states of nature are given in Table E-2.

Decision analysis population projections are provided in Table E6 for each state of nature and several state-dependent future catch series. The NCS will drop below the overfished threshhold if catch levels are based on the 40-10 rule and the high *M* scenario, but the true state of nature is either the base case or low *M* scenario. This also occurs if catches are based on the base case model but the low *M* state of nature is correct. All other scenarios lead to depletion levels above 25% in 2016. Under the 60-20 rule, only the high *M* catch with a low *M* true state of nature leads to a depletion level in 2016 below 25%. In the SCS, all combinations of catch and true state of nature under either control rule lead to a depletion level in 2016 larger than 25%.

Table E-6. Decision analysis of different states of nature under different catch histories and fishery control rules for each cabezon substock.

NCS 40-10/$F_{45\%}$

			State of Nature					
			Low M (F= 0.2/M=0.25) p = 0.18		Base Case M (F=0.25/M=0.3) p = 0.58		High M (F=0.3/M=0.35) p = 0.24	
	Year	OY	Spawning Biomass	Depletion	Spawning Biomass	Depletion	Spawning Biomass	Depletion
	2005	59	323	30%	440	40%	637	49%
	2006	59	286	27%	393	35%	567	44%
	2007	40	256	24%	360	32%	523	40%
	2008	40	249	23%	353	32%	515	40%
	2009	43	255	24%	366	33%	536	41%
Catch based on	2010	49	273	26%	396	36%	583	45%
Low M model	2011	55	293	28%	431	39%	637	49%
	2012	60	312	29%	464	42%	687	53%
	2013	65	328	31%	493	44%	731	56%
	2014	68	342	32%	518	47%	769	59%
	2015	72	354	33%	540	49%	802	62%
	2016	74	364	34%	559	50%	829	64%
	2005	59	323	30%	440	40%	637	49%
	2006	59	286	27%	393	35%	567	44%
	2007	44	256	24%	360	32%	523	40%
	2008	43	222	21%	351	32%	490	38%
	2009	48	207	19%	363	33%	493	38%
Catch based on	2010	58	206	19%	390	35%	526	41%
Base Case	2011	68	208	20%	420	38%	567	44%
	2012	77	207	19%	445	40%	603	47%
	2013	84	202	19%	465	42%	634	49%
	2014	89	194	18%	481	43%	660	51%
	2015	93	184	17%	494	44%	683	53%
	2016	96	173	16%	503	45%	702	54%
	2005	59	323	30%	440	40%	637	49%
	2006	59	286	27%	393	35%	567	44%
	2007	157	256	24%	360	32%	523	40%
	2008	136	176	17%	283	25%	447	35%
	2009	134	129	12%	246	22%	422	33%
Catch based on	2010	142	101	9%	235	21%	433	33%
High M Catch	2011	151	75	7%	229	21%	452	35%
	2012	157	42	4%	218	20%	466	36%
	2013	161	5	1%	202	18%	475	37%
	2014	164	8	1%	184	17%	481	37%
	2015	166	0	0%	164	15%	486	37%
	2016	168	0	0%	144	13%	490	38%

Table E-6. Continued.

NCS 60-20/$F_{50\%}$

			State of Nature					
		OY	Low M (F= 0.2/M=0.25)		Base Case M (F=0.25/M=0.3)		High M (F=0.3/M=0.35)	
		Commerical	p = 0.18		p = 0.58		p = 0.24	
	Year	Removals	Spawning Biomass	Depletion	Spawning Biomass	Depletion	Spawning Biomass	Depletion
	2005	59	323	30%	440	40%	637	49%
	2006	59	286	27%	393	35%	567	44%
	2007	44	256	24%	360	32%	523	40%
	2008	44	247	23%	351	32%	513	40%
	2009	46	251	24%	362	33%	532	41%
Catch based on	2010	50	267	25%	391	35%	578	45%
Low M model	2011	53	287	27%	425	38%	632	49%
	2012	57	306	29%	459	41%	684	53%
	2013	60	325	30%	490	44%	730	56%
	2014	63	341	32%	519	47%	770	59%
	2015	65	356	33%	544	49%	806	62%
	2016	67	370	35%	566	51%	836	65%
	2005	59	323	30%	440	40%	637	49%
	2006	59	286	27%	393	35%	567	44%
	2007	44	256	24%	360	32%	523	40%
	2008	43	247	23%	351	32%	513	40%
	2009	48	251	24%	363	33%	533	41%
Catch based on	2010	58	266	25%	390	35%	578	45%
Base Case	2011	68	281	26%	420	38%	627	48%
	2012	77	292	27%	445	40%	670	52%
	2013	84	298	28%	465	42%	706	55%
	2014	89	301	28%	481	43%	736	57%
	2015	93	301	28%	494	44%	760	59%
	2016	96	299	28%	503	45%	780	60%
	2005	59	323	30%	440	40%	637	49%
	2006	59	286	27%	393	35%	567	44%
	2007	101	256	24%	360	32%	523	40%
	2008	89	212	20%	317	29%	480	37%
	2009	92	190	18%	304	27%	478	37%
Catch based on	2010	105	181	17%	311	28%	505	39%
High M Catch	2011	119	172	16%	320	29%	536	41%
	2012	129	155	15%	322	29%	560	43%
	2013	136	132	12%	319	29%	577	45%
	2014	141	105	10%	313	28%	590	46%
	2015	144	75	7%	304	27%	599	46%
	2016	147	44	4%	294	26%	606	47%

SCS 40-10/$F_{45\%}$

			State of Nature					
		OY	Low ($Depletion_{2005}$=0.2)		Base Case		High ($Depletion_{2005}$=0.35)	
		Commerical	p = 0.16		p = 0.58		p = 0.26	
	Year	Removals	Spawning Biomass	Depletion	Spawning Biomass	Depletion	Spawning Biomass	Depletion
	2005	10	51	21%	72	29%	89	35%
	2006	10	63	26%	90	36%	110	43%
	2007	20	78	31%	112	45%	132	52%
	2008	20	80	32%	117	47%	137	54%
	2009	20	79	32%	117	47%	136	54%
Catch based on	2010	21	81	33%	118	47%	136	54%
Low model	2011	22	83	34%	119	47%	135	54%
	2012	23	86	35%	119	48%	135	54%
	2013	23	88	36%	120	48%	134	53%
	2014	24	89	36%	120	48%	134	53%
	2015	24	90	37%	120	48%	132	52%
	2016	24	92	37%	120	48%	131	52%
	2005	10	51	21%	72	29%	89	35%
	2006	10	63	26%	90	36%	110	43%
	2007	30	78	31%	112	45%	132	52%
	2008	29	74	30%	111	45%	131	52%
	2009	28	69	28%	106	43%	125	50%
Catch based on	2010	27	67	27%	103	41%	121	48%
Base Case	2011	27	66	27%	101	40%	118	47%
	2012	27	66	27%	100	40%	116	46%
	2013	27	66	27%	100	40%	114	45%
	2014	26	67	27%	99	40%	113	45%
	2015	26	67	27%	99	39%	112	44%
	2016	26	67	27%	98	39%	111	44%
	2005	10	51	21%	72	29%	89	35%
	2006	10	63	26%	90	36%	110	43%
	2007	34	78	31%	112	45%	132	52%
	2008	32	73	29%	110	44%	129	51%
	2009	31	67	27%	104	42%	121	48%
Catch based on	2010	30	64	26%	101	40%	115	46%
High Catch	2011	29	64	26%	99	40%	112	44%
	2012	28	64	26%	98	39%	109	43%
	2013	28	64	26%	97	39%	107	42%
	2014	28	64	26%	97	39%	105	42%
	2015	27	65	26%	97	39%	104	41%
	2016	27	65	26%	96	39%	103	41%

Table E-6. Continued.

SCS 60-20/$F_{50\%}$

		OY	State of Nature					
			Low ($Depletion_{2005}$=0.2)		Base Case (F=0.25/M=0.3)		High (Depletion2005=0.2)	
		Commerical	p = 0.16		p = 0.58		p = 0.26	
	Year	Removals	Spawning Biomass	Depletion	Spawning Biomass	Depletion	Spawning Biomass	Depletion
	2005	10	51	21%	72	29%	89	35%
	2006	10	63	26%	90	36%	110	43%
	2007	10	78	31%	112	45%	132	52%
	2008	12	85	34%	123	49%	142	56%
	2009	14	89	36%	127	51%	146	58%
Catch based on	2010	15	93	38%	130	52%	148	59%
Low model	2011	17	98	40%	134	53%	151	60%
	2012	18	103	42%	136	55%	152	60%
	2013	19	106	43%	138	55%	153	60%
	2014	20	109	44%	139	56%	152	60%
	2015	21	112	45%	140	56%	152	60%
	2016	21	113	46%	140	56%	151	60%
	2005	10	51	21%	72	29%	89	35%
	2006	10	63	26%	90	36%	110	43%
	2007	22	78	31%	112	45%	132	52%
	2008	22	79	32%	116	46%	136	54%
	2009	21	77	31%	115	46%	134	53%
Catch based on	2010	21	78	32%	115	46%	133	53%
Base Case	2011	22	80	33%	116	46%	132	52%
	2012	22	83	34%	117	47%	132	52%
	2013	22	85	35%	118	47%	132	52%
	2014	23	87	35%	118	47%	132	52%
	2015	23	89	36%	119	48%	132	52%
	2016	23	91	37%	120	48%	131	52%
	2005	10	51	21%	72	29%	89	35%
	2006	10	63	26%	90	36%	110	43%
	2007	27	78	31%	112	45%	132	52%
	2008	26	76	31%	116	46%	133	53%
	2009	25	72	29%	115	46%	128	51%
Catch based on	2010	24	71	29%	115	46%	125	50%
High Catch	2011	24	72	29%	116	46%	124	49%
	2012	24	74	30%	117	47%	123	49%
	2013	24	75	31%	118	47%	123	49%
	2014	23	77	31%	118	47%	123	49%
	2015	23	79	32%	119	48%	123	49%
	2016	23	80	33%	120	48%	122	49%

Research Recommendations

1. Accurate accounting of removals, especially from the recreational and live-fish fisheries: Fisheries primarily exploited by recreational and live-fish commercial fisheries are traditionally hard to monitor. More effort to monitor these fishery sectors may be necessary to accurately monitor fishing mortality.

2. A fishery-independent survey of cabezon population abundance: The current fishery-independent survey being developed in the Morro Bay area will become an important input into future assessments of cabezon. Expansion of this survey will increase its usefulness as an index of abundance for central and northern California.

3. A study of the stock structure of cabezon: This assessment assumes two substocks of cabezon along the California coast. Current work on cabezon stock structure should be included in the next assessment.

4. Age validation/ age determination: Catch age-composition data were not available for this assessment. Accurate ageing is crucial to understand the population dynamics of a species, especially those for which there is limited survey information. Information on the age-structure of the catches for each fishery sector would substantially improve some aspects of the assessment.

5. A better understanding of the relationship between CPUE and population size: Changes in recreational CPUE indices are assumed to reflect changes in population size in a linearly proportional manner. The results of the assessment would be severely in error if this assumption were substantially violated. Therefore, if future assessments depend on CPUE data, it is vital that the relationship between CPUE and population size be quantified.

6. Alternative assessment procedures: The need for greater spatial resolution in the management of nearshore fisheries also increases the amount of data required to perform traditional stock assessments. Alternative assessment procedures that are less data-hungry, but still provide relevant management outputs should be developed to address this need. In addition, the nest-guarding behavior of males gives new values to males in the cabezon population. Another metric other than spawning biomass may be needed to help account for the male portion of the population in reference points.

7. Effect of climate on cabezon: Several of the data sources in this assessment (*e.g.* the power-plant impingement and CalCOFI indices, and some length-composition data) indicate that there was potentially good recruitment after 1999 (and before 1977 for the impingement data) whereas these same sources indicate that recruitment was very poor prior to 1999 in the SCS. Cabezon may be influenced by climatic/oceanic regimes. A better understanding of the relationship between cabezon population dynamics and climate would reduce the uncertainty of future assessments.

8. Sex-specific data: Given the strong correlation of color to gender in cabezon (O'Connell 1953; Lauth 1987; Grebel 2003), collection of sex-specific information (at least recording fish color) would greatly enhance future assessments.