Assessment of Vermilion Rockfish in Southern and Northern California

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Executive summary – Vermilion rockfish

Stock: This is the first assessment of vermilion rockfish (*Sebastes miniatus)* stocks in California waters, with separate assessments for areas north and south of Pt. Conception; these regions are referred to as northern California and southern California respectively. Small amounts of vermilion rockfish are also caught in Oregon and Washington, but those stocks were not assessed. Genetic information suggests that vermilion rockfish may consist of more than one species, but nothing is known about how those species may differ.

Catches: Reliable species compositions are available only since the late 1970's, requiring approximate reconstruction of earlier landings back to 1915. Based on consistent differences in length compositions, catches of vermilion rockfish were divided into four different fisheries in each region. In southern California two recreational fishery components are included, but these were combined in the north. A separate trawl fishery is identified in the north, but trawl catches have been insignificant in the south.

Table ES1. Recent vermilion rockfish landings (mt).

	Southern California					Northern California				
	Hook	SetNet	CPFV	Private	Total	Hook	SetNet	Trawl	Sport	Total
1990	129	11	82	74	296	61	61	1	113	236
1991	174	19	71	64	328	126	14	1	146	287
1992	152	27	59	53	291	104	0	10	212	326
1993	139	23	18	73	253	151	20	21	200	392
1994	216	12	50	105	383	85	11	15	137	248
1995	111	3	23	141	278	50	11	16	76	153
1996	72	2	72	93	239	64	9	10	52	135
1997	80	1	5	7	93	64	7	14	46	131
1998	82	0	31	30	143	44	6	28	77	155
1999	18	0	99	52	169	34	0	9	81	124
2000	5	0	35	59	99	13	0	1	77	91
2001	3	0	17	31	51	11	0	3	75	89
2002	5	0	30	31	66	6	0	0	82	88
2003	0	0	60	59	119	6	0	0	204	210
2004	5	0	133	34	172	10	0	0	72	82

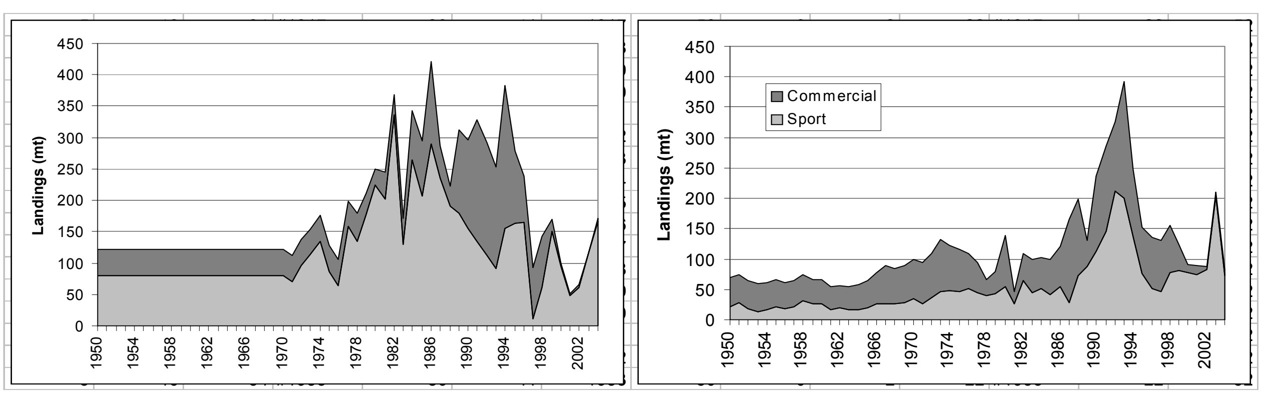

Figure ES1. Historical catches of vermilion rockfish.

Data and assessment: This is the first stock assessment of vermilion rockfish, and separate models were developed for California waters north and south of Pt. Conception. Data included documented and reconstructed landings of each fishery segment (assumed discard rate was zero). Length composition of catches by fishery segment were provided to the model, with the most extensive coverage in the sport fisheries. RecFIN trip-based CPUE series were estimated for 1980-2003 in both regions, and a site-based CPUE series was estimated for northern California, based on CDFG on-board sampling of CPFVs from 1987-1998. For both assessments, the statistical assessment model (SS2 versions 1.18 and 1.19) was configured to estimate population parameters for the period 1915 to the beginning of 2005. The resource was assumed to be unfished prior to 1915. Recruitment strengths of individual yearclasses were estimated beginning in1970.

Unresolved problems and major uncertainties: The data were not sufficiently informative to resolve the history and status of the stock at conventional levels of certainty, so no single model in presented for either region. In each case, two models are presented as approximate upper and lower bounds of the likely range of results. The stock-recruitment relationships (SRRs) were unclear, but have strong influence on estimated depletion levels. The model likelihood tended to favor a Ricker SRR with oscillating pre-1970 biomass and relatively higher current biomass. In disagreement with the STAT Team, the STAR Panel placed an exclusive prior probability (1.0) on a Beverton-Holt SRR. In this assessment, the Ricker SRR is not intended for consideration in fishery management.

Reference Points: The following reference points were obtained from the Lower and Upper bound models for Southern and Northern California. The lower and upper bounds are with respect to estimated relative depletion and ABC.

Table ES2. Management reference points for vermilion rockfish.

	Southern California		Northern California	
Bound	Lower	Upper	Lower	Upper
Unfished spawning biomass (SB0)	6726(0.04)	12627(0.06)	5722(0.08)	5532(0.42)
Current spawning biomass (SB2005)	2029(0.30)	11072(0.20)	2344(0.37)	4920(0.71)
Relative depletion (2005)	30%(0.30)	88%(0.29)	41%(0.27)	89%(0.15)
Unfished summary (age 1+) biomass (B0)	7812	14571	6690	6476
Current summary (age 1+) biomass (B2005)	3294	15824	3246	6636
Unfished recruitment (R0)	664	1222	569	554
SB(40%) (MSY proxy size = 0.4 x SB0)	2690	5051	2289	2213
Exploitation rate at MSY (rockfish proxy F50%)	0.0403	0.0370	0.0498	0.0495
MSY (F50% x 40% x B0)	126	216	133	128
ABC (F50% x B2005)	133	585	162	328

Values in parentheses are CVs

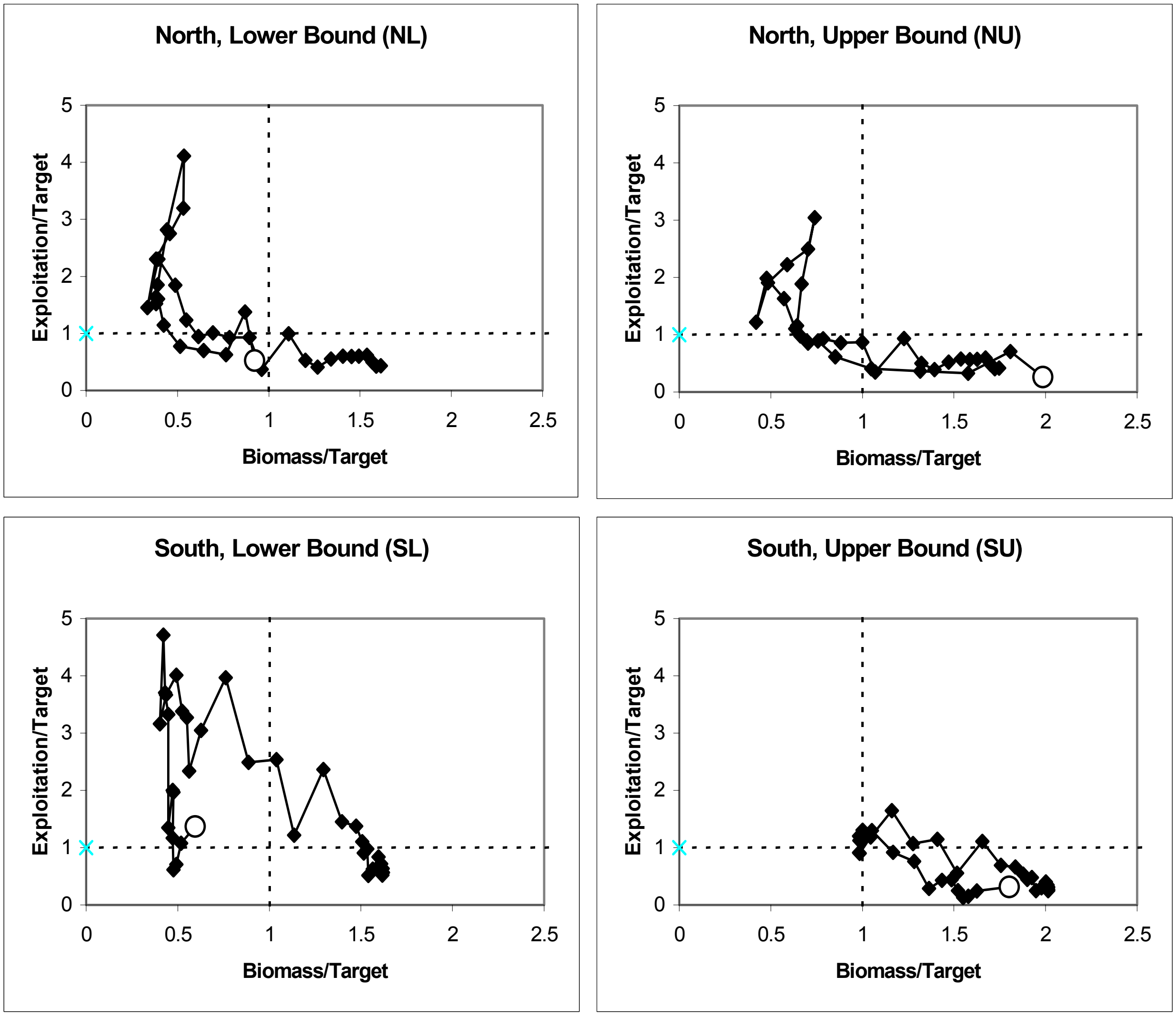

Figure ES2. "Phase diagrams" of historical status of vermilion rockfish since 1970. Open circle is value for 2004.

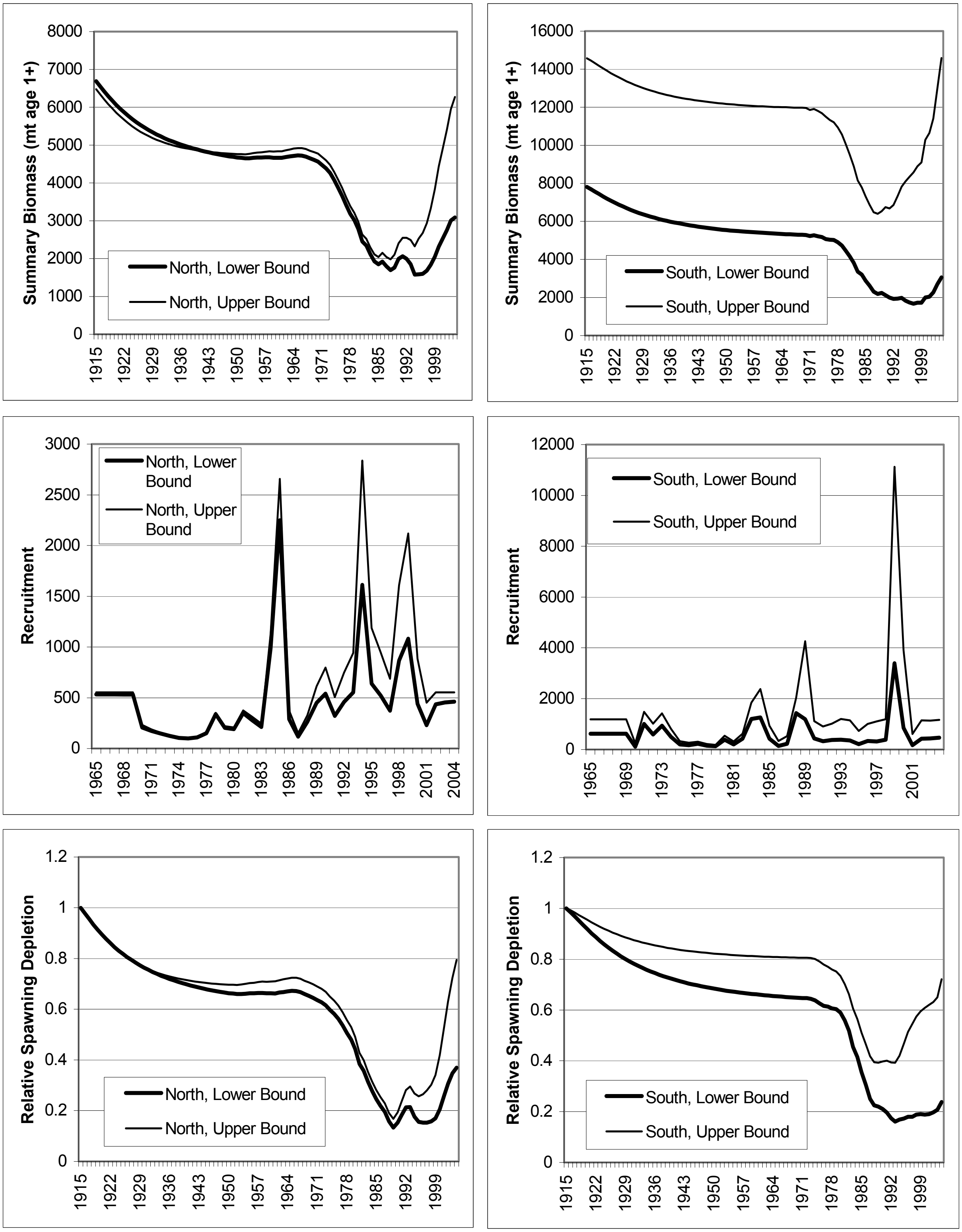

Figure ES3. Biomass time series, recruitment and spawning depletion.

Table ES3. Time series of stock biomass, recruitment and exploitation rate (of available biomass) by fishery for the northern California models.

Year	Total Biomass	Age 1+ Biomass	Spawning Biomass	Age-0 Recruits	H&L Catch	H&L Expl. rate	SetNet Catch	SetNet Expl. rate	Trawl Catch	Trawl Expl. rate	Sport Catch	Sport Expl. rate	Stock Depletion
Northern California, Lower Bound													
Unfished	6757	6690	5722	569									100%
1990	2056	1993	878	542	61	7.8%	61	10.1%	1	0.3%	113	5.4%	15%
1991	2095	2057	1048	320	126	14.1%	14	1.8%	1	0.2%	146	7.7%	18%
1992	2048	1994	1219	459	104	11.5%	0	0.0%	10	2.0%	212	13.0%	21%
1993	1916	1851	1226	554	151	18.4%	20	2.5%	21	4.1%	200	14.1%	21%
1994	1769	1579	1010	1613	85	12.7%	11	1.8%	15	3.5%	137	11.4%	18%
1995	1661	1586	895	638	50	8.3%	11	2.0%	16	4.3%	76	6.7%	16%
1996	1658	1597	874	521	64	10.8%	9	1.7%	10	2.8%	52	4.4%	15%
1997	1725	1681	876	372	64	10.3%	7	1.3%	14	3.9%	46	3.3%	15%
1998	1938	1836	902	865	44	6.4%	6	1.1%	28	7.5%	77	4.4%	16%
1999	2175	2047	969	1082	34	4.3%	0	0.0%	9	2.2%	81	4.1%	17%
2000	2367	2315	1176	438	13	1.4%	0	0.0%	1	0.2%	77	3.8%	21%
2001	2563	2536	1473	229	11	1.0%	0	0.0%	3	0.5%	75	3.6%	26%
2002	2807	2756	1752	434	6	0.5%	0	0.0%	0	0.0%	82	3.7%	31%
2003	3062	3009	1991	454	6	0.5%	0	0.0%	0	0.0%	204	8.5%	35%
2004	3139	3085	2113	462	10	0.7%	0	0.0%	0	0.0%	72	3.1%	37%
2005	3302	3246	2344	476									41%
Northern California, Upper Bound													
Unfished	6541	6476	5532	554									100%
1990	2501	2407	1071	797	61	6.1%	61	8.2%	1	0.2%	113	4.6%	19%
1991	2609	2549	1304	507	126	11.0%	14	1.4%	1	0.2%	146	6.4%	24%
1992	2640	2551	1555	749	104	8.7%	0	0.0%	10	1.5%	212	10.4%	28%
1993	2604	2493	1635	942	151	13.3%	20	1.9%	21	3.0%	200	10.8%	30%
1994	2658	2323	1478	2838	85	8.4%	11	1.2%	15	2.3%	137	8.0%	27%
1995	2669	2529	1421	1187	50	5.1%	11	1.3%	16	2.6%	76	4.4%	26%
1996	2784	2673	1466	946	64	6.3%	9	1.0%	10	1.6%	52	2.8%	27%
1997	3014	2933	1550	687	64	5.7%	7	0.7%	14	2.1%	46	2.0%	28%
1998	3512	3322	1674	1609	44	3.4%	6	0.6%	28	3.9%	77	2.5%	30%
1999	4087	3837	1884	2118	34	2.2%	0	0.0%	9	1.1%	81	2.3%	34%
2000	4539	4435	2320	885	13	0.7%	0	0.0%	1	0.1%	77	2.1%	42%
2001	4973	4920	2912	453	11	0.5%	0	0.0%	3	0.2%	75	1.9%	53%
2002	5477	5412	3490	553	6	0.2%	0	0.0%	0	0.0%	82	1.9%	63%
2003	6010	5945	4001	553	6	0.2%	0	0.0%	0	0.0%	204	4.4%	72%
2004	6339	6274	4392	553	10	0.3%	0	0.0%	0	0.0%	72	1.5%	79%
2005	6701	6636	4920	554									89%

Table ES4. Time series of stock biomass, recruitment and exploitation rate (of available biomass) by fishery for the southern California models.

Year	Total Biomass	Age 1+ Biomass	Spawning Biomass	Age-0 Recruits	H&L Catch	H&L Expl. rate	SetNet Catch	SetNet Expl. rate	CPFV Catch	CPFV Expl. rate	Private Catch	Private Expl. rate	Stock Depletion
Southern California, Lower Bound													
Unfished	7891	7812	6726	664									100%
1990	2170	2118	1411	438	129	8.3%	11	1.7%	82	8.5%	74	7.3%	21%
1991	2027	1988	1323	329	174	12.2%	19	3.3%	71	6.7%	64	6.0%	20%
1992	1967	1923	1170	372	152	11.6%	27	5.3%	59	5.0%	53	4.3%	17%
1993	1984	1939	1082	381	139	10.5%	23	4.9%	18	1.4%	73	5.5%	16%
1994	2016	1973	1133	359	216	15.2%	12	2.6%	50	4.1%	105	7.8%	17%
1995	1861	1836	1160	208	111	8.0%	3	0.7%	23	2.2%	141	11.6%	17%
1996	1782	1743	1206	333	72	5.3%	2	0.5%	72	7.5%	93	8.5%	18%
1997	1709	1671	1207	319	80	6.0%	1	0.2%	5	0.6%	7	0.7%	18%
1998	1775	1730	1269	382	82	5.9%	0	0.0%	31	3.6%	30	3.0%	19%
1999	2127	1728	1282	3388	18	1.3%	0	0.0%	99	11.7%	52	5.5%	19%
2000	2101	2001	1269	844	5	0.4%	0	0.0%	35	4.4%	59	6.7%	19%
2001	2058	2039	1282	164	3	0.2%	0	0.0%	17	1.9%	31	3.4%	19%
2002	2313	2263	1324	429	5	0.3%	0	0.0%	30	2.0%	31	2.2%	20%
2003	2747	2695	1394	437	0	0.0%	0	0.0%	60	3.2%	59	3.0%	21%
2004	3115	3060	1601	464	5	0.2%	0	0.0%	133	6.6%	34	1.5%	24%
2005	3354	3294	2029	506									30%
Southern California, Upper Bound													
Unfished	14715	14571	12627	1222									100%
1990	6879	6747	5020	1117	129	2.2%	11	0.4%	82	4.2%	74	3.4%	40%
1991	6780	6673	5057	905	174	3.0%	19	0.7%	71	3.3%	64	2.7%	40%
1992	6987	6867	4965	1016	152	2.6%	27	1.0%	59	2.1%	53	1.7%	39%
1993	7470	7327	4959	1207	139	2.2%	23	0.8%	18	0.6%	73	2.1%	39%
1994	7960	7825	5308	1144	216	3.0%	12	0.4%	50	1.6%	105	2.8%	42%
1995	8180	8094	5890	731	111	1.5%	3	0.1%	23	0.8%	141	3.9%	47%
1996	8450	8332	6480	1002	72	0.9%	2	0.1%	72	2.5%	93	2.7%	51%
1997	8700	8570	6885	1108	80	1.0%	1	0.0%	5	0.2%	7	0.2%	55%
1998	9035	8894	7249	1197	82	1.0%	0	0.0%	31	1.1%	30	0.9%	57%
1999	10411	9100	7507	11126	18	0.2%	0	0.0%	99	3.6%	52	1.6%	59%
2000	10741	10281	7683	3906	5	0.1%	0	0.0%	35	1.3%	59	1.9%	61%
2001	10712	10640	7827	607	3	0.0%	0	0.0%	17	0.6%	31	0.9%	62%
2002	11536	11402	7973	1141	5	0.1%	0	0.0%	30	0.6%	31	0.6%	63%
2003	13130	12996	8206	1138	0	0.0%	0	0.0%	60	0.9%	59	0.8%	65%
2004	14716	14579	9103	1161	5	0.0%	0	0.0%	133	2.0%	34	0.4%	72%
2005	15965	15824	11072	1200									88%

Table ES5. Total exploitation rate for the four models.

Model	Northern California				
		Lower Bound		Upper Bound	
Year	Total Catch	Age 1+ Biomass	Total Exp. Rate	Age 1+ Biomass	Total Exp. Rate
1990	236	1993	12%	2407	10%
1991	287	2057	14%	2549	11%
1992	326	1994	16%	2551	13%
1993	392	1851	21%	2493	16%
1994	248	1579	16%	2323	11%
1995	153	1586	10%	2529	6%
1996	135	1597	8%	2673	5%
1997	131	1681	8%	2933	4%
1998	155	1836	8%	3322	5%
1999	124	2047	6%	3837	3%
2000	91	2315	4%	4435	2%
2001	89	2536	4%	4920	2%
2002	88	2756	3%	5412	2%
2003	210	3009	7%	5945	4%
2004	82	3085	3%	6274	1%

Model	Southern California				
		Lower Bound		Upper Bound	
Year	Total Catch	Age 1+ Biomass	Total Exp. Rate	Age 1+ Biomass	Total Exp. Rate
1990	296	2118	14%	6747	4%
1991	328	1988	16%	6673	5%
1992	291	1923	15%	6867	4%
1993	253	1939	13%	7327	3%
1994	383	1973	19%	7825	5%
1995	278	1836	15%	8094	3%
1996	239	1743	14%	8332	3%
1997	93	1671	6%	8570	1%
1998	143	1730	8%	8894	2%
1999	169	1728	10%	9100	2%
2000	99	2001	5%	10281	1%
2001	51	2039	3%	10640	0%
2002	66	2263	3%	11402	1%
2003	119	2695	4%	12996	1%
2004	172	3060	6%	14579	1%

Table ES6. Uncertainty in estimates of spawning stock biomass.

	No. Calif. Lower Bound			No. Calif. Upper Bound			So. Calif. Lower Bound			So. Calif. Upper Bound		
	Spawning Biomass	Standard Error	CV	Spawning Biomass	Standard Error	CV	Spawning Biomass	Standard Error	CV	Spawning Biomass	Standard Error	CV
unfished	5723	230	4%	5532	346	6%	6726	519	8%	12627	5341	42%
1915	5723	230	4%	5532	346	6%	6726	519	8%	12627	5341	42%
1920	5118	237	5%	4936	354	7%	6173	513	8%	12049	5335	44%
1925	4677	241	5%	4507	358	8%	5684	502	9%	11511	5316	46%
1930	4371	244	6%	4230	360	9%	5321	495	9%	11114	5304	48%
1935	4153	246	6%	4058	361	9%	5056	490	10%	10831	5299	49%
1940	3995	248	6%	3954	362	9%	4859	487	10%	10628	5298	50%
1945	3879	250	6%	3891	362	9%	4712	487	10%	10482	5301	51%
1950	3793	252	7%	3852	362	9%	4600	487	11%	10377	5305	51%
1955	3791	254	7%	3890	362	9%	4514	488	11%	10301	5309	52%
1960	3790	255	7%	3923	362	9%	4448	489	11%	10245	5314	52%
1965	3848	256	7%	4004	361	9%	4397	491	11%	10204	5319	52%
1970	3692	258	7%	3864	362	9%	4358	492	11%	10175	5323	52%
1971	3637	258	7%	3811	362	10%	4351	493	11%	10170	5324	52%
1972	3588	259	7%	3763	363	10%	4352	493	11%	10173	5325	52%
1973	3521	259	7%	3698	363	10%	4333	493	11%	10156	5325	52%
1974	3417	260	8%	3597	363	10%	4293	493	11%	10112	5323	53%
1975	3327	259	8%	3509	362	10%	4211	489	12%	9988	5293	53%
1976	3217	253	8%	3401	354	10%	4144	481	12%	9833	5225	53%
1977	3068	242	8%	3253	339	10%	4127	470	11%	9725	5157	53%
1978	2900	228	8%	3084	320	10%	4079	459	11%	9593	5099	53%
1979	2747	212	8%	2927	300	10%	4057	448	11%	9484	5041	53%
1980	2539	197	8%	2714	279	10%	3968	432	11%	9265	4950	53%
1981	2198	183	8%	2368	258	11%	3759	413	11%	8864	4802	54%
1982	2047	169	8%	2210	239	11%	3486	391	11%	8355	4607	55%
1983	1795	155	9%	1952	221	11%	3056	366	12%	7657	4380	57%
1984	1587	143	9%	1739	204	12%	2793	342	12%	7121	4139	58%
1985	1406	131	9%	1555	190	12%	2385	319	13%	6443	3898	60%
1986	1255	121	10%	1402	177	13%	2050	296	14%	5861	3676	63%
1987	1117	112	10%	1266	166	13%	1686	276	16%	5280	3480	66%
1988	904	104	12%	1056	158	15%	1513	262	17%	4976	3360	68%
1989	766	100	13%	929	155	17%	1477	257	17%	4954	3378	68%
1990	878	105	12%	1071	166	16%	1411	260	18%	5020	3513	70%
1991	1048	120	11%	1304	195	15%	1323	265	20%	5057	3649	72%
1992	1219	141	12%	1555	233	15%	1170	265	23%	4965	3728	75%
1993	1226	158	13%	1635	266	16%	1082	269	25%	4959	3831	77%
1994	1010	172	17%	1478	289	20%	1133	290	26%	5308	4133	78%
1995	895	186	21%	1421	311	22%	1160	323	28%	5890	4634	79%
1996	874	203	23%	1466	337	23%	1206	359	30%	6480	5116	79%
1997	876	223	25%	1550	367	24%	1207	389	32%	6885	5467	79%
1998	902	249	28%	1674	404	24%	1269	415	33%	7249	5715	79%
1999	969	287	30%	1884	457	24%	1282	438	34%	7507	5903	79%
2000	1176	348	30%	2320	541	23%	1269	458	36%	7683	6035	79%
2001	1473	427	29%	2912	646	22%	1282	476	37%	7827	6109	78%
2002	1752	504	29%	3490	747	21%	1324	493	37%	7973	6152	77%
2003	1991	571	29%	4001	830	21%	1394	517	37%	8206	6235	76%
2004	2113	635	30%	4392	908	21%	1601	587	37%	9103	6715	74%
2005	2344	707	30%	4920	993	20%	2029	743	37%	11072	7853	71%

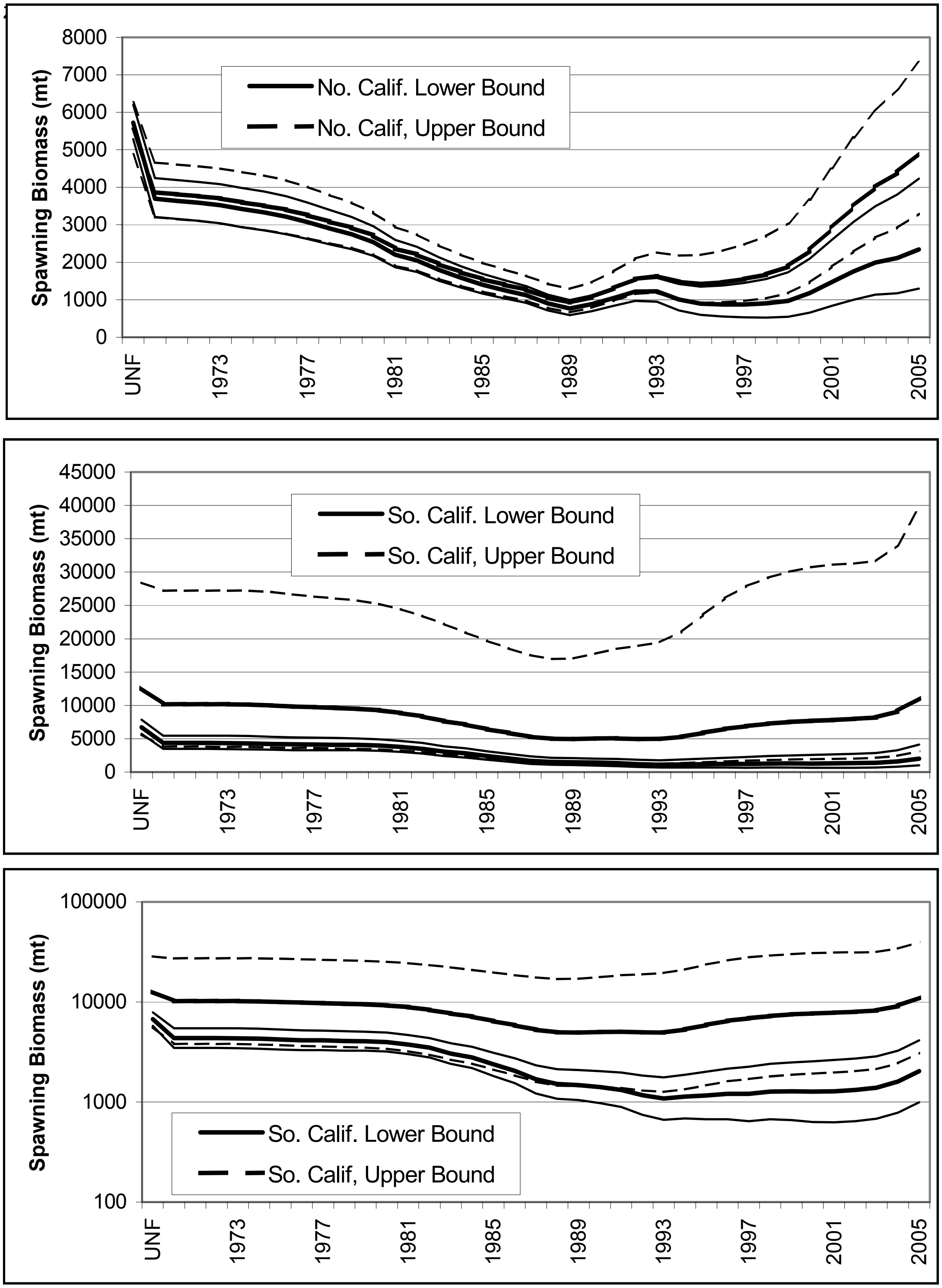

Figure ES4. Uncertainty in estimates of spawning biomass. Confidence limits are ±1.96SE, lognormal. Upper panel is northern California, lower panels are southern California with alternative scaling.

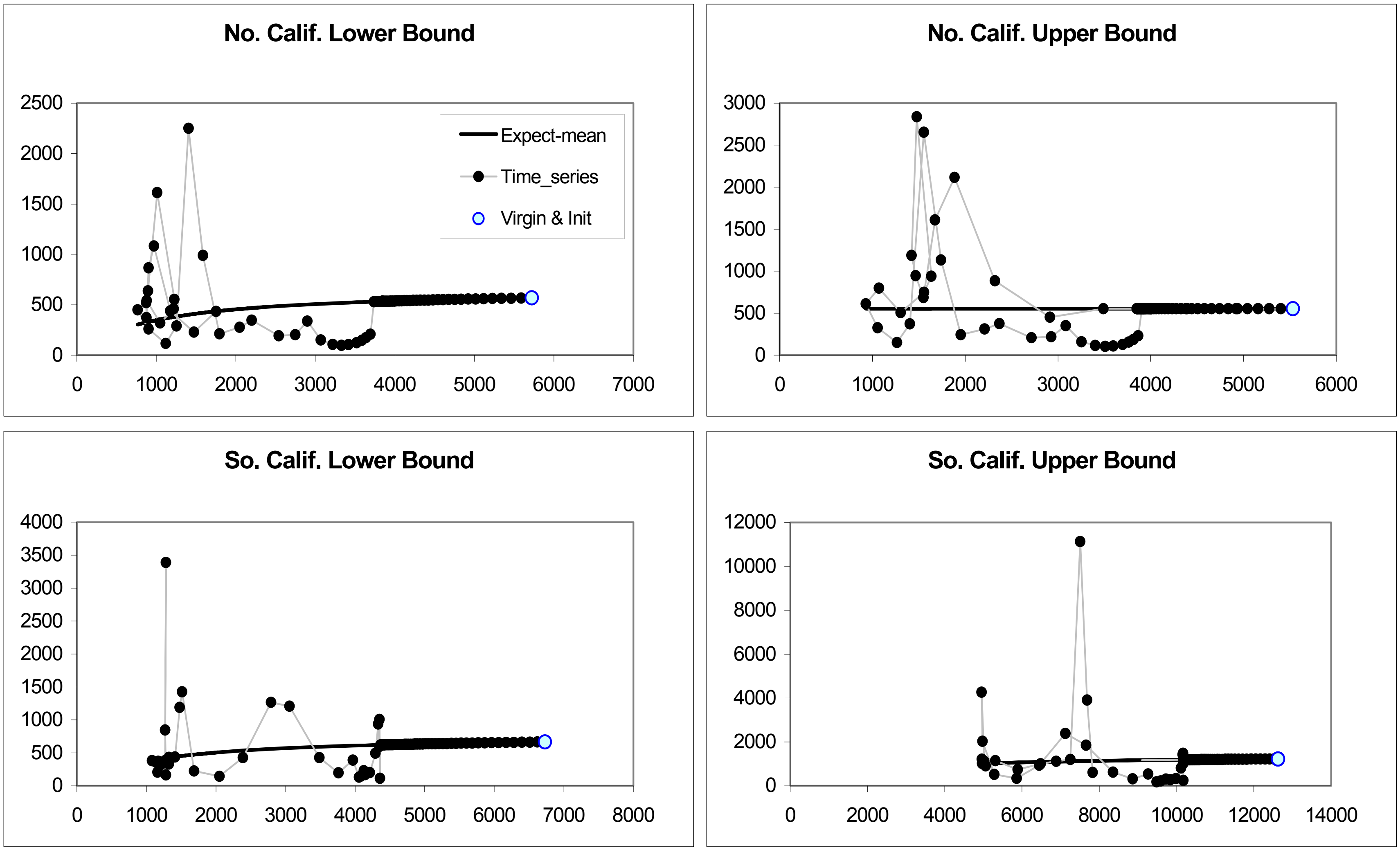

Figure ES5. Stock-recruitment relationships estimated by alternative models. Northern California upper bound model has a steepness of h=1, others are h=0.65.

Exploitation status: All models for both regions indicate that abundance will be above the Precautionary Threshold by 2007. Only the Lower Bound model for Southern California indicates abundance to be currently in the Precautionary Zone (30% in 2005) but biomass is increasing rapidly due to the strong 1999 year class.

Management performance: Vermilion rockfish has not been singled out for species management. With the exception of the Southern California Upper Bound model, both regions experienced a period of overfishing in the early 1990's, and depleted abundance into the late 1990s, but those conditions no longer apply.

Forecasts: Forecasts for the models are shown in the upper left and lower right panels of the decision tables; ABC values are shown under "Catch." Strong recruitments in both regions result in increasing through 2007, or later in some models. Projected values of ABC are generally larger than recent catches except for the Southern California Lower Bound model, which is similar to recent catches.

Decision tables: The uncertainty given by the Lower and Upper Bound models is explored in the decision tables. The Northern California models differ mainly in estimates of unfished biomass, and indicate fairly similar current abundances. Consequently, the decisions reflected in the northern California model entail little risk. However, the two Southern California models indicate quite different levels of abundance. Projections indicate that taking the ABC from the Southern California Upper Bound model would be severe overfishing and would deplete the stock if the Lower Bound model is true.

Research and data needs: The primary data need is clarification of the biological (physical identification, age, growth, maturity, etc.) and ecological (distribution inshore-offshore, and alongshore) properties of the genetically distinct species that are presently called vermilion rockfish. The large recruitment variability may allow development of recruitment indexes, as suggested by Milton Love's (pers. comm.) observations of young-of-the-year vermilion rockfish at oil platforms in the Santa Barbara Channel.

Table ES7. Projections and decision table for northern California vermilion rockfish.

					State of Nature					
					h=0.65 approx lower bound			h=1 approx upper bound		
Management Action	year	Catch Hook&Line	Sport	Total	SpawnBio	Depletion	Exp Rate	SpawnBio	Depletion	Exp Rate
assume h=0.65	2005	10	90	100	4205	43%	2%	4920	89%	2%
	2006	15	90	105	4234	44%	2%	5407	98%	2%
	2007	25	196	221	4259	44%	4%	5753	104%	4%
	2008	25	197	222	4195	43%	4%	5790	105%	4%
	2009	25	197	222	4150	43%	4%	5686	103%	4%
	2010	25	198	223	4123	42%	4%	5491	99%	4%
	2011	25	198	223	4107	42%	4%	5241	95%	3%
	2012	25	198	223	4098	42%	4%	4962	90%	3%
	2013	25	198	223	4094	42%	4%	4670	84%	3%
	2014	25	198	223	4093	42%	4%	4378	79%	3%
	2015	25	198	223	4093	42%	4%	4094	74%	3%
	2016	25	198	223	4095	42%	4%	3823	69%	3%
assume h=1	2005	10	90	100	4205	43%	2%	4920	89%	2%
	2006	15	90	105	4234	44%	2%	5407	98%	2%
	2007	37	206	243	4259	44%	3%	5753	104%	3%
	2008	35	190	225	4168	43%	3%	5758	104%	3%
	2009	33	177	210	4113	42%	3%	5647	102%	3%
	2010	31	166	197	4090	42%	3%	5467	99%	3%
	2011	30	158	188	4094	42%	4%	5252	95%	3%
	2012	28	150	178	4114	42%	4%	5025	91%	3%
	2013	27	144	171	4152	43%	4%	4797	87%	3%
	2014	25	139	164	4200	43%	4%	4578	83%	3%
	2015	24	135	159	4257	44%	5%	4372	79%	3%
	2016	23	132	155	4321	44%	5%	4183	76%	3%

Table ES8. Projections and decision table for southern California vermilion rockfish.

						State of Nature					
						CPUE emph2 approx lower bound			CPUE emph5 approx upper bound		
Management Action	year	Catch Hook&Line	CPFV	Private	Total	SpawnBio	Depletion		SpawnBio	Depletion	
assume CPUE emph 2	2005	10	135	35	180	2029	30%	5%	11072	88%	1%
	2006	10	135	35	180	2464	37%	5%	13153	104%	1%
	2007	7	117	32	156	2731	41%	4%	14552	115%	1%
	2008	7	113	31	151	2868	43%	4%	15300	121%	1%
	2009	8	111	29	148	2923	43%	4%	15609	124%	1%
	2010	8	111	28	147	2938	44%	4%	15648	124%	1%
	2011	8	111	28	147	2934	44%	4%	15524	123%	1%
	2012	8	111	28	147	2925	43%	4%	15300	121%	1%
	2013	7	112	27	146	2916	43%	4%	15018	119%	1%
	2014	7	112	27	146	2909	43%	4%	14705	116%	1%
	2015	7	112	27	146	2903	43%	4%	14378	114%	1%
	2016	7	112	27	146	2898	43%	4%	14048	111%	1%
assume CPUE emph 5	2005	10	135	35	180	2029	30%	5%	11072	88%	1%
	2006	10	135	35	180	2464	37%	5%	13153	104%	1%
	2007	29	469	131	629	2731	41%	18%	14552	115%	4%
	2008	28	423	115	566	2471	37%	18%	14873	118%	3%
	2009	28	391	102	521	2131	32%	20%	14766	117%	3%
	2010	27	368	93	488	1768	26%	22%	14409	114%	3%
	2011	26	351	86	463	1414	21%	26%	13916	110%	3%
	2012	25	336	81	442	1079	16%	32%	13357	106%	3%
	2013	24	323	77	424	766	11%	42%	12777	101%	3%
	2014	22	312	74	408	**472**	**7%**	52%	12201	97%	3%
	2015	22	302	71	395	**242**	**4%**	62%	11646	92%	3%
	2016	21	293	69	383	**93**	**1%**	72%	11123	88%	3%

note: bold values indicate that model was unable to take specified catch

Assessment of Vermilion Rockfish in Southern and Northern California

Introduction

This is the first attempt at assessing vermilion rockfish (*Sebastes miniatus*). An important aspect of this analysis is that recent genetic investigations of tissues indicate that so-called vermilion rockfish may be more than one genetically distinct species, at least in southern California waters (John Hyde, SWFSC, La Jolla, pers. comm.) At the present time, nothing is known of the properties of the component species. This assessment was necessarily conducted as if vermilion rockfish were a single species, but it must be recognized that a mixture of two species is unlikely to be portrayed accurately by a single species model.

Vermilion rockfish occur from Prince William Sound, Alaska to central Baja California, and from shallow nearshore depths to at least 400 m (Love et al. 2002). Sexes are not strongly dimorphic, and there is no known pattern of migration or bathymetric demography, allowing construction of a comparatively simple fishery model. Data sources and fishery patterns from southern California (Mexico to Pt. Conception) and northern California (Pt. Conception to Oregon) waters allow development of separate assessment models, which could subsequently be combined if they are found to share sufficiently similar patterns.

This species has long been a target of both commercial and recreational fishermen, and is valued for its appearance and eating quality. In 1937-38, vermilion rockfish were the fourth most commonly marketed rockfish species caught by commercial hook and line fishermen in the vicinity of Monterey, California (Phillips, 1939). In recent recreational fisheries, RecFIN statistics show that vermilion rockfish has become increasingly important. Among rockfishes caught in the southern California recreational fishery, vermilion rockfish ranked #3 in the 1980s, and #1 in both the 1990s and 2000-2004 period. In the northern California recreational fishery, vermilion rockfish ranked #10 in the 1980s, #4 in the 1990s and #2 in 2000-2004.

Catches of vermilion rockfish in Oregon and Washington have been much smaller than those in California (Table 1). Catches from Mexican waters exist but are not known. This stock assessment addresses only the portion of the population residing off California.

Table 1. Landed catch (mtons) of vermilion rockfish by area during the period 1993-2002. Values are from RecFIN and PacFIN.

	So. Calif.	No. Calif.	Oregon	Washington
Recreational	1004	751	43	1
Commercial	691	376	73	1

Management History and Performance: Vermilion rockfish have not been managed as a separately identified species. The PFMC has included vermilion rockfish in the "Other rockfish" category of the "Sebastes complex" which has also been divided geographically into northern and southern management areas with a dividing line in the vicinity of Cape Mendocino. All of the southern management area is in California. Vermilion rockfish is classified as a "shelf rockfish" in recent PFMC management regulations. Beginning in 2001, recreational fishing in southern and central California waters was subjected to a complicated series of time closures, depth restrictions and bag limits (Table 2).

Data

<u>Biological information</u>

The length-weight relationship

W(kg) = 0.00001744 * L(cm-FL) ^2.995

was calculated from 138 fish collected in 2003 by the NWFSC southern California hook and line survey. This relationship is similar to others found in the literature.

Lengths and ages of 271 vermilion rockfish are shown in Figure 1. Male and female lengths (FL) at age are similar, allowing a single-sex treatment in the assessment model. A least squares fit of the Schnute (1981) parametrization of the von Bertalanffy growth curve gives a lower growth rate parameter (k) than the unconstrained fits of the SS2 model to the historical length compositions, and higher values of lengths at age 4 and age 30. The direct fit to the data is probably influenced by a selectivity bias (though the NWFSC survey may have less of a bias than the historical fishery samples), which would result in an overestimate of length at age 4 and an underestimate of the growth rate parameter. Sensitivity analyses examine the effect on the model when the least squares parameter estimates are used as Bayesian prior probability distributions.

	growth rate (k)	length at age 4	length at age 30
least squares fit	0.1089 (0.00878)	32.815 (0.2781)	55.7093 (0.3851)
southern California*	0.1932 (0.00698)	28.680 (0.2556)	53.7380 (0.4584)
northern California*	0.1643 (0.00660)	26.780 (0.3111)	53.5410 (0.4082)

* values are from models using a Beverton-Holt SRR because the estimated variances are more reliable than for the Ricker SRR in SS2 version 1.18.

The approximate spawning ogive

Frac Mature = exp(0.5*(L-38))/(1+exp(0.5*(L-38)))

where L is cm-FL, was obtained by fitting the following values given by Wylie Echeverria (1987): L(first maturity)=37cm, L(50% maturity)=37cm, and L(100% maturity)=46cm. For purposes of estimation, the value of L(first maturity) was reduced to 36cm.

A natural mortality rate (M) of 0.1yr^{-1} is assumed, based on maximum observed ages in a sample of 242 fish sampled mostly in the 1980s (ages provided by Masako Suzuki and Don Pearson, NMFS). The two oldest fish in the sample were estimated to be 50 and 82 years of age, respectively. Inverse application of Hoenig's relationship between natural mortality rate and oldest observed individual indicates that if M = 0.1, the expected oldest fish in a sample of this size would be approximately 65 years old, which is consistent with observation.

Growth parameters were estimated internally by the assessment model. Presence of clear progressions of length modes in compositions from various fisheries and sequences of years suggests that this approach is adequately supported by the data.

Landings

Landings of individual species taken by commercial and recreational fisheries have been monitored for most years since about 1980, but this assessment attempts to begin the time series in 1950, requiring reconstruction of earlier catch values. Like most species of rockfish, vermilion rockfish landings are difficult to estimate for earlier years because of lack of monitoring programs and limited species identifications in the receipts and logbooks.

Historical catches from southern California (Figure 2) have been larger than those from northern California (Figure 3). In southern California, the recreational fishery has taken substantially more vermilion rockfish than the commercial fishery except during the 1990s when catches by the two segments were of similar magnitude. Northern California catches have been about evenly divided between the two fisheries. In both areas, commercial landings declined to very low levels in recent years due to restrictions imposed by the PFMC. Details of the catches are given in Tables 3 and 4. The following sections describe the sources of the catch estimates and the methods used to reconstruct unknown values.

Vermilion rockfish are not assumed to have been discarded in the commercial fishery. Discards are accounted for in the RecFIN data on the recreational fishery, but are infrequent.

Southern California

Commercial fishery: California commercial landings for 1978-2004 were obtained from the CALCOM data base (D. Pearson, NMFS, pers. comm). Values from CALCOM are slightly larger than those from PacFIN due to a more aggressive algorithm for recovery of unknown gears by CALCOM.

Reconstructions: Pre-1978 landings for hook and line and set net gears were assumed to be the same as those for 1978. This may underestimate the commercial catch during the 1950's, as there was an increase in fishing power during the 1950's, especially due to improvements in engines (Tom Ghio, pers. comm.).

Recreational fishery: Landings by the private boat and partyboat (aka. Commercial Passenger Fishing Vessel, CPFV) segments of the recreational fishery are treated separately in the southern California model (see length compositions below). Landings (including fish reported as discarded dead) by fishery segment for 1980-1989 and 1993-2004 were obtained from the RecFIN database. Partyboat landings in numbers were estimated for 1975-1978 based on species compositions from a CDFG partyboat sampling program (P. Serpa, CDFG, pers. comm.), which were applied to the catch of rockfish reported by the partyboat logbooks (K. Hill, NMFS, pers. comm). Year-specific average weights were derived from CDFG sampled length compositions, and were used to derive annual recreational catch in weight.

Reconstructions: The RecFIN data gap in 1990-1993 was filled by linearly interpolating the total estimated recreational landings between 1989 and 1994, and allocating that total by the average private and partyboat proportions. The partyboat catch in 1989 was interpolated between the above-described estimate for 1978 and the RecFIN estimate for 1980. Partyboat catches in numbers for 1970 to 1974 were assumed to be the same fraction of logbook-reported partyboat catch as during 1975-78, and average fish weight was assumed to be equal to the average from known years from 1975 to 2003. Private boat recreational catches for 1970 to 1979 were assumed to be 73% of the partyboat catch, based on RecFIN catches for the early 1980s. Pre-1970 values of private boat and partyboat catches were assume to be equal to their 1970 values. This may overestimate the private boat catch of vermilion rockfish during the early years, as Pinkas et al. (1968) estimated that in 1964, private boats caught only 8.5% as many rockfish as partyboats in southern California.

Northern California

Commercial fishery: California commercial landings for 1978-2004 were obtained from the CALCOM data base (D. Pearson, NMFS, pers. comm). Values from CALCOM are slightly larger than those from PacFIN due to a more aggressive algorithm for recovery of unknown gears by CALCOM. Phillips (1939) reported the quantity and species composition of rockfishes sold in Monterey fish markets during 1937-1938. Some information on species composition of the 1957-1958 catch in Morro Bay is given by Heimann and Miller (1960).

Unlike southern California, trawling takes significant quantities of vermilion rockfish in northern California. Trawl catches of rockfish from 1954-1963 were obtained from Nitsos (1965). Species compositions from Morro Bay in 1957-1958 were obtained from Heimann and Miller (1960), and compositions for the entire northern California trawl fishery for 1962-1963 were obtained from Nitsos (1965). Trawl catches of vermilion rockfish in 1973 were obtained from Gunderson et al. (1974). Estimated vermilion rockfish catches by the foreign trawl fleet in the Monterey and Conception INPFC areas from 1966 to 1976 were obtained from Rogers (2003).

Reconstructions: Pre-1978 landings for hook and line and set net gears were assumed to be the same as those for 1978.

Recreational fishery: Landings by the private boat and partyboat (aka. CPFV) segments of the recreational fishery are combined in the northern California model (see length compositions below). Landings (including fish reported as discarded dead) by fishery segment for 1980-1989 and 1993-2004 were obtained from the RecFIN database. Estimated landings in numbers of fish by the partyboat segment for 1990-1996 were provided by Deb Wilson-Vandenberg (CDFG, pers. comm.), and these were multiplied by the average weights calculated from the annual length compositions.

Reconstructions: The RecFIN data gap for private boats in 1990-1993 was filled by linearly interpolating the total estimated recreational landings between 1989 and 1994. The historical fraction of vermilion rockfish in the Monterey Bay area partyboat catch was taken from Mason (1995) and was applied to the post 1947 partyboat rockfish catch from logbooks (Young, 1969, and K. Hill, NMFS, pers. comm.), and was expanded to northern California based on the average ratio of northern California to Monterey area catches from logbooks. Fish were assumed to have the long term average weight of 1.77kg/fish reported by Miller and Gottshall (1965). The private boat catch was assumed to conform to the average ratio of private to partyboat catch during the period 1980-1989 reported in RecFIN. These reconstructed catches may be low, given that for the year 1958, Heimann and Miller (1960) estimated that vermilion rockfish composed about 5% of the partyboat rockfish catch in the Morro Bay area, and applying that percentage and the above average weight to the rockfish catch reported by partyboat logbooks from Morro Bay (Young 1969) results in an estimated catch of 29 mtons.

Length and Age Compositions

Length compositions for the commercial fisheries were obtained from CALCOM. Length compositions for the recreational fisheries were obtained from RecFIN (1980-1989 and 1993-2004), and were supplemented by independent sampling conducted by CDFG. Length compositions from southern California partyboats in 1975-1978 and 1986-1989 were provided by Paulo Serpa (CDFG, pers. comm.). Length compositions from CDFG sampling of the northern California partyboat fishery for 1978-1984 were obtained from the CALCOM (Don Pearson, NMFS, pers. comm.), and compositions for 1986-1998 were provided by Deb Wilson-Vandenberg (CDFG, pers. comm.). In addition, 133 vermilion rockfish otoliths from a 2003 hook and line survey of southern California waters were provided by John Harms (NWFSC), and age determinations for these fish were provided by Masako Suzuki and Don Pearson (SWFSC, Santa Cruz).

A preliminary comparison of length compositions (see Appendix 1) indicated substantial differences between southern California and northern California patterns. Consequently, independent stock assessments are developed for these two regions. In northern California, length compositions from the private boat and partyboat fisheries were similar, allowing the recreational fishery to be treated as a single entity. In southern California, length compositions from private boat and partyboat segments differed, so these two segments of the recreational fishery are distinguished in the southern California assessment.

Time series of length compositions for the various fishery segments used in the assessments are shown in 4a-d and 5a-d, and sample sizes are given in Tables 5 and 6. In all, the southern California assessment uses 33033 length measurements taken from 4532 separate trips, and the northern California assessment uses 24460 length measurements taken from 4314 separate trips. Sample sizes are unevenly distributed among fishery segments and years.

Abundance Indexes

Recreational fishery catch per unit effort (CPUE) provided abundance indexes for the southern California and northern California population segments. For the years 1980-1989 and 1993-2003, the MRFFS intercept data contained in the RecFIN data base provided catches and associated angler effort. Data for 2004 exist, but became available too late to be included in this assessment. The CDFG northern California partyboat monitoring program provided data supporting an independent abundex for the years 1986-1998.

RecFIN CPUE: Southern California and northern California trip-level summaries of partyboat catch and angler effort from the RecFIN data base were provided by Wade VanBuskirk, (pers. comm.). These RecFIN intercept data reflect sampling and interviews conducted at the end of a fishing trip, and do not include information on specific fishing locations. Because the data include both relevant trips, in which vermilion rockfish were reasonably likely to be taken, and non-relevant trip such as trips targeting salmon or tuna, the logistic regression method of Stephens and MacCall (2004) was used to obtain a subset of the trip data that would be appropriate for calculating vermilion rockfish CPUE. This method uses the species composition from each trip catches to determine whether vermilion rockfish were likely to have been encountered on that trip.

The top 50 species in frequency of occurrence for each region were extracted, and vermilion rockfish were separated as being the target species. The remaining 49 species served as potential explanatory variables. Two species of tunas and three species of salmon were combined into single categories for southern and northen California analyses respectively. This resulted in 48 species being considered in the southern California analysis and 47 species in the northern California analysis. Logistic regression of vermilion rockfish presence/absence on categorical presence/absence of these explanatory species provided predicted probabilities that vermilion rockfish would be taken on a trip, given the other species that were taken on that trip. Prior to the analysis, some trips were excluded from the data set if they were too short (<0.25hr) or too long (>14hr). Species associations (coefficients from the logistic regressions) are shown in Figures 6 and 7.

Defining the appropriate subset of the data for use in calculating CPUE requires establishing a threshold probability for inclusion. The threshold probability recommended by Stephens and MacCall (2004) is based on an equal number of false negatives (trips that are excluded from the selected set, but the target is present) and false positives (trips that are included in the selected set, but for which the target is absent). Those threshold probability values were 0.25 for southern California and 0.4 for northern California. However it may be possible to gain precision by increasing the number of positive occurrences of the target species in the subset, i.e., by reducing the number of false negatives despite an increase in false positives. For this analysis, the threshold probability that resulted in the lowest average CV of the annual indexes was used, assuming that up to some point, the CV (as a nominal measure of precision) is marginally improved.by the larger numbers of actual positive records more than it is degraded by including a larger number of trips that did not catch the target. The threshold probability values that produced the lowest Cvs of the annual indexes were 0.20 for both southern California and for northern Californa.

Selection of the threshold probability defines the subset of data to be used for calculation of the CPUE index. The abundance index is calculated by a GLM using a delta-gamma distribution (R language code provided by Edward Dick, NMFS). An exploratory GLM including all years, all counties, six two-month waves, and distance from shore (inside/outside three miles from land) effects was first used to determine if the model could be simplified based on similarity of estimated effects. The final southern California GLM did not incorporate any simplifications, and included 21 year effects, six two-month wave effects, five county effects, and two distance from shore effects. The final northern California GLM was simplified somewhat, and included 21 year effects, two season effects, and seven county effects; distance from shore was not included. In both cases, the year effects serve as the abundance index (Figures 8 and 9). Precision of the estimated year effects was estimated by use of a jackknife procedure. Sample sizes and year effects are given in Table 7a. Analyses of deviance are given in Table 7b. Details of the explanatory effects are given in Table 8. County effects for northern California CPUE are shown in Figure 10.

CDF&G Partyboat CPUE: The California Department of Fish and Game conducted on-board monitoring of partyboat catches in Northern California from 1987 to 1998. Presence of location and depth information associated with catch and effort at individual fishing sites (Deb Wilson-Vandenberg, CDFG, pers. comm.) allowed a more direct identification of appropriate records for use in calculating a CPUE index of abundance. The analysis used only those fishing sites (70 sites) where vermilion rockfish were caught in five or more different years. An exploratory delta-gamma GLM included years, months, sites and depth as effects. The values of the month effects suggested that there were three seasonal periods, and that December behaved more like January-March. Accordingly, years were redefined to go from December to November, and the 12 months were reduced to three seasons: December-March, April-July, and August-November. There was a tendency for CPUE to increase with depth, so eight depth bins were used, beginning at 0-10 fathoms, and in 10 fathom increments with the final bin including all depths greater than 70 fathoms (see Table 9 for sample sizes). The final delta-gamma GLM contained 12 year effects, three season effects, 70 location effects (Figure 11) and eight depth effects (Figure 12). The year effects were used as the CPUE index of abundance (Figure 13), and precision was calculated by a jackknife procedure. An analysis of deviance is given in Table 7b, and sample sizes and year effects are given in Table 9.

Assessment Models

Two pre-STAR assessment models, here called PSNORTH and PSSOUTH, were presented to the STAR Panel review. The sensitivity analyses in this document use those pre-STAR assessments as the reference base. In view of the uncertainty inherent in the data, the STAR review was unable to produce best-estimate models, but produced two models for each region that are intended to serve as approximate bounds on the likely status of the stock. These models are referred to as, STARNL, STARNU, STARSL and STARSU, where N and S indicate north and sourh, and L and U indicate approximate lower and upper bounds.

The pre-STAR assessments mostly used version 1.18 of the Stock Synthesis 2 (SS2) model developed by Richard Methot (NMFS), although some exploratory work used earlier versions of SS2. A version 1.19 (released 4/28/05) was used for some of the later sensitivity analyses and was used for the STAR models. The latter version differs mainly in its improved ability to determine values of some management reference points and improved estimates of standard errors and correlations.

Details common to all models

After initial exploratory runs, the CV of length at age was fixed at a value of 0.8 for all ages; this is consistent with available information, and added stability to model estimation. The first year in the model is 1950, at which time age structure is assumed to be in equilibrium with background catch levels and the average unfished level of recruitment. The standard deviation of recruitment deviations (sigmaR) is assumed to be 0.7. Diffuse priors were assumed for all estimated parameters. No time-varying pararmeters were considered

Effective sample sizes: Observed sample sizes (Nfish) for the length compositions were replaced by "effective sample sizes" based on McAllister and Ianelli's (1997) description of the ratio of the variance of the expected proportion (p) from a multinomial distribution from sample size Neff to the mean squared error of the observed proportion (p') relative to the model's predictions (p), i.e., N_{eff} = sum[p(1-p)]/sum[(p-p')^2]. However, this relationship is subject to statistical variability, and should hold true only on average. A log-log linear regression was used as a "smoother," and effective sample sizes used in the model were the predicted values from this regression given the year-specific observed sample size. No correction was made for the geometric mean bias associated with the log-transform. During the exploratory phase of model development, values of effective sample size were recalculated each time a substantial change was made in model specifications, especially in specifications that have a strong effect on predicted length compositions, such as selectivity curves for individual fishery segments. Regressions of effective sample size on observed sample size for the pre-STAR southern and northern California base models are shown in Figures 14 and 15. Estimated selectivity curves are shown in Figures 16 and 17.

Details common to pre-STAR models

The models begin in 1950, with a background catch for previous years. Recruitments are estimated for individual years (as deviations from the fitted stock-recruitment relationship) beginning in 1950. Population estimates for the 1950s and 1960s should not be considered reliable, and this aspect of the model mainly serves to provide "initial conditions" at the time of the earliest observed data in the 1970s. A Ricker SRR is assumed, based on improved log-likelihood relative to a Beverton-Holt SRR (which takes on a limiting case of constant expected recruitment if steepness is freely estimated). Effective sample sizes were calculated iteratively, but CVs of CPUE indexes were used as originally calculated. Based models used emphasis factors of 1.0 on all likelihood components.

Results of pre-STAR models

Southern California base model (PSSOUTH)

The model reflects data collected between Pt. Conception and the Mexican border. Likelihood components are given in Table 10. Four fleets are represented: Hook and Line, Set Net (gillnet), Recreational partyboat (a.k.a., CPFV), and Recreational private boat. A standard deviation of 0.1 was assumed for the ages sampled in 2003, as this helped to "pin" the dominant year class as being from 1999, given the influence of large numbers of length observations in the data and internal estimation of the growth curve in the SS2 model. Treating the two recreational fisheries separately (i.e., with separately estimated selectivity curves) was justified by a large improvement in likelihood. Likelihood improvements also favored including descending limbs in the selectivity curves for the two recreational fisheries, but favored simpler asymptotic models for the two commercial fisheries (Figure 16). The base model assumes a Ricker SRR, which was favored over a Beverton-Holt SRR by 3.2 log-likelihood points. The Beverton-Holt SRR, (which had an estimated steepness of 1.0) also produced implausible historical recruitment patterns.

The estimated time series of abundance indicates that vermilion rockfish declined in abundance from the 1970s to 1980s, and the population was depleted during the late 1980s an early 1990s (Figure 18). The estimated trajectory of abundance prior to 1970 establishes the initial size composition of the model, and should be ignored. Abundance increased rapidly in the late 1990s due to a good 1989 year class and a slight overall improvement in recruitment in the 1990s (Figure 19). The 1999 year class was extraordinarily large, as has been seen for a wide variety of west coast species. The fit to the CPUE abundance index (Figure 20) is not very good, but a tight fit should not be expected, given the imprecision shown in Figure 8. The estimated Ricker stock-recruitment relationship is shown in Figure 21, and the goodness of fit to the length compositions is shown in Figure 22a-d.

Northern California base model (PSNORTH)

The model reflects data collected between Pt. Conception and the Oregon border. Likelihood components are given in Table 10. Four fleets are represented: Hook and Line, Set Net (gillnet), Trawl, and combined Recreational boat modes. As in the southern California case, likelihood improvement favored including a descending limb in the selectivity curves for the recreational fishery, but favored the simpler asymptotic models for the three commercial fisheries (Figure 17). The base model assumes a Ricker SRR, which was favored over a Beverton-Holt SRR by 26 log-likelihood points.

The estimated time series of abundance indicates that northern California vermilion rockfish also declined in abundance from the 1970s to the late 1980s, but did not reach as severe a depletion as in the south (Figure 23). Again, the estimated trajectory of abundance prior to 1970 establishes the initial size composition of the model, and should be ignored. Abundance increased rapidly in the 1990s due to a good 1985 year class and generally improved recruitment in the 1990s (Figure 24). The 1999 year class was large, but unlike southern California, was not extraordinary. The fits to the CPUE abundance indexes (Figure 25) are moderately good, but again, a tight fit should not be expected, given the imprecision shown in Figures 9 and 13. The estimated Ricker stock-recruitment relationship is shown in Figure 26, and the goodness of fit to the length compositions is shown in Figure 27a-d.

Sensitivity Analyses (pre-STAR models)

Both models were examined for sensitivity to data sources, stock-recruitment relationships, and natural mortality rate (Tables 11 and 12). Sensitivity to data sources was determined by alternatively reducing and emphasizing each data source, with lambda values respectively set at 0.1 and 10. Both Ricker and Beverton-Holt stock-recruitment relationships were considered at lambda values of 1 and 0.1. The latter case tends toward independent estimation of annual recruitment values, and the two models tend to converge.

Natural mortality rates (M) of 0.06, 0.08. 0.12 and 0.14 were compared with the base value of 0.10 (Tables 11a and 12a). Estimated abundances and ABCs are higher for higher assumed rates of natural mortality. Estimated relative depletion shows higher relative abundances for higher M in southern California, but estimated relative depletion is not affected by assumed M in northern California. Importantly, because these are primarily length based models, with internally estimated growth parameters, aspects of mortality rate and growth can be confounded, and improved likelihood is not a reliable indicator of a better value of the natural mortality rate.

Effect of using externally estimated growth parameters as priors is also shown in Tables 11a and 12a. Growth parameters were estimated from the data shown in Figure 1. The externally estimated growth rate parameter is considerably lower than the internally estimated value, and the small standard errors on the externally estimated parameters place strong constraints when they are used as priors in the model. In addition to reporting total log likelihood, I report and adjusted log likelihood by subtracting the value of the log likelihood that arises from the prior probabilities. If the three growth parameters were fixed (the strongest possible prior probability) the model would be smaller by three estimated parameters, and likelihoods could be evaluated accordingly. Use of relatively precise prior probability distributions is somewhat intermediate in model parameterization, and this adjusted log likelihood may be useful for evaluating results. Note that tightly constrained growth parameters may allow comparison of likelihood values among alternative natural mortality rates.

Using externally estimated growth parameters results in poorer adjusted log likelihood values for both southern California (24.1 points) and northern California (12.0 points); from the viewpoint of differences in log likelihood and the potential bias due to unrecognized length selectivity effects, these values do not justify restricting the values of three parameters. With regard to natural mortality rate, the adjusted log likelihood favors the higher rate in southern California, and the lower rate in northern California. Use of a Beverton-Holt SRR still results in poorer log likelihood values than the Ricker SRR used in the constrained version of the base models.

Results of STAR review

Details common to STAR models

The models begin in 1915, with no catches assumed to exist before that time. Recruitments are taken from the stock-recruitment relationship until 1970 when the model begins to estimate recruitment values for individual years. A Beverton-Holt SRR is assumed, with steepness fixed at either the freely estimated value of h=1 (constant expected recruitment), or at h=0.65, based on Dorn's (2002) Bayesian meta-analysis of steepness in west coast rockfish stocks. Effective sample sizes were calculated iteratively, and CVs of CPUE indexes were adjusted by a multiplicative factor so that the residuals had a standard deviation of 1. Emphasis values larger than 1 were used on some likelihood elements.

Southern California models (STARSL and STARSU)

The two Southern California models, STARSL and STARSU, represent approximate lower and upper bounds to the current status of the stock relative to the corresponding unfished condition. For southern California, the lower bound model places an emphasis of 2.0 on the abundance index, and the upper bound model uses an emphasis of 5.0; both models use a Beverton-Holt SRR with steepness h = 1 (i.e., constant expected recruitment). Re-scaled effective sample sizes and abundance index CV's are given in Table 13.

The STAR model fits to the southern California CPUE data (Figure 28) are similar to pre-STAR model fits. Fits to the length compositions are indistinguishable from the pre-STAR model.

The estimated time series of spawning biomasses (Figure 29) shows that there was a period of lower biomasses from the mid-1980s to late 1990s, and in the lower bound model, estimated biomasses fell below the overfished threshold. Both models indicate a currently healthy stock. Recruitment is episodic, and there appear to have been four major recruitment events in the 30 years of model estimates (Figure 30). These recruitment events occurred in 1971-73, 1983-84, 1988-89 and an especially strong recruitment occurred in 1999. Dates of these recruitment events are approximate, due to the length-based nature of the assessment model. Stock-recruitment relationships are shown in Figure 31.

Figure 32 describes the history of exploitation as a "phase diagram." The lower bound model shows a long period of overfishing and relative depletion, but the upper bound model has generally stayed within the target range of abundances and fishing rates. The history of fishing intensities expressed as SPR is shown in Figure 33. The lower bound model indicates that SPR has fallen below the proxy MSY level of 50% for most years since the late 1970s, whereas the upper bound model shows only a brief period of overfishing during the early 1980s.

Northern California models (STARNL and STARNU)

The two Northern California models, STARNL and STARNU, represent approximate lower and upper bounds to the current status of the stock relative to the corresponding unfished condition. Emphasis on the abundance indexes is held at 1.0 for both northern California models, and the lower bound model uses a steepness of $h = 0.65$, while the upper bound model uses a steepness of $h = 1$ (i.e., constant expected recruitment). Re-scaled effective sample sizes and abundance index CV's are given in Table 13.

The STAR model fits to the northern California CPUE data (Figure 28) are similar to pre-STAR model fits, except the STAR models with Beverton-Holt SSRs are unable to produce as low an abundance in the late 1970s. Fits to the length compositions are indistinguishable from the pre-STAR model.

The estimated time series of spawning biomasses (Figure 29) shows that in northern California there also was a period of lower biomasses from the mid-1980s to late 1990s. Both upper and lower bound models, show estimated biomasses that fell below the overfished threshold. The current stock appears to be healthy, due to a trend of increasing recruitment. Recruitment in the north is also episodic, and there appear to have been three major recruitment events in the 30 years of model estimates (Figure30). These recruitment events occurred ca. 1985, 1994 and 1999. The 1999 year class was only moderately large in northern California, and does not appear to be as strong, relatively, as in southern California. With the exception of 1999, there is no evidence of shared strong year classes, giving support to development of separate regional stock assessments. Stock-recruitment relationships are shown in Figure 31. The model estimates a long string of poor recruitments from1970 to 1984 (annual values of recruitment begin to be estimated in 1970), suggesting that the stock may experience prolonged periods of poor recruitment. The low recruitments at higher stock sizes are more consistent with a Ricker SRR (cf. Figures 21 and 26), but the STAR Panel rejected use of a Ricker model in this assessment.

Figure 32 describes the history of exploitation as a "phase diagram." Both lower and upper bound models show a long period of overfishing and relative depletion preceding the recent increase in abundance. The history of fishing intensities expressed as SPR is shown in Figure 33. Both models indicate that SPR has fallen below the proxy MSY level of 50% for most years since the late 1970s, but has been at of above MSY proxy levels in recent years.

Projections

Likely catches for years 2005 and 2006 were provided by members of the GMT. For subsequent years through 2016, catches were assumed to result from an SPR=50% fishing intensity. Projected abundance (expressed as spawning stock size relative to it corresponding unfished level) and catches are shown in Figure 34; values including projected catches by each fishery segment are given in Tables 14 and 15. Except for the southern California lower bound model, these projected catches are much larger than have been achieved in recent years, and are unlikely to be realized under current management and market conditions. Nonetheless, all projections show relative abundance to be above the "precautionary level" of 40% Bunfished for all years from 2007 to 2016.

Decision Tables

In the southern Califonia assessment, the STAR Panel considered the major dimension of uncertainty to be the appropriate level of weight assigned to the time series of abundance indexes, with emphasis factors of 2 and 5 defining the lower and upper bound models respectively. In the northern California assessment, the STAR Panel considered the steepness of the assumed Beverton-Holt stock-recruitment relationship to be the major dimension of uncertainty, with values of h = 0.65 and h = 1 defining the lower and upper bound models respectively. Tables 14 and 15 present the results of treating these alternative models as possible "true states of nature" and describe the consequences of attempting to realize a future series of catches given that the alternative model describes the population dynamics and productivity. The STAR Panel and STAT Team were unwilling to assign probabilities to the alternative models, so the decision tables should be considered on a "what if..." basis. The most serious consequence is if the high catch levels for southern California are attempted when the lower bound model is actually true, in which case rapid stock depletion occurs.

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Table 2. Summary of recent regulations.

Commercial		Recreational
	1990	
Limits on set line length established Gill nets not allowed within 30 fm		
	1994	
	Marine Resources Protection Act (MRPA) established 4 small reserves	
Federal groundfish split into limited entry (LE) and open access (OA) LE trip limits = 80,000 pounds per month OA trip limits = 40,000 pounds per month Gillnets not allowed within 3 miles of shore		
	1995	
Additional limitations for set lines established No set line fishing on weekends north of Santa Cruz Fishing restricted in Districts 12 & 13		
	1996	
Finfish trap permit required Limits on the number of traps established Hook and line limited to 150 hooks within 1 mile of shore		
	1999	
OA trip limits reduced = 2,000 per month south of 40° 10'		
	2000	
Two-month closures established Significant trip limit reductions		Two-month closure established Bag limit reduced from 15 to 10 rockfish
	2001	
	Cowcod Conservation Area (CCA) established No rockfish fishing allowed within CCA Depth restrictions established (20 - 150 fms closed)	
	2002	
	Nearshore Fishery Management Plan adopted	
Commercial rockfish fishery closed early		Recreational rockfish fishery closed early
	2003	
	California Rockfish Conservation Area (RCA) established Restricts groundfish fishing by season and depth	
Commercial rockfish fishery closed early		Recreational rockfish fishery closed Jan - June

Table 3. Catch (mtons) of vermilion rockfish in southern California.

	Hook&Line	SetNet	Partyboat	Private boat	Commercial	Recreational	Total
pre-1950	36	5	46	34	41	80	121
1950	36	5	46	34	41	80	121
1951	36	5	46	34	41	80	121
1952	36	5	46	34	41	80	121
1953	36	5	46	34	41	80	121
1954	36	5	46	34	41	80	121
1955	36	5	46	34	41	80	121
1956	36	5	46	34	41	80	121
1957	36	5	46	34	41	80	121
1958	36	5	46	34	41	80	121
1959	36	5	46	34	41	80	121
1960	36	5	46	34	41	80	121
1961	36	5	46	34	41	80	121
1962	36	5	46	34	41	80	121
1963	36	5	46	34	41	80	121
1964	36	5	46	34	41	80	121
1965	36	5	46	34	41	80	121
1966	36	5	46	34	41	80	121
1967	36	5	46	34	41	80	121
1968	36	5	46	34	41	80	121
1969	36	5	46	34	41	80	121
1970	36	5	46	34	41	80	121
1971	36	5	41	30	41	71	112
1972	36	5	55	41	41	96	137
1973	36	5	65	48	41	113	154
1974	36	5	78	57	41	135	176
1975	36	5	50	37	41	87	128
1976	36	5	37	27	41	64	105
1977	36	5	91	67	41	158	199
1978	41	5	77	57	46	134	180
1979	23	11	102	75	34	177	211
1980	18	8	117	107	26	224	250
1981	28	16	165	36	44	201	245
1982	25	7	230	106	32	336	368
1983	33	9	100	30	42	130	172
1984	51	28	174	90	79	264	343
1985	55	33	97	110	88	207	295
1986	103	28	191	99	131	290	421
1987	32	20	46	189	52	235	287
1988	29	2	72	119	31	191	222
1989	122	12	113	66	134	179	313
1990	129	11	82	74	140	156	296
1991	174	19	71	64	193	135	328
1992	152	27	59	53	179	112	291
1993	139	23	18	73	162	91	253
1994	216	12	50	105	228	155	383
1995	111	3	23	141	114	164	278
1996	72	2	72	93	74	165	239
1997	80	1	5	7	81	12	93
1998	82	0	31	30	82	61	143
1999	18	0	99	52	18	151	169
2000	5	0	35	59	5	94	99
2001	3	0	17	31	3	48	51
2002	5	0	30	31	5	61	66
2003	0	0	60	59	0	119	119
2004	5	0	133	34	5	167	172

Table 4. Catch (mtons) of vermilion rockfish in northern California.

	Hook&Line	SetNet	Trawl	Commercial	Recreational	Total
pre-1950	50	0	2	52	22	74
1950	46	0	2	48	22	70
1951	45	0	2	47	28	75
1952	44	0	2	46	19	65
1953	43	0	2	45	14	59
1954	42	0	2	44	17	61
1955	41	0	4	45	21	66
1956	40	0	4	44	18	62
1957	39	0	4	43	21	64
1958	38	0	5	43	31	74
1959	37	0	3	40	27	67
1960	36	0	4	40	27	67
1961	35	0	2	37	17	54
1962	34	0	2	36	20	56
1963	34	0	3	37	17	54
1964	33	0	8	41	17	58
1965	32	0	13	45	20	65
1966	31	0	20	51	27	78
1967	30	0	32	62	27	89
1968	29	0	30	59	26	85
1969	28	0	34	62	28	90
1970	27	0	38	65	34	99
1971	26	0	43	69	26	95
1972	25	0	48	73	36	109
1973	24	0	62	86	46	132
1974	23	0	51	74	48	122
1975	22	0	47	69	46	115
1976	21	0	37	58	52	110
1977	20	0	29	49	45	94
1978	4	0	23	27	39	66
1979	2	0	35	37	43	80
1980	34	0	51	85	54	139
1981	2	0	18	20	26	46
1982	30	0	15	45	65	110
1983	25	2	27	54	45	99
1984	1	6	44	51	52	103
1985	1	13	43	57	42	99
1986	31	31	4	66	54	120
1987	29	66	43	138	28	166
1988	56	49	21	126	72	198
1989	34	6	3	43	88	131
1990	61	61	1	123	113	236
1991	126	14	1	141	146	287
1992	104	0	10	114	212	326
1993	151	20	21	192	200	392
1994	85	11	15	111	137	248
1995	50	11	16	77	76	153
1996	64	9	10	83	52	135
1997	64	7	14	85	46	131
1998	44	6	28	78	77	155
1999	34	0	9	43	81	124
2000	13	0	1	14	77	91
2001	11	0	3	14	75	89
2002	6	0	0	6	82	88
2003	6	0	0	6	204	210
2004	10	0	0	10	72	82

Table 5. Sample sizes (number of fish) of length compositions by fishery segment and year.

Year	Southern California					Northern California				
	Hook&Line	SetNet	Partyboat	Private boat	Sum	Hook&Line	SetNet	Trawl	Recreational	Sum
1975			1341		1341					
1976			1520		1520					
1977			2063		2063					
1978			2099		2099				31	31
1979									83	83
1980			154	177	331	19			99	118
1981			248	81	329				47	47
1982			288	216	504				107	107
1983			219	83	302			35	92	127
1984			424	118	542			109	138	247
1985			366	160	526			36	149	185
1986	356	172	1838	144	2510	17			130	147
1987	119	55	2237	114	2525		28	13	247	288
1988	118		2789	100	3007		28		785	813
1989	367	13	2351	115	2846		21		1361	1382
1990	40				40	12	111		583	706
1991	31				31	87			388	475
1992	106	51			157	410		13	1173	1596
1993			20	83	103	1222	66	61	1602	2951
1994	99		55	84	238	563	51	12	1103	1729
1995	512	26	41	91	670	290	96		1204	1590
1996	336	59	201	97	693	534	36	44	1046	1660
1997	635		13	12	660	421	34	59	1316	1830
1998	898	20	281	28	1227	242	70		848	1160
1999	91		1164	230	1485	536		21	825	1382
2000			835	131	966	151			326	477
2001	14		288	81	383	111			270	381
2002	96		985	123	1204	75			613	688
2003			1097	301	1398	24			1091	1115
2004			2028	1305	3333	40			3105	3145
Sum	3818	396	24945	3874	33033	4754	541	403	18762	24460

Table 6. Sample sizes (Ntrips) of length compositions by fishery segment and year.

	Southern California					Northern California				
Year	Hook&Line	SetNet	Partyboat	Private boat	Sum	Hook&Line	SetNet	Trawl	Recreational	Sum
1975			175		175					
1976			199		199					
1977			167		167					
1978			160		160				25	25
1979									24	24
1980			51	79	130	1			71	71
1981			41	40	81				34	34
1982			40	70	110				78	78
1983			57	38	95			4	61	65
1984			158	56	214			16	87	103
1985			98	68	166			6	81	87
1986	61	142	241	49	493	1			75	76
1987	30	86	195	32	343		2	1	63	66
1988	16		233	34	283		2		119	121
1989	50	14	237	34	335		7		160	167
1990	4				4	3	8		45	56
1991	1				1	6			56	62
1992	11	11			22	77		1	125	203
1993			11	35	46	170	3	11	334	518
1994	6		31	33	70	107	4	1	262	374
1995	37	7	15	31	90	57	10		168	235
1996	47	28	41	37	153	77	2	2	237	318
1997	53		8	10	71	61	2	6	294	363
1998	71	2	62	15	150	24	3		285	312
1999	7		205	85	297	87		2	230	319
2000			121	35	156	64			116	180
2001	1		78	24	103	47			101	148
2002	4		150	47	201	18			176	194
2003			137	80	217	8			275	283
2004			n/a	n/a	n/a	17			n/a	17
Sum	399	290	2911	932	4532	824	43	24	3424	4315

Table 7a. CPUE abundance indexes (year effects) from GLM analyses of the RecFIN intercept sampling.data, and sample sizes.

	Southern California				Northern California			
Year	Year effect	CV	Ntrips	Npos	Year effect	CV	Ntrips	Npos
1980	0.040	0.66	27	8	0.0044	0.43	43	11
1981	0.118	0.46	19	8	0.0017	0.58	16	4
1982	0.027	0.58	27	5	0.0075	0.54	14	6
1983	0.056	0.42	33	14	0.0023	0.58	21	4
1984	0.199	0.36	33	22	0.0059	0.40	28	12
1985	0.292	0.43	37	17	0.0035	0.36	43	15
1986	0.419	0.45	39	24	0.0032	0.37	38	11
1987	0.418	0.57	8	5	0.0047	0.40	22	8
1988	0.405	0.62	17	12	0.0140	0.32	24	14
1989	0.171	0.56	12	11	0.0166	1.04	7	2
1993	0.202	0.91	5	2	0.0076	0.34	44	19
1994	0.290	0.77	12	4	0.0097	0.36	39	19
1995	0.045	0.60	12	5	0.0140	0.47	23	12
1996	0.204	0.38	18	11	0.0108	0.28	63	32
1997	0.067	0.82	10	3	0.0687	0.13	165	121
1998	0.123	0.46	38	15	0.0390	0.22	53	32
1999	0.412	0.26	70	46	0.0183	0.20	71	43
2000	0.307	0.32	78	51	0.0213	0.57	15	9
2001	0.188	0.28	52	28	0.0170	0.32	38	18
2002	0.536	0.25	99	67	0.0212	0.25	41	28
2003	0.803	0.24	94	62	0.0419	0.16	55	49
Total			740	420			863	469

Table 7b. Analyses of deviance for the delta-GLM abundance indexes.

Partyboat catch/hour from Southern California RecFIN

	Df	Deviance Resid.	Df	Resid. Dev		
Presence-Absence (binomial)						P(>|Chi|)
NULL			739	1012.30		
YEAR	20	66.52	719	945.78		6.7E-07
AREA	1	0.37	718	945.41		5.4E-01
CNTY	4	7.60	714	937.81		1.1E-01
WAVE	5	13.31	709	924.50		2.0E-02
Positive Observations (gamma)					F	Pr(>F)
NULL			419	759.59		
YEAR	20	139.68	399	619.91	3.75	1.7E-07
AREA	1	9.66	398	610.25	5.19	2.3E-02
CNTY	4	7.73	394	602.52	1.04	3.9E-01
WAVE	5	43.60	389	558.92	4.68	3.7E-04

Partyboat catch/hour from Northern California RecFIN

	Df	Deviance Resid.	Df	Resid. Dev		
Presence-Absence (binomial)						P(>|Chi|)
NULL			862	1189.85		
YEAR	20	120.92	842	1068.93		1.9E-16
CNTY	6	59.53	836	1009.39		5.6E-11
WAVE	1	11.58	835	997.81		6.7E-04
Positive Observations (gamma)					F	Pr(>F)
NULL			468	547.95		
YEAR	20	174.92	448	373.02	11.35	2.2E-16
CNTY	6	66.57	442	306.46	14.40	5.1E-15
WAVE	1	0.93	441	305.52	1.21	2.7E-01

Partyboat catch/hour from Northern California CDFG monitoring

	Df	Deviance Resid.	Df	Resid. Dev		
Presence-Absence (binomial)						P(>|Chi|)
NULL			1997	2757.93		
shiftyear	12	49.36	1985	2708.57		1.8E-06
month	2	29.50	1983	2679.07		3.9E-07
location	69	378.13	1914	2300.94		3.4E-44
depthbin	7	10.89	1907	2290.05		1.4E-01
Positive Observations (gamma)					F	Pr(>F)
NULL			1075	1233.51		
shiftyear	12	65.22	1063	1168.29	6.44	4.1E-11
month	2	16.39	1061	1151.90	9.71	6.7E-05
location	69	422.91	992	728.99	7.26	2.2E-16
depthbin	7	14.48	985	714.51	2.45	1.7E-02

Table 8. Values of effects in GLM models of recreational partyboat CPUE.

Southern California RecFIN		Northern California RecFIN	
County		County	
sandiego	0.1800	sanluis	0.0391
orange	0.1216	monterey	0.0097
losangeles	0.1878	santacruz	0.0168
ventura	0.2047	sanmateo	0.0118
stabarbara	0.3231	alameda	0.0052
		sonoma	0.0089
		mendocino	0.0053
Wave		Wave	
1	0.1558	1 and 6	0.0084
2	0.4265	2 thru 5	0.0144
3	0.1247		
4	0.0831		
5	0.2849	**Northern California**	
6	0.2741	**CDFG**	
		Season	
Area		Dec-Mar	0.0014
Nearshore	0.1535	Apr-July	0.0020
Offshore	0.2516	Aug-Nov	0.0024

Table 9. CPUE abundance indexes (year effects) from GLM analyses of the CDFG northern California partyboat monitoring data, and sample sizes.

Year	Year effect	CV	Nsite visits	Npos
1987	0.00073	0.49	45	12
1988	0.00152	0.25	160	85
1989	0.00229	0.24	222	132
1990	0.00296	0.24	98	60
1991	0.00178	0.28	69	48
1992	0.00260	0.27	216	127
1993	0.00246	0.26	216	124
1994	0.00173	0.32	209	115
1995	0.00225	0.33	233	118
1996	0.00157	0.47	226	93
1997	0.00195	0.37	173	87
1998	0.00258	0.32	126	67
Total			1993	1068

Table 10. Likelihood components for pre-STAR vermilion rockfish models.

Southern California (PSSOUTH)		
Total neg log likelihood	750.27	
Indices	33.22	
RecFIN CPUE		33.22
Length comps	682.03	
Hook&Line		135.37
SetNet		56.18
Rec Partyboat		303.94
Rec Private boat		186.55
Age Comps	14.64	
Stock-Recruitment Relationship	20.02	
Parameter Priors	0.35	

Northern California (PSNORTH)		
Total neg log likelihood	657.56	
Indices	63.10	
RecFIN CPUE		57.77
CDFG CPUE		5.34
Length comps	564.41	
Hook&Line		141.81
SetNet		74.33
Trawl		70.18
Recreational		278.08
Stock-Recruitment Relationship	27.34	
Parameter Priors	2.71	

Table 11. Sensitivity analysis of pre-STAR southern California model (PSSOUTH). Base model is shown in bold.

	Emphasis at 0.1					Emphasis at 10				
	B2005	Depl2005	F50%	ABC2005	like	B2005	Depl2005	F50%	ABC2005	like
Base model (emph 1)	**6061**	**1.20**	**0.0478**	**289**	**750.3**					
CPUE										
RecFIN Partyboat	257	0.03	0.0483	12	714.3	8519	1.53	0.0460	392	1025.4
LenComps										
Hook&Line	5817	1.15	0.0476	277	624.8	13740	1.21	0.0392	539	1732.0
SetNet	6064	1.19	0.0478	290	699.1	5078	1.02	0.0475	241	1220.7
Partyboat	7555	1.24	0.0437	330	448.9	84	0.01	0.0496	4	3218.9
Private boat	6322	1.30	0.0486	307	573.5	6814	0.94	0.0424	289	2268.8
AgeComps										
NWFSC Survey	5400	1.06	0.0482	260	735.6	10485	2.10	0.0468	491	824.6
Finit	6055	1.20	0.0478	289	750.2	6062	1.20	0.0478	290	750.3
Stock-Recruitment										
Ricker (emph 1)	**6061**	**1.20**	**0.0478**	**289**	**750.3**					
Ricker	6996	1.39	0.0480	335	729.4	3455	0.69	0.0464	160	871.2
Beverton-Holt (emph 1)	4622	0.48	0.0477	220	753.5					
Beverton-Holt	6355	0.66	0.0479	304	730.9	2462	0.26	0.0465	115	885.2

Table 11a. Sensitivity analysis of pre-STAR southern California model, cont. Base model is shown in bold.

	Emphasis at 0.1					
	B2005	Depl2005	F50%	ABC2005	like	notes
Base model (emph 1)	**6061**	**1.20**	**0.0478**	**289**	**750.3**	
Natural Mort Rate (emph 1)						
M=0.06	5036	0.61	0.0342	172	755.7	
M=0.08	5157	0.84	0.0413	213	754.0	
M=0.10	**6061**	**1.20**	**0.0478**	**289**	**750.3**	
M=0.12	6296	1.31	0.0535	337	750.7	
M=0.14	6732	1.35	0.0586	394	753.8	
Externally est growth parameters						L(tot)-L(priors) = 749.9 in base model
M=0.08	5296	0.77	0.0401	212	798.9	L(tot)-L(priors) = 777.7
M=0.10	5545	0.99	0.0467	259	795.6	L(tot)-L(priors) = 774.0
M=0.12	6018	1.11	0.0526	316	794.9	L(tot)-L(priors) = 772.9
M=0.10, B&H SRR	4889	0.47	0.0466	228	799.4	L(tot)-L(priors) = 777.9
First year to estimate rect devs						
1950	**6061**	**1.20**	**0.0478**	**289**	**750.3**	LnR(0) = 5.56; R large in early 1950s
1960	5526	1.11	0.0477	264	751.6	LnR(0) = 5.54; R small 1960-1970
1970	6697	1.11	0.0443	297	760.1	LnR(0) = 5.31; R large in early 1970s

Table 12. Sensitivity analysis of pre-STAR northern California model (PSNORTH). Base model is shown in bold.

	Emphasis at 0.1					Emphasis at 10				
	B2005	Depl2005	F50%	ABC2005	like	B2005	Depl2005	F50%	ABC2005	like
Base Model (emph 1)	**11035**	**1.48**	**0.0468**	**517**	**657.5**					
CPUE										
RecFIN Partyboat	6824	1.04	0.0475	324	601.2	21456	1.94	0.0455	976	1080.3
CDFG Partyboat	11154	1.54	0.0470	524	653.1	8364	1.20	0.0463	387	696.6
LenComps										
Hook&Line	11436	1.46	0.0460	526	527.9	9427	1.40	0.0478	451	1873.1
SetNet	11527	1.46	0.0468	540	590.3	9047	1.45	0.0470	426	1304.9
Trawl	10915	1.46	0.0472	515	593.8	18520	1.50	0.0438	811	1270.0
Recreational	10101	1.62	0.0458	462	392.4					
Finit	11035	1.48	0.0468	517	657.5	10615	1.49	0.0469	498	658.0
Stock-Recruitment										
Ricker (emph 1)	**11035**	**1.48**	**0.0468**	**517**	**657.5**					
Ricker	20033	1.89	0.0468	937	624.6	5503	1.16	0.0476	262	773.6
Beverton-Holt (emph 1)	8956	1.08	0.0477	427	691.4					
Beverton-Holt	22040	2.51	0.0469	1033	631.1	2605	0.35	0.0496	129	854.6

Table 12a. Sensitivity analysis of pre-STAR northern California model, cont. Base model is shown in bold.

	Emphasis at 0.1					
	B2005	Depl2005	F50%	ABC2005	like	notes
Base Model (emph 1)	**11035**	**1.48**	**0.0468**	**517**	**657.5**	
Natural Mort Rate (emph 1)						
M=0.06	8209	1.45	0.0328	269	649.7	
M=0.08	9309	1.46	0.0402	374	654.3	
M=0.10	**11035**	**1.48**	**0.0468**	**517**	**657.5**	
M=0.12	15877	1.46	0.0426	676	659.9	
M=0.14	14866	1.48	0.0527	783	659.7	
Externally est growth parameters						L(tot)-L(priors) = 654.9 in base model
M=0.08	7150	1.26	0.0398	285	672.0	L(tot)-L(priors) = 663.7
M=0.10	8003	1.33	0.0469	375	674.4	L(tot)-L(priors) = 666.9
M=0.12	9964	1.37	0.0534	532	675.2	L(tot)-L(priors) = 667.8
M=0.10, B&H SRR	9412	0.97	0.0482	454	696.5	L(tot)-L(priors) = 690.7
First year to estimate rect devs						
1950	**11035**	**1.48**	**0.0468**	**517**	**657.5**	LnR(0) = 6.54; 1956 yearclass is large
1960	9939	1.51	0,0470	467	661.2	LnR(0) = 6.29; 1961 yearclass is large
1970	12988	1.95	0.0483	627	697.5	LnR(0) = 6.26; 1970-77 yearclasses small

Table 13. Effective sample sizes and re-scaled Cvs of abundance indexes for STAR models. Values are scaled to produce approximately N(0,1) residuals.

	Southern California					Northern California					
	Effective Sample Size				Rescaled CV	Effective Sample Size				Rescaled CV	
Year	Hook&Line	SetNet	Partyboat	Private boat	RecFIN	Hook&Line	SetNet	Trawl	Recreational	RecFIN	CDFG
1975			200								
1976			215								
1977			257								
1978			260						32		
1979									61		
1980			56	63	1.3	4			68	1.29	
1981			74	39	0.9				42	1.73	
1982			81	71	1.2				72	1.62	
1983			69	39	0.8			8	65	1.73	
1984			101	49	0.7			35	85	1.19	
1985			93	59	0.8			9	89	1.09	
1986	38	65	240	55	0.9	4			82	1.12	
1987	21	16	270	48	1.1		7	2	124	1.19	0.56
1988	20		307	44	1.2		7		262	0.96	0.29
1989	39	3	278	48	1.1		6		374	3.12	0.28
1990	11					3	15		216		0.28
1991	10					14			166		0.33
1992		15				48		2	339		0.31
1993			17	39	1.8	115	11	17	415	1.01	0.3
1994	19		31	39	1.5	61	10	2	326	1.07	0.37
1995	47	6	26	41	1.2	36	14		345	1.4	0.38
1996	37	18	65	43	0.8	59	8	11	315	0.85	0.54
1997	54		13	12	1.6	49	8	16	366	0.39	0.43
1998	65	5	80	20	0.9	31	12		275	0.67	0.37
1999	18		184	74	0.5	59		4	270	0.6	
2000			151	52	0.6	21			148	1.72	
2001	6		81	39	0.6	17			131	0.94	
2002	18		166	50	0.5	12			223	0.77	
2003			177	87	0.5	5			324	0.47	
2004			254	216		7			638		

Table 14. Projections and decision table for southern California vermilion rockfish.

Management Action	year	Catch Hook&Line	Catch CPFV	Catch Private	Catch Total	State of Nature: CPUE emph2 approx lower bound SpawnBio	CPUE emph2 Depletion		CPUE emph5 approx upper bound SpawnBio	CPUE emph5 Depletion	
assume CPUE emph 2	2005	10	135	35	180	2029	30%	5%	11072	88%	1%
	2006	10	135	35	180	2464	37%	5%	13153	104%	1%
	2007	7	117	32	156	2731	41%	4%	14552	115%	1%
	2008	7	113	31	151	2868	43%	4%	15300	121%	1%
	2009	8	111	29	148	2923	43%	4%	15609	124%	1%
	2010	8	111	28	147	2938	44%	4%	15648	124%	1%
	2011	8	111	28	147	2934	44%	4%	15524	123%	1%
	2012	8	111	28	147	2925	43%	4%	15300	121%	1%
	2013	7	112	27	146	2916	43%	4%	15018	119%	1%
	2014	7	112	27	146	2909	43%	4%	14705	116%	1%
	2015	7	112	27	146	2903	43%	4%	14378	114%	1%
	2016	7	112	27	146	2898	43%	4%	14048	111%	1%
assume CPUE emph 5	2005	10	135	35	180	2029	30%	5%	11072	88%	1%
	2006	10	135	35	180	2464	37%	5%	13153	104%	1%
	2007	29	469	131	629	2731	41%	18%	14552	115%	4%
	2008	28	423	115	566	2471	37%	18%	14873	118%	3%
	2009	28	391	102	521	2131	32%	20%	14766	117%	3%
	2010	27	368	93	488	1768	26%	22%	14409	114%	3%
	2011	26	351	86	463	1414	21%	26%	13916	110%	3%
	2012	25	336	81	442	1079	16%	32%	13357	106%	3%
	2013	24	323	77	424	766	11%	42%	12777	101%	3%
	2014	22	312	74	408	**472**	**7%**	52%	12201	97%	3%
	2015	22	302	71	395	**242**	**4%**	62%	11646	92%	3%
	2016	21	293	69	383	**93**	**1%**	72%	11123	88%	3%

note: bold values indicate that model was unable to take specified catch

Table 15. Projections and decision table for northern California vermilion rockfish.

Management Action	year	Catch Hook&Line	Catch Sport	Catch Total	State of Nature: h=0.65 approx lower bound SpawnBio	Depletion	Exp Rate	h=1 approx upper bound SpawnBio	Depletion	Exp Rate
assume h=0.65	2005	10	90	100	4205	43%	2%	4920	89%	2%
	2006	15	90	105	4234	44%	2%	5407	98%	2%
	2007	25	196	221	4259	44%	4%	5753	104%	4%
	2008	25	197	222	4195	43%	4%	5790	105%	4%
	2009	25	197	222	4150	43%	4%	5686	103%	4%
	2010	25	198	223	4123	42%	4%	5491	99%	4%
	2011	25	198	223	4107	42%	4%	5241	95%	3%
	2012	25	198	223	4098	42%	4%	4962	90%	3%
	2013	25	198	223	4094	42%	4%	4670	84%	3%
	2014	25	198	223	4093	42%	4%	4378	79%	3%
	2015	25	198	223	4093	42%	4%	4094	74%	3%
	2016	25	198	223	4095	42%	4%	3823	69%	3%
assume h=1	2005	10	90	100	4205	43%	2%	4920	89%	2%
	2006	15	90	105	4234	44%	2%	5407	98%	2%
	2007	37	206	243	4259	44%	3%	5753	104%	3%
	2008	35	190	225	4168	43%	3%	5758	104%	3%
	2009	33	177	210	4113	42%	3%	5647	102%	3%
	2010	31	166	197	4090	42%	3%	5467	99%	3%
	2011	30	158	188	4094	42%	4%	5252	95%	3%
	2012	28	150	178	4114	42%	4%	5025	91%	3%
	2013	27	144	171	4152	43%	4%	4797	87%	3%
	2014	25	139	164	4200	43%	4%	4578	83%	3%
	2015	24	135	159	4257	44%	5%	4372	79%	3%
	2016	23	132	155	4321	44%	5%	4183	76%	3%

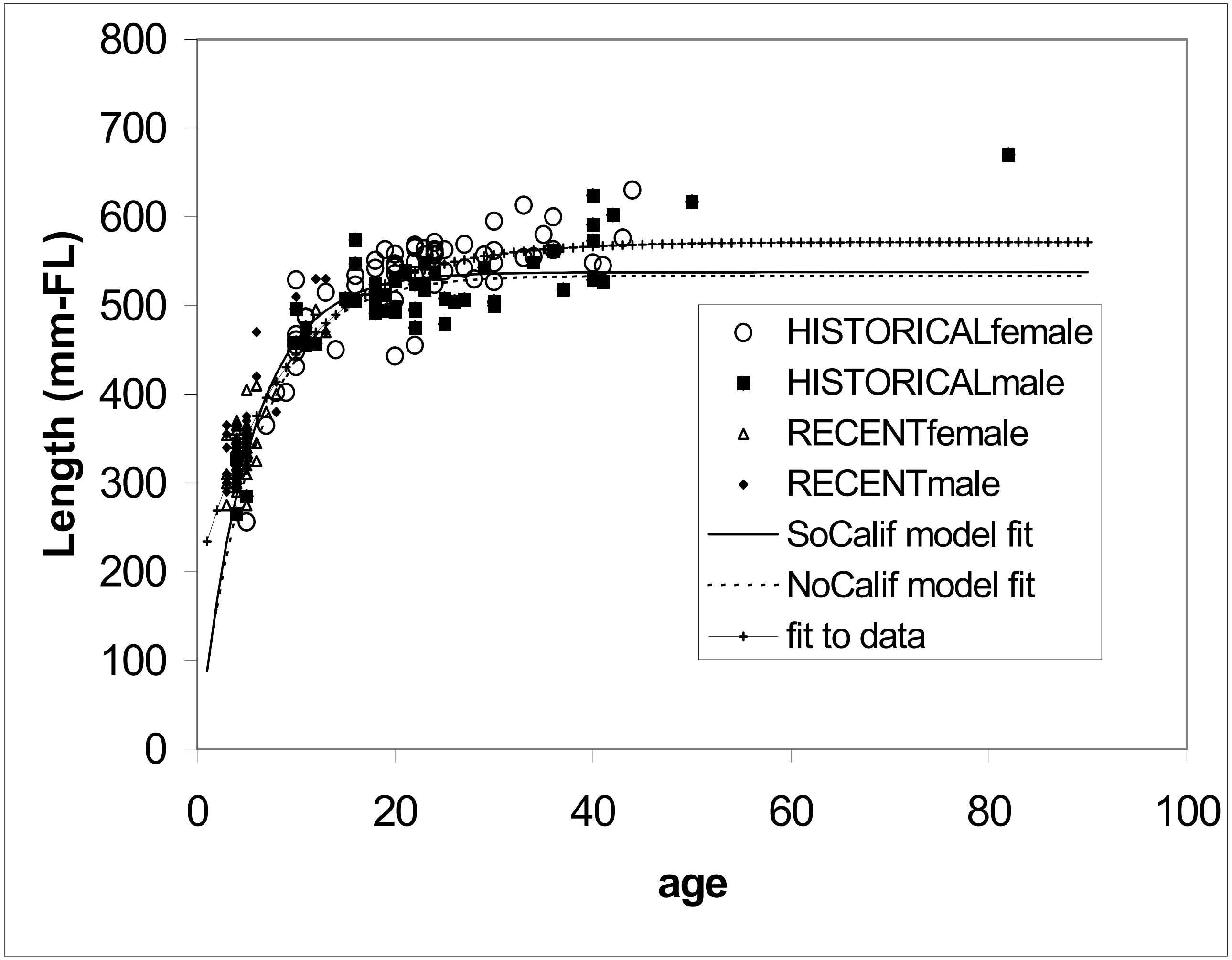


Figure 1. Vermilion rockfish age and growth. Length and age of 138 vermilion rockfish from northern California fisheries monitoring samples (called "Historical"), and 133 vermilion rockfish collected on a 2003 NWFSC survey in southern California (called "Recent"). Unconstrained SS2 model fit to length compositions is compared to least squares fit to these data.

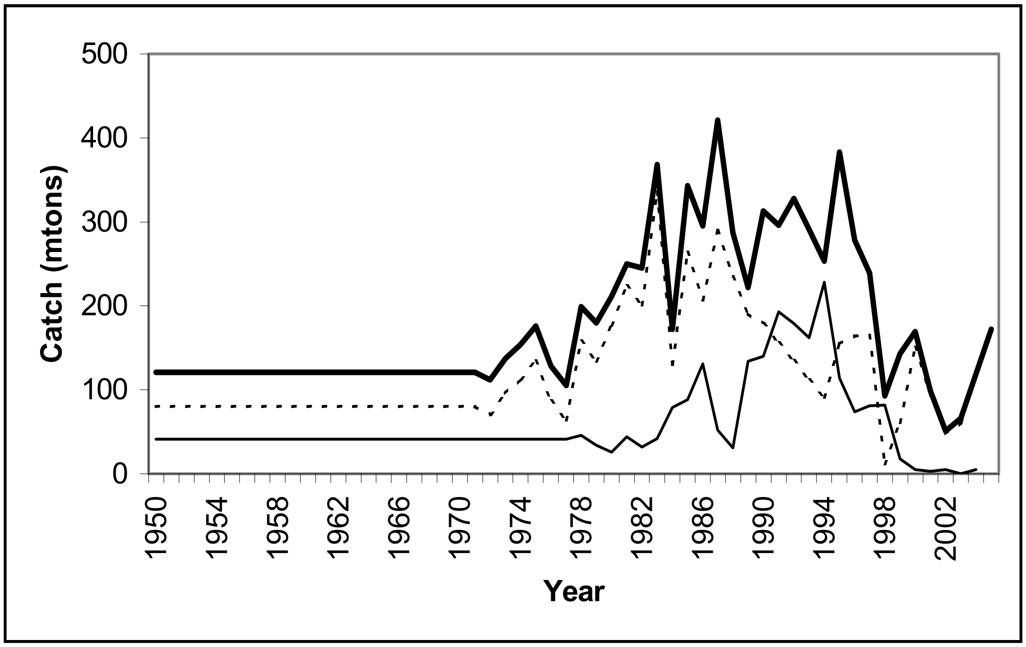


Figure 2. Historical catches of vermilion rockfish in southern California. Light solid line is commercial catch, light broken line is recreational catch, heavy solid line is total catch.

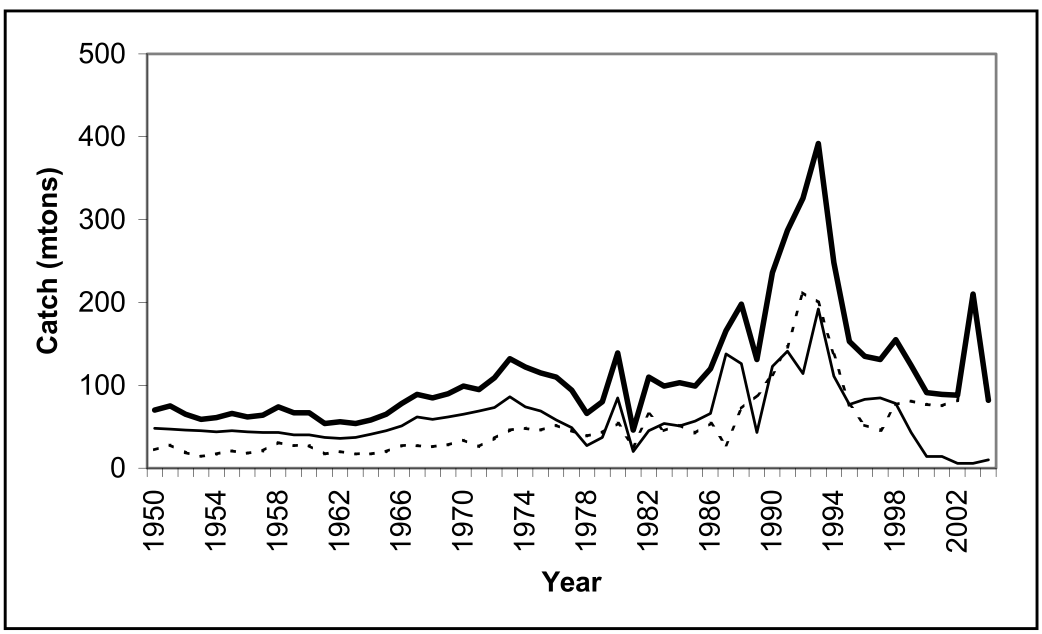


Figure 3. Historical catches of vermilion rockfish in northern California. Light solid line is commercial catch, light broken line is recreational catch, heavy solid line is total catch.

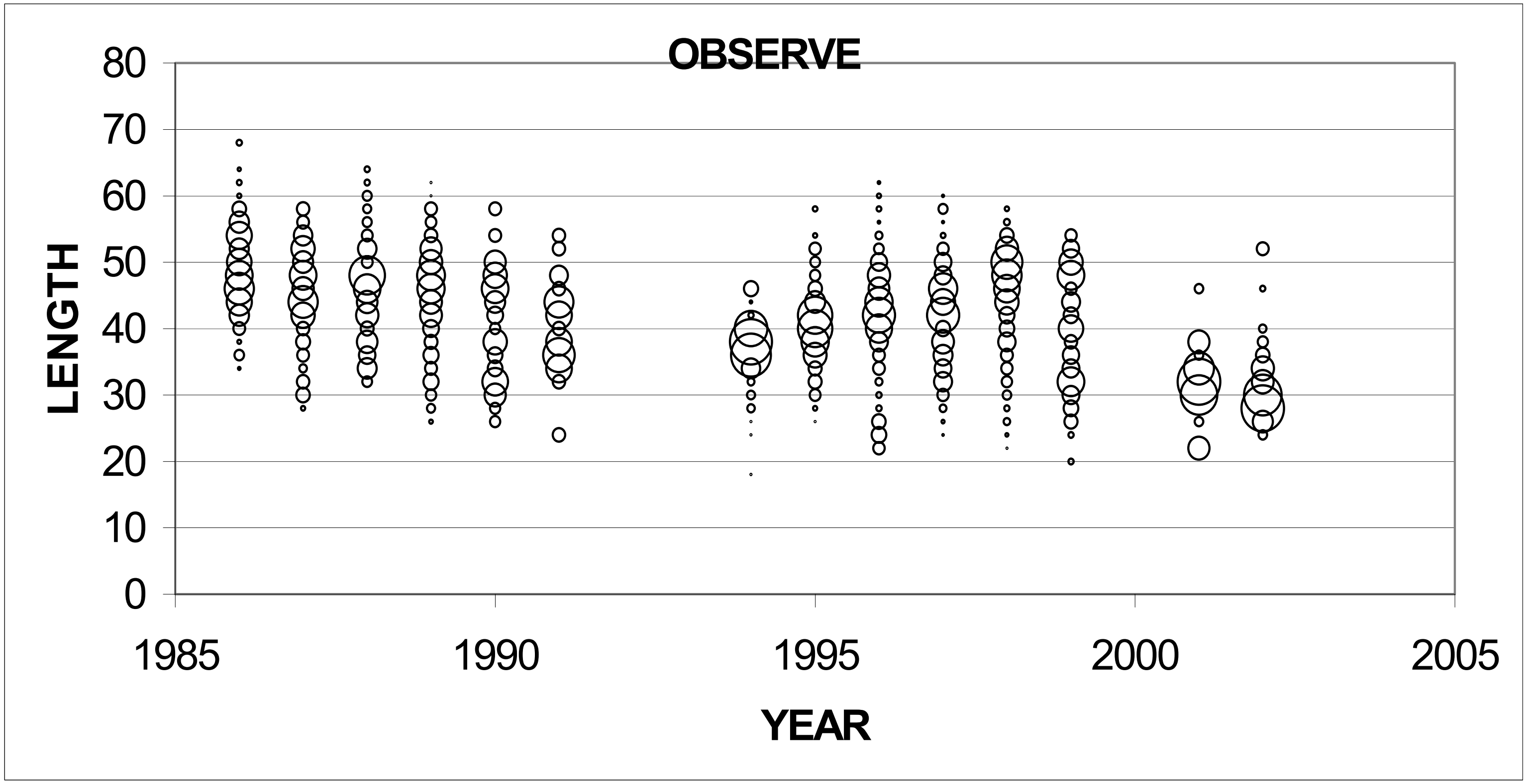


Figure 4a. Observed length composition of vermilion rockfish caught by southern California commercial hook and line fishery.

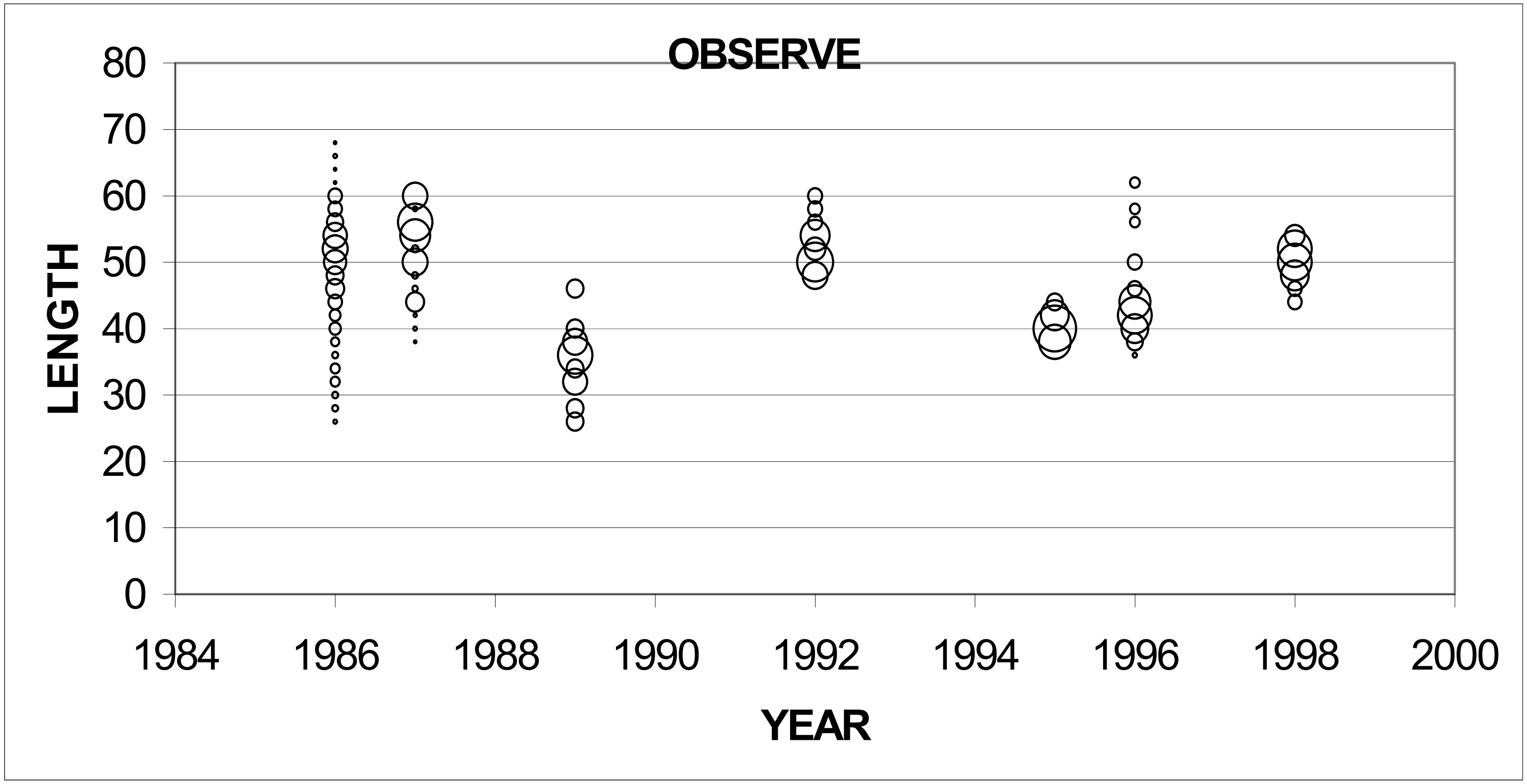


Figure 4b. Observed length composition of vermilion rockfish caught by southern California commercial set net fishery.

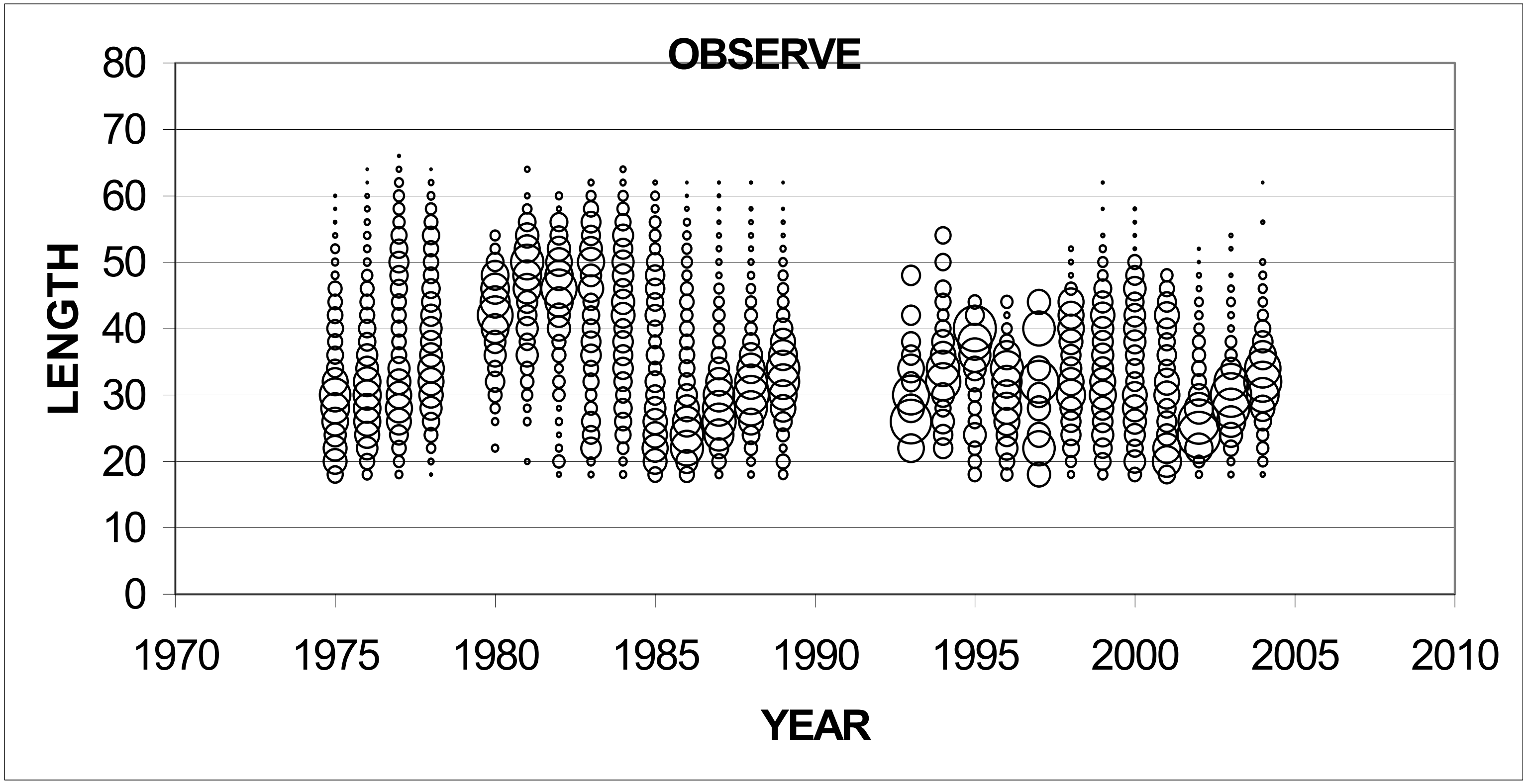


Figure 4c. Observed length composition of vermilion rockfish caught by southern California partyboat (CPFV) recreational fishery.

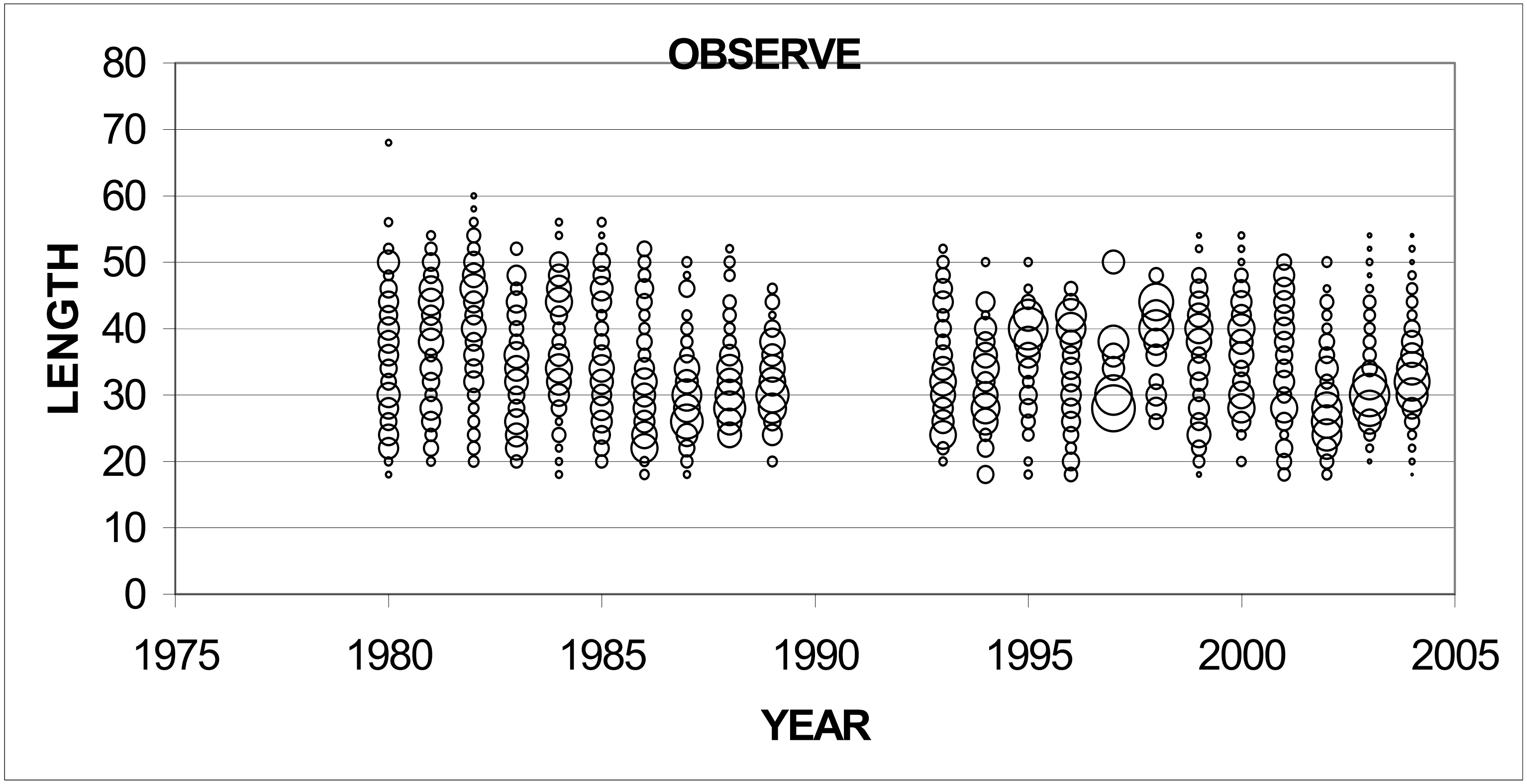


Figure 4d. Observed length composition of vermilion rockfish caught by southern California private boat recreational fishery.

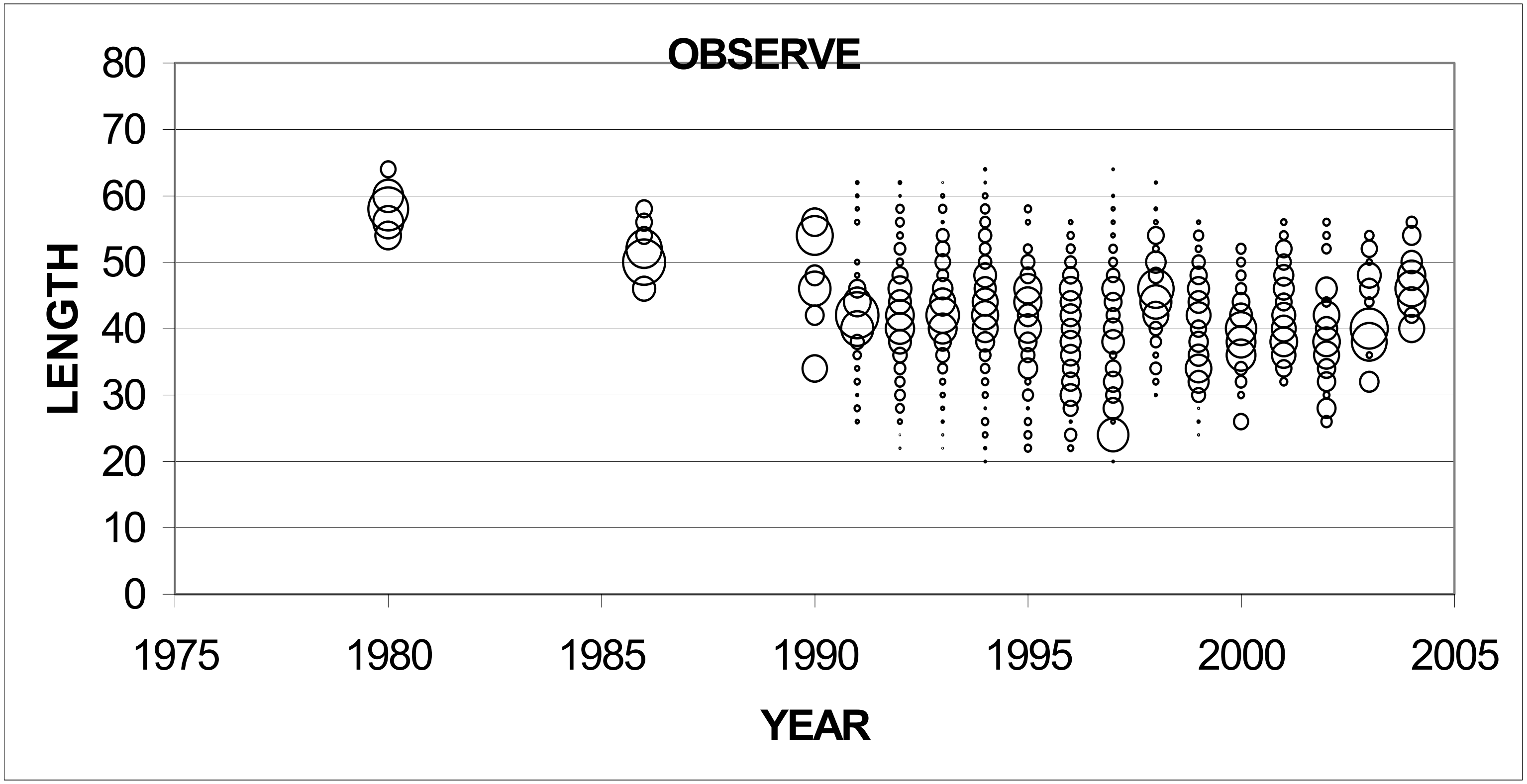


Figure 5a. Observed length composition of vermilion rockfish caught by northern California commercial hook and line fishery.

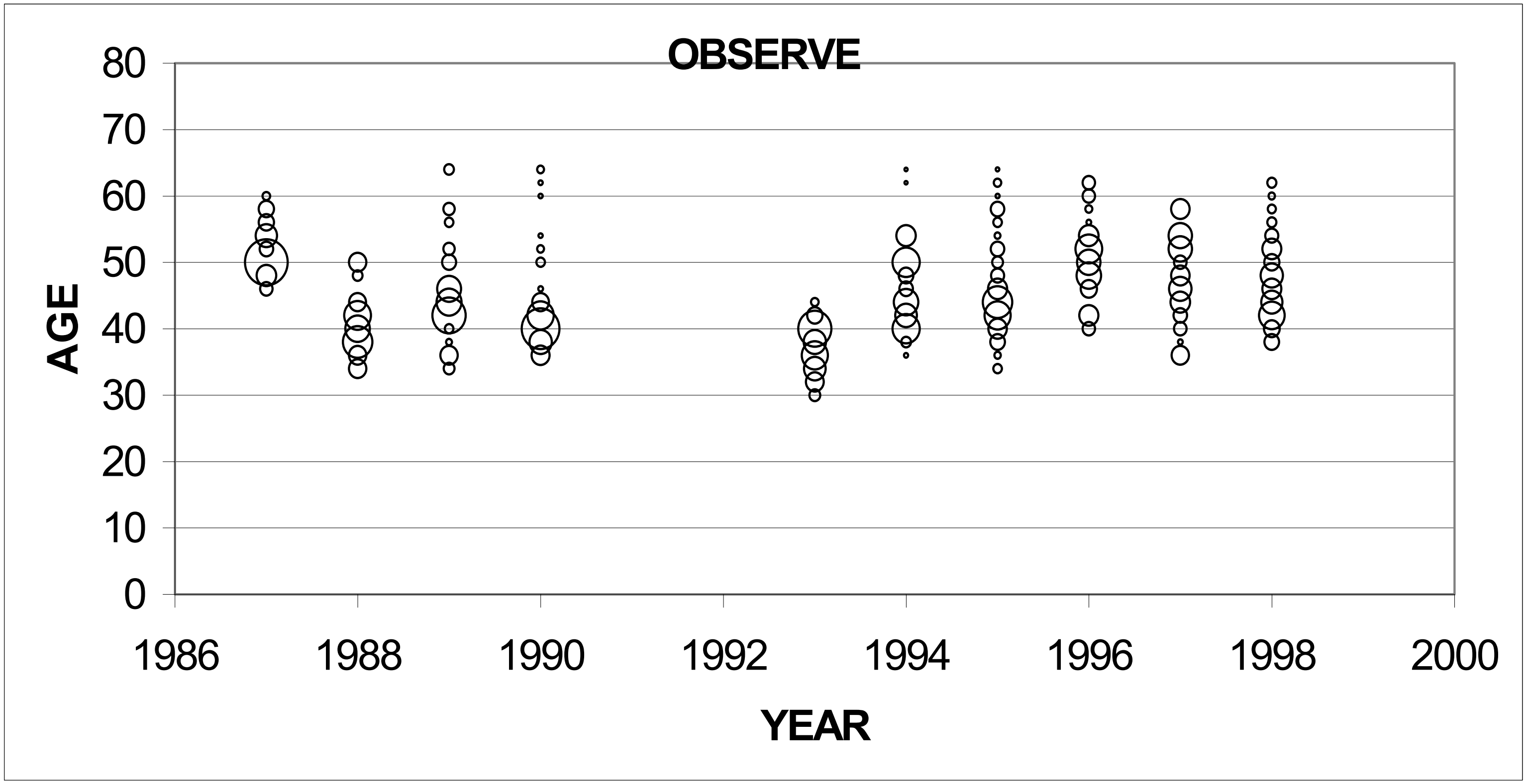


Figure 5b. Observed length composition of vermilion rockfish caught by northern California commercial set net fishery.

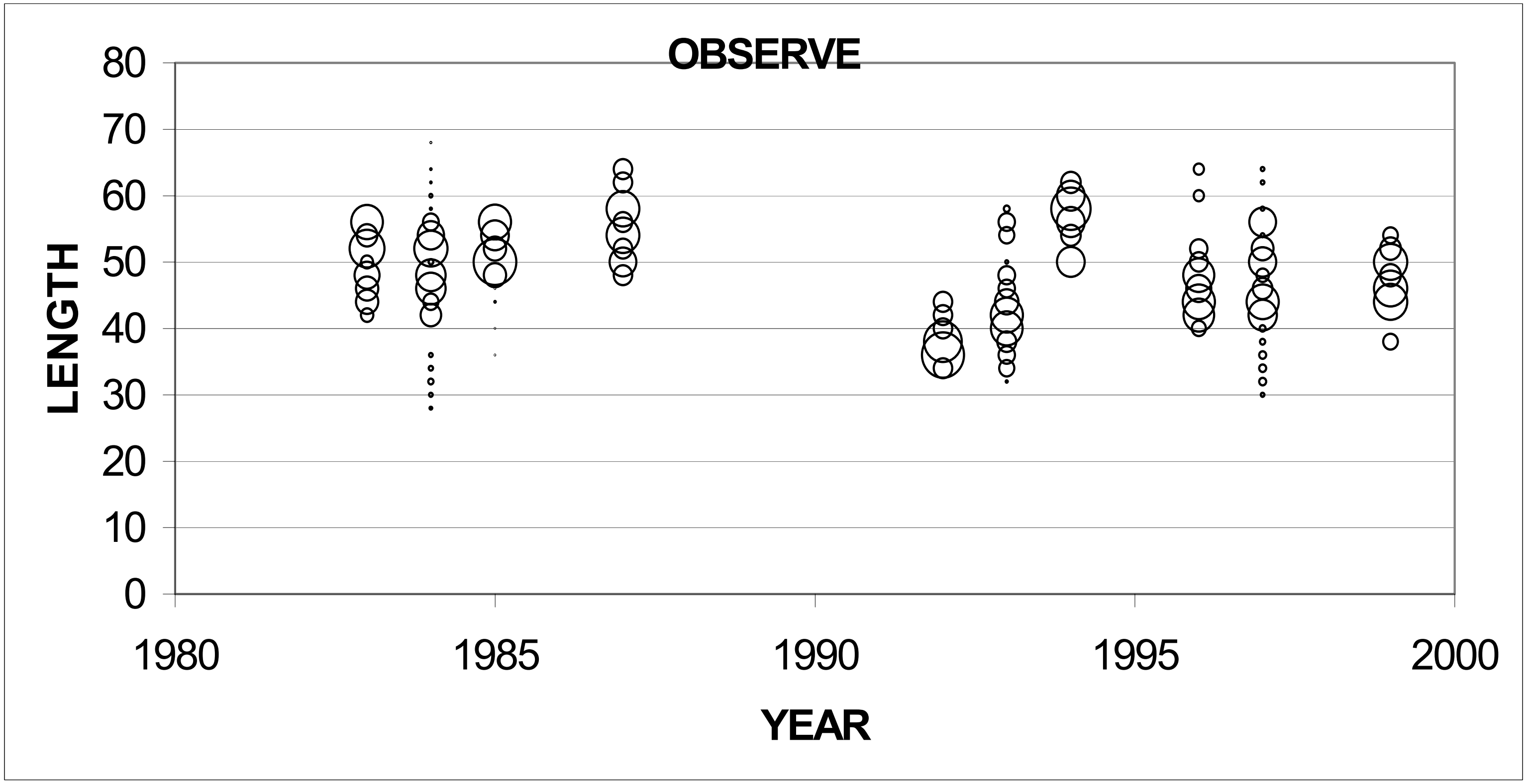


Figure 5c. Observed length composition of vermilion rockfish caught by northern California commercial trawl fishery.

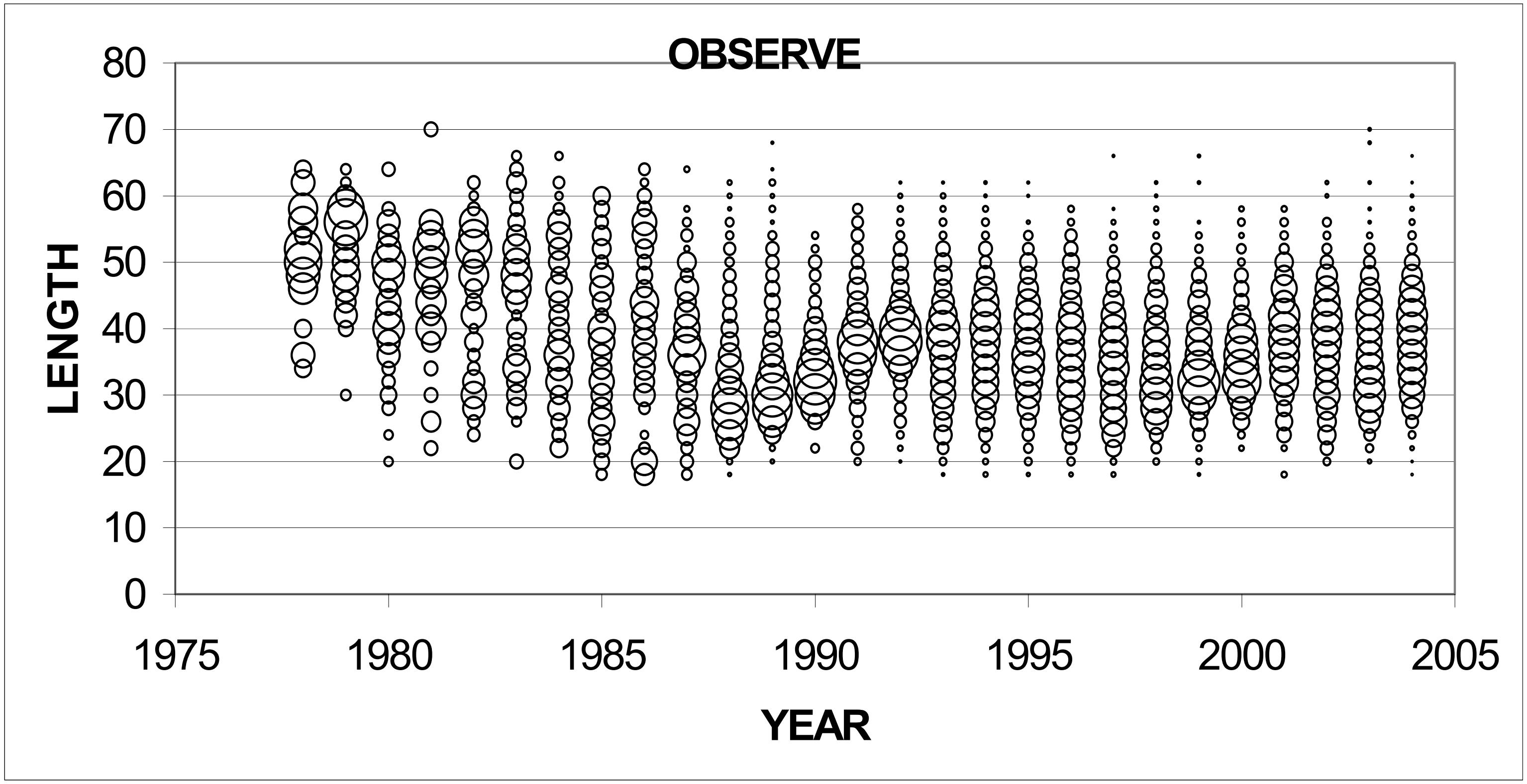


Figure 5d. Observed length composition of vermilion rockfish caught by northern California combined recreational fisheries

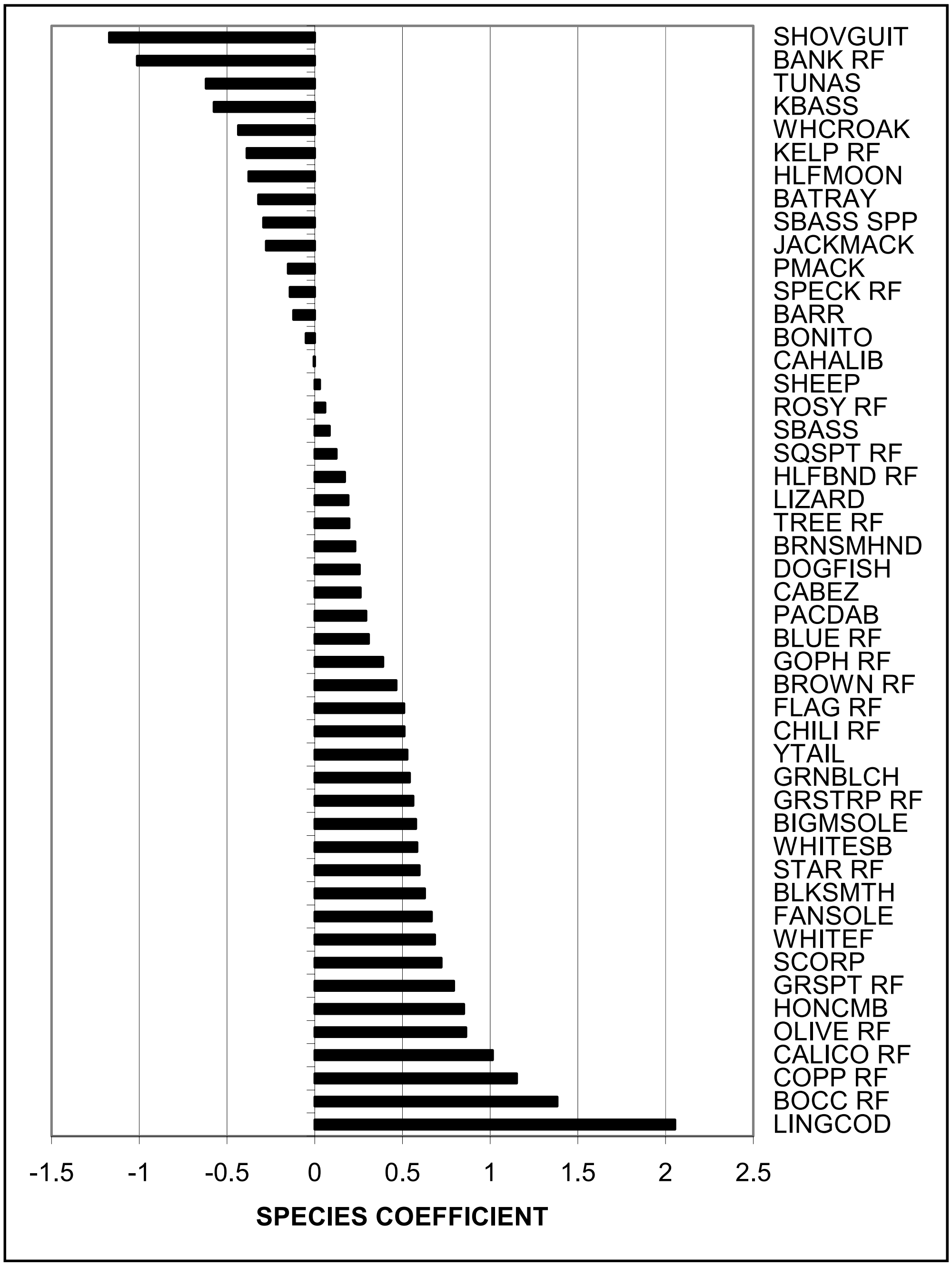


Figure 6. Species coefficients for identification of vermilion rockfish trip in the southern California partyboat fishery.

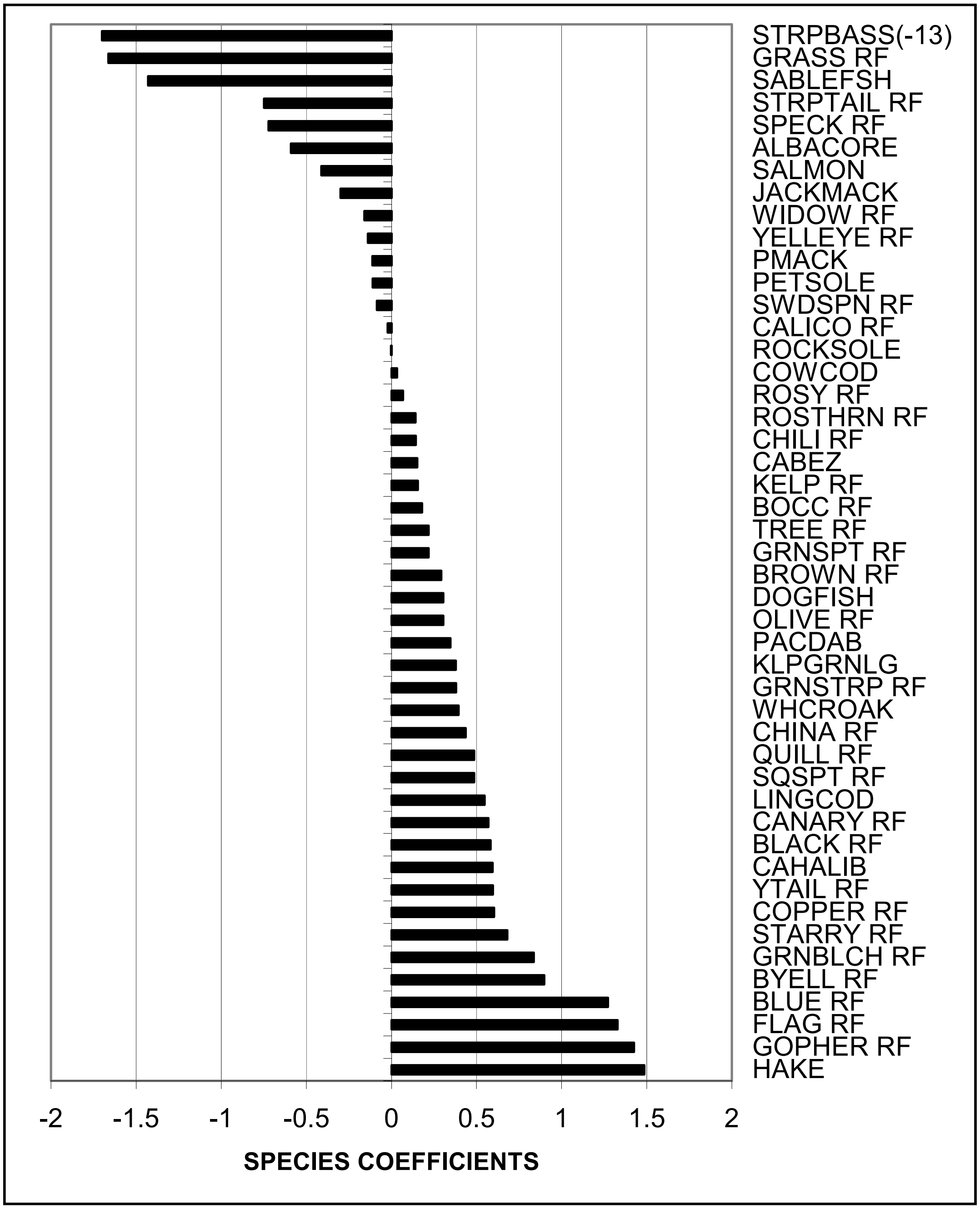


Figure 7. Species coefficients for identification of vermilion rockfish trip in the northern California partyboat fishery.

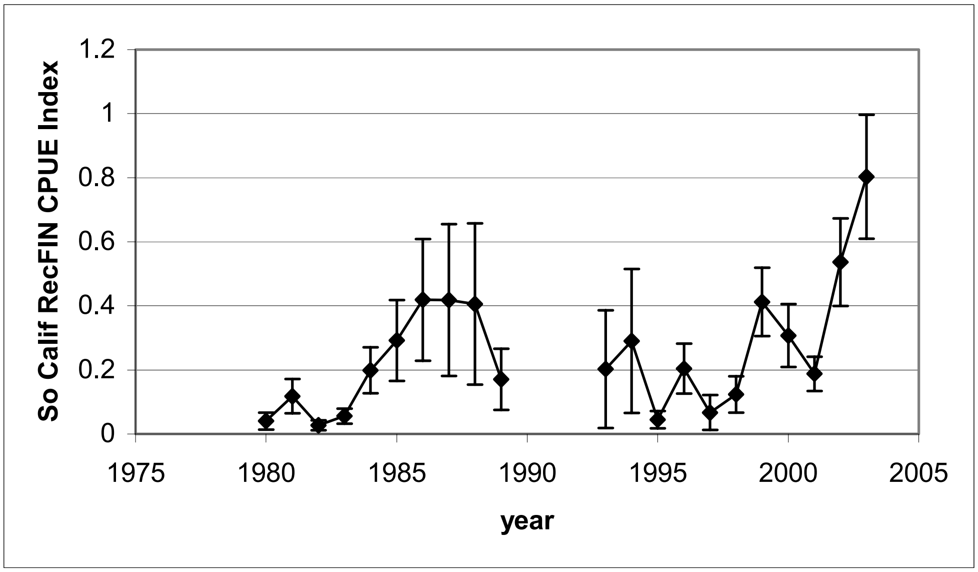


Figure 8. Index of vermilion rockfish abundance in southern California, based on GLM of RecFIN CPUE data. Error bars are +/- 1 SE.

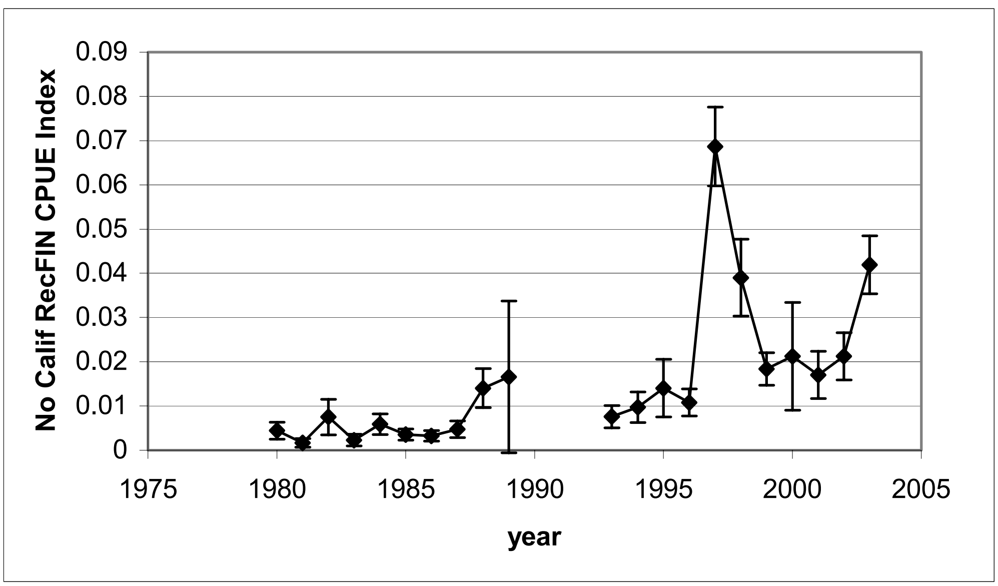


Figure 9. Index of vermilion rockfish abundance in northern California, based on GLM of RecFIN CPUE data. Error bars are +/- 1 SE.

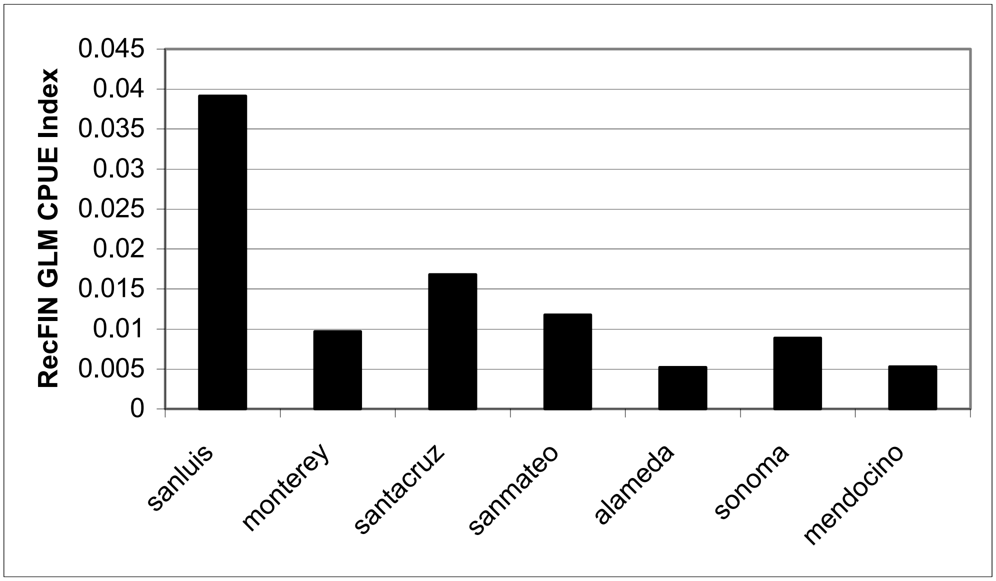


Figure 10. County effects from GLM of northern California RecFIN CPUE.

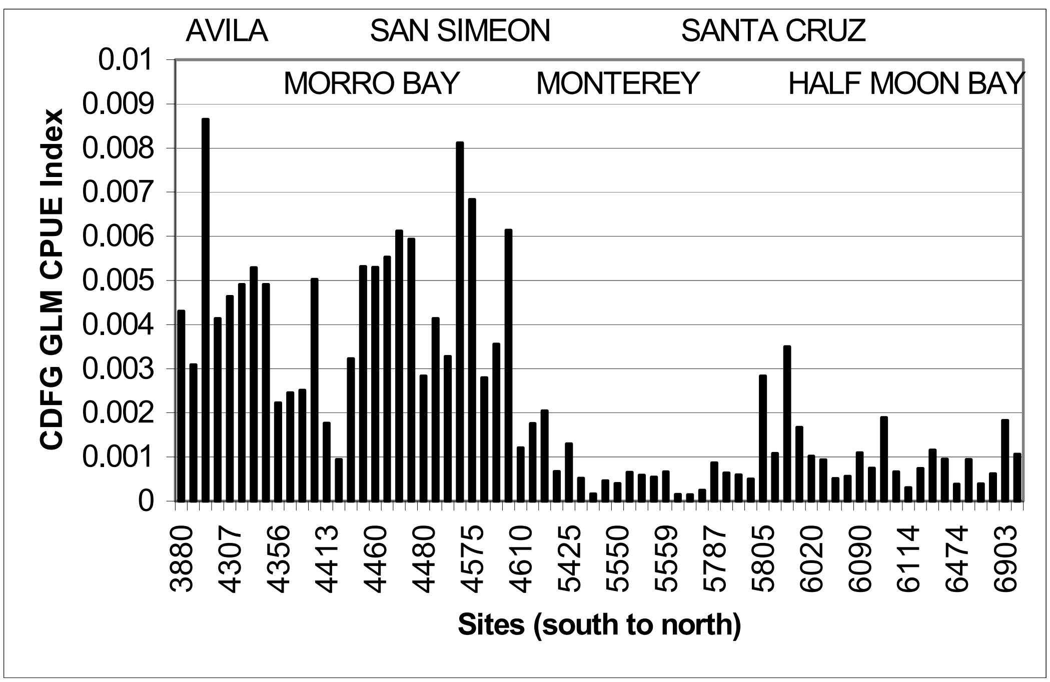


Figure 11. Location effects from GLM of northern California CDFG CPUE.

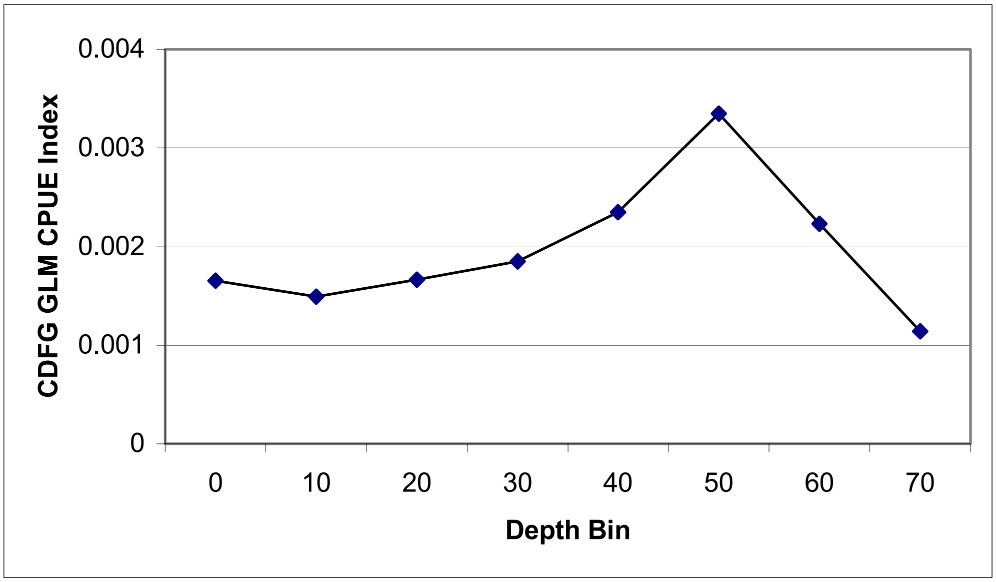


Figure 12. Effect of bottom depth on recreational CPUE of vermilion rockfish in CDFG northern California samples.

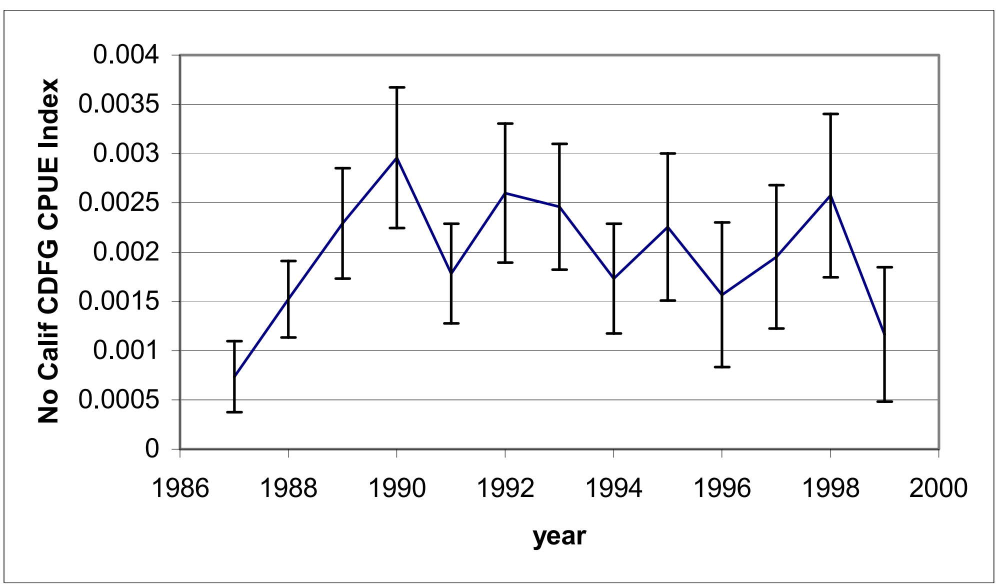


Figure 13. Index of vermilion rockfish abundance in northern California, based on GLM of CDFG CPUE data. Error bars are +/- 1 SE.

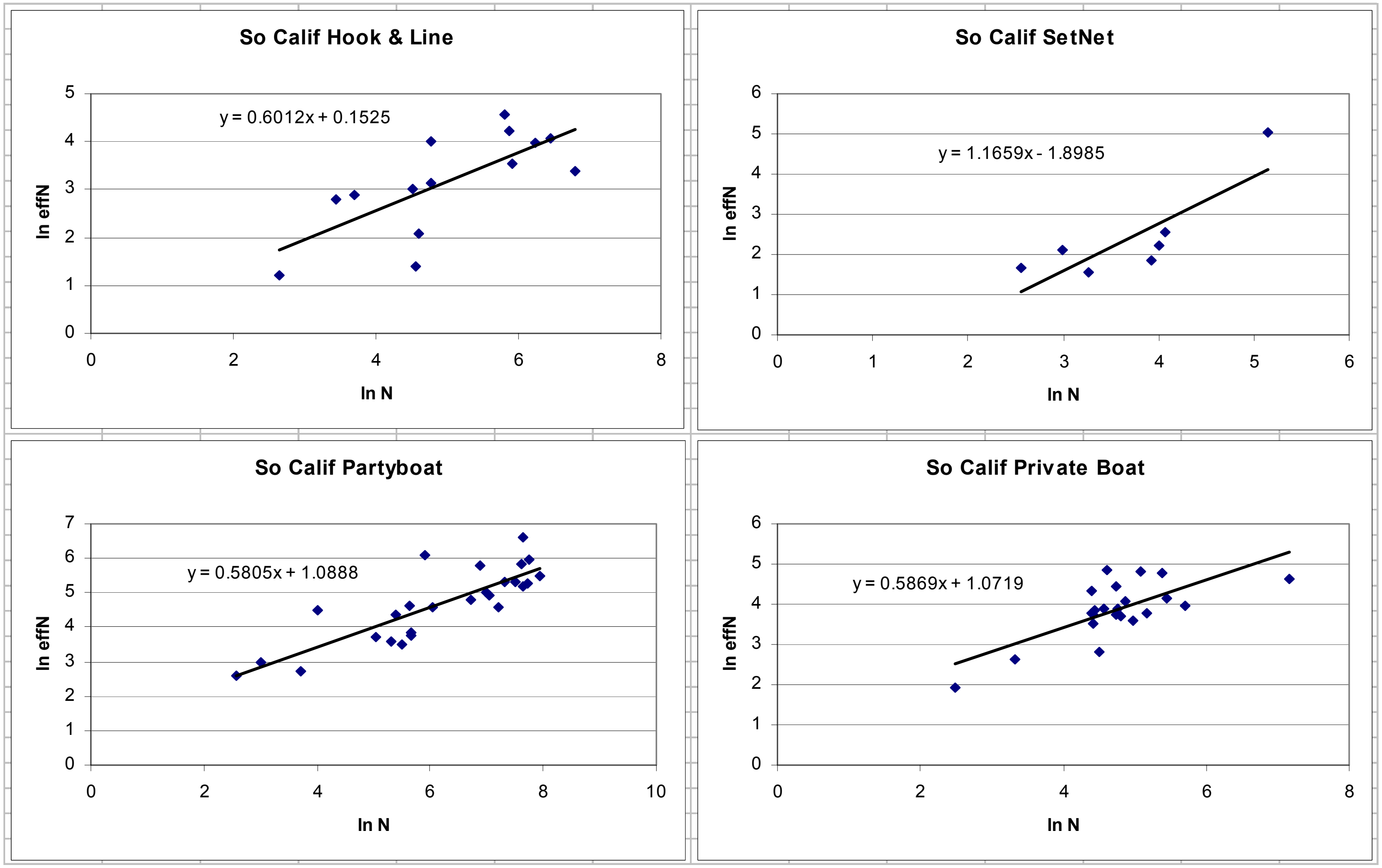


Figure 14. Calculation of effective sample sizes for southern California length compositions (model PSSOUTH).

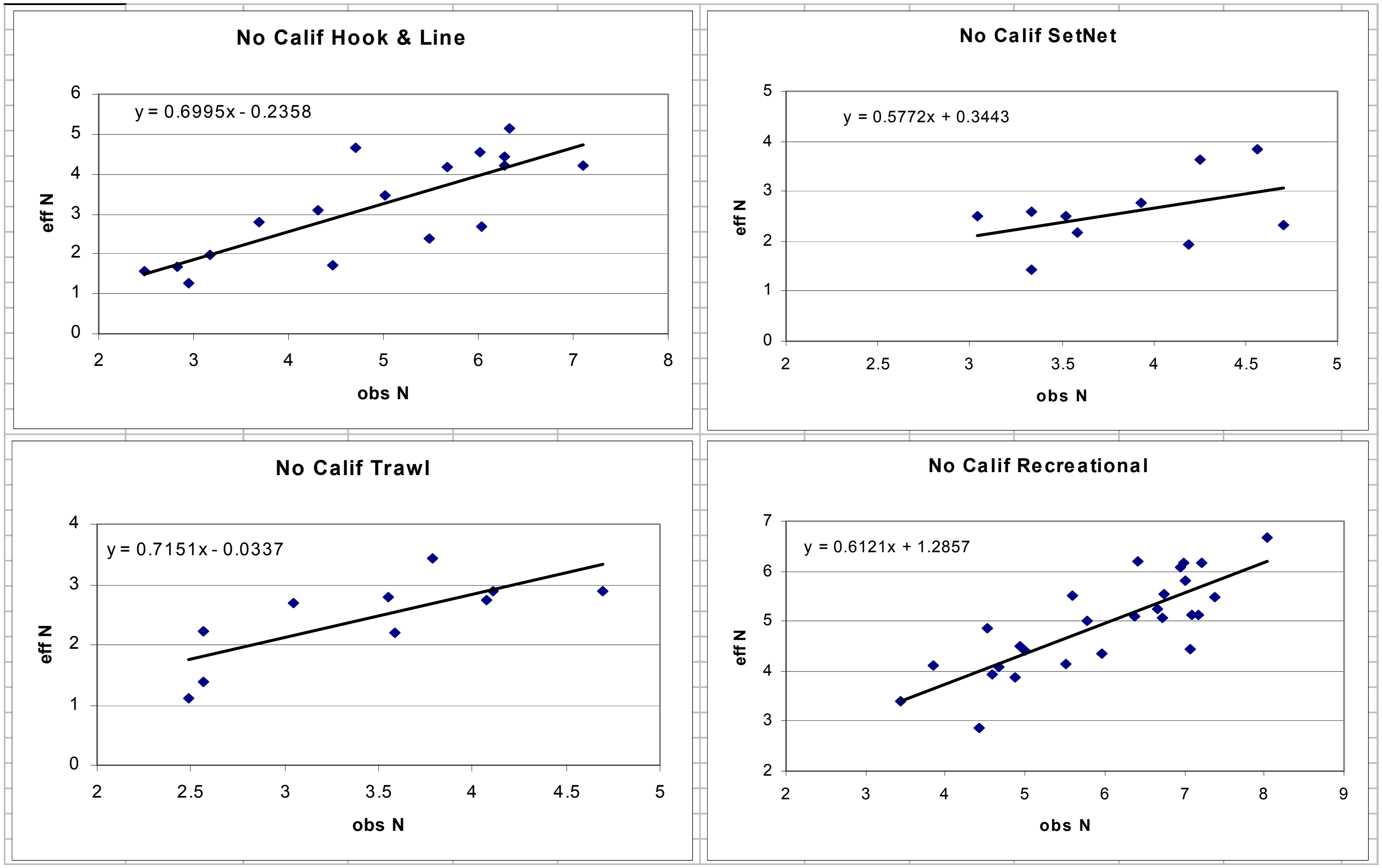


Figure 15. Calculation of effective sample sizes for northern California length compositions (model PSNORTH).

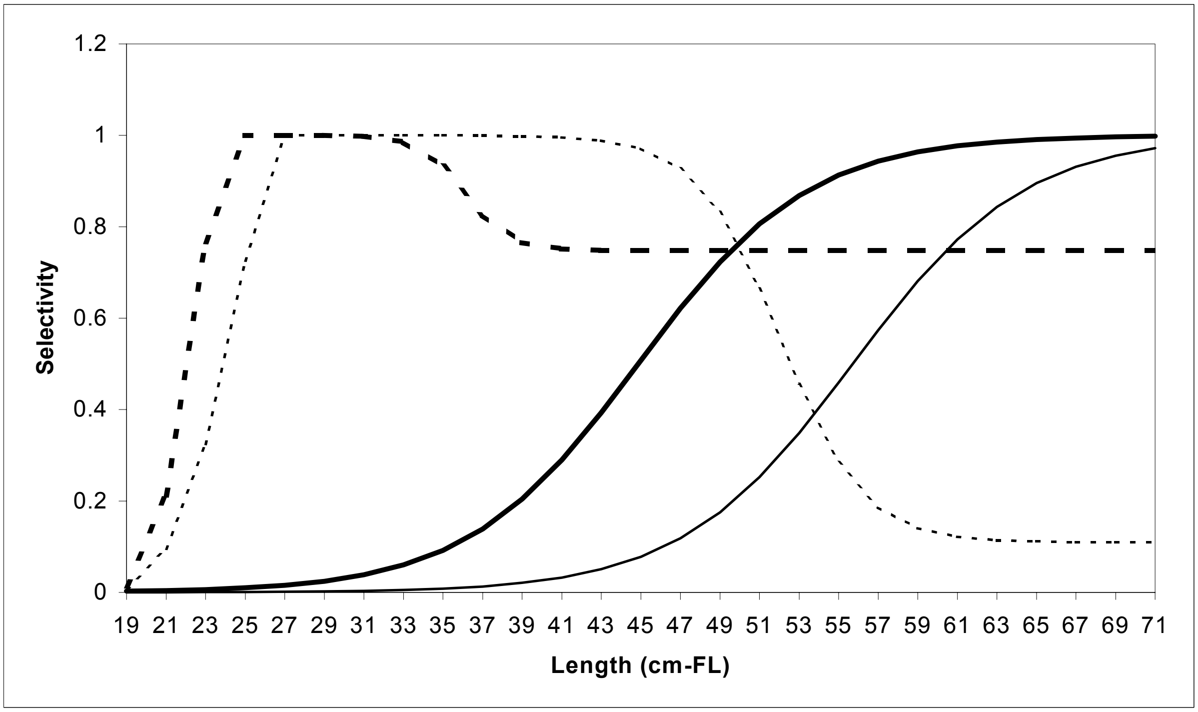


Figure 16. Estimated selectivity curves for southern California fishery segments (model PSSOUTH). Dark solid line is commercial hook & line; light solid line is setnet; dark broken line is recreational partyboat; light broken line is recreational private boat.

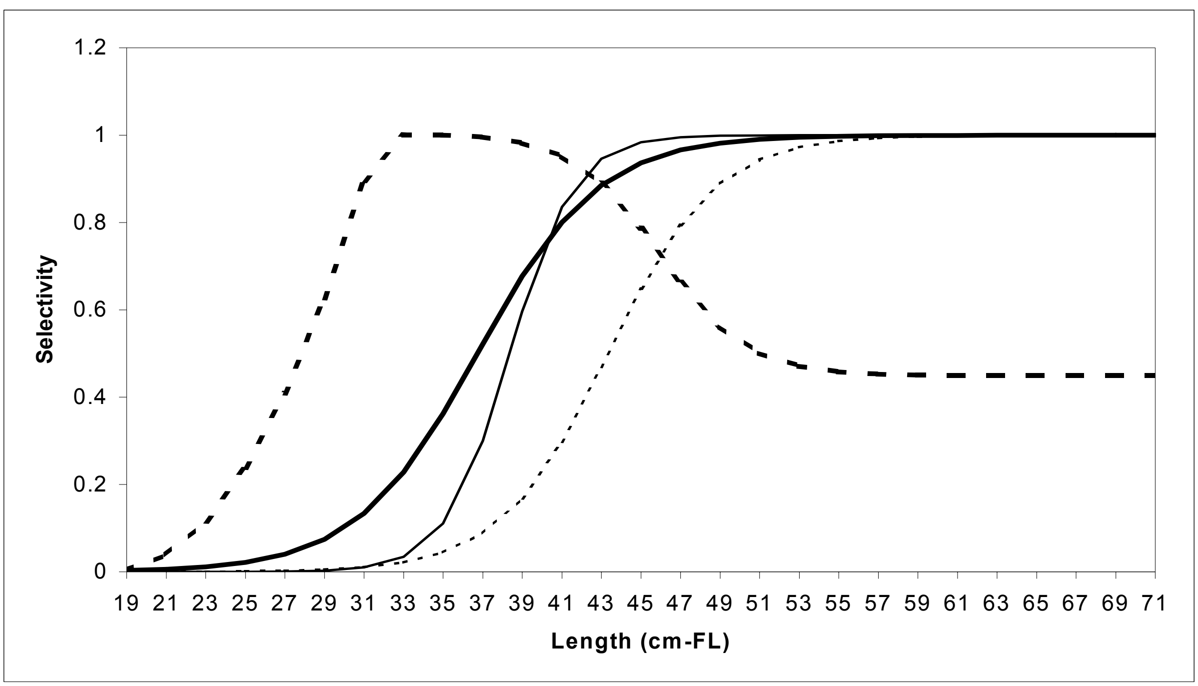


Figure 17. Estimated selectivity curves for northern California fishery segments (model PSNORTH). Dark solid line is commercial hook & line; light solid line is setnet; dark broken line is recreational fishery; light broken line is trawl.

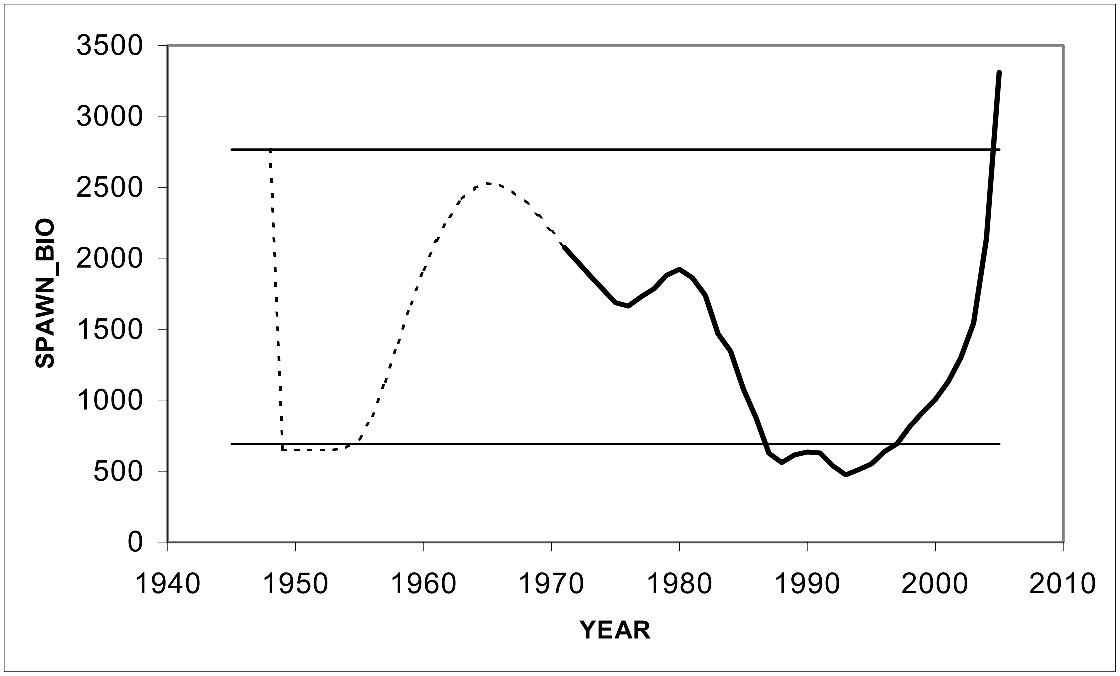


Figure 18. Estimated time series of spawning biomass of vermilion rockfish in southern California (model PSSOUTH). Early period (dotted line) is unreliable. Upper horizontal line is estimated average unfished abundance; lower horizontal line is overfished threshold.

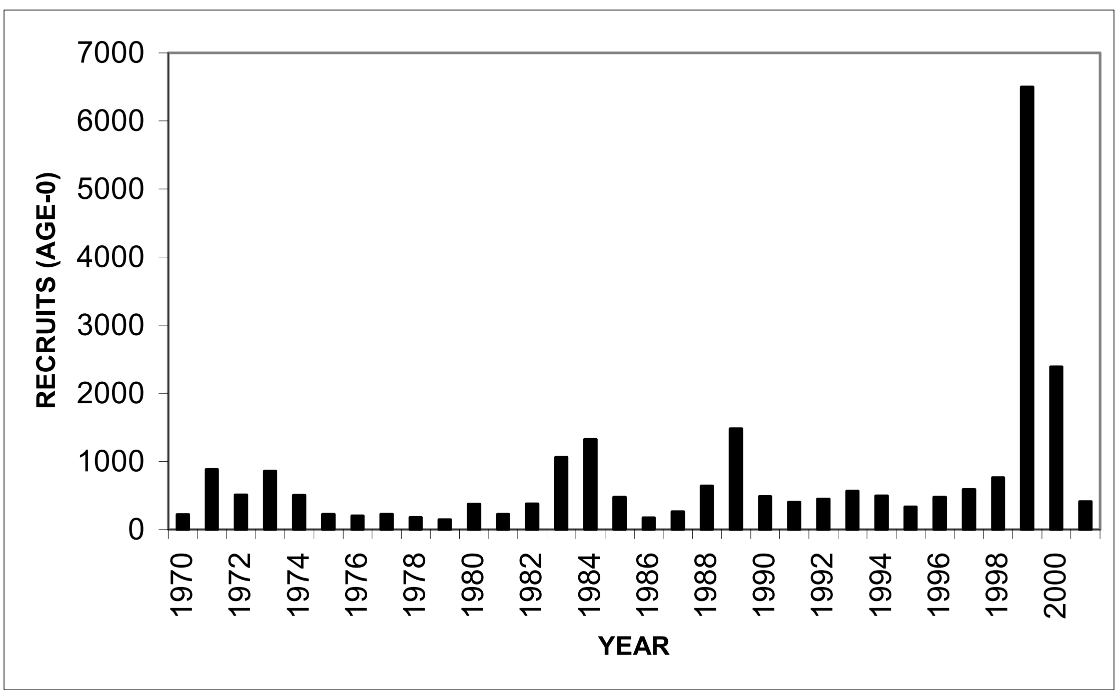


Figure 19. Estimated recruitments to the southern California segment (model PSSOUTH).

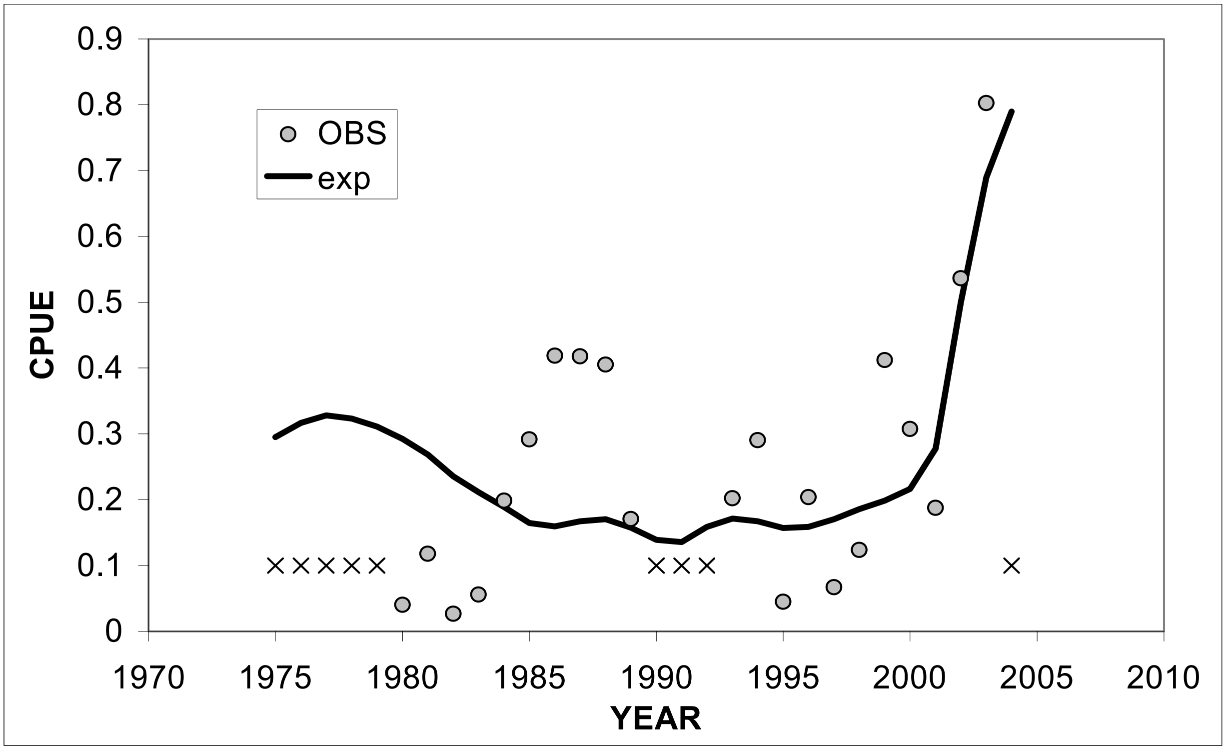


Figure 20. PSSOUTH model fit to southern California RecFIN CPUE.

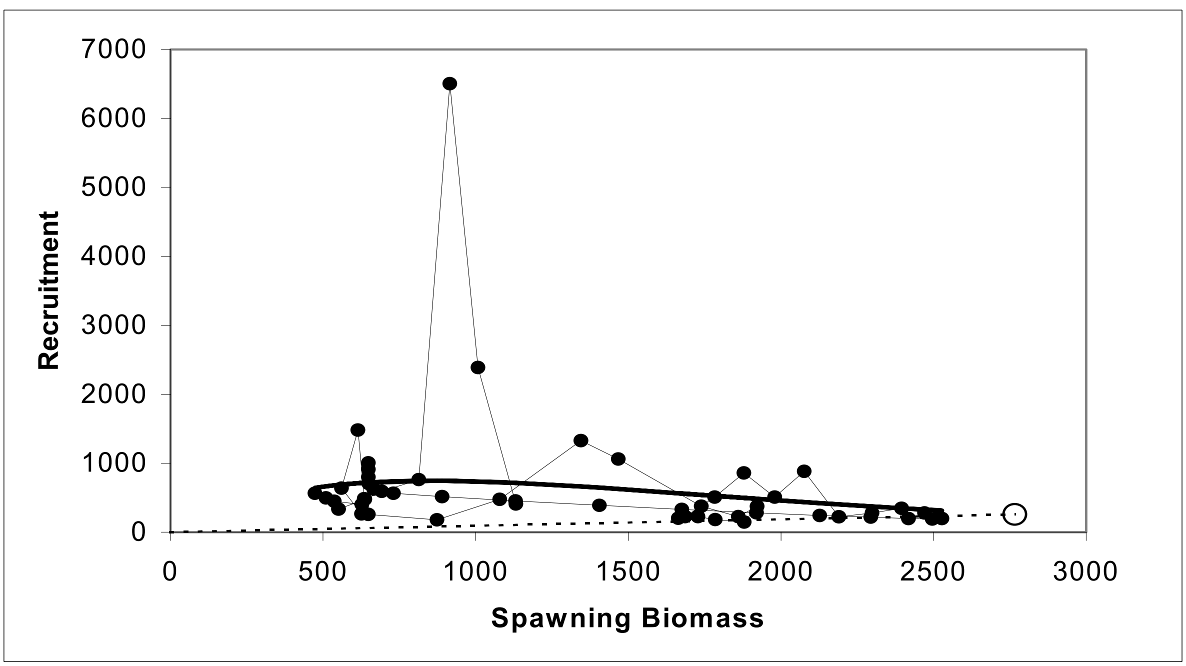


Figure 21. Model PSSOUTH estimated stock-recruitment relationship for southern California vermilion rockfish (model PSSOUTH). Diagonal broken line is replacement at F=0. Large circle indicates unfished condition.

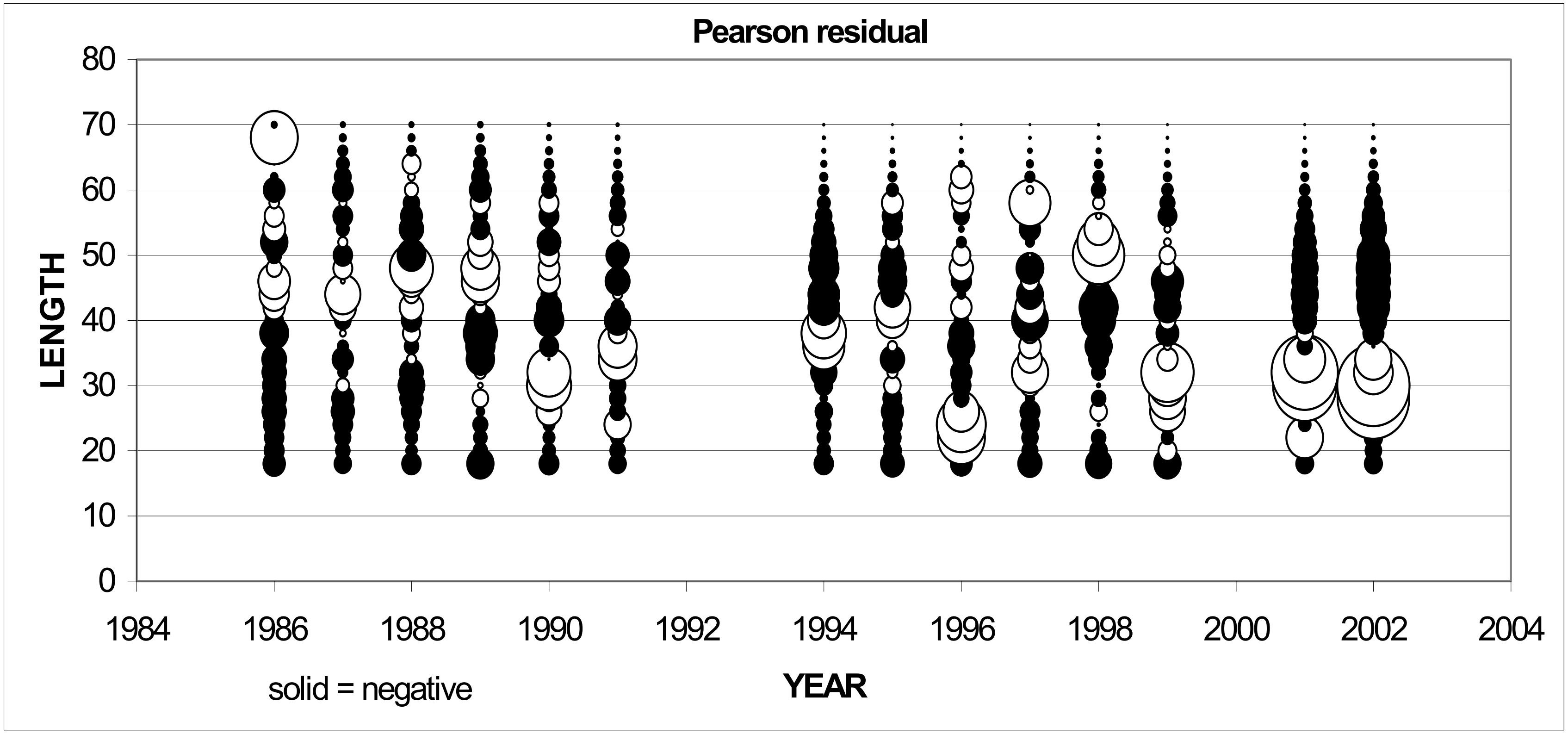


Figure 22a. Model PSSOUTH goodness of fit to southern California commercial hook and line fishery length compositions of vermilion rockfish. Size of circle is proportional to Pearson residual.

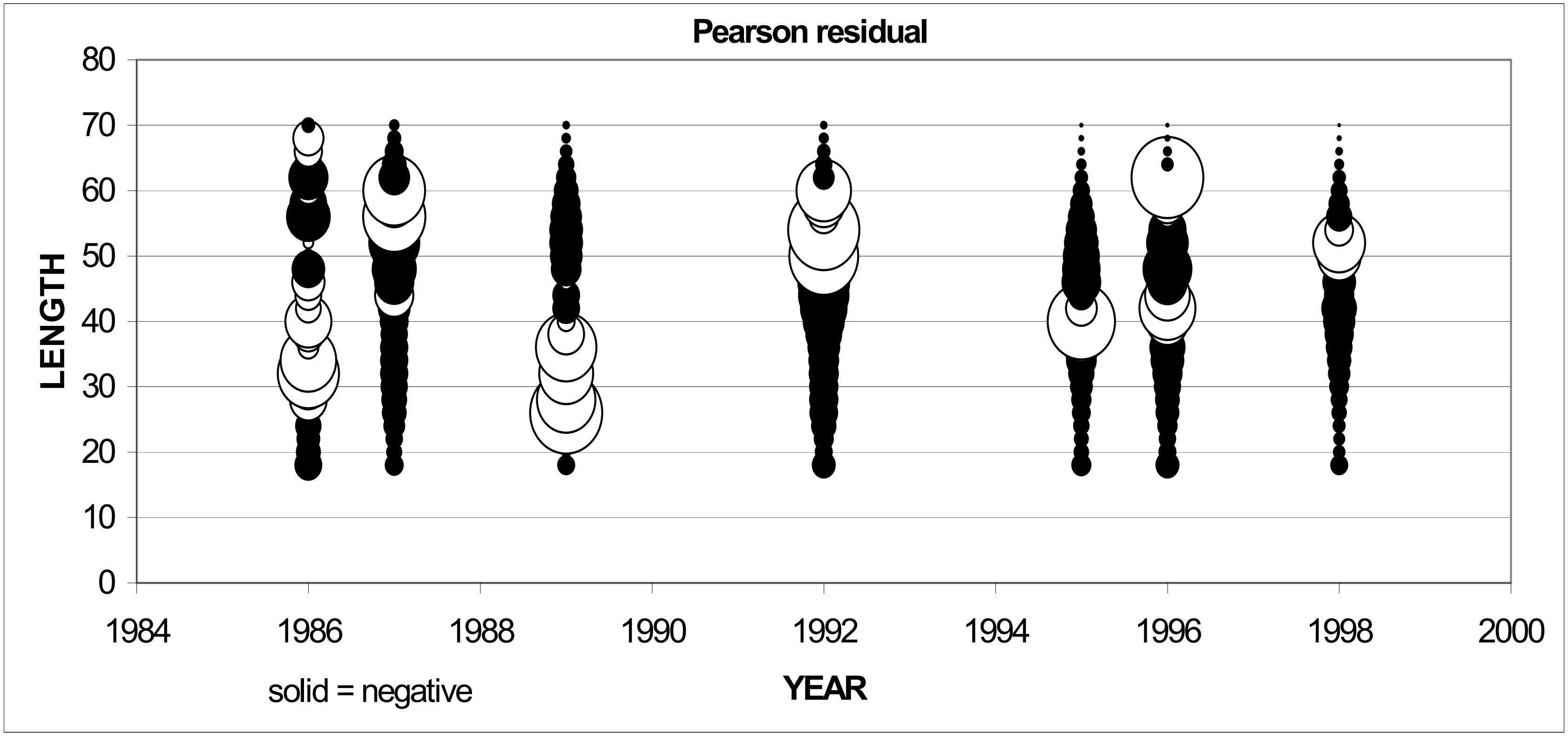


Figure 22b. Model PSSOUTH goodness of fit to southern California commercial set net fishery length compositions of vermilion rockfish. Size of circle is proportional to Pearson residual.

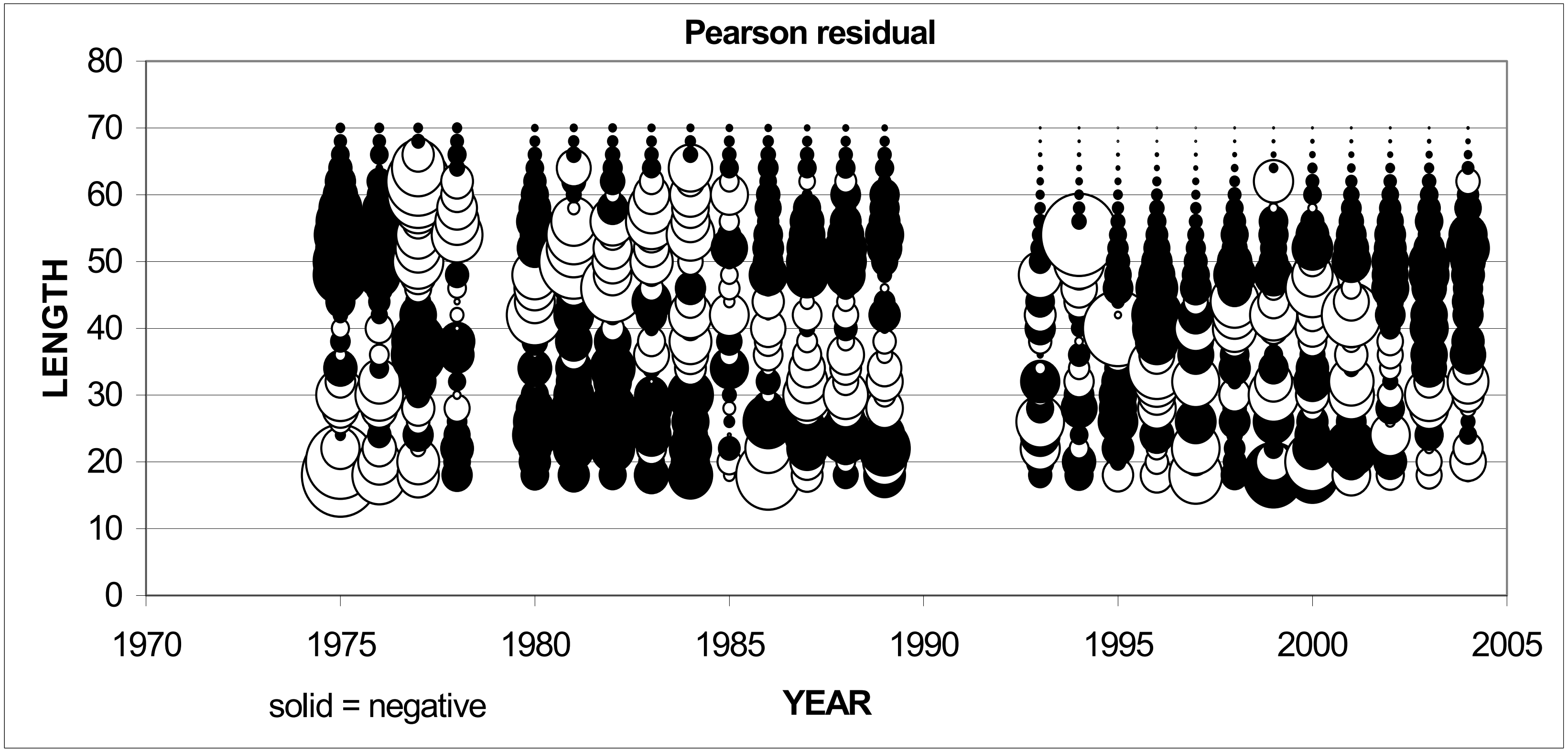


Figure 22c. Model PSSOUTH goodness of fit to southern California partyboat (CPFV) recreational fishery length compositions of vermilion rockfish. Size of circle is proportional to Pearson residual.

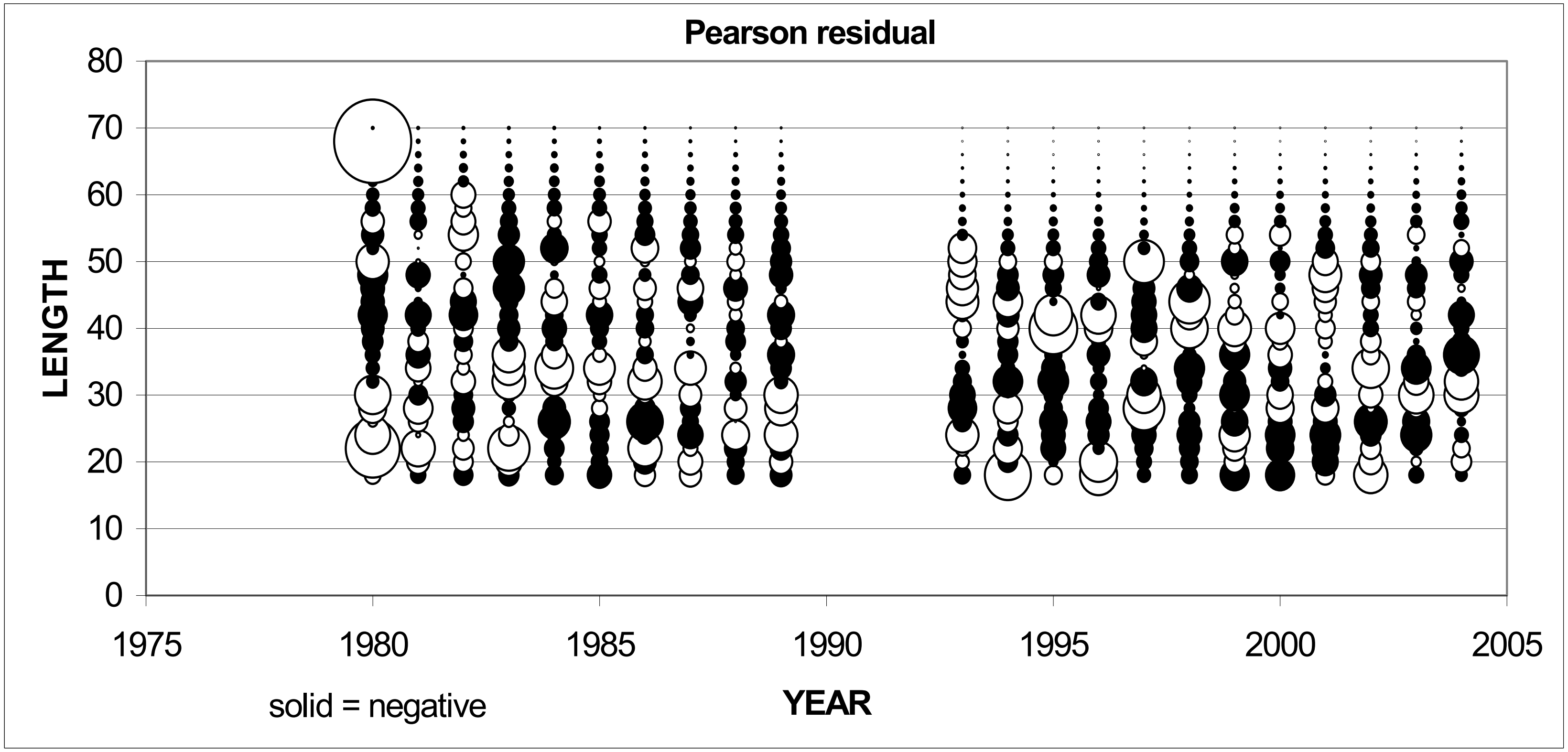


Figure 22d. Model PSSOUTH goodness of fit to southern California private boat recreational fishery length compositions of vermilion rockfish. Size of circle is proportional to Pearson residual.

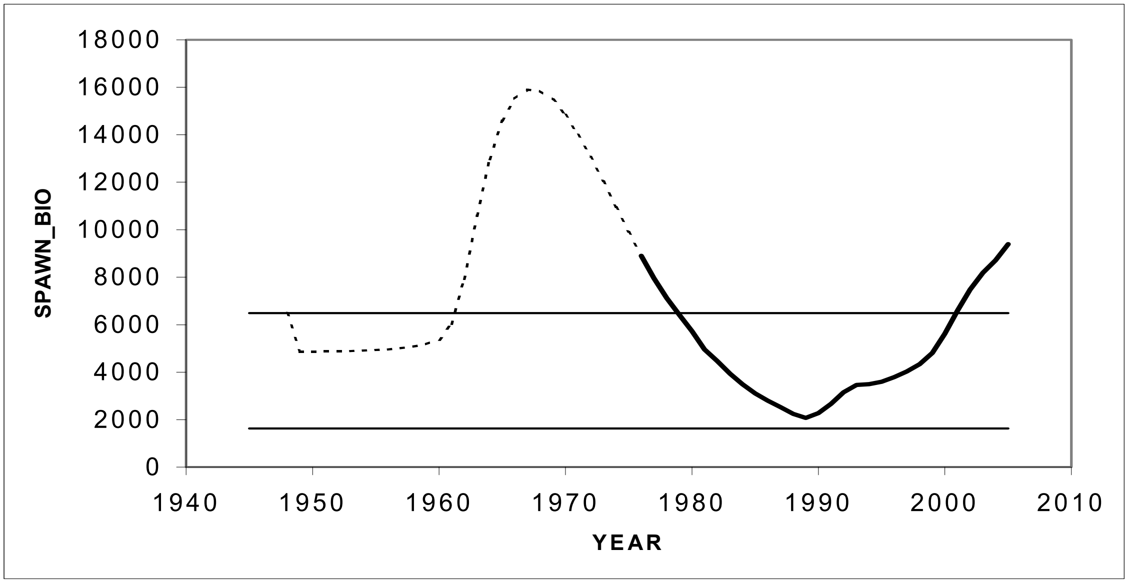


Figure 23. Model PSNORTH estimated time series of spawning biomass of vermilion rockfish in northern California. Early period (dotted line) is unreliable. Upper horizontal line is estimated average unfished abundance; lower horizontal line is overfished threshold.

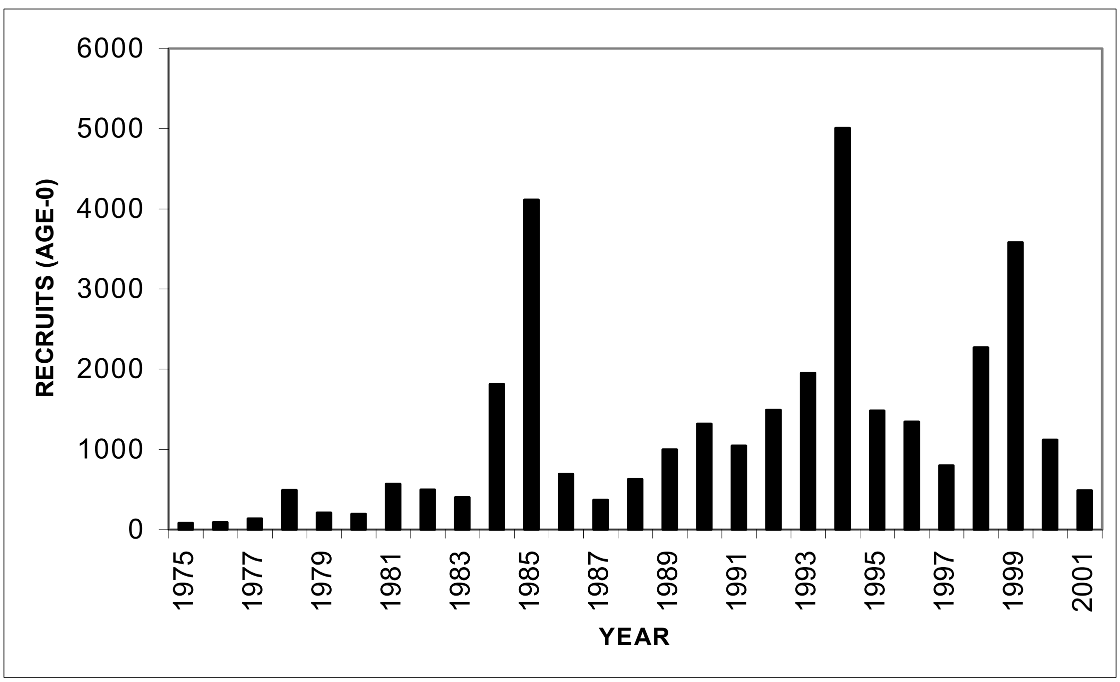


Figure 24. Model PSNORTH estimated recruitments to the northern California segment.

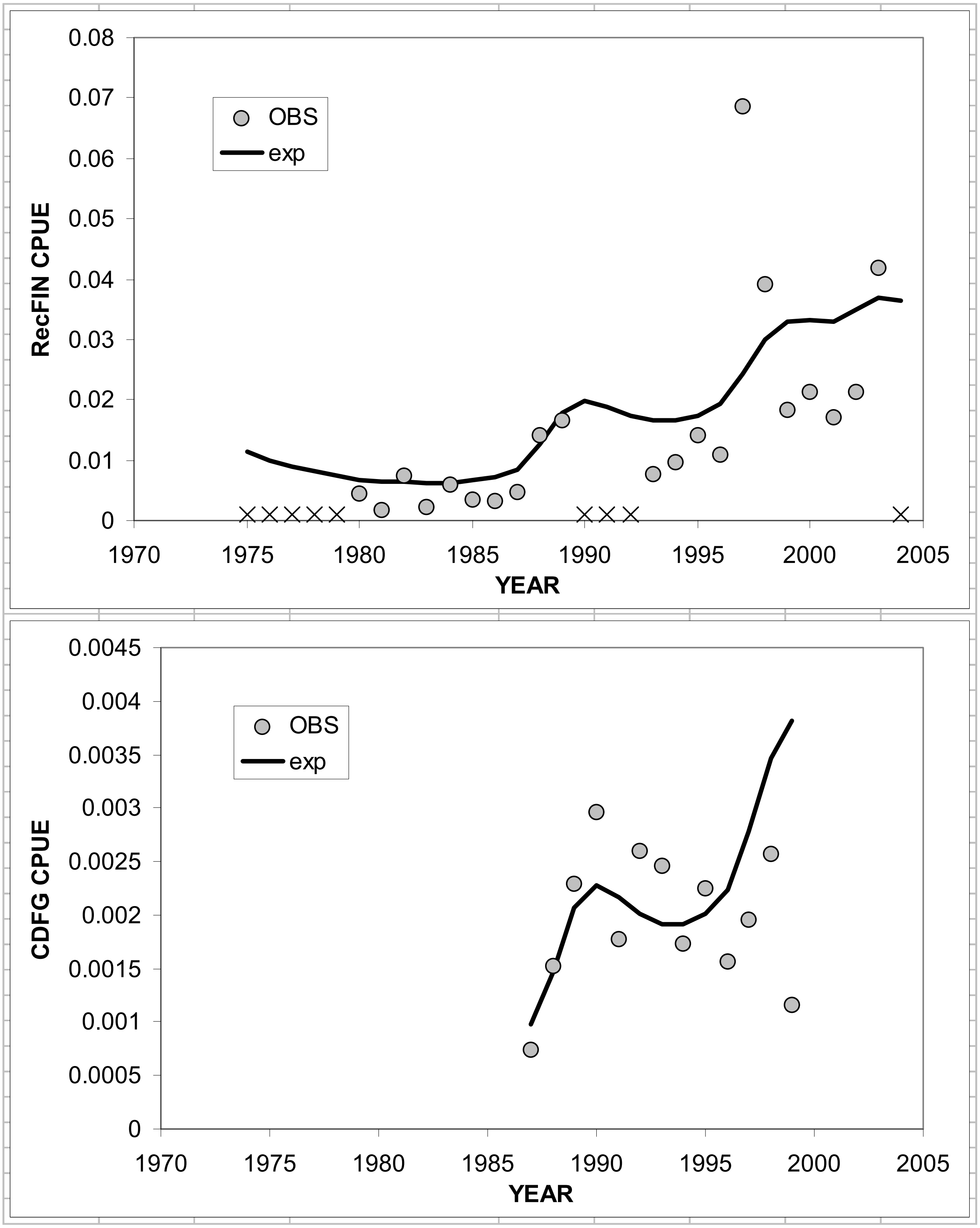


Figure 25. Model PSNORTH fit to northern California CPUE indexes. Upper panel is RecFIN CPUE; lower panel is CDFG CPUE.

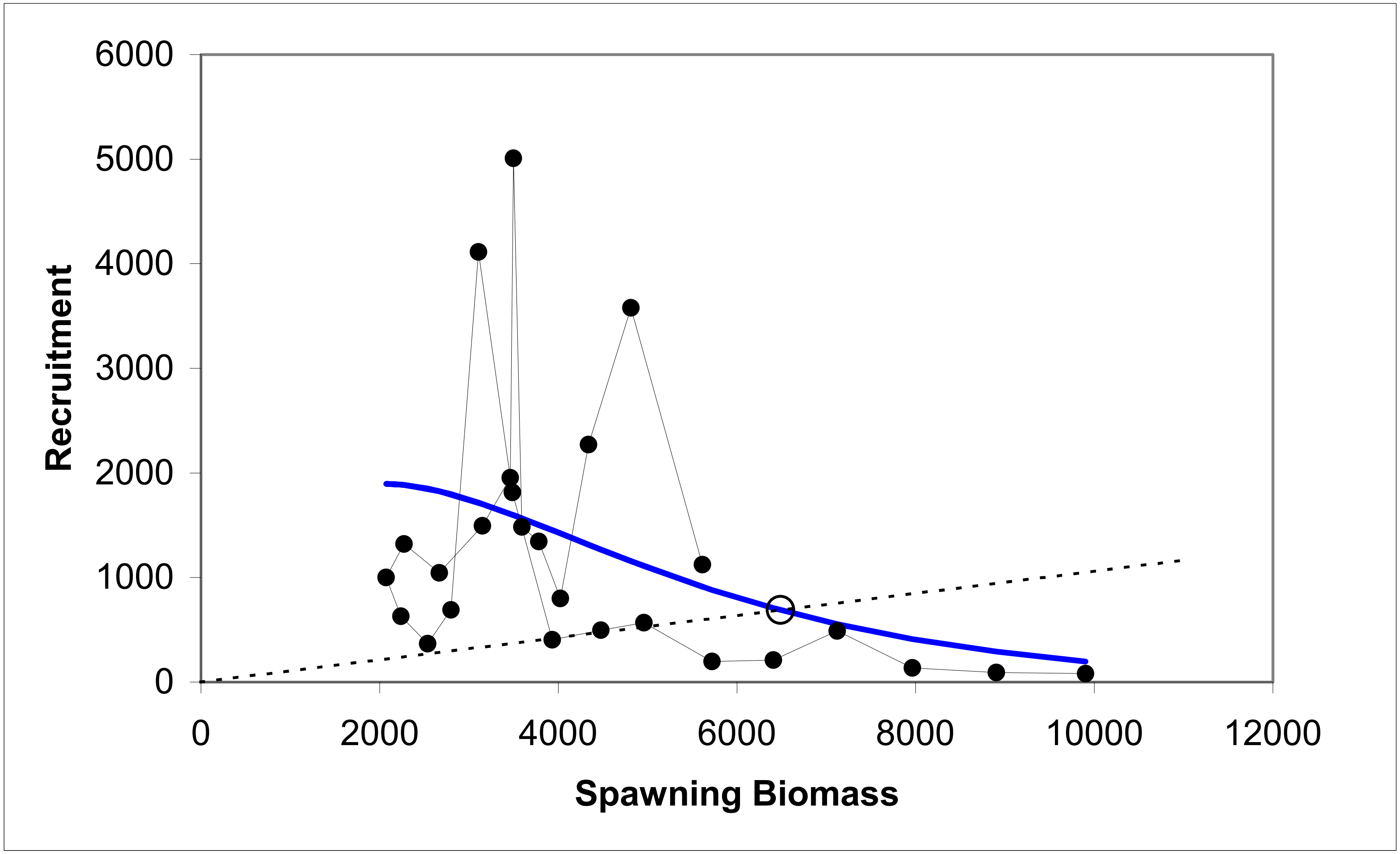


Figure 26. Model PSNORTH estimated stock-recruitment relationship for northern California vermilion rockfish. Diagonal broken line is replacement at F=0. Large circle indicates average unfished condition.

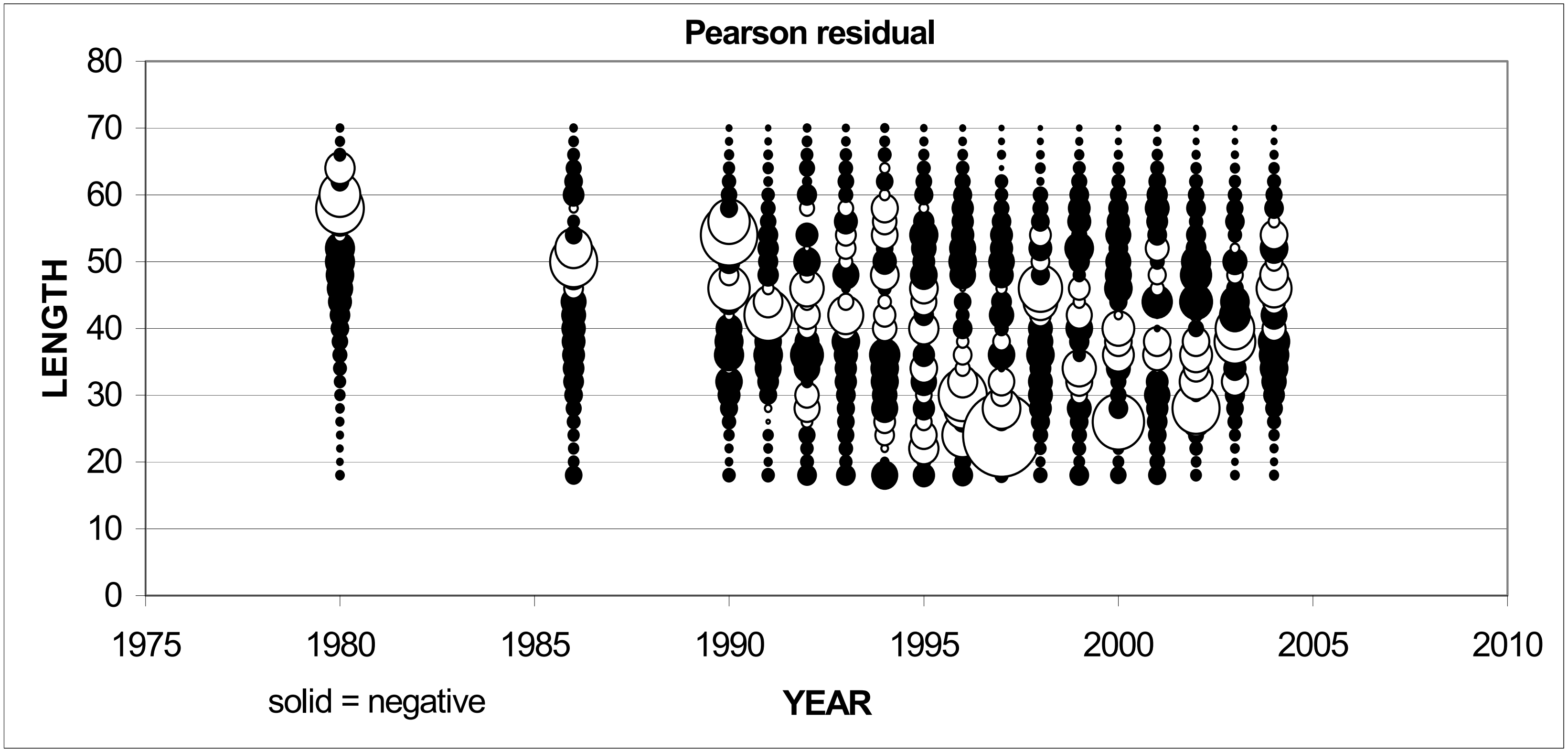


Figure 27a. Model PSNORTH goodness of fit to northern California commercial hook and line fishery length compositions of vermilion rockfish. Size of circle is proportional to Pearson residual.

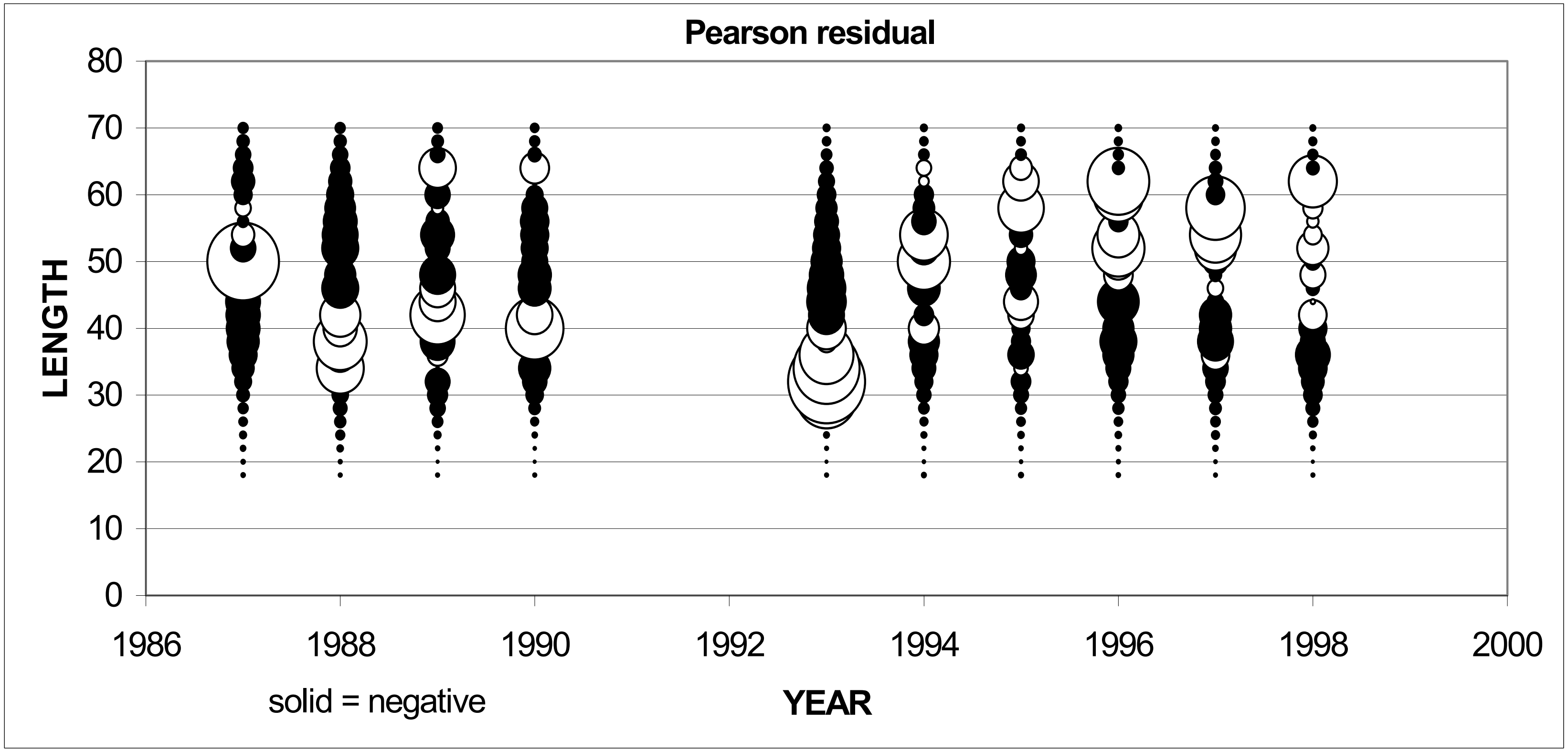


Figure 27b. Model PSNORTH goodness of fit to northern California commercial set net fishery length compositions of vermilion rockfish. Size of circle is proportional to Pearson residual.

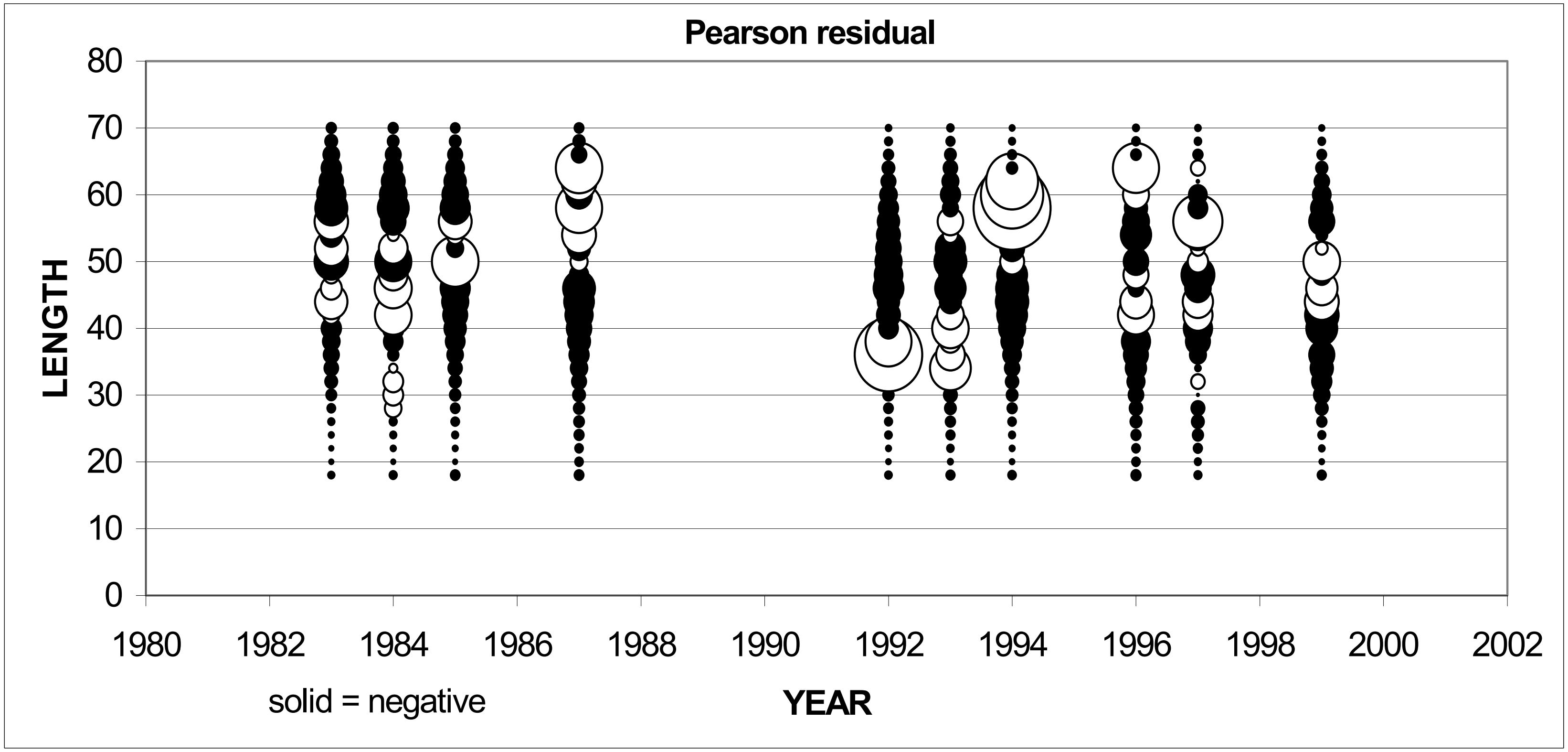


Figure 27c. Model PSNORTH goodness of fit to northern California commercial trawl fishery length compositions of vermilion rockfish. Size of circle is proportional to Pearson residual.

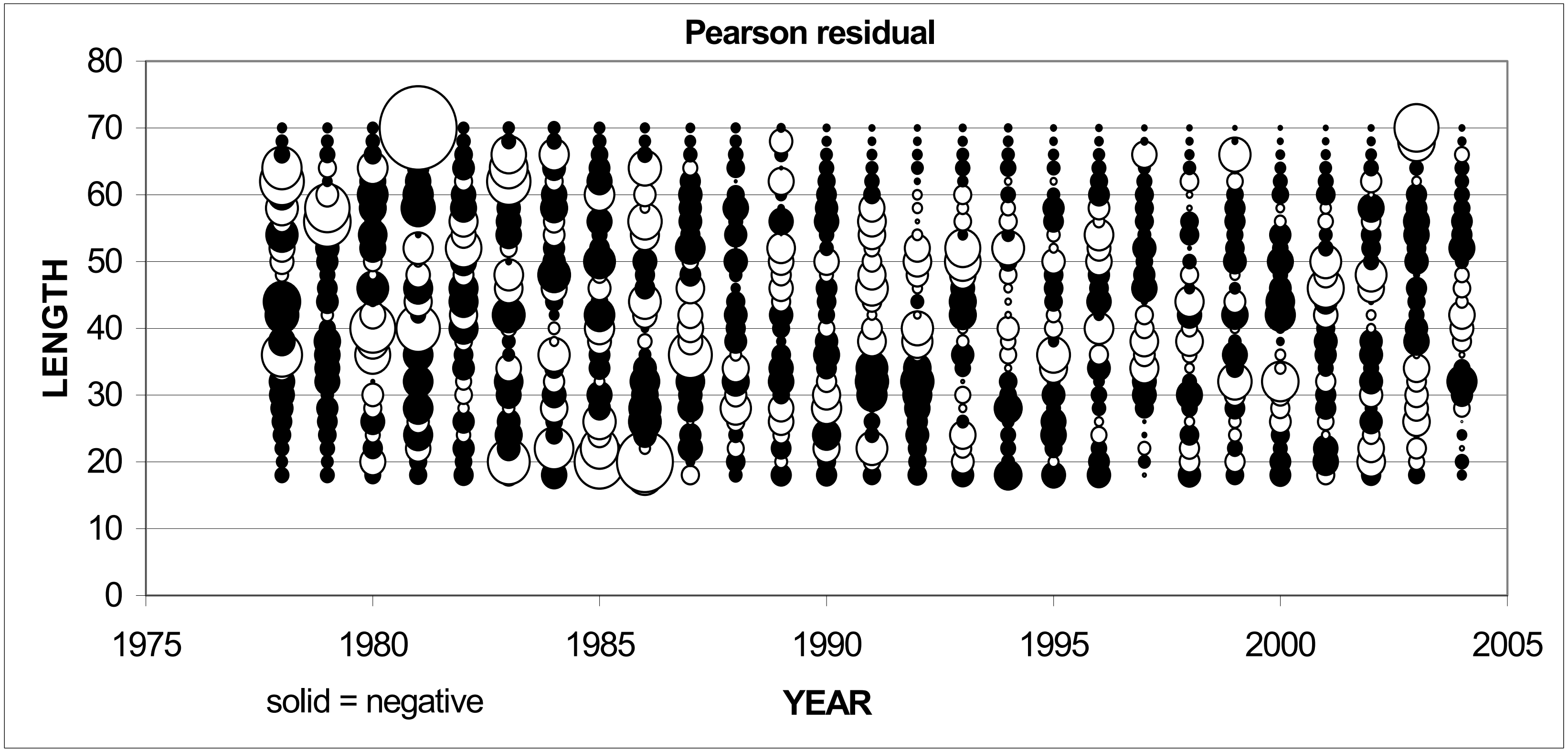
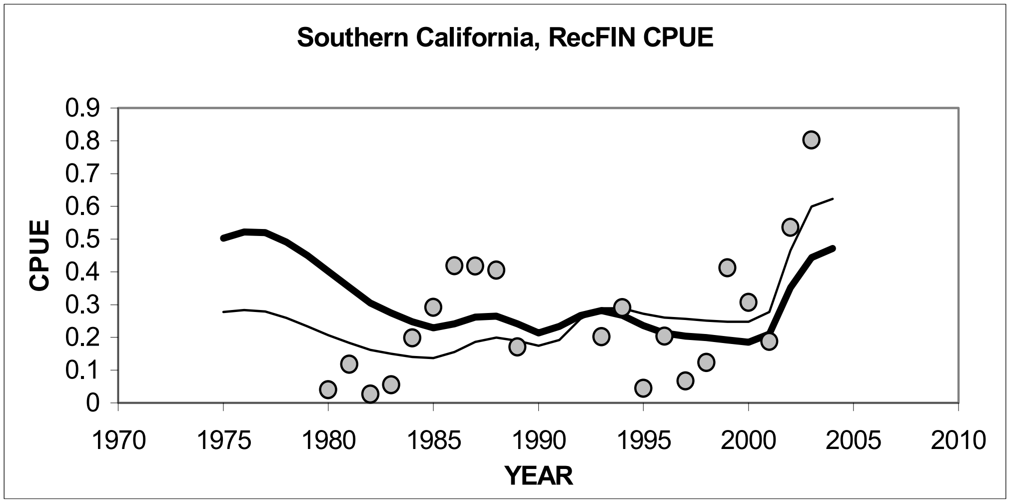
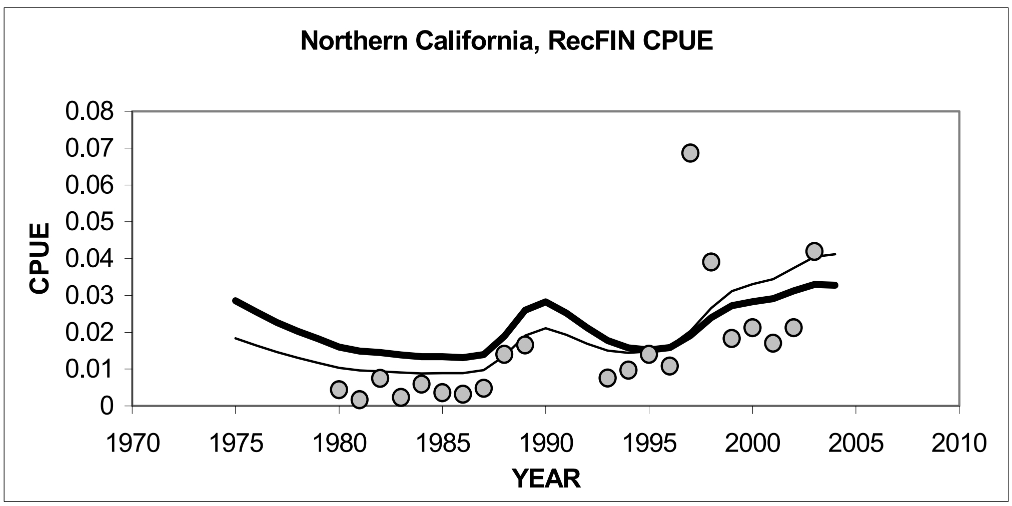


Figure 27d. Model PSNORTH goodness of fit to northern California combined recreational fishery length compositions of vermilion rockfish. Size of circle is proportional to Pearson residual.





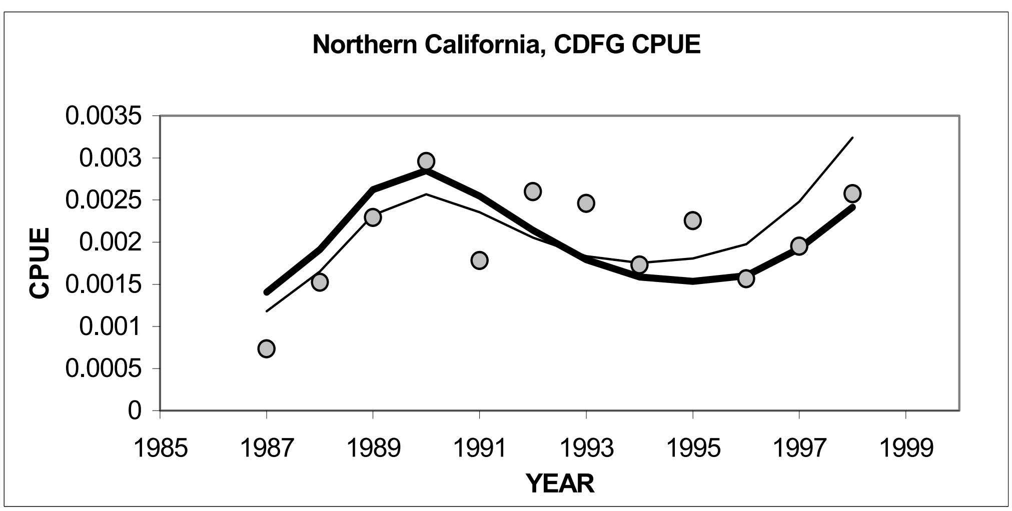


Figure 28. STAR model fits to abundance indexes. Thick line is lower bound model and thin line is upper bound model.

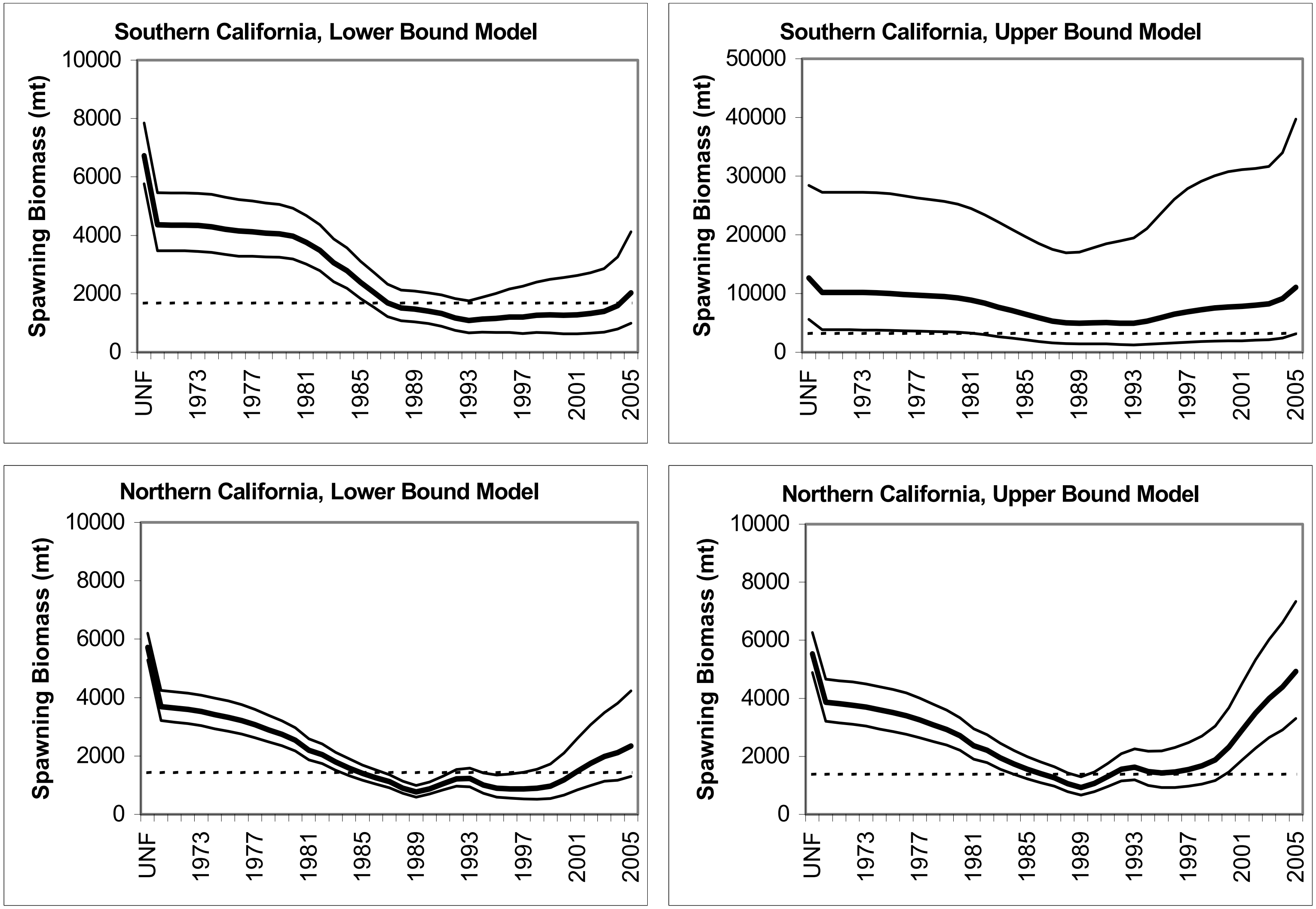


Figure 29. Estimated historical biomasses from the alternative models. Confidence intervals are ±1.96SE, lognormal. Horizontal broken line is overfished threshold (0.25*Bunfished). Note different scaling in upper right panel.

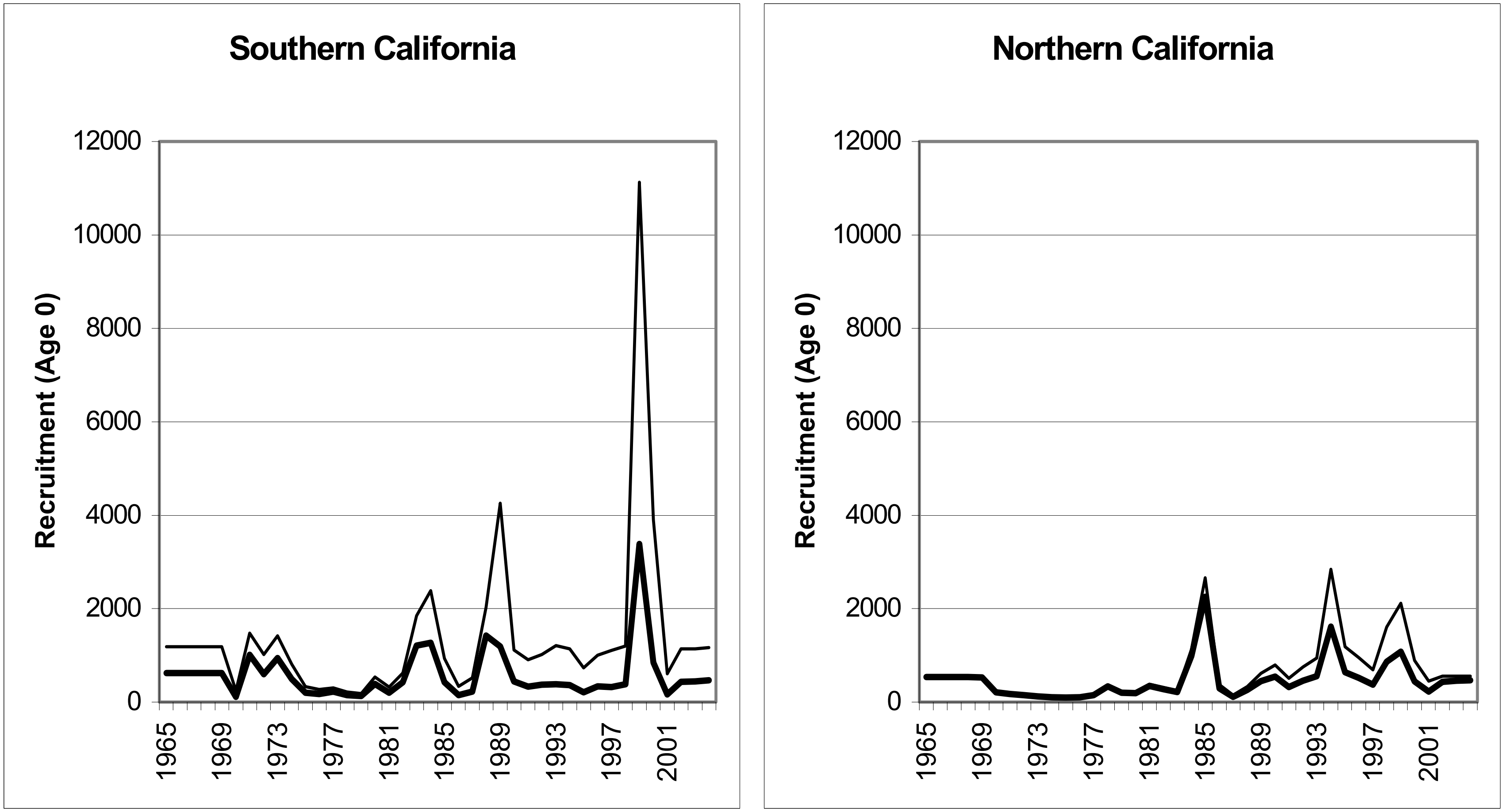


Figure 30. Estimated historical recruitments from the alternative models. Thick line is lower bound model, thin line is upper bound model.

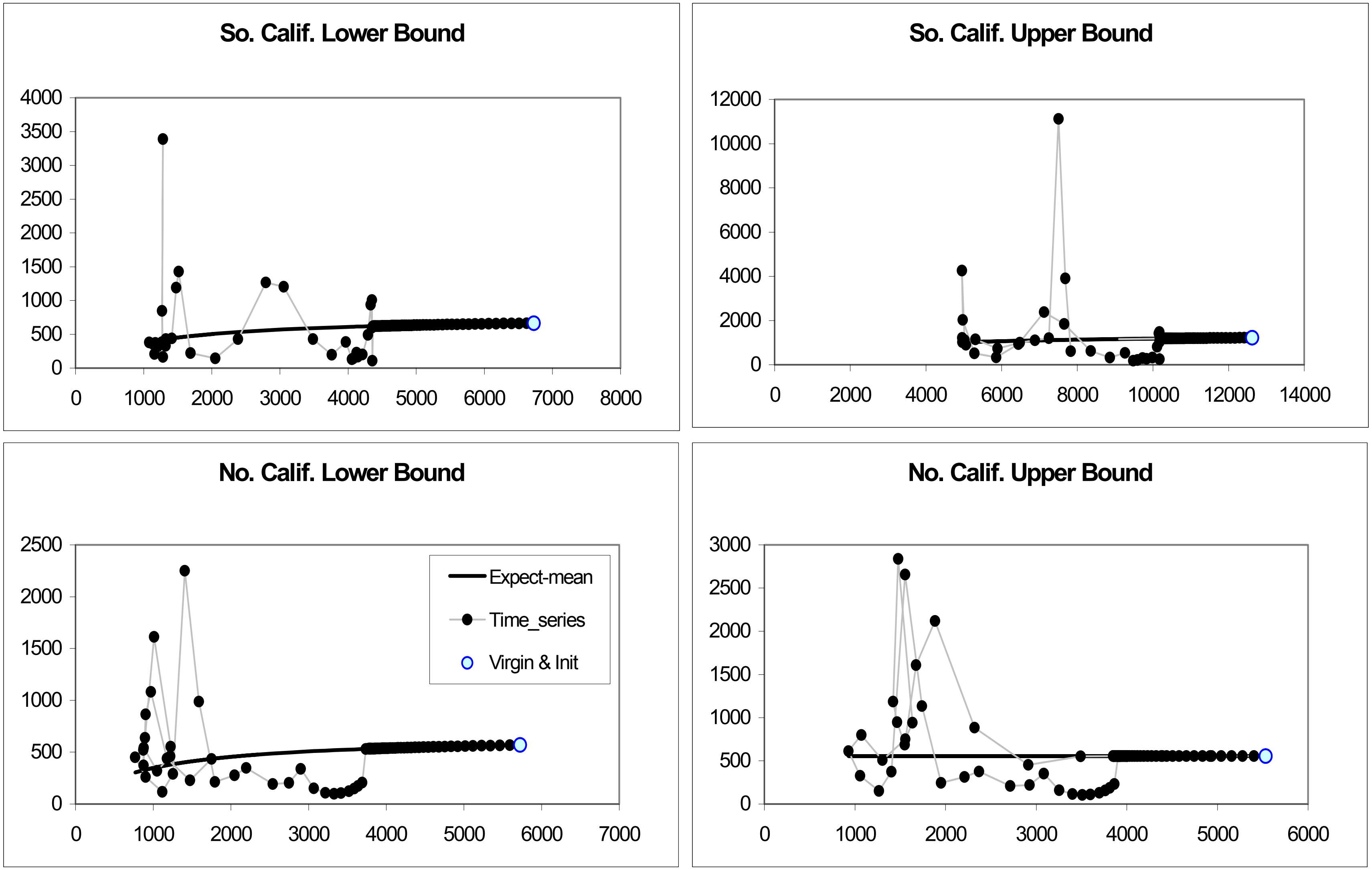


Figure 31. Stock-recruitment relationships for the alternative STAR models.

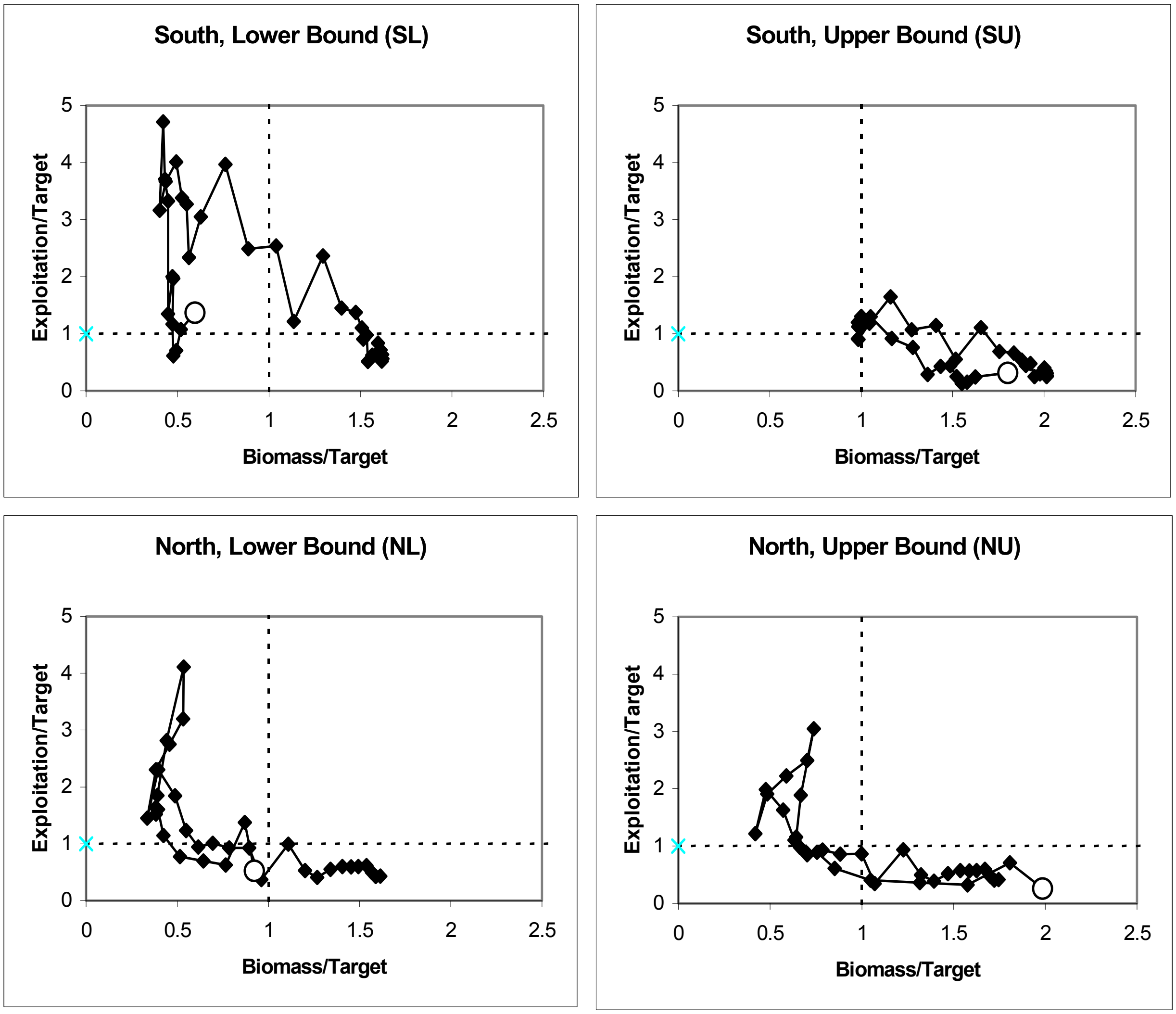
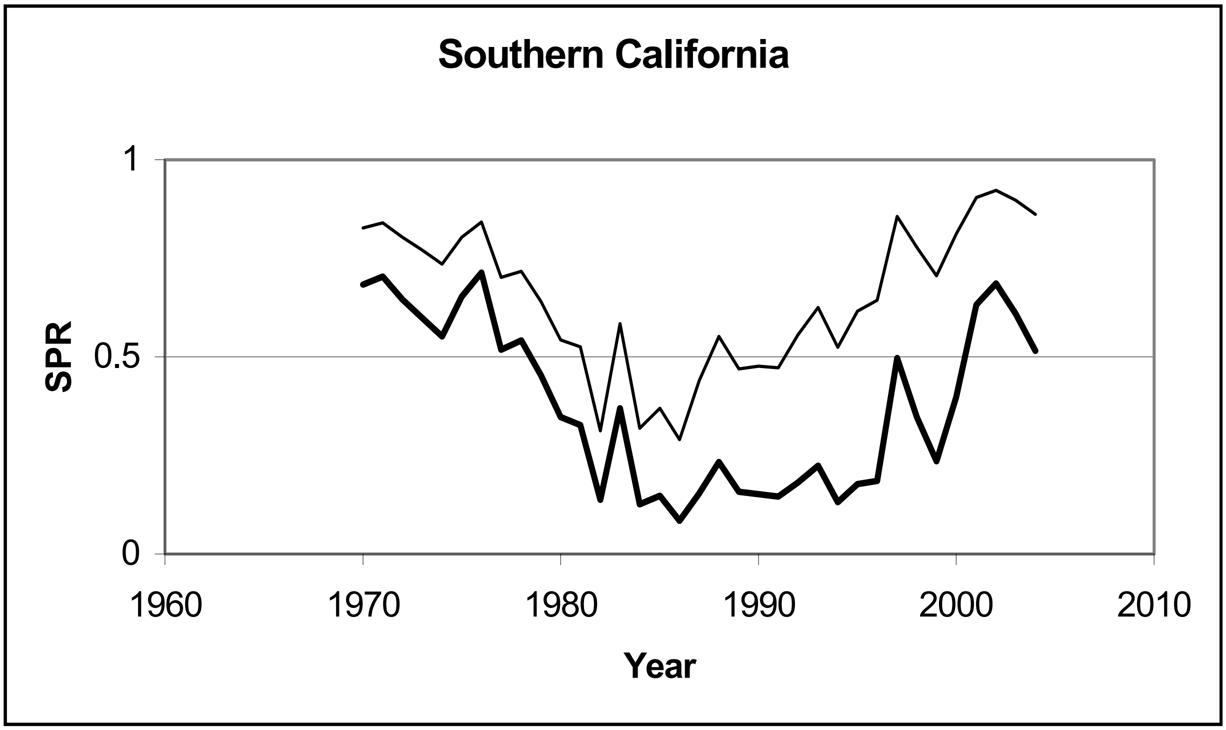


Figure 32. History of exploitation and relative spawning abundance.



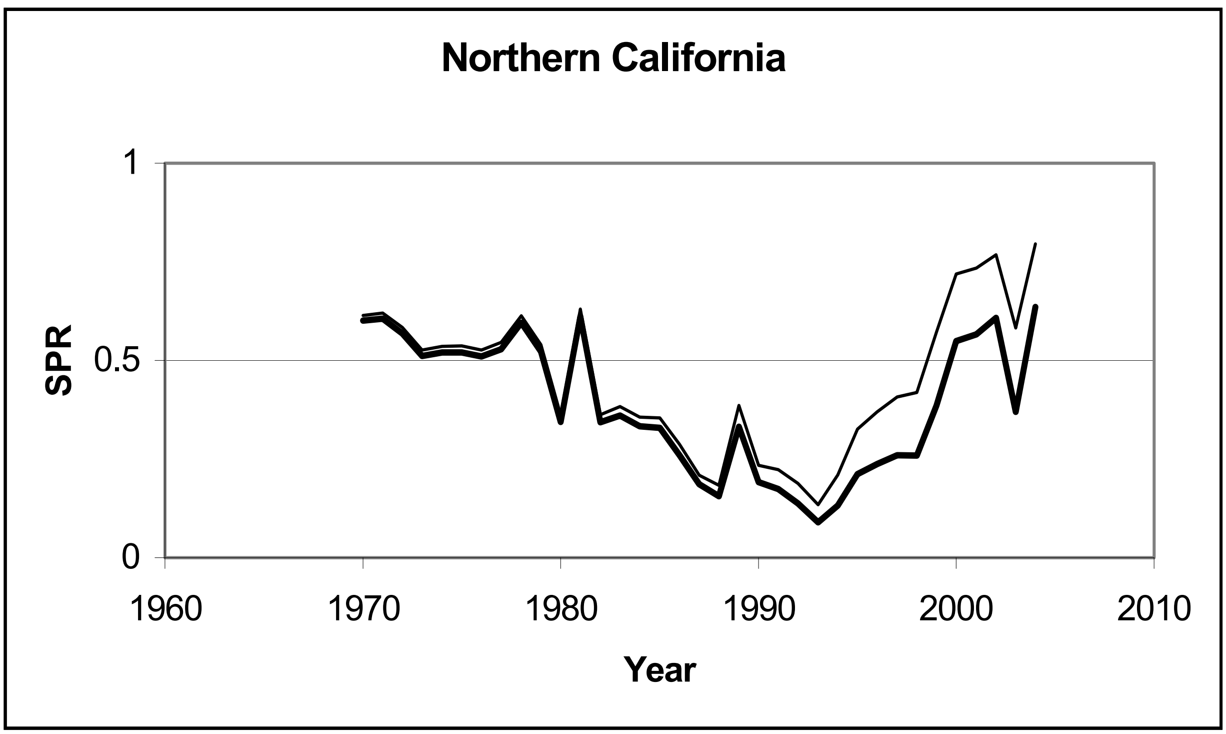


Figure 33. History of estimated fishing intensity expressed as SPR. Thick line is lower bound model and thin line is upper bound model.

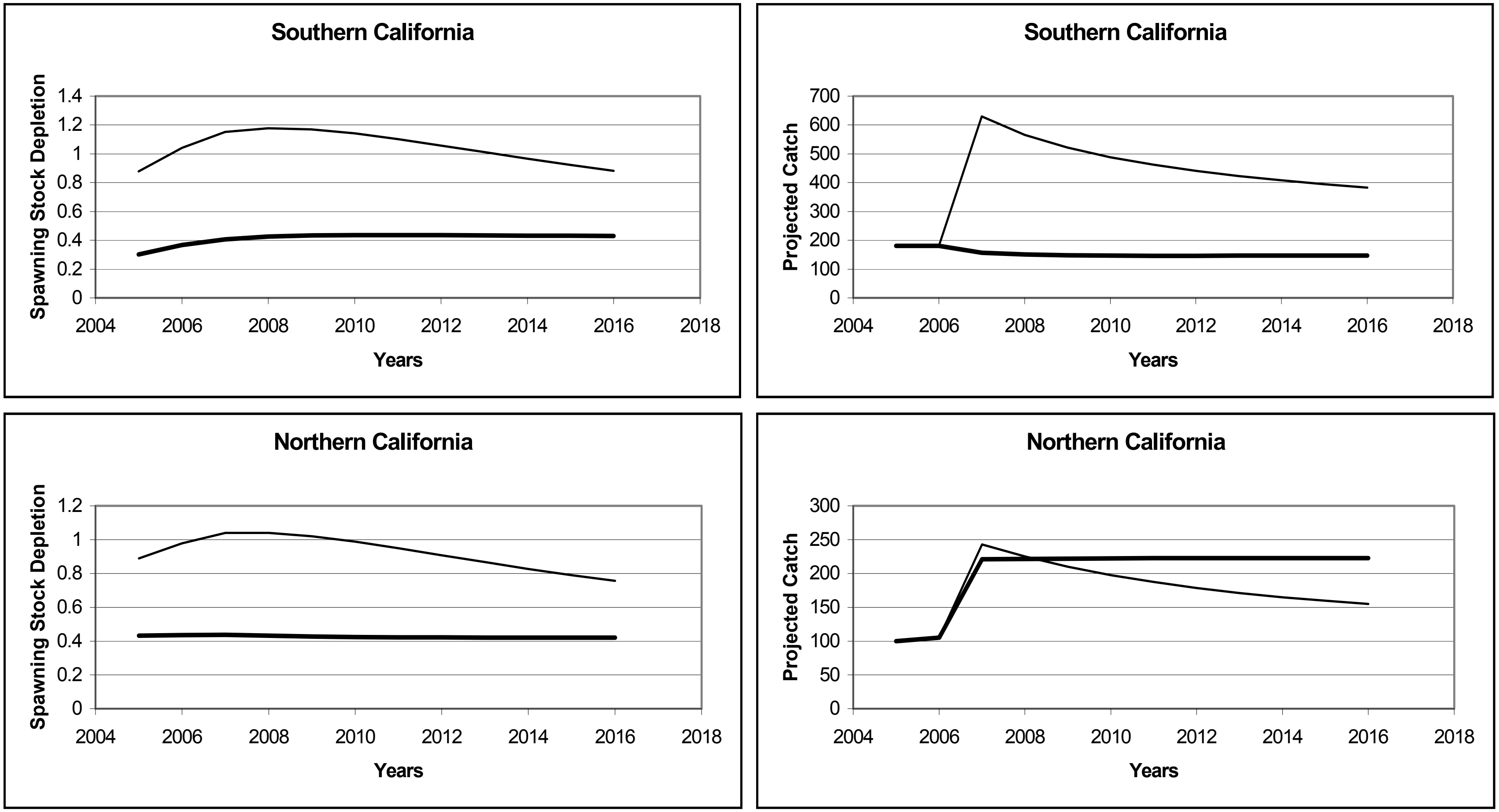


Figure 34. Projected abundance relative to unfished spawning stock biomass, and projected catches at SPR=50%.

Appendix A – Pre-assessment examination of recreational fishery length frequencies of vermilion rockfish.

Relationship between partyboat (CPFV) and private boat length frequencies

On average, recreational landings of vermilion rockfish have been about evenly split between partyboats (a.k.a. commercial passenger fishing vessels, CPFVs) and private boats in both Southern and Northern California. However, sampling for length frequencies has favored partyboat fishing modes, especially in Southern California. Part of the reason is that partyboats provide nearly twice the average number of fish per intercept sample. If the two recreational fishery segments have identical selectivity curves, then samples from the two fishery segments can simply be combined. However, there is a possibility that partyboats and private boats target somewhat different demographic segments of the population. Here I examine that possibility by comparing RecFIN/MRFSS length frequencies for the period 1993 to 2003.

In Southern California there seems to be a slight tendency for small fish to be relatively more abundant in the partyboat catches (Figures PP1a-c), especially since 1996. This suggests that different selectivity curves should be estimated for the two Southern California recreational fishery segments. In contrast, the Northern California length frequency samples (Figures PP2a-c) do not show consistent differences, and can be combined for analysis of the Northern California fishery.

Only partyboat samples are used in the comparisons that follow.

Multiple length frequency sample sources (combine or exclude?)

At various times, separate partyboat sampling programs were conducted by the California Department of Fish and Game (CDFG) and by the MRFSS program (available from the RecFIN data base). Sample sizes are summarized in Tables LF1 and LF2. All length frequencies shown here are expressed in fork length (FL). The question is whether to use one or the other source of length frequency data in this stock assessment, or if they were presumably sampled independently, to combine them.

Southern California samples: The MRFSS program sampled length frequencies from Southern California recreational fisheries from 1980 to 1989, and from 1993 to 2003. Separate partyboat sampling programs were conducted by CDFG from 1975 to 1978 and from 1986 to 1989 (Paulo Serpa, CDFG, pers. comm.). The 1975 to 1978 CDFG samples are the only source of recreational fishery length frequencies prior to the beginning of the MRFSS program in 1980. The CDFG samples taken from 1986 to 1989 appear to be independent of the RecFIN/MRFSS samples (Figure LF1), so the two sources were combined.

Northern California samples: The MRFSS program sampled length frequencies from Northern California recreational fisheries from 1980 to 1989, and from 1993 to 2003. A separate partyboat sampling program was conducted by CDFG from 1987 to 1998 (Deb Wilson-Vandenberg, CDFG, pers. comm.). Length frequencies of vermilion rockfish from the two Northern California sources are compared in Figures LF2a-c. The two distributions appear to be independent except in years 1997 and 1998 where they are nearly identical. Consequently, length frequency samples from 1987 to 1996 were combined, and RecFIN values were used for 1997 and 1998. The CDFG samples are the only source of length frequency information for years 1990-1992.

Comparison of length frequencies from Southern California and Northern California

The stock structure is not known. Year-by-year comparisons of length frequencies from Southern California and Northern California partyboats (Figures LF3a-e) indicates that these two geographic areas may not share the same recruitment patterns.

Until 1987, Northern California sample sizes were relatively small, and only in 1986 is there a clear discrepancy between the patterns in the two areas (Figure LF3b). A strong recruitment in Southern California is first apparent in 1985 (modal length 220mmFL), and in 1986 that mode (220 to 240mmFL) does not appear at all in the Northern California samples. This recruitment mode continues to dominate the Southern California length frequency in1987 (260mmFL), while in Northern California a weak mode at the same length is now apparent. By 1988 and 1989 (Figure LF3c), both areas show very similar length compositions, but the southern California fish are slightly larger in both years.

There are no Southern California samples in 1990-1992, and Southern California sample sizes are very small during much of the 1990's. A new Southern California cohort (modes at 260 and 300mmFL; sample size is very small) appears in 1993 (Figure LF3c), and the Southern California mode is consolidated at 320mmFL in 1994. The 1993 1nd 1994Northern California samples arre large, but show only a very slight indication of a corresponding modal length group. In Northern California a distinct cohort (modal length 340-360mmFL) finally appears in 1995 (Figure LC3d). The 1995 Southern California sample is again small, but shows a distinct mode at 400mmFL. From 1993 to 1996, the Northern California length compositions show an abundance os large fish that do not appear t in the Southern California samples.

Lengths compositions are roughly in agreement in 1997 and 1998 (Figure LC3d), but the Northern California compositions for 1999 to 2001 show a much narrower range of lengths than the Southern California samples. A very strong Southern California recruitment event can be seen beginning in 2001(mode at 200-220mmFL) and 2002 (mode at 240-260mmFL). This young cohort becomes visible later in the Northern California and is first seen in 2002. This cohort dominates the length compositions in both areas in 2003 (mode at 280-300mmFL). In 2002 and 2003, larger fish are still relatively abundant in Northern California, but the incoming cohort comprises most of the overall abundance in Southern California.

Tracking the relative abundance of the large fish component is more difficult. In Southern California, fish of length 540mm or greater are seen regularly in length compositions up to about 1986. The southern California length compositions end at about 540mm from 1987 to 1994, and rarely exceed 460-480mm since the mid-1990's. There appears to have been a severe depletion of large fish in Southern California since the early 1980s. In parallel to Southern California, Northern California fish larger than 540mm are common before 1986, and are rare afterward. However, unlike Southern California, fish in the 460 to 540mm length range continue to appear in Northern California after the mid 1990's.

Some of the behavior of the recruiting modes could be modeled by a two- to three-year delay in recruitment to the Northern California population (i.e., a shift in the selectivity curve toward larger size at entry). However, differences in lengths at age in the two areas are likely to cause difficulty in fitting a length-based model. The differences in relative abundance of large fish between the two areas strongly argues for separate models of the Southern California and Northern California segments of the vermilion rockfish population.

Table LF1. Sample sizes of vermilion rockfish length compositions from Southern California recreational fisheries.

	Partyboat				Private boat		Total	
	CFG		RecFIN		RecFIN			
Year	Nfish	Ntrips	Nfish	Ntrips	Nfish	Ntrips	Nfish	Ntrips
1975	1341	175					1341	175
1976	1520	199					1520	199
1977	2063	167					2063	167
1978	2099	160					2099	160
1979								
1980			154	51	177	79	331	130
1981			248	41	81	40	329	81
1982			288	40	216	70	504	110
1983			219	57	83	38	302	95
1984			424	158	118	56	542	214
1985			366	98	160	68	526	166
1986	1146	138	692	103	144	49	1982	290
1987	2098	160	139	35	114	32	2351	227
1988	2509	142	280	91	100	34	2889	267
1989	1950	162	401	75	115	34	2466	271
1990								
1991								
1992								
1993			20	11	83	35	103	46
1994			55	31	84	33	139	64
1995			41	15	91	31	132	46
1996			201	41	97	37	298	78
1997			13	8	12	10	25	18
1998			281	62	28	15	309	77
1999			1164	205	230	85	1394	290
2000			835	121	131	35	966	156
2001			288	78	81	24	369	102
2002			985	150	123	47	1108	197
2003			1097	137	301	80	1398	217
Total	14726	1303	8191	1608	2569	932	25486	3843

Table LF2. Sample sizes of vermilion rockfish length compositions from Northern California recreational fisheries.

	Partyboat					Private boat		Total	
		CFG		RecFIN		RecFIN			
Year	Nfish	Ntrips	Nsites	Nfish	Ntrips	Nfish	Ntrips	Nfish	Ntrips
1975									
1976									
1977									
1978									
1979									
1980				35	22	24	19	59	41
1981				8	7	15	11	23	18
1982				30	22	39	25	69	47
1983				25	16	47	30	72	46
1984				36	19	78	51	114	70
1985				86	37	64	44	150	81
1986				43	26	88	49	131	75
1987	64	23	25	129	17	56	23	249	63
1988	674	68	100	53	20	59	31	786	119
1989	1274	107	134	37	26	50	27	1361	160
1990	583	45	48					583	45
1991	388	56	62					388	56
1992	1173	125	146					1173	125
1993	1079	128	162	45	16	479	190	1603	334
1994	753	126	164	75	24	276	112	1104	262
1995	968	72	156	86	37	151	59	1205	168
1996	630	70	147	300	108	116	59	1046	237
1997	*1278*	*98*	*177*	1225	157	92	39	1317	196
1998	*662*	*81*	*118*	727	141	121	63	848	204
1999				571	126	254	104	825	230
2000				129	38	197	78	326	116
2001				199	63	71	38	270	101
2002				378	87	236	89	614	176
2003				586	145	506	130	1092	275
Total	9526	999	1439	4803	1154	3019	1271	17348	3424

Note: CFG samples from 1997 and 1998 (italicised) are nearly identical to RecFIN samples; only RecFIN data were used for those years.

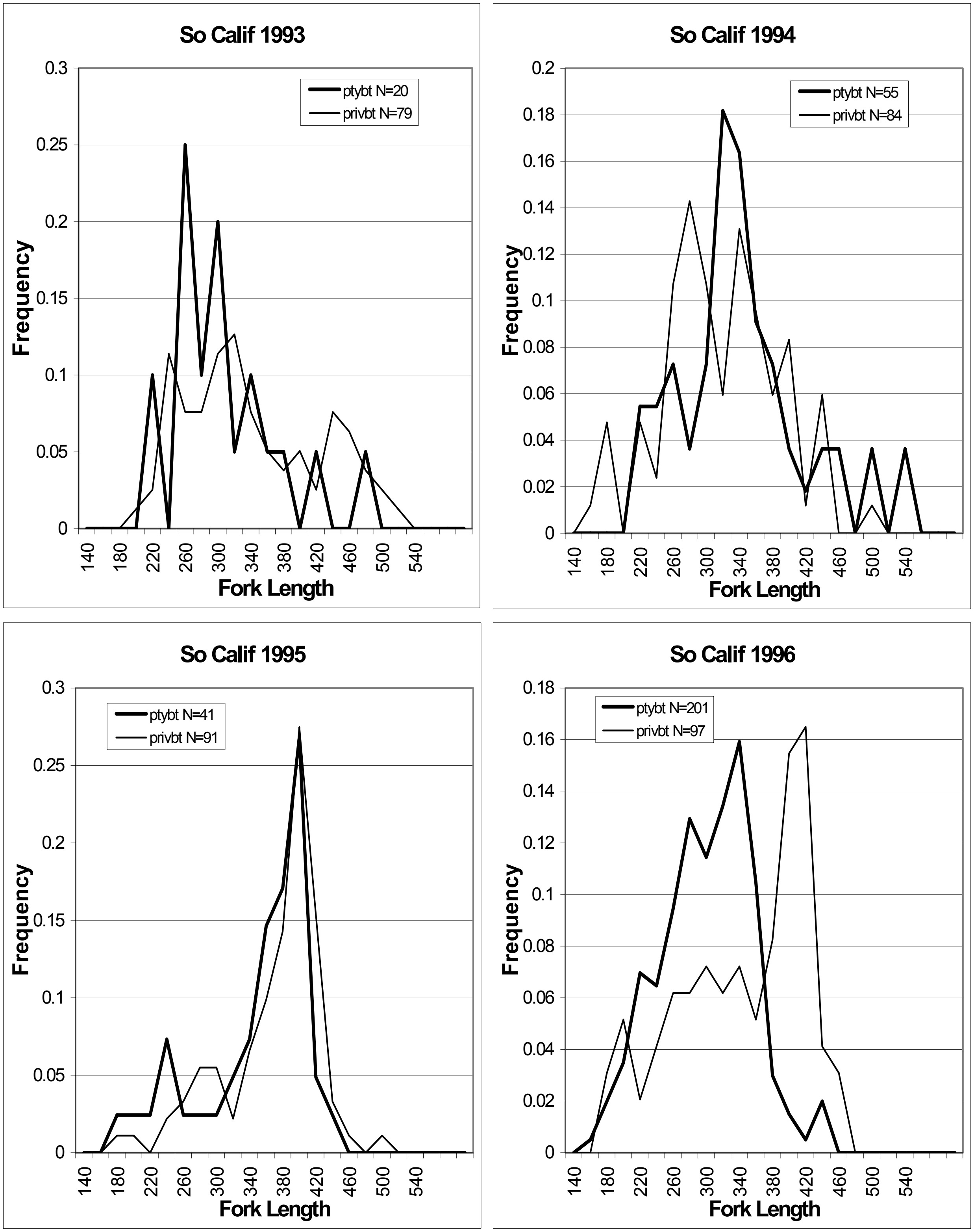
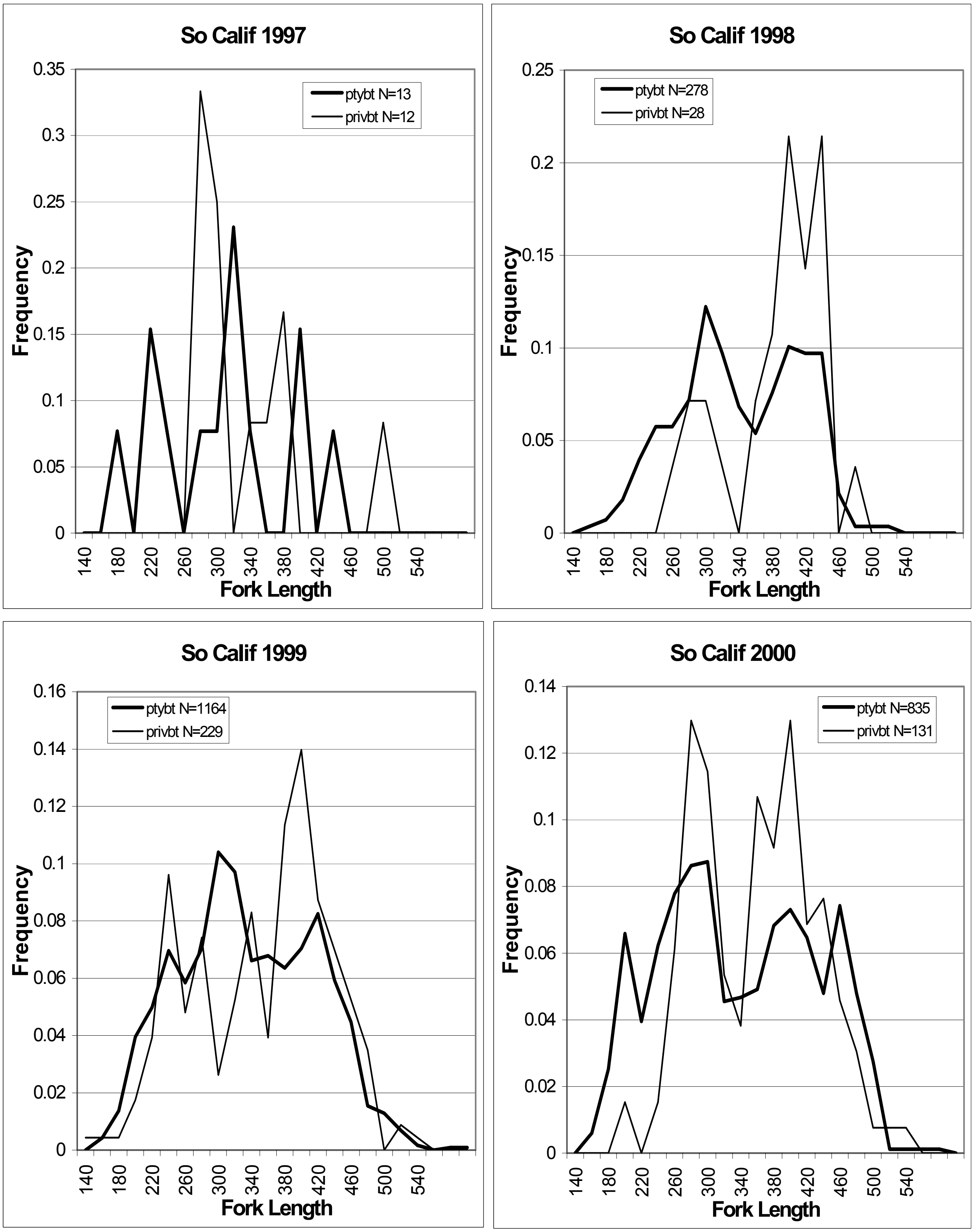


Figure PP1a. Comparison of vermilion rockfish length frequencies from Southern California partyboats (CPFVs) and private boats.



So Calif 1997
ptybt N=13
privbt N=12
Frequency
Fork Length
So Calif 1998
ptybt N=278
privbt N=28
Frequency
Fork Length
So Calif 1999
ptybt N=1164
privbt N=229
Frequency
Fork Length
So Calif 2000
ptybt N=835
privbt N=131
Frequency
Fork Length

Figure PP1b.

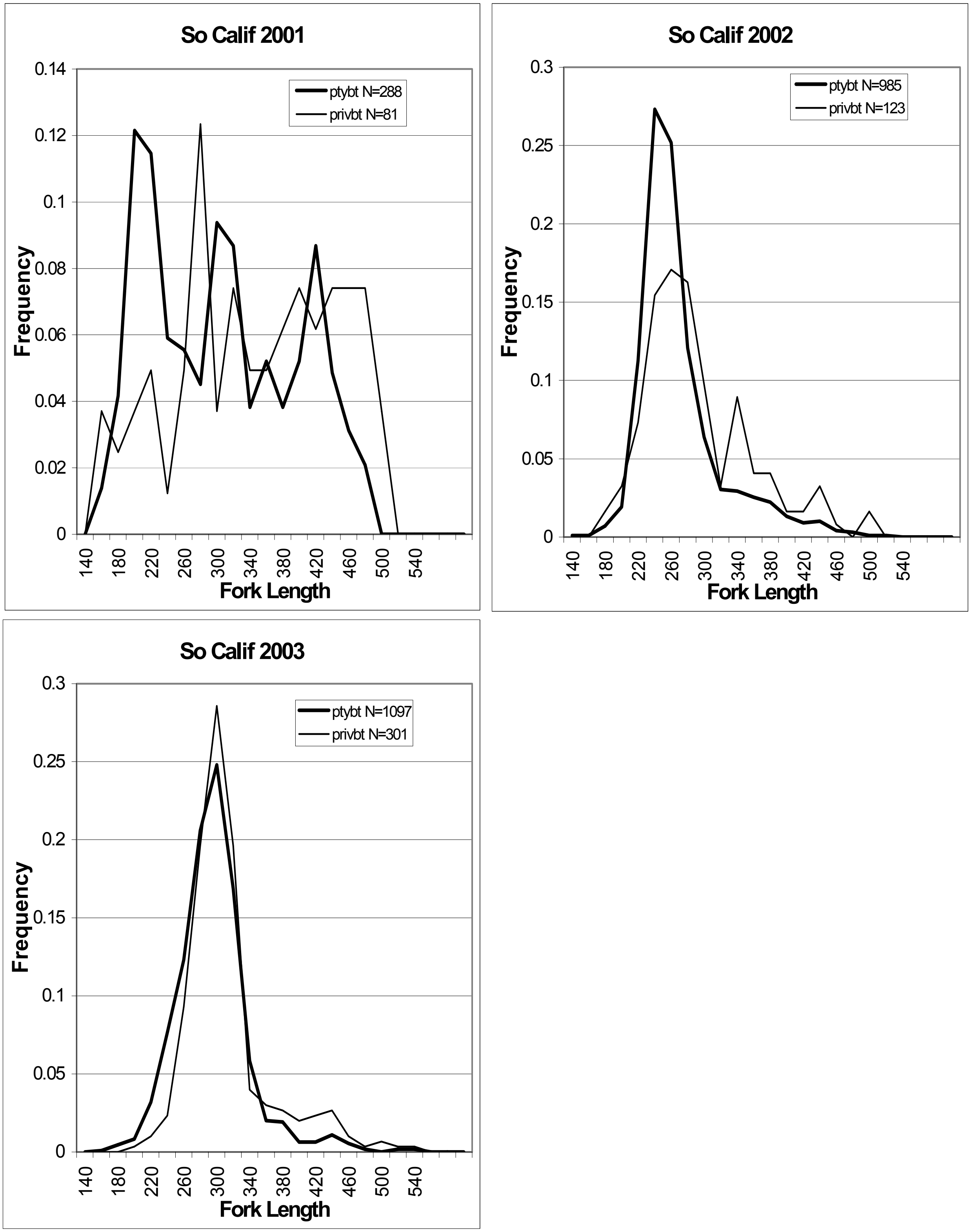

So Calif 2001
ptybt N=288
privbt N=81
Frequency
Fork Length
So Calif 2002
ptybt N=985
privbt N=123
Frequency
Fork Length
So Calif 2003
ptybt N=1097
privbt N=301
Frequency
Fork Length

Figure PP1c.

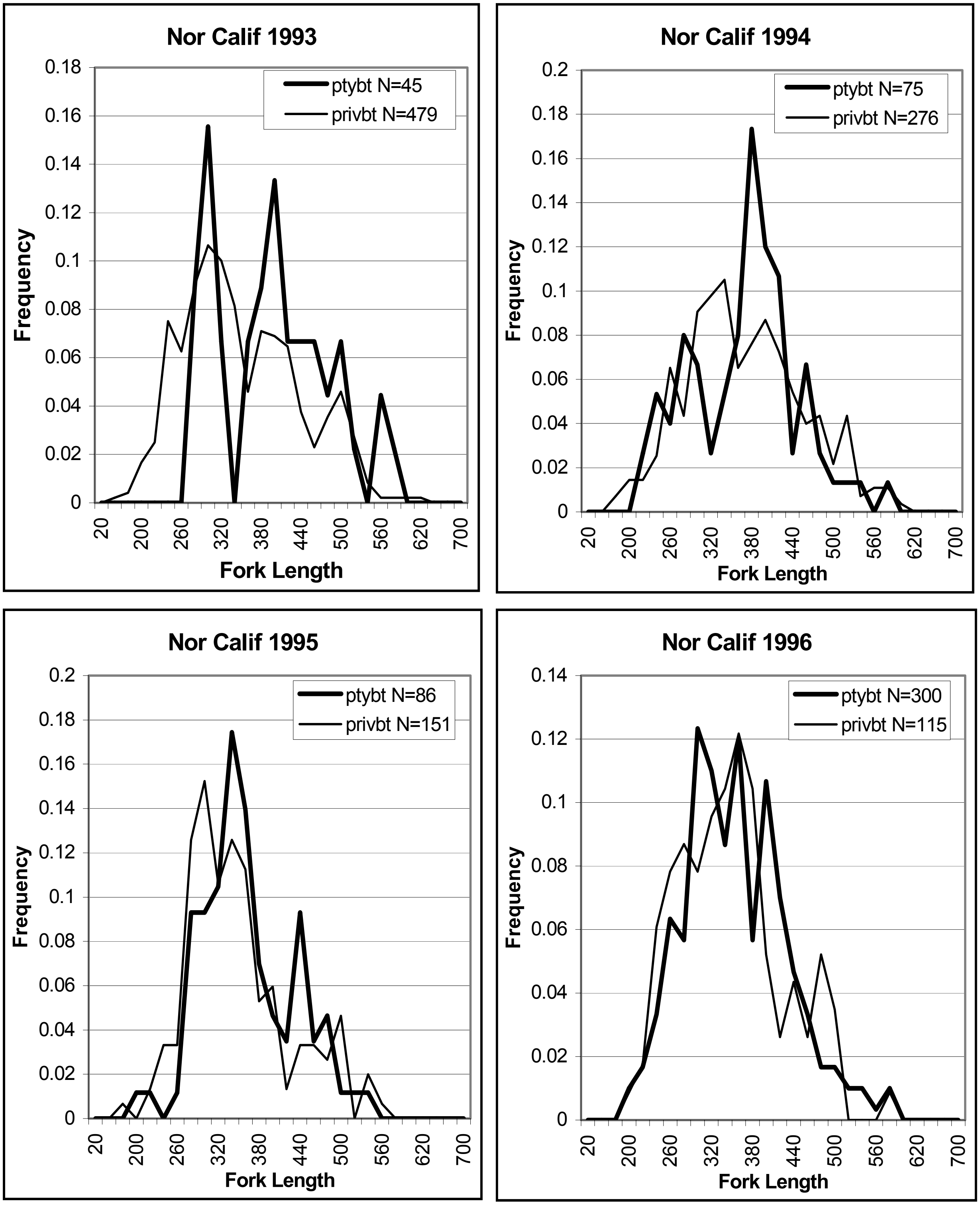


Figure PP2a. Comparison of vermilion rockfish length frequencies from Northern California partyboats (CPFVs) and private boats.

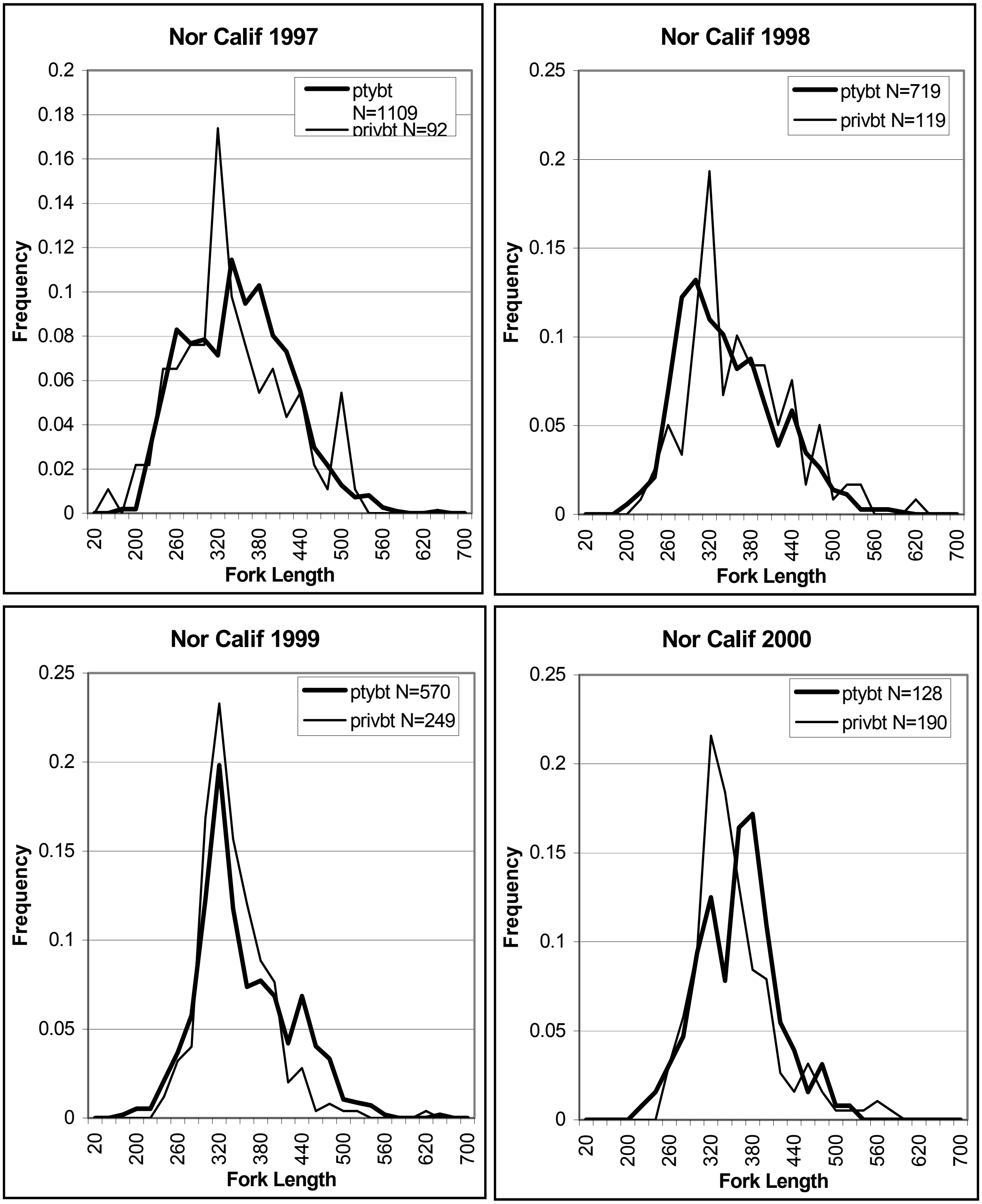

Nor Calif 1997
ptybt N=1109
privbt N=92
Frequency
Fork Length
Nor Calif 1998
ptybt N=719
privbt N=119
Frequency
Fork Length
Nor Calif 1999
ptybt N=570
privbt N=249
Frequency
Fork Length
Nor Calif 2000
ptybt N=128
privbt N=190
Frequency
Fork Length

Figure PP2b.

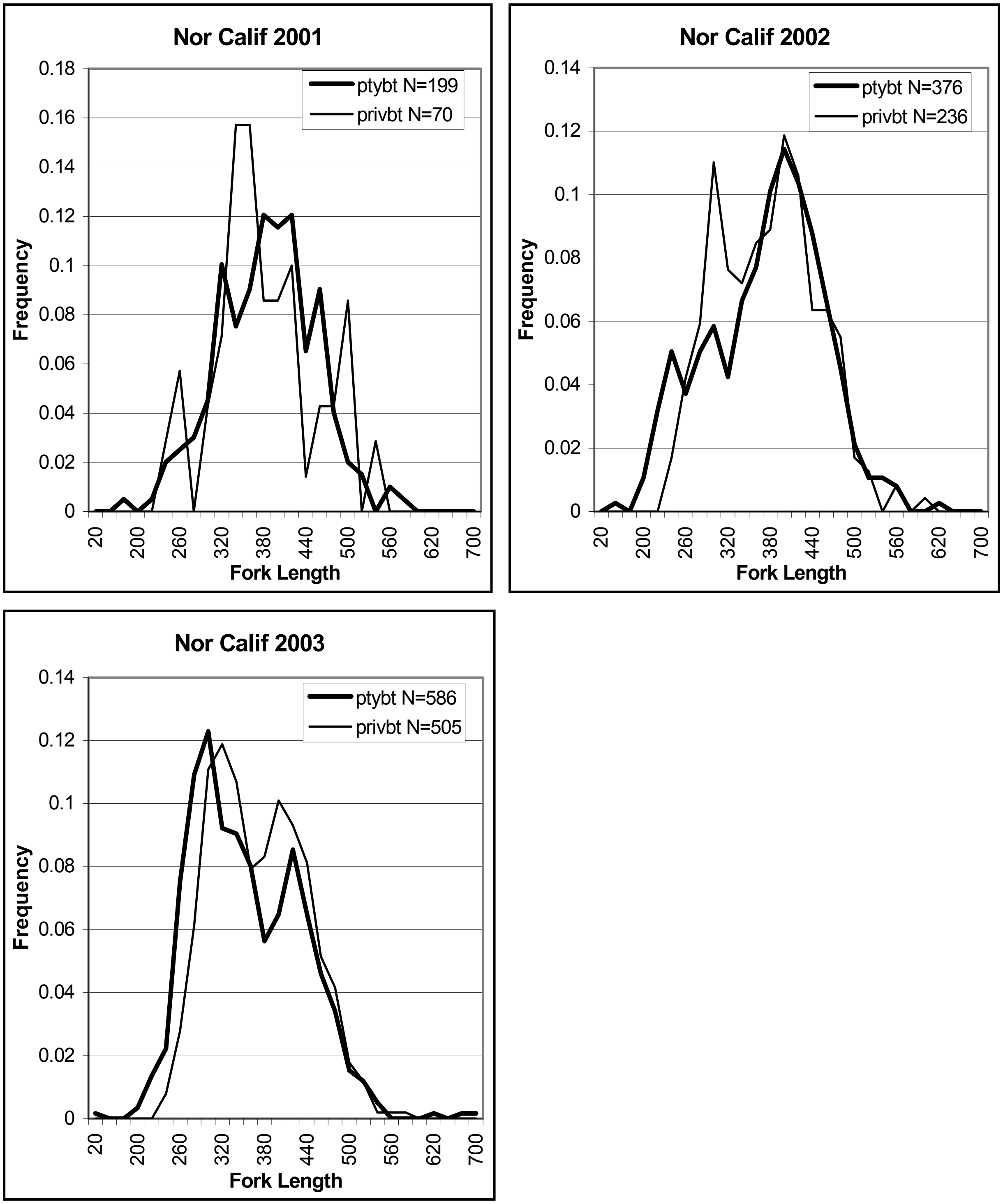

Nor Calif 2001
ptybt N=199
privbt N=70
Frequency
Fork Length
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18
20 200 260 320 380 440 500 560 620 700
Nor Calif 2002
ptybt N=376
privbt N=236
Frequency
Fork Length
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14
20 200 260 320 380 440 500 560 620 700
Nor Calif 2003
ptybt N=586
privbt N=505
Frequency
Fork Length
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14
20 200 260 320 380 440 500 560 620 700

Figure PP2c.

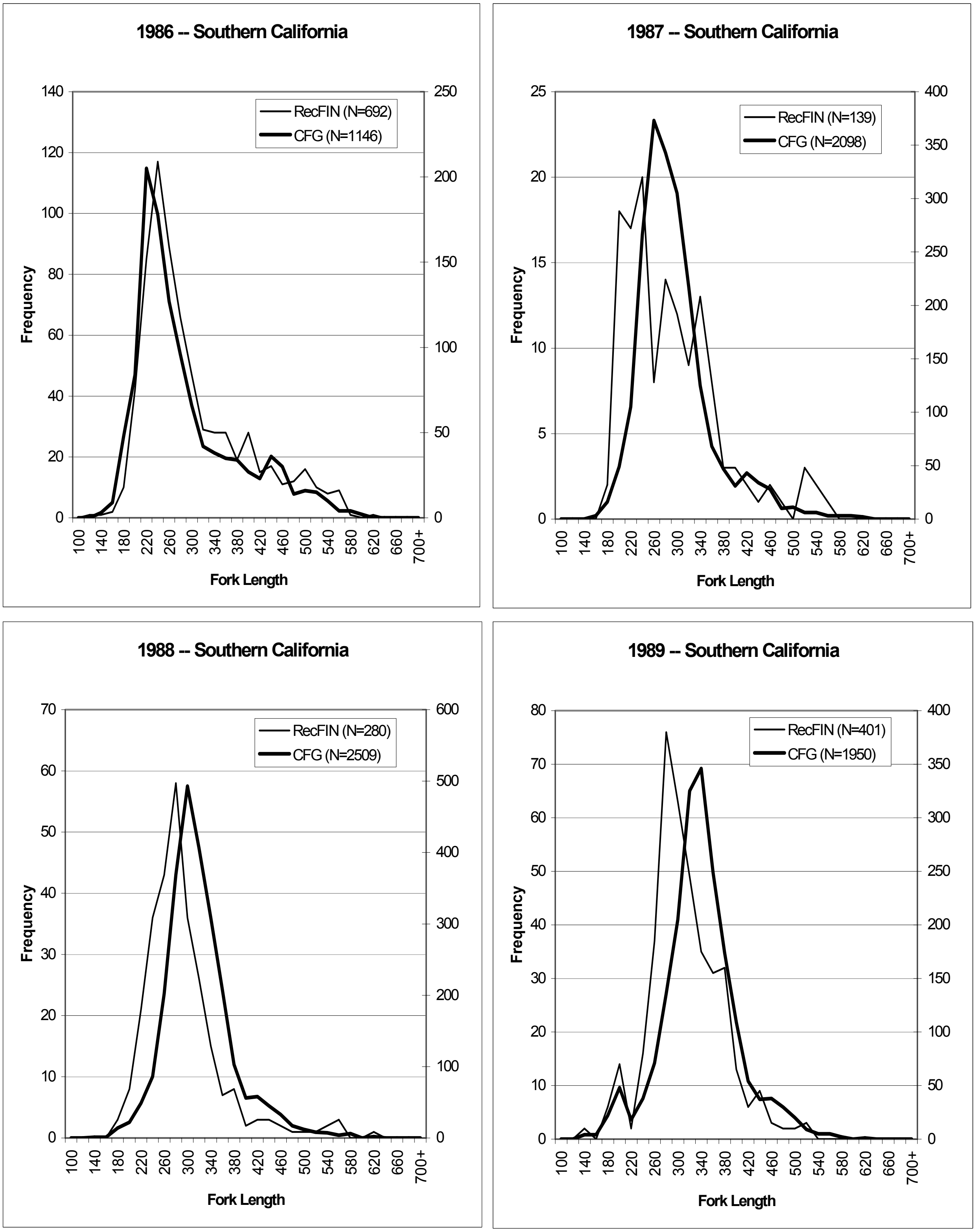


Figure LF1. Comparison of vermilion rockfish length frequencies from Southern California sampled by RecFIN/MRFSS and CDFG.

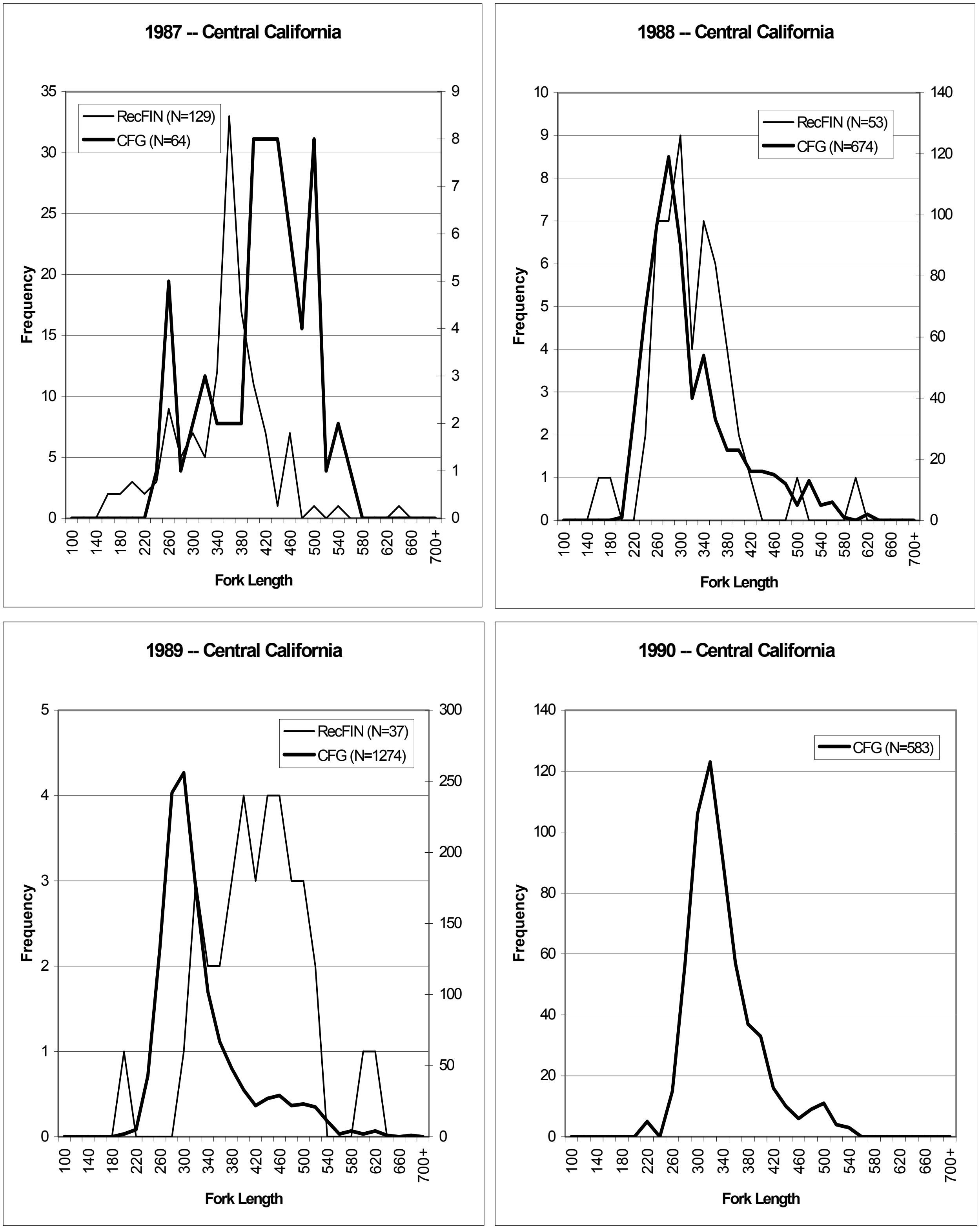


Figure LF2a. Comparison of length frequencies from Northern California RecFIN and CFG partyboat sampling program. No RecFIN/MRFSS samples were taken in 1990.

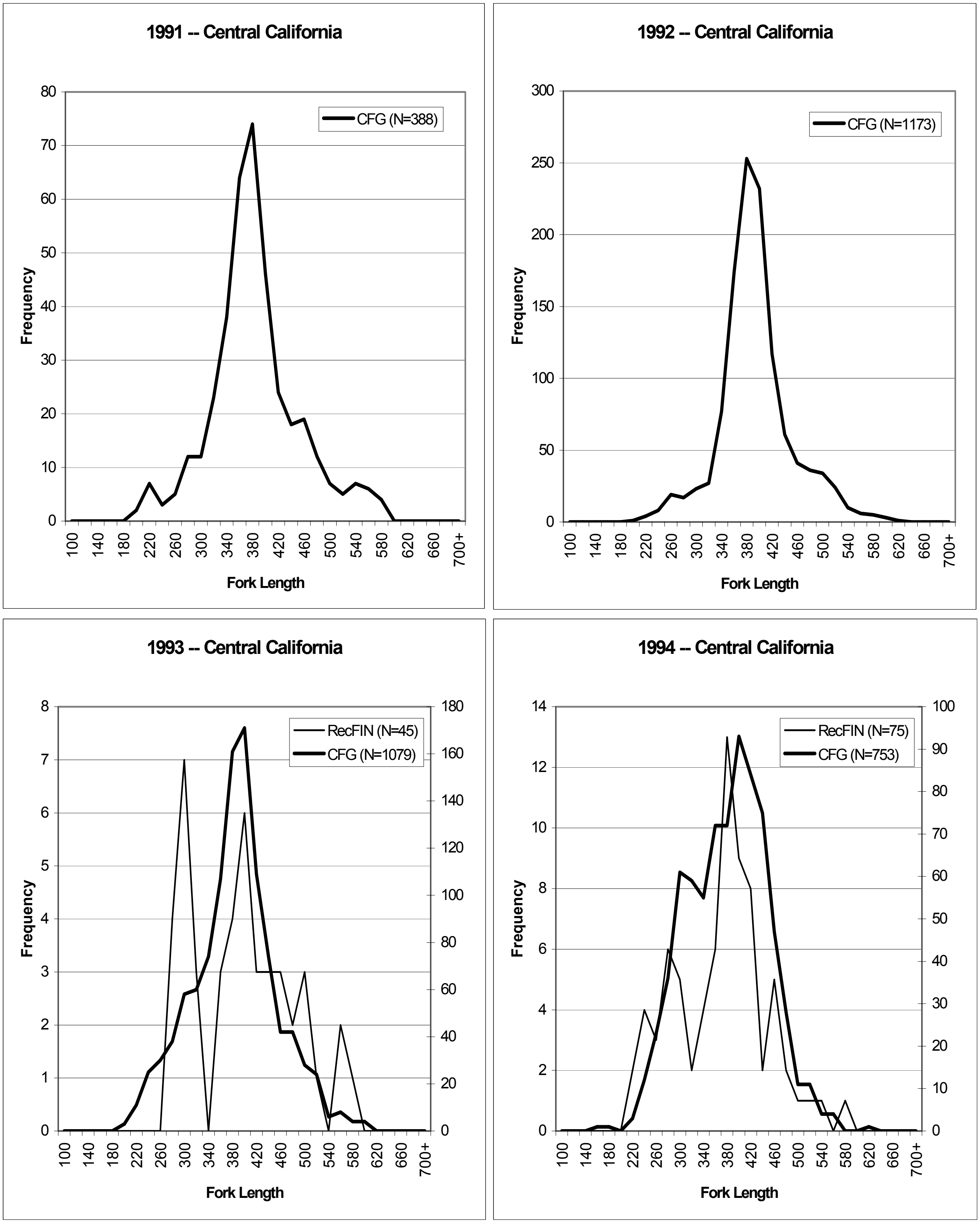


Figure LF2b. No RecFIN/MRFSS samples were taken in 1991 and 1992.

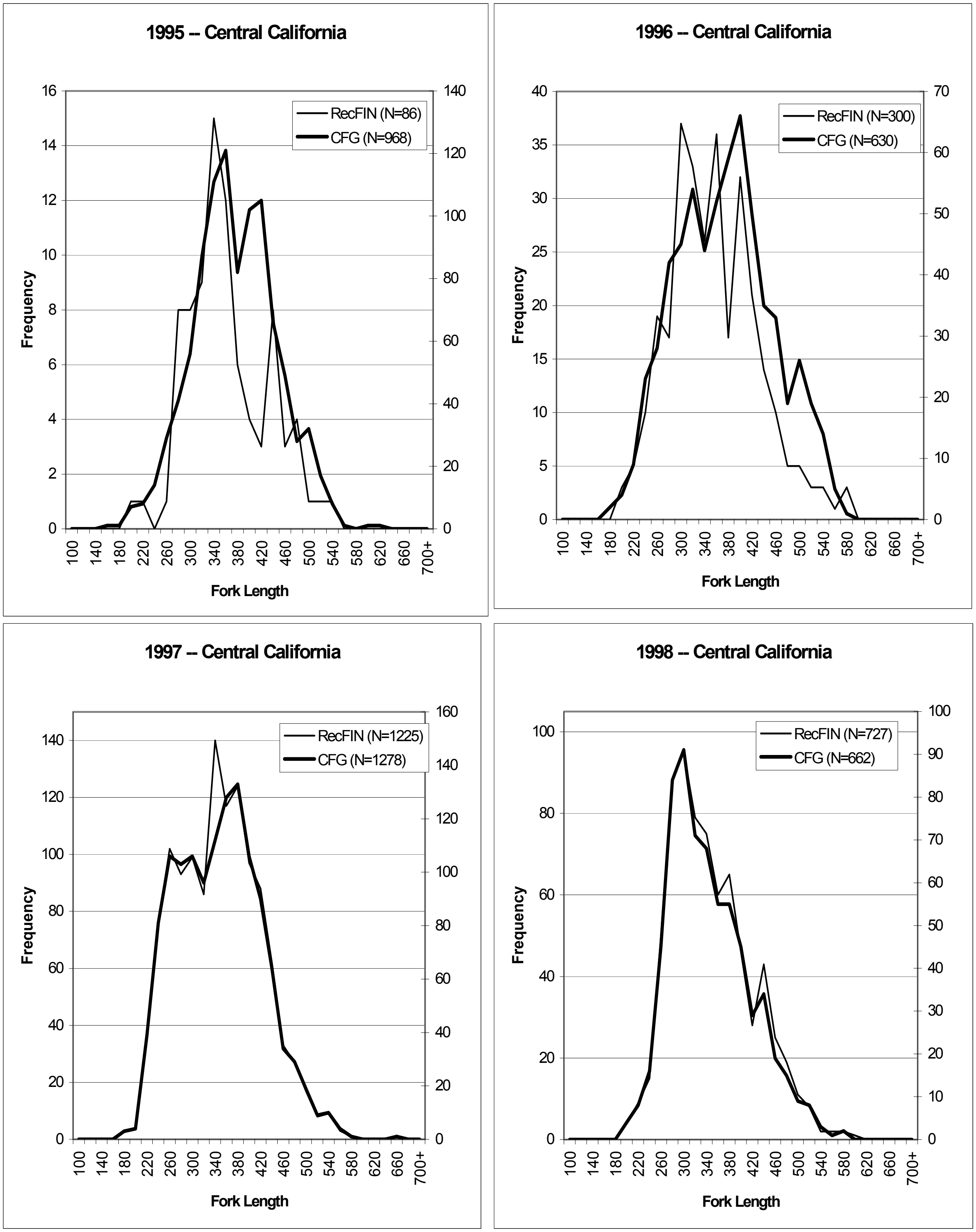

1995 -- Central California
RecFIN (N=86)
CFG (N=968)
Frequency
Fork Length
1996 -- Central California
RecFIN (N=300)
CFG (N=630)
Frequency
Fork Length
1997 -- Central California
RecFIN (N=1225)
CFG (N=1278)
Frequency
Fork Length
1998 -- Central California
RecFIN (N=727)
CFG (N=662)
Frequency
Fork Length

Figure LF2c.

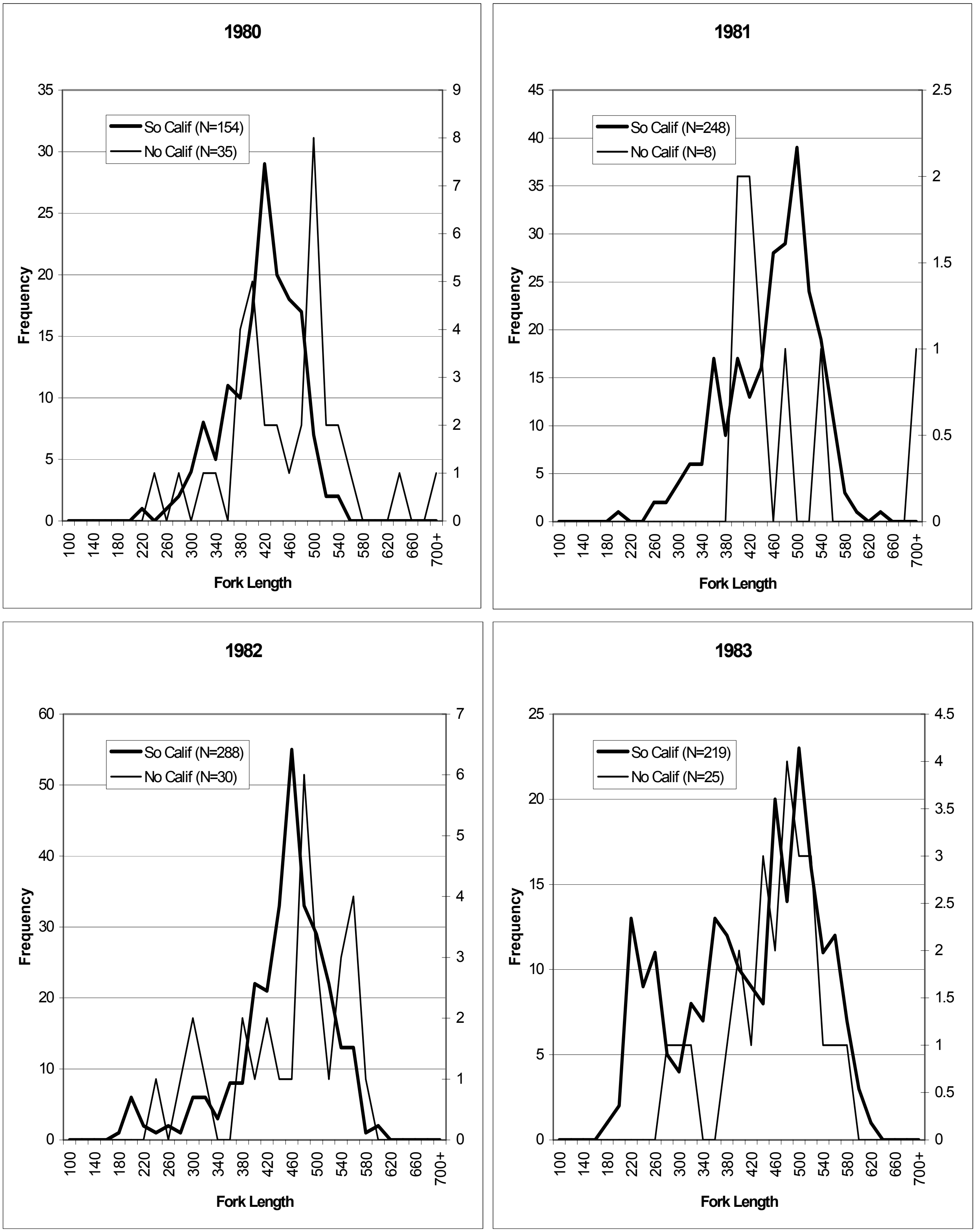

1980
So Calif (N=154)
No Calif (N=35)
Frequency
Fork Length
1981
So Calif (N=248)
No Calif (N=8)
Frequency
Fork Length
1982
So Calif (N=288)
No Calif (N=30)
Frequency
Fork Length
1983
So Calif (N=219)
No Calif (N=25)
Frequency
Fork Length

Figure LF3a.

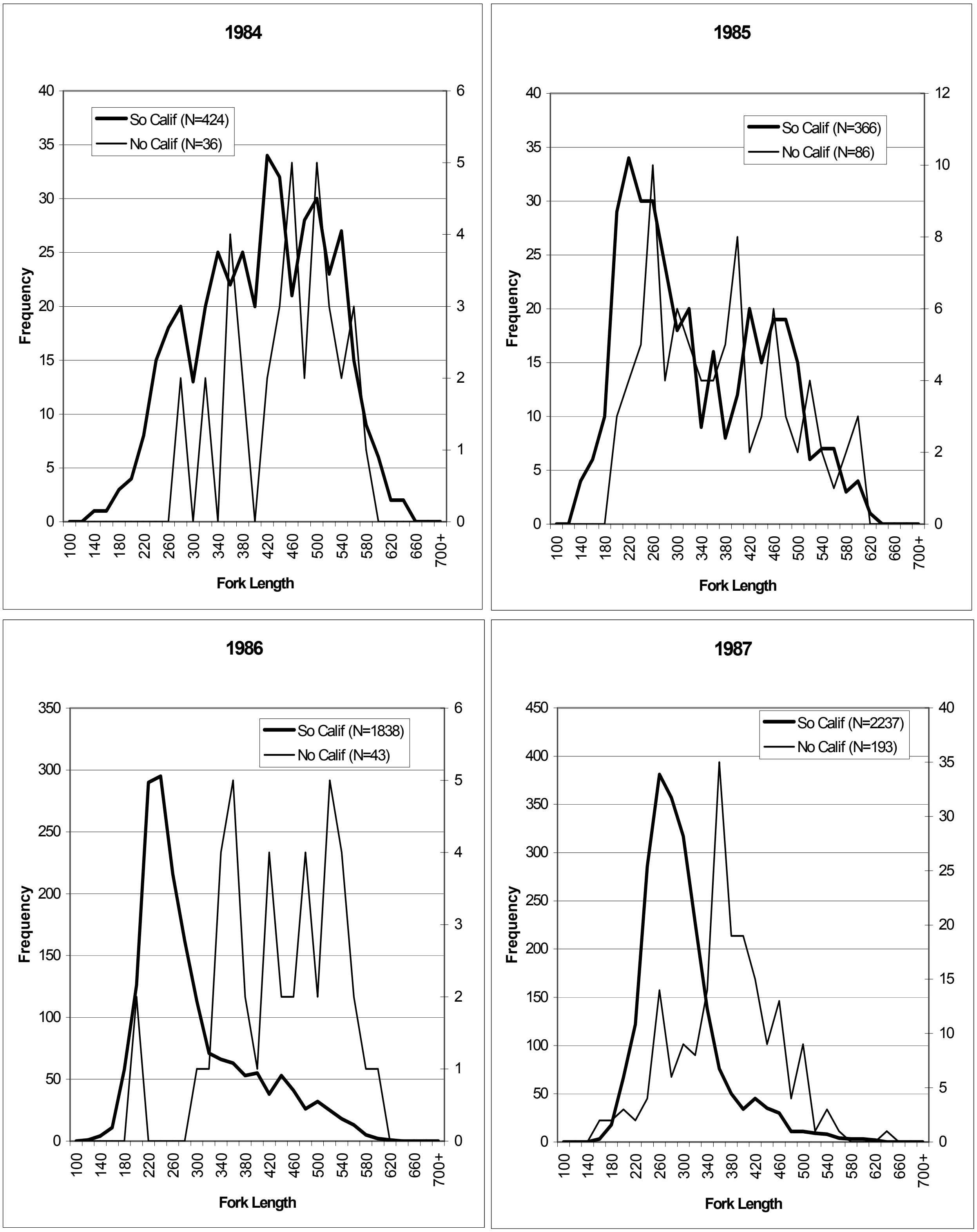

1984
So Calif (N=424)
No Calif (N=36)
Frequency
Fork Length
1985
So Calif (N=366)
No Calif (N=86)
Frequency
Fork Length
1986
So Calif (N=1838)
No Calif (N=43)
Frequency
Fork Length
1987
So Calif (N=2237)
No Calif (N=193)
Frequency
Fork Length

Figure LF3b.

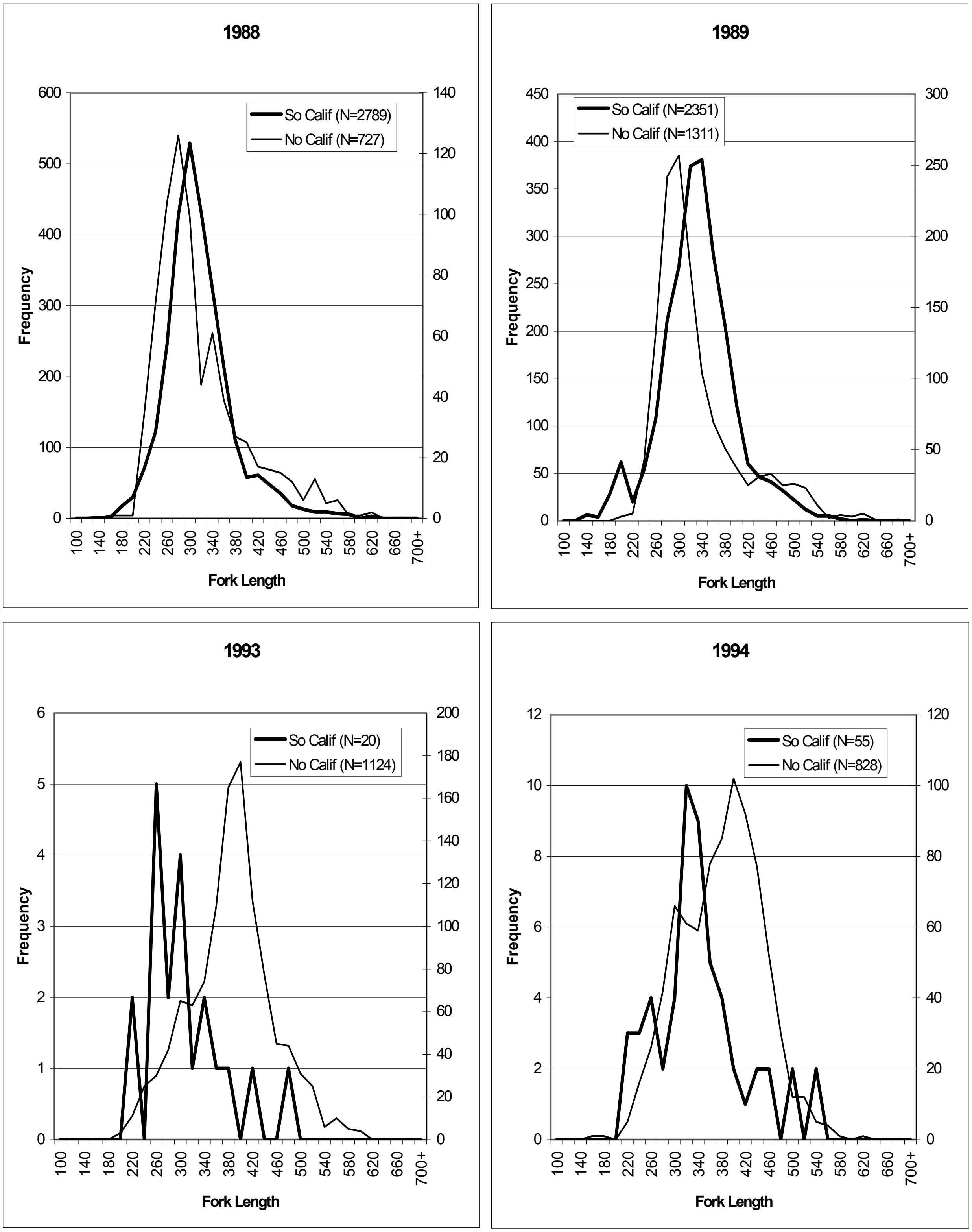
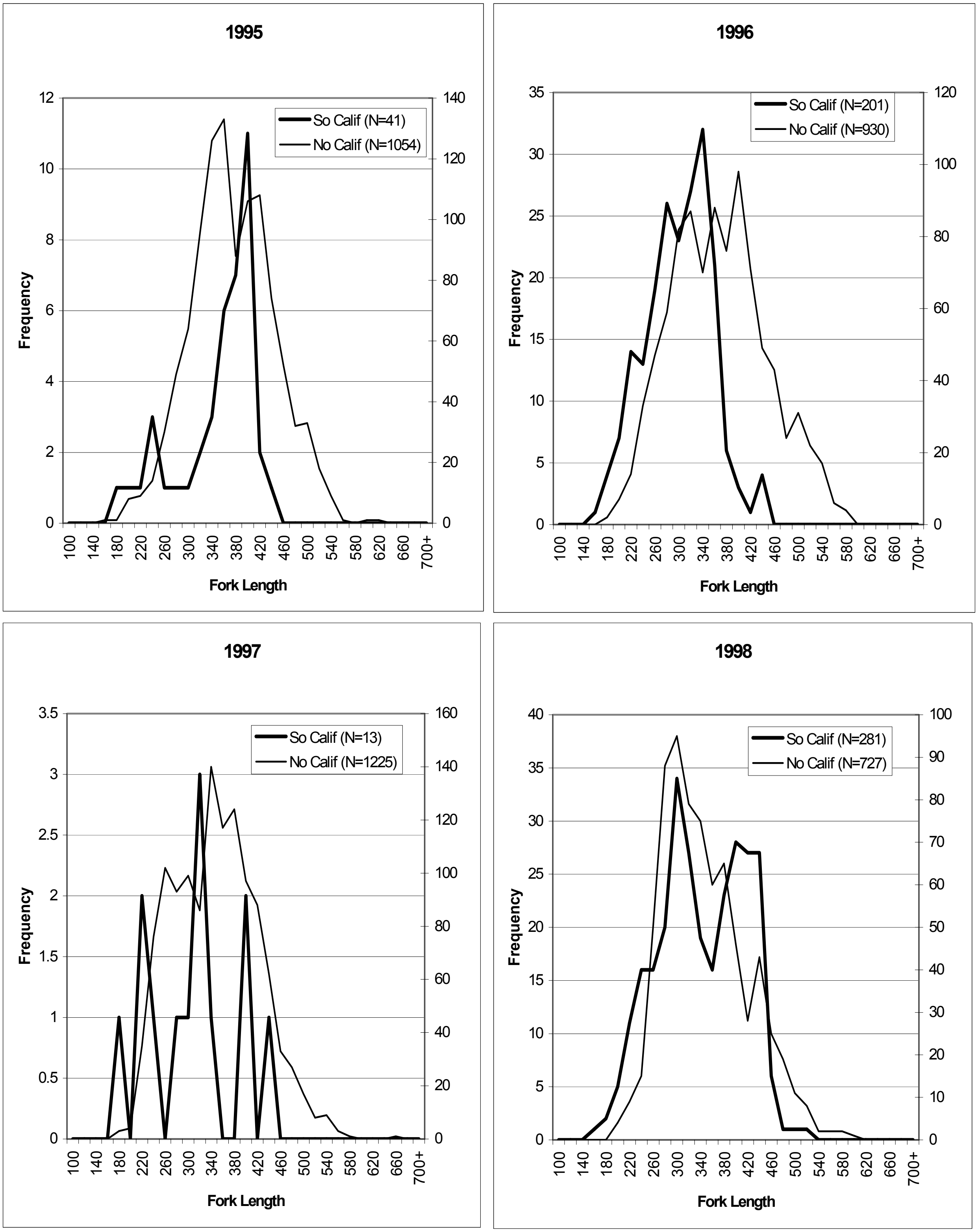
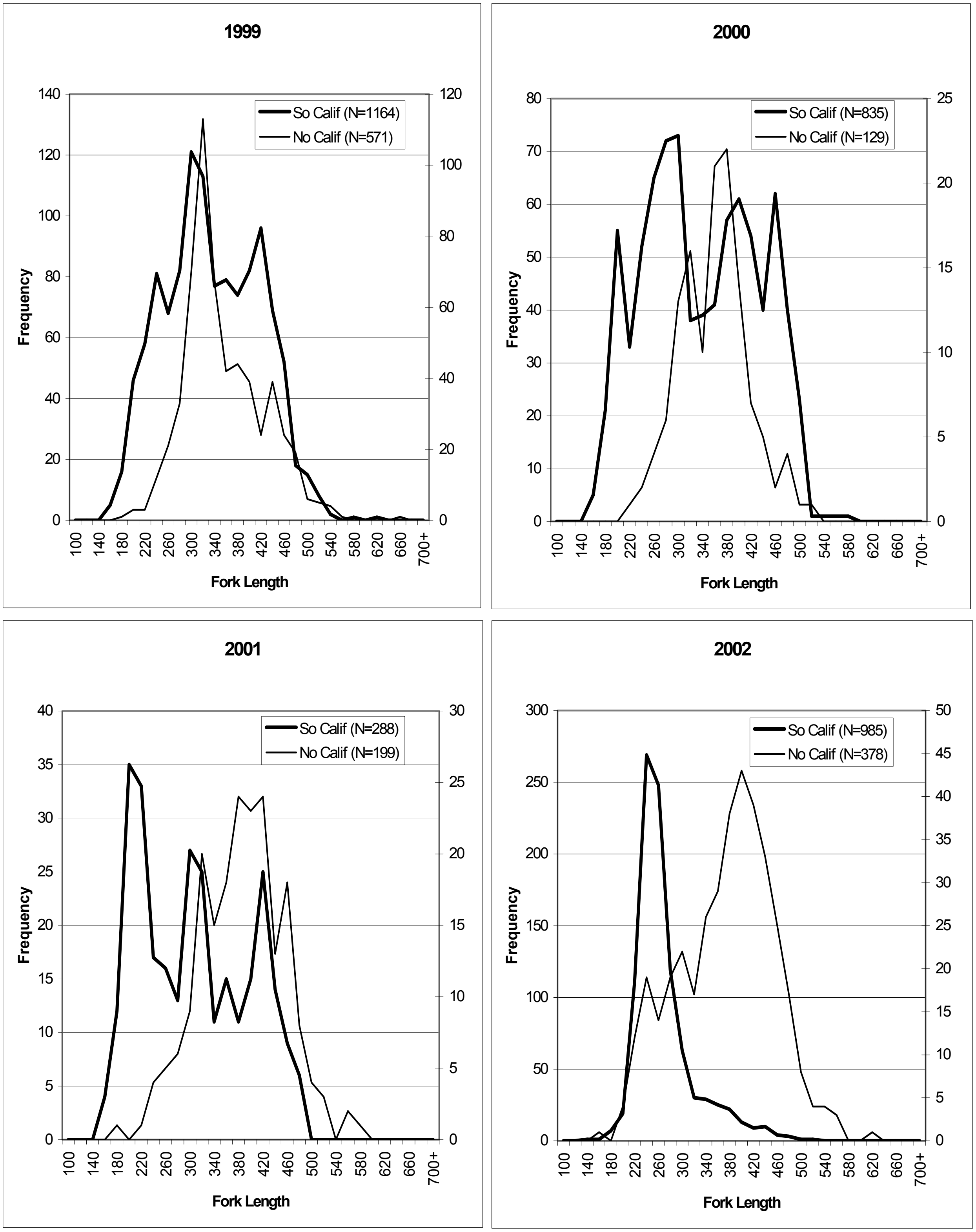

1988
So Calif (N=2789)
No Calif (N=727)
Frequency
Fork Length
1989
So Calif (N=2351)
No Calif (N=1311)
Frequency
Fork Length
1993
So Calif (N=20)
No Calif (N=1124)
Frequency
Fork Length
1994
So Calif (N=55)
No Calif (N=828)
Frequency
Fork Length

Figure LF3c.



1995
So Calif (N=41)
No Calif (N=1054)
Frequency
Fork Length
1996
So Calif (N=201)
No Calif (N=930)
Frequency
Fork Length
1997
So Calif (N=13)
No Calif (N=1225)
Frequency
Fork Length
1998
So Calif (N=281)
No Calif (N=727)
Frequency
Fork Length

Figure LC3d.


1999
So Calif (N=1164)
No Calif (N=571)
Frequency
Fork Length
100 140 180 220 260 300 340 380 420 460 500 540 580 620 660 700+
0 20 40 60 80 100 120 140
0 20 40 60 80 100 120
2000
So Calif (N=835)
No Calif (N=129)
Frequency
Fork Length
0 10 20 30 40 50 60 70 80
0 5 10 15 20 25
2001
So Calif (N=288)
No Calif (N=199)
Frequency
Fork Length
0 5 10 15 20 25 30 35 40
0 5 10 15 20 25 30
2002
So Calif (N=985)
No Calif (N=378)
Frequency
Fork Length
0 50 100 150 200 250 300
0 5 10 15 20 25 30 35 40 45 50
Figure LC3e.

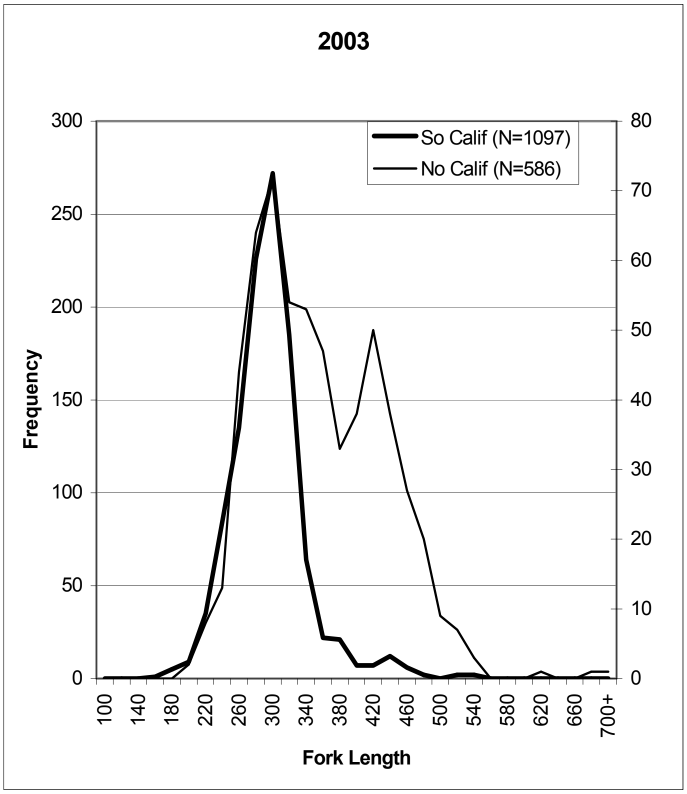

2003
So Calif (N=1097)
No Calif (N=586)
Frequency
Fork Length
300
250
200
150
100
50
0
80
70
60
50
40
30
20
10
0
100
140
180
220
260
300
340
380
420
460
500
540
580
620
660
700+

Figure LC3f.

Appendix B. Data file for southern California assessments.

```
# base data for vermilion rockfish southern california
# MODEL DIMENSIONS
1915    # start_year
2004    # end_year
1               # N_seasons_per_year
12              #_vector_with_N_months_in_each_season
1               #_spawning_season_-_spawning_will_occur_at_beginning_of_this_season
4               #_N_fishing_fleets
1               # N surveys; data type ID below is sequential with the fisheries
SChook%SCnet%SCparty%SCpriv%Harms
0.5  0.5  0.5  0.5 0.5
1               #_number_of_genders(1/2)
50              #_accumulator_age;_model_always_starts_with_age_0
0       0       0       0    # previous (mt) for each fishing fleet
36      5       46      34      #1915
36      5       46      34      #1916
36      5       46      34      #1917
36      5       46      34      #1918
36      5       46      34      #1919
36      5       46      34      #1920
36      5       46      34      #1921
36      5       46      34      #1922
36      5       46      34      #1923
36      5       46      34      #1924
36      5       46      34      #1925
36      5       46      34      #1926
36      5       46      34      #1927
36      5       46      34      #1928
36      5       46      34      #1929
36      5       46      34      #1930
36      5       46      34      #1931
36      5       46      34      #1932
36      5       46      34      #1933
36      5       46      34      #1934
36      5       46      34      #1935
36      5       46      34      #1936
36      5       46      34      #1937
36      5       46      34      #1938
36      5       46      34      #1939
36      5       46      34      #1940
36      5       46      34      #1941
36      5       46      34      #1942
36      5       46      34      #1943
36      5       46      34      #1944
36      5       46      34      #1945
36      5       46      34      #1946
36      5       46      34      #1947
36      5       46      34      #1948
36      5       46      34      #1949
36      5       46      34      #1950
36      5       46      34      #1951
36      5       46      34      #1952
```

36	5	46	34	#1953
36	5	46	34	#1954
36	5	46	34	#1955
36	5	46	34	#1956
36	5	46	34	#1957
36	5	46	34	#1958
36	5	46	34	#1959
36	5	46	34	#1960
36	5	46	34	#1961
36	5	46	34	#1962
36	5	46	34	#1963
36	5	46	34	#1964
36	5	46	34	#1965
36	5	46	34	#1966
36	5	46	34	#1967
36	5	46	34	#1968
36	5	46	34	#1969
36	5	46	34	#1970
36	5	41	30	#1971
36	5	55	41	#1972
36	5	65	48	#1973
36	5	78	57	#1974
36	5	50	37	#1975
36	5	37	27	#1976
36	5	91	67	#1977
41	5	77	57	#1978
23	11	102	75	#1979
18	8	117	107	#1980
28	16	165	36	#1981
25	7	230	106	#1982
33	9	100	30	#1983
51	28	174	90	#1984
55	33	97	110	#1985
103	28	191	99	#1986
32	20	46	189	#1987
29	2	72	119	#1988
122	12	113	66	#1989
129	11	82	74	#1990
174	19	71	64	#1991
152	27	59	53	#1992
139	23	18	73	#1993
216	12	50	105	#1994
111	3	23	141	#1995
72	2	72	93	#1996
80	1	5	7	#1997
82	0	31	30	#1998
18	0	99	52	#1999
5	0	35	59	#2000
3	0	17	31	#2001
5	0	30	31	#2002
0	0	60	59	#2003
5	0	133	34	#2004

#_Fishery CPUE series

```
30	#_N_observations
1975	1	3	-0.1	-0.1	#catch/hourGLM
1976	1	3	-0.1	-0.1	#catch/hourGLM
1977	1	3	-0.1	-0.1	#catch/hourGLM
1978	1	3	-0.1	-0.1	#catch/hourGLM
1979	1	3	-0.1	-0.1	#catch/hourGLM
1980	1	3	0.04019499	1.3	#catch/hourGLM
1981	1	3	0.11792058	0.9	#catch/hourGLM
1982	1	3	0.02663614	1.2	#catch/hourGLM
1983	1	3	0.05582269	0.8	#catch/hourGLM
1984	1	3	0.19865848	0.7	#catch/hourGLM
1985	1	3	0.29173847	0.8	#catch/hourGLM
1986	1	3	0.4187366	0.9	#catch/hourGLM
1987	1	3	0.41773026	1.1	#catch/hourGLM
1988	1	3	0.40548258	1.2	#catch/hourGLM
1989	1	3	0.17054455	1.1	#catch/hourGLM
1990	1	3	-0.1	-0.1	#catch/hourGLM
1991	1	3	-0.1	-0.1	#catch/hourGLM
1992	1	3	-0.1	-0.1	#catch/hourGLM
1993	1	3	0.20247713	1.8	#catch/hourGLM
1994	1	3	0.29036966	1.5	#catch/hourGLM
1995	1	3	0.04471702	1.2	#catch/hourGLM
1996	1	3	0.20365481	0.8	#catch/hourGLM
1997	1	3	0.0669773	1.6	#catch/hourGLM
1998	1	3	0.12344528	0.9	#catch/hourGLM
1999	1	3	0.41219274	0.5	#catch/hourGLM
2000	1	3	0.30727767	0.6	#catch/hourGLM
2001	1	3	0.18770507	0.6	#catch/hourGLM
2002	1	3	0.53631843	0.5	#catch/hourGLM
2003	1	3	0.80270679	0.5	#catch/hourGLM
2004	1	3	-0.1	-0.1	#catch/hourGLM
# Discard section #
#_Discard_Biomass
2	# 1=biomass (mt),2=fraction
0	# N_discard observations
 # Year Seas Type	Value		CV
 # Mean BodyWt (in kg)
0	# N observations
 # Partition=1 means discarded catch, 2 means retained catch, 0 means whole catch (discard+retained)"
 # Year	Seas	Type	Partition	Value	CV
0.001		#  min_proportion_for_compressing_tails_of_observed_composition -1 is no compession
0.00001		# constant added to expected frequencies
27	#_N_length_bins
 #_lower_edge_of_length_bins
18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
	54	56	58	60	62	64	66	68	70
 #	This is the section where lencomps are entered (both fishery & survey) - by year x season x fleet
69	#N_length_observations
 # Gender = 1 means female only
 # Gender = 2 means male only
 # Gender = 0 means both (each) gender that together sum to 1.0
```

1975	1	3	0	2	200	48	108	106	94	132	159	187	130	55	53	42	52
	46	38	35	11	10	14	4	2	1	1	0	0	0	0	0		#
	socalparty																
1976	1	3	0	2	215	21	48	98	135	159	165	173	166	111	96	65	64
	47	45	42	27	12	11	11	7	6	4	1	1	0	0	0		#
	socalparty																
1977	1	3	0	2	257	17	35	61	105	185	219	194	168	141	72	59	71
	60	65	86	95	113	92	74	43	39	35	22	9	2	0	0		#
	socalparty																
1978	1	3	0	2	260	2	11	25	57	90	143	174	201	214	157	130	143
	127	105	98	72	73	68	89	57	35	17	9	1	0	0	0		#
	socalparty																
1980	1	3	0	2	56	0	0	1	0	1	2	4	8	5	11	10	17
	29	20	18	17	7	2	2	0	0	0	0	0	0	0	0		#
	socalparty																
1981	1	3	0	2	74	0	1	0	0	2	2	4	6	6	17	9	17
	13	16	28	29	39	24	19	11	3	1	0	1	0	0	0		#
	socalparty																
1982	1	3	0	2	81	1	6	2	1	2	1	6	6	3	8	8	22
	21	33	55	33	29	22	13	13	1	2	0	0	0	0	0		#
	socalparty																
1983	1	3	0	2	69	1	2	13	9	11	5	4	8	7	13	12	10
	9	8	20	14	23	16	11	12	7	3	1	0	0	0	0		#
	socalparty																
1984	1	3	0	2	101	3	4	8	15	18	20	13	20	25	22	25	20
	34	32	21	28	30	23	27	15	9	6	2	2	0	0	0		#
	socalparty																
1985	1	3	0	2	93	10	29	34	30	30	24	18	20	9	16	8	12
	20	15	19	19	15	6	7	7	3	4	1	0	0	0	0		#
	socalparty																
1986	1	3	0	2	240	58	126	290	295	216	162	113	71	66	63	53	55
	38	53	41	26	32	25	18	13	5	2	1	0	0	0	0		#
	socalparty																
1987	1	3	0	2	270	18	67	122	286	381	357	317	227	138	76	50	34
	45	35	30	11	11	9	8	4	3	3	2	0	0	0	0		#
	socalparty																
1988	1	3	0	2	307	17	30	70	122	245	427	529	432	323	214	111	58
	61	48	35	18	13	9	9	7	6	0	3	0	0	0	0		#
	socalparty																
1989	1	3	0	2	278	28	62	20	54	108	212	268	374	381	280	206	122
	60	46	41	32	22	12	5	5	2	0	1	0	0	0	0		#
	socalparty																
1993	1	3	0	2	17	0	0	2	0	5	2	4	1	2	1	1	0
	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0		#
	socalparty																
1994	1	3	0	2	31	0	0	3	3	4	2	4	10	9	5	4	2
	1	2	2	0	2	0	2	0	0	0	0	0	0	0	0		#
	socalparty																
1995	1	3	0	2	26	1	1	1	3	1	1	1	2	3	6	7	11
	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0		#
	socalparty																

1996	1	3	0	2	65	4	7	14	13	19	26	23	27	32	21	6	3
	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0		#
	socalparty																
1997	1	3	0	2	13	1	0	2	1	0	1	1	3	1	0	0	2
	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		#
	socalparty																
1998	1	3	0	2	80	2	5	11	16	16	20	34	27	19	16	23	28
	27	27	6	1	1	1	0	0	0	0	0	0	0	0	0		#
	socalparty																
1999	1	3	0	2	184	16	46	58	81	68	82	121	113	77	79	74	82
	96	69	52	18	15	8	2	0	1	0	1	0	0	0	0		#
	socalparty																
2000	1	3	0	2	151	21	55	33	52	65	72	73	38	39	41	57	61
	54	40	62	40	23	1	1	1	1	0	0	0	0	0	0		#
	socalparty																
2001	1	3	0	2	81	12	35	33	17	16	13	27	25	11	15	11	15
	25	14	9	6	0	0	0	0	0	0	0	0	0	0	0		#
	socalparty																
2002	1	3	0	2	166	7	19	111	269	248	119	63	30	29	25	22	13
	9	10	4	3	1	1	0	0	0	0	0	0	0	0	0		#
	socalparty																
2003	1	3	0	2	177	5	9	35	84	135	226	272	185	64	22	21	7
	7	12	6	2	0	2	2	0	0	0	0	0	0	0	0		#
	socalparty																
2004	1	3	0	2	254	6	27	40	40	82	172	313	429	394	215	120	71
	36	26	23	16	10	0	0	4	0	0	1	0	0	0	0		#
	socalparty																
1980	1	4	0	2	63	1	2	12	12	8	12	16	7	9	12	13	14
	10	12	9	3	15	3	0	2	0	0	0	0	0	1	0		#
	socalpriv																
1981	1	4	0	2	39	0	1	3	2	5	7	2	4	7	2	9	7
	5	9	8	3	4	2	1	0	0	0	0	0	0	0	0		#
	socalpriv																
1982	1	4	0	2	71	0	4	6	6	5	4	6	15	12	15	11	23
	12	16	29	19	15	6	7	3	1	1	0	0	0	0	0		#
	socalpriv																
1983	1	4	0	2	39	0	2	7	7	8	4	4	8	8	9	3	3
	5	6	2	5	0	2	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1984	1	4	0	2	49	1	1	1	4	1	5	9	13	15	9	4	3
	6	15	13	9	7	0	1	1	0	0	0	0	0	0	0		#
	socalpriv																
1985	1	4	0	2	59	0	4	6	8	12	14	11	15	18	10	6	5
	3	11	14	8	8	3	1	2	0	0	0	0	0	0	0		#
	socalpriv																
1986	1	4	0	2	55	2	2	18	16	11	13	12	16	10	4	6	3
	3	6	8	4	4	5	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1987	1	4	0	2	48	1	3	5	9	21	14	18	10	13	4	3	3
	2	0	5	1	2	0	0	0	0	0	0	0	0	0	0		#
	socalpriv																

1988	1	4	0	2	44	0	0	0	10	11	18	15	11	12	7	3	2
	3	3	0	2	2	1	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1989	1	4	0	2	48	0	2	0	8	6	16	22	14	13	9	13	5
	1	4	2	0	0	0	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1993	1	4	0	2	39	0	1	2	10	7	6	9	10	7	5	3	4
	2	6	5	3	2	1	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1994	1	4	0	2	39	4	0	4	2	9	12	9	5	11	8	5	7
	1	5	0	0	1	0	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1995	1	4	0	2	41	1	1	0	2	3	5	5	2	6	9	13	25
	14	3	1	0	1	0	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1996	1	4	0	2	43	3	5	2	4	6	6	7	6	7	5	8	15
	16	4	3	0	0	0	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1997	1	4	0	2	12	0	0	0	0	0	4	3	0	1	1	2	0
	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1998	1	4	0	2	20	0	0	0	0	1	2	2	1	0	2	3	6
	4	6	0	1	0	0	0	0	0	0	0	0	0	0	0		#
	socalpriv																
1999	1	4	0	2	74	1	5	9	22	11	17	6	12	19	9	26	32
	20	16	12	8	0	2	1	0	0	0	0	0	0	0	0		#
	socalpriv																
2000	1	4	0	2	52	0	2	0	2	8	17	15	7	5	14	12	17
	9	10	6	4	1	1	1	0	0	0	0	0	0	0	0		#
	socalpriv																
2001	1	4	0	2	39	2	3	4	1	4	10	3	6	4	4	5	6
	5	6	6	6	3	0	0	0	0	0	0	0	0	0	0		#
	socalpriv																
2002	1	4	0	2	50	2	4	9	19	21	20	12	4	11	5	5	2
	2	4	1	0	2	0	0	0	0	0	0	0	0	0	0		#
	socalpriv																
2003	1	4	0	2	87	0	1	3	7	28	59	86	59	12	9	8	6
	7	8	3	1	2	1	1	0	0	0	0	0	0	0	0		#
	socalpriv																
2004	1	4	0	2	216	1	8	11	16	50	91	232	293	221	118	101	56
	22	29	26	15	4	8	2	0	0	0	0	0	0	0	0		#
	socalpriv																
1986	1	1	0	2	38	0	0	0	0	0	0	0	0	22	250	44	380
	1029	1644	2208	1870	1558	937	1605	1029	478	53	72	29	0	87	0		#
	HKL	356															
1987	1	1	0	2	21	0	0	0	0	0	17	169	134	54	123	175	138
	471	743	395	608	348	483	300	125	142	0	0	0	0	0	0		#
	HKL	119															
1988	1	1	0	2	20	0	0	0	0	0	0	0	92	322	239	387	151
	458	389	634	1102	114	304	114	77	64	81	27	27	0	0	0		#
	HKL	118															

1989	1	1	0	2	39	0	0	0	0	40	168	255	565	350	544	419	601
	1151	1152	1755	1807	1213	1094	392	303	358	4	4	0	0	0	0		#
	HKL	367															
1990	1	1	0	2	11	0	0	0	0	1012	1012	4048	6072	2024	2024	5098	1012
	2374	3736	6460	5098	4086	0	1362	0	1362	0	0	0	0	0	0		#
	HKL	40															
1991	1	1	0	2	10	0	0	0	3028	0	0	0	3028	12112	18168	12112	3028
	12112	15140	3028	6056	0	3028	3028	0	0	0	0	0	0	0	0		#
	HKL	31															
#1992	1	1	0	2	1	0	0	0	18	90	216	72	0	84	84	125	148
	1009	2672	4868	3372	8890	4554	4513	6411	5066	8548	0	0	0	0	0		
	HKL	106 delete year due to anomalous freqs															
1994	1	1	0	2	19	21	0	0	15	21	579	617	474	3190	14516	16133	10050
	278	72	1935	0	0	0	0	0	0	0	0	0	0	0	0		#
	HKL	99															
1995	1	1	0	2	47	0	0	0	0	2	34	187	268	258	795	1111	1746
	1730	592	281	165	146	204	32	0	42	0	0	0	0	0	0		#
	HKL	512															
1996	1	1	0	2	37	0	0	197	305	260	48	48	75	202	200	474	950
	1455	1046	598	714	389	139	77	11	40	29	11	0	0	0	0		#
	HKL	336															
1997	1	1	0	2	54	0	0	0	2	8	40	104	254	219	275	363	159
	793	446	614	224	219	103	18	4	67	4	0	0	0	0	0		#
	HKL	635															
1998	1	1	0	2	65	0	0	4	27	91	64	165	229	285	298	660	469
	500	1168	1404	1814	2019	1043	393	86	42	0	0	0	0	0	0		#
	HKL	898															
1999	1	1	0	2	18	0	40	0	40	200	255	322	812	324	308	181	685
	257	381	156	827	624	312	156	0	0	0	0	0	0	0	0		#
	HKL	91															
2001	1	1	0	2	6	0	0	337	0	58	0	1011	1348	674	58	337	0
	0	0	58	0	0	0	0	0	0	0	0	0	0	0	0		#
	HKL	14															
2002	1	1	0	2	18	0	0	0	42	226	992	780	262	274	102	60	36
	0	0	18	0	0	80	0	0	0	0	0	0	0	0	0		#
	HKL	96															
1986	1	2	0	2	65	0	0	0	0	18	41	44	92	92	41	74	146
	124	194	340	306	538	649	569	291	198	199	10	9	19	9	0		#
	NET	172 delete 70cm fish, presume misIDed															
1987	1	2	0	2	16	0	0	0	0	0	0	0	0	0	0	12	21
	18	453	41	54	865	62	1269	1651	30	842	0	0	0	0	0		#
	NET	55															
1989	1	2	0	2	3	0	0	0	0	716	716	0	1432	716	2864	1432	716
	0	0	716	0	0	0	0	0	0	0	0	0	0	0	0		#
	NET	13															
1992	1	2	0	2	15	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	9	18	6	12	3	3	3	0	0	0	0	0		#
	NET	51															
1995	1	2	0	2	6	0	0	0	0	0	0	0	0	0	0	277	490
	209	70	0	0	0	0	0	0	0	0	0	0	0	0	0		#
	NET	26															

1996	1	2	0	2	18	0	0	0	0	0	0	0	0	0	2	26	70
	113	96	21	0	21	0	0	10	10	0	10	0	0	0	0		#
	NET	59															
1998	1	2	0	2	5	0	0	0	0	0	0	0	0	0	0	0	0
	0	6	6	24	36	36	12	0	0	0	0	0	0	0	0		#
	NET	20															
50	# age bins for limited age info, followed by vector of age bins																
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49		
1	# num aging error matrices to generate, followed by true ages and std devs																
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	
.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	
1	#num age comps																
2003	1	5	0	2	1	-1	-1	10	0	0	0	17	78	27	5	1	2
	0	1	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	#Harms survey, readings adjusted for edge									
0	#_N_size@age_observations																
#_environmental_data																	
0	#	N_variables															
0	#	N_observations															
999	# end-of-file-marker																

Appendix C. Data file for northern California assessments.

```
# MODEL DIMENSIONS
1915	# start_year
2004	# end_year
1		# N_seasons_per_year
12		#_vector_with_N_months_in_each_season
1		#_spawning_season_-_spawning_will_occur_at_beginning_of_this_season
4		#_N_fishing_fleets
1		# N surveys; data type ID below is sequential with the fisheries
NChook%NCnet%NCtrawl%NCrec%CDFG
0.5  0.5  0.5  0.5 0.5
1		#_number_of_genders(1/2)
50		#_accumulator_age;_model_always_starts_with_age_0
0	0	0	0	# previous (mt) for each fishing fleet
50	0	2	22	#1915
50	0	2	22	#1916
50	0	2	22	#1917
50	0	2	22	#1918
50	0	2	22	#1919
50	0	2	22	#1920
50	0	2	22	#1921
50	0	2	22	#1922
50	0	2	22	#1923
50	0	2	22	#1924
50	0	2	22	#1925
50	0	2	22	#1926
50	0	2	22	#1927
50	0	2	22	#1928
50	0	2	22	#1929
50	0	2	22	#1930
50	0	2	22	#1931
50	0	2	22	#1932
50	0	2	22	#1933
50	0	2	22	#1934
50	0	2	22	#1935
50	0	2	22	#1936
50	0	2	22	#1937
50	0	2	22	#1938
50	0	2	22	#1939
50	0	2	22	#1940
50	0	2	22	#1941
50	0	2	22	#1942
50	0	2	22	#1943
50	0	2	22	#1944
50	0	2	22	#1945
50	0	2	22	#1946
50	0	2	22	#1947
50	0	2	22	#1948
50	0	2	22	#1949
46	0	2	22	#1950
45	0	2	28	#1951
44	0	2	19	#1952
```

43	0	2	14	#1953
42	0	2	17	#1954
41	0	4	21	#1955
40	0	4	18	#1956
39	0	4	21	#1957
38	0	5	31	#1958
37	0	3	27	#1959
36	0	4	27	#1960
35	0	2	17	#1961
34	0	2	20	#1962
34	0	3	17	#1963
33	0	8	17	#1964
32	0	13	20	#1965
31	0	20	27	#1966
30	0	32	27	#1967
29	0	30	26	#1968
28	0	34	28	#1969
27	0	38	34	#1970
26	0	43	26	#1971
25	0	48	36	#1972
24	0	62	46	#1973
23	0	51	48	#1974
22	0	47	46	#1975
21	0	37	52	#1976
20	0	29	45	#1977
4	0	23	39	#1978
2	0	35	43	#1979
34	0	51	54	#1980
2	0	18	26	#1981
30	0	15	65	#1982
25	2	27	45	#1983
1	6	44	52	#1984
1	13	43	42	#1985
31	31	4	54	#1986
29	66	43	28	#1987
56	49	21	72	#1988
34	6	3	88	#1989
61	61	1	113	#1990
126	14	1	146	#1991
104	0	10	212	#1992
151	20	21	200	#1993
85	11	15	137	#1994
50	11	16	76	#1995
64	9	10	52	#1996
64	7	14	46	#1997
44	6	28	77	#1998
34	0	9	81	#1999
13	0	1	77	#2000
11	0	3	75	#2001
6	0	0	82	#2002
6	0	0	204	#2003
10	0	0	72	#2004

#_Fishery CPUE series

```
42	#_N_observations
1975	1	4	-0.001	-1	#nocal recfin catch/angler
1976	1	4	-0.001	-1	#nocal recfin catch/angler
1977	1	4	-0.001	-1	#nocal recfin catch/angler
1978	1	4	-0.001	-1	#nocal recfin catch/angler
1979	1	4	-0.001	-1	#nocal recfin catch/angler
1980	1	4	0.00441	1.29	#nocal recfin catch/angler
1981	1	4	0.00168	1.73	#nocal recfin catch/angler
1982	1	4	0.00749	1.62	#nocal recfin catch/angler
1983	1	4	0.00228	1.73	#nocal recfin catch/angler
1984	1	4	0.00586	1.19	#nocal recfin catch/angler
1985	1	4	0.00354	1.09	#nocal recfin catch/angler
1986	1	4	0.00320	1.12	#nocal recfin catch/angler
1987	1	4	0.00475	1.19	#nocal recfin catch/angler
1988	1	4	0.01403	0.96	#nocal recfin catch/angler
1989	1	4	0.01657	3.12	#nocal recfin catch/angler
1990	1	4	-0.001	-1	#nocal recfin catch/angler
1991	1	4	-0.001	-1	#nocal recfin catch/angler
1992	1	4	-0.001	-1	#nocal recfin catch/angler
1993	1	4	0.00757	1.01	#nocal recfin catch/angler
1994	1	4	0.00971	1.07	#nocal recfin catch/angler
1995	1	4	0.01403	1.40	#nocal recfin catch/angler
1996	1	4	0.01078	0.85	#nocal recfin catch/angler
1997	1	4	0.06865	0.39	#nocal recfin catch/angler
1998	1	4	0.03901	0.67	#nocal recfin catch/angler
1999	1	4	0.01833	0.60	#nocal recfin catch/angler
2000	1	4	0.02125	1.72	#nocal recfin catch/angler
2001	1	4	0.01701	0.94	#nocal recfin catch/angler
2002	1	4	0.02120	0.77	#nocal recfin catch/angler
2003	1	4	0.04194	0.47	#nocal recfin catch/angler
2004	1	4	-0.001	-1	#nocal recfin catch/angler
1987	1	5	0.000734773	0.56	#CDFG CPUE
1988	1	5	0.001523154	0.29	#CDFG CPUE
1989	1	5	0.002292355	0.28	#CDFG CPUE
1990	1	5	0.00295726	0.28	#CDFG CPUE
1991	1	5	0.001780964	0.33	#CDFG CPUE
1992	1	5	0.002598697	0.31	#CDFG CPUE
1993	1	5	0.002460459	0.30	#CDFG CPUE
1994	1	5	0.0017308	0.37	#CDFG CPUE
1995	1	5	0.002254317	0.38	#CDFG CPUE
1996	1	5	0.001567228	0.54	#CDFG CPUE
1997	1	5	0.001952223	0.43	#CDFG CPUE
1998	1	5	0.00257512	0.37	#CDFG CPUE
# Discard section #
#_Discard_Biomass
2	# 1=biomass (mt),2=fraction
0	# N_discard observations
 # Year Seas Type	Value	CV
 # Mean BodyWt (in kg)
0	# N observations
 # Partition=1 means discarded catch, 2 means retained catch, 0 means whole catch (discard+retained)
 # Year	Seas	Type	Partition	Value	CV
0.001		#  min_proportion_for_compressing_tails_of_observed_composition -1 is no compession
```

0.00001 # constant added to expected frequencies
27 #_N_length_bins
#_lower_edge_of_length_bins

18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
	54	56	58	60	62	64	66	68	70								

\# This is the section where lencomps are entered (both fishery & survey) - by year x season x fleet
64 #N_length_observations
\# Gender = 1 means female only
\# Gender = 2 means male only
\# Gender = 0 means both (each) gender that together sum to 1.0

1980	1	1	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	81	108	189	108	0	27	0	0	0		
1986	1	1	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	1332	0	4662	3330	666	666	666	0	0	0	0	0	0		
1990	1	1	0	2	3	0	0	0	0	0	0	0	0	2997	0	0	0
	1617	0	4851	1714	0	0	6468	3234	0	0	0	0	0	0	0		
1991	1	1	0	2	14	0	0	0	0	172	417	73	390	245	693	2095	12343
	21607	8684	3257	245	265	0	0	249	172	109	109	0	0	0	0		
1992	1	1	0	2	48	0	0	2	1	37	109	160	147	193	299	779	1292
	1276	783	860	379	77	200	64	107	99	6	17	0	0	0	0		
1993	1	1	0	2	115	0	0	2	4	20	41	70	104	265	534	818	2319
	3244	1894	1155	371	642	558	431	21	178	33	3	0	0	0	0		
1994	1	1	0	2	61	0	4	10	37	69	6	44	67	117	173	497	921
	1030	912	667	719	233	174	234	152	115	37	4	10	0	0	0		
1995	1	1	0	2	36	0	0	30	38	32	4	80	24	245	123	217	476
	285	520	514	153	125	51	0	14	30	0	0	0	0	0	0		
1996	1	1	0	2	59	0	0	49	206	8	320	652	457	402	593	630	519
	657	645	746	364	199	115	75	29	0	0	0	0	0	0	0		
1997	1	1	0	2	49	0	7	0	2234	39	874	502	862	527	118	1193	841
	444	687	1158	396	172	142	41	31	27	14	0	7	0	0	0		
1998	1	1	0	2	31	0	0	0	0	0	0	16	86	300	68	283	412
	1593	2454	3184	538	1014	96	631	43	20	0	13	0	0	0	0		
1999	1	1	0	2	59	0	0	0	6	12	6	427	997	1623	955	833	587
	1400	1018	1118	660	400	103	222	35	0	0	0	0	0	0	0		
2000	1	1	0	2	21	0	0	0	0	304	0	63	182	220	1284	1266	1418
	723	455	162	143	113	144	0	0	0	0	0	0	0	0	0		
2001	1	1	0	2	17	0	0	0	0	0	0	0	54	230	559	706	576
	537	255	410	359	201	251	74	32	0	0	0	0	0	0	0		
2002	1	1	0	2	12	0	0	0	0	47	141	16	130	133	268	309	197
	277	32	180	0	0	35	19	19	0	0	0	0	0	0	0		
2003	1	1	0	2	5	0	0	0	0	0	0	0	80	0	8	284	320
	0	18	80	122	8	54	18	0	0	0	0	0	0	0	0		
2004	1	1	0	2	7	0	0	0	0	0	0	0	0	0	0	0	150
	50	175	250	175	100	0	75	25	0	0	0	0	0	0	0		
1987	1	2	0	2	7	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	800	1902	8604	906	2204	1102	1102	302	0	0	0	0	0		
1988	1	2	0	2	7	0	0	0	0	0	0	0	0	2739	2739	7755	5247
	6314	2508	0	836	2739	0	0	0	0	0	0	0	0	0	0		
1989	1	2	0	2	6	0	0	0	0	0	0	0	0	15	37	5	10
	132	76	71	0	24	16	0	10	17	0	0	12	0	0	0		
1990	1	2	0	2	15	0	0	0	0	0	0	0	0	0	813	1252	3426
	1679	699	64	0	193	136	57	0	0	57	57	136	0	0	0		

1993	1	2	0	2	11	0	0	0	0	0	0	284	774	1133	1611	1174	2608
	540	142	0	0	0	0	0	0	0	0	0	0	0	0	0		
1994	1	2	0	2	10	0	0	0	0	0	0	0	0	0	24	108	856
	550	682	208	256	860	0	432	0	0	0	16	12	0	0	0		
1995	1	2	0	2	14	0	0	0	0	0	0	0	0	64	41	181	295
	578	714	315	146	100	163	31	68	157	17	48	14	0	0	0		
1996	1	2	0	2	8	0	0	0	0	0	0	0	0	0	0	0	158
	342	0	262	578	526	684	368	26	52	158	158	0	0	0	0		
1997	1	2	0	2	8	0	0	0	0	0	0	0	0	0	296	24	148
	172	368	468	320	148	516	516	0	320	0	0	0	0	0	0		
1998	1	2	0	2	12	0	0	0	0	0	0	0	0	0	0	52	62
	158	108	89	120	57	91	43	22	17	11	22	0	0	0	0		
1983	1	3	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0
	148	458	469	576	133	1124	392	915	0	0	0	0	0	0	0		
1984	1	3	0	2	35	0	0	0	0	0	15	29	49	36	29	0	0
	704	392	1435	1456	47	1794	1147	411	11	20	5	6	0	2	0		
1985	1	3	0	2	9	0	0	0	0	0	0	0	0	0	3	0	1
	0	9	3	1488	5192	1484	2223	2964	0	0	0	0	0	0	0		
1987	1	3	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	661	1322	661	1983	661	1983	0	661	661	0	0	0		
1992	1	3	0	2	2	0	0	0	0	0	0	0	0	303	1515	1212	303
	303	303	0	0	0	0	0	0	0	0	0	0	0	0	0		
1993	1	3	0	2	17	0	0	0	0	0	0	0	5	183	201	285	762
	789	430	204	225	10	0	181	201	32	0	0	0	0	0	0		
1994	1	3	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	648	0	324	648	1296	648	324	0	0	0	0		
1996	1	3	0	2	11	0	0	0	0	0	0	0	0	0	0	0	226
	1025	1142	694	1045	351	339	0	0	0	117	0	117	0	0	0		
1997	1	3	0	2	16	0	0	0	0	0	0	12	36	36	36	24	29
	571	729	275	114	527	340	12	508	12	0	12	12	0	0	0		
1999	1	3	0	2	4	0	0	0	0	0	0	0	0	0	0	162	0
	0	810	810	324	810	324	162	0	0	0	0	0	0	0	0		
1978	1	4	0	2	32	0	0	0	0	0	0	0	0	1	2	0	1
	0	0	3	4	5	5	1	3	3	0	2	1	0	0	0		
1979	1	4	0	2	61	0	0	0	0	0	0	1	0	0	0	0	2
	5	4	6	8	7	6	7	18	13	4	1	1	0	0	0		
1980	1	4	0	2	68	0	1	0	1	0	2	3	2	2	6	6	11
	8	7	4	11	13	7	5	6	2	0	0	2	0	0	0		
1981	1	4	0	2	42	0	0	1	0	2	0	1	0	1	0	2	5
	2	5	2	6	5	7	4	3	0	0	0	0	0	0	1		
1982	1	4	0	2	72	0	0	0	2	2	6	8	6	2	2	4	1
	8	3	4	11	6	16	11	10	2	1	2	0	0	0	0		
1983	1	4	0	2	65	0	2	0	0	1	4	4	4	8	4	3	4
	1	5	9	10	7	8	4	3	2	2	4	2	1	0	0		
1984	1	4	0	2	85	0	0	5	3	4	8	5	11	8	14	8	7
	6	6	11	4	7	7	10	8	2	1	2	0	1	0	0		
1985	1	4	0	2	89	2	4	5	6	12	7	8	11	7	7	12	13
	3	6	10	9	3	6	6	3	4	5	0	0	0	0	0		
1986	1	4	0	2	82	6	10	2	1	0	2	7	6	7	8	9	7
	10	12	4	4	3	5	9	9	3	3	1	2	0	0	0		
1987	1	4	0	2	124	3	5	4	11	19	10	13	11	21	41	22	20
	17	10	16	5	10	1	4	2	1	0	0	1	0	0	0		

1988	1	4	0	2	262	1	3	35	72	111	129	110	51	67	46	29	26
	18	17	17	14	8	13	6	7	1	2	2	0	0	0	0		
1989	1	4	0	2	374	0	3	5	45	134	245	258	179	109	75	59	40
	25	38	35	26	27	27	12	2	6	3	6	1	0	1	0		
1990	1	4	0	2	216	0	0	5	0	15	57	106	123	91	57	37	33
	16	10	6	9	11	4	3	0	0	0	0	0	0	0	0		
1991	1	4	0	2	166	0	2	7	3	5	12	12	23	38	64	74	46
	24	18	19	12	7	5	7	6	4	0	0	0	0	0	0		
1992	1	4	0	2	339	0	1	4	8	19	17	23	27	77	174	253	232
	117	61	41	36	34	24	10	6	5	3	1	0	0	0	0		
1993	1	4	0	2	415	2	11	23	61	60	85	116	111	113	132	199	210
	143	95	56	61	53	38	10	11	6	5	1	0	0	0	0		
1994	1	4	0	2	326	3	4	9	23	44	54	91	88	88	96	106	126
	112	92	63	42	18	24	7	7	4	1	1	0	0	0	0		
1995	1	4	0	2	345	2	8	11	19	35	68	87	112	145	150	96	115
	110	79	57	36	40	18	12	2	0	1	1	0	0	0	0		
1996	1	4	0	2	315	2	8	16	40	56	69	91	98	83	102	88	104
	74	54	46	30	35	22	17	6	5	0	0	0	0	0	0		
1997	1	4	0	2	366	3	6	37	82	108	100	106	102	149	124	129	103
	92	67	35	28	22	9	9	3	1	0	0	0	1	0	0		
1998	1	4	0	2	275	0	4	10	18	56	92	108	102	83	72	75	57
	34	52	27	25	13	10	4	2	2	1	1	0	0	0	0		
1999	1	4	0	2	270	1	3	3	15	29	44	116	171	106	72	66	58
	29	46	25	21	7	6	4	1	0	0	1	0	1	0	0		
2000	1	4	0	2	148	0	0	1	2	10	17	31	57	46	47	39	30
	13	9	8	7	2	3	1	2	1	0	0	0	0	0	0		
2001	1	4	0	2	131	1	0	1	6	9	7	12	25	26	29	30	29
	31	14	21	11	10	3	2	2	1	0	0	0	0	0	0		
2002	1	4	0	2	223	0	4	12	23	24	33	48	35	43	49	59	71
	64	48	40	30	12	7	4	5	0	1	1	0	0	0	0		
2003	1	4	0	2	324	0	2	8	17	58	95	128	114	108	87	75	89
	97	79	53	41	18	13	4	1	1	0	1	0	0	1	1		
2004	1	4	0	2	638	1	1	7	19	55	148	225	257	315	307	313	329
	341	261	216	148	83	32	24	11	7	3	1	0	1	0	0		

0 # age bins for limited age info, followed by vector of age bins
0 # num aging error matrices to generate, followed by true ages and std devs
0 #num age comps
0 #_N_size@age_observations
#_environmental_data
0 # N_variables
0 # N_observations
999 # end-of-file-marker

Appendix D. Parameter file for southern California assessments (lower bound model).

```
# finalsouthh65emph2.ctl
 1          #_N_growthmorphs
#_assign_sex_to     each_morph (1=female,2=male)
 1
 1          #_N_Areas_(populations)
 1          1          1          1          1   # 4 fisheries and 1 survey
 0          #do_migration_(0/1)
# time blocks for time varying parameters
 0          #_N_Block_Designs
# Natural_mortality_and_growth_parameters_for_each_morph
 1                     # Last_age_for_natmort_young
 2                     # First_age_for_natmort_old
 4                     # age_for_growth_Lmin
 30                    # age_for_growth_Lmax
 -4                    # MGparm_dev_phase
# LO      HI      INIT               PRIOR   P_type  SD      PHASE   env-var  use_dev  dev_minyr dev_maxyr  dev_stddev  block_type use_block
# morph1 females
0.01      0.3     0.1       0.1       0       0.1     -5      0       0       0       0       0       0       0       #M1_natM_young
0         0       0         0         0       0.1     -5      0       0       0       0       0       0       0       #M1_natM_old_as_exponential_offset(rel_young)
10        50      28        29        0       99      3       0       0       0       0       0       0       0       #M1_Lmin
40        70      53.       53.7      0       99      3       0       0       0       0       0       0       0       #M1_Lmax
0.05      0.25    0.19      0.197     0       99      3       0       0       0       0       0       0       0       #M1_VBK
0.03      0.1     0.08      0.06      0       99      -3      0       0       0       0       0       0       0       #M1_CV-young
0.03      0.1     0.08      0.06      0       99      -3      0       0       0       0       0       0       0       #M1_CV-old_as_exponential_offset(rel_young)
# Add 2+2*gender lines to read the wt-Len and mat-Len parameters
 -3       3       1.744E-05 1.744E-05 0       0.1     -3      0       0       0       0       0.5     0       0       #Female wt-len-1
 -3       3       2.995     2.995     0       0.8     -3      0       0       0       0       0.5     0       0       #Female wt-len-2
 -3       3       38.0      38.0      0       0.8     -3      0       0       0       0       0.5     0       0       #Female mat-len-1
 -3       3       -0.5      -0.5      0       0.8     -3      0       0       0       0       0.5     0       0       #Female mat-len-2
 -3       3       1.        1.        0       0.8     -3      0       0       0       0       0.5     0       0       #Female eggs/gm intercept
 -3       3       0.        0.        0       0.8     -3      0       0       0       0       0.5     0       0       #Female eggs/gm slope
# pop*gmorph lines For the proportion of each morph in each area
          0       1         1         1       0       0.5     -3      0       0       0       0       0.5     0       0       #frac to morph in area 1
# pop lines For the proportion assigned to each area
          0       1         1         1       0       0.8     -3      0       0       0       0       0.5     0       0       #frac to area 1
#_custom-env_read
0         #_      0=read_one_setup_and_apply_to_all_env_fxns;     1=read_a_setup_line_for_each_MGparm_with_Env-var>0
#_custom-block_read
0         #_      0=read_one_setup_and_apply_to_all_MG-blocks;  1=read_a_setup_line_for_each_block  x       MGparm_with_block>0
#         LO      HI        INIT      PRIOR   Pr_type SD      PHASE
#_Spawner-Recruitment_parameters
1         # SR_fxn:  1=Beverton-Holt  2 = Ricker
#LO       HI      INIT      PRIOR     Pr_type SD      PHASE
3         31      8         6.5       0       99      1       #Ln(R0)
0.2       10      0.65      1         0       99      -2      #steepness
0         2       0.7       0.8       0       0.8     -3      #SD_recruitments
-5        5       0         0         0       1       -3      #Env_link
-5        5       0         0         0       1       -3      #init_eq
 0 # index of environmental variable to be used
# recruitment_residuals
# start_rec_year    end_rec_year        Lower_limit         Upper_limit phase
          1970      2001      -15       15      2
```

```
#init_F_setup, for each fleet
# LO        HI      INIT        PRIOR   P_type      SD      PHASE
 0          1       0           0.05    0           1       -1      # fleet soCAhook
 0          1       0           0.05    0           1       -1      # fleet soCAnet
 0          1       0           0.05    0           1       -1      # fleet soCAparty
 0          1       0           0.05    0           1       -1      # fleet soCApriv
# Catchability
#_add_parm_row_for_each_positive_entry_below(row_then_column)
# Float(0/1)  #Do-power(0/1)  #Do-env(0/1)  #Do-dev(0/1)  #env parm  # for each fleet and survey
 0      0       0       0       0   1       # soCAhook
 0      0       0       0       0   1       # soCAnet
 0      0       0       0       0   1       # soCAparty
 0      0       0       0       0   1       # soCApriv
 0      0       0       0       0   0       # Harms ages
# LO    HI      INIT    PRIOR   P_type  SD      PHASE
#  -5   0       -2      -1      0       10      1       # log(Q) survey (not used, need one line for every "1" above)
#_SELEX_&_RETENTION_PARAMETERS
#_Length selex
# Selex_type  Do_retention(0/1)     Do_male     Mirrored_selex_number
 1              0                   0           0       # fleet 1 soCAhook, Size selex: 1=logistic
 1              0                   0           0       # fleet 2 soCAnet, Size selex: 1=logistic
 7              0                   0           0       # fleet 3 soCAparty, Size selex: 1=logistic
 7              0                   0           0       # fleet 4 soCApriv, Size selex: 1=logistic
 0              0                   0           0       # Harms ages
#_Age selex
# Selex_type        Do_retention(0/1)   Do_male     Mirrored_selex_number
 10                 0                   0           0       # fleet 1 soCAhook, Age selex: 10=flat
 10                 0                   0           0       # fleet 2 soCAnet, Age selex: 10=flat
 10                 0                   0           0       # fleet 3 soCAparty, Age selex: 10=flat
 10                 0                   0           0       # fleet 4 soCApriv, Age selex: 10=flat
 10                 0                   0           0       # Harms ages
# LO    HI      INIT    PRIOR   P_type  SD      PHASE  env-var   use_dev  dvminyr  dvmaxyr  dev_sd  Block_type useblock
# soCAhook length selectivity
 10     60      45      28      0       99      2       0       0       0       0       0       0       0       #L50
 0.001  20      12      4       0       99      2       0       0       0       0       0       0       0       #diff05-95
# soCAnet length selectivity
 10     60      55      28      0       99      2       0       0       0       0       0       0       0       #L50
 0.001  20      12      4       0       99      2       0       0       0       0       0       0       0       #diff05-95
# soCAparty length selectivity
#       LO      HI      INIT    PRIOR   PR_type SD      PHASE   env-variable    use_dev dev_minyr dev_maxyr dev_stddev Block_Pattern
        10      70      23.5    23.5    0       5       2       0       0       0       0       0.5     0       0       #peak
        0.00001 0.1     0.0001  0.0001  0       0.5     -4      0       0       0       0       0.5     0       0       #init
        -3      10      1.15    1.15    0       0.5     1       0       0       0       0       0.5     0       0       #infl
        0.001   5       .039    .039    0       0.1     3       0       0       0       0       0.5     0       0       #slope
        -5      10      1.13    1.13    0       1       3       0       0       0       0       0.5     0       0       #final
        -5      10      -1.35   -1.35   0       1       4       0       0       0       0       0.5     0       0       #infl2
        .001    5       0.68    .68     0       0.3     5       0       0       0       0       0.5     0       0       #slope2
        0.1     10      4       4       0       1       5       0       0       0       0       0.5     0       0       #width of top
# soCApriv length selectivity
#       LO      HI      INIT    PRIOR   PR_type SD      PHASE   env-variable    use_dev dev_minyr dev_maxyr dev_stddev Block_Pattern
        10      70      26      26      0       5       2       0       0       0       0       0.5     0       0       #peak
        0.00001 0.1     0.0001  0.0001  0       0.5     -4      0       0       0       0       0.5     0       0       #init
        -3      10      1.1     1.1     0       0.5     1       0       0       0       0       0.5     0       0       #infl
```

0.001	5	.029	.029	0	0.1	3	0	0	0	0	0.5	0	0	#slope
-5	10	-2.08	-2.08	0	1	3	0	0	0	0	0.5	0	0	#final
-5	10	0.15	0.15	0	1	4	0	0	0	0	0.5	0	0	#infl2
.001	5	0.48	.48	0	0.3	5	0	0	0	0	0.5	0	0	#slope2
0.1	10	4	4	0	1	5	0	0	0	0	0.5	0	0	#width of top

#_custom-env_read
0 #_ 0=read_one_setup_and_apply_to_all;_1=Custom_so_read_1_each
#_custom-block_read
0 #_ 0=read_one_setup_and_apply_to_all;_1=Custom_so_see_detailed_instructions_for_N_rows_in_Custom_setup
-4 #_phase_for_selex_parm_devs
1 #_max_lambda_phases:_read_this_Number_of_values_for_each_componentxtype_below
0 #sd_offset (0/1) multiple this times Log(sd) when calculating the likelihood
#_cpue_lambdas (one for each fleet/survey?)
0 # fishery soCAhook
0 # fishery soCAnet
2 # fishery soCAparty
0 # fishery soCApriv
0 # no CPUE from Harms
discard lambda
0 # fishery soCAhook
0 # fishery soCAnet
0 # fishery soCAparty
0 # fishery soCApriv
0 # no CPUE from Harms
#_meanwtlambda(one_for_all_sources)
0
#_lenfreq_lambdas
1 # fishery soCAhook
1 # fishery soCAnet
1 # fishery soCAparty
1 # fishery soCApriv
0 # Harms survey
#_age_freq_lambdas
0 # fishery soCAhook
0 # fishery soCAnet
0 # fishery soCAparty
0 # fishery soCApriv
1 # Harms survey
#_size@age_lambdas
0 # fishery soCAhook
0 # fishery soCAnet
0 # fishery soCAparty
0 # fishery soCApriv
0 # Harms survey
initial F lambda
0 # init equil catch
1 #_recruitment_deviations_lambda
1 #_parm_prior_lambda
1 #_parm_dev_timeseries_lambda
100 # crashpen lambda
0.9 #max F
#_end-of-file-marker
999

Appendix E. Parameter file for northern California assessments (lower bound model).

```
# finalnorthh65.CTL
1  #_N_morphs
1  1 #_N_areas
 1 1 1 1 1 #_area_assignments
0 #_Do_migration
0 #_Nblocks
1
2
4
30
-4
#_growth_parms
# LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
 0.01 0.3 0.1 0.1 0 0.1 -5 0 0 0 0 0 0 0
 0 0 0 0 0 0.1 -5 0 0 0 0 0 0 0
 10 50 26.9157 27 0 99 3 0 0 0 0 0 0 0
 40 70 52.7167 52 0 99 3 0 0 0 0 0 0 0
 0.05 0.25 0.156994 0.16 0 10 3 0 0 0 0 0 0 0
 0.03 0.1 0.09 0.08 0 0.1 -3 0 0 0 0 0 0 0
 0.03 0.1 0.09 0.07 0 0.1 -3 0 0 0 0 0 0 0
 -3 3 1.744e-005 1.744e-005 0 0.1 -3 0 0 0 0 0.5 0 0
 -3 3 2.995 2.995 0 0.8 -3 0 0 0 0 0.5 0 0
 -3 3 38 38 0 0.8 -3 0 0 0 0 0.5 0 0
 -3 3 -0.5 -0.5 0 0.8 -3 0 0 0 0 0.5 0 0
 -3 3 1 1 0 0.8 -3 0 0 0 0 0.5 0 0
 -3 3 0 0 0 0.8 -3 0 0 0 0 0.5 0 0
 0 1 1 1 0 0.5 -3 0 0 0 0 0.5 0 0
 0 1 1 1 0 0.8 -3 0 0 0 0 0.5 0 0
0 #_custom_MG-env_setup
0 #_custom_MG-block_setup

#_S-R_parm_setup
1
 3 31 7 6.6 0 10 1
 0.2 1 0.65 0.8 0 99 -2
 0 2 0.7 0.8 0 0.8 -3
 -5 5 0 0 0 1 -3
 -5 5 0 0 0 1 -3
0 #_S-R_env_link
1970 2001 -15 15 2 #_recr_devs
#_initial_F_parms
 0 1 0 0.05 0 1 -1
 0 1 0 0.05 0 1 -1
 0 1 0 0.05 0 1 -1
 0 1 0 0.05 0 1 -1
#_Q_setup
 0 0 0 0 0 0
 0 0 0 0 0 0
 0 0 0 0 0 0
 0 0 0 0 0 0
 0 0 0 0 0 0
#_selex_types
```

1 0 0 0 # 1
1 0 0 0 # 2
1 0 0 0 # 3
7 0 0 0 # 4
5 0 0 4 # 5
10 0 0 0 # 6
10 0 0 0 # 7
10 0 0 0 # 8
10 0 0 0 # 9
15 0 0 4 # 10

#_selex_parms
#_size_sel: 1
10 50 39.5952 38 0 99 2 0 0 0 0 0 0 0 # 1
0.01 12 9.54354 10 0 99 2 0 0 0 0 0 0 0 # 2
#_size_sel: 2
10 50 39.8666 39 0 99 2 0 0 0 0 0 0 0 # 3
0.001 12 5.62008 5 0 99 2 0 0 0 0 0 0 0 # 4
#_size_sel: 3
10 50 46.2711 45 0 99 2 0 0 0 0 0 0 0 # 5
0.01 12 8.89328 8 0 99 2 0 0 0 0 0 0 0 # 6
soCAparty length selectivity

#	LO	HI	INIT	PRIOR	PR_type	SD	PHASE	env-variable		use_dev	dev_minyr	dev_maxyr	dev_stddev	Block_Pattern	
	10	70	23.5	23.5	0	5	2	0	0	0	0	0.5	0	0	#peak
	0.00001	0.1	0.0001	0.0001	0	0.5	-4	0	0	0	0	0.5	0	0	#init
	-3	10	1.15	1.15	0	0.5	1	0	0	0	0	0.5	0	0	#infl
	0.001	5	.039	.039	0	0.1	3	0	0	0	0	0.5	0	0	#slope
	-5	10	1.13	1.13	0	1	3	0	0	0	0	0.5	0	0	#final
	-5	10	-1.35	-1.35	0	1	4	0	0	0	0	0.5	0	0	#infl2
	.001	5	0.68	.68	0	0.3	5	0	0	0	0	0.5	0	0	#slope2
	0.1	10	4	4	0	1	5	0	0	0	0	0.5	0	0	#width of top

#_size_sel: 4
10 50 27.6358 28 0 99 2 0 0 0 0 0 0 0 # 7
0.001 12 5.36706 5 0 99 2 0 0 0 0 0 0 0 # 8
#_size_sel: 5
1 1 1 1 0 10 -2 0 0 0 0 0 0 0 # 9
27 27 27 27 0 10 -2 0 0 0 0 0 0 0 # 10
#_age_sel: 1
#_age_sel: 2
#_age_sel: 3
#_age_sel: 4
#_age_sel: 5
0 #_custom_sel-env_setup
0 #_custom_sel-block_setup
-4 #_selparmdev-phase
#_lambdas
1 #_maxlambdaphase
0 #_sd_offset
0
0
0
1
1 #_survey

0
0
0
0
0 #_discard
0 #_meanbodyweight
1
1
1
1
0 #_lencomp
0
0
0
0
0 #_agecomp
0
0
0
0
0 #_size-age
0 #_init_equ_catch
1 #_recruitments
0 #_parameter-priors
1 #_parameter-dev-vectors
100 #_crashPenLambda
0.9 #_maximum allowed harvest rate
999