STOCK ASSESSMENT OF PACIFIC MACKEREL WITH RECOMMENDATIONS FOR THE 2001-2002 MANAGEMENT SEASON

EXECUTIVE SUMMARY

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by

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INTRODUCTION

The following summarizes stock assessment results and harvest guideline recommendations for Pacific mackerel (*Scomber japonicus*) developed for the Pacific Fishery Management Council's (PFMC) management season of July 1, 2001 to June 30, 2002. This Executive Summary will be included in the PFMC's Stock Assessment and Fishery Evaluation (SAFE) report for coastal pelagic species (CPS), which will be distributed prior to the June 2001 PFMC meeting. A full stock assessment report will not be developed until 2002 when the first formal stock assessment review (STAR) for this species will be conducted.

METHODS

We used a modified virtual population analysis (VPA) stock assessment model ('ADEPT', Jacobson 1993), based on Gavaris' (1988) procedure, to estimate biomass of Pacific mackerel that employs both fishery-dependent and fishery-independent data to estimate abundance. ADEPT adjusts or "tunes" biomass estimates using the fishery-independent indices of relative abundance. ADEPT has been used to assess Pacific mackerel for the past seven years. A conventional VPA back-calculates age-structured biomass estimates utilizing catch-at-age data, weight-at-age data, natural mortality estimates, and fishing mortality (F) estimates for the most recent year (referred to as 'terminal F'). ADEPT improves upon a conventional VPA by choosing terminal F and other parameters to obtain the best statistical fit (lowest log-scale sums of squares) between VPA output and survey indices of relative abundance, including spotter pilot sightings, CalCOFI larval data from southern California, recreational fishery catch-per-unit-effort, power plant impingement rates, and triennial trawl survey data. The crux of the estimate lies in the models' ability to estimate terminal F based upon the survey indices, essentially using them to adjust the conventional VPA output.

The assessment model is based on an annual time increment and now incorporates 72 years (1929 to 2000) of fishery data, including landings (Table 1, Figure 1), age composition (Figure 2), and mean weights-at-age (Figure 3). Abundance estimates are adjusted by the model to better match the fishery-independent (survey) indices of relative abundance, including aerial spotter sightings (Lo et al. 1992; Figure 4), CalCOFI larval data (Figure 5), recreational fishery catch-per-unit-effort (Figures 6 & 7), triennial shelf survey, and power plant impingement rates. As in past assessments, component likelihoods for most surveys were weighted equally to a value of 1.0. The power plant impingement index (age-0 Pacific mackerel caught in cooling water at San Onofre Nuclear Generating Station) represents a relatively small portion of the coastline and was therefore down-weighted to 0.1. ADEPT also has the ability to weight influence of annual survey observations using the coefficient of variation (CV; a measure of relative variation in any sample). As per Hill et al. (1999) and Hill (2000), we calculated CVs for each survey and re-scaled the CVs to the median value. Re-scaling CVs of each survey to a value of 1.0 had the effect of maintaining equal weighting among surveys while down-weighting annual observations within surveys for poorly-sampled or highly-variable years.

We used ADEPT to calculate biomass estimates through the end of 2000 (calendar year), and then projected an estimate of biomass for July 1, 2001, based upon: 1) the number of Pacific mackerel estimated to comprise each year class at the beginning of 2000; 2) the modeled estimates of fishing mortality during 2000; 3) the assumptions for natural mortality (M=0.5) and F through the first half of 2001; and 4) estimates of age-specific growth.

RESULTS

The coast-wide harvest of Pacific mackerel increased in calendar year 2000 from relatively low levels in 1999. The combined directed fisheries off California and Ensenada (northern Baja California, Mexico) yielded 30,387 mt, compared to 19,697 mt in 1999 (Table 1, Figure 1). California landings for the calendar year 2000 totaled 23,205 mt - over twice the 1999 yield. The Ensenada fishery experienced a 29% decrease in yield, from 10,168 mt in 1999 to 7,182 mt in 2000 (Table 1). The U.S. commercial fishery was allocated a 20,740 mt harvest guideline for the 2000-2001 (July-June) season based on a July 1, 2000 biomass estimate of 116,967 mt (Hill 2000). High local availability of young mackerel led to a dramatic increase in southern California landings during the first several months of the 2000-2001 season. As of October 31, 2000, the U.S. fishery (based primarily in San Pedro, CA) had landed approximately 19,776 mt, or 95% of the harvest guideline, with less than 1,100 mt remaining. The National Marine Fisheries Service closed the directed fishery on October

27, 2000. An incidental allowance guideline was implemented, permitting up to 20% by weight Pacific mackerel in landings in other CPS fisheries. The incidental allowance was amended in February 2001 to include a trip limit of up to one metric ton of 'pure' Pacific mackerel to be landed by both limited entry and non-CPS fishermen. NMFS closed the Pacific mackerel season on March 27, 2001, eliminating the 20% incidental catch, however, the 1 mt allowance remains in effect.

ADEPT recalculates biomass for all years in the 72-year time series. Differences in biomass estimates between assessment years can be caused by interannual variation in landings, shifts in fishery age composition, and changes in relative abundance as measured by fishery-independent surveys. As is true for all age-structured population models, abundance-at-age estimates are the least certain for the most recent years when the youngest year classes have not yet become fully vulnerable to, or utilized by, the fishery. Compounding this uncertainty is the general lack of fishery or survey data for Pacific mackerel outside the Southern California Bight. Catch-at-age and weight-at-age data have not been made available from the Ensenada fishery, which is comparable in volume to the California fishery.

Biomass trends for the current assessment were similar to those estimated during the 2000 stock assessment (Hill 2000; Table 2, Figure 8). Biomasses for the current assessment were slightly higher over the most recent decade (average of 7% higher), however, the most recent two years (1999 & 2000) dropped below estimates from the 2000 assessment (Hill 2000). The current estimate of July 1, 1999 biomass is estimated to be 17.5% lower than last years' estimate, and the 2000 biomass is 24.9% lower than last year's projection. The more precipitous decline in biomass can be attributed in part to a weak 1998 year class combined with high fishing mortality during the 1998 fishery. The 1998 fishery was the second largest on record (71,355 mt), but 71% of these landings were made by the Ensenada fleet (Table 1).

The July 1, 2000 biomass projection was based on ADEPT results and certain assumptions about recruitment in January, 2000, and fishing mortality during the first half of 2001 (Table 3). ADEPT's estimates of recruitment are unreliable for the most recent year, so recruitment was forecast based on recent trends in reproductive success. Recruits per spawning biomass was high during the late 1970s and early 1980s, but has remained relatively low since 1982 (Figure 9). The relationship between spawning biomass in July and number of recruits (age-0) in the following January was regressed for the period 1982/83 to 1998/99 (Figure 10). Based on this regression, we estimated approximately 249 million age-zero fish in January 2000. Based on this recruitment value and an estimate of fishing mortality during the first half of 2001, we estimate the July 1, 2001, age 1+ biomass will be approximately 84,090 mt (Table 3).

HARVEST GUIDELINE FOR 2001-2002

In Amendment 8 (PFMC 1998), the recommended maximum sustainable yield control rule for Pacific mackerel was:

HARVEST = (BIOMASS-CUTOFF) x FRACTION x STOCK DISTRIBUTION

where HARVEST is the U.S. harvest guideline, CUTOFF (18,200 mt) is the lowest level of estimated biomass at which harvest is allowed, FRACTION (30%) is the fraction of biomass above CUTOFF that can be taken by fisheries, and STOCK DISTRIBUTION (70%) is the average fraction of total BIOMASS in U.S. waters. BIOMASS (84,090 mt) is the estimated biomass of fish age 1 and over for the whole stock as of July 1, 2001. **Based on this formula, the 2001-2002 season harvest guideline should be 13,837 mt** (Table 4, Figure 11). This harvest guideline is 33% lower than the 2000-2001 season, but similar to the average yield (14,053 mt) realized by the fishery since the 1992-1993 season (Table 4).

REFERENCES

Gavaris, S. 1988. An adaptive framework for the estimation of population size. Can. Atl. Fish. Sci. Adv. Comm. (CAFSAC) Res. Doc. 88/29: 12p.

Hill, K. T. 2000. Status of the Pacific mackerel resource and fishery in 1999 with management recommendations for 2000-2001 (Executive Summary). Pacific Fishery Management Council, June 2000 Briefing Book Attachment F.3.a. 9 p.

Hill, K. T., M. Yaremko, and L. D. Jacobson. 1999a. Status of the Pacific mackerel resource and fishery in 1998. Calif. Dep. Fish Game. Marine Region Admin. Rep. 99-3. 57 p.

Hill, K. T., M. Levey, and M. Dege. 1999b. Status of the Pacific mackerel resource and fishery in 1999. Calif. Dep. Fish Game, Marine Region, Report to the California Legislature. 65 p.

Jacobson, L.D. 1993. ADEPT: Software for VPA analysis using Gavaris's procedure. National Marine Fisheries Service, Southwest Fisheries Science Center. Admin. Rep. LJ-93-02: 71p.

Lo, N. C. H., L. D. Jacobson, and J. L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

PFMC 1998. Amendment 8 (to the northern anchovy fishery management plan) incorporating a name change to: the coastal pelagic species fishery management plan. Pacific Fishery Management Council, Portland, OR.

Table 1. Commercial and recreational landings (metric tons) of Pacific mackerel in California and Ensenada (northern Baja California, Mexico), for calendar years 1929 to 2000.

Year	CA Com.	MX Com.	CA Rec.	Total	Year	CA Com.	MX Com.	CA Rec.	Total
1929	26,297	0	134	26,431	1965	3,198	7,615	365	11,177
1930	7,499	0	134	7,633	1966	2,100	5,290	493	7,883
1931	6,466	0	134	6,600	1967	530	949	260	1,739
1932	5,658	0	134	5,792	1968	1,422	107	190	1,718
1933	31,576	0	134	31,711	1969	1,070	201	288	1,559
1934	51,641	0	134	51,776	1970	282	0	311	593
1935	66,419	0	135	66,554	1971	71	0	538	609
1936	45,605	0	43	45,648	1972	49	0	590	639
1937	27,641	0	85	27,726	1973	25	0	478	503
1938	36,218	0	119	36,337	1974	61	0	246	307
1939	36,700	0	234	36,934	1975	131	0	312	443
1940	54,660	0	196	54,856	1976	298	0	123	421
1941	35,456	0	112	35,569	1977	9,220	0	1,163	10,383
1942	23,838	0	112	23,950	1978	21,520	0	2,256	23,776
1943	34,117	0	112	34,229	1979	35,823	0	3,053	38,876
1944	37,947	0	112	38,058	1980	38,188	0	2,612	40,800
1945	24,366	0	112	24,478	1981	42,450	0	1,368	43,818
1946	24,438	852	112	25,401	1982	35,019	0	1,559	36,578
1947	21,082	1,263	345	22,690	1983	35,454	135	1,541	37,130
1948	17,865	515	479	18,859	1984	45,572	128	1,609	47,309
1949	22,576	1,352	225	24,153	1985	40,514	2,581	1,113	44,208
1950	14,810	2,029	142	16,981	1986	46,557	4,882	880	52,318
1951	15,204	1,321	99	16,624	1987	41,212	2,081	1,433	44,727
1952	9,347	1,052	148	10,547	1988	43,991	4,882	797	49,670
1953	3,403	1,178	118	4,698	1989	38,637	13,383	691	52,711
1954	11,519	5,681	700	17,900	1990	39,850	35,757	1,126	76,732
1955	10,573	9,799	338	20,710	1991	32,162	17,445	1,190	50,798
1956	22,686	10,725	259	33,669	1992	19699	24,338	778	44,815
1957	28,143	2,035	365	30,542	1993	12,680	7,739	726	21,145
1958	12,541	449	327	13,317	1994	10,043	13,318	1,060	24,421
1959	17,056	495	213	17,764	1995	8,667	4,821	885	14,373
1960	16,697	2,982	191	19,869	1996	10,287	5,604	691	16,582
1961	20,008	5,965	274	26,247	1997	20,615	12,477	943	34,034
1962	22,036	3,231	280	25,547	1998	20,073	50,726	555	71,355
1963	18,254	7,966	352	26,572	1999	9,527	10,168	221	19,916
1964	12,169	8618	243	21030	2000	23206	7182	236	30624

Figure 1. Pacific mackerel landings, 1929 to 2000.

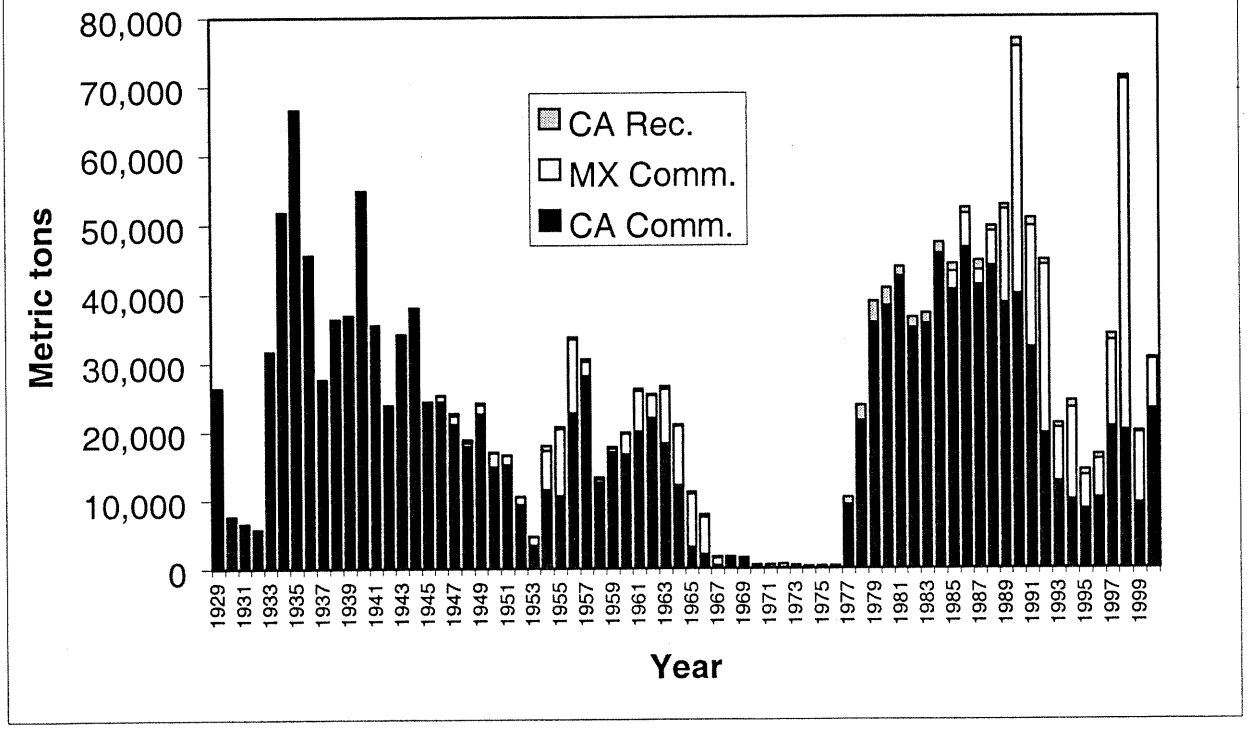

Figure 2. Proportional catch-at-age
California commercial fishery

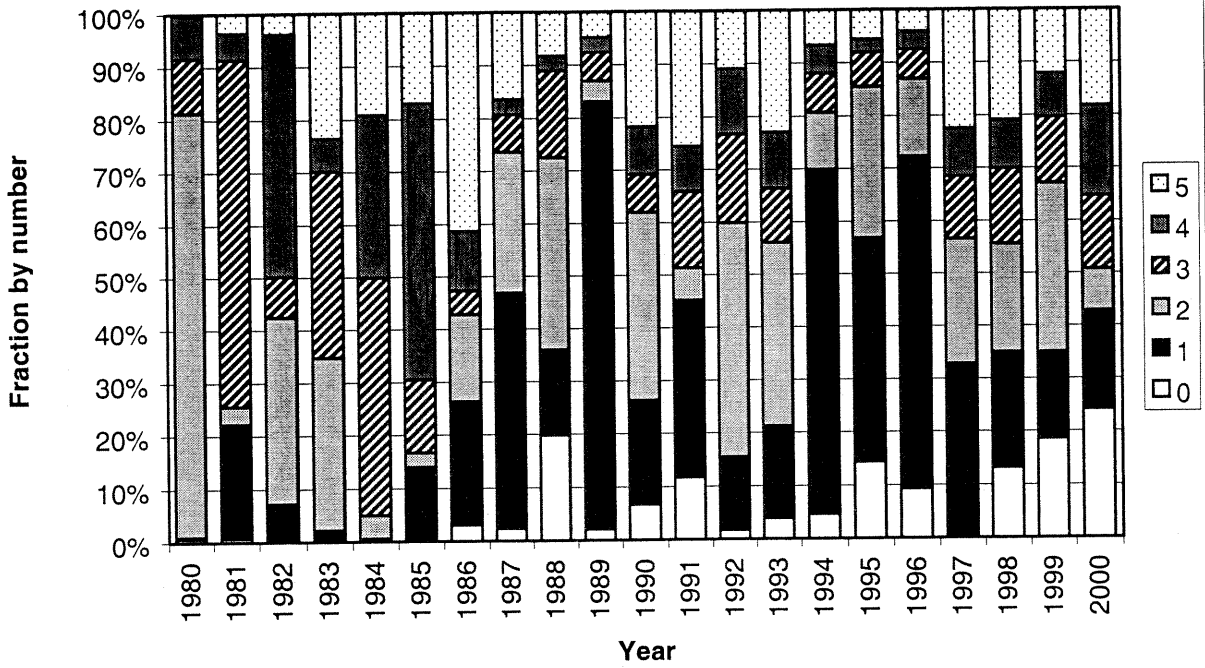

Figure 3. Mean weight-at-age
California Commercial Fishery

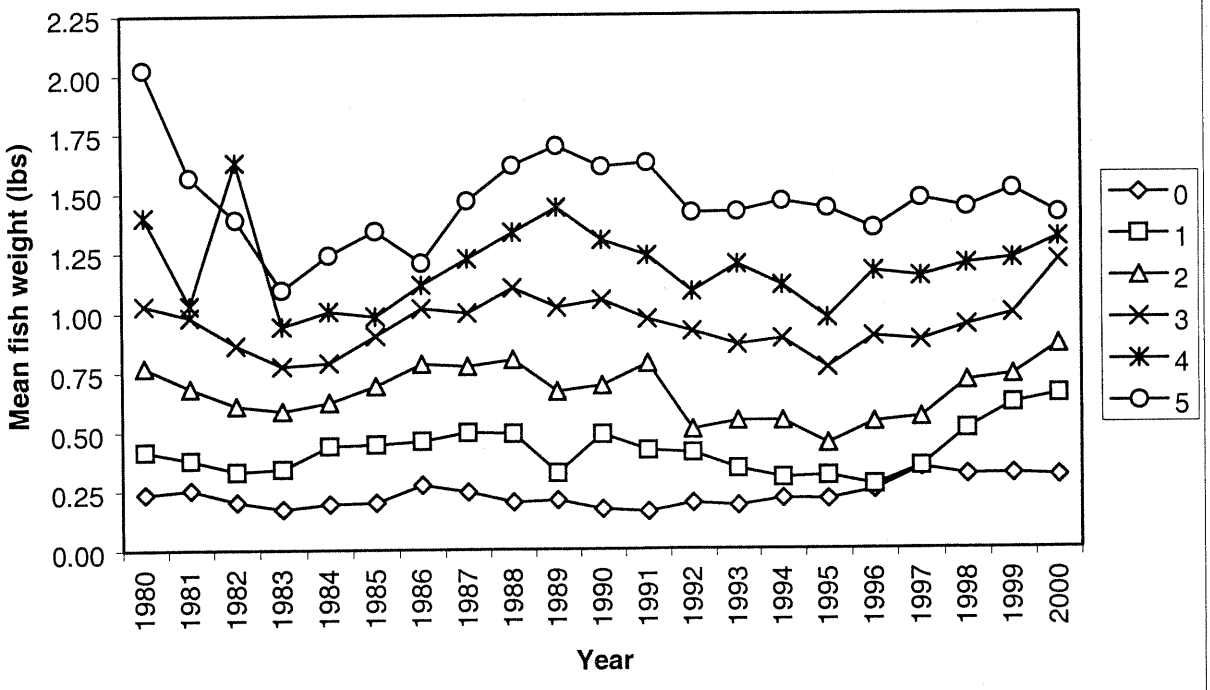

Figure 4. Aerial Spotter Index

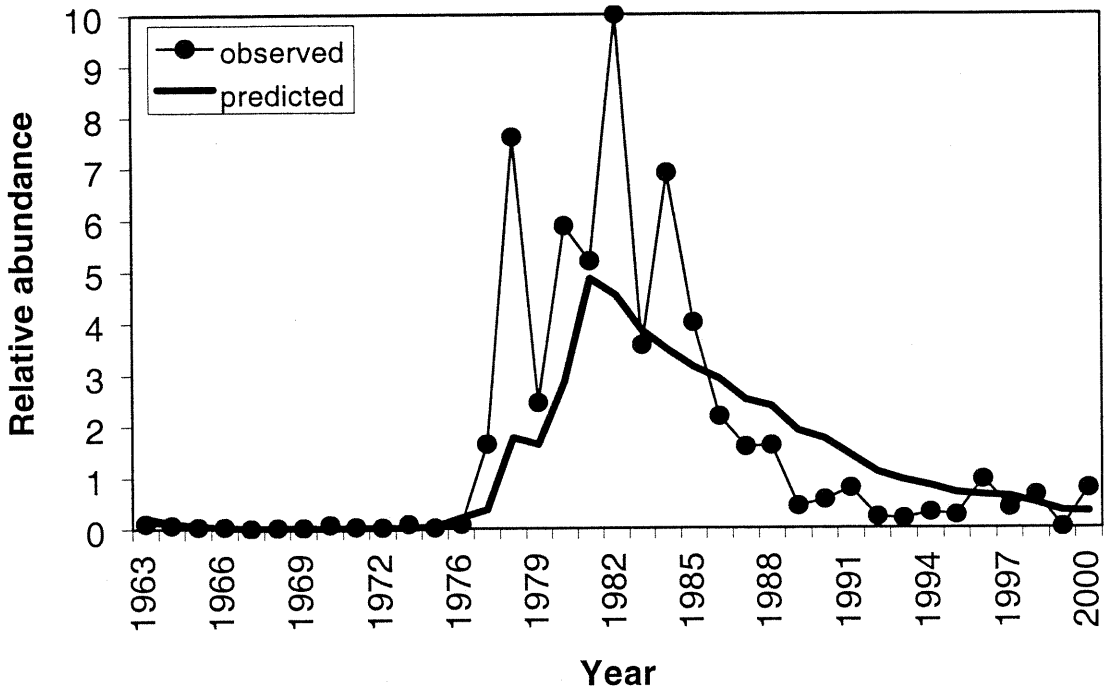

Figure 5. CalCOFI Larval Index

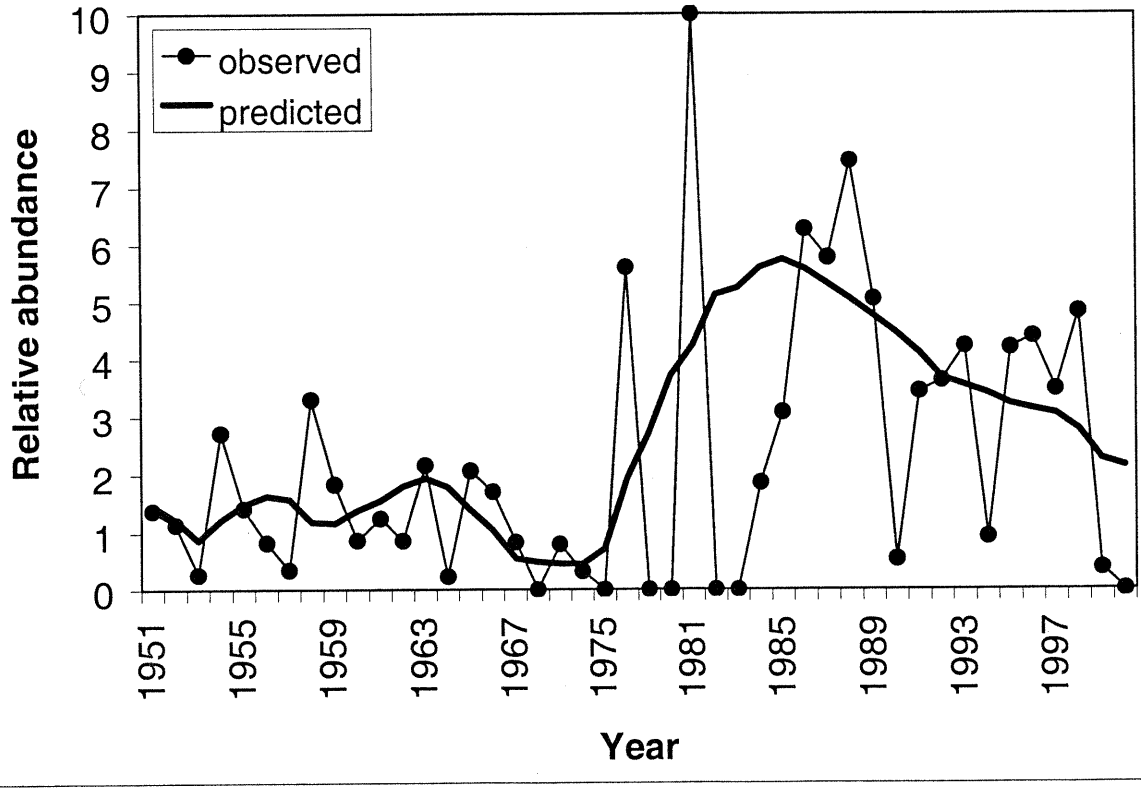

Figure 6. So. Calif. CPFV Index

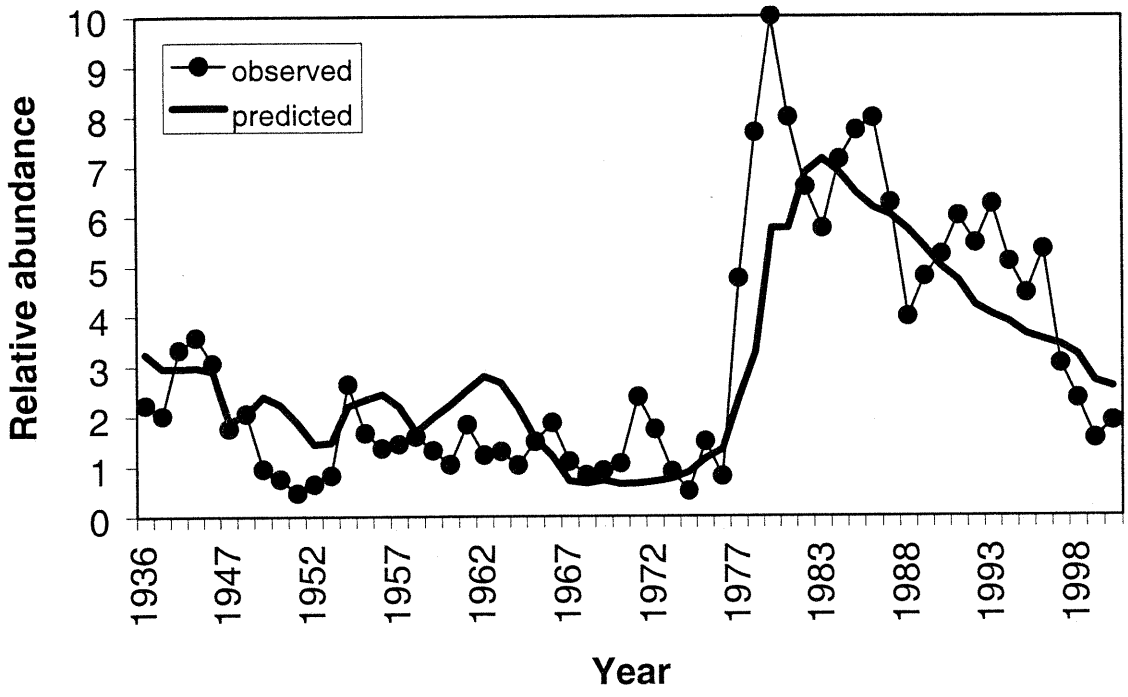

Figure 7. No. Calif. CPFV Index

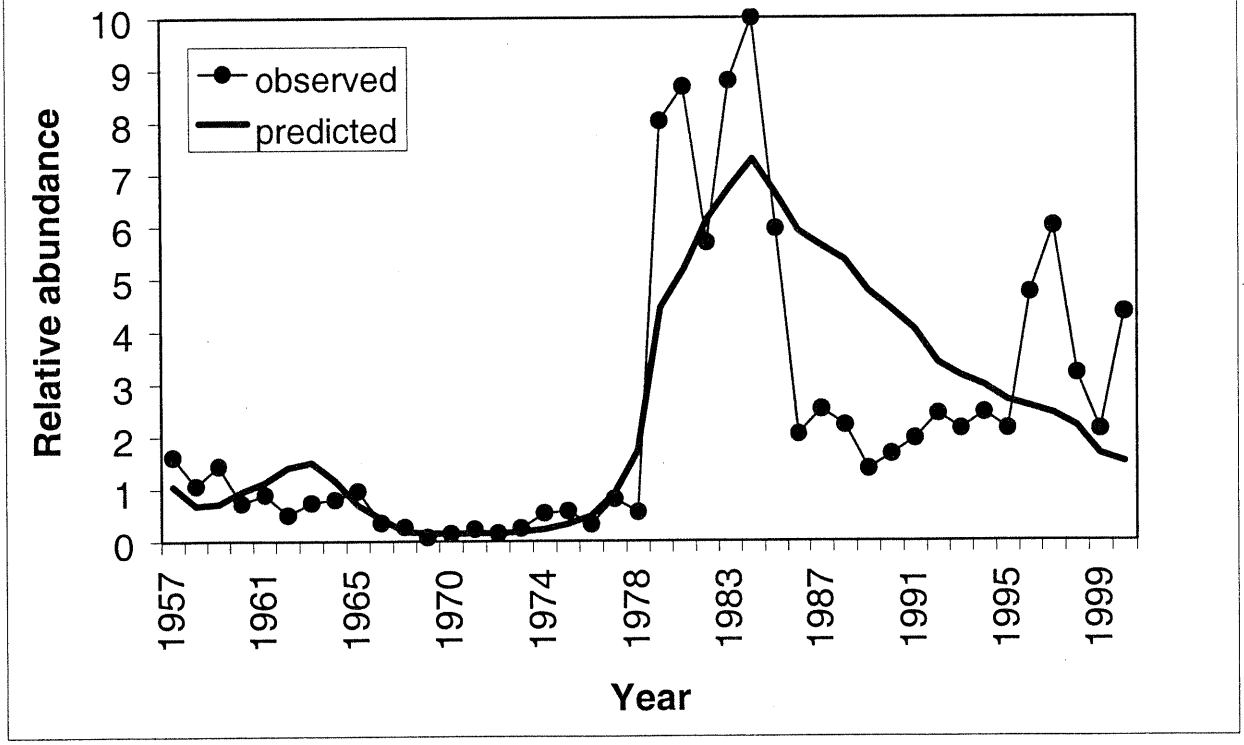

Table 2. Historical estimates of Pacific mackerel biomass (age 1+, metric tons) and recruitment (age 0, number $1x10^6$) estimated using the ADEPT model. The July 1, 2001 biomass was projected based on estimates in Table 3.

YEAR	Age 1+ Biomass (metric tons)	Recruits (millions)		YEAR	Age 1+ Biomass (metric tons)	Recruits (millions)
1929	155,896	1,020		1965	13,080	26
1930	223,033	1,392		1966	4,765	6
1931	296,408	1,552		1967	1,876	10
1932	365,252	1,106		1968	1,696	15
1933	350,660	373		1969	2,127	6
1934	289,642	167		1970	1,602	7
1935	192,454	187		1971	1,763	9
1936	127,778	399		1972	2,072	13
1937	114,806	319		1973	2,894	21
1938	105,650	549		1974	4,834	52
1939	116,944	363		1975	11,067	32
1940	91,214	312		1976	13,932	737
1941	86,466	635		1977	94,141	490
1942	114,291	233		1978	164,761	4,654
1943	105,889	210		1979	539,726	673
1944	84,429	217		1980	716,136	3,021
1945	65,560	68		1981	838,298	7,831
1946	41,260	57		1982	1,475,490	1,664
1947	20,911	582		1983	1,331,845	756
1948	57,101	311		1984	1,158,493	1,084
1949	60,937	35		1985	1,003,484	1,479
1950	42,660	15		1986	909,398	1,128
1951	22,102	10		1987	844,204	621
1952	8,371	199		1988	708,052	1,722
1953	26,419	497		1989	623,981	712
1954	61,973	193		1990	540,751	998
1955	55,240	328		1991	477,128	545
1956	62,799	66		1992	335,265	712
1957	33,036	98		1993	306,084	534
1958	21,457	332		1994	268,426	395
1959	44,194	282		1995	216,950	452
1960	51,912	473		1996	200,788	394
1961	81,419	266		1997	180,591	261
1962	97,143	41		1998	137,993	107
1963	70,707	25		1999	92,390	215
1964	36,733	10		2000	87,868	---
			FORECAST:	2001	***84,090***	

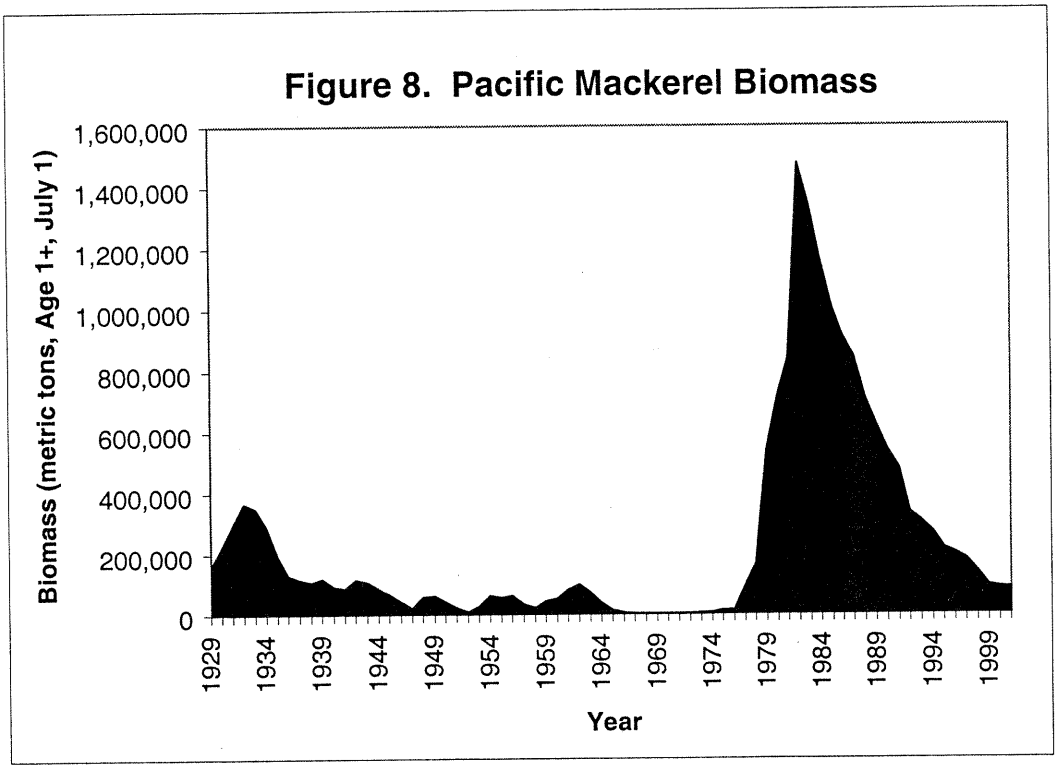

Figure 9. Recruits/Spawning Biomass

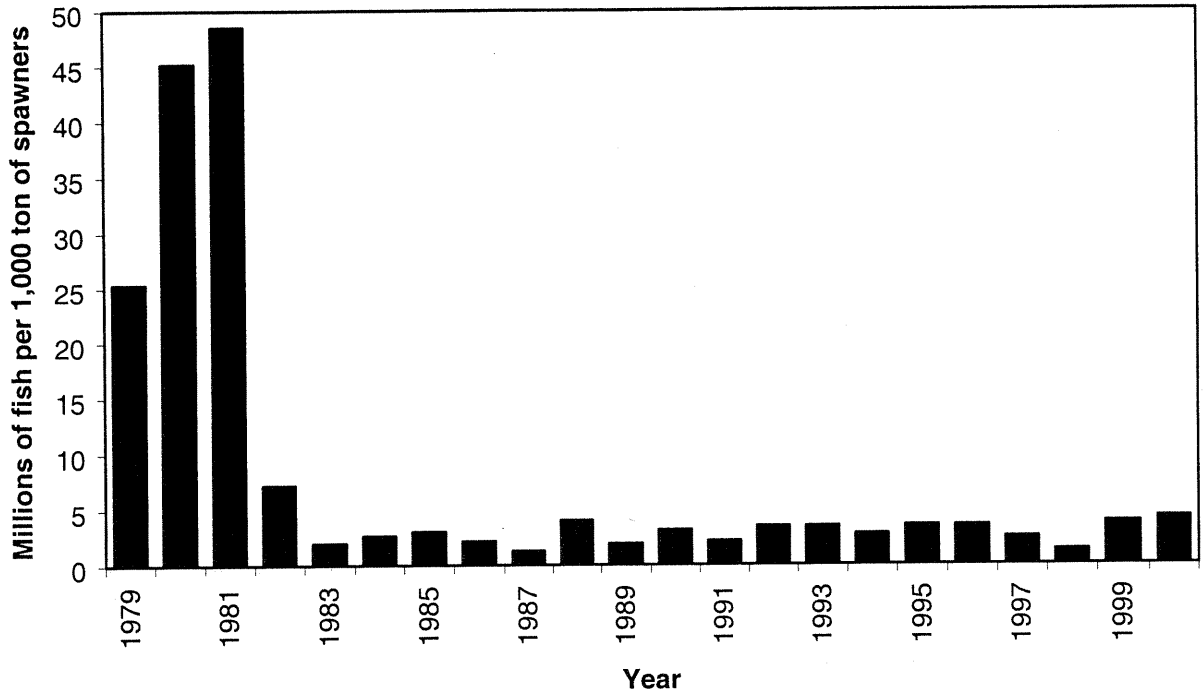

Figure 10. Recruitment Forecast for Biomass Projection

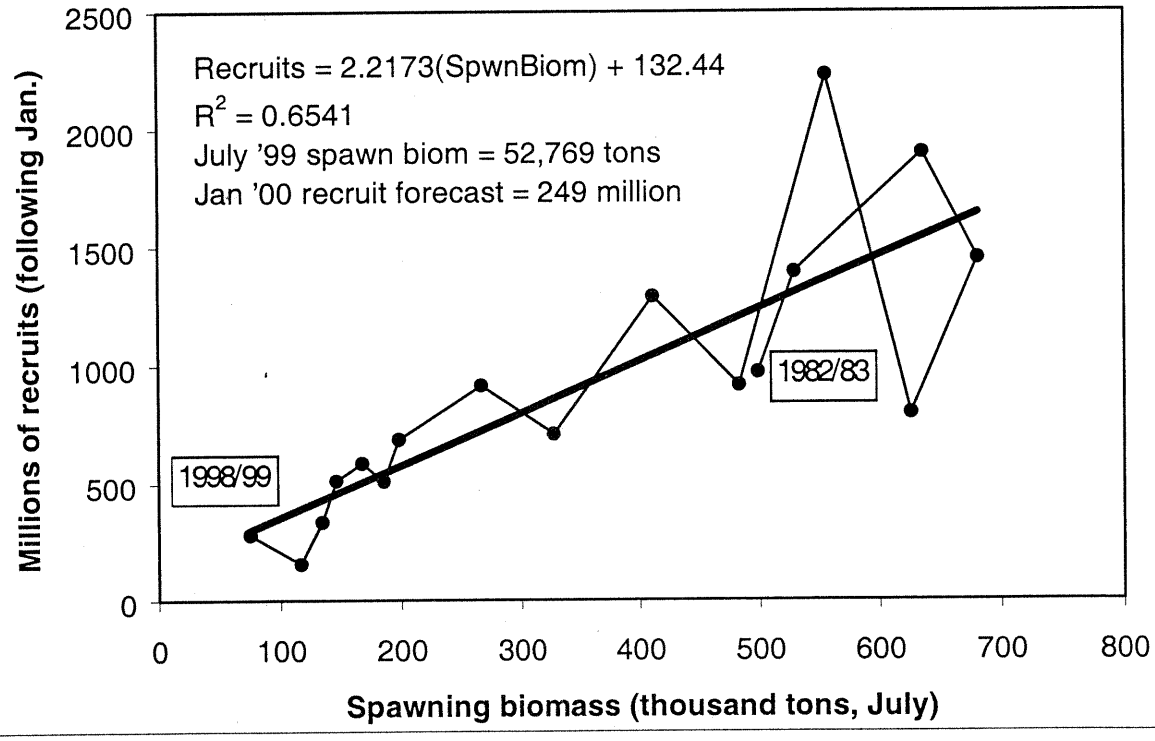

Table 3. Projected Pacific mackerel biomass and calculated harvest guideline for the 2001/2002 management season.

Age	#Fish (10^6) Jan 2000	F Mort 2000	#Fish (10^6) Jan 2001	Selectivity 2001	F Mort* 2001	#Fish (10^6) July 2001	Wt-at-Age (lbs/fish)	Projected Biomass (mt) July 2001
0	249	0.107						
1	163	0.114	136	0.200	0.026	104	0.649	30,779
2	38	0.213	88	0.373	0.048	67	0.857	26,061
3	42	0.366	19	0.642	0.083	14	1.209	7,636
4	36	0.570	18	1.000	0.129	13	1.305	7,639
5+	39	0.570	26	1.000	0.129	19	1.405	11,974
							TOTAL (mt)=	**84,090**

*Annual F in 2001 = 0.1294 <----- adjusted to match projected catch of 3,350 mt for Jan-Jun, 2001.

HARVEST GUIDELINE = (BIOMASS - CUTOFF) x FRACTION x STOCK DISTRIBUTION
where: BIOMASS=84,090; CUTOFF=18,200 mt; FRACTION=30%; STOCK DISTRIBUTION=70%

HARVEST GUIDELINE for 2001-2002 = 13,837 mt

Table 4. Commercial landings (California directed fishery) and quotas (92/93 to 98/99) or harvest guidelines (99/00 to present) for Pacific mackerel. See also Figure 11 below.

Season	Landings (mt)	Quota/HG (mt)
92/93	18,307	34010
93/94	10,793	23147
94/95	9,372	14706
95/96	7,615	9798
96/97	9,788	8709
97/98	23,413	22045
98/99	19,578	30572
99/00	6,732	42,819
36891	20,882	20740
01/02	-------	**13837**