STATUS OF PACIFIC MACKEREL AND TRENDS IN BIOMASS, 1978–1993

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ABSTRACT

Estimates from virtual population analysis indicate that Pacific mackerel (*Scomber japonicus*) biomass increased during 1978–82 to the highest level on record (829,000 short tons), and then declined to less than 100,000 tons by 1993 (estimates for recent years are imprecise). High biomass in early years was due to the strong 1978 and 1980–82 year classes. The declining biomass after 1982 was due to lower recruitment. Current conditions appear similar to those in the mid 1940s, when Pacific mackerel declined after a period of high abundance. Abundance data and biomass indices during recent years were affected by ENSO conditions; more accurate estimates of biomass and assessment of ENSO effects will be possible after environmental conditions return to normal.

Recent catch levels (46,000 and 23,000 tons year^{-1} during 1992 and 1993) were large relative to biomass, and may have exceeded the target 30% total exploitation rate that is the basis for management in California. The economic condition of the fishery is poor, and resources available for management are at an all-time low because of changing priorities and financial constraints. Landings of Pacific mackerel increased in Mexico during recent years while California landings remained relatively constant, and biomass declined. Thus the future of the Pacific mackerel stock and fishery are uncertain.

RESUMEN

Estimaciones obtenidas por el análisis virtual de poblaciones indican que la biomasa de la macarela (*Scomber japonicus*) alcanzó durante 1978–82 los máximos niveles que hayan sido registrados (829,000 toneladas cortas), y subsecuentemente declinó a menos de 100,000 tons. cortas en 1993 (las estimaciones en años recientes son imprecisas). Los altos niveles de biomasa referidos se debieron a la fuerza de las clases de edad de 1978 y 1980–82, mientras que el decremento después de 1982 se debió a los bajos niveles de reclutamiento. Las condiciones actuales parecieran asemejarse a aquellas de mediados de los años 40, cuando la macarela declinó después de un periodo de alta abundancia. En años recientes, los datos de abundancia e índices de biomasa fueron afectados por condiciones El Niño-Oscilación Austral. Será posible obtener estimaciones mas exactas cuando las condiciones ambientales retornen a la normalidad.

Los niveles de captura recientes (46,000 y 23,000 tons. cortas año^{-1} en 1992 y 1993) fueron relativamente altos respecto a la biomasa, y podrían haber excedido los niveles fijados como meta, tasa de explotación de 30% del total, que es la base de la administración en California. La condición económica de la pesquería es mala, y debido a restricciones económicas y cambios de las prioridades, los recursos disponibles para la administración de la pesquería son mas escasos que nunca. En años recientes, se han incrementado los desembarcos de macarela en México, mientras que en California los desembarcos se han mantenido constantes, y la biomasa ha declinado. Por lo tanto, el futuro del stock y la pesquería de macarela son inciertos.

INTRODUCTION

Pacific mackerel (*Scomber japonicus*, also known as chub mackerel) are a mainstay of the southern California purse seine fishery (Konno and Wolf 1992; Thomson 1993). The purpose of this report is to document trends in Pacific mackerel biomass during 1978–93 and to extend the time series of estimates for 1929–84 in Prager and MacCall 1988. We obtained the biomass estimates by virtual population analysis (VPA), using the ADAPT procedure (Gavaris 1988), with fishery data stratified by quarter (see Jacobson et al. 1994 for data and analytical details).

There were three indices of relative abundance (table 1 and figure 1). The SPOTTER index was calculated from fish spotter logs in the same way as for northern anchovy (*Engraulis mordax*; Lo et al. 1992), except that data were aggregated by April–March annual periods. Thus we used data for April 1988–March 1989 as an index of relative abundance during the first quarter of 1989.

California Cooperative Oceanic Fisheries Investigations (CalCOFI) data for Pacific mackerel were used in two indices of relative abundance (table 1 and figure 1). The index DENSITY was the density of Pacific mackerel larvae per unit area calculated from catches in bongo nets. The index PROP+ was the proportion of bongo tows that were positive for Pacific mackerel larvae (Mangel

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TABLE 1
Indices of Relative Abundance for Pacific Mackerel

Year	SPOTTER (short tons block^{-1})	CV	DENSITY (larvae 10 m^{-2})	CV	PROP+	*N* (tows)
1978	21.93	0.44	9.9054	0.32	0.1377	247
1979	40.46	0.42	—	—	—	—
1980	31.44	0.42	—	—	—	—
1981	31.20	0.44	45.5338	0.36	0.3333	105
1982	32.42	0.42	—	—	—	—
1983	38.56	0.43	—	—	—	—
1984	32.25	0.47	2.1382	0.60	0.0536	112
1985	40.39	0.47	3.5956	0.46	0.1642	67
1986	21.21	0.48	2.8246	0.44	0.1000	70
1987	15.50	0.46	18.7083	0.66	0.0941	85
1988	6.50	0.51	4.5224	0.45	0.1282	78
1989	11.23	0.53	2.4788	0.45	0.0843	83
1990	3.04	0.60	0.3052	1.00	0.0130	77
1991	3.14	0.55	0.5695	0.59	0.0698	43
1992	4.40	0.52	0.2694	0.53	0.0430	93
1993	2.48	0.68	0.0603	1.00	0.0116	86

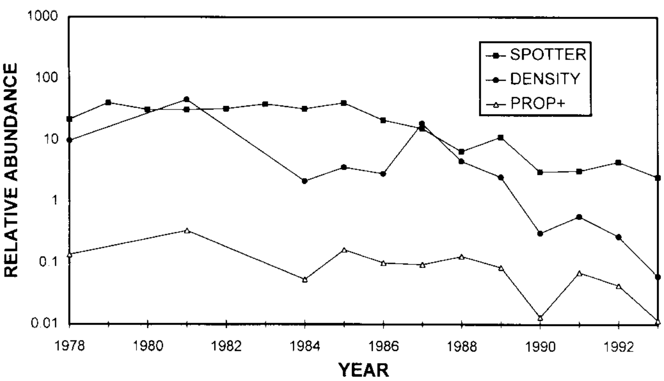

Figure 1. Indices of abundance for Pacific mackerel plotted in log scale for comparison.

and Smith 1990; Smith 1990). For purposes of standardization, CalCOFI indices were calculated with data from the current CalCOFI sampling grid (covering roughly the Southern California Bight; Hewitt 1988) that were collected during April–September of each year, when spawning is most common (MacCall and Prager 1988).

RESULTS

SPOTTER and DENSITY data (table 2 and figure 2) yielded VPA results that were generally similar to results from SPOTTER and PROP+ data (not shown; see Jacobson et al. 1994). Pacific mackerel biomass increased dramatically during 1978–82 to the highest level on record—829,000 tons (throughout this paper *tons* refers to short tons). VPA results and relative abundance data (table 1 and figure 1) indicate that biomass declined after 1982 to relatively low levels by 1993. High biomass in early years was due to the strong 1978 and 1980–82 year classes (MacCall et al. 1985). The decrease in biomass after 1982 was due to lower recruitment.

TABLE 2
Biomass and Recruitment Estimates (Age Zero Fish on July 1) for Pacific Mackerel, 1979–93, from the ADAPT Model Using SPOTTER with DENSITY Data

Year	Biomass (1,000 short tons)	CV[a]	Recruitment (million fish)
1978	78	0.01	1,985
1979	303	0.06	428
1980	363	0.08	1,987
1981	550	0.15	3,154
1982	829	0.19	1,366
1983	781	0.22	280
1984	691	0.24	234
1985	498	0.25	992
1986	504	0.31	795
1987	480	0.37	434
1988	442	0.50	911
1989	340	0.54	260
1990	269	0.67	267
1991	185	0.75	135
1992	71	1.21	30
1993	35	1.58	16

[a]Calculated using a parametric bootstrap procedure with 50 iterations.

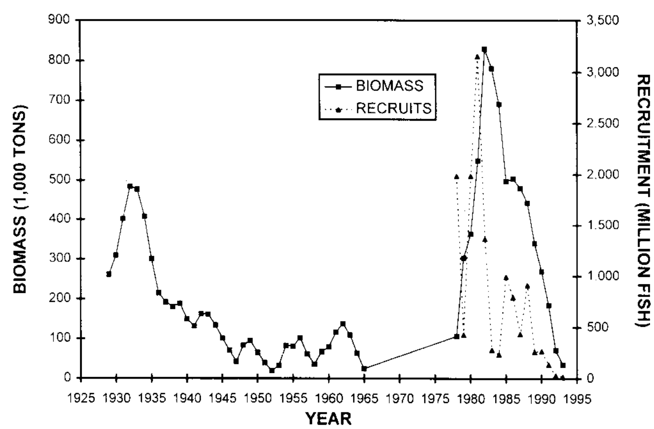

Figure 2. Biomass of Pacific mackerel during 1929–65 from Prager and MacCall 1988, and during 1978–93 from ADAPT (with SPOTTER and DENSITY data). Recruitment is the number of age zero fish on July 1.

Biomass estimates from ADAPT for Pacific mackerel during recent years (table 2 and figure 2) were probably too low because ENSO conditions during 1992–93 displaced pelagic fish to the north (Brodeur and Pearcy 1986) and away from the Southern California Bight area covered by CalCOFI and fish spotters. In 1993, for example, Pacific mackerel were sighted near the Queen Charlotte Islands, British Columbia—north of the normal limit of their distribution (California Department of Fish and Game 1994). Thus effects of ENSO and changes in biomass are confounded in the decline of SPOTTER and CalCOFI data during 1992–93, and in the resulting biomass estimates from the ADAPT procedure. It will be possible to more accurately measure 1992–93 biomass and assess the effects of ENSO on

TABLE 3
Pacific Mackerel Landings (Short Tons), 1978-93

Year	Calif. Commer.	Calif. Recr.	Mexican Commer.	Total
1978	12,448	1,898	9,309	23,655
1979	30,495	2,618	6,348	39,461
1980	32,544	2,997	4,668	40,209
1981	42,916	1,574	2,273	46,763
1982	31,759	1,841	4,977	38,577
1983	35,857	1,626	1,721	39,204
1984	46,422	1,573	2,345	50,340
1985	38,240	1,227	8,005	47,472
1986	45,560	1,092	10,340	56,992
1987	45,852	969	869	47,690
1988	48,072	838	4,926	53,837
1989	40,263	641	16,399	57,303
1990	41,959	1,065	39,400	82,423
1991	34,545	823	19,277	54,645
1992	21,700	738	24,001	46,439
1993	13,358	991	8,863[a]	23,212[a]

[a]Preliminary estimates.

abundance indices after environmental conditions return to normal.

Biomass estimates for Pacific mackerel were imprecise (CV > 30%) during 1986–93, and severely so (CV > 50%) after 1989 (table 2). This lack of precision was exacerbated by imprecise indices of abundance (table 1), low levels of fishing mortality in some years (Pope 1972), and by abundance data that were a "one way trip" (continuously decreasing; Hilborn and Walters 1992). It is likely, moreover, that we overestimated precision because we did not consider errors in landings and catch-at-age data, uncertainty about index and fishery selectivities, and effects of ENSO in our bootstrap variance calculations.

In view of the ENSO conditions, and considering all uncertainties, we estimate that Pacific mackerel biomass during 1993 was less than 100,000 tons. Thus current conditions appear similar to those in the mid 1940s, when Pacific mackerel declined to less than 100,000 tons after a period of high abundance (figure 2). After 1945, the stock varied around an average biomass of about 70,000 tons until the fishery collapsed in 1965.

Recent catch levels (46,000 and 23,000 tons year^{-1} during 1992 and 1993; table 3) were large relative to biomass estimates (<100,000 tons) and may have exceeded the target 30% total exploitation rate that is the basis for California management (quotas are set at 30% of the Pacific mackerel biomass above 20,000 tons). The California fishery is managed with quotas that make no allowance for Mexican harvests, and the Mexican fishery is not regulated by a quota. Thus, if current biomass is as low as we estimate or if recruitment is poor, catches in the next few years may be large enough to deplete the stock of Pacific mackerel.

The Pacific mackerel fishery in California is at a crossroad, and its future is uncertain. Economic conditions in the fishery are poor (Thomson et al. 1993; California Department of Fish and Game 1994). Resources available for management at state and federal levels are currently low because of changing priorities, low revenues from landings taxes, and other financial constraints. The CDFG lacked resources to age Pacific mackerel collected in port samples during 1994, and stock assessment may not be possible in 1995 because of a lack of personnel and data. Landings of Pacific mackerel increased in Mexico during recent years while California landings remained relatively constant, and biomass declined (tables 2 and 3). Thus the Pacific mackerel fishery in California, already beset with economic problems, faces reduced management during a period of increased total landings and potentially low biological productivity.

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