# THE NORTHERN ANCHOVY SPAWNING BIOMASS FOR THE 1981–82 CALIFORNIA FISHING SEASON

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## ABSTRACT

The biomass of the central subpopulation of the northern anchovy during the 1981 spawning season is estimated to be 2,803,000 short tons, based on the larva census method. Anchovy stock was surveyed over its geographic range on four cruises during the six-month period from January to June. The anchovy larvae in the plankton samples were sorted, counted, and measured, and the data were summarized to form larva census information for estimating the anchovy spawning biomass. The resulting 1981 estimate of 2,803,000 tons is approximately 58 percent greater than the 1980 estimate of 1,775,000 tons. The optimum yield for the central subpopulation in the 1981-82 fishing season is 601,000 short tons, as specified by the yield formula given in the Pacific Fishery Management Council's Northern Anchovy Fishery Management Plan. Within the U.S. 200-mile Fishery Conservation Zone, the optimum yield is 420,700 tons.

## RESUMEN

La biomasa de la subpoblación de *Engraulis mordax* durante la temporada del desove en 1981 se calculó ser de 2,803,000 toneladas cortas, basado en el método de censo de larvas. La existencia de anchoveta fue reconocida durante cuatro cruceros por toda su extensión geográfica, durante un período de seis meses entre enero y junio. Las larvas de anchoveta en las muestras de plancton fueron separadas, contadas, y medidas, y los datos fueron resumidos para formar la información del censo de larvas para estimar la biomasa de desove de anchovetas. La estimación resultante para 1981 de 2,803,000 toneladas es aproximadamente el 58 por ciento más que la de 1980, de 1,775,000 toneladas. El rendimiento óptimo para la subpoblación central durante la temporada de pesca en 1981–82 es 601,000 toneladas cortas, especificado por la fórmula de rendimiento presentada por el Pacific Fishery Management Council en su Plan de Administración de la Pesquería de Anchoveta del Norte. Dentro de las 200 millas que abarca la Zona de Conservación de la Pesquería de los EE.UU., el rendimiento óptimo es 420,700 toneladas.

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## INTRODUCTION

The harvest plan for northern anchovy, *Engraulis mordax,* in California is specified in the Pacific Fishery Management Council's (PFMC) Northern Anchovy Fishery Management Plan (FMP), first implemented in 1978. The optimum yield for the U.S. fishing season is set according to the optimum yield formula given in the FMP and based on the current estimate of the spawning biomass. The purpose of this annual report, the fourth in a series, is to document the 1981 estimate of the spawning biomass of northern anchovy for the 1981–82 California fishing season. The 1981 biomass estimate is derived by the larva census procedure first developed by Smith (1972) and documented in Appendix I of the Anchovy FMP (PFMC 1978). Stauffer and Parker (1980) later developed the calibration for an annual larva census from the six-month winter-spring larva census. The 1981 anchovy larva data were collected on four cruises during winter and spring in the 1981 California Cooperative Oceanic Fisheries Investigations (CalCOFI) egg and larva survey. This survey was directed by the National Marine Fisheries Service, Southwest Fisheries Center (SWFC). Other agencies cooperating in the multicruise survey were Scripps Institution of Oceanography (SIO), Instituto Nacional de Pesca, Mexico (INP), and National Ocean Survey (NOS). Samples from Mexican waters were taken by permission of the Secretaria de Relaciones Exteriores under diplomatic note numbers 315052, 315576, 315611, 315984, and 316422.

## LARVA SURVEY

The 1981 egg and larva survey of the central subpopulation of the northern anchovy was part of the 1981 triennial CalCOFI survey of the California Current region. The 1981 CalCOFI survey comprised six multiship cruises and sampled CalCOFI stations from line 60 at 38°N off San Francisco to line 137 at 25°N off central Baja California, Mexico, out to station 90—160 to 240 nautical miles offshore (Figure 1). To survey and estimate the spawning biomass of the central subpopulation of northern anchovies by July 1, 1981, as required by the FMP, we processed and analyzed plankton samples from only eight of the twenty-four CalCOFI regions (4, 5, 7, 8, 9, 11, 13,

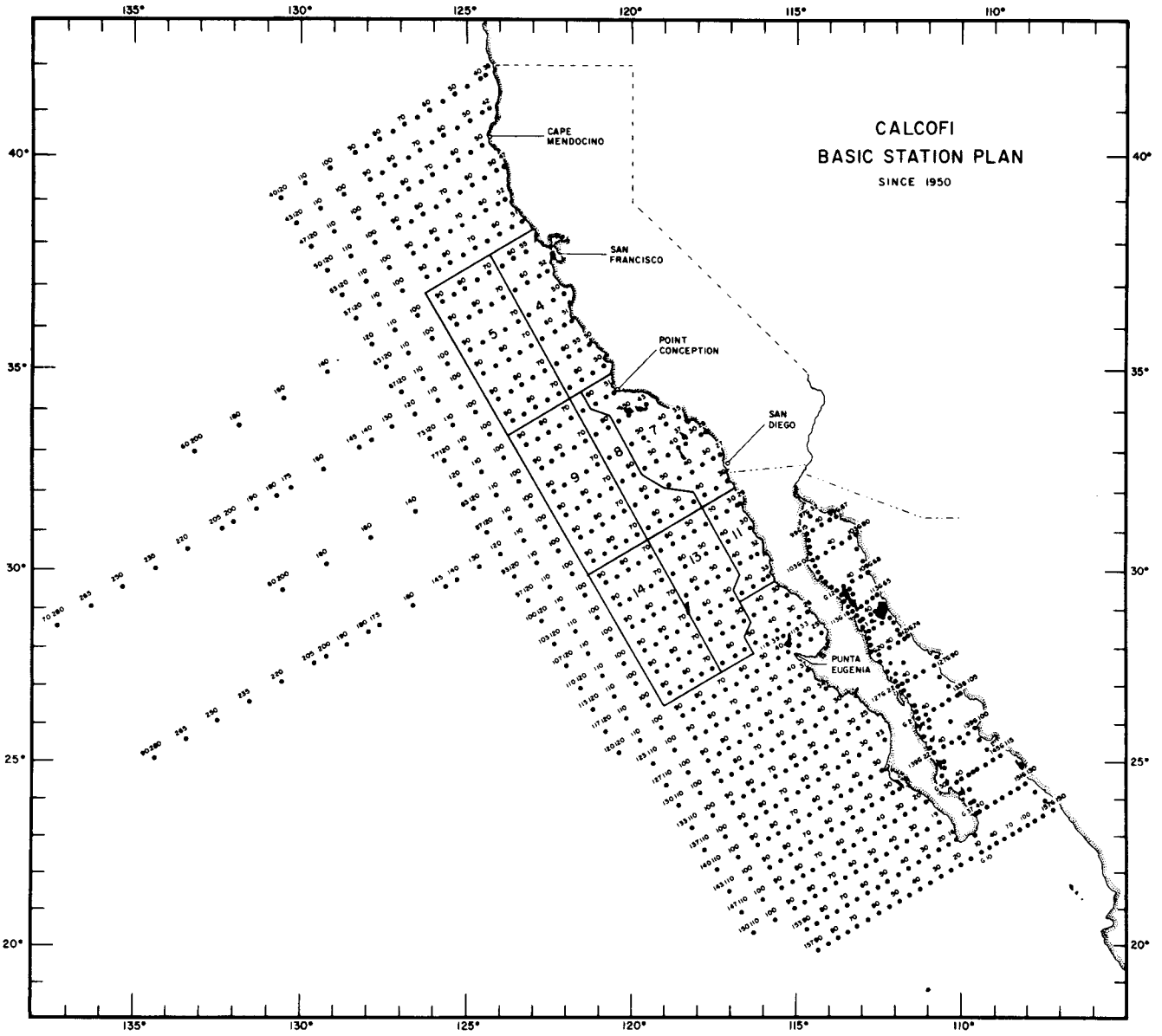


Figure 1. CalCOFI basic station plan. The geographic range of the central subpopulation of northern anchovy is within the eight numbered regions.

and 14) and from the four cruises conducted in the winter and spring. Approximately 130 CalCOFI stations were routinely occupied per cruise within these eight regions. As outlined in Figure 1, these geographic regions coincide with the range of the central subpopulation (Vrooman et al. 1980). The four winter and spring cruises covered the major portion of the anchovy spawning season (Stauffer and Parker 1980).

The anchovy survey cruises were scheduled at approximately six-week intervals beginning in early January (Table 1). Each cruise was about four weeks long. The January cruise was conducted over CalCOFI lines 110 through 60 by the R/V *David Starr Jordan* from January 7 to February 1. The second cruise,

TABLE 1
**Schedule of the 1981 Egg and Larva Cruises**

| Cruise number | Cruise month | Survey quarter | Vessel name | Date | CalCOFI area |
|---|---|---|---|---|---|
| 8101 | January | Winter | *Jordan* | 1/7-2/1 | Lines 110 to 60 |
| 8102 | February | Winter | (1) *Jordan* | 2/12-3/10 | Lines 110 to 60 within regions 4,7,8,11, and 13 |
| | | | (2) *New Horizon* | 2/12-3/8 | Lines 60 to 110 within regions 5,9, and 14; lines 113 to 130 |
| 8104 | April | Spring | (1) *Jordan* | 3/31-4/27 | Lines 110 to 100 in region 11; lines 97 to 60 |
| | | | (2) *New Horizon* | 4/7-4/28 | Lines 100 to 133 |
| 8105 | May | Spring | (1) *Jordan* | 5/18-6/13 | Lines 90 to 110 |
| | | | (2) *New Horizon* | 5/19-6/8 | Lines 87 to 60 |

8102, was run with two ships, *Jordan* and R/V *New Horizon,* beginning February 12 and finishing March 10. The cruise plan for the *Jordan* included an egg survey of CalCOFI regions 4, 7, 8, 11, and 13 to estimate the anchovy biomass by the egg production method (Parker 1980). Stormy weather in February prevented the ship from surveying the stations in region 9 during cruise 8102. The first cruise of the spring quarter, 8104, began March 31 and ended April 28. The *Jordan,* conducting a second egg survey in regions 7, 8, and 11, occupied inshore stations on lines 110 to 100 and all routine stations on lines 97 to 60. The *New Horizon* surveyed the southern lines beginning with line 100, duplicating occupancy of region 11. The last cruise, 8105, began May 18 and ended June 13. The *Jordan* surveyed from lines 90 to 110, the *New Horizon* from lines 87 to 60.

The plankton samples were collected and processed with methods identical to the 1979 and 1980 surveys reported by Stauffer (1980) and Stauffer and Picquelle (1981). The plankton was sampled with a CalCOFI bongo net towed at a 45° angle from a maximum depth of 200 meters (Smith and Richardson 1977). The plankton samples from the starboard half of the bongo net were sorted. All of the plankton in a sample was sorted if the station was beyond 200 miles from shore or if the plankton volume was less than 26 ml; otherwise, a 50 percent aliquot of the sample was sorted. In all, 534 samples were collected and processed. Nineteen stations in region 11 were occupied twice during cruise 8104. The larva counts for these paired samples were averaged for the cruise. Because cruise 8105 ended June 13, time was too short to sort all the plankton samples for the July 1 deadline. Therefore, samples were not sorted for the stations in region 5 offshore of central California—a region with few anchovy larvae in May in the past. The larva data were entered into the computerized CalCOFI data management system where the data are edited, filed, processed, and summarized into larva census values for winter and spring quarters.

## SURVEY RESULTS

The geographic distribution of anchovy larvae in 1981 has expanded somewhat farther offshore compared to the past three years. The number of larvae per station was low in the January cruise. The number of larvae per station in the February-March cruise increased tenfold over the January samples. The peak occurred in the April cruise, with the number of larvae 50 percent greater than in the February-March cruise. By May-June the number of larvae per station had decreased to a level similar to that in January. As shown in Figure 2, larvae in northern regions 4 and 5 were most abundant in the winter quarter cruises. Off Baja California, anchovy larvae were most abundant during March and April. Few larvae were taken there in the January and June cruises. The Southern California Bight, represented by region 7, contained the largest portion of the anchovy larvae. For the first time since 1975, a number of anchovy larvae were found in offshore region 9 during the April cruise. Unfortunately, stations in region 9 were not occupied during the February-March cruise. The large size of the larvae in region 9 suggests that the larvae were relatively old and were probably carried offshore by the California Current and upwelling plumes arising off central California. The first major upwelling of the 1981 season occurred from March 26 to April 9 off central and southern California (A. Bakun, Pacific Environmental Group, pers. comm.).

Of the 255 stations occupied in the winter quarter, 56 percent, or 143 contained anchovy larvae. For the spring quarter, 51 percent, or 134 out of 260 stations contained anchovy larvae. The larva census compiled for the eight regions of the central subpopulations is $11{,}127.4 \times 10^9$ larvae for the winter quarter and $14{,}164.3 \times 10^9$ larvae for the spring quarter. The combined winter-spring larva census, $L_{WS}$, is $25{,}921.7 \times 10^9$ larvae (Table 2).

TABLE 2
**Estimated Larval Abundance ($10^{12}$ larvae) for the Central Subpopulation from Appendix I, Table 2, FMP**

| Year | Winter | Spring | Winter & spring | Annual | Spawner biomass in millions of short tons |
|---|---|---|---|---|---|
| 1951 | .298 | .690 | .988 | 1.841 | .180 |
| 1952 | .407 | .457 | .864 | 1.600 | .156 |
| 1953 | 1.210 | .373 | 1.583 | 5.208 | .510 |
| 1954 | 4.469 | .988 | 5.457 | 7.838 | .768 |
| 1955 | 5.588 | 1.709 | 7.297 | 8.618 | .845 |
| 1956 | 1.911 | 1.206 | 3.117 | 4.944 | .485 |
| 1957 | 5.954 | 4.308 | 10.262 | 11.960 | 1.172 |
| 1958 | 8.114 | 5.236 | 13.350 | 15.087 | 1.479 |
| 1959 | 6.341 | 8.155 | 14.496 | 15.440 | 1.514 |
| 1960 | 7.552 | 7.547 | 15.099 | 15.713 | 1.540 |
| 1961 | .992 | 6.714 | 7.706 | 11.827 | 1.159 |
| 1962 | 4.814 | 23.567 | 28.381 | 30.478 | 2.986 |
| 1963 | 17.377 | 24.818 | 42.195 | 43.407 | 4.254 |
| 1964 | 8.941 | 14.383 | 23.324 | 29.599 | 2.901 |
| 1965 | 19.155 | 22.690 | 41.845 | 47.540 | 4.659 |
| 1966 | 15.103 | 15.865 | 30.968 | 36.452 | 3.572 |
| 1969 | 19.756 | 6.538 | 26.294 | 30.594 | 2.998 |
| 1972 | 8.213 | 14.335 | 22.548 | 28.373 | 2.781 |
| 1975 | 29.754 | 4.071 | 33.825 | 36.768 | 3.603 |
| 1978 | 6.704 | 4.184 | 10.888 | 13.306 | 1.304 |
| 1979 | 6.546 | 9.124 | 15.670 | 17.580 | 1.723[1] |
| 1980 | — | — | — | 18.110 | 1.775[2] |
| 1981 | 11.127 | 14.164 | 25.292 | 28.603 | 2.803[3] |

Spawner biomass in tons is calculated from annual larvae abundance; spawner biomass = $9.8 \times 10^{-8} \times$ larvae abundance, from Smith 1972.
[1]Stauffer and Parker 1980
[2]Stauffer 1980
[3]Stauffer and Picquelle 1981.

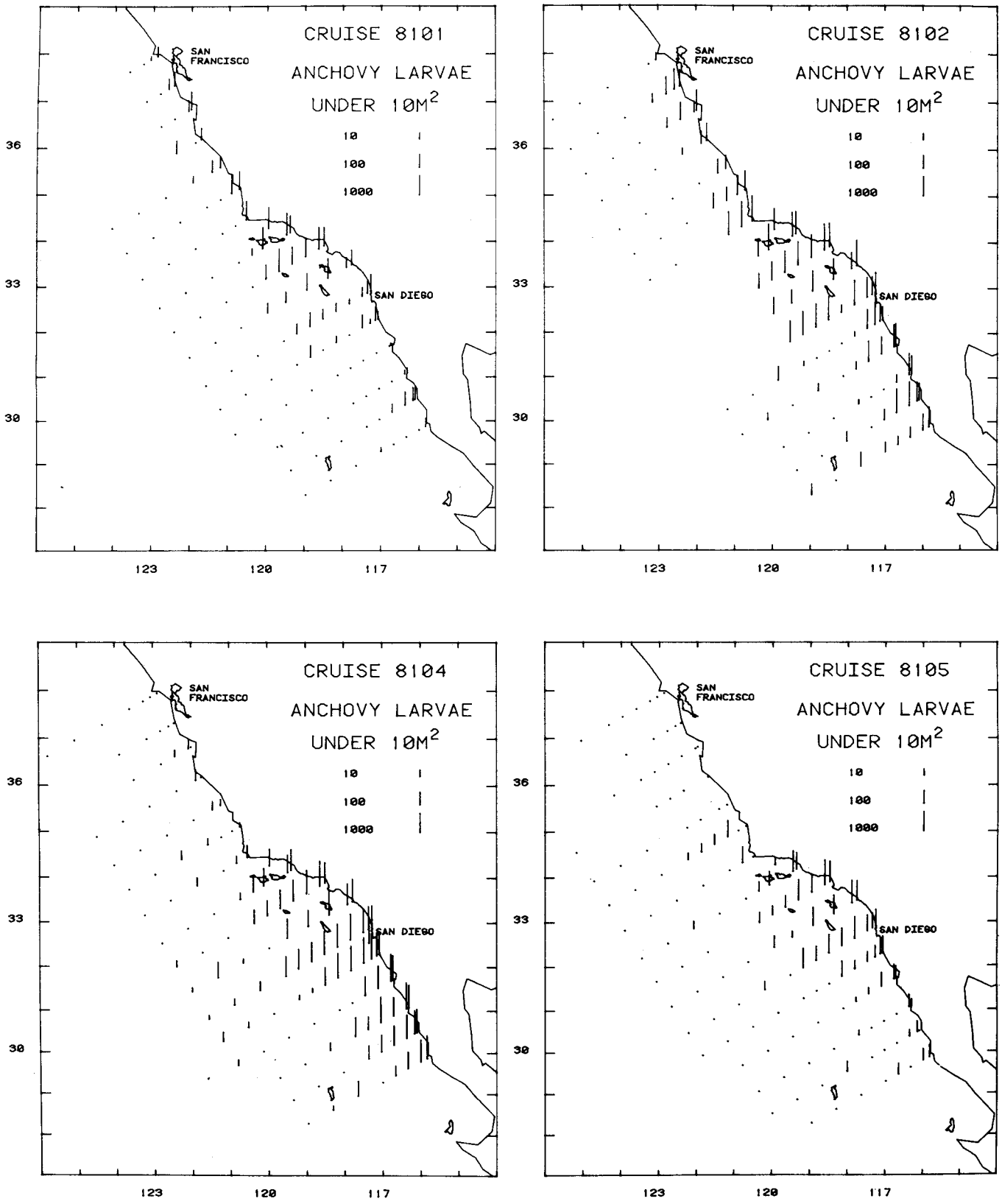


Figure 2. Occupied stations for the 1981 cruises, and geographic distribution of anchovy larvae for the central subpopulation in the winter and spring. The vertical bars represent the logarithm of the number of larvae under 10 $m^2$ of sea surface.

## BIOMASS ESTIMATE

The larva census estimates of anchovy biomass for the years 1951–69 developed by Smith (1972) are based on annual larva census values. Stauffer and Parker (1980) expanded the winter-spring larva census to an annual larva census, $L$, with the regression equation,

$$L = 1.062\, L_{WS} + 1{,}743 \times 10^9.$$

The equation is based on larva census data for 1951–75 summarized by CalCOFI regions as outlined in Figure 1. From this equation, the 1981 annual larva census is $28{,}602.7 \times 10^9$ larvae. The estimate of the 1981 spawning biomass, with Smith's (1972) equation,

$$B = 9.8 \times 10^{-8} L,$$

is 2,803,000 short tons. This is a 58 percent increase over the 1980 estimate of 1,775,000 tons, and is the third consecutive year with an increase in the biomass estimate since the 1978 low of 1,304,000 tons (Figure 3). The 1981 larva census values for the winter and spring quarters and the resulting biomass estimate are nearly identical to survey results for 1964 and, more recently, 1972.

## OPTIMUM YIELD

The optimum yield for the 1981-82 fishing season for the estimated biomass of 2,803,000 tons is 601,000 tons based on the formula specified in the Northern Anchovy FMP (PFMC 1978). The optimum yield in the U.S. Fishery Conservation Zone (FCZ) is 70 percent or 420,700 short tons, The U.S. capacity to process anchovies, including live bait, is estimated to be 371,885 tons. The difference of 48,815 tons is available to joint ventures or to foreign fisheries within the U.S. FCZ as TALFF (Total Allowable Level of Foreign Fishing). The 1981–82 quota for the U.S. commercial fishery was set at 359,285 tons by National Marine Fisheries Service. However, the California Fish and Game Commission established a 150,000 short-ton limit on the amount of northern anchovy that could be processed by shore-based reduction plants in California because of the discrepancy between the 1980 estimates of biomass using the larva census method and the newly developed egg production method (Stauffer and Picquelle 1981).

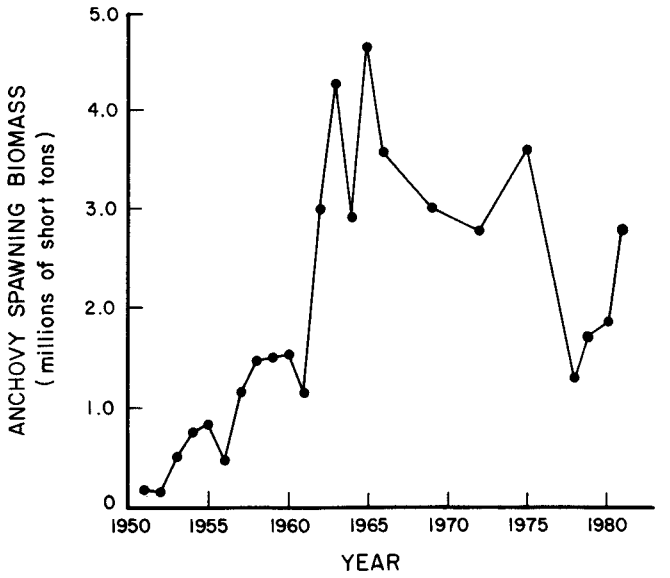


Figure 3. Estimated spawning biomass for the central subpopulation of northern anchovies, 1951–81.

## ACKNOWLEDGMENTS

We thank many people for their efforts in collecting and processing the CalCOFI egg and larva data used in this estimation. They include Scripps Institution of Oceanography (SIO) plankton sorting group,Southwest Fisheries Center CalCOFI group, and crews of NOAA Ship R/V *David Starr Jordan* and SIO R/V *New Horizon*. We could not have accomplished this task without everyone's full cooperation and extra effort.

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