# BIOMASS OF THE SUBPOPULATIONS OF NORTHERN ANCHOVY *ENGRAULIS MORDAX* GIRARD

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During the California Cooperative Oceanic Fisheries Investigations (CalCOFI) anchovy larvae have been collected by standard methods described by Ahlstrom (1948, 1953) on a standard station plan (inside back cover) in waters off the west coast from Oregon to the tip of Baja California every year 1951–1966 and in 1969. The data from 1951 through 1958 is shown by year, month, station and size group of larvae in 269 charts of the area in CalCOFI Atlas No. 9, 1968, which also includes a brief account of methods, with references. The total number of larvae each year in the known range of the northern anchovy *Engraulis mordax*, calculated by methods discussed in Ahlstrom (1968) and Messersmith, Baxter and Roedel (1969) is shown in the last column of Table 1.

The biomass of spawning anchovy adults was calculated from $B_a = 98.2\ L_a$ where $B_a$ is the biomass in millions of tons and $L_a$ is the number of larvae times $10^{12}$ (Smith, MS). The standard error of prediction is about 9%. The biomass each year for the entire region survey area is shown in Figure 1 and given in the last column of Table 2. The biomass increased from about 640,000 tons in 1951 to over 6 million tons in 1962. Since 1962 it has remained high, fluctuating between about 5 and 8 million tons. The preliminary estimate for 1969 based on those collections which have been sorted and counted to date is 5.4 million tons.

These figures represent all the northern anchovies which spawn off the coast from San Francisco to Cape San Lazaro, Baja California, Mexico. McHugh (1951), from a study of variations in certain meristic characters of *E. mordax*, concluded that three geographic-

TABLE 1

**Numbers × $10^{12}$ of anchovy larvae (regional census estimates, Smith, MS) in four geographical areas.**

| Year | Northern subpopulation | Central subpopulation | | Southern subpopulation | |
|---|---|---|---|---|---|
| | Central California | Southern California | Northern Baja Calif. | Southern Baja Calif. | Total |
| 1951 | 111 | 1,474 | 1,525 | 3,394 | 6,504 |
| 1952 | 76 | 879 | 3,301 | 3,876 | 8,132 |
| 1953 | 2 | 4,446 | 3,774 | 5,410 | 13,632 |
| 1954 | 1,164 | 6,041 | 2,671 | 8,657 | 18,533 |
| 1955 | 24 | 4,864 | 9,249 | 2,963 | 17,100 |
| 1956 | 247 | 3,294 | 6,071 | 5,603 | 15,215 |
| 1957 | 130 | 11,799 | 4,257 | 3,854 | 20,040 |
| 1958 | 3,930 | 11,655 | 7,003 | 5,684 | 28,272 |
| 1959 | 3,506 | 12,439 | 4,729 | 2,789 | 23,463 |
| 1960 | 637 | 8,791 | 10,748 | 11,238 | 31,414 |
| 1961 | 1,054 | 7,518 | 5,357 | 18,609 | 32,538 |
| 1962 | 979 | 23,102 | 21,324 | 18,353 | 63,758 |
| 1963 | 1,577 | 32,745 | 16,763 | 10,448 | 61,533 |
| 1964 | 5,221 | 34,046 | 5,330 | 7,656 | 52,253 |
| 1965 | 1,256 | 49,634 | 13,631 | 14,771 | 79,292 |
| 1966 | 4,001 | 35,360 | 6,947 | 5,892 | 52,200 |

TABLE 2

**Spawning biomass in thousands of tons of anchovies in each of the three subpopulations (Smith, MS).**

| Year | Northern subpopulation | Central subpopulation | Southern subpopulation | Total |
|---|---|---|---|---|
| 1951 | 11 | 294 | 333 | 639 |
| 1952 | 7 | 410 | 381 | 798 |
| 1953 | 0 | 807 | 531 | 1,388 |
| 1954 | 114 | 855 | 850 | 1,820 |
| 1955 | 2 | 1,386 | 291 | 1,679 |
| 1956 | 24 | 919 | 550 | 1,494 |
| 1957 | 13 | 1,576 | 378 | 1,967 |
| 1958 | 386 | 1,832 | 558 | 2,776 |
| 1959 | 344 | 1,686 | 274 | 2,304 |
| 1960 | 63 | 1,918 | 1,103 | 3,084 |
| 1961 | 103 | 1,264 | 1,827 | 3,194 |
| 1962 | 96 | 4,362 | 1,802 | 6,260 |
| 1963 | 155 | 4,861 | 1,026 | 6,041 |
| 1964 | 513 | 3,866 | 752 | 5,130 |
| 1965 | 123 | 6,211 | 1,450 | 7,785 |
| 1966 | 393 | 4,154 | 578 | 5,125 |

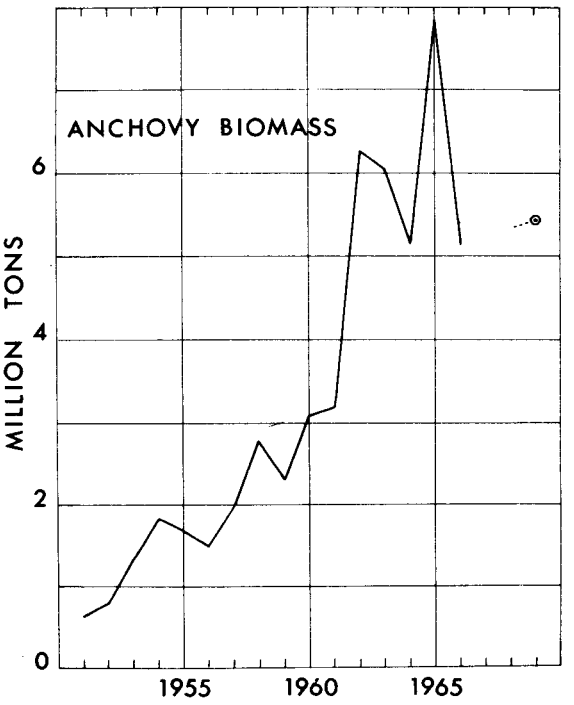


FIGURE 1. Total spawning biomass of anchovies in the CalCOFI survey area, calculated from the numbers of anchovy larvae collected each year.

ally separate subpopulations could be found over this range and suggested as approximate boundary markers Point Conception on the California coast and Cedros Island off Baja California. Genetic studies on adult anchovies, using serum transferrins (Vrooman and Paloma, MS), confirm McHugh's findings of three subpopulations and also show that the winter distribution of the three groups generally fits his description. Figure 2 is a schematic representation of the distribution of the subpopulations.

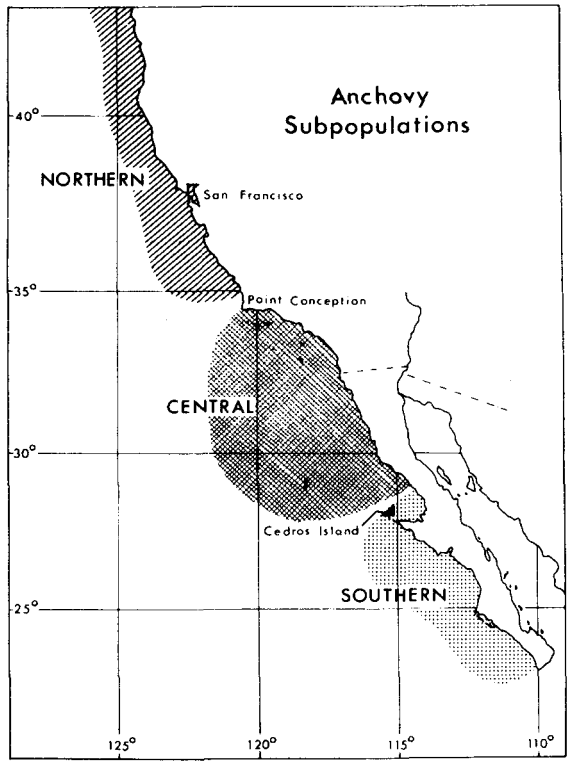


**FIGURE 2. Schematic diagram of the winter distribution of the three subpopulations of the northern anchovy, *Engraulis mordax*.**

When the CalCOFI grid is divided into four areas and the numbers of anchovy larvae in each is used as an index of abundance, geographical differences in changes of biomass with time may be seen. The four areas are 1) Central California—all CalCOFI station lines between San Francisco and Point Conception, 2) Southern California—Point Conception to Ensenada, Baja California, 3) Northern Baja California—Ensenada to Cedros Island, and 4) Southern Baja California—Cedros Island to Cape San Lazaro. From this data (Table 1, Figure 3) it can be seen that the greatest increase by far has taken place in the Southern California area.

By combining the Southern California and Northern Baja California areas the larvae are divided roughly into the three subpopulations (Figure 4). Table 2 shows the biomass of spawning adults as calculated from this data. From these representations it is apparent that although during 1960–66 the biomass of the southern subpopulation was on the average twice as great as during 1951–59, the ratio for the same periods in the central subpopulation was three and a half. The ratio for the northern subpopulation was intermediate.

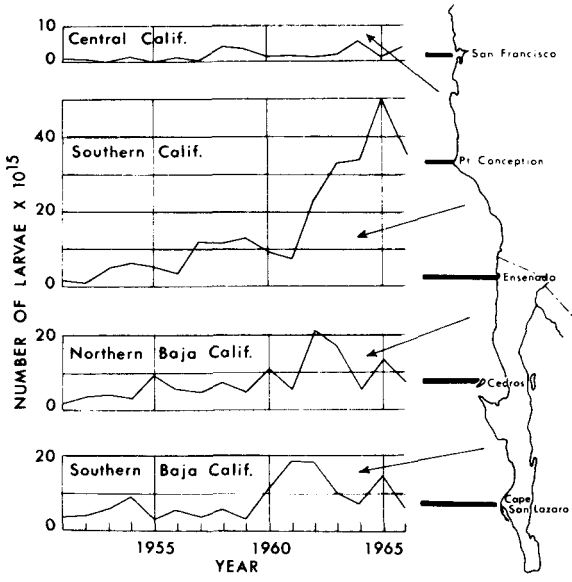


**FIGURE 3. Regional census estimates of northern anchovy, *Engraulis mordax*, for the years 1951–1966 (Smith, MS).**

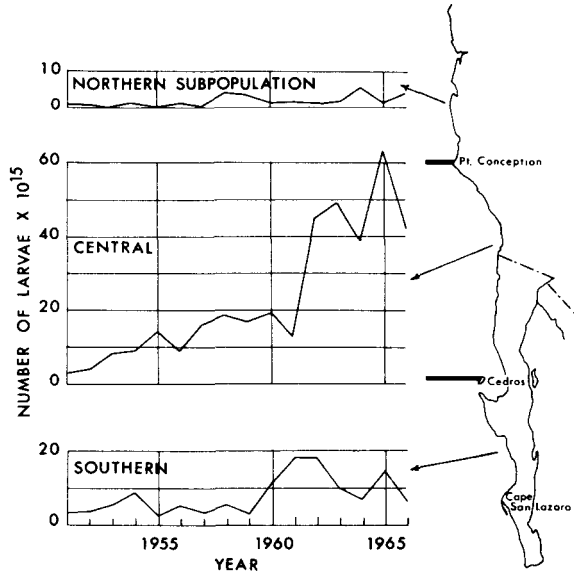


**FIGURE 4. Regional census estimates of northern anchovy larvae for each of the three subpopulations in the CalCOFI area, 1951–1966.**

The number of larvae may be used as a fair approximation of the total biomass of adult anchovies in the central subpopulation because the cruise pattern covered essentially their whole range at all seasons in all years. In the northern region collections of larvae have been made as far north as the California-Oregon border, but not with sufficient regularity and geographic coverage to make a satisfactory basis for calculating the total biomass of the northern subpopulation. The situation is the same for the southern subpopulation south of Cape San Lazaro. Details of the area covered and the stations occupied are given by Ahlstrom (1966).

Vrooman and Paloma (lc) observed a considerable shift of the central subpopulation north in the summer and south in the winter. These authors noted that in winter and early spring when most of the anchovy spawning takes place, the boundary between the northern and central subpopulations is as shown in Figure 3. Also, Haugen, Messersmith and Wickwire (1969) observed that a few of the anchovies tagged in the central California region were recovered in southern California and vice versa. These findings we believe do not impair the evidence of an essential distinction between the northern and central subpopulations.

Within the CalCOFI area between San Francisco and Cape San Lazaro, the mean total biomass of anchovies for the five year period 1962–66 was 6.1 million tons. The central subpopulation amounted to 4.7 million tons or 77.3% of that total. The southern subpopulation, with about 1.1 million tons, made up 18.5%, while the northern subpopulation contributed only 0.26 million tons or 4.2% of the 5-year mean.

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