ANCHOVY

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Anchovies were not fished in any great quantities along the Pacific Coast until 1946. In Canada, Washington, and Oregon the catch has been used for reduction and dead bait. Canada's peak catch occurred in 1941 (over 7,000 tons); Washington's in 1949 (over 450 tons); Oregon's in 1953 (84 tons). With the decline of the Pacific sardine stocks, however, the anchovy has been extensively fished off California.

There are two distinct fisheries: live bait and commercial. Each fishery is represented by different fleets of boats using different types of gear, and the statistical records of each are compiled separately. Each is treated individually in the historical discussion which follows.

THE COMMERCIAL FISHERY

Catch Records

The California commercial anchovy catch is utilized for the following purposes: dead fish-bait (fresh, frozen, salted, and chemically treated), fresh market fish, reduction into meal and oil, canning for both human consumption and pet food, "chum" for use in the Pacific mackerel scoop fishery, and fish food used in state fish hatcheries.

The year 1916 marks the inception of tabulation of fish and fishery products landed in California ports. From then to 1956 about 200 tons of anchovies have been landed yearly as dead bait for use in the sport fishery and in the commercial salmon and albacore fisheries. Any appreciable increase in the catch above this quantity can be attributed to increased demands for other commercial purposes. Several periods of increased catch are indicated in Table 4.

TABLE 4

CALIFORNIA ANCHOVY LANDINGS BY PORT, 1916-55 (IN TONS)

Year	Eureka	San Francisco	Monterey	Santa Barbara	Los Angeles	San Diego	Total
1916	--	119.8	125.7	--	20.1	--	265.6
1917	--	50.1	187.8	--	26.4	--	264.3
1918	--	134.2	270.2	--	24.7	4.9	434.0
1919	--	153.0	352.5	--	288.4	10.8	804.7
1920	--	110.6	156.9	--	2.3	15.1	284.9
1921	--	87.6	741.4	--	5.2	139.1	973.3
1922	--	75.4	68.2	--	182.4	0.2	326.2
1923	--	92.0	42.5	--	19.0	--	153.5
1924	--	5.3	148.5	1.7	17.9	--	173.4
1925	--	13.0	0.7	--	32.8	--	46.5
1926	--	1.7	24.3	--	4.1	--	30.1
1927	--	139.1	28.3	--	16.1	0.6	184.1
1928	--	62.8	87.7	--	27.9	0.3	178.7
1929	--	119.8	41.0	--	30.4	--	191.2
1930	--	130.9	21.7	--	5.2	1.9	159.7
1931	--	82.3	52.4	--	18.9	0.1	153.7
1932	--	73.8	60.0	--	15.8	--	149.6
1933	--	92.5	45.4	--	20.7	--	158.6
1934	--	33.5	63.7	--	31.5	--	128.7
1935	--	37.2	38.2	--	14.0	--	89.4
1936	1.0	66.5	15.1	--	14.9	--	97.5
1937	--	51.0	22.1	--	40.0	--	113.1
1938	--	125.9	17.0	--	224.6	--	367.5
1939	--	107.4	6.0	--	960.5	--	1,073.9
1940	--	6.9	18.7	--	3,125.9	7.3	3,158.8
1941	--	0.3	16.6	16.6	2,019.1	--	2,052.6
1942	--	2.7	74.5	--	769.7	0.2	847.1
1943	--	39.4	99.2	--	646.8	--	785.4
1944	--	55.0	424.0	--	1,465.1	1.4	1,945.5
1945	0.2	146.0	63.9	--	598.3	--	808.4
1946	--	131.9	124.0	2.5	702.2	0.2	960.8
1947	2.2	195.1	7,747.9	99.7	1,423.5	1.8	9,470.2
1948	6.8	190.1	3,627.8	102.1	1,486.2	4.9	5,417.9
1949	--	108.2	741.4	240.8	566.6	4.1	1,661.1
1950	0.4	169.3	1,273.3	145.9	850.1	0.3	2,439.3
1951	--	142.0	2,525.0	100.8	703.2	6.4	3,477.4
1952	--	2,915.5	19,867.8	3,516.8	1,578.7	12.6	27,891.4
1953	--	1,536.3	6,847.5	17,367.6	17,164.9	1.4	42,917.7
1954	0.7	130.9	122.6	8,403.7	12,546.0	1.2	21,205.1
1955*	--	103.4	3,441.7	1,630.8	17,166.6	3.2	22,345.7

* Preliminary figures.

The first increase of catch occurred during the period from 1918 to 1921 when anchovies were reduced for oil and meal in Central California. In 1922 there was an immediate halt to this activity for in 1921 "teeth" were put into a law enacted in 1919 that made it illegal to reduce any fish (other than a certain percentage of sardines) without a special permit issued by the Fish and Game Commission.

During the period from 1922 to 1939 the annual catch remained around 150 to 200 tons, the bulk being used in Central California for dead bait. The second marked increase of the commercial catch commenced in 1939 with the expansion of the anchovy fishery in Southern California, where only small poundages had been landed before. In 1939 there was a marked increase in the take of anchovies, which were ground and used as "chum" in the Pacific mackerel scoop fishery. In the period 1939 through 1941 between 1,000 and 3,000 tons per year were so used. During World War II fishing activity was limited and the catch of anchovies dropped. The bulk was still used in Southern California in the mackerel fishery.

With the decline of stocks of Pacific mackerel and sardines off the coast of California, an immediate need arose for packs of other species to supply domestic and foreign markets. Inasmuch as anchovy stocks appeared large enough and could be taken with current fishing methods, many experimental packs were made. Domestically, they encountered serious sales resistance, but the anchovy "sardine style" pack in tomato sauce was favorably received in several Asiatic and South American countries. The industry then centered its activities on processing fish that

could sell readily on the export market. The catch increased from about 1,000 tons in 1946 to over 9,000 tons in 1947. In 1948, in response to this rapidly expanding use of anchovies, the then Division of Fish and Game placed case pack requirements upon the canners to insure proper handling of the fish and to prevent excessive reduction of whole fish during the canning process.

In 1949 and 1950 sardines temporarily "returned" to Californian waters; as a result there was lessened interest in anchovies and the catch lessened. However, when the sardines declined rapidly in 1951, anchovies were again desired and permanent markets for anchovy products were sought, for it now seemed that the sardine population was indeed at a very low level of abundance. In 1952 the remaining Central California plants went into nearly full production, utilizing anchovies taken along the coast from Monterey to Point Reyes. In early 1953 the anchovy concentrations off Central California became very limited and fishing activity was centered in the Port Hueneme-Santa Barbara area. The export market continued to serve as an outlet for anchovy packs and domestic sales also increased.

Coincident with the development of anchovy canning in 1946 was the increased use of fishery products in pet foods. Pacific and jack mackerel were the main constitutents of these packs, but in 1953 and in 1954 a ready supply of these species was not available and anchovies were used for pet food. The combined use of anchovies for dead bait and canning brought about an all-time peak commercial catch of over 42,000 tons in 1953.

The decrease of the catch in 1954 and 1955 can be attributed to several factors, the principal one being limited orders for export packs, partly because of the competition with "sardine style" packs produced in South Africa and Japan. There was also considerable speculation in 1953 and it is probable that reserve inventories on hand in 1954 contributed to the smaller take. Sardines again appeared in commercial quantities off Southern California in 1954 and in 1955 and during the sardine season little interest was paid to anchovies, thus contributing further to the decrease in catch.

It is doubtful whether the yearly commercial catch has ever been limited by the supply of fish. It is known that variations in abundance and distribution of anchovy stocks have limited operations in certain areas but this has usually resulted in a mere shift of operations to other areas and the state-wide yearly tonnage has probably not been affected.

Since anchovies have become commercially important and live-bait catches are increasing yearly there has been a growing concern about the possibility of over-exploitation of the anchovy stocks along the coast of California.

In 1955 legislation was enacted as follows:

> "During the period from September 1, 1955 to March 31, 1956, the total amount of anchovies which may be taken or received for canning, including canned pet food, shall not be more than 21,000 tons. During the period from April 1, 1956, to March 31, 1957, the total amount of anchovies which may be taken or received for canning, including canned pet food, shall be not more than 35,000 tons."

The 35,000-ton figure was arrived at by averaging the total catches for the years 1952 and 1953.

To insure that young, immature anchovies are not processed the following regulation also was enacted in 1955:

> "No anchovies less than five inches in length measured from tip of snout to tip of tail may be purchased for any purpose except for use as bait; provided, that the allowable percentage of undersized anchovies which may be contained in any load or lot purchased shall be not more than 25 percent by weight of all anchovies in said load or lot."

Fishery Methods

From 1916 to 1946 anchovy fishing was conducted almost solely by fishermen using "Monterey style" lampara nets. "Half-ring" and purse seine nets were occasionally used to take anchovies, but these nets were primarily used in the sardine and mackerel fisheries. With the advent of anchovy canning, large tonnage hauls were desired by the processors and more net boats using purse seines were employed. Efficiency and expediency were desired, for even though export orders were large, they were limited, and the operation that could pack the most fish made the most profit.

In 1946 a postwar daytime fishery developed in the Port Hueneme-Santa Barbara area when jack mackerel became important. For several years thereafter three or four aerial spotters worked in conjunction with six to ten boats developing new fishing techniques and becoming familiar with the behavior of many commercially important species, including the anchovy. A new style lampara net (named the Porter seine after one of the principal inventors) was developed to catch fish more efficiently under the guidance of an aerial observer. Thus, when the market for canned anchovies developed in Southern California, in 1952, the daytime operation came into its own and proved to be more efficient than the purse seine nighttime operation that had worked so successfully in Central California. Within a year many more boats adopted the Porter seine or a net of similar construction and in 1954 as many as eight aerial observers were known to be operating at one time in Southern California.

Transport of small pelagic fish caught in areas 80 to 100 miles from the processing plant has always

been an economic hardship to the fishing industry. Most boats cannot efficiently carry loads of fresh fish for long distances because of spoilage and/or mechanical breakdown. To solve this problem, trucking was undertaken when long distances were involved. This method was used first in 1946 when sardines became scarce in Central California waters. It was sufficiently successful to warrant its use in late 1952 and early 1953 when a commercially important concentration of anchovies appeared in the Port Hueneme-Santa Barbara area. These fish were trucked to Central California and to the Los Angeles-Long Beach area on a grand scale. This era was short-lived, however, for in mid-1954 concentrations of anchovies appeared near the ports where the processing plants were located, enabling the fishermen to bring the fish directly to the cannery. Some short-distance trucking still continues but only to inland canneries having no boat landing facilities.

LIVE-BAIT FISHERY

The live-bait fishery of Southern California has increased steadily since the first records were obtained in 1939. These records, which include the total number of scoops and the number of hauls per year for each boat in the fleet, have been tabulated since 1939 except for a three-year period during World War II (1943-45). Anchovies have always been the mainstay of the live-bait fishery. Prior to 1951, 15 to 20 percent of the live-bait catch consisted of young sardines but since that date only traces of sardines have been mixed with the anchovies. The yearly live-bait catch has ranged from 1,500 tons in 1939 to nearly 7,000 tons in 1952 (see Table 5).

TABLE 5

LIVE-BAIT CATCH OF ANCHOVIES IN SOUTHERN CALIFORNIA, 1939-55 (CATCH FROM 1942-45 NOT RECORDED)

Year	Catch (tons)
1939	1,503.2
1940	2,006.0
1941	1,587.7
1942	257.5
1943	--
1944	--
1945	--
1946	2,748.1
1947	2,854.0
1948	3,725.5
1949	2,802.4
1950	3,823.8
1951	5,141.9
1952	6,810.4
1953	6,391.5
1954	6,686.0
1955	6,122.3

The most common current method of attracting anchovies for live bait is with a bright light suspended from a skiff at night. This light attracts the fish and causes them to concentrate near the surface around the skiff. The skiff is usually placed in bays or semi-protected coves in late evening and when sufficient fish have been concentrated, a boat using a small "bait" net encircles them. After they are crowded into a small section of the net they are scooped out with a long-handled brail into live-bait tanks on sport boats en route to the sportfishing grounds or are transported short distances in bait tanks to floating bait receivers situated near the centers of sportfishing activity. "Scoops" range from nine pounds per scoop at San Clemente City to 20 pounds per scoop at San Diego. Live bait is also taken in the early morning hours by boats making "sets" on visible surface schools. Within the past few years daytime catches of live bait have been made by boats working in conjunction with aerial observers.

The market for live bait has not been subject to the economic instability characteristic of the anchovy commercial market. There is a demand for live bait throughout the sportfishing season in Southern California (April through October) and if anchovies are present there is a limited but steady market.

The live-bait fishery is, however, dependent upon local stocks of anchovies as live fish are difficult to transport over long distances without specialized equipment and even then it is a costly operation. On the other hand, the commercial fishery utilizes anchovies from anywhere along the coast.

The use of live bait for sportfishing originated in the southern part of the state and has spread slowly to the north. At present the northernmost live-bait operation is at Morro Bay.

LIFE HISTORY

The northern anchovy, *Engraulis mordax mordax*, is one of the most abundant of the schooling pelagic fishes along the Pacific coast of North America. Adults of this species have been collected from Magdalena Bay, Baja California, to the north end of Vancouver Island; eggs and larvae have been found as far offshore as 300 miles. This species is more "shore-bound" than most of the other schooling pelagic fishes. Seldom are concentrations of adult anchovies found farther than 20 miles from shore. Apparently the distribution and behavior of the spawning adults offshore is quite unlike that exhibited by anchovies when they school in the inshore continental shelf area. Adult anchovies have not been observed schooling near the surface offshore nor have they been readily attracted to a light at night.

Subpopulations

Of primary interest are the problems regarding the existence of more than one population of anchovies within the range of their distribution, the probable geographic boundaries of these subpopulations, and the extent of intermingling between them.

Subpopulation studies (McHugh, 1952) based on meristic counts of fin rays, gill rakers, and vertebrae revealed the probable occurrence of at least three subpopulations along the Pacific coast: one extending

from British Columbia to Northern California, one off Southern California and northern Baja California, and one off central and southern Baja California. An additional meristic study has substantiated the previous work. An anchovy population which inhabits San Francisco Bay has been given the subspecific name of *E. m. nanus* by Hubbs (1925).

There is a fairly continuous offshore distribution of anchovy eggs and larvae between San Francisco and Magdalena Bay. This fact tends to cast doubt upon the validity of the subpopulations delimited by McHugh because there does not seem to be a separation either in space or time of the spawning adults. Most structures used in meristic studies are formed during the egg and very early larval stage. If there was homogeneous spawning throughout the entire distributional range and if survival of the young from this spawning was relatively equal throughout, there would be little chance of detecting a subpopulation by this method. However, the fact that there are persistent, significant meristic variations between stocks along the coast stimulates the need for additional studies on the life history of the anchovy, especially movements between the areas mentioned.

Commercial and live-bait catch records and sampling localities from the *Yellowfin* have aided in clarifying the picture but as yet the data are insufficient to justify positive determination of the subpopulations, as distinguished by McHugh. The following summary of anchovy life history data is pertinent to the subpopulation problem:

(1) By following locations of catches and by noting movements of fish through aerial survey it has been found that the anchovy does not exhibit an extended latitudinal migratory behavior as does the Pacific sardine. Concentrations of anchovies in Central California have been studied for several years and no movement to the south in late fall and winter has been noted. Actually there was some evidence that anchovies in Monterey moved north along the coast to the San Francisco region in late fall and winter of 1952.

(2) There is a significant break in the inshore distribution of adult and juvenile anchovies in Central California (Figure 9). Over the past six years no samples of anchovies have been taken on the *Yellowfin* in the area between Monterey and Cape San Martin. Similarly no commercial or live-bait catches have been made in this area.

(3) Age and growth studies of the commercial catch indicate a high degree of heterogeneity of anchovy stocks in Central and Southern California. When anchovies decreased in abundance in early 1953 in Central California there was a coincidental increase

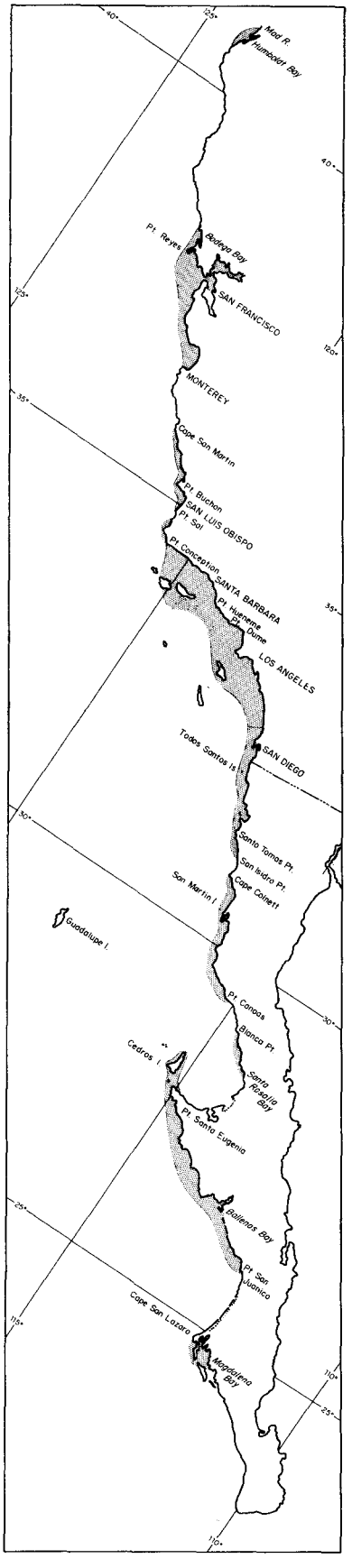

FIGURE 9. Adult anchovy distribution inshore. Data from commercial and live-bait catches; *Yellowfin* samples, 1949-53; and aerial observations, 1952-55.

in the stocks off Southern California a few months later. Consequently it was thought by many that these observations represented a mass movement of the fish from Central California to the southern part of the state. Analyses of samples collected in both regions proved this not so. It was found that 49 percent of the anchovies caught off Central California in February and March, 1953, were of the 1949 year-class and older, whereas only 3.7 percent of the fish in the Santa Barbara region from April to July, 1953, were of these year-classes. Thus the fish that "disappeared" off Central California obviously did not reappear off Southern California. The age composition of the 1952-53, 1953-54, and 1954-55 commercial catch (Figure 10) demonstrates considerable differ-

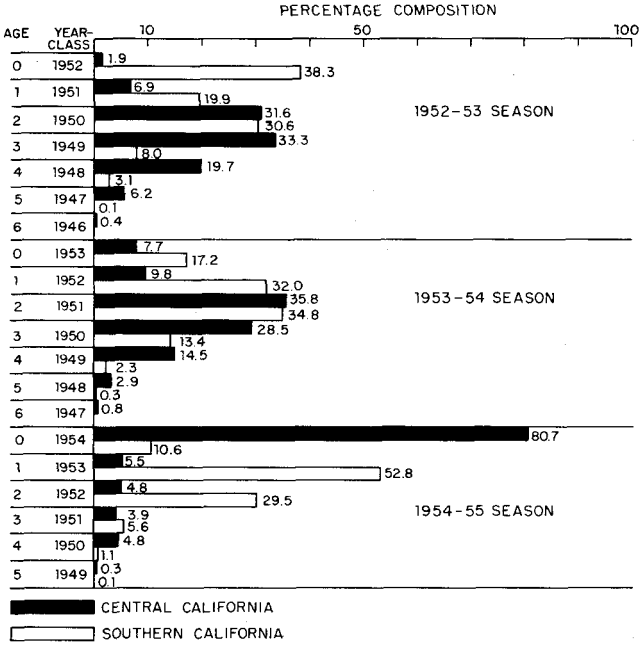

FIGURE 10. Age composition of the 1952-53, 1953-54, and 1954-55 California commercial anchovy catch. The anchovy season extends from 1 April to 31 March of the next year.

ences in the ages of the Southern and Central California stocks.

(4) Heterogeneity of stocks in the Southern California region is evident when one examines the results of the 1955 live-bait sampling program. Although no significance tests have been applied to the data, preliminary analyses reveal indications of local stocks and of possible mass movements of fish along the Southern California coast. The 1954 year-class made up only 7.0 percent of the live-bait anchovy catch at San Diego in April and May (Table 6) whereas all fish at Santa Barbara were of the 1954 year-class during this same period. Except for a large percentage of 1954 year-class anchovies at Oceanside there was a progressive increase in strength

TABLE 6

PERCENTAGE AGE COMPOSITION OF LIVE-BAIT ANCHOVY CATCH, APRIL AND MAY, 1955

Port	Year-Class			
	1955	1954	1953	1952
San Diego	--	7.0	73.5	19.5
Oceanside	0.3	68.8	30.3	0.6
San Clemente	--	35.6	58.8	5.6
Newport	--	51.8	41.7	6.5
Los Angeles	0.4	58.0	38.4	3.2
Santa Monica	--	87.8	11.5	0.7
Port Hueneme	--	76.4	20.4	3.2
Santa Barbara	--	100.0	--	--

of the 1954 year-class to the north or, conversely, a progressive decrease in the 1953 and 1952 year-class strength from San Diego to Santa Barbara in April and May, 1955. By comparing year-class strength (grouped in two-month intervals from April through November) of anchovies caught at San Diego, Port Hueneme, and Santa Barbara evidence is found of a movement either upcoast or inshore (or both) of a stock of anchovies consisting mainly of 1953 and 1952 year-class adults. There was a continuing increase in the percentage of these older fish in the Port Hueneme and Santa Barbara areas (Table 7)

TABLE 7

AGE COMPOSITION BY TWO-MONTH INTERVALS OF THE LIVE-BAIT ANCHOVY CATCH AT THREE PORTS IN 1955

Months	Year-Class				
	1955	1954	1953	1952	1951
A. San Diego					
April-May	--	7.0	73.5	19.5	--
June-July	1.7	20.2	68.5	9.6	--
August-September	18.9	17.9	57.2	6.0	--
B. Port Hueneme					
April-May	--	76.7	20.1	3.2	--
June-July	16.5	60.3	14.7	8.5	--
August-September	15.1	52.0	25.2	7.7	--
October-November	2.0	38.0	48.0	11.0	1.0
C. Santa Barbara					
April-May	--	100.0	--	--	--
June-July	--	90.6	8.3	1.1	--
August-September	19.7	57.7	18.5	4.1	--
October-November	12.0	43.0	44.0	1.0	--

whereas at San Diego the relative percentages of the 1952, 1953, and 1954 year-classes remained fairly constant throughout the entire period from April through September, 1955. It is hoped that with increased sampling of both the live-bait and commercial fisheries and the development of a systematic airplane-boat survey, seasonal movements and changes in abundance can be measured and followed more accurately.

Abundance

For many years fishermen have stated that anchovies are unpredictable as to where they will appear and how many will be there when they do appear. At times during the years of heavy sardine fishing,

certain areas along the coast were avoided because of the concentrations of anchovies present. During other years it was reported that there was apparently little intermingling between sardines and anchovies on the fishing grounds. Research conducted in 1938, 1939, and 1940 (Phillips and Radovich, 1952) pointed out that large numbers of anchovy schools were present in the inshore young sardine nursery areas.

It is difficult to estimate either a relative or absolute abundance of anchovy stocks prior to 1946 for little effort was made by fishermen and research agencies to learn about their movements or to take note of changes in abundance. Since 1946, more attention has been given the anchovy by researchers and the fishing industry and with the advent of aerial observations concentrations are now readily discovered and the news is quickly circulated. The apparent increase in anchovy stocks since 1950 may be attributed in part to the increased attention given to anchovies and to the relatively large size of the anchovy stocks in comparison to the scarcity of stocks of other species, but studies under way do suggest that there was an actual increase in Southern California stocks, especially in 1952, 1953, and 1954, and a decrease in these same years in Central California.

Since 1952, records of movements of anchovies entering the Southern California inshore area suggest that there is an increase of adult anchovies in the early spring (March-April), a peak of abundance sometime in June, July, or August, and a decrease in numbers in the fall and winter months. In Central California the occurrence of concentrations or school groups has been more erratic and there is little suggestion of a seasonal pattern as has been observed in Southern California. The population has been much smaller in Central California and consequently the movements of the fish have been more difficult to follow.

Fluctuations in abundance and seasonal changes in availability are exhibited by all schooling pelagic species, particularly anchovies. The anchovy is a comparatively short-lived fish. Few ever attain six years of age, indicating a very high natural mortality rate. Recent food studies of larger predatory fishes have disclosed that anchovies constitute a major food item. Stomach analyses of ocean-caught adult king salmon (*Onchorhynchus tshauytscha*) have disclosed that anchovies made up 36 percent of the yearly feed of salmon sampled off San Francisco in 1955.

In view of the fact that anchovies are very short-lived, sudden decreases in total abundance are certain to occur if, by chance, there should be several consecutive years in which spawn survival was poor. A constant recruitment would be necessary to maintain a continuous high-level population but such consistency is unknown among pelagic fishes. In heavily fished Central California the local stocks of comparatively old fish (three-, four-, and five-year-olds) decreased very rapidly in the spring of 1953. Age readings of the commercial catch and routine plane and boat censuses indicated that the 1951, 1952, and 1953 year-classes were weak off Central California and that total mortality was probably considerably greater than recruitment during these three years. Conversely, the 1951, 1952, and 1953 year-classes were strong off Southern California and despite a heavy catch the anchovy population has remained at a high level of abundance. Apparently recruitment was greater than or as great as total mortality in Southern California.

For a look into the future, the anchovy stocks of Southern California will probably remain at a high level of abundance for several more years, since estimates of the 1954 year-class indicate that it is as strong as or possibly stronger than any year-class measured since 1952, when intensive research was started on the anchovy. The 1954 year-class has already contributed materially to the comeback of the Central California fishery (Figure 5) and aerial censuses indicate an increasing buildup of anchovy stocks in Monterey Bay and off San Francisco.

Reproductive Potential

As with all animals subjected to high mortality and a consequent short life the anchovy has a high reproductive capacity. The presence of developing intermediate modes of eggs in the mature ovary, similar to that of the Pacific sardine (Clark, 1934), indicates that an anchovy spawns more than once a season. Of special significance is the fact that anchovy spawning takes place during every month of the year along the California and Baja California coast (Bolin, 1936, and Ahlstrom, 1950). Material supplied by research on the *Yellowfin* (Cruise 53-Y-8) showed an abundance of young 1953 year-class anchovies in Baja California in September and October of that year. These young fish apparently originated from two distinct spawnings since two modes show in the length-frequency data (Figure 11). Most records of young fish concentrations indicate that the spawning during early winter and spring contributes most to the annual recruitment of young fish.

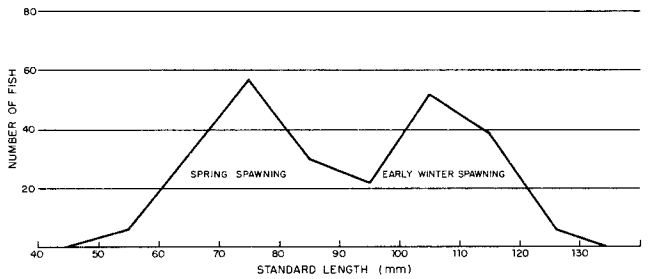

FIGURE 11. Number of anchovies by length grouping of the 1953 year-class in September and October, 1953, off Northern Baja California (data from Cruise 53-Y-8).

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