

# THE FISHERY FOR NORTHERN ANCHOVY, *ENGRAULIS MORDAX*, OFF CALIFORNIA AND BAJA CALIFORNIA IN 1975

HUMBERTO CHÁVEZ AND SILVIA SILVA  
Instituto Nacional de Pesca

and

JOHN S. SUNADA  
Marine Resources Region  
California Department of Fish and Game

## ABSTRACT

Anchovy landings during 1975 totaled 200,663 metric tons (221,201 tons) of which 143,786 mt (158,505 tons) were caught by the U.S. and 56,877 mt (62,695 tons) by Mexico. Age data from both countries were dominated by the 1972 year class. Anchovy mean lengths ranged from 116.8 mm standard length (Baja California) to 137.7 mm standard length (central California). Female to male ratios ranged from 1.6 to 1 (southern California) to 2.8 to 1 (Baja California).

## EXTRACTO

El desembarque de anchoveta en el año 1975 fue de un total de 200,663 toneladas metuco (221,201 toneladas) de las cuales 143,786 mt (158,505 tons) fueron capturadas por los Estados Unidos y 56,877 mt (62,695 tons) por Mexico.

Los datos de la edad fueron denominados por ambos países en la clase año 1972.

El longitud promedio de la anchoveta es de 116.8 mm longitud patron (Baja California) hasta 137.77 mm longitud patron (Central California).

Hembras y machos son de una proporción de 1.6: 1 (Sur California) hasta 2.8: 1 (Baja California).

## INTRODUCTION

The northern anchovy resources off the coast of California and Baja California support a fishery conducted by fishermen of both the United States and Mexico. The major portion of the catch is made from the same stock which occurs from about San Quintin, Baja California, to north of San Francisco, California. Major ports of landing are Ensenada, Los Angeles, Oxnard and Monterey (Figure 1).

Since both countries primarily are fishing the same stocks, the Instituto Nacional de Pesca and the California Department of Fish and Game have entered into an informal cooperative program designed to monitor the anchovy fishery of each country. This program includes using comparable sampling techniques, processing samples in the same way, gathering similar logbook information, and holding bi-monthly meetings to calibrate aging techniques and exchange data.

Besides the Instituto Nacional de Pesca/California Department of Fish and Game fishery monitoring

program, cooperative research programs concerning anchovies have been established between California Cooperative Oceanic Fisheries Investigations (CalCOFI) Agencies and the Instituto Nacional de Pesca. In addition to the California Department of Fish and Game, these agencies include the National Marine Fisheries Service, Scripps Institution of Oceanography, and California Academy of Sciences. These programs have focused on stock assessment, physical oceanography, and data management, and have included joint participation in cruises, calibration of acoustic equipment, egg and larvae surveys, publications, and the training of Mexican personnel.

This publication is an attempt to document the anchovy fishery in both Baja California and California for 1975.

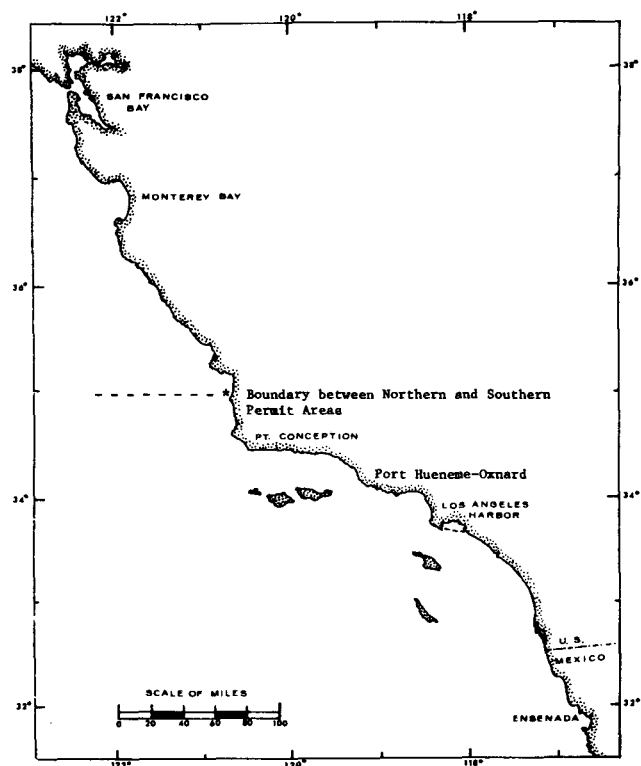


FIGURE 1. California anchovy fishing areas.

**ANCHOVY BIOLOGY**

Northern anchovies occur from Cape San Lucas, Baja California, to the Queen Charlotte Islands, British Columbia. They are pelagic schooling fishes generally found in coastal waters between 14.6°C and 20.0°C. CalCOFI surveys indicate anchovies are most abundant from Magdalena Bay, Baja California, to San Francisco, California. Eggs and larvae have been found from Cape San Lucas to Cape Mendocino, California, and as far as 300 miles offshore; however, most occur within 100 miles of shore.

Some anchovies reach sexual maturity at the end of their first year of life when 10.2 cm to 11.4 cm total length long. Studies of the commercial catch indicate all are mature at the end of 2 years and are 12.7 cm to 14 cm (TL) long. Female anchovies, 11.4 cm to 16 cm to total length, contain 4,025 to 21,297 eggs in an advanced stage of development.

Although spawning occurs in every month of the year, it usually peaks during late winter and early spring with another minor peak in early fall. The eggs are ovoid, clear, and translucent, and require 2 to 4 days to hatch, depending on temperature.

The northern anchovy is relatively short lived, rarely exceeding 4 years of age and 17.8 cm in total length, although individuals 7 years old and 22.9 cm (TL) long have been recorded. They apparently are indiscriminate filter feeders excepting

phytoplankton and zooplankton. In addition, they will feed on small fish. Anchovies along with squid, euphasids, pelagic red crabs, and lanternfishes are preyed upon heavily by most predator species in waters off Baja California and California. In southern California waters the average annual mortality rate is 66.5% (McCall, 1973).

Meristic measurements done in the 1940's (McHugh, 1951), blood genetics work (Vrooman and Smith, 1971), and an otolith variation study (Spratt, 1972) all indicate there are three distinct groups of anchovies off Baja California and California (Figure 2). The limits of these populations are not clearly defined at this time and appear to shift seasonally. The southern population probably extends from Cape San Lucas to approximately Punta Baja, Baja California; the central from the Punta Baja area to north of San Francisco, California; and the northern stocks occur north of this area. There is a certain amount of overlapping between the populations.

Anchovy movement within a population group is an important factor. A tagging study initiated in 1966 and concluded in 1969, has provided considerable information concerning movements of anchovies in waters off California and northern Baja California. During the course of this study, a total of 418,762 anchovies was tagged and 1,600 tags were recovered (Figure 3).

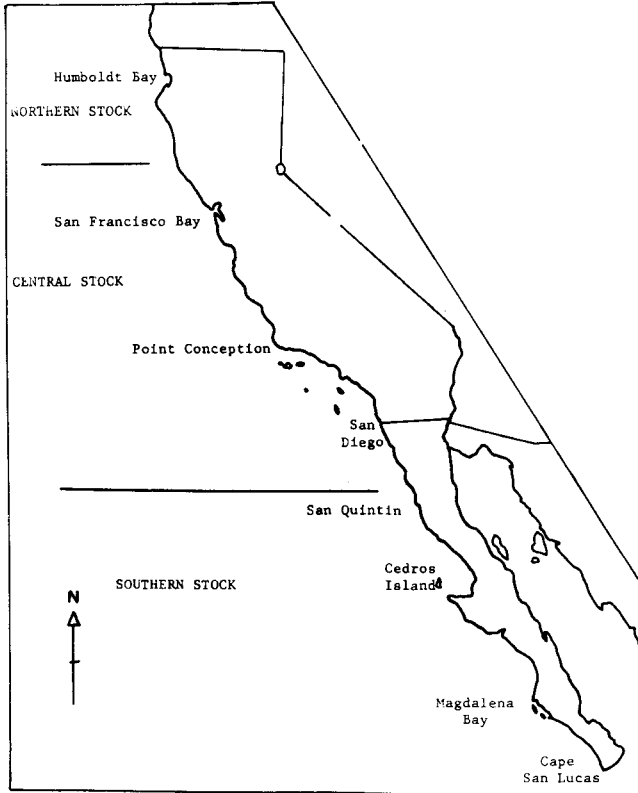


FIGURE 2. Distribution of anchovy subpopulations.

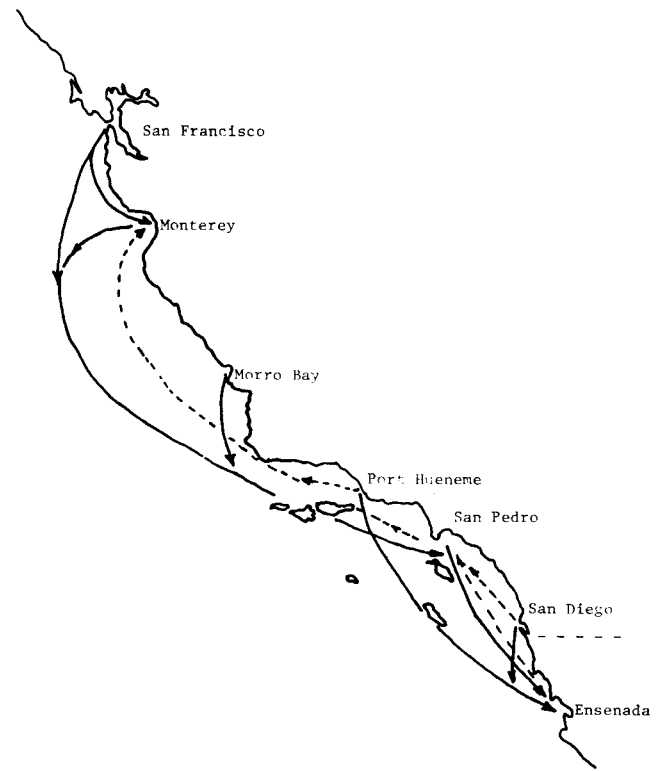


FIGURE 3. Anchovy tagging migration.

Tag recoveries demonstrated coastwide movements in both southerly or northerly directions. Fish tagged in San Francisco Bay were captured in Monterey Bay and off southern California; fish tagged in Monterey Bay were taken off southern California as were fish tagged in Morro Bay; and fish tagged at Port Hueneme, off Santa Catalina Island, in the Los Angeles-Long Beach Harbor, off San Clemente Island, and at San Diego were captured by the fleet operating out of Ensenada, Baja California. Conversely, fish tagged at Ensenada were captured in the southern California fishery. Fish tagged at San Diego, off San Clemente Island, off Santa Catalina Island, and at Port Hueneme were captured in Monterey Bay. Numerous recoveries were made of fish tagged in San Diego and captured on the southern California fishing grounds.

An offshore to inshore movement was documented when five fish tagged off San Clemente and Santa Catalina Islands were captured in the Los Angeles Harbor.

Inshore to offshore movements were demonstrated by fish tagged in Los Angeles-Long Beach Harbors being caught in offshore southern California fishing grounds and by the Ensenada fleet off Baja California.

Tag returns have shown that anchovies move quite widely within the area covered by the study, and that there is interchange of fish between central California, southern California, and northern Baja California fishing grounds.

The dominant and prevailing schooling behaviors of anchovies generally render them invulnerable to capture using present commercial fishing techniques. Only a small portion of the population is vulnerable at any particular time, even in periods of relatively high availability. There are periods of time lasting up to several months when virtually the entire population cannot be fished effectively (Mais, 1974).

By far the most prevalent and common schooling behavior of anchovies off northern Baja California and southern California is the formation of small, very low density near-surface schools during daylight hours.

A schooling behavior favorable for commercial harvest occurs from fall through winter. Large schools occur during daylight hours over the deep water basin and channels adjacent to the coast. School densities are relatively light but more dense than those mentioned above. At sundown these schools disperse into a course scattering layer until around midnight when distinct schools begin to form. The schools are usually the largest and densest slightly before dawn. This behavior has been recorded as occurring in August off Baja California and occasionally with juvenile fish in June off southern California.

### THE CALIFORNIA FISHERY

An anchovy fishery has been conducted by California fishermen since 1916 although landings were of minor importance with significant landings occurring in 1947 and 1953 (Frey, 1971). In November of 1965, permission was granted for an anchovy fishery for reduction resulting in a gradual increase in landings, reaching a record high of 143,786 metric tons (158,505 tons) in 1975 (Table 1). This considerable rise was due to both increased demands of fish meal products and rising fish prices.

The present fishery is conducted in two geographical areas: Monterey Bay and southern California (Figure 1). The Monterey fleet, numbering 12 vessels, consists of seven lampara and five purse seine boats (Table 2). Average length of a boat is 13 m (42.6 ft) with a mean catch capacity of

TABLE 1  
California Anchovy Landings From 1965 to 1975 \*

Year	Landings *
1965.....	2,600
1966.....	28,250
1967.....	31,574
1968.....	14,096
1969.....	61,361
1970.....	87,310
1971.....	40,690
1972.....	62,687
1973.....	120,325
1974.....	74,920
1975.....	143,786
Total.....	667,599 *
Short tons.....	735,894

\* Metric tons.

TABLE 2  
California Anchovy Fleet for 1975

	Location		
	Monterey	Port Hueneme	San Pedro
Total number of boats .....	12	2	42
Average length (in meters) .....	13	24	19
Range .....	6-22	20-28	11-28
Average holding capacity (metric tons) .....	21	131	76
Range .....	5-29	81-181	23-181
Combined fleet capacity (metric tons) .....	200	262	2,540
Number of boats by month			
January .....	3	2	35
February.....	6	2	27
March.....	4	2	30
April.....	-	2	27
May.....	-	2	26
June.....	-	-	3
July.....	-	-	2
August.....	4	-	2
September.....	7	2	34
October.....	5	2	35
November.....	4	2	31
December.....	2	2	30

21 mt (23 tons). Maximum fleet capacity totaled 200 mt (220 tons) per day. Southern California maintains two fleets; the major one based at San Pedro, totals 42 boats consisting of 3 lampara and 39 purse seine vessels. Average boat length is 19 m (62 ft) and mean holding capacity of 76 mt (84 tons). Combined fleet capacity is 2540 mt (2800 tons) per day (Table 2). The minor Port Hueneme fleet totals no more than two boats with a mean length of 24 m (79 ft) and a 131 mt (144 tons) catch capacity. Daily maximum fleet capacity totaled 262 mt (289 tons). The majority of the boats are equipped with sonar and acoustic instruments and are aided by spotter planes in locating schools.

Fishing takes place during both day and night hours with daytime fishing occurring in spring while fall months are characterized by night and early morning fishing. The San Pedro fleet usually leaves port after midnight and returns within 12 hours if fish are located nearby in the San Pedro Channel. Trips as long as 2 days are common when fishing occurs in the Santa Barbara Channel, a distance of approximately 90 nautical miles. Monterey boats travel relatively short distances due to lack of shelter from severe weather conditions and smaller boat sizes.

Fleet size increases or decreases with fishing interests in other species. The number of boats remained constant throughout the year except during the summer, when reduction fishing was allowed only in central California (Table 2). The stable number of boats fishing for anchovy was the result of unavailability of other species such as jack mackerel, *Trachurus symmetricus*, and Pacific bonito, *Sarda chiliensis*.

Four processing plants are situated in the southern area with a capacity of processing 1677 mt (1850 tons) per day. Monterey area has two reduction facilities with a daily processing capacity of 200 mt (220 tons).

Anchovy price stabilized to \$30 per short ton with periodic fluctuations between \$29 to \$31 per ton. Price was dependent upon several economic factors including the supply of Peruvian fish meal and domestic soybean meal.

### Regulations

The following regulations have been established during the previous 10 years and apply generally to the California reduction fishery which accounts for 99% of all landings.

The California reduction fishery consists of two areas; the northern zone, an area north of Point Buchon and the southern zone, the area south of Point Buchon (Figure 1).

The fishery is regulated by a season which opens August 1 in the northern zone and September 15 in the southern zone. All reduction fishing ceases in both areas on May 15 or when the quota is attained. Quotas are determined prior to each season. Quotas

for the 1974-75 season were 13,608 mt (15,000 tons) north of Point Buchon and 104,326 mt (115,000 tons) south of this point. The 1975-76 season's quotas were 13,608 mt (15,000 tons) for the north and 136,078 mt (150,000 tons) for the south.

Fishing for reduction purposes in the southern area has been assigned to all waters beyond 3 nautical miles of the coastline in addition to local restrictions of 4 to 6 miles in certain areas. Santa Monica Bay and the east side of Santa Catalina Island are restricted areas.

California has established a minimum size of 127 mm total length (TL) or approximately 108 mm standard length (SL), with an undersize allowance of 15% by weight. All vessels are required to have identification numbers on their sides. The fishermen also are required to maintain and return daily records of fishing activities in forms provided by the Department of Fish and Game. All reduction permits and fishing can be suspended on 48 hours notice by the California Fish and Game Commission when approaching the quota.

### Commercial Catch Landings

The final 1975 landings from all sources in California totaled 143,786 mt (158,505 tons). Of this total, 80% was landed at Los Angeles Harbor, 16% at Port Hueneme and 4% at Monterey-San Francisco area (Table 3). The reduction fishery accounted for 99% of the commercial take of anchovies, with the remaining 1% caught for frozen bait and human consumption.

TABLE 3  
California Anchovy Landings for 1975 \*

Months	Monterey-San Francisco	Port Hueneme	Los Angeles Harbor	Total
January.....	1,332	2,667	12,918	16,917
February.....	811	1,543	6,414	8,768
March.....	180	438	3,928	4,546
April.....	71	919	16,134	17,124
May.....	142	1,095	14,148	15,385
June.....	34	26	41	101
July.....	68	27	51	146
August.....	653	11	70	734
September.....	1,126	1,863	12,030	15,019
October.....	1,506	5,450	16,630	23,586
November.....	550	4,314	13,632	18,496
December.....	378	4,720	17,866	22,964
Total.....	6,851	23,073	113,862	143,786
%.....	4.8	16.0	79.2	100.0%

\*Metric tons.

Fishing in southern California has been traditionally excellent during spring and fall months as indicated by large landings during those months (Table 3). December yielded the largest total with 22,586 mt (24,896 tons). Monthly productions for February and March were considerably less with 7,957 mt (8,771 tons) and 4,366 mt (4,813 tons) respectively, coinciding with the onset of spawning.

TABLE 4  
Southern California Reduction Landings by Block Origin and Area—1975 \*

Area	Block #	January	February	March	April	May	September	October	November	December	Total %
Santa Barbara .....	653-670	2,221	1,179	377	839	827	1,329	5,143	11,730	4,947	28,592
% .....		14.3	14.9	8.8	4.9	5.6	9.6	23.5	65.1	22.1	21.0
Port Hueneme .....	682-688	439	365	27	0	90	191	1,111	1,964	2,943	7,130
% .....		2.8	4.6	0.6	0	0.6	1.4	5.1	10.9	13.1	5.2
Point Dume .....	701-707	409	26	876	0	316	597	891	729	5,144	8,988
% .....		2.7	0.3	20.6	0	2.1	4.3	4.1	4.0	22.8	6.6
San Pedro Channel .....	719-743	11,270	6,152	1,635	11,108	10,352	11,293	11,108	3,517	8,677	75,112
% .....		72.6	77.7	38.4	65.1	68.4	81.8	50.6	19.6	38.3	55.2
Catalina Island .....	758-762	1,100	195	1,295	4,700	2,876	412	3,665	57	851	15,149
% .....	805-807	7.6	2.4	30.4	27.3	19.1	2.9	16.7	0.03	3.7	11.1
Oceanside .....	757,802-848	79		52	407	648					1,186
% .....		0.5		1.1	2.4	4.3					0.9
Total .....		15,516	7,917	4,262	17,054	15,038	13,822	21,918	17,997	22,535	136,157
% .....		11.4	5.8	3.1	12.5	11.1	10.2	16.1	13.2	16.6	

\* Metric tons.

LEGEND

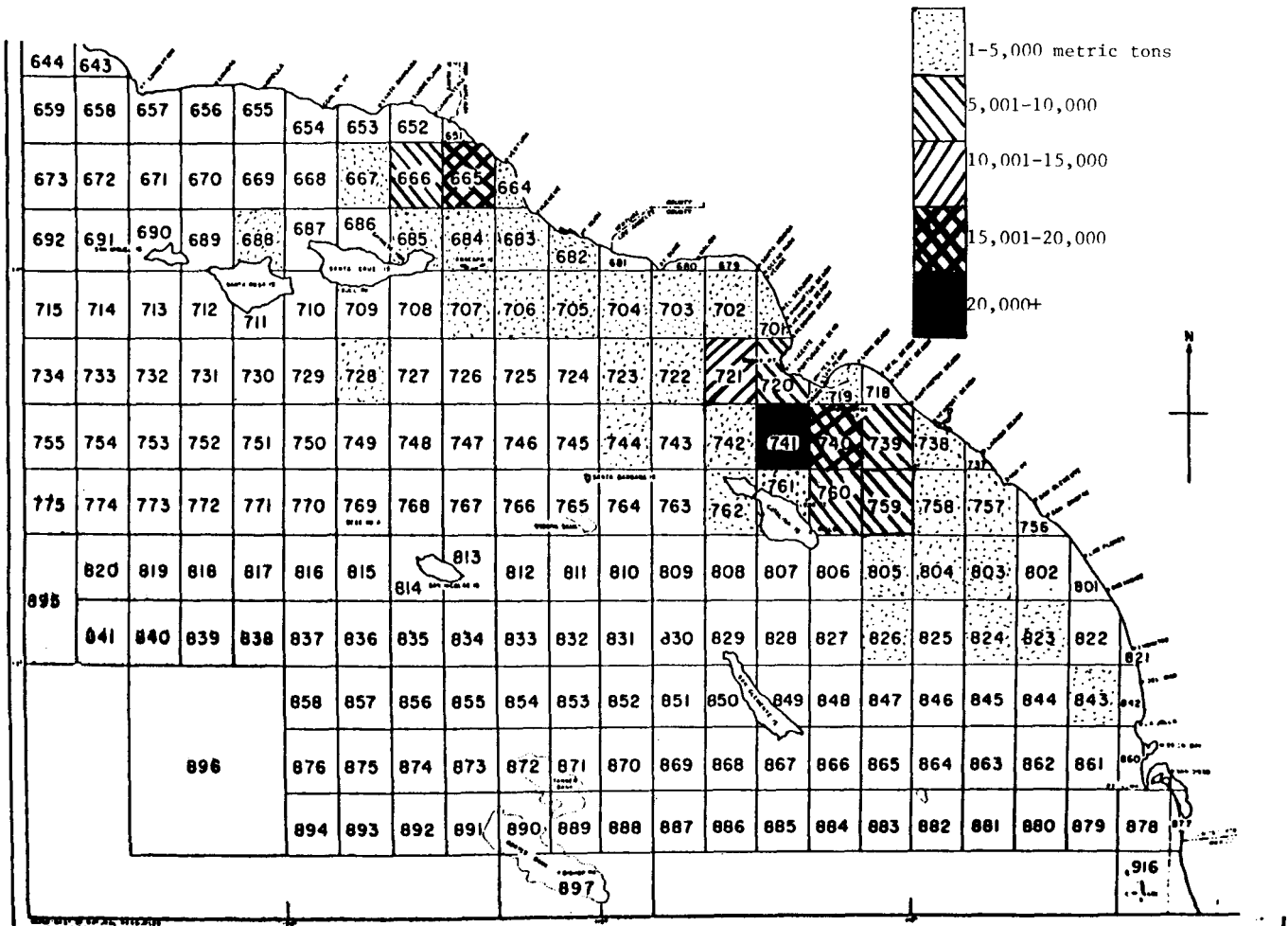


FIGURE 4. Anchovy landings by block area for southern California.

Central California landings occurred mainly during the fall with October (Table 3) accounting for 1,506 mt (1,660 tons). This region encountered severe weather conditions during winter and spring months, reducing fishing effort.

**Area of Catch**

The majority of the southern California landings occurred in the San Pedro Channel, which accounted for 55% of the catch, while the second most productive area was the Santa Barbara area amounting to 21% (Table 4; Figure 4). Santa Catalina Island area contributed 11% while Port Hueneme, Point Dume and Oceanside totaled the remaining 13%.

Central California's catches were mainly centered in Monterey Bay with major concentrations off Moss Landing (Figure 5; Table 5). Since the fishing activities were highly concentrated in few areas, any noticeable monthly trends in areas of catch were not apparent.

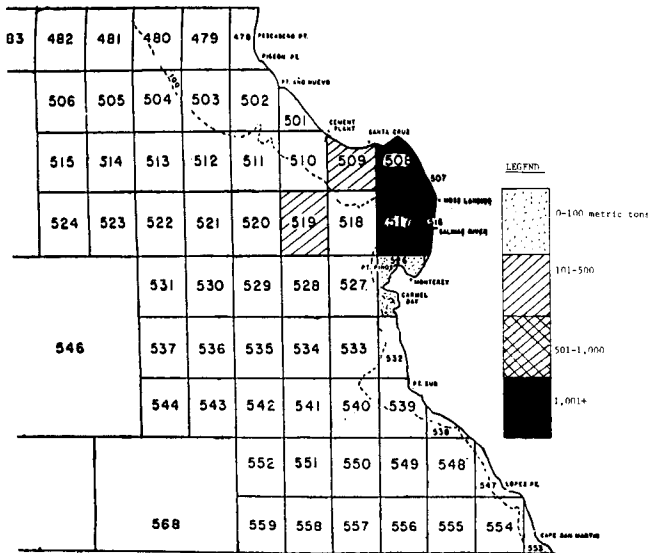


FIGURE 5. Anchovy landings by block area for central California.

**FISHERY MONITORING**

**Sampling Plan**

The anchovy sampling program for San Pedro is accomplished by using a stratified random sampling plan. A stratum consists of 5,000 short tons of anchovies and within a stratum, 30 samples are selected from 30 random numbers representing the cumulative tonnage. From the boat load, a sample cluster of 500 grams (1.1 lbs.) is collected; however, only 250 grams (0.55 lb) are processed as a sample (Witeck, 1975). Data concerning age, length, weight, sex and sexual maturity are recorded for analysis.

The central California sampling plan consists of one sample from a purse seiner and one from a lampara boat per day. The samples of 250 grams (0.55

lb) are processed in the same manner as in southern California.

**Age Composition**

Age and length data were collected from commercial samples totaling 8,950 fish from southern California and 254 individuals from central California (Sunada 1977; 1978). All age determinations were made using otoliths rather than scales. Methods and techniques used in aging were described by Collins and Spratt (1969).

The southern California catch was dominated throughout the year by 1973 and 1972 cohorts comprising 33.1% and 34.4% by number respectively (Table 6). Other year classes; 1971 and 1970, contributed significantly with 15.9% and 5.7% respectively. The fish of the year (1975 year class) did not appear until fall when they became vulnerable to the gear and contributed less than 1%. The 1974 year class contributed 9.4% of the catch.

Central California samples indicated the 1971 and 1970 year classes dominated the catch, with 31.1% and 26.3% respectively, followed by the 1972 year

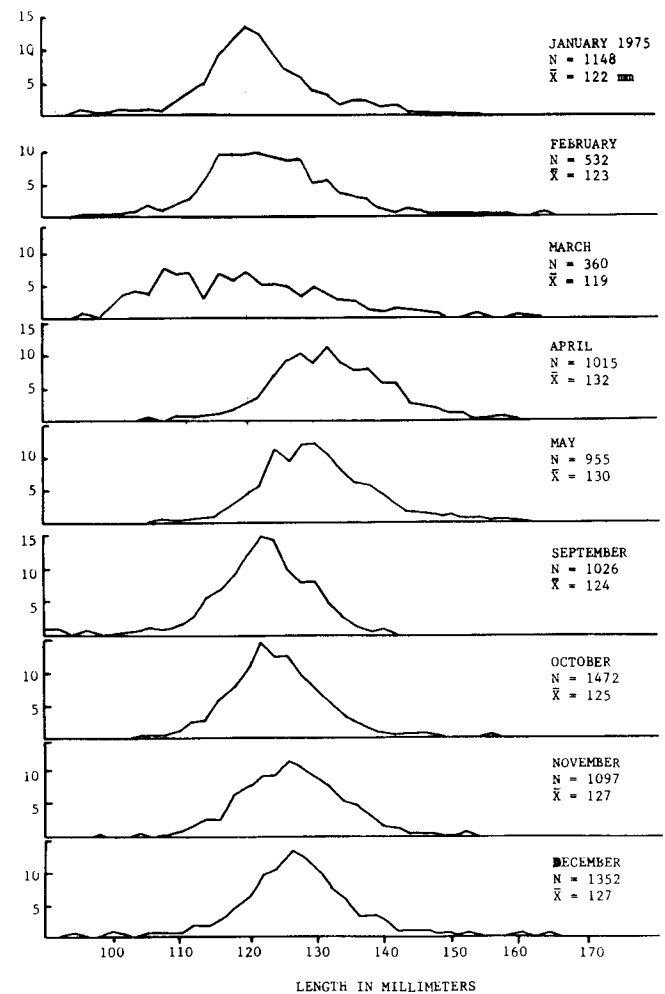


FIGURE 6. Length Distribution of Anchovies Landed at Terminal Island during 1975.

TABLE 5  
Anchovy Reduction Landings for Central California—1975 \*

Block #	January	February	March	August	September	October	November	December	Total
508.....				460	379	530			1,369
% .....				87.8	37.6	35.9			22.9
509.....						54	54		108
% .....						3.7	10.8		1.7
516.....					197	715	411	369	1,692
% .....					19.5	48.5	82.2	100	27.2
517.....	1,331	811	180	64	367	27	35		2,815
% .....	100	100	100	12.2	36.4	1.8	.7		45.4
519.....						150			150
% .....						10.2			2.4
526.....					66				66
% .....					6.5				1.0
Total .....	1,331	811	180	524	1,008	1,475	500	369	6,200
% .....	21.5	13.1	2.9	8.4	16.3	23.8	8.1	5.9	

\* Metric Tons.

TABLE 6  
Anchovy Age Composition by Year Class for Southern California

Year class	1975	1974	1973	1972	1971	1970	1969	1968	Total
January									
Numbers .....		51	223	518	258	86	12		1,148
% .....		4.4	19.4	45.1	22.5	7.5	1.0		
February									
Numbers .....		41	135	188	123	39	6		532
% .....		7.7	25.4	35.3	23.1	7.3	1.1		
March									
Numbers .....		128	98	42	47	39	5	1	360
% .....		35.6	27.2	11.7	13.1	10.8	1.4	-	
April									
Numbers .....		23	146	297	329	185	33	2	1,015
% .....		2.3	14.4	29.3	32.4	18.2	3.2	-	
May									
Numbers .....		30	188	359	266	93	16	3	955
% .....		3.1	16.7	37.6	27.8	9.7	1.7	-	
June									
Numbers .....		-	-	-	-	-	-	-	-
% .....									
July									
Numbers .....		-	-	-	-	-	-	-	-
% .....									
August									
Numbers .....		-	-	-	-	-	-	-	-
% .....									
September									
Numbers .....	8	157	508	297	48	7	1		1,026
% .....	0.7	15.7	49.5	28.9	4.6	0.6	-		
October									
Numbers .....	5	205	685	459	99	18			1,471
% .....	0.3	13.9	46.5	31.1	6.7	1.2			
November									
Numbers .....	3	86	436	442	111	18			1,096
% .....	0.2	7.8	39.7	40.2	10.1	1.6			
December									
Numbers .....	24	123	544	482	147	24	3		1,347
% .....	1.7	9.0	40.2	36.0	10.8	1.7	-		
Total									
Numbers .....	40	844	2,963	3,084	1,428	509	76	6	8,950
% .....	0.4	9.4	33.1	34.4	15.9	5.7	0.8	0.1	

TABLE 7  
Anchovy Age Composition by Year Class for Central California

Year Class	1975	1974	1973	1972	1971	1970	1969	Total
January								
Number .....	-	1	5	9	25	17	5	62
% .....	-	1.6	8.1	27.4	40.3	27.4	8.1	-
February								
March								
Number .....	-	-	2	3	7	6	2	20
% .....	-	-	10.0	15.0	35.0	30.0	10.0	-
April								
May								
June								
July								
August								
Number .....	-	-	4	8	11	9	-	32
% .....	-	-	12.5	25.0	34.4	28.1	-	-
September								
Number .....	-	-	8	17	20	24	4	73
% .....	-	-	10.9	23.3	27.4	32.9	5.5	-
October								
Number .....	8	1	7	12	11	8	2	49
% .....	16.3	2.0	14.3	24.5	22.4	16.3	4.1	-
November								
Number .....	1	1	3	4	5	3	1	18
% .....	5.6	5.6	16.7	22.2	27.8	16.7	5.6	-
December								
Total	9	3	29	53	79	67	14	254
%	3.5	1.1	11.4	20.8	31.1	26.3	5.5	-

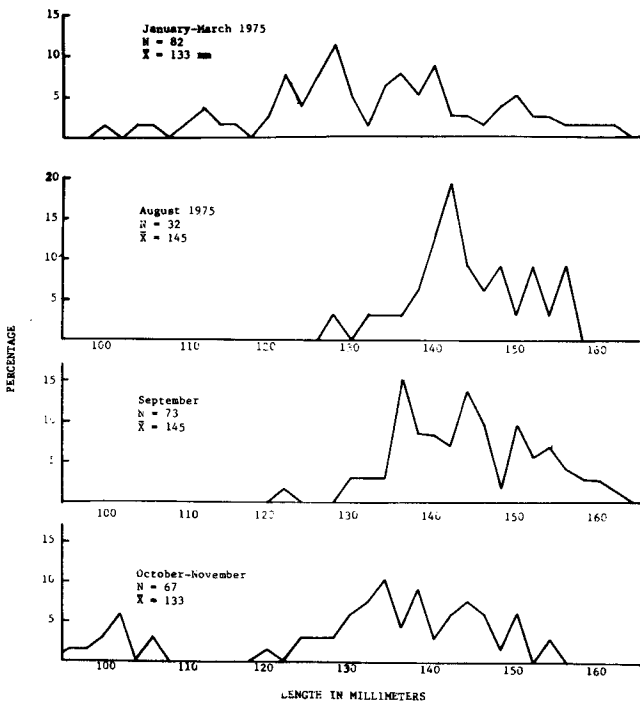


FIGURE 7. Length Distribution of Anchovies Landed at MOSS Landing during 1975.

class which contributed 20.8% (Table 7). In contrast to the southern area, the 1973 year class comprised only 11.4%, while the 1974 year class was a mere 1.2% of the total. The 1975 year class fish were more numerous with 3.5%

**Length Composition**

Anchovies from southern California ranged from 88 to 170 mm standard length (103 mm to 200 mm total length) with an average length of 125.8 mm SL or 148 mm TL. Monthly length distributions revealed a single mode throughout most of the year with exceptions in February, and March (Figure 6). The wide distribution in February and March was the result of the presence of the 1973 and 1974 year class fish. After March, the 1972 and 1971 year class fish regained their prominence in the catch as indicated by the single mode and by the age composition (Figure 6, Table 6).

Length composition for September exhibited a major peak at 124 mm SL and a minor one at 130 mm SL, which represented the 1973 year class and the 1972 year class respectively. The remaining months revealed a single mode near 127 mm SL (Figure 6). Young-of-the-year fish (1975 year class) were observed in minor numbers during December when small fish were noted (Figure 6).



Central California fish ranged from 92 mm to 173 mm SL (108 mm to 203 mm TL) with a mean length of 137.7 mm SL (162 mm TL). Modes were less distinct due to small sample sizes, although a pronounced peak occurred in August (Figure 7). Monthly mean lengths were generally larger than San Pedro samples, due to the presence of older fish in the catch. Small fish did appear early and late in the year, representing the 1974 and 1975 year classes (Figure 7).

**Sex Composition and Maturity**

The sexual maturation index is based on methods devised by Hjort (1914), using seven stages, with Stage 1 being immature, progressing in development with each stage, culminating with Stage 6 as spawning condition. Stage 7 is considered the spent condition.

Sex composition of the San Pedro catch remained fairly constant throughout the year, with 38.4% being males and 61.6% females, although February samples displayed a near 1:1 ratio (Table 8).

TABLE 8  
Anchovy Sex Ratios for Southern California

Month	Male		Female	
	Number	%	Numbers	%
January.....	440	38.4	704	61.6
February.....	255	48.0	276	52.0
March.....	139	40.4	205	59.6
April.....	384	37.9	628	62.1
May.....	345	36.5	600	63.5
September.....	298	36.1	611	67.9
October.....	578	40.2	858	59.8
November.....	409	39.4	628	60.6
December.....	473	36.8	812	63.2
Total.....	3,321	38.4	5,322	61.6

Ratio 1.60 Females : 1 Male

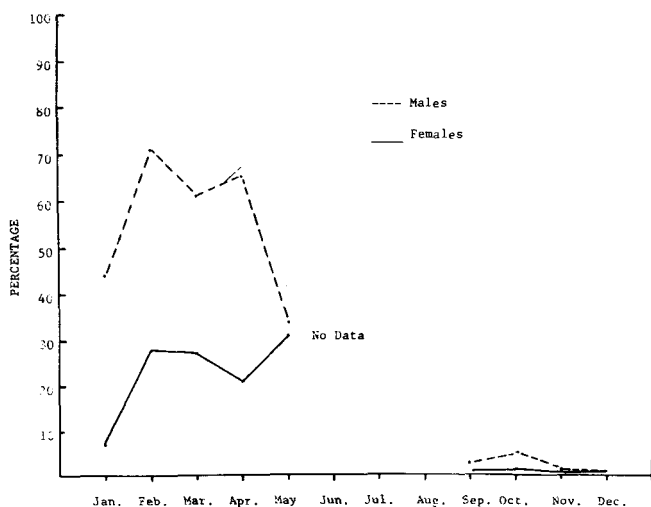


FIGURE 8. Percent Occurrence of Mature and Near-mature Stages (4-6) in southern California anchovies.

Sexual development of anchovies occurred throughout the year, reaching mature and near-mature conditions (Stages 4-6) in February, March, and May (Figure 8). Males appeared to mature earlier than females.

TABLE 9  
Anchovy Sex Ratio for Central California

Month	Male		Female	
	Numbers	%	Numbers	%
January.....	29	48.3	31	51.7
February.....	-	-	-	-
March.....	7	35.0	13	65.0
April.....	-	-	-	-
May.....	-	-	-	-
June.....	-	-	-	-
July.....	-	-	-	-
August.....	8	25.8	23	74.2
September.....	20	27.4	53	72.6
October.....	15	32.6	31	67.4
November.....	8	44.4	10	55.6
December.....	-	-	-	-
Total.....	87	35.1	161	64.9

Ratio 1.85 Females : 1 Male

Central California anchovy sex composition was similar to that of southern California with 35.08% male and 64.92% females (Table 9). The sex ratio reached a near 1:1 ratio during January (Table 9). Since adequate samples were not obtained during peak spawning time, maturity development could not be determined.

**RESEARCH CRUISES**

The California Department of Fish and Game has annually conducted pelagic fish survey cruises since 1950, as a part of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) program. During 1975, eight cruises were conducted by the ALASKA by the Assessment of Commercial Fisheries Resources Project. Of eight cruises, five were acoustic surveys to determine the distribution and abundance of the northern anchovy. Other efforts included the gathering of limited oceanographic data relating to fish distribution; determining the abundance of Pacific mackerel and sardine; and conducting surveys with respect to other pelagic fish and invertebrate species (Mais, 1976).

**FISHERY OF BAJA CALIFORNIA**

The harvesting of anchovies for canning and human consumption was initiated in Ensenada in 1950 as a consequence of the first signs of sardine scarcity in the coastal waters next to this port (Flores, 1970). However, it wasn't until 1964 that the local packers decided to utilize the species on an industrial scale, installing two plants with special equipment for the cutting and canning of anchovies that year. According to Flores (1970), in 1965 and 1966 four more packers diversified their activities by including

anchovies in their installations with the corresponding increase in the landings. In 1975, nine Ensenada plants processed this species for the purpose of fish meal and canning.

### The Fishery

Generally the fishing operations are carried out in the vicinity of Ensenada, although the boats travel greater distances when anchovies are scarce, some

traveling as far north as the Coronado Islands, some 45 nautical miles from port (Figure 9), and to the south they ventured to Punta Colnett, a locality situated approximately 55 nautical miles from Ensenada. The boats operate at a maximum distance of 3 miles from the coast.

In 1975 33 boats were involved with anchovy fishing; the number of boats per month varied from five (December) to 26 (July). After October or November, the majority of the boats moved to the Gulf of California where they fished for Monterey sardines, *Sardinops sagax*, and crinuda sardines, *Opisthonema libertate*.

The gross tonnage of the vessels varied from 19 to 499 metric tons (21 to 550 tons) with an average of 111.3 mt (122.7 tons); the ship length fluctuated from 8 to 53 m (21.2); the breadth was from 4 to 12 m (5.9), and the age of the vessels varied from 2 to 61 years (26.1). Only one boat fished with a lampara net (Castellanos, 1975); the rest used round haul nets made of nylon; the nets measured lengthwise from 252 to 600 m, with an average of 381.8 m.

In general, the boats left the port in the early hours of the day and returned the same day; this occurred mostly from June to August when practically the whole fleet worked in the waters off Ensenada; the trips were very short in the winter when smaller boats continued to fish anchovies, while the rest of the fleet moved to the Gulf of California. During the preceding months the proportion of the trips with a 2 day duration increased while some boat operators traveling to Cabo Colnett took 3 days to return to port.

The capture of anchovies occurred frequently at night, because the location of the fish was almost always visual and easy to distinguish during hours of darkness. All of the boats had an echo sounder and four had sonar. Five of the boats in 1975 fished in combination with light airplanes for locating anchovy schools.

The official system of fishery statistics collected information about landings but not of where the catches were made. Information about catch locations was obtained from logs which were distributed to the skippers, but since this information is voluntary, not all skippers provided it, at least not on a constant basis. The completed information from the logs analyzed in 1975 provided us with an idea of the movements of the fleet during the year in the principal fishing zones.

The proximate zone near Ensenada (including Bahia de Todos Santos, Punta Banda, La Bufadora, Canal de Punta Banda and the area surrounding the Isla Todos Santos) constituted the principal fishing area from January to July and then in September and December. The second important zone was to the north of Ensenada, between Salsipuedes and La Mision, with the exception of September, when the secondary fishing grounds were Punta Colnett and the area between Rosarita and the Coronado Islands.

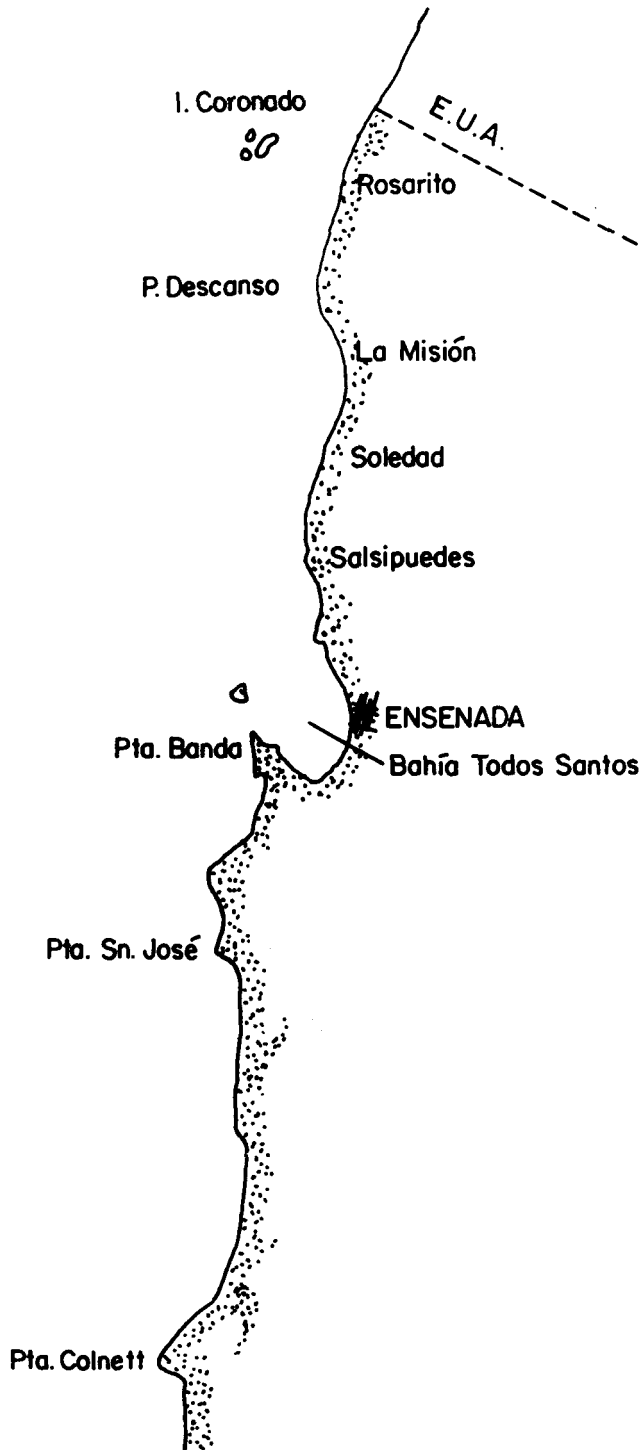


FIGURE 9. Anchovy fishing grounds off Baja California.

In August and November the area between Salsipuedes and La Mision was fished with more intensity, while in October the boats with the greatest range operated mostly off Cabo Colnett.

In 1975 the boats caught anchovies on 1373 trips; the numbers of trips per month fluctuated from 6 (December) to 314 (June). The number of trips by month are as follows: January, 151 trips; February, 45; March, 46; April, 47; May, 116; June, 314; July, 309; August, 158; September, 126; October, 36; November, 19; and December, 6.

The minimum and maximum catch attained by a boat in a fishing day was 1.1 mt (1.2 tons) in May and 259.8 mt (286 tons) in June respectively. It was observed that the average monthly catch per trip was most reduced in February and March, and reaching the maximum between June and September.

Anchovy landings at Ensenada constitute the majority of anchovies landed in Mexico and have been increasing in recent years reaching 56,877 mt (62,695 tons) in 1975 (Table 10). Minor landings have been recorded occasionally in other Baja California localities such as Cedros Island, Bahia Tortugas, the Coronados Islands, and San Quintin.

TABLE 10  
Anchovy Landings at Ensenada, Baja California,  
From 1962 to 1975 \*

Year	Landings *
1962.....	669
1963.....	944
1964.....	4,599
1965.....	9,171
1966.....	13,243
1967.....	20,104
1968.....	14,267
1969.....	3,871
1970.....	27,977
1971.....	20,079
1972.....	30,047
1973.....	15,424
1974.....	44,987
1975.....	56,877

\* Metric tons.

With respect to 1975, the greatest production was in June and July (Table 11) with a monthly average of 4,739.7 mt (5,224 tons). Fishing was permitted during the entire year.

Other species fished besides anchovies were, in order of importance, jurel, *Seriola dorsalis*; charrito, *Trachurus symmetricus*; bonito, *Sarda chiliensis*; and mackerel, *Scomber japonicus*.

Nine plants processed anchovies during 1975; three of them were dedicated exclusively to the production of fish meal, four to canning, and the rest combined both products. According to official statistics of the Subsecretary of Fishery (now the Department of Fishery) 93.1% of anchovies captured in 1975 was reduced to fish meal, and the rest canned for human consumption. Both products

TABLE 11  
Anchovy Landings at Ensenada During 1975 \*

Months	Fish Meal	Canning	Total *
January.....	5,179	209	5,388
February.....	631	114	745
March.....	722	42	764
April.....	1,207	85	1,292
May.....	4,358	158	4,516
June.....	14,578	805	15,383
July.....	13,535	1,091	14,626
August.....	5,389	718	6,107
September.....	4,373	559	4,932
October.....	2,471	19	2,490
November.....	396	89	485
December.....	145	4	149
Total *.....	52,984	3,893	56,877
Short tons.....	58,404	4,291	62,695

\* Metric tons.

were designated for the national market, with the fish meal used for protein supplements and as food for poultry and pigs (Jimenez and Esparza, 1976).

The price per metric ton of anchovies for reduction fluctuated from \$450 to \$475 (U.S. \$36 to \$38) and from \$625 to \$650 (U.S. \$50 to \$52) for canning.

#### Regulations

In Baja California the anchovy fishery has no regulations with respect to closed seasons, minimum size, etc., there is only a condition of the Local Fishing Office which prohibits the operation of boats with a hold capacity of more than 100 mt (110 tons) in the Bahia de Todos Santos.

#### Fishery Monitoring

The first investigations regarding commercial fishing of anchovies off Baja California were carried out in 1965 and 1966 by personnel of the Station of Biology Fishery of the National Institute of Biological Fishery Investigation. The results obtained concerning the fishery were printed as a Professional Thesis (Flores, 1970) with a limited distribution.

In 1974, within the Fishery Exploration Program of the National Institute of Fishery, the Section of Sardines and Anchovies was created, which conducted studies of *Engraulis mordax* based on samples from the commercial landings. In October 1974 the Anchovy Program was established, and investigations regarding this species were enlarged considerably, increasing the duties of the research vessels ANTONIO ALZATE and ALEJANDRO DE HUMBOLDT. Besides the biological aspect, studies of food technology and methods of fishing were included, as well as management considerations.

#### Sampling Plan

The fishing zone of the anchovy fleet was divided into 10 mile squares, considered subzones. At the Ensenada landing dock, a daily sample of anchovies was obtained which weighed 1 kilo from each of the subzones in which the boats worked.

At the dock the following data were recorded: date and locality of fishing, boat name and total catch of anchovy. From the 1 k sample, 250 gms were taken upon which biological studies were carried out. The following data were recorded for each individual anchovy: standard length, sex and sexual maturity, gonadal length and weight, eviscerated and whole weight of the specimen, fat contents, and stomach contents; otoliths were taken to determine the age, as were female gonads in the advanced stage of maturity for determining fecundity. The criteria utilized to determine the stage of sexual maturity, stomach content, and fatty content were described by Sokolov and Wong (1974). Length measurements

only were taken for the remaining 750 gms of the anchovy sample.

As previously indicated, logs were distributed to the skippers of the commercial boats for the purpose of determining fleet movements, zones of major production, accompanying species, etc. Monthly processing plants submit a record of daily catches.

#### Age Composition

The ages of the fish were from 0 to 5 years old. While 1972 year class fish dominated the catch with 42.6% by number, the 1971 and 1973 year classes constituted 15.8% and 24.9% respectively (Table 12).

TABLE 12  
Anchovy Age Composition by Year Class for Baja California

Year Class	1975	1974	1973	1972	1971	1970	1969	Total
January								
Numbers .....	-	18	28	129	44	7	-	226
% .....		7.9	12.3	57.0	19.4	3.0		
February								
Numbers .....	-	7	6	9	1	-	-	23
% .....		30.4	26.0	39.1	4.3			
March								
Numbers .....	5	38	56	15	7	2	-	123
% .....	4.0	30.8	45.5	12.1	5.6	1.6		
April								
Numbers .....	-	6	14	16	15	1	-	52
% .....		11.5	26.9	30.7	28.8	1.9		
May								
Numbers .....	-	1	12	23	28	6	1	71
% .....		1.4	16.9	32.3	39.4	8.4	1.4	
June								
Numbers .....	1	4	49	94	16	1		165
% .....	0.6	2.4	29.6	56.9	9.6	0.6		
July								
Numbers .....	1	9	53	84	31	6		184
% .....	0.5	4.8	28.8	45.6	16.8	3.2		
August								
Numbers .....	3	7	18	30	7			65
% .....	4.6	10.7	27.6	46.1	10.7			
September								
Numbers .....	26	16	26	50	19	1		138
% .....	18.8	11.5	18.8	36.2	13.7	0.7		
October								
Numbers .....	-	2	3	4	2	1		12
% .....		16.6	25.0	33.3	16.6	8.3		
November								
Number .....	2	6	6	9	2	1		26
% .....	7.6	23.0	23.0	34.6	7.6	3.8		
December								
Numbers .....	-	-	-	-	-	-	-	-
% .....								
Total								
Numbers .....	38	114	271	463	172	26	1	1,085
% .....	3.5	10.5	24.9	42.6	15.8	2.3	0.9	

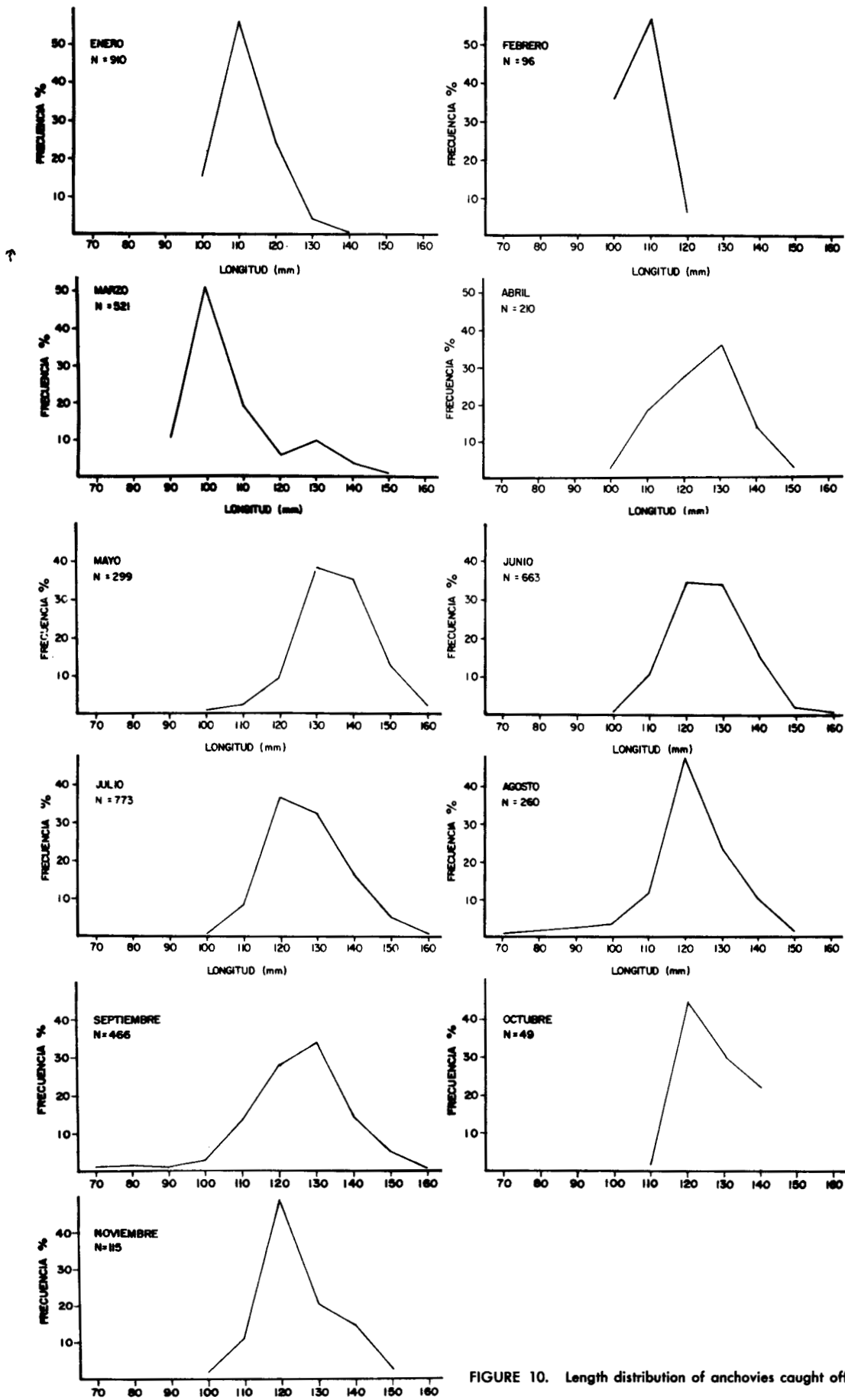


FIGURE 10. Length distribution of anchovies caught off Baja California.

### Size Composition

The size range of all samples studies was from 62 to 158 mm SL; or 72 mm to 185 mm TL; the average length of the fish was 116.7 mm SL or 135 mm TL. The sizes which dominated the samples were from 11 to 13 cm SL. Individuals less than 100 mm SL occurred every month except for October, appearing with a greater abundance from January to March, principally in the latter month. These fishes represented 11.4% of the total of individuals measured (Figure 10).

### Sex Composition

Sex composition of the samples was 73.7% female and 26.3% males; every month (Table 13) females appeared in greater abundance, changing the proportion of 56.6% in April to 100% in October.

TABLE 13  
Anchovy Sex Ratios From Ensenada

Month	Males		Females	
	Number	%	Number	%
January .....	73	32.3	153	67.7
February .....	9	39.1	14	60.8
March .....	45	36.5	78	63.4
April .....	23	43.4	30	56.6
May .....	16	22.8	54	77.1
June .....	43	25.9	123	74.1
July .....	18	9.7	167	90.2
August .....	24	39.3	37	60.6
September .....	18	16.9	88	83.0
October .....	-	-	12	100.0
November .....	7	28.0	18	72.0
December .....	-	-	-	-
Total .....	276	26.3	774	73.7

Ratio 2.8 Females: 1 Male

Individuals in the reproduction stages occurred from January to September with a maximum in March (Figure 11). Silva and Villamar (1976) indicated that the species has two peak reproductive periods of diverse intensity during the year.

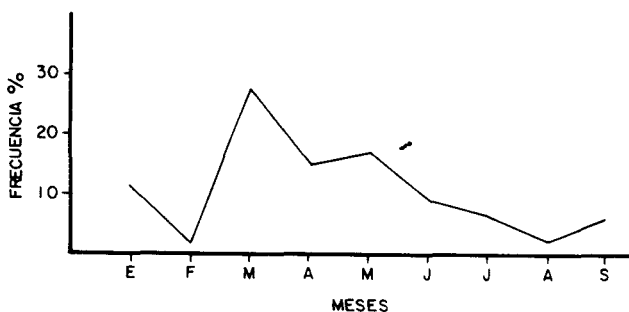


FIGURE 11. Percent occurrence of mature and near-mature stages in Baja California anchovies.

### RESEARCH CRUISES

Besides the study of commercial catches, during 1975 the research vessels ANTONIO ALZATE and ALEJANDRO DE HUMBOLDT conducted 10 cruises during different seasons of the year and covering the western coast of Baja California. These cruises consisted of conducting acoustic surveys in order to determine the distribution and abundance of anchovies; taking samples for biological studies of anchovies as well as other principal species and such as squid, hake, and pelagic red crab; collecting ichthyoplankton, to become acquainted with the distribution and abundance of eggs and larvae of anchovies to estimate the reproductive biomass; and recording various meteorological and hydrographic parameters.

### REVIEW OF U.S.-MEXICAN FISHERIES

#### The Fisheries

Mexico and the United States have fished a common stock of anchovies for many years. An anchovy fishery has been conducted by California fishermen since at least 1916 and landings reached a record high of 143,786 mt (158,505 tons) in 1975.

Mexico has allowed an anchovy fishery since 1950 although landings were not significant until 1964 when two plants were built in Ensenada for canning. By 1975, nine plants were processing anchovies for fishmeal and canning. In that year, Mexican fishermen harvested 56,877 mt (62,695 tons) of anchovies.

The combined anchovy take by the two countries has increased substantially since 1970, reaching a record high of over 200,000 mt (221,191 tons) in 1975 (Table 14). From 1965 through 1975, 923,646 mt (1,018,135 tons) were harvested, with an annual mean take of nearly 84,000 mt (92,300 tons). The U.S. take amounted to nearly 72% of the total landings during the 11 year period; Mexico's share was 28% (Table 14).

TABLE 14  
Anchovy Landings From U.S. and Mexico During 1965 Through 1975\*

Year	U.S.	%	Mexico	%	Total
1965 .....	2,600	22.1	9,171	77.9	11,771
1966 .....	28,250	68.1	13,243	31.9	41,493
1967 .....	31,574	61.1	20,104	38.9	51,678
1968 .....	14,096	49.7	14,267	50.3	28,363
1969 .....	61,361	94.1	3,871	5.9	65,232
1970 .....	87,310	75.7	27,977	24.3	115,287
1971 .....	40,690	67.0	20,079	33.0	60,769
1972 .....	62,687	67.6	30,047	32.4	92,734
1973 .....	120,325	88.6	15,424	11.4	135,749
1974 .....	74,920	62.5	44,987	37.5	119,907
1975 .....	143,786	71.6	56,877	28.4	200,663
Total .....	667,599		256,047		923,646
% .....		72.3		27.7	100.0%
Short Tons .....	735,894		282,241		1,018,135

\* Metric tons.

Fishing occurred in three distinct areas: near Ensenada, Baja California, in the southern California Bight; and in Monterey Bay. Within these areas, 56 American and 33 Mexican boats were involved in anchovy fishing during 1975. The average size of the Mexican boat was slightly larger and heavier than its American counterpart (Table 15). Most vessels from both countries were equipped with sonar and frequently assisted by spotter planes. Major fishing grounds were located from 20 to 100 miles from port. Extreme fishing areas for American fishermen ranged from Point Conception to Oceanside whereas Mexican fishermen traveled as far as Coronado Islands and Punta Colnett (Figure 9). Fishing was conducted mainly at night by both groups of fishermen during summer and fall months, although spring fishing occurred predominately during the day.

TABLE 15  
U.S. and Mexican Fishing Vessel Information

	U.S.	Mexico
Total Number of Boats .....	56	33
Mean Vessel Size (Meters) .....	19.0	21.2
Range.....	6-28	8-53
Mean Vessel Weight (Metric Tons) .....	76.0	111.3
Range.....	5-181	19-499

The degree of involvement or effort with this fishery varies according to fish availability and presence of more desirable species. In Ensenada the majority of the fleet departs during the fall for the Gulf of California sardine fishery. Likewise, U.S. boats fish other desirable species when available, such as jack mackerel, bluefin tuna, and bonito. This diversity in effort has some effect upon anchovy landings in certain years.

**Regulations**

The following regulations have been established during the past 10 years and apply generally to the California reduction fishery.

The California reduction fishery season opens on August 1 for the region north of Point Buchon, and September 15 for the area south of this point. All reduction fishing ceases in both areas on May 15 or when the quota is attained. Quotas are determined prior to each season and increases can be made. Quotas for the 1974-75 season were 13,608 mt (15,000 tons) for the northern area (north of Point Buchon) and 104,326 mt (115,000 tons) south of this point. The 1975-76 season's quotas were 13,608 mt (15,000 tons) for the month and 136,078 mt (150,000 tons) in the south.

Fishing for reduction purposes has been assigned to all water beyond 3 miles of the coastline in addition to local restrictions of 4 to 6 miles in certain areas. Santa Monica Bay and the eastside of Santa Catalina Island are restricted areas.

California has established a minimum size of 127 mm total length (TL) or approximately 108 mm standard length (SL), with an undersize allowance of 15% by weight.

All vessels are required to have identification numbers on their sides. Fishermen also are required to maintain and return daily records of fishing activities on forms provided by the Department of Fish and Game. All reduction permits and fishing can be suspended on 48 hours notice by the California Fish and Game Commission when approaching the quota.

The Mexican fishery is not restricted by quota, season, or minimum size limits. The only regulation concerns the restriction of fishing in Todos Santos Bay by vessels larger than 100 mt (110 tons).

**Catch by Month and Area**

The combined American and Mexican take of anchovies during 1975 totaled 200,663 mt (221,201 tons) of which 143,786 mt (158,505 tons) were caught by the U.S. Monthly landings fluctuated considerably, with the major share of California's take occurring during the fall and spring months, whereas Mexico's fishermen were most successful during the summer (Table 16). The noticeable decline in California's landings during the summer was due to the closure of the reduction fishery which accounted for 99% of the anchovy harvest. Both countries had low landings in March which may have been the effects of spawning, a period when the fish were less vulnerable to fishing.

TABLE 16  
Anchovy Landings for 1975 \*

Month	California	Mexico	Total
January.....	16,917	5,388	22,305
February .....	8,768	745	9,513
March.....	4,546	764	5,310
April.....	17,124	1,292	18,416
May.....	15,385	4,516	19,901
June.....	101	15,383	15,484
July.....	146	14,626	14,772
August.....	734	6,107	6,841
September.....	15,019	4,932	19,951
October.....	23,586	2,490	26,076
November.....	18,496	485	18,981
December.....	22,964	149	23,113
Total.....	143,786	56,877	200,663
Short tons .....	158,505	62,696	221,201
Percent .....	71.7	28.3	100.0%

\* Metric tons.

Primary Mexican fishing grounds were located near Ensenada during January to July and later in December, while secondary areas were located north of Ensenada, between Salsipuedes and La Mision, which were heavily fished in August and November. Coronados Islands near the U.S.-Mexican border and Punta Colnett in the south were major fishing areas in September while fishing operations in October occurred only near Punta Colnett.

Southern California boats ranged from the Santa

Barbara Channel to the City of Oceanside, although the primary fishing areas during January to May were the San Pedro Channel and near Santa Catalina Island. The San Pedro Channel also was the primary fishing grounds in September and October. This region accounted for 55% of the total annual catch. The Santa Barbara region with 21% of the annual take was the second most productive area. Central California's fishery was limited to Monterey Bay with the region's total accounting for 4% of U.S. anchovy landings.

### Fishery Monitoring

#### Methods and Materials

Sampling methods for the two countries were not standardized due to the varied differences in the two fisheries, although the results were comparable. The American method was the same as since the beginning of reduction fishery in 1968 (Collins, 1971). Mexico's sampling plan utilized the same 250 gram sample weight size although an additional 750 grams were taken for length measurements. The 250 gram sample was processed in the same manner as

### Results

#### Age Composition

Age data from southern California and Baja California indicated the annual catches were dominated by fish of the 1972 year class (34.4% southern California and 42.6% Baja California) followed by the 1973 year class (33.1% and 24.9% respectively) (Figure 12). The 1971 year class was present in near identical proportions (16% in southern California and 15.8% in Baja California) although the 1970 year class occurred in (5.7% greater numbers from San Pedro samples in contrast to 2.3% of Ensenada landings. Proportions of the 1974 year class were similar between southern California (9.4%) and Ensenada (10.5%) samples while the 1975 year class contributed little to both fisheries, amounting to 0.5% for southern California's landings and 3.5% of Mexico's total.

Central California's age structure consisted of older fish, mainly the 1971 year class (31.7%) and the 1970 year class (26.4%). In contrast to San Pedro and Ensenada samples, this area contained only 11.4% from the 1973 year class and 20.8% 1972 year class (Figure 12).

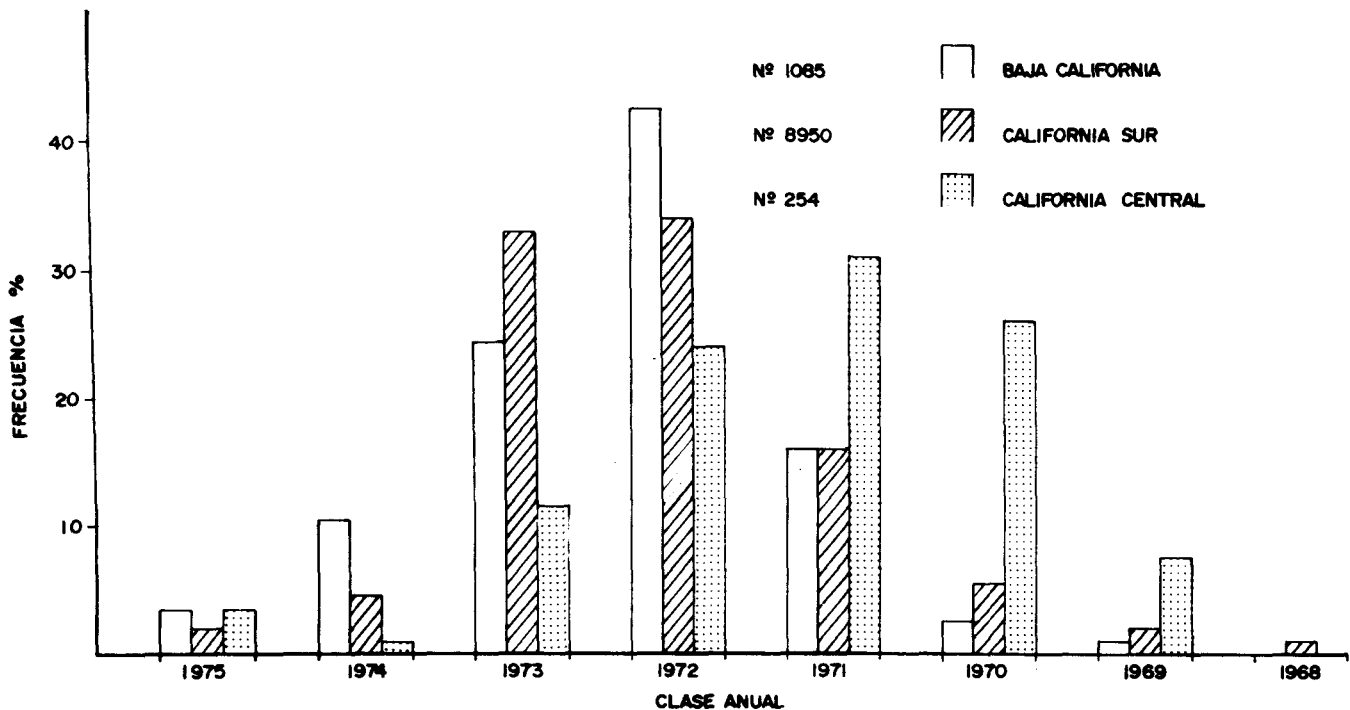


FIGURE 12. Age composition of anchovies caught off California and Baja California.

the American method.

Age determination was accomplished by the use of otoliths by both countries along criteria developed by Collins and Pratt (1969).

Monthly age compositions derived from Californian and Mexican samples compared quite similarly in most months, although August's data differed greatly due to California's samples



originating from central California (Figure 13). Samples from this region contain a greater percentage of older fish as was previously stated. In both countries, recruitment of the 1974 year class appeared in late winter, although that year class did not constitute a significant portion of the catch (Figure 13).

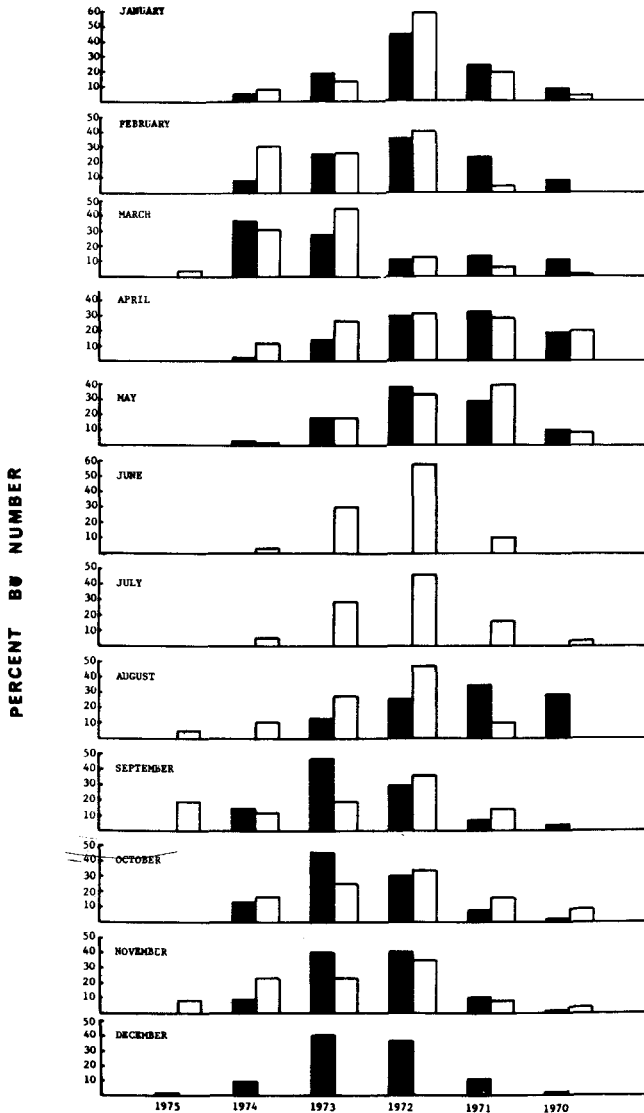


FIGURE 13. Monthly anchovy age composition by year class: solid bars California, open bars Baja California.

In September, the 1975 year class appeared in nearly 19% of the Mexican samples while comprising a mere 0.7% of the Californian samples. The lack of size regulations in Mexico could account for this high percentage of the 1975 year class since these fish (smaller than 100 mm) would not be vulnerable to the U.S. fishery due to the size restriction.

**Length Composition**

Fish ranged from 65 mm SL in Baja California to 173 mm SL in central California (Figure 14). The

average fish lengths differed greatly from Baja California with 117 mm SL, southern California with 126 mm SL and central California 138 mm SL. The length distribution from these areas exhibited discernable modes with considerable overlap, although the Mexican catch contained a considerable number of fish smaller than 110 mm SL (Figure 14).

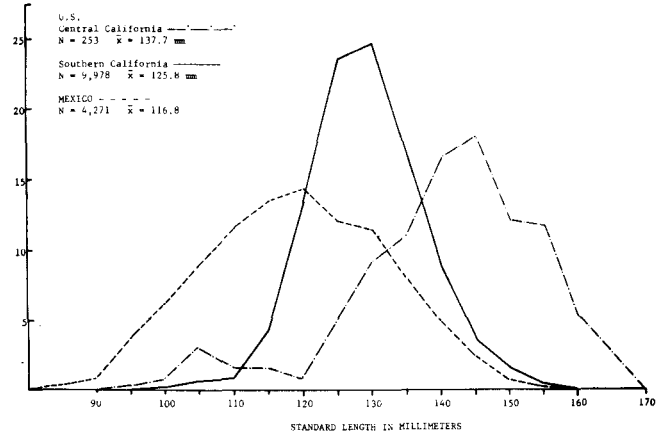


FIGURE 14. Annual length frequency distributions of anchovies taken off California and Baja California.

Length frequencies from Ensenada and California samples demonstrated a difference from one another during the winter; the former samples contained small fish (Figure 15). Size compositions from both areas became nearly identical during May and this correlated closely with the age data.

The absence of a reduction fishery in California during June and July precluded any length comparisons between the two fisheries for these months. In August, the lengths of central California specimens were considerably greater than those of Ensenada specimens (Figure 15).

A divergence between the Ensenada and California length frequencies was observed during fall, being most noticeable in November (Figure 15). During that month, San Pedro based fishermen fished extensively in the Santa Barbara region, which accounted for 65% of the month's total. Mexican fishing activities during the fall occurred at the extreme north and south ends of the fishery, the Coronado Islands and Punta Colnett areas respectively.

**Sex Composition and Maturity**

Sex ratios were nearly constant throughout most of the year for all areas, with females outnumbering the males as great as 2.8 to 1 (Table 17). Ensenada samples had the greatest female-male proportion of 2.8 to 1, while southern California exhibited a 1.6 to 1 ratio and central California with a ratio of 1.8 to 1 (Table 17). The ratios approached a near 1:1 value first in central California during January followed by southern California in February while Ensenada data showed a 1.3:1 ratio in April (Table 17).

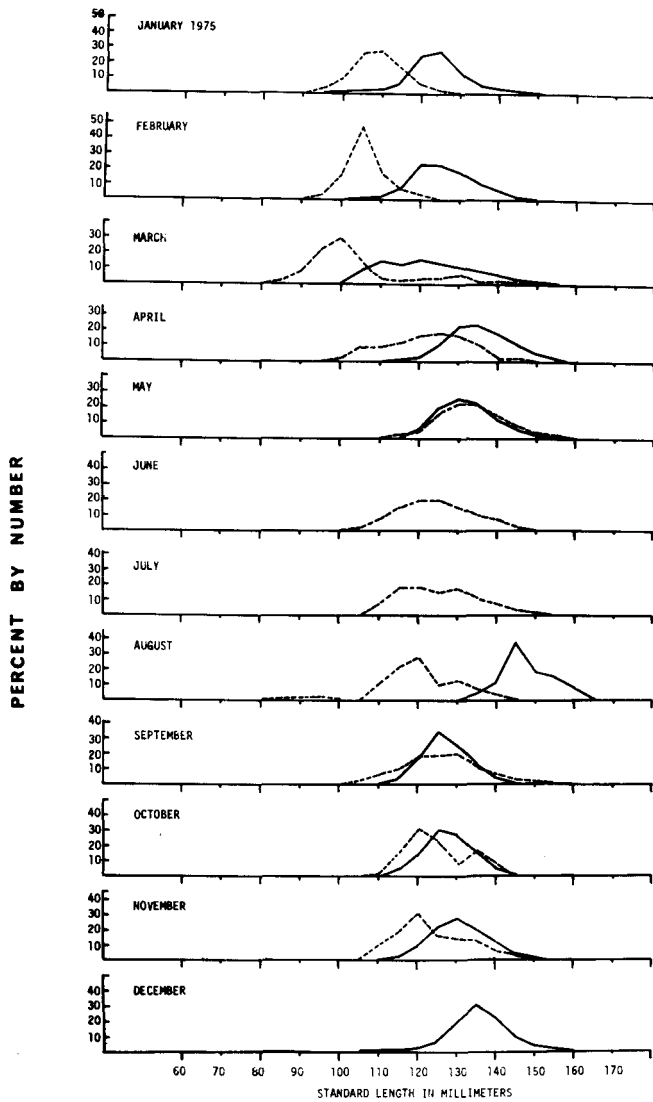


FIGURE 15. Length frequency distributions of anchovies by month; Baja California ----, California —.

TABLE 17  
Anchovy Sex Ratios for U.S. and Mexico, Percentage by Numbers

Month	Central California		Southern California		Mexico	
	Male	Female	Male	Female	Male	Female
January	48.3	51.7	38.4	61.6	32.3	67.7
February	-	-	48.0	52.0	39.1	60.8
March	35.0	65.0	40.4	59.6	36.5	63.4
April	-	-	37.9	62.1	43.4	56.6
May	-	-	36.5	63.5	22.8	77.1
June	-	-	-	-	25.9	74.1
July	-	-	-	-	9.7	90.2
August	25.8	74.2	-	-	39.3	60.6
September	27.4	72.6	36.1	67.9	16.9	83.0
October	32.6	67.4	40.2	59.8	0	100.0
November	44.4	55.6	39.4	60.6	28.0	72.0
December	-	-	36.8	63.2	-	-
Total	35.1	64.9	38.4	61.6	26.3	73.7
Sex ratio	1.85 F:1M		1.60 F:1M		2.80 F:1M	

Sexual development of southern California and Baja California anchovies was observed throughout the year, reaching mature and near mature stages during February through May (Figure 16). Maturity development could not be determined from central California due to small sample sizes. Maturity development of Mexican fish declined in the summer months with a minor increase in September. California's data indicated the spawning peaked during the period of February through May, with a minor spawning peak in September (Figure 16).

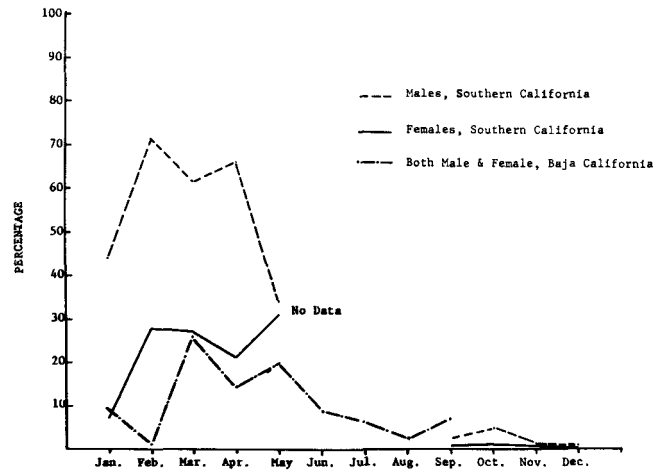


FIGURE 16. Percent occurrence of mature and near-mature stages (4-6) in southern California and Baja California anchovies.

Both Mexican and American data indicate a presence of two spawning peaks, which confirmed the findings of Silva and Villamar (1976) who determined two distinct reproductive periods.

RESEARCH CRUISES

During 1975, eight sea survey cruises were conducted by the California Department of Fish and Game, and 10 cruises by the staff of the Instituto Nacional de Pesca (INP). The objectives for both agencies were the gathering of limited oceanographic data relating to fish distribution; to determine by acoustic methods, the distribution and abundance of the northern anchovy; and to survey other pelagic fish and invertebrate species.

CONCLUSION

The anchovy fishery has recently become a significant fishery, especially since 1970. During 1975, the California Department of Fish and Game and Mexico's Instituto Nacional de Pesca (INP) have collaborated in a joint CalCOFI study concerning the anchovy resource. Results from this study provided important insights into this fishery.

Annual landings of both countries have been increasing since 1970 in response to an increased demand and rising prices of fishmeal. The major

fishing effort of California fishermen occurred mainly during fall and spring months while Ensenada based fishermen fished mainly during the summer. In both fisheries, anchovy fishing was influenced by the absence or presence of other species.

Age composition from both American and Mexican samples were similar, while the size frequencies displayed differences during winter and fall months. Sex ratios of the samples revealed a higher proportion of females among the Mexican samples.

Results indicate the Mexican fishery harvested anchovies from both the southern and central subpopulations. While the exact proportions cannot be ascertained without further study, the major portion was from the central stocks.

## REFERENCES

- Castellanos, C. E. 1975. Listado y código de embarcaciones cerqueras de la Región Noroeste del país. Enero 1975. SIC. Subsecretaría de Pesca INP/SI:i 25:1-14.
- Chavez, H. 1976. Informe de los trabajos efectuados en el Programa Anchoveta. Mem. Prim. Simp. Nac. Rec. Pesq. Mas. Mex., 2:149-157.
- Collins, Robson A. 1971. Size and age composition of northern anchovies, *Engraulis mordax*, in the California reduction and canning fisheries 1968-69 season. Calif. Fish Game, 57(4):283-289.
- Collins, Robson A., and J. D. Spratt. 1969. Age determination of northern anchovies, *Engraulis mordax*, for otoliths. Calif. Dept. Fish and Game, Fish. Bull., (147):39-55.
- Escudero, M., R. M. Olvera, y A. Villamar. 1976. Estimación de la biomasa de reproductores de anchoveta, *Engraulis mordax* Girard, a partir del censo larval en la costa occidental de Baja California, Mexico. (Nov. 1974-Dic. 1975). Mem. Prim. Simp. Nac. Rec. Pesq. Mas. Mex.: 119-130.
- Flores V., M. 1970. Contribución al conocimiento y pesquería de la anchoveta *Engraulis mordax* Girard, 1856. (Tesis Profesional, ENCB-IPN), 80 p.
- Frey, Herbert W. (Ed.) 1971. California's living marine resources and their utilization. State of California, The Resources Agency, Calif. Dept. of Fish and Game, 148 p.
- García, W. 1976. Método de prospección acústica para poblaciones pelágicas. Mem. Prim. Simp. Nac. Rec. Pesq. Mas. Mex., 2:347-358.
- Hjort, J. 1914. Fluctuations in the great fisheries of northern Europe-Herring, Rapports et Proc-Verbaux. Cons. Perm. Intern. Expl. Mar., 20:1-81.
- Jiménez M., R., y L. E. Esparza. 1976. Algunos aspectos sobre la demanda actual y futura de la producción de anchoveta en México. Inst. Nal. de Pesca INP/SI: i 52: 1-41.
- MacCall, Alec, D. 1973. The mortality rate of *Engraulis mordax* in southern California. Calif. Dept. Fish and Game, Mar. Res. Tech. Rept., (4):1-23.
- Mais, Kenneth F. 1974. Pelagic fish surveys in the California Current. Calif. Dept. Fish and Game, Fish. Bull., (162): 1-79.
- . (comp.). 1976. California Department of Fish and Game sea survey cruises, 1975. Mar. Res. Comm., Calif. Coop. Ocean. Fish. Invest., Data Rept., (25):1-22.
- McHugh, J. Z. 1951. Meristic variations and populations of northern anchovy (*Engraulis mordax*). Scripps Inst. Oceanogr. Bull., 6 (3):123-160.
- Melcer, J., y A. Cota. 1976. Pérdida de blancos acústicos y su dependencia en el rango. Mem. Prim. Simp. Nac. Rec. Pesq. Mas. Mex., 2:23-34.
- . W. García, E. Mondragón y A. Cota. 1976. Estimaciones de biomasa y distribución de peces pelágicos con métodos hidroacústicos en la Corriente de California frente a la costa occidental de Baja California. Mem. Prim. Simp. Nac. Rec. Pesq. Mas. Mex., 2:301-344.
- Messersmith, James D., and staff. 1969. The northern anchovy (*Engraulis mordax*) and its fishery 1965-68. Calif. Dept. Fish and Game, Fish. Bull., (147):1-102.
- Olvera, R. M., M. Escudero, y A. Villamar. 1976. Distribución y abundancia de larvas de *Engraulis mordax* Girard, en la costa occidental de Baja California, México (Noviembre 1974-Diciembre 1975). Mem. Prim. Simp. Nac. Rec. Pesq. Mas. Mex., 1:295-313.
- Silva, S., y A. Villamar. 1976. Edad y crecimiento de la anchoveta (*Engraulis mordax*), en aguas de Baja California. Mem. Prim. Simp. Nac. Rec. Pesq. Mas. Mex., 2:159-200.
- Sokolov, V., y M. Wong. 1974. Programa general para las investigaciones de los peces pelágicos del Golfo de California. CEPM., (3):1-51.
- Spratt, Jerome D. 1972. The use of otoliths to separate groups of northern anchovies. Calif. Dept. Fish and Game, Mar. Res. Tech. Rept., (1):1-25.
- Sunada, John S. 1977. Northern anchovy age and size composition, 1974-75 season. Calif. Dept. Fish and Game, Mar. Res. Tech. Rept., (36):21 p.
- . 1978. The northern anchovy fishery for the 1975-76 season. Calif. Dept. Fish and Game, Mar. Res. Tech. Rept. (39): 1-25.
- Villanueva, E., y J. L. Castro Aguirre. 1976. Ensayo de correlación entre diversos parámetros ambientales y larvas de anchoveta (*Engraulis mordax* Girard) en la costa occidental de Baja California, México. Mem. Prim. Simp. Nac. Rec. Pesq. Mas. Mex., 2:109-147.
- Vrooman, Andrew M., and P. E. Smith. 1971. Biomass of the subpopulations of northern anchovy, *Engraulis mordax*, Girard. Calif. Coop. Oceanic. Fish. Invest. Rept., 15:49-51.
- Witeck, Eugene R. 1975. Southern California anchovy reduction fishery, sampling plan review. Calif. Rept. Fish and Game, Mar. Res. Admin. Rept., (75-7):1-28.