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**DIVISION OF FISH AND GAME OF CALIFORNIA
FISH BULLETIN No. 25**

Fishing Areas Along the California Coast For the Sardine (*Sardina caerulea*)¹



By
the
CALIFORNIA STATE FISHERIES LABORATORY

¹ The California sardine has been separated generically from the European and called *Sardinops caerulea* by Carl L. Hubbs (Proceedings, California Academy of Sciences, Vol. 18, pp. 261–265, 1929).

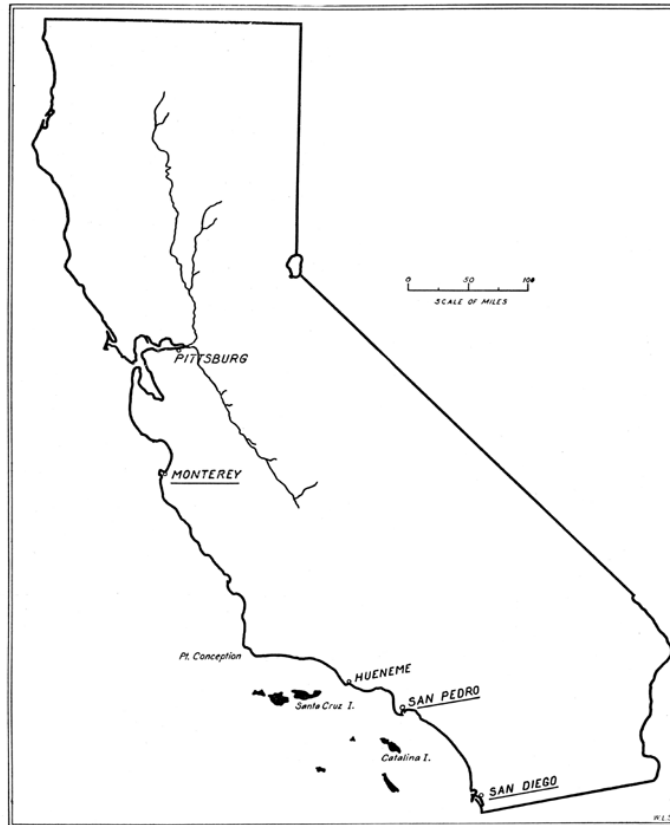


FIG. 1. Outline map of California to show the location of the sardine canning sites of the state. The three names underlined are the most important in the sardine industry.

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1. Introduction

By W. L. SCOFIELD

1.1. SIGNIFICANCE OF CATCH LOCALITY RECORDS

It is the purpose of this bulletin to record the sardine fishing localities off the California coast. This fishery was of minor importance before the World War but during the last twelve or fourteen years it has had a phenomenal growth, so that it now occupies the position of major importance among the fisheries of the state. A detailed knowledge of the areas fished during this period of development, is an essential to the understanding of this great industry. The all important question as to whether or not there is over-utilization of the supply of sardines can be approached only with a knowledge of what areas have been fished from year to year and what the yield from each area has been. Catch records alone, without considering the areas fished, are of limited value in studies of the abundance of fish. We are therefore presenting these locality records as a preliminary to future discussions resulting from our studies of the sardine supply along the coast of California.

1.2. LOCATION OF CANNERIES

In California the extensive utilization of sardines is the result of canning operations and the fishing grounds are confined to the regions adjacent to the packing plants. As yet, all sardine canneries have located in the southern half of the state but this choice has been only partially determined by fish supply. Certainly the lack of convenient harbors, undeveloped transportation facilities, scattered population, uncertain supply of skilled labor, and lack of factory and boat repair shops north of the Golden Gate have been contributing factors in confining the location of canneries to the southern portion of the state.

The five points along our coast at which sardines are utilized for canning are, in order of their importance, Monterey, San Pedro, San Diego, Pittsburg, and Hueneme. (See figure 1.) Monterey and San Pedro are the chief canning centers utilizing the larger sized sardines. San Diego packs small sardines principally and only limited amounts of the large sizes. Beginning with the 1925–1926 fishing season, one cannery at Pittsburg on upper San Francisco Bay (Suisun Bay) has packed large sizes. In the fall of 1929 a new sardine packing plant opened at Hueneme (near Oxnard, Ventura County). A new cannery at Newport (Orange County) opened in the fall of 1929 but packed only mackerel during its first season.

1.3. FISHING AREAS SUPPLYING THE PITTSBURG AND HUENEME PLANTS

The fishing boats supplying the cannery at Pittsburg seldom attempt to make catches in San Francisco Bay, the area which furnished the fish for the first sardine packing establishment on the Pacific Coast.

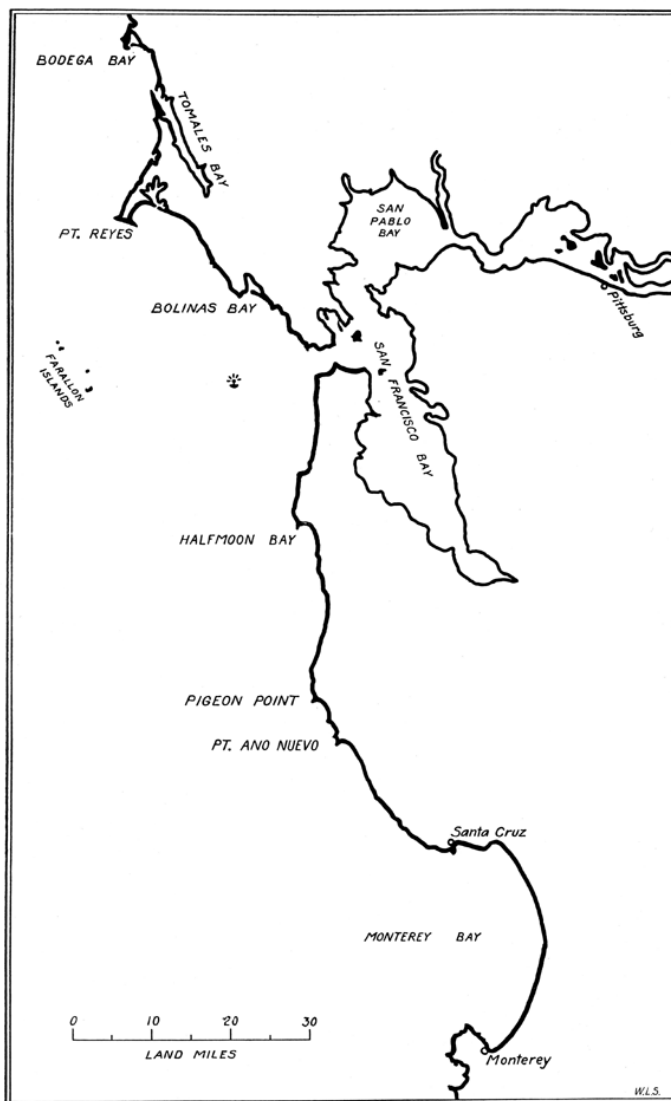


FIG. 2. Map of the fishing area covered by boats supplying the Monterey and Pittsburg canneries.

FIG. 2. Map of the fishing area covered by boats supplying the Monterey and Pittsburg canneries

The Pittsburg lampara boats fish in the open sea outside the Golden Gate, chiefly between San Francisco and Point Reyes. A few catches are taken a little to the north of Point Reyes and occasional trips are made south to Halfmoon Bay. (See figure 2.)

The boats operating for the Hueneme plant are usually successful in making their catches within a few miles of Hueneme Point, and during their first fishing season confined their activities to the Santa Barbara Channel.

The catch localities for the three fishing ports of Monterey, San Pedro and San Diego are described in detail in the following pages of this bulletin.

1.4. ACKNOWLEDGMENTS

Our program for the investigation of the California sardine industry includes sampling the commercial catch of the three chief fishing centers at frequent and regular intervals. At the time of sampling, the field investigator questions the captain or other crew member of the boats from which fish samples are taken and obtains detailed information concerning the boat catch, including locality where net hauls were made. These records of the time, place and tons of catch for each seine haul are of increasing worth as they accumulate and have been of great value in this locality study as well as in other of our investigations. We are now able to reap benefits from the conscientious effort expended by our field investigators during past years. The rainy midnight hours at the canneries were not spent in vain. We feel deeply indebted to the former and present staff members who gathered the data which form the basis for this publication. Their names are given in table 1. To this list there should be added the name of Mr. H. B. Holmes, who cooperated with Mr. Higgins in the sampling at San Pedro for the 1920-1921 fishing season. We appreciate the work of Miss Annie Gillespie in draughting many of the graphs here published and gratefully acknowledge the assistance of Miss Kathryn Karmelich in correcting, typing and proof reading manuscripts.

TABLE 1

Sardine Sampling, Giving Locality, Date and Name of the Field Worker who Collected and Measured Representative Fish Samples Taken from the Commercial Catch

MONTEREY			
O. E. Sette.....	November 1919-March	1920	
W. L. Scofield.....	November 1920-December	1924	
W. A. Selle.....	January 1925-September	1925	
R. F. Classic.....	October 1925-March	1926	
C. B. Andrews.....	July 1926-March	1927	
S. S. Whitehead.....	May 1927-March	1928	
M. J. Lindner.....	August 1928-August	1929	
J. B. Phillips.....	September 1929-February	1930	
SAN PEDRO			
Elmer Higgins.....	December 1919-April	1923	
H. H. Greene.....	January 1924-April	1924	
G. A. Rounsefell.....	October 1924-February	1925	
J. A. Craig.....	March	1925	
C. B. Andrews.....	October 1925-March	1926	
V. G. Russell.....	October 1926-May	1927	
L. E. Herz.....	September 1927-May	1928	
D. H. Fry, Jr.....	October 1928-May	1929	
R. S. Croker.....	November 1929-March	1930	
SAN DIEGO			
S. S. Whitehead.....	May 1926-April	1927	
H. C. Godsil.....	January 1928-April	1930	

TABLE 1

Sardine Sampling, Giving Locality, Date and Name of the Field Worker who Collected and Measured Representative Fish Samples Taken from the Commercial Catch

CALIFORNIA STATE FISHERIES LABORATORY.
June, 1930.

2. Fishing Localities at Monterey from November, 1919, to March, 1929, for the California Sardine (*Sardina caerulea*)¹

By MILTON J. LINDNER

2.1. GENERAL

The sardine fishing at Monterey is no longer confined to local waters as it was until the season of 1924–1925. Beginning with 1924–1925 the seining area extended gradually northward until in 1928–1929 the boats fished as far as Halfmoon Bay, a distance of about seventy miles northwest from Monterey. Previous to the 1924–1925 season the netting was restricted to Monterey Bay, a lyre-shaped bight twenty-three miles from point to point, and by far the greater portion of the fishing was performed in the waters near the town of Monterey.

The expansion of the fishing grounds has been to the north only, and not to the south. The chief reason why there has been no southern fishing, according to the fishermen, is that below Point Pinos occur "bad currents" which jam the wings of the net together making it impossible to impound the sardines. Also, when fish are scarce within the bay the boatmen are fairly certain of making a haul if they will go to the north, while to the south they would be in unexplored waters as far as sardine seining is concerned; and they are unwilling to take this chance with the possible loss of a night's work.

Every evening during the fishing season the boats leave the port of Monterey and start their search for the schools of sardines, which are detected by large, pale luminescent areas in the darkened waters. The method of finding the schools by the luminescence they cause makes fishing difficult in the day time or through the full moon period; hence, the netting is done only at night and during the dark of the moon. When the extent of the school, its movements, and the direction of the wind and currents have been determined to the satisfaction of the captain, the net is cast and the haul is made. After the boats have secured their quota of sardines for the night they head back towards the canneries of Monterey to unload their fares.

Until November, 1921, there was a cannery at Santa Cruz, but the quantities unloaded at that port were of little consequence in comparison to the Monterey landings. (See ^{table 2}) With the closing of the Santa Cruz plant the main receiving stations for the sardines have been the canneries of Monterey, located in the cove on the southern portion of the bay, although a few hundred pounds have been brought each year to the fresh fish markets of both Monterey and Santa Cruz.

¹ Contribution No. 97 from the California State Fisheries Laboratory, March, 1930.

TABLE 2
Monthly Sardine Landings in Tons at the Port of Monterey

Month	Seasons									
	1919-20	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	1926-27	1927-28	1928-29
June.....	1,040	765	380	8	727	17	391	1	1,393	64
July.....	4,593	808	471	707	2,236	673	2,200	69	6,141	19
August.....	6,551	5,996	2,945	3,296	2,556	9,063	12,944	3,030	10,871	21,673
September.....	4,474	6,313	2,689	3,842	8,838	11,017	13,376	15,680	22,914	24,942
October.....	4,994	4,580	1,982	5,046	7,281	8,866	3,150	15,877	6,630	17,072
November.....	4,694	3,785	3,010	4,095	6,397	8,591	7,805	9,497	950	2,172
December.....	5,921	1,842	2,127	2,659	4,922	7,577	1,002	4,485	6,840	4,261
January.....	6,465	146	1,825	4,943	6,045	8,922	10,522	15,526	9,760	14,827
February.....	3,200	293	825	4,168	5,920	9,477	9,900	9,027	27,544	21,284
March.....	1,071	301	3	169	872	3,039	8,491	2,967	2,946	13,592
April.....	21	112	12	13	71	33	12	233	10	51
May.....	13	15	19	261	53	38	17	467	21	38
Totals.....	43,037	24,956	16,288	29,207	45,918	67,313	69,810	76,859	99,020	120,295

TABLE 2
Monthly Sardine Landings in Tons at the Port of Monterey

TABLE 3
Monthly Sardine Landings in Tons at the Port of Santa Cruz

Month	Seasons			
	1919-20	1920-21	1921-22	1922-29
June.....	48			Small catches of two or three hundred pounds a month for bait purposes
July.....	142	165		
August.....	524	530	620	
September.....	355	742	738	
October.....	640	742	635	
November.....	385	636		
December.....	284	183		
January.....	493			
February.....	200			
March.....				
April.....				
May.....				
Totals.....	3,071	2,978	1,993	

TABLE 3
Monthly Sardine Landings in Tons at the Port of Santa Cruz

2.2. SOURCE AND RELIABILITY OF MATERIAL

The locality records upon which this work is based are those obtained from the reports made by the "sampler" for each boat that he samples.² The sampler's information is gained by questioning the captain or member of the crew who comes ashore to assist in unloading the fish. A record is made of the general position and the distance offshore in which the sardines were caught. The fishermen determine their location by the direction traveled and the length of time required to arrive at the fishing grounds, or, if the night is clear, by the lights of the surrounding towns, beacons, etc., and by the contour of the shore line. The crews know fairly accurately the speed with which their boats will travel under the various weather conditions encountered, enabling them to determine the distance they had to go for the sardines.

The data are as reliable as may be expected from the answers of the men and from their methods of determining distances at night. The

² The samples are gathered for studying the size of the sardines caught commercially for the canneries. Samples were taken daily until July, 1923, when work done by Sette showed that semi weekly samples of 5 boats each were sufficient to give the required data. See Fish Bulletin No. 11 (1926) of the Fish and Game Commission of California, Part II, "Sampling the California Sardine: A Study of the Adequacy of Various Systems at Monterey," by O. E. Sette; and for a more detailed discussion of the notes obtained by the sampler, see page 197 of the same publication, Part V, "The Sardine at Monterey: Dominant Size-classes and their Progression, 1919-1923," by W. L. Scofield.

inshore catches and those near Monterey, obviously, are more accurate than the ones farther from port and farther offshore, which may, in some cases, be in error as much as three miles. Whenever any doubts occurred concerning the validity of the place of seining of a fare, this boatload was eliminated from the material used.³ (See table 4.)

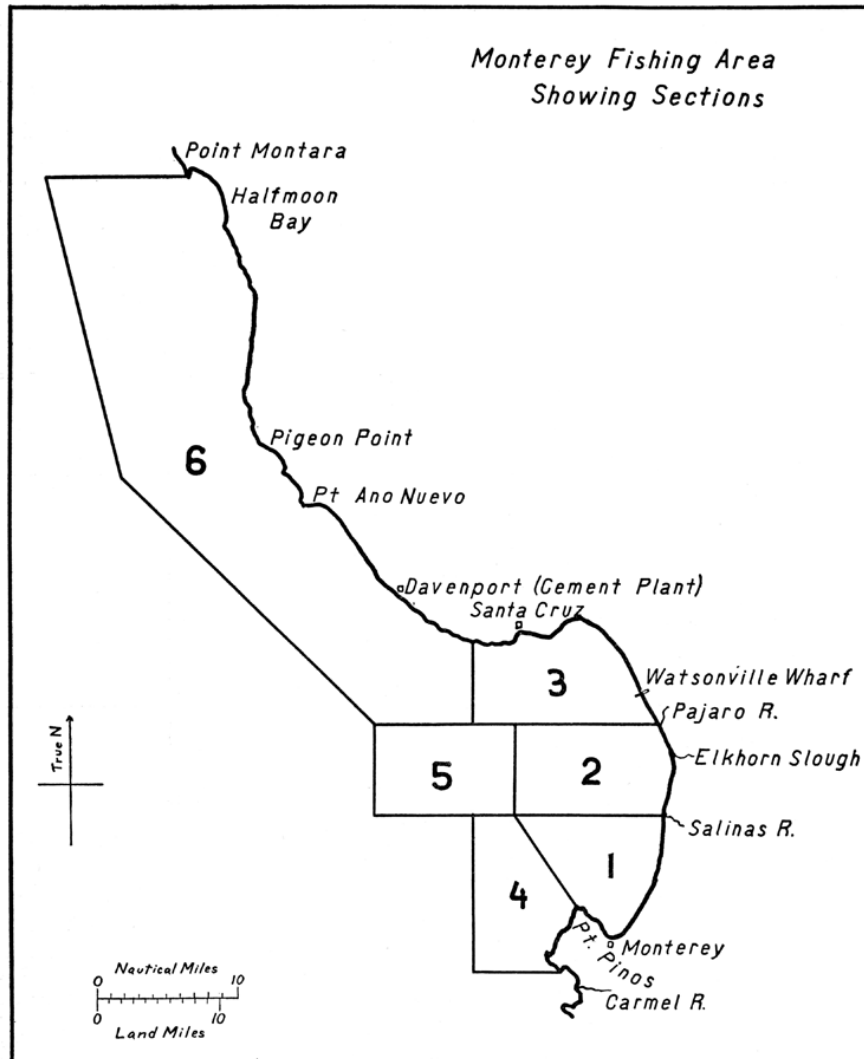


FIG. 3. Entire Monterey fishing area divided into six sections for convenience in handling the data. The sections include the localities of all the catches, for which we have records, from November, 1919, to March, 1929.

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The fishing localities used in this paper are those for the Monterey sardine crews only, as there were no data available for the small Santa Cruz fleet. Furthermore this account deals only with the fishing localities

³ A boat usually makes more than one haul a night, sometimes 10 or 12, but most frequently from 2 to 5. Whenever these were made in different places, the position of the one yielding the greatest tonnage was taken as the fishing locality of that boat for the night. See page 54 of Fish Bulletin No. 19 (1929) of the Division of Fish and Game of California, "Sardine Fishing Methods at Monterey, California," by W. L. Scofield.

ties from November, 1919, when the sampling of the commercial catch was started, until March, 1929, the end of the 1928–1929 season.

2.3. BOATS AND GEAR

The number of boats fishing sardines at Monterey has increased rapidly—from 25 in the 1919–1920 season to 61 in 1928–1929, a rise of 244 per cent in 10 years. With the addition in the number of crews there has come also an increase in the size and capacity of the boats.⁴

The majority of craft fishing throughout this period used the lampara (Italian round haul) type of net. Occasionally a crew used a ring lampara, but without much success. In 1926, two purse seine boats were introduced. These were larger than the lampara and could travel greater distances with less expense since they were equipped with diesel engines, while the lampara fleet had mainly gas engines. Another advantage possessed by the purse seiner was that it carried the catch in the hold, while the lampara boat being much smaller was hampered with the towing of a lighter.

2.4. DIVISION OF FISHING AREA INTO SECTIONS

In order to facilitate the handling of the data and to minimize the errors in the exact locations of the catches, the entire fishing area was divided into six sections. (See figure 3.) The sections include the localities of all the catches for which we have records, and there is little probability of many of the catches having been made outside these boundaries during the period covered by this report. The sections were chosen to show the changes that occur in fishing localities within a season and from year to year; therefore they are not of equal dimensions. Each of the sections 1 to 5 cover roughly 85 square miles of water, while section 6 covers about 570 square miles. The relatively small amount of fishing done in section 6 made it unnecessary to subdivide this great expanse into smaller divisions. Sections 1, 2 and 3 were constructed so as to include all of Monterey Bay.

2.5. OMISSION OF THE 1920–1921 SEASON

The 1920–1921 season has been omitted from all of the following calculations as its use would cause unnecessary complications in the interpretation of the data. This season varied greatly from the ordinary, due to post-war economic conditions that affected all branches of industry. (See figure 4.) After the previous year's hold-over orders had been filled, the canneries operated only for short periods, packing just enough fish to supply the immediate demands of the market, which resulted in a small total catch. By far the greater part of the fishing was done at the first of the season; *i.e.*, from August to December, 1920; and since samples were taken from November, 1920, till March, 1921, there were more recorded during November and December than in January, February and March, which gave undue weight to the November and December data. Throughout these two months the "period of scarcity" appears in the Monterey fishery, necessitating the boatmen going farther for the sardines at this time than at any other stage of the year. The overweighting given to this period made the data for the 1920–1921 season much out of proportion to what they should have been.

⁴ A complete description of the vessels and nets used in sardine fishing and the modifications that have occurred in both may be found in Fish Bulletin No. 19.

These abnormalities could be eliminated to a great extent by a complicated system of weightings; but in a presentation such as this it was deemed better to use actual data and omit this season from the calculations.

2.6. EARLY FISHING LOCALITIES

We have no records of the fishing localities previous to November, 1919, but some of the fishermen say that prior to this year, when the industry was in its infancy, they sometimes worked in the open ocean off Monterey Bay.⁵ This does not indicate that there was a scarcity of sardines in the early years; rather it designates the poorly developed methods of locating the schools. The netting was performed during both the night and the day with neither method well understood as there were few boats and nearly all the crews were composed of men who were

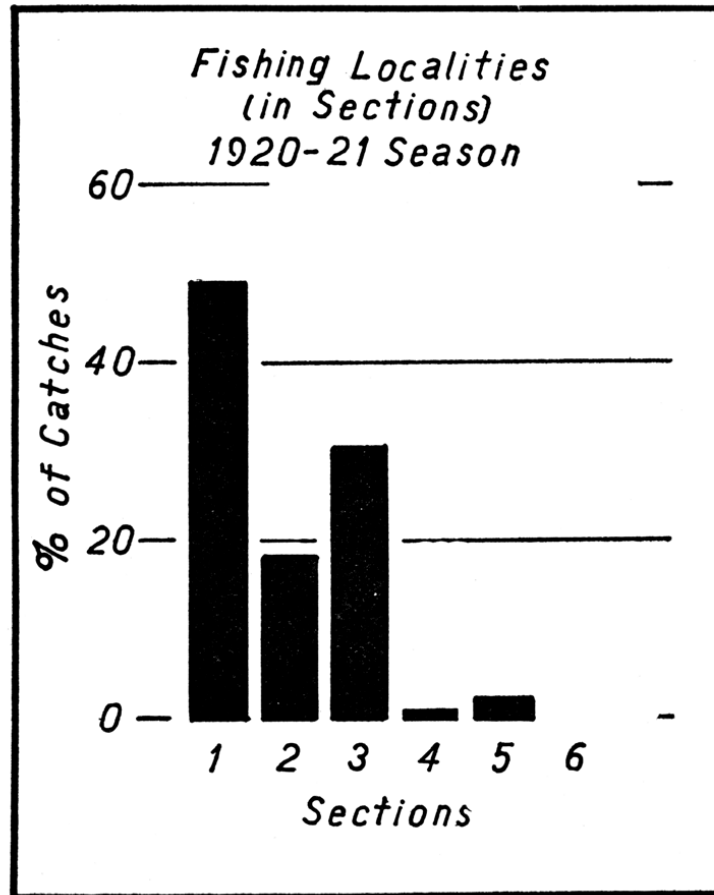


FIG. 4. Monterey fishing localities by sections for the 1920–1921 season. Comparison with figures 9 and 13 shows the irregularities of this season. (Note: The 1920–1921 season has been omitted from all of the following figures except figure 13.)

novices at this sort of fishing. After several years (about 1919) the day seining was discontinued.

The increase in the number of vessels has also enhanced the facility with which schools are located. The boats cruise around with lights doused until one makes a catch. The brailing lights of this successful netter are then turned on to enable the scooping of the fish from the net into the lighter. The other boats, upon seeing the light, know that a haul has been made; hence they immediately head towards it, as it may mean the presence of a school of fish and a possible catch. With this method of fishing the more crews out on any given night the better the

⁵ See page 9 of Fish Bulletin No. 19.

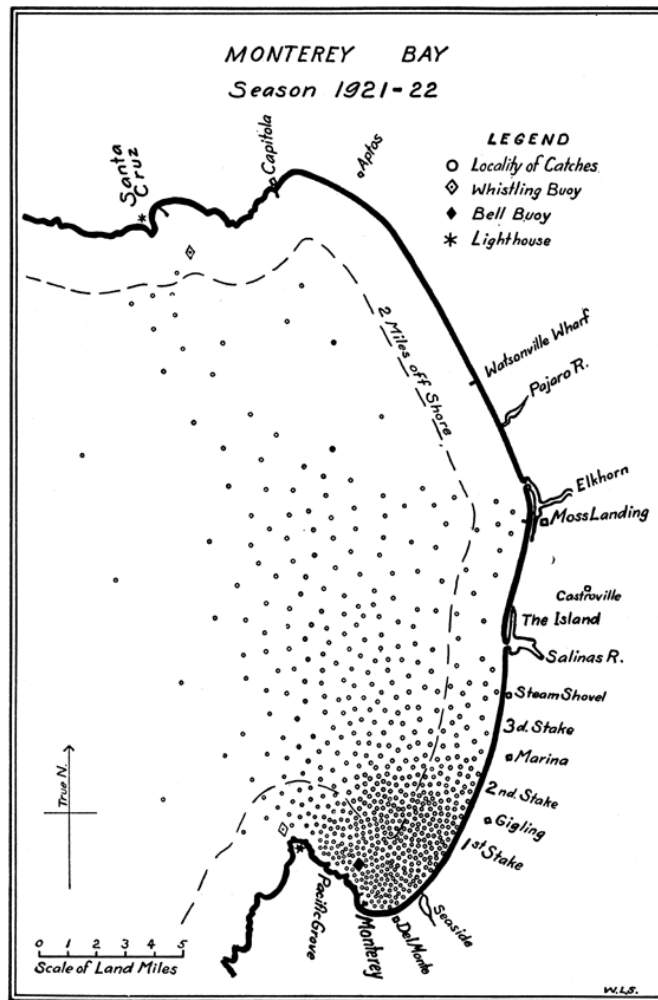


FIG. 5. Fishing localities for 1921-1922 season. This season is typical for the 1919-1924 period. Few catches were made outside the boundaries of Monterey Bay, and few on the Santa Cruz side of the bay. Most of the catches were concentrated within 5 miles of Monterey. Compare with figure 6 for contrast with later years. (From Scofield, W. L. Sardine Fishing Methods at Monterey, California. Division of Fish and Game of California, Fish Bulletin No. 19, Fig. 3, 1929.)

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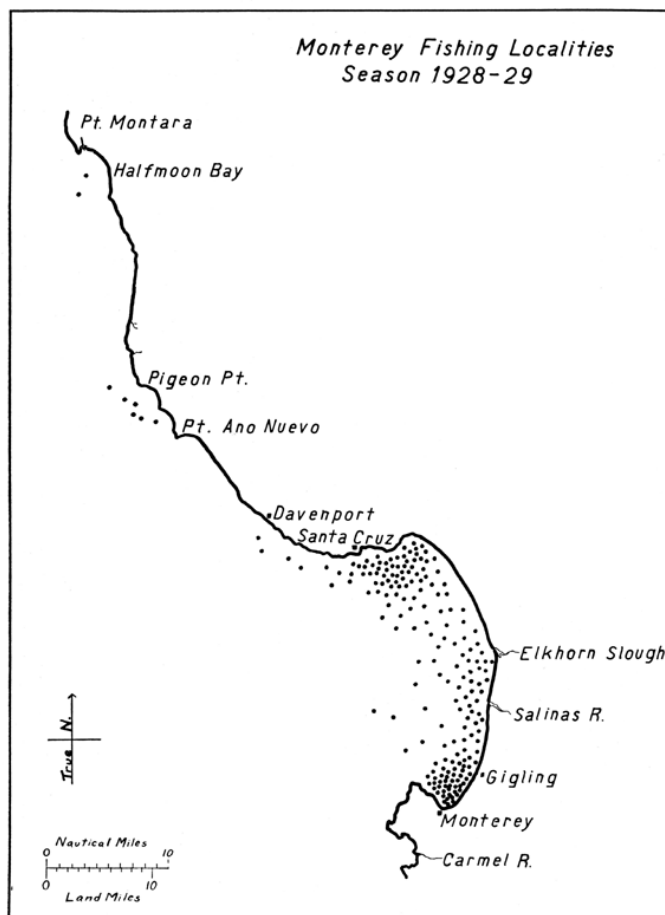


FIG. 6. Fishing localities for the 1928-1929 season showing spread of catches over all of Monterey Bay and north along the coast to Halfmoon Bay. The fishing has not extended south of Monterey, as may be seen by comparing with figure 5. Each dot represents the fishing locality of a boat from which samples were taken.

FIG. 6. Fishing localities for the 1928-1929 season showing spread of catches over all of Monterey Bay and north along the coast to Halfmoon Bay. The fishing has not extended south of Monterey, as may be seen by comparing with figure 5. Each dot represents the fishing locality of a boat from which samples were taken

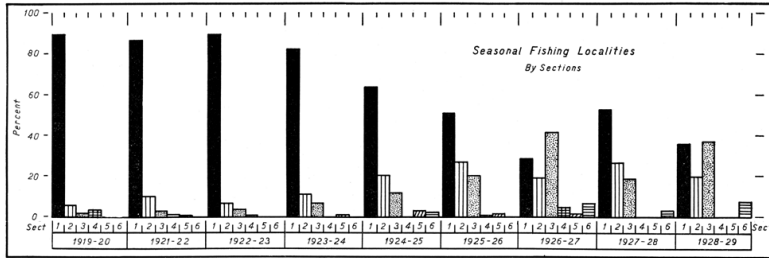


FIG. 7. Seasonal fishing localities for Monterey by sections. Until 1923-1924 over 80 per cent of the fishing was performed in section 1. Section 3 shows the greatest increase in fishing.

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chances of finding a school, for 61 boats can cover a larger area in a given time than can 25.

2.7. THE MONTEREY FISHERY PERIOD, 1919–1924

The time between November, 1919, and March, 1924, may be called the "Monterey Fishery Period," for throughout these years the seining was done almost entirely within the bay⁶ and nearly ninety per cent of the catches were made within ten miles of Monterey. The schools were plentiful and the fishermen had become acquainted with the methods required to capture them. There were sufficient quantities of sardines in the waters near Monterey to supply the demand, making it unnecessary for the fleet to travel far for catches, which were usually small because of the limits imposed by the canneries.⁷

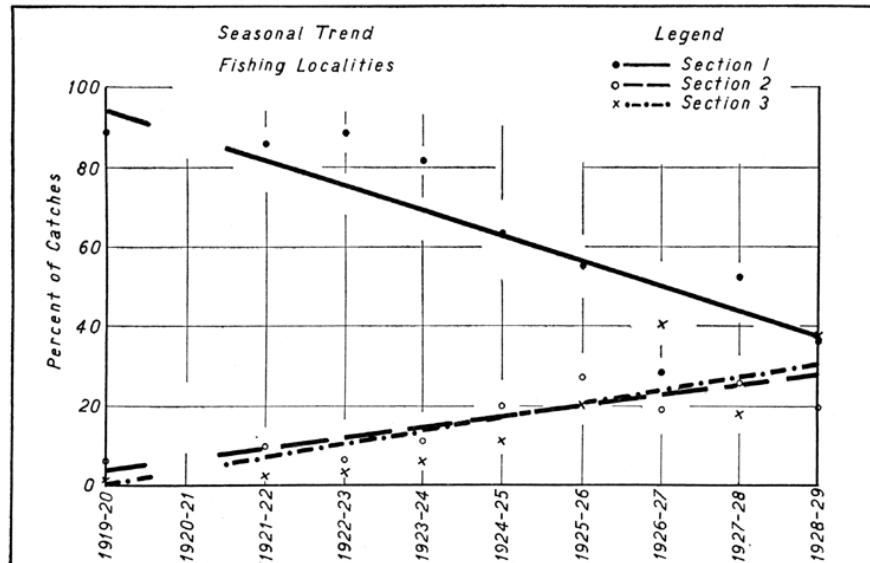


FIG. 8. Seasonal trend of fishing performed in sections 1, 2 and 3. Line fitted by eye.

FIG. 8. Seasonal trend of fishing performed in sections 1, 2 and 3. Line fitted by eye

The 1921–1922 season may be taken as exemplifying this period. As will be noted from the map (see fig. 5) the great majority of the catches were made in the cove near the town of Monterey, while very few fares were taken in the waters around Santa Cruz or outside the boundaries of the bay.

2.8. THE MONTEREY-SANTA CRUZ FISHERY PERIOD, 1924–1929

Beginning with 1924–1925, the Santa Cruz portion of the bay and the coast from Santa Cruz north to Halfmoon Bay has been increasing gradually in importance as a sardine fishing area. The records show that for two seasons (1926–1927 and 1928–1929) there were more catches made in section 3 than in any other section, which indicates that for

⁶ With the exception of a few loads taken outside of the bay in the proximity of and a few miles to the south of Point Pinos, *i. e.*, section 4. A few catches were made in section 5, which is also outside the bay.

⁷ The canneries could pack only a definite amount of fish each day, and in order to insure against more than they could handle a fixed limit for each boat was imposed by the canners. The limits between 1919 and 1924 were comparatively small, ranging from 5 to 25 tons per night with 15 tons the customary amount. On occasions no limits were placed on the boats (usually during the period of scarcity) allowing them to bring in all the fish that they could catch. For a more thorough discussion of cannery limits see Fish Bulletin No. 19, pages 56–59.

these two years there were probably more fish available to the fishermen on the Santa Cruz side of the bay than on the Monterey side.

This extension in distance from Monterey of the fishing localities has been caused by the failure of the local waters to furnish the tonnages needed by the growing industry. The rapidly increasing annual demand required more fish than could be supplied by local areas; hence the gradual spreading of the boats to more distant grounds. (See figs. 7 and 8.) Obviously, if the local sections could provide the necessary amounts of fish, there would be no need on the part of the seiners to search out other fishing places.

The 1928–1929 season is typical for this period. (See fig. 6.) Contrasted with 1921–1922 (see fig. 5) there is shown a decided change in fishing localities, from a concentration within 5 miles off Monterey to a general fishery over the entire bay and on up the coast to Halfmoon Bay. In other words, the seining area has been spreading gradually to the north, until during 1928–1929 the loads taken extended from Monterey to Halfmoon Bay, a distance of about 70 miles.

2.9. CHANGE IN FISHING LOCALITIES WITHIN A SEASON

The fishing season, as far as catch localities are concerned, may be divided into three parts: the summer, fall and winter periods, respectively. (See figs. 10, 11 and 12.) During the summer months the sardines are caught close to Monterey and as the season progresses they are caught farther and farther away, until in November and December most of the fishing is done around Santa Cruz and north along the coast in the open ocean. Usually around the middle of January the seining comes back into the bay proceeding in the direction of Monterey, until in February most of the fishing is done within 5 miles of the town.

These changes in fishing grounds do not come at precisely the same time each season, nor are they as evident in the earlier years as in the later. (See fig. 9.) They are apparently caused by the relative abundance of available fish in the bay at different times of the year. Evidently during the summer there is a large supply of small fish in the bay and as the season progresses these either leave or are fished out (probably both are concurrent factors) causing the boats to go constantly farther for their loads. Then in the latter part of December or in early January there occurs an influx of large winter stock into Monterey Bay. With the coming of these large sardines the bay is replenished and the fishing is again carried on near Monterey.

As may be gathered from the preceding paragraph, the three locality periods are closely correlated with the sizes of sardines caught at Monterey.⁸ Throughout the late summer and early fall the fish average about 8½ inches (210 mm.) in body length. Then comes the transitional period of late November, December and early January when they are mixed in size, both the small summer and large winter specimens are caught. During the latter part of January, all of February, and most of March the large winter ones appear. These average about 9½ inches (235 mm.) in body length.

⁸ Fish Bulletin No. 13 (1928) of the Division of Fish and Game of California, "The Seasonal Average Length Trends at Monterey of the California Sardine (*Sardina caerulea*)," by Carroll B. Andrews.

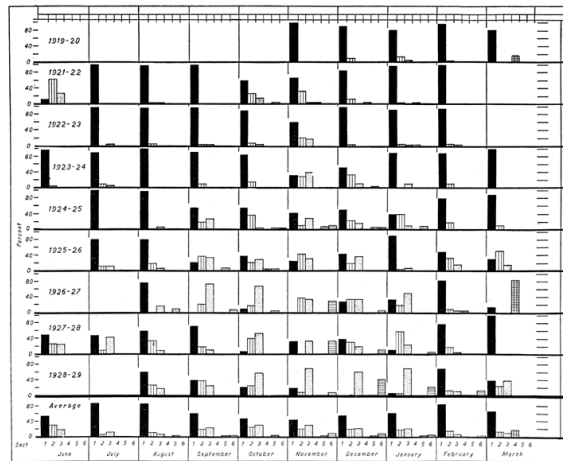


FIG. 9. Seasonal fishing localities at Monterey by months, plotted in monthly percentage of catches for each section. This figure illustrates three characteristics of the Monterey sardine fishery.

1. The period of scarcity, with the peak in November, has been increasing since 1922-1923. This may be followed most readily by noting the height of the black bars (section 1) for each successive year.
2. The fishing is carried on near Monterey (section 1) during the first of the season (August) and during the last of the season (February).
3. The appearance and disappearance of the period of scarcity is more or less gradual. (See average of 9 seasons.)

FIG. 9. Seasonal fishing localities at Monterey by months, plotted in monthly percentage of catches for each section. This figure illustrates three characteristics of the Monterey sardine fishery

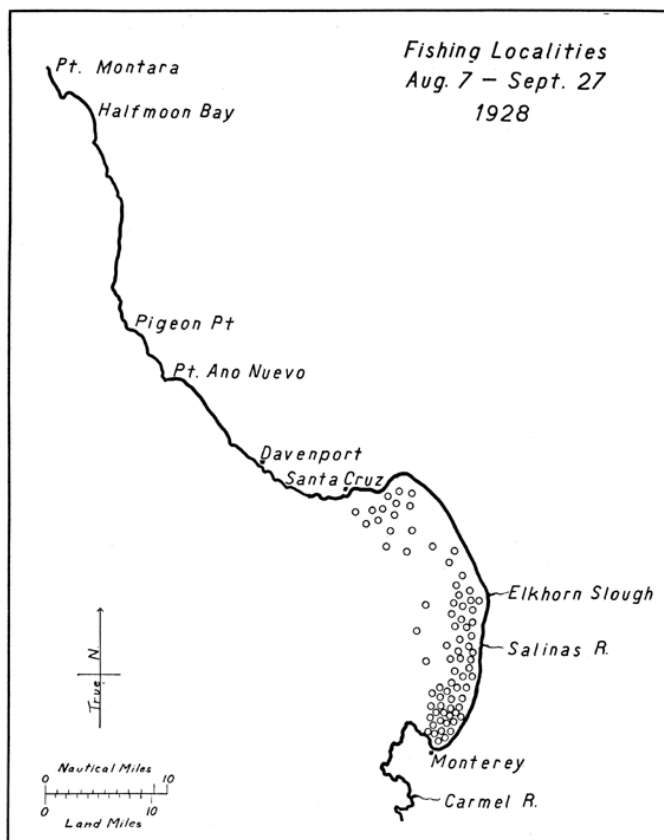


FIG. 10. Monterey catch localities during the summer period of 1928. The fishing was carried on within the confines of Monterey Bay and most of it near the town of Monterey. This indicates the portion of the season in which smaller fish are captured. Each circle represents the fishing locality of a boat sampled.

FIG. 10. Monterey catch localities during the summer period of 1928. The fishing was carried on within the confines of Monterey Bay and most of it near the town of Monterey. This indicates the portion of the season in which smaller fish are captured. Each circle represents the fishing locality of a boat sampled

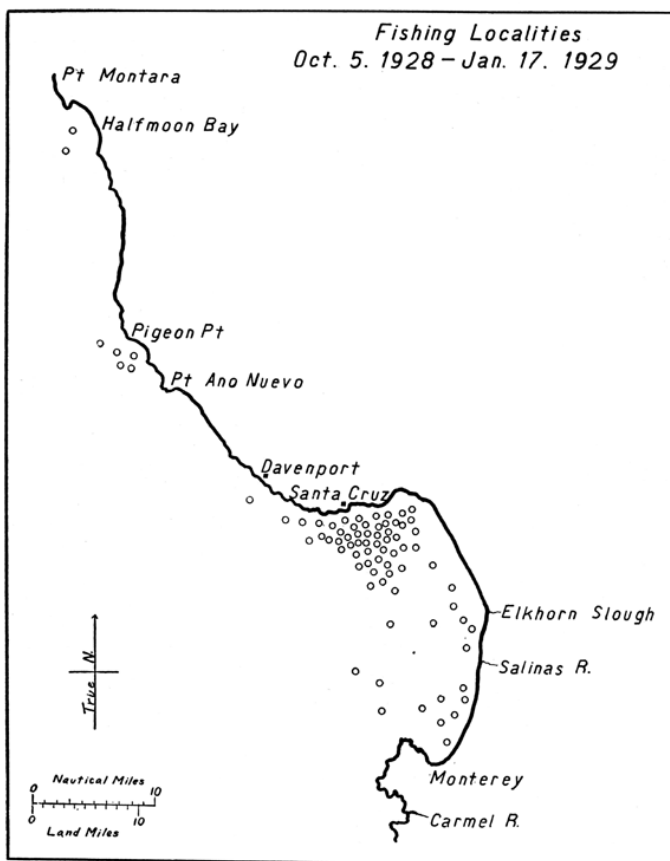


FIG. 11. Monterey catch localities during the period of scarcity. The fishing is concentrated near Santa Cruz with only a few catches made near Monterey. Since the boats anchor at Monterey they necessarily pass through the waters that yielded vast amounts of fish in the summer period (fig. 8), but this same area appears barren throughout the period of scarcity.

FIG. 11. Monterey catch localities during the period of scarcity. The fishing is concentrated near Santa Cruz with only a few catches made near Monterey. Since the boats anchor at Monterey they necessarily pass through the waters that yielded vast amounts of fish in the summer period (fig. 8), but this same area appears barren throughout the period of scarcity

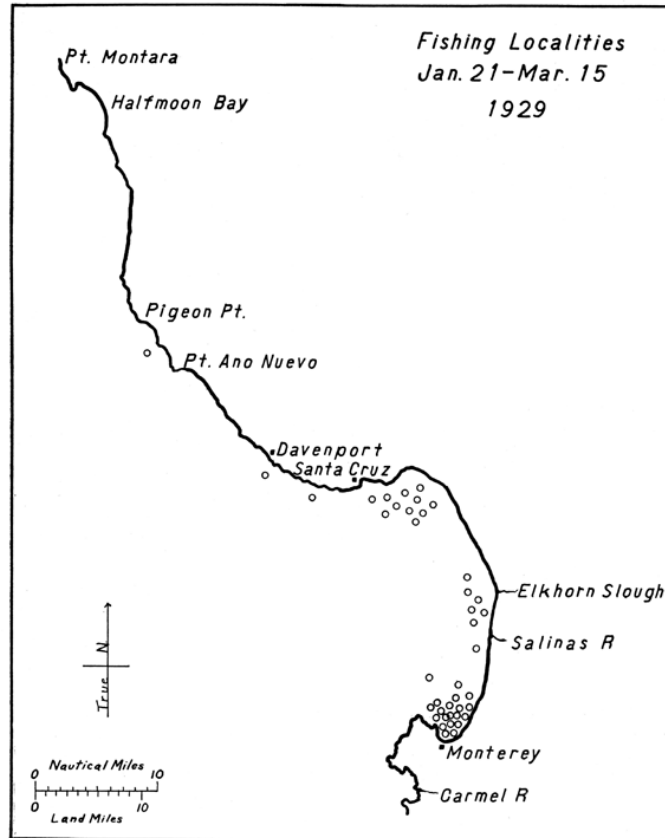


FIG. 12. Monterey catch localities January 21-March 15, 1929. The fishing has again returned to the southern portion of Monterey Bay. The localities are fairly similar to those of the summer fishery (fig. 10), and they represent the fishing grounds for the large winter sardines.

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2.10. EXTENSION OF PERIOD OF SCARCITY

The period of scarcity, which occurs throughout the late fall and early winter months, is that portion of the season when the sardines apparently are not plentiful within Monterey Bay. The peak of this period comes either in November or December during which time there is a stage of several weeks duration when hardly any fish are caught within the bay, and almost all the hauls are made north of Santa Cruz in the open ocean.

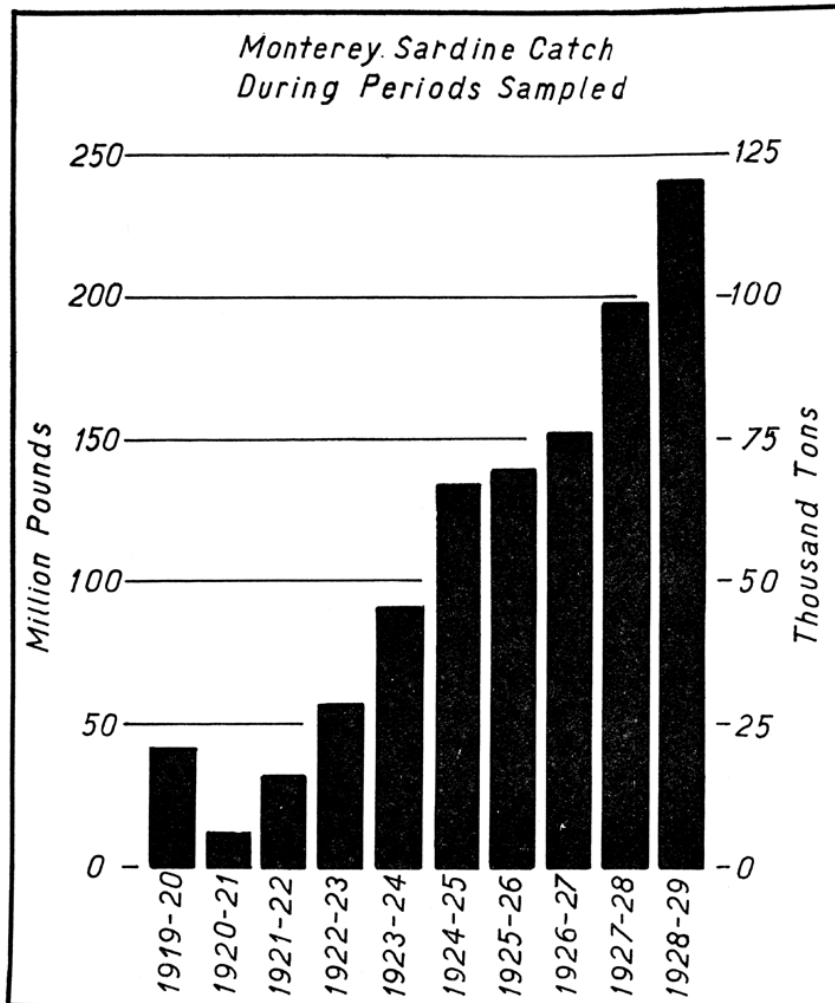


FIG. 13. Sardine landings at the port of Monterey during the periods in which samples were taken. Note the post-war slump of 1920-1921 and the succeeding increase in seasonal catches. The time covered by the samples may be secured from table 4.

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Usually there is not a sudden disappearance of the fish but a more or less gradual diminution. (See fig. 9.)

As stated above, this dearth is preceded by an abundance of small fish which seem to disappear gradually causing the period of scarcity.

This is broken by the appearance of large winter sardines in the bay and the surrounding waters.

The period of scarcity, as indicated by the proportion of catches in section 1, has been increasing in proportions each season; from 1921–1922, when there was a slight indication of it in October and November, until 1928–1929, when it extended from October until January. (See fig. 9.) This expansion is caused, most probably, by the great growth in the annual catch, and by the failure of the local fishing grounds to meet a drain of such magnitude, making it necessary for the fishermen to take more distant voyages. Depletion may also be a factor in this great extension of fishing operations.

2.11. TONNAGE FROM SECTION 1

The total poundage of sardines brought into Monterey has climbed rapidly since the post-war slump of 1920 and 1921. (See fig. 13.) But

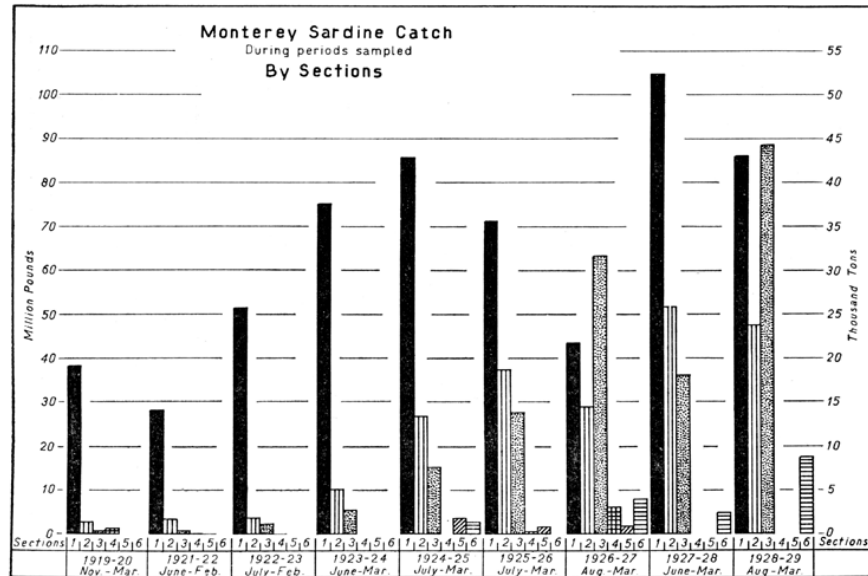


FIG. 14. Monterey sardine catch by sections during the periods covered by the samples. Notice the great increase in catch made in section 3. Compare with figure 15.

FIG. 14. Monterey sardine catch by sections during the periods covered by the samples. Notice the great increase in catch made in section 3. Compare with figure 15

interestingly enough, the take in the waters near Monterey has not grown in the same degree as the total catch.⁹ In spite of the great growth in fishing gear and effort, the tonnage netted in section 1 has remained fairly constant since 1923–1924. (See fig. 15.) The increase in annual landings has been due largely to the exploitation of more distant grounds. This indicates that, with the present methods of operating and with the present supply of fish, section 1 can furnish only between thirty thousand and fifty thousand tons of sardines each season. If more than this amount is desired a greater area is needed in which to work; hence the expansion of the fishing grounds each succeeding year.

⁹ The tonnages for each section were obtained by multiplying the percentage of the catches made in the various sections by the total amount of sardines landed at Monterey each year during the time covered by the samples.

2.12. 1929–1930 SEASON

A striking change in fishing methods was brought forth in the 1929–1930 season at Monterey. The success of the purse seiners throughout the period of scarcity of the previous year paved the way for the introduction of a large fleet of these vessels. The larger size, greater cruising radius, and lower operating expense enabled these ships to search out more distant fishing grounds than could the smaller, gasoline-propelled, lighter-towing, lampara type. Along with the introduction of the purse seine fleet a change occurred in the kind of net used by the lampara

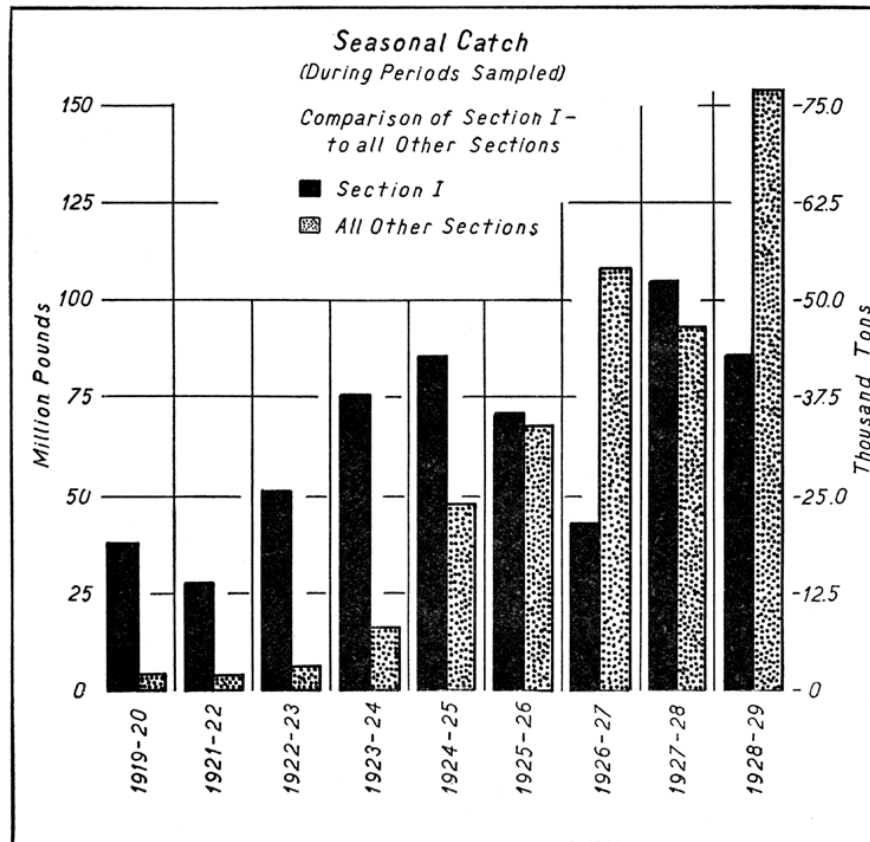


FIG. 15. Comparison of seasonal catch of section 1 with the combined seasonal catches of the other five sections. The great increase in annual catch as shown in figure 13 has been caused mostly by an augmented catch in the combined sections rather than by an increased yearly tonnage from section 1

FIG. 15. Comparison of seasonal catch of section 1 with the combined seasonal catches of the other five sections. The great increase in annual catch as shown in figure 13 has been caused mostly by an augmented catch in the combined sections rather than by an increased yearly tonnage from section 1

boats. These smaller craft rapidly converted their nets into purselamparas,¹⁰ because this latter was more successful than the lampara.

According to Phillips,¹¹ who conducted the sampling at Monterey for the 1929–1930 season, purse seine boats from Monterey occasionally fished as far north as Point Reyes, which is about 120 miles north of Monterey, while Halfmoon Bay and the Farallon Islands were frequent

¹⁰ The type of ring-lampara has changed considerably since 1919. This net is still in the process of evolution.

¹¹ Fish Bulletin No. 23 of the Division of Fish and Game of California, "Success of the Purse Seine Boat in the Sardine Fishery at Monterey, California (1929–1930 Fishing Season)," by J. B. Phillips, 1930.

seining grounds. These were unheard of distances in the old days of gasoline-engined lamparas.

2.13. SUMMARY

1. To meet the increased demand for sardines the fishing area at Monterey has been expanding to the north each year.

2. A period of scarcity in Monterey Bay sardine fishing appears every year throughout the late fall and early winter months.

3. This period of scarcity has been increasing in duration since the 1921–1922 season.

4. Although there has been an augmentation in the fishing effort and gear, the quantity of sardines taken from section 1 has remained fairly constant since the 1923–1924 season.

TABLE 4
Table of Boats Sampled at Monterey, Showing Catch Localities

	Number of catches sampled						Total monthly sample
	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	
1919-20—							
November.....	11						11
December.....	1	1					12
January.....	36	6	2				44
February.....	44	1					45
March.....	19			4			23
Seasonal totals.....	121	8	2	4			135
1920-21—							
November.....	3	17	55		4		79
December.....	44	17	8				69
January.....	7						7
February.....	14			1			15
March.....	24	8					27
April.....	8						8
Seasonal totals.....	100	37	63	1	4		205
1921-22—							
June.....	1	5	2				8
July.....	20						20
August.....	124	1	1				126
September.....	115						115
October.....	55	28	12			1	91
November.....	51	24	1	1			77
December.....	40	6		1			47
January.....	71	1		1			73
February.....	30						30
Seasonal totals.....	507	60	16	3	1		587
1922-23—							
July.....	42		1				43
August.....	116	6					122
September.....	99	2	1				102
October.....	90	8	4				102
November.....	54	19	17				90
December.....	39	1					40
January.....	94	6	1	1			102
February.....	72	3	1				76
Seasonal totals.....	606	45	25	1			677
1923-24—							
June.....	46	1					47
July.....	23	2	1				26
August.....	37						37
September.....	32	3					35
October.....	29	5					34
November.....	9	8	11				28
December.....	20	13	4		1		38
January.....	26		3				29
February.....	16	2					18
March.....	11						11
Seasonal totals.....	249	34	19		1		303
1924-25—							
July.....	6						6
August.....	38		1				39
September.....	23	8	11				42
October.....	21	14	1		1	1	38
November.....	13	3	9		2	3	30
December.....	13	6	4		1	1	25
January.....	13	13	3		3		32
February.....	20	5					25
March.....	16	2					18
Seasonal totals.....	163	51	29		7	5	255

TABLE 4
Table of Boats Sampled at Monterey, Showing Catch Localities

TABLE 4—Continued
Table of Boats Sampled at Monterey, Showing Catch Localities

	Number of catches sampled						Total monthly sample
	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	
1925-26—							
July.....	16	2	2				20
August.....	24	5	1				30
September.....	7	12	11		2		32
October.....	9	5	7	1	1		23
November.....	8	13	10				31
December.....	7	3	6				16
January.....	28	1	2				31
February.....	16	11	5				32
March.....	8	13	4				25
Seasonal totals.....	123	65	48	1	3		240
1926-27—							
August.....	10		2		1		13
September.....		6	22			2	30
October.....	3	5	19		1		28
November.....		8	7			6	21
December.....	5	6	6			1	18
January.....	9	5	13				27
February.....	20	2	1	1			24
March.....	1			6			7
Seasonal totals.....	48	32	70	7	2	9	168
1927-28—							
June.....	4	2	2				8
July.....	9	2	8				19
August.....	21	12	3				36
September.....	32	8	5				45
October.....	1	6	8				15
November.....	1		1			1	3
December.....	10	8	5			3	26
January.....	2	10	4			1	17
February.....	21	5	1				27
March.....	6						6
Seasonal totals.....	107	53	37			5	202
1928-29—							
August.....	22	9	6				37
September.....	15	14	9				38
October.....	6	7	16				29
November.....	3	1	11			1	16
December.....			9			6	15
January.....	1	1	13			4	19
February.....	17	3	2			3	25
March.....	5	3	5				13
Seasonal totals.....	69	38	71			14	192

TABLE 4
Table of Boats Sampled at Monterey, Showing Catch Localities

3. Fishing Localities off San Pedro From 1919 to 1929 for the California Sardine (*Sardina caerulea*)¹

By FRANCES N. CLARK

3.1. INTRODUCTION

Although sardine fishing is carried on over a wide area in the waters off San Pedro, intensive fishing is confined to definite localities within this area. Fishing boats operate along the coast northward to Point Dume and southward to Point San Juan and occasionally as far as the town of Oceanside. offshore fishing occurs around the Channel Islands from Santa Cruz to San Clemente.

In the early history of the fishery, sardines were taken off the mainland only, but during the interval from 1919 to 1929, a decided extension in the fishing grounds has taken place. This enlarging of the sardine fishing area off San Pedro is the result of the introduction of "purse seine" boats during the winter of 1924–1925. Previous to this date fishing had been carried on by "lampara" or "round haul" boats only.² The purse seine boats, larger vessels than the lampara boats, are operated by "black oil" or diesel engines. These engines of a size small enough to be used in the lampara boats have not proven satisfactory until recently, and the smaller craft have been run by gasoline engines. Because of the lower cost of the fuel consumed by the diesel engines, the purse seine boats can cruise for much greater distances and still make a profit on their catch. Thus their use has enabled the fishermen to search for sardines around the Channel Islands as well as off the mainland.

So few purse seine boats operated during the 1924–1925 season that the fishing area was little affected by the until the following year. As a result of this change in fishing methods, the ten-season's data on fishing localities, collected by the California State Fisheries Laboratory, fall into two periods: the first six years from the autumn of 1919 to the spring of 1925, and the next four years from the autumn of 1925 to the spring of 1929. The data have been so treated in this discussion.

Since sardines are caught off San Pedro for only a certain portion of each year, from October to the following April or May, the data must be grouped into fishing seasons and cannot be treated by calendar years. The fishing area for the first portion of the season, October to December, differs from that for the latter portion and consequently the data for each period have been further subdivided into a fall fishery and a winter and spring fishery.

¹ Contribution No. 98 from the California State Fisheries Laboratory, January, 1930.

² For descriptions of purse seine and lampara nets and methods of operating, see the following references:

Higgins, Elmer, and Harlan B. Homes. Methods of sardine fishing in southern California. California Fish and Game, Vol. 7, No. 4, pp. 219–237, 1921.

Scofield, N. B. The purse seine. California Fish and Game, Vol. 10, No. 4, pp. 182–186, 1924.

Scofield, W. L. Purse seines for California sardines. California Fish and Game, Vol. 12, No. 1, pp. 16–19, 1926.

Skogsberg, Tage. Preliminary investigation of the purse-seine industry of southern California. California Fish and Game Commission, Fish Bulletin No. 9, pp. 88–95, 1925.

3.2. SOURCE OF THE DATA

Accurate information concerning the place of capture of sardines is difficult to obtain. These facts must be secured from the commercial fishermen, who are reluctant at times to disclose the locality of their operations and frequently, due to night fishing and foggy weather, are not able to give the exact place where their catch was made.

Since 1919 the California State Fisheries Laboratory has been carrying on an extensive investigation of the California sardine. In collecting the material for this study the captains of fishing boats have been questioned carefully concerning the place of capture of specific catches. During the first two years five fishermen were questioned daily, and during the last seven seasons five fishermen were questioned semiweekly. This discussion is based on the information thus obtained. While the data are subject to the errors mentioned above, they have been gathered with all the care possible and are deemed sufficiently accurate to justify the general conclusions here drawn. The data were collected by nine different members of the laboratory staff and their work is gratefully acknowledged.

3.3. THE 1919–1925 PERIOD

As mentioned previously, the data have been divided into two time intervals. The first comprises six fishing seasons, from 1919 to 1925, during which time fishing was carried on by small boats operating lampara nets. Figures 16 and 17 show the localities where sardines were caught during this period. The fishing area in the fall portion of the season, October to December, is indicated in figure 16 and for the winter and spring, January to May, in figure 17. Because of numerous data, the location of individual catches could not be shown. The circles indicate only the general regions in which catches were made. Circles placed closer together denote areas in which most intensive fishing occurred.

As is evident from figures 16 and 17, during the six seasons, 1919 to 1925, all sardine fishing took place comparatively close to the mainland. A few catches were made off Santa Catalina Island, but these form an insignificant part of the total. While fall and winter and spring fishing took place in the same general area, the winter and spring fishery extended much farther to the southward than did the fall fishery. With the exception of a few catches made off Santa Catalina Island, no fishing occurred south of San Pedro during the fall months, October to December. The major portion of the fishing took place in Santa Monica Bay between Point Vincente and Point Dume. During the winter and spring months, January to May, many sardine catches were made in Santa Monica Bay, but intensive fishing was carried on in the region between Point Vincente and San Pedro, with catches occurring as far south as Point San Juan. The sardine fishery thus showed a decided movement to the southward as the season advanced from the fall to the winter and spring months. No differences could be demonstrated between the winter and spring fishery and these time intervals have been grouped together in this study.

A more detailed analysis of the fishing area was made by Higgins³ for the winter of the 1920–1921 season. The localities corresponded very closely to those for the six seasons from 1919 to 1925, and a similar analysis has not been made for the later seasons.

³ Higgins, Elmer. A study of the fluctuations in the sardine fishery at San Pedro. California Fish and Game Commission, Fish Bulletin No. 11, pp. 128–131, 1926.

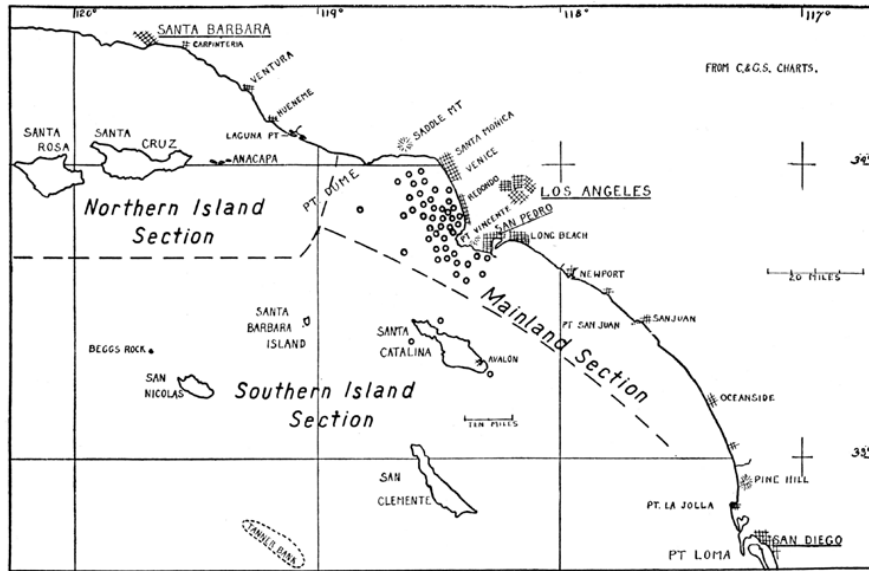


FIG. 16. Fishing localities off San Pedro for the California sardine during October, November and December of the six-year period, 1919-1925. Circles indicate only the general regions in which catches were made, and do not show the exact location of each catch.

FIG. 16. Fishing localities off San Pedro for the California sardine during October, November and December of the six-year period, 1919-1925. Circles indicate only the general regions in which catches were made, and do not show the exact location of each catch

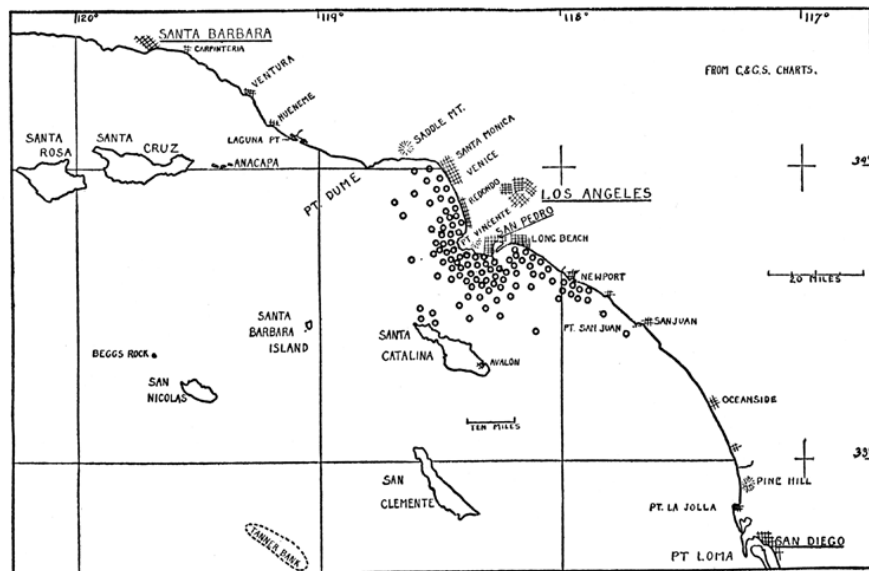


FIG. 17. Fishing localities off San Pedro for the California sardine during January to May of the six-year period, 1919-1925. Circles indicate only the general regions in which catches were made and do not show the exact location of each catch.

FIG. 17. Fishing localities off San Pedro for the California sardine during January to May of the six-year period, 1919-1925. Circles indicate only the general regions in which catches were made and do not show the exact location of each catch

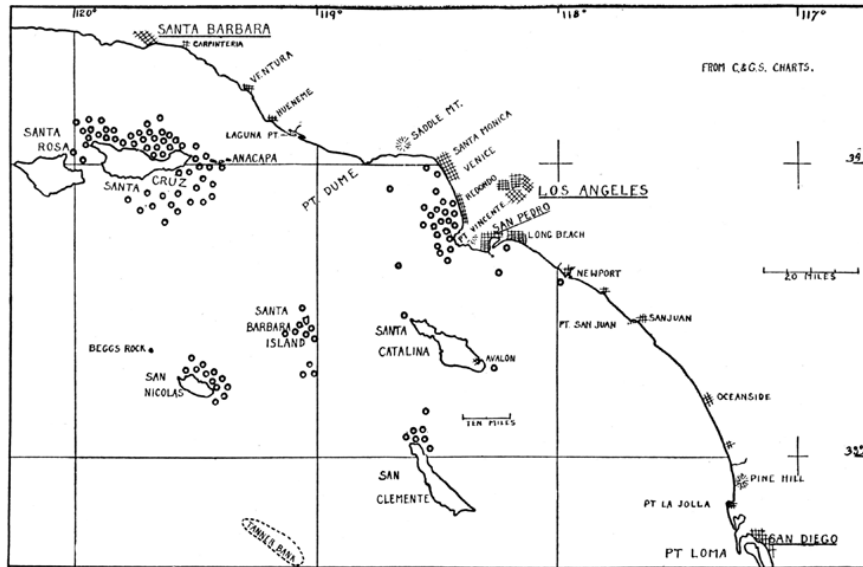


FIG. 18. Fishing localities off San Pedro for the California sardine during October, November and December of the four-year period, 1925-1929. Circles indicate only the general regions in which catches were made, and do not show the exact location of each catch. The number of circles in each section approximates the percentage of catches made in that section.

FIG. 18. Fishing localities off San Pedro for the California sardine during October, November and December of the four-year period, 1925-1929. Circles indicate only the general regions in which catches were made, and do not show the exact location of each catch. The number of circles in each section approximates the percentage of catches made in that section

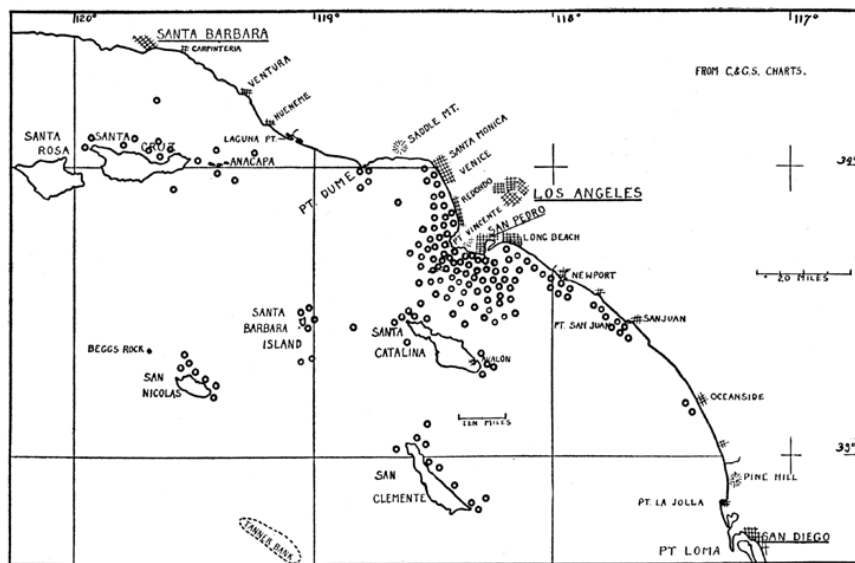


FIG. 19. Fishing localities off San Pedro for the California sardine during January to May of the four-year period, 1925-1929. Circles indicate only the general regions in which catches were made, and do not show the exact location of each catch. The number of circles in each section approximates the percentage of catches made in that section

FIG. 19. Fishing localities off San Pedro for the California sardine during January to May of the four-year period, 1925-1929. Circles indicate only the general regions in which catches were made, and do not show the exact location of each catch. The number of circles in each section approximates the percentage of catches made in that section

3.4. THE 1925–1929 PERIOD

The four sardine fishing seasons from the fall of 1925 to the spring of 1929 showed a decided change in the fishing area when contrasted with the 1919–1925 period. As stated above, larger boats were introduced into the San Pedro fishery during the winter of 1924–1925, but the fishing area did not change until the fall of 1925. Since that date sardine boats have operated farther from the mainland. The fishing areas for the 1925–1929 period are indicated in figures 18 and 19. As in the previous two figures the circles indicate only the general region in which catches were made, and not the exact location of each catch.

The fall fishery, October to December, as shown in figure 18, contrasts markedly with the fall fishery for the previous six years. During the last four years the most intensive fishing occurred off Santa Cruz Island with many catches made off San Nicolas, Santa Barbara and San Clemente islands. In the previous six years no catches were recorded from the vicinity of these islands. The mainland fishery during the fall months for the six- and four-year time intervals was, on the other hand, practically identical. During the 1919–1925 period no mainland fishing occurred south of San Pedro and, similarly, during the 1925–1929 period, although two catches were recorded south of this point, the amount of sardines thus caught was practically negligible. The mainland fishery for the months from October to December was centered around Point Vincente and Santa Monica Bay in both periods.

The winter and spring fishing area during 1925–1929 (see fig. 19) also differed markedly from the same time interval for 1919–1925. While the most intensive fishing during the last four years occurred off the mainland, many catches were made around the islands. On the other hand, the winter and spring mainland fishery was very similar for the six- and four-year intervals. During the latter period a few fishing boats cruised farther to the southward, some catches being made as far south as Oceanside, but the intensive fishing was carried on from Point Vincente to San Pedro as in the previous six years.

The fall fishery for 1925–1929 differed from the winter and spring fishery of the same period in much the same manner as the fall fishery differed from the winter and spring for 1919–1925. The island fishing in the fall was most intensive around Santa Cruz, while in the winter and spring more fishing took place off San Nicolas, Santa Barbara, Santa Catalina, and San Clemente islands. The mainland fishery showed the same southward movement. In the fall the fishing area lay north of San Pedro, while in the winter and spring the fishing region extended farther to the south.

The approximate distances in nautical miles (6,080 feet) from the San Pedro breakwater lighthouse along the main courses of navigation to specific points in the sardine fishing area are as follows:

Anacapa Island	58 miles
Santa Cruz Island (eastern end)	68 miles
Santa Cruz Island (western end)	91 miles
Santa Rosa Island (eastern end)	89 miles
Santa Barbara Island	41 miles
San Nicolas Island	65 miles
Santa Catalina Island (eastern end)	24 miles
Santa Catalina Island (western end)	23 miles
San Clemente Island (eastern end)	54 miles
San Clemente Island (western end)	50 miles
Point Dume	34 miles
Oceanside	53 miles

3.5. NUMBER OF TONS AND PERCENTAGE OF THE CATCH FROM THE ISLANDS AND FROM THE MAINLAND

That the extension after 1925 of the sardine fishing area off San Pedro was much more marked during the fall than during the winter and spring months is indicated by tables 5 and 6 and figures 20 and 21. For the

TABLE 5

Number and Percentage of Sardine Catches from which Data were Secured During October, November and December in Each of the Three San Pedro Sections

Season	Mainland		Northern Island		Southern Island		Total
	Number	Per cent	Number	Per cent	Number	Per cent	
1919-20.....	1	100.0					1
1920-21.....							
1921-22.....							
1922-23.....	34	100.0					34
1923-24.....							
1924-25.....	82	97.6			2	2.4	84
1925-26.....	45	58.4	32	41.6			77
1926-27.....	2	4.5	42	95.5			44
1927-28.....	12	30.8	11	28.2	16	41.0	39
1928-29.....	1	1.5	16	24.6	48	73.9	65
Totals.....	177		101		66		344

TABLE 5

Number and Percentage of Sardine Catches from which Data were Secured During October, November and December in Each of the Three San Pedro Sections

TABLE 6

Number and Percentage of Sardine Catches from which Data were Secured During the Months from January to May in Each of the Three San Pedro Sections

Season	Mainland		Northern Island		Southern Island		Total
	Number	Per cent	Number	Per cent	Number	Per cent	
1919-20.....	123	100.0					123
1920-21.....	227	100.0					227
1921-22.....	64	100.0					64
1922-23.....	96	100.0					96
1923-24.....	88	92.6			7	7.4	95
1924-25.....	113	100.0					113
1925-26.....	67	79.8	15	17.8	2	2.4	84
1926-27.....	76	69.7	4	3.7	29	26.6	109
1927-28.....	95	80.5			23	19.5	118
1928-29.....	56	50.5	10	9.0	45	40.5	111
Totals.....	1,005		29		106		1,140

TABLE 6

Number and Percentage of Sardine Catches from which Data were Secured During the Months from January to May in Each of the Three San Pedro Sections

compiling of the data used in these tables and figures, the sardine fishing area was divided into three sections: the mainland fishery from Point Dume to Oceanside, the northern island fishery comprising catches made off Santa Rosa, Santa Cruz and Anacapa islands, and the southern island fishery embracing catches made off Santa Barbara, San Nicolas, Santa Catalina, and San Clemente islands. (See fig. 16.)

As mentioned above, practically no island fishing was carried on until after the introduction of the purse seine in the winter of 1924–1925. Since that date island fishing has increased steadily. After 1925 the fall

fish were taken almost entirely from around the islands, and in addition, the percentage of fish brought from the islands, during the winter and spring months, has shown a steady increase. In the fall of the 1927–1928 and the 1928–1929 seasons more fish were taken from the southern islands than from the northern in contrast to the two previous seasons when the most fish came from the northern islands. Whether this change is due

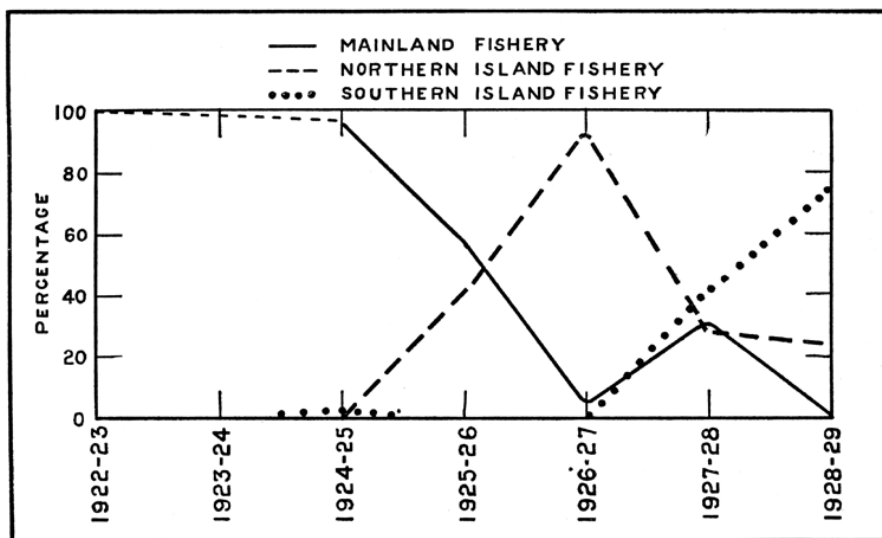


FIG. 20. Percentage by seasons of the sardine catches made during October, November and December in each of the three San Pedro fishing areas.

FIG. 20. Percentage by seasons of the sardine catches made during October, November and December in each of the three San Pedro fishing areas

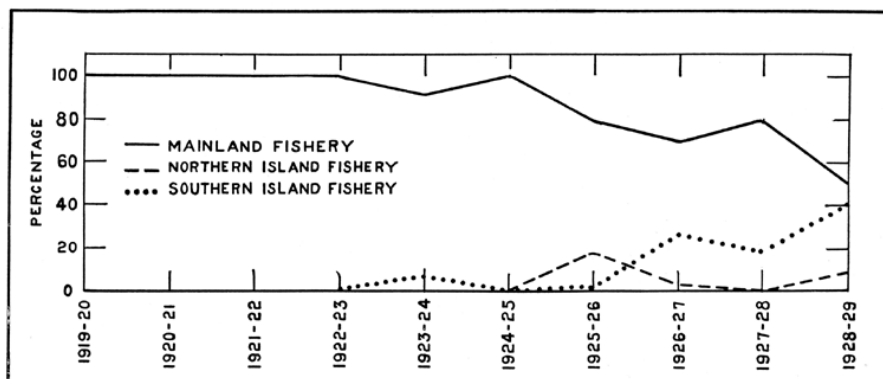


FIG. 21. Percentage by seasons of sardine catches made during the months from January to May in each of the three San Pedro fishing areas.

FIG. 21. Percentage by seasons of sardine catches made during the months from January to May in each of the three San Pedro fishing areas

to a chance selection of boat captains questioned by the members of the laboratory staff collecting the data, or whether it indicates a definite change in the fishing area, cannot as yet be determined.

With the exception of the 1925–1926 season, during the winter and spring months practically all the island fish came from the southern island group; probably the result of the extension of the fishery to the southward as the season advanced.

TABLE 7
Number and Percentage of Sardine Catches from which Data were Secured During the Entire Season in Each of the Three San Pedro Sections

Season	Mainland		Northern Island		Southern Island		Total
	Number	Per cent	Number	Per cent	Number	Per cent	
1919-20.....	124	100.0					124
1920-21.....	227	100.0					227
1921-22.....	64	100.0					64
1922-23.....	130	100.0					130
1923-24.....	88	92.6			7	7.4	95
1924-25.....	195	99.0			2	1.0	197
1925-26.....	112	69.6	47	29.2	2	1.2	161
1926-27.....	78	51.0	46	30.1	29	18.9	153
1927-28.....	107	68.2	11	7.0	39	24.8	157
1928-29.....	57	32.4	26	14.8	93	52.8	176
Totals.....	1,182		130		172		1,484

TABLE 7
Number and Percentage of Sardine Catches from which Data were Secured During the Entire Season in Each of the Three San Pedro Sections

To show more clearly the extension of the San Pedro sardine fishing region, the number and percentages of catches made in each of the three

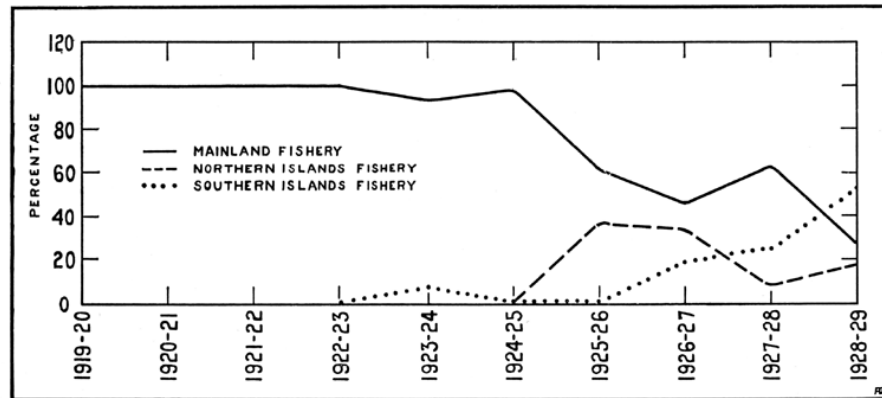


FIG. 22. Percentage of the sardine catches made during the entire season in each of the three San Pedro fishing areas.

FIG. 22. Percentage of the sardine catches made during the entire season in each of the three San Pedro fishing areas

sections were compiled by seasons. The results of this compilation are shown in table 7 and figure 22. Until the 1925-1926 season, almost all the fishing occurred off the mainland. Since 1925, the percentage of catches made off the islands has increased steadily, the increase being most marked in the southern island fishery.

The decline in the percentage of catches made off the mainland does not necessarily indicate that the total amount of sardines caught in this section has decreased. A computation of the number of pounds of sardines taken in each of the three sections would clarify this point. Such a computation, however, involved several difficulties, since no absolute measure of the tonnage from each region was available. The simplest method would have been to multiply the total number of pounds of fish landed each season by the percentage of catches made in each section. This method, which is based on the assumption that all boats bring in an equal amount of fish in each delivery, over-emphasizes the mainland fishery. Because the smaller boats fished in the mainland area only and the larger boats fished in both the mainland and the island areas, the

average catch per boat was smaller for the mainland section. This difference in the size of the catch per boat in each region is shown in table 8. The over-emphasis of the mainland fishery could be avoided by basing the percentage of landings from each of the three areas on the number of tons brought in by the boats from which the data were secured. This

TABLE 8
Average Number of Tons of Sardines per Load Taken in Each of the Three San Pedro Sections

Season	Mainland	Northern Island	Southern Island
1925-26.....	13.6	26.0	17.2
1926-27.....	28.0	32.9	32.0
1927-28.....	22.9	35.1	31.0
1928-29.....	27.2	48.3	39.4

TABLE 8
Average Number of Tons of Sardines per Load Taken in Each of the Three San Pedro Sections

procedure accounts for the differences in the size of catch made by each boat, but, due to an error inherent in the method of securing the data, neglects the mainland fishery approximately as much as the former method over-emphasises this section. During the winter months when the major portion of the sardine catch is made off the mainland, many more boats are operating than during the fall months when the major portion of the catch is made off the islands. Since data from only five boats were obtained during each semiweekly period regardless of the number of boats making deliveries, the second method neglects the mainland area in that it does not consider the larger number of deliveries made by the smaller boats.

The truest measure of the number of pounds of sardines delivered from each of the three fishing areas would be secured by calculating the percentage of deliveries from each section during each semiweekly period. This percentage should be based on the number of tons delivered by the boats from which data were secured. These percentages multiplied by the total number of tons delivered in a semiweekly interval would give an accurate record of the total amount of sardines taken in each of the three areas. A summation of these semiweekly results would show the total yearly landings. This last method, however, necessitates records of the total semiweekly catches throughout each season. Such data have been calculated for the 1927-1928 and the 1928-1929 seasons only. A compilation of the data for these two seasons by this system was made as a check on the reliability of the first two methods. This check showed that the first method, based on the number of catches and therefore disregarding differences in size of catches, emphasized the mainland fishery to about the same extent as the second, based on the number of tons delivered by each boat and disregarding the greater number of deliveries made by the smaller boats, neglected the mainland fishery. Both processes favored the southern islands slightly and neglected the northern island section.

To secure the most accurate measure possible of sardines delivered from each area, the percentages obtained by the first and second calculations were combined and averaged, and the percentages from the two island sections further combined. The results secured thus contrast the entire island fishery with the mainland fishery. These final percentages multiplied by the total catch for each season gave the data shown in figure 23 and table 9.

TABLE 9

Number of Pounds of Sardines Taken off the Mainland and off the Islands Based on an Average of the Percentage of Catches and the Percentage of Tons

Season	Mainland	Northern and Southern Islands	Totals
1919-20	31,432,000		31,432,000
1920-21	23,310,000		23,310,000
1921-22	38,301,000		38,301,000
1922-23	66,336,000		66,336,000
1923-24	64,891,000	5,186,000	70,077,000
1924-25	190,741,000	1,927,000	192,668,000
1925-26	76,144,000	47,466,000	123,610,000
1926-27	59,939,000	70,363,000	130,302,000
1927-28	86,101,000	48,853,000	134,954,000
1928-29	63,430,000	175,027,000	238,457,000

TABLE 9

Number of Pounds of Sardines Taken off the Mainland and off the Islands Based on an Average of the Percentage of Catches and the Percentage of Tons

The exceptionally large catch of sardines made in the 1924–1925 season is very evident in figure 23. Practically the entire catch came from the

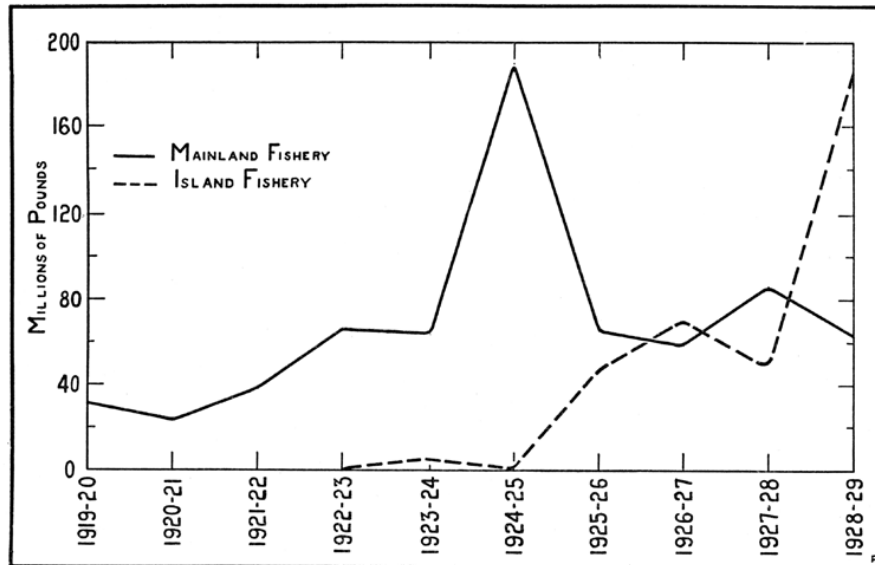


FIG. 23. Number of pounds of sardines taken each season off San Pedro in the mainland area and in the island areas.

FIG. 23. Number of pounds of sardines taken each season off San Pedro in the mainland area and in the island areas

mainland fishing area. The explanation for such a large catch in the mainland section is difficult to ascertain. During this season, however, the reduction law limiting the amount of sardines used for oil and fertilizer was practically inoperative for a couple of months. This enabled the canners to run large quantities of sardines through their reduction plants, and as a result, many more tons of fish were handled than in the immediately preceding and succeeding years. But how the mainland fishing area was able to supply such an unprecedented demand for sardines is not easily understood. A phenomenal abundance of fish seems the only explanation. The 1924–1925 season is reputed in the industry to have been marked by such an abundance. Fish were reported as unusually numerous and very close to shore. The cause of this unusual abundance may have been the presence in the catch of a dominant group of

sardines comprising one or more year classes. Such a dominant group first appeared in the fishery in 1922,⁴ and probably reached a maximum of abundance in 1924–1925. Thus exceptional numbers of sardines accompanied by a great demand for the fish brought about a catch in the mainland section in the 1924–1925 season which has never been equalled either before or since.

With the exception of the 1924–1925 season, the amount of fish taken in the mainland area has shown little increase since 1922–1923. The increase in the total catch which occurred in the later years resulted from fishing in the island sections and not from an increase in the amounts taken off the mainland. The conclusion seems justified that the mainland fishery has reached a maximum of production and to supply the greater demand for sardines evinced during the last few years, the fishermen have been compelled to go farther from port and to cruise over larger and larger areas.

3.6. PERCENTAGE OF THE CATCH TAKEN WITHIN THREE MILES FROM SHORE

While sardine fishermen have shown, during the past four years, a marked tendency to cruise over a much wider area when searching for schools of sardines, catches are still made relatively close to either the shores of the islands or the mainland. This is evident in figures 16 to 19, and also in table 10 and figure 24, which give the percentage of the catches made within three miles from shore. In compiling these data the technical

TABLE 10
Number and Percentage of Sardine Catches from which Data were Secured, Grouped According to Distance from Shore

Season	Within the three-mile limit				Without the three-mile limit				Totals
	Definitely		Probably		Definitely		Probably		
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	
1919-20.....	6	4.8	112	90.4	5	4.0	1	0.8	124
1920-21.....	80	36.0	23	10.4	118	53.1	1	0.5	222
1921-22.....	44	67.7			21	32.3			65
1922-23.....	76	58.0	3	2.3	52	39.7			131
1923-24.....	34	35.8	40	42.2	18	18.9	3	3.1	95
1924-25.....	96	48.7	8	4.1	92	46.7	1	0.5	197
1925-26.....	40	25.2	41	25.8	67	42.1	11	6.9	159
1926-27.....									
1927-28.....	34	22.4	36	23.7	45	29.6	37	24.3	152
1928-29.....	28	15.7	28	15.7	95	53.4	27	15.2	178
Totals.....	438		291		513		81		1,323

TABLE 10
Number and Percentage of Sardine Catches from which Data were Secured, Grouped According to Distance from Shore

custom of considering bays within the three-mile limit has been adopted. Thus all catches made in Santa Monica Bay, or within three miles from a line drawn from Point Dume to Point Vincente, have been classed as three miles from shore. No other bays occur in the sardine fishing area off San Pedro. The three-mile limit also includes catches made within that distance from any island. Because the information secured from the fishermen was not always exact, four categories have been used in table 10: catches definitely within the three-mile limit, catches probably within the three-mile limit, catches definitely without the three-mile

⁴ Higgins Elmer. A study of the fluctuations in the sardine fishery at San Pedro. California Fish and Game Commission, Fish Bulletin No. 11, pp. 132-151, 1926.

limit, and catches probably without the three-mile limit. No distances from shore were obtained for the 1926–1927 season and these data had to be omitted from the compilation.

Considering the total catches for the ten seasons from 1919–1929, 33 per cent were certainly made within three miles from shore and an additional 22 per cent were probably made within that distance. For those beyond three miles, 39 per cent were definitely without the limit and 6 per cent probably so. If the first two categories are combined probably 55 per cent of the sardine catches off San Pedro have been made within three miles from shore.

Figure 24 results from the combination of the four groups of table 10 into two classifications: catches probably within three miles from shore and catches probably beyond three miles. These data indicate that during the last three or four seasons the fishermen have tended to fish farther from shore than in former years, but the catches within the three-mile limit did not fall appreciably below 50 per cent of the total until 1928–1929.

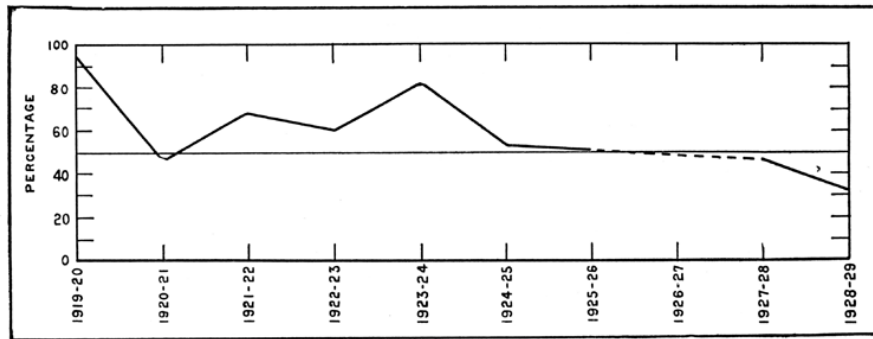


FIG. 24. Percentage of sardine catches probably made within three miles from shore in the San Pedro fishing region.

FIG. 24. Percentage of sardine catches probably made within three miles from shore in the San Pedro fishing region

3.7. SUMMARY

The fishing localities off San Pedro for the California sardine lie off the mainland between Point Dume and the town of Oceanside and around the Channel Islands from Santa Cruz to San Clemente.

Until the introduction of the purse seine boats in 1925, sardines were taken almost exclusively off the mainland. Since 1925 the number of catches off the islands has continually increased. Although the percentage of catches made off the mainland has decreased since 1925, the amount of sardines caught in this area has remained relatively constant. To meet the increasing demand for fish, fishermen have been compelled to go farther from port and to cruise over larger areas.

During the fall portion of any fishing season the major part of the catch is taken to the north of Point Vincente, while during the winter and spring months a greater percentage of the catch is made south of this point.

During the ten years from 1919 to 1929 probably 55 per cent of the catches were made within three miles from shore, but the last two seasons of this period showed a decrease in the number of catches within this range.

4. A Discussion of the Localities in which the California Sardine (*Sardina caerulea*) was taken in the San Diego Region, 1928–1929¹

By H. C. GODSIL

In a discussion of the localities in which San Diego sardine catches are made, it is essential at the outset to recognize that different populations of sardines are involved at different seasons of the year. The situation is somewhat confusing, but when the characteristics of the different groups are understood, then the significance of the locality of catch becomes apparent.

A survey of the sardine population at San Diego throughout the year discloses the following facts: In the months January to April, inclusive, there are present locally, large, adult sardines. These fish, which are taken in great quantity, are packed in the one-pound oval can. In size they range from about 20 to 26 centimeters (about 7 $\frac{3}{4}$ to 10 $\frac{1}{4}$ inches) in body length. By the latter part of April they are usually gone, and they do not reappear locally until the following January. A second group—of young fish—ranging in size from about 11 to 15 centimeters (about 4 $\frac{1}{4}$ to 6 inches) in body length, is also present in this period, *i. e.*, from about January to June or later. Fish of this group are taken in considerable quantity, and are packed in the quarter-pound square can in the European style. The season for this group extends from January to June or July. At this time the larger fish of the group disappear from the catch. The smaller ones, which by July or August, have grown beyond the range of size adapted for the quarter-pound pack, remain in the local waters throughout the remainder of the year, and constitute a third, distinct group of fish. In the fall months these fish range in size from about 15 to 18 centimeters (about 6 to 7 inches) in body length, and they are packed in very small quantities in square or oval cans of the half-pound size.

We have locally, therefore, three distinct, commercial sizes of sardines, namely: the large, adult fish (taken from January to April) of the one-pound oval pack; the very young fish of the quarter-pound pack, taken at about the same season; and the slightly larger, half-pound size derived from the preceding group, and taken in the fall. Since this arbitrary commercial grouping is based upon a biological characteristic, namely, size, it is not surprising that the localities in which the various groups are taken are likewise correlated with this factor; for the habitat of each group is apparently correlated with the age—or size—of the fish, and with a differential movement of fish of different age classes. Accordingly, in the discussion to follow, it will be convenient to adhere to this grouping, and to treat each group as a distinct unit.

The data presented herein were collected in the following manner: In the two years, 1928 and 1929, samples of the commercial catch of sardines were taken at frequent intervals, and the length of the fish determined.

¹ Contribution No. 99 from the California State Fisheries Laboratory, May, 1930.

The captain of the boat from which a sample was taken was questioned, and an attempt made to ascertain the general locality in which the catch was made, and the approximate distance from shore. This information has been checked on numerous occasions by personal observations of the writer, and the general localities in which the different groups are taken have been definitely established. The results have been plotted in figure 25. Each mark represents a single boat catch. No attempt has been made to plot these with accuracy, as the data do not justify this. They are merely rough approximations designed to indicate the main fishing areas. The crosses represent the catches of large, adult sardines; the triangles those of the intermediate group (half-pound size); and the circles mark the localities in which the young sardines were taken. In the case of fish of the half- and quarter-pound pack, the fishing areas, as depicted in figure 25, actually represent the extent of the habitat of the two groups. This point is mentioned here, as the criticism has been raised that the areas exploited by the fishermen may represent only a small—and the most accessible—portion of a vaster area in which fish abound. However, in this particular case repeated observations have shown that the bulk of the local sardine population is confined within the respective areas depicted in the figure. This statement does not apply, however, to the large adult sardine. These fish range over a vastly greater area, which undoubtedly extends far beyond the limits shown in figure 25.

An inspection of the figure shows that the bulk of the catch of the very young fish is taken from a comparatively restricted area, namely, the waters adjacent to the Coronado Strand. In fact, the actual percentage exceeds that shown, for it was not feasible to include all the catches from this area recorded in the data. Moreover the writer was more interested in showing the extent of this region than the exact proportion of the catch taken from the inshore waters. It will be noted that the heaviest fishing takes place close inshore. Many of the catches are made just beyond the line of breakers. As the distance from shore increases, the number of catches drops off rapidly. This is actually due, as the writer has often corroborated, to a greater abundance of fish in the inshore waters. However, the concentration of fishing at the northern end of the Strand does not necessarily mean that sardines are more abundant here. It is apparently due, in part at least, to the fact that the boats, rounding the breakwater, cruise along the Strand in a southerly direction until fish are sighted. Nevertheless, there is undoubtedly some significance in the concentration of fishing within this area.

Some distance north, we find another fishing area in the La Jolla region. Young sardines seem to be abundant in this region also. The boats, however, fish in this locality only when—as happens from time to time for unknown reasons—the sardines disappear from the Coronado Strand area. It will be noted that no catches are recorded from the Ocean-Mission Beach region. Occasional catches are undoubtedly made here, but apparently the region is not one of abundance. Casually this seems somewhat strange, for the topography of the shore line is identical with that of the La Jolla and Coronado Strand areas. The writer was much interested in this matter, and sought some plausible explanation for it. It may be that oceanographical factors are responsible for this phenomenon. Thus, Dr. E. G. Moberg, of the Scripps Institution of Oceanography, informs the writer that the two regions—the entrance to

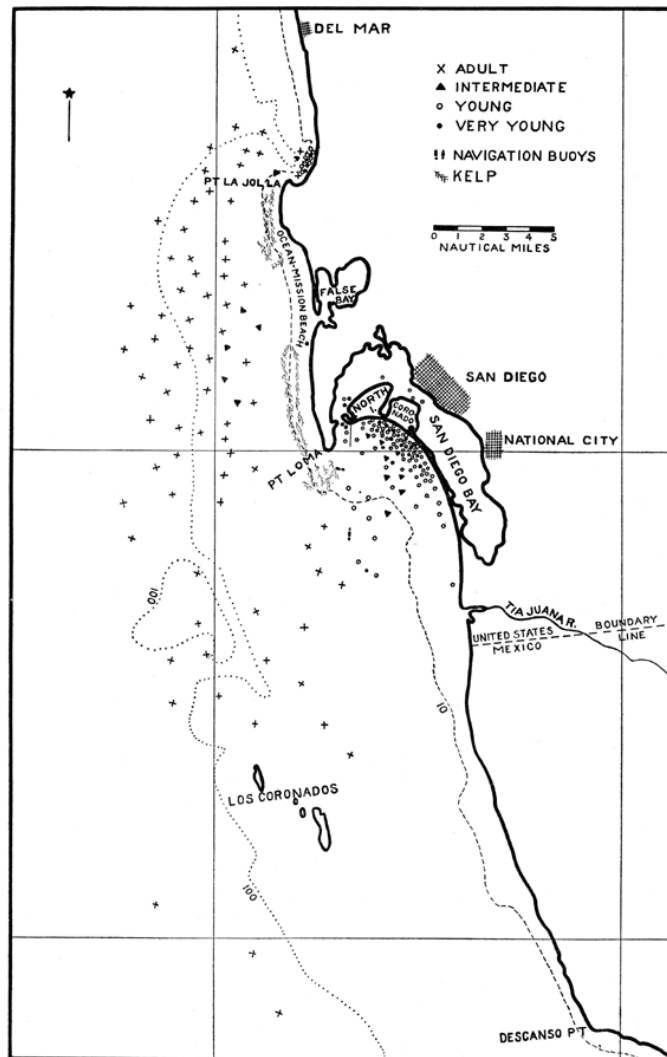


FIG. 25. Localities in the vicinity of San Diego, California, in which sardines of different sizes were taken in 1928 and 1929.

FIG. 25. Localities in the vicinity of San Diego, California, in which sardines of different sizes were taken in 1928 and 1929

San Diego Bay and the La Jolla area—are somewhat comparable. The former is characterized by low water temperatures and usually by an abundance of plankton, while the latter is one of variable temperatures and plankton abundance. Upwelling of colder water in both areas is undoubtedly a major contributing factor to these conditions. Scanty and sporadic observations in the Mission-Ocean Beach area indicate, on the other hand, that this region differs markedly in the above respects. Consistently high water temperatures and a dearth of plankton seem to indicate a smaller amount of upwelling in this vicinity. If, as seems probable, upwelling of colder water favors plankton development, it may be that the absence of sardines in the Ocean-Mission Beach area is correlated with the lack of plankton as a food supply.

It will be noted that occasional catches are made within the San Diego Bay. These are the bait catches. During the summer months when live bait is extensively used in commercial fishing, a large percentage of the sardines may be taken within the bay. The writer is inclined to believe, from personal observations, that young sardines frequent the bay in quantity only in the summer months, and even then there are periods when no sardines are seen within the bay.

Scattered among the catches of young fish are some of the extremely small sardines, resulting from the spawning of the year. These are indicated in figure 25 by solid black dots. These fish, according to the time of year, range from 3 to 10 centimeters (about 1 ¼ to 4 inches) in body length. Apparently their habitat is the same as that of the larger fish discussed above. Surveying the several localities from which young sardines are taken, it appears that they are always taken in relatively shallow water—10 fathoms or less—invariably adjacent to a long stretch of sandy beach.

The second group for consideration is that of immature fish of the intermediate half-pound size. These fish range from 15 to 18 centimeters (6 to 7 inches) in body length. They are derived from fish of the quarter-pound size by growth, and differ from them only in size and the season in which they are taken. As stated above the demand for them is small, and in consequence the data pertaining to the group are meager. However there are sufficient observations to warrant some tentative conclusions regarding their habitat.

During the fall months these fish are taken in the same localities frequented by the young sardines. In figure 25 the catches of these fish are indicated by triangles. There appears to be evidence that they are frequently encountered farther from shore than the smaller fish, though in the same general locality. In the winter months, however, half-pound sardines are taken some distance from shore along the coast line between Point Loma and La Jolla. Thus in February, 1929, great schools of them were present in this section for a period of two or three weeks. This locality is one where the large, adult sardines are taken, and it suggests that with increasing size the sardines move offshore to different habitats. Moreover, at this time the identity of the group is lost, and no traces of it, as a unit, are subsequently to be found in the existing data.

The presence of the large adult sardines in the San Diego region is apparently associated with a spawning migration. In consequence there is little constancy in the existing population; neither are the catches confined to any definite localities. The fishing area stretches from Los Coronados Islands in the south to Point La Jolla in the north. Occasionally,

when fish are scarce, the boats go farther afield, and one recorded catch was made at Oceanside. This, however, is somewhat doubtful. Figure 25 shows that the majority of catches are made between Point Loma and Point La Jolla. All catches are made at some distance from shore in relatively deep water, ten to one hundred or more fathoms. The distance from shore varies from about one to ten or twelve miles, with perhaps a majority of catches between four and eight miles distant. The problem of estimating distances is extremely difficult, and these figures are, at best, very rough approximations. Beyond these facts, there is little to be said in regard to this group. Fishermen claim that they now have to go farther for their fish than formerly, but since no authentic observations are available for earlier years, it is not possible to discuss this change.

4.1. SUMMARY

From the data at hand it is possible to draw the following conclusions:

1. Very young sardines (11 to 15 centimeters body length) frequent inshore waters, invariably those adjacent to long stretches of beach. The local areas of greatest abundance are the Coronado Strand area and the La Jolla region.
2. Fish of the intermediate (half-pound) size, ranging from 15 to 18 centimeters in body length, are taken in the inshore regions throughout the fall, while in the winter months, as in February, 1929, they may be present in great numbers at a considerable distance from shore, at almost any point along the local coast line.
3. The large, adult sardines, present locally from January to April, are taken over a wide area, at distances from one to ten or twelve miles from shore. The actual fishing area stretches from Los Coronados Islands in the south to Point La Jolla in the north.

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