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Average Lunar Month Catch by California Sardine Fishermen 1932–33 Through 1948–49

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1. INTRODUCTION

1.1. Other Measures of Return per Unit of Effort

Several studies have been made of the return to the fishermen per unit of effort expended in fishing along the Pacific coast for the sardine, Sardinops caerulea. The first, by Hart (1933), was based on the British Columbia fishery for the years 1925–32. Hart calculated the average season catch per boat and the average daily catch per boat. Appropriate corrections were made to eliminate the influence of differences between boats in the total number of days fished within the season. The data indicated an increase in the return to the fishermen in the last three seasons included in the study.

In California until about 1930 the daily tonnage delivered by fishing boats was determined by the capacity of the processing plants and not by the availability* of sardines on the fishing grounds. Gradually increasing plant capacities and corresponding increases in size of boats and adoption of more efficient fishing methods resulted in a continuing increase in the fishermen's catches. When plant capacities were large enough to absorb the tonnages delivered on most days, limitations were no longer placed on the boat's catch or were infrequent enough to have little effect on the average catch. This condition was reached in the early thirties, and by 1932–33 it was possible to use the fisherman's catch as a rough measure of the availability of the sardine population on the fishing grounds.

Clark (1939) then calculated the average lunar month catch for the Monterey and the San Pedro sardine fisheries for 1932–33 through 1937–38. Although some limitations were at times placed on the daily catch of the fishermen these were disregarded as negligible. Boat sizes were increasing throughout the time interval and to meet this problem the catch of each boat was compared to the catch of the same boat for the corresponding lunar month of the previous season. This study showed an increase in the average lunar month catch from 1932–33 through 1934–35 and then a decline through 1937–38.

The above study assumed that the influence of many items which determine fishing success would average out in calculations covering several years. Such factors are the limitations placed on the fisherman's daily catch, the number of hours of darkness, and changes in weather

* * Factors influencing availability, as the term is here used, are the total abundance of fish in the population and environmental conditions which bring the fish within the range of fishing operations.

conditions. To determine their importance, Silliman and Clark (1945) calculated the average weekly catch adjusted as far as possible to eliminate the influence of these factors. The calculations were carried through 1941–42 and applied to the fisheries out of the ports of San Francisco, Monterey and San Pedro. They indicated an increase in average weekly catch from 1932–33 through 1934–35, a decline to 1937–38 and an upward trend to 1941–42. The adjustments made to eliminate extraneous factors which might affect fishing success, however, did not change the seasonal averages sufficiently to justify continuance of such elaborate and time consuming calculations. The adjustments either failed to accomplish the end desired or the extraneous influences were unimportant in a study covering a period of years.

The present report covers the results of a study using the same boat catches as in the two former investigations for the seasons of 1932–33 through 1941–42, and extending the calculations through 1948–49. The method of treatment has been simplified by use of the average lunar month instead of the average lunar week catch, by making no adjustments for the influence of hours of darkness or unfavorable weather, or for the effect of limits except in the 1948–49 season. The fisherman's success has been measured both in tons per lunar month and in number of fish per month.

1.2. Results

As shown by former studies, for all of California the return to the fisherman for a month's fishing increased from 1932–33 through 1934–35, decreased through 1937–38, increased through 1941–42, again decreased through 1947–48 and finally showed a slight increase in 1948–49. This pattern held for the combined catch of all California and for each of the ports of San Francisco, Monterey and San Pedro both in tons per month and in numbers of fish per month. With the exception of numbers per month in the San Francisco fishery, however, the increase from 1937–38 to 1941–42 did not bring the catch up to the level of 1934–35, and in tonnage per month all succeeding seasons were below those of 1932–33 through 1936–37. The higher level of the average monthly catch from 1938–39 through 1941–42 when measured in numbers was caused by a greater proportion of young fish on the fishing grounds, indicating that more fish were necessary to produce a ton. This was especially evident in the San Francisco fishery.

2. SOURCE OF MATERIAL

As in previous studies the material from which the return per unit of effort has been calculated is the record of the daily landings of individual fishing vessels. For the shore landings these records are collected by the California Division of Fish and Game as a part of its statistical system. The dealer or processor who buys sardines from the fisherman makes out a receipt in triplicate showing the total poundage, the name of the vessel, the price and the area in the ocean where the fish were caught. The Division of Fish and Game receives the third copy of this receipt and it constitutes the daily landing record of each fishing boat.

The records of the deliveries to the reduction ships, which operated off San Francisco from 1930 to 1938, were obtained by the United States

Fish and Wildlife Service from the books of the companies. The collection and compilation of these records filled a serious gap in the San Francisco data.

3. METHODS

3.1. Lunar Month as a Unit of Effort

Practically all sardine fishing in California takes place during hours of darkness either before moonrise or after moonset. Under such conditions the fishermen locate the schools by the luminescence emanating from the small plants and animals disturbed by the fish movements. For this reason the entire fishery revolves around the moon phases. The boats tie up for five to six days at the full moon, and a lunar month, called a dark by the fishermen, is reckoned from full moon to full moon. The lunar month, therefore, constitutes a logical time unit in the sardine fishery and has been selected as the unit of effort for this study.

The records of catch collected by the California Division of Fish and Game include the deliveries after successful fishing nights but do not record the nights when the fishermen sought fish but failed to make catches. The frequency of such failures constitutes an important factor in the measurement of the abundance of sardines on the fishing grounds and the lack of information about nights when no fish were caught precludes the use of a single fishing night as a unit of effort. A lunar week is an unsatisfactory unit since the weeks immediately preceding and following the full moon comprise nights when the hours of darkness are consistently decreasing or increasing as the moon waxes and wanes. The lunar week as used by Silliman and Clark required complicated adjustments for the variations in the hours of darkness whereas the lunar month avoids such adjustments.

In some years the season opened or closed during a lunar month, or strikes prevented fishing for a part of a month. To make use of all material these months were counted as fractions, one-fourth, one-half or three-fourths. No smaller units were used. The dates of the lunar months are given in Table 1.

3.2. Correction for Limits in 1948–49

In the 1948–49 season the price of meal and oil had dropped but the price of the fish to the fisherman remained at a high level. Consequently there was little profit in reducing whole sardines into meal and oil and the processors were reluctant to buy fish for this purpose. The market for canned sardines was also uncertain and the canners restricted the amount of fish received for canning. As a result, on many nights the boats were permitted to bring in limited catches only. These limits were sometimes as low as 25 tons per boat.

At both Monterey and San Pedro the staff interviews a number of fishing boat captains each week and obtains records of the tonnage caught the previous night and whether any limit had been placed on the amount of fish which could be delivered. These records for 1948–49 showed that at Monterey during the lunar months of "October," "November" and "December" 31.3 percent of the catches were held down because of limits. The catches not affected by limits averaged 42.30 tons and the limited catches averaged 28.65 tons, a ratio of 1.476. Since only 31.3 percent of the catches were affected by limits .313 x .475 gives a

factor of .149 for weighting all catches made during these three lunar months. The catches made in "October-December" were, therefore, multiplied by 1.149. Catches made in "August," "September" and "January" were not adjusted, because no limits were in effect in these months.

TABLE 1

Dates of Lunar Months Used for the Comparison of the Catch of Each Boat With Its Catch in the Corresponding Lunar Month of the Previous Season

Lunar month	1932-33	1933-34	1934-35	1935-36	1936-37
"August"	Aug. 17–Sept. 14	Aug. 6–Sept. 4	July 27–Aug. 24	Aug. 14–Sept. 12	Aug. 2–Aug. 31
"September"	Sept. 15–Oct. 14	Sept. 5–Oct. 3	Aug. 25–Sept. 23	Sept. 13–Oct. 11	Sept. 1–Sept. 29
"October"	Oct. 15–Nov. 13	Oct. 4–Nov. 2	Sept. 24–Oct. 22	Oct. 12–Nov. 10	Sept. 30–Oct. 29
"November"	Nov. 14–Dec. 12	Nov. 3–Dec. 1	Oct. 23–Nov. 21	Nov. 11–Dec. 10	Oct. 30–Nov. 28
"December"	Dec. 13–Jan. 10	Dec. 2–Dec. 31	Nov. 22–Dec. 20	Dec. 11–Jan. 8	Nov. 29–Dec. 27
"January"	Jan. 11–Feb. 8	Jan. 1–Jan. 29	Dec. 21–Jan. 19	Jan. 9–Feb. 7	Dec. 28–Jan. 26
"February"	Feb. 9–Mar. 10	Jan. 30–Feb. 28	Jan. 20–Feb. 17	Feb. 8–Mar. 7	Jan. 27–Feb. 25
"March"	Mar. 11–April 10	Mar. 1–Mar. 29	Feb. 18–Mar. 19	Mar. 8–April 5	Feb. 26–Mar. 27

Lunar month	1937–38	1938–39	1939–40	1940–41	1941–42
"August"	July 24–Aug. 20	Aug. 11–Sept. 8	Aug. 1–Aug. 29	Aug. 18–Sept. 16	Aug. 8–Sept. 5
"September"	Aug. 21–Sept. 19	Sept. 9–Oct. 8	Aug. 30–Sept. 27	Sept. 17–Oct. 16	Sept. 6–Oct. 5
"October"	Sept. 20–Oct. 18	Oct. 9–Nov. 6	Sept. 28–Oct. 26	Oct. 17–Nov. 14	Oct. 6–Nov. 3
"November"	Oct. 19–Nov. 17	Nov. 7–Dec. 6	Oct. 27–Nov. 25	Nov. 15–Dec. 13	Nov. 4–Dec. 3
"December"	Nov. 18–Dec. 16	Dec. 7–Jan. 5	Nov. 26–Dec. 25	Dec. 14–Jan. 11	Dec. 4–Jan. 1
"January"	Dec. 17–Jan. 15	Jan. 6–Feb. 3	Dec. 26–Jan. 23	Jan. 12–Feb. 10	Jan. 2–Jan. 31
"February"	Jan. 16–Feb. 14	Feb. 4–Mar. 5	Jan. 24–Feb. 22	Feb. 11–Mar. 12	Feb. 1–Mar. 1
"March"	Feb. 15–Mar. 16	Mar. 6–April 4	Feb. 23–Mar. 1	Mar. 13–April 11	Mar. 2–Mar. 31

Lunar month	1942–43	1943–44	1944–45	1945–46	1946–47
"August"	July 29–Aug. 26	Aug. 16–Sept. 13	Aug. 4–Sept. 1	July 25–Aug. 22	Aug. 12–Sept. 10
"September"	Aug. 27–Sept. 24	Sept. 14–Oct. 13	Sept. 2–Oct. 1	Aug. 23–Sept. 20	Sept. 11–Oct. 9
"October"	Sept. 25–Oct. 24	Oct. 14–Nov. 12	Oct. 2–Oct. 31	Sept. 21–Oct. 20	Oct. 10–Nov. 8
"November"	Oct. 25–Nov. 22	Nov. 13–Dec. 11	Nov. 1–Nov. 29	Oct. 21–Nov. 19	Nov. 9–Dec. 7
"December"	Nov. 23–Dec. 22	Dec. 12–Jan. 10	Nov. 30–Dec. 29	Nov. 20–Dec. 18	Dec. 8–Jan. 6
"January"	Dec. 23–Jan. 20	Jan. 11–Feb. 8	Dec. 30–Jan. 27	Dec. 19–Jan. 17	Jan. 7–Feb. 5
"February"	Jan. 21–Feb. 18	Feb. 9–Mar. 10	Jan. 28–Feb. 26	Jan. 18–Feb. 16	Feb. 6–Mar. 7
"March"	Feb. 19–Mar. 21				

Lunar month	1947–48	1948–49			
"August"	Aug. 2–Aug. 30	July 22–Aug. 19			
"September"	Aug. 31–Sept. 28	Aug. 20–Sept. 17			
"October"	Sept. 29–Oct. 28	Sept. 18–Oct. 16			
"November"	Oct. 29–Nov. 27	Oct. 17–Nov. 15			
"December"	Nov. 28–Dec. 26	Nov. 16–Dec. 14			
"January"	Dec. 27–Jan. 25	Dec. 15–Jan. 13			
"February"	Jan. 26–Feb. 24	Jan. 14–Feb. 12			

TABLE 1

Dates of Lunar Months Used for the Comparison of the Catch of Each Boat With Its Catch in the Corresponding Lunar Month of the Previous Season

At San Pedro limits were placed on 57.0 percent of the catches made throughout the season. Catches not affected by limits averaged 47.09 tons and limited catches averaged 38.23 tons, a ratio of 1.232. Multiplying .570 x .232 gives .132 as the correction factor. All San Pedro catches used in the study were, therefore, multiplied by 1.132.

3.3. Selection of Boats

The only gear used in the sardine fishery is the roundhaul net, either a purse seine or a ring net. The length of boat varies from about 40 feet to about 110 feet, with the length and depth of the net proportional to the boat size. Boats of all sizes were included in the study. The only criterion was that the vessel fished in comparable lunar months of two seasons. During the first half of the interval covered by this report some boats fished for mackerel more consistently than for sardines. This was especially true in Southern California. Consequently, all boats whose total monthly catch consisted of less than half sardines were eliminated from the study. In the later seasons the mackerel fishery had decreased to the point where these fish were taken only incidentally, and it was assumed that the fishermen were primarily seeking sardines.

To eliminate as far as possible the effect of increased boat size and more efficient gear, the catch of each boat was compared with its catch in the corresponding lunar month of the previous season. Therefore, a vessel that did not fish at all in one of the two seasons compared was not included, and catches made in a month for which there was no matching month in the other season were also omitted.

In any lunar month some vessels did not fish the entire month due to breakdowns or other reasons independent of availability of fish. The criterion for including the catch of a boat for any specific lunar month was that the vessel made deliveries in at least two of the four weeks involved. When there were no more than two fishing weeks available in a given lunar month, or "dark," as at the beginning or end of the season, or due to strikes, that month was counted as a half-dark, and a boat was included if it delivered during only one week.

The poor sardine fishing in 1946–48 and 1947–48 necessitated some modifications of the above rule. In the 1948–49 season, fishing had improved enough so that the rule was again followed strictly. In 1946–47, no changes were made for San Pedro; but the fishing was so poor at San Francisco and Monterey that boats known (from observation or interview) to be present and available for fishing at those ports, for either whole or part darks, were considered as fishing during the time they were present, even though they did not go out every night. The catch for an entire month in many cases was recorded as zero. In 1947–48, fishing was still very poor in Monterey and practically nonexistent in San Francisco. One delivery in a dark was accepted as evidence that the boat was fishing the whole month. In San Pedro, sardine fishing was relatively poor, but large amounts of jack and Pacific mackerels were caught. Deliveries of these latter fish were counted, in the application of the criterion of deliveries in two weeks out of the month, as evidence that a boat was fishing. Fishermen were searching for sardines and delivering mackerel because sardines could not be found.

The number of boats entering into the study is compared with the total number in the fleet in Table 2. This table also gives a comparison of the tonnage caught by the selected boats with the total tonnage delivered. In no instance did the selected fleet comprise less than 40 percent of the total and it was more than half for all but four seasons. The maximum was 81 percent in 1945–46.

TABLE 2

Number of Boats Used in the Calculation of the Average Lunar Month Catch Compared With the Total Number of Boats Fishing

Seasons compared	Number of boats						Tons		
	San Francisco	Monterey	San Pedro	All California			Used in analysis	Total	Percent of total
				Number used in analysis*	Total fishing	Percent of total			
1932-33	21	24	34	80	168	48	169,748	248,956	68
1933-34							192,464	381,662	50
1933-34	26	35	53	115	190	61	257,564	381,662	67
1934-35							348,064	597,226	58
1934-35	30	49	64	145	242	60	383,817	597,226	64
1935-36							292,710	557,996	52
1935-36	33	50	81	163	249	65	329,598	557,996	59
1936-37							307,103	723,731	42
1936-37	48	46	103	178	316	56	365,281	723,731	50
1937-38							188,627	413,384	46
1937-38	54	44	102	178	379	47	224,037	413,384	54
1938-39							302,930	572,466	53
1938-39	92	42	96	212	325	65	319,640	572,466	56
1939-40							317,086	531,878	60
1939-40	58	43	79	176	335	53	233,489	531,878	44
1940-41							225,180	454,709	50
1940-41	56	69	75	202	321	63	294,566	454,709	65
1941-42							338,254	583,463	58
1941-42	42	21	71	143	297	48	257,738	583,463	44
1942-43							286,989	501,341	57
1942-43	42	43	70	151	208	73	343,468	501,341	69
1943-44							289,050	473,522	61
1943-44	49	39	73	151	206	73	330,887	473,522	70
1944-45							330,636	548,415	60
1944-45	48	54	76	170	226	75	357,370	548,415	65
1945-46							256,383	396,090	65
1945-46	15	58	88	182	224	81	301,990	396,090	76
1946-47							158,924	227,470	70
1946-47		59	179	224	281	80	164,431	227,470	72
1947-48							87,809	110,137	80
1947-48		62	185	248	352	70	88,330	110,137	80
1948-49							114,180	159,117	72

* Does not equal sum of three ports since certain boats could be used for one comparison but not for another.

TABLE 2

Number of Boats Used in the Calculation of the Average Lunar Month Catch Compared With the Total Number of Boats Fishing

3.4. Linkage

To measure fishing success for each of the seasons in the paired comparisons the monthly poundages delivered by all boats used each season were summed. The total number of lunar months that all of these boats fished in the season was also determined. This total poundage was then divided by the total boat months to obtain an average lunar month catch for each season. The average of the second season was divided by the average of the first and the ratio of the two seasons established (Tables 4–7, column 3). The tonnage in the average lunar month catch of 1932–33 was multiplied by the ratio between 1932–33 and 1933–34 to determine the lunar month tonnage for 1933–34. The value thus obtained for 1933–34 was then multiplied by the ratio between 1933–34

and 1934–35 to give the lunar month tonnage for 1934–35 linked to 1932–33. This process was repeated for each succeeding season (Tables 4–7, column 4) to determine the average lunar month catch for each season in terms of 1932–33. Percentage changes were calculated in a similar manner by taking 1932–33 as 100 percent (Tables 4–7, column 5). This resulted in a measure of the return to the fishermen in terms of a fleet of the size and efficiency of that of 1932–33. Any other season could have been selected as the base year and the relative changes would have remained the same.

3.5. Measure of Return per Unit of Effort for All California

Other studies of fishing success for sardines have been based on the catches at individual ports. Such comparisons are also included in this report for San Francisco, Monterey and San Pedro. Since other investigations (Clark and Janssen 1945) have demonstrated that the same sardine population is fished along the entire California coast, a calculation for all California was made by pooling all deliveries without regard to the port from which the vessels were operating. Many boats fished out of two ports within the month and occasionally a vessel made deliveries to all three ports. This consideration of the entire California coast as a single fishing ground gives a broader and more general picture of availability of sardines than do the happenings at individual ports.

TABLE 3

Total California Sardine Catch in Tons and Numbers of Fish for the Season, August-March (Numbers in Millions of Fish, 000,000 Omitted)

Season	San Francisco		Monterey		San Pedro-San Diego		All California	
	Tons	Numbers	Tons	Numbers	Tons	Numbers	Tons	Numbers
1932-33	76,207	366	89,257	496	83,492	509	248,956	1,371
1933-34	103,287	490	151,937	830	126,438	790	381,662	2,110
1934-35	183,620	927	229,992	1,345	183,614	1,225	597,226	3,497
1935-36	225,061	1,237	184,113	1,118	148,822	1,053	557,996	3,408
1936-37	375,019	2,232	206,229	1,273	142,483	937	723,731	4,442
1937-38	199,798	1,196	104,464	725	109,122	867	413,384	2,788
1938-39	244,251	1,732	180,090	1,513	148,125	1,437	572,466	4,682
1939-40	211,471	1,544	227,231	1,721	93,176	863	531,878	4,128
1940-41	117,817	886	165,145	1,424	171,747	1,712	454,709	4,022
1941 42	185,921	1,441	249,717	2,378	147,825	1,524	583,463	5,343
1942-43	115,586	732	183,158	1,337	202,597	1,920	501,341	3,989
1943-44	126,132	717	212,383	1,496	135,007	1,241	473,522	3,454
1944-45	136,337	692	234,613	1,652	177,465	1,466	548,415	3,810
1945-46	83,483	454	142,282	895	170,325	1,444	396,090	2,793
1946-47	2,850	18	26,790	187	197,830	1,688	227,470	1,893
1947-48	375	3	14,448	131	95,314	792	110,137	926
1948-49	1,369	14	40,427	475	117,321	1,004	159,117	1,493

TABLE 3

Total California Sardine Catch in Tons and Numbers of Fish for the Season, August-March (Numbers in Millions of Fish, 000,000 Omitted)

3.6. Calculations Based on Number of Fish in the Catch

Variations in the tonnage taken by the fishermen do not tell all that should be known about changes in the availability of sardines on the fishing grounds. When there are decided changes in the sizes of sardines in the fishery the numbers in each ton will vary accordingly. Consequently, calculations were made of the average lunar month catch in numbers as well as in tons.

TABLE 4

Average Lunar Month Catch for All California (In Tons)

Seasons	Average monthly catch		Linkage (Average monthly catch)		Total catch tons	Total boat months
	Tons	Ratio	Tons	Percent		
1	2	3	4	5	6	7
1932-33	426.0		426	100.0	248,956	584.4
1933-34	486.6	1.1423	487	114.2	381,662	783.7
1933-34	459.5					
1934-35	602.7	1.3116	639	149.8	597,226	934.6
1934-35	600.2					
1935-36	458.8	.7644	488	114.5	557,996	1143.4
1935-36	509.4					
1936-37	467.4	.9176	448	105.1	723,731	1615.5
1936-37	495.3					
1937-38	255.6	.5161	231	54.2	413,384	1,789.5
1937-38	279.0					
1938-39	377.2	1.3520	312	73.3	572,466	1,834.8
1938-39	387.0					
1939-40	383.9	.9920	310	72.7	531,878	1,715.7
1939-40	404.7					
1940-41	403.6	.9973	309	72.5	454,709	1,471.6
1940-41	466.5					
1941-42	515.6	1.1053	342	80.1	583,463	1,706.0
1941-42	446.7					
1942-43	497.4	1.1135	381	89.2	501,341	1,315.9
1942-43	528.4					
1943-44	448.1	.8480	323	75.6	473,522	1,466.0
1943-44	508.7					
1944-45	507.1	.9969	322	75.4	548,415	1,703.2
1944-45	634.8					
1945-46	455.4	.7174	231	54.1	396,090	1,714.7
1945-46	464.2					
1946-47	235.4	.5071	117	27.4	227,470	1,944.2
1946-47	246.2					
1947-48	130.7	.5309	62	14.5	110,137	1,776.4
1947-48	123.4					
1948-49	263.5	2.1353	132	31.0	159,117	1,205.4

TABLE 4

Average Lunar Month Catch for All California (In Tons)

TABLE 5

Average Lunar Month Catch for San Francisco (In Tons)

Seasons	Average monthly catch		Linkage (Average monthly catch)		Total catch tons	Total boat months
	Tons	Ratio	Tons	Percent		
1	2	3	4	5	6	7
1932-33	571.3		571	100.0	76,207	133.5
1933-34	627.1	1.0977	627	109.8	103,287	164.7
1933-34	619.7					
1934-35	867.8	1.4004	878	153.8	183,620	209.1
1934-35	867.7					
1935-36	802.0	.9243	812	142.2	225,061	277.2
1935-36	761.9					
1936-37	679.5	.8918	724	126.8	375,019	518.0
1936-37	690.8					
1937-38	351.8	.5093	369	64.6	199,798	541.5
1937-38	369.7					
1938-39	394.9	1.0682	394	69.0	244,251	619.9
1938-39	380.9					
1939-40	464.7	1.2200	481	84.2	211,471	439.6
1939-40	449.4					
1940-41	486.0	1.0814	520	91.1	117,817	226.6
1940-41	533.4					
1941-42	649.3	1.2173	633	110.9	185,921	293.7
1941-42	572.4					
1942-43	490.9	.8576	543	95.1	115,586	212.9
1942-43	627.4					
1943-44	623.5	.9938	540	94.5	126,132	233.6
1943-44	685.7					
1944-45	396.9	.5788	313	54.7	136,337	435.6
1944-45	598.7					
1945-46	453.0	.7566	237	41.4	83,483	352.2

TABLE 5

Average Lunar Month Catch for San Francisco (In Tons)

Both numbers and tons of fish in the total catch are given by seasons in Table 3. Two methods were used to convert tonnage into numbers. For the past 30 years the Bureau of Marine Fisheries has sampled the sardine catch and made measurements of the lengths of the fish. The average weight at each millimeter of length has also been determined. From these length frequencies and average weights per millimeter of length, for the seasons 1932–33 through 1935–36, the average number of fish per ton was calculated at each port for the entire season. The total tonnage was then multiplied by the average number per ton to obtain the numbers of sardine in the total catch. For the seasons 1936–37 through 1940–41 similar calculations were made for each lunar month and the total numbers of fish in each month were summed to obtain season totals. Beginning with 1941–42, each sample of fish measured for length was also weighed. The average weekly weight of the fish at each port was used to convert the total weekly tonnage into total number. The sums of these weekly totals gave the season total number of fish.

TABLE 6
Average Lunar Month Catch for Monterey (In Tons)

Seasons	Average monthly catch		Linkage (Average monthly catch)		Total catch tons	Total boat months
	Tons	Ratio	Tons	Percent		
1	2	3	4	5	6	7
1932-33	434.9		435	100.0	89,257	205.2
1933-34	432.5	.9945	433	99.5	151,937	350.9
1933-34	400.2					
1934-35	620.5	1.5505	671	154.3	229,992	342.8
1934-35	604.5					
1935-36	427.1	.7065	474	109.0	184,113	388.4
1935-36	518.8					
1936-37	550.6	1.0613	503	115.7	206,229	410.0
1936-37	680.6					
1937-38	316.0	.4643	234	53.7	104,464	446.4
1937-38	393.1					
1938-39	609.3	1.5500	363	83.2	180,090	496.1
1938-39	603.6					
1939-40	628.0	1.0404	378	86.6	227,231	601.1
1939-40	638.4					
1940-41	496.7	.7780	294	67.4	165,145	561.7
1940-41	574.3					
1941-42	693.0	1.2067	355	81.3	249,717	703.4
1941-42	553.2					
1942-43	532.2	.9620	342	78.2	183,158	535.5
1942-43	499.4					
1943-44	529.8	1.0609	363	83.0	212,383	585.1
1943-44	678.5					
1944-45	629.3	.9275	337	77.0	234,613	696.2
1944-45	839.7					
1945-46	487.0	.5800	195	44.7	142,282	729.7
1945-46	556.9					
1946-47	120.3	.2160	42	9.7	26,790	637.9
1946-47	123.2					
1947-48	66.3	.5381	23	5.2	14,448	628.2
1947-48	38.5					
1948-49	127.7	3.3169	76	17.2	40,427	531.9

TABLE 6
Average Lunar Month Catch for Monterey (In Tons)

TABLE 7

Average Lunar Month Catch for San Pedro (In Tons)

Seasons	Average monthly catch		Linkage (Average monthly catch)		Total catch * tons	Total boat months
	Tons	Ratio	Tons	Percent		
1	2	3	4	5	6	7
1932-33	335.3		335	100.0	83,492	249.2
1933-34	452.7	1.3501	452	135.0	126,438	279.7
1933-34	420.1					
1934-35	450.9	1.0733	485	144.9	183,614	378.6
1934-35	404.3					
1935-36	286.4	.7084	344	102.6	148,822	432.6
1935-36	356.5					
1936-37	271.5	.7616	262	78.1	142,483	543.8
1936-37	281.8					
1937-38	172.9	.6136	161	47.9	109,122	677.8
1937-38	182.3					
1938-39	231.5	1.2699	204	60.8	148,125	726.1
1938-39	251.1					
1939-40	197.4	.7861	160	47.8	93,176	582.4
1939-40	210.2					
1940-41	307.6	1.4634	234	70.0	171,747	734.0
1940-41	383.8					
1941-42	314.3	.8189	192	57.3	147,825	769.9
1941-42	331.9					
1942-43	479.5	1.4447	277	82.8	202,597	731.4
1942-43	541.4					
1943-44	318.0	.5874	163	48.6	135,007	828.3
1943-44	308.1					
1944-45	490.3	1.5914	259	77.3	177,465	685.2
1944-45	509.2					
1945-46	446.3	.8765	227	67.8	170,325	750.3
1945-46	434.5					
1946-47	283.3	.6520	148	44.2	197,830	1,336.7
1946-47	297.5					
1947-48	134.2	.4511	67	19.9	95,314	1,422.6
1947-48	131.0					
1948-49	279.4	2.1328	143	42.4	117,321	820.4

* Includes tonnage delivered at San Diego.

TABLE 7

Average Lunar Month Catch for San Pedro (In Tons)

The total catch in tons was then divided by the total catch in numbers to determine the average weight of the sardine for the season. These calculations were made for all California and for each of the three ports. The average lunar month catch in tons for each of the paired seasons was then divided by the average weight and the average lunar period catch in numbers thus obtained. (Columns 2, 3, 4, Tables 8–11.) The ratios between the paired seasons and the linked values were then calculated in the same manner as was done for the return per lunar month in tons.

TABLE 8

Average Lunar Month Catch for All California (In Numbers)

Seasons	Average weight (tons)	Tons per lunar month	Number per lunar month	Ratio	Linkage (Average monthly catch)		Total catch numbers	Total boat months
					Numbers	Percent		
1	2	3	4	5	6	7	8	9
1932-33	.000182	426.0	2,340,659		2,340,659	100.00	1,371,349,600	585.9
1933-34	.000181	486.6	2,688,398	1.1486	2,688,481	114.86	2,109,753,600	784.7
1933-34	.000181	459.5	2,538,674					
1934-35	.000171	602.7	3,524,561	1.3883	3,732,418	159.46	3,497,064,900	936.9
1934-35	.000171	600.2	3,509,942					
1935-36	.000164	458.8	2,797,561	.7970	2,974,737	127.09	3,407,798,900	1145.6
1935-36	.000164	509.4	3,106,098					
1936-37	.000163	467.4	2,867,485	.9232	2,746,277	117.33	4,441,916,800	1617.4
1936-37	.000163	495.3	3,038,650					
1937-38	.000148	255.6	1,727,027	.5684	1,560,984	66.69	2,788,745,600	1786.5
1937-38	.000148	279.0	1,885,135					
1938-39	.000122	377.2	3,091,803	1.6401	2,560,170	109.38	4,683,042,700	1829.2
1938-39	.000122	387.0	3,172,131					
1939-40	.000129	383.9	2,975,969	.9382	2,401,951	102.62	4,127,771,600	1718.5
1939-40	.000129	404.6	3,136,434					
1940-41	.000113	403.6	3,571,681	1.1388	2,735,342	116.86	4,021,823,800	1470.3
1940-41	.000113	466.5	4,128,319					
1941-42	.000109	515.6	4,730,275	1.1458	3,134,155	133.90	5,343,901,500	1705.1
1941-42	.000109	446.7	4,098,165					
1942-43	.000126	497.4	3,947,619	.9633	3,019,132	128.99	3,988,448,700	1321.1
1942-43	.000126	528.4	4,193,651					
1943-44	.000137	448.1	3,270,803	.7799	2,354,621	100.60	3,453,436,700	1466.7
1943-44	.000137	508.7	3,713,139					
1944-45	.000144	507.1	3,521,528	.9484	2,233,123	95.41	3,809,906,500	1706.1
1944-45	.000144	634.8	4,408,333					
1945-46	.000142	455.4	3,207,042	.7275	1,624,597	69.41	2,792,801,200	1719.1
1945-46	.000142	464.2	3,269,014					
1946-47	.000120	235.4	1,961,667	.6001	974,921	41.65	1,893,083,100	1941.8
1946-47	.000120	246.2	2,051,667					
1947-48	.000119	130.7	1,098,319	.5353	521,875	22.30	926,939,400	1776.2
1947-48	.000119	123.4	1,036,975					
1948-49	.000107	263.5	2,462,617	2.3748	1,239,349	52.96	1,492,529,399	1204.3

TABLE 8

Average Lunar Month Catch for All California (In Numbers)

TABLE 9

Average Lunar Month Catch for San Francisco (In Numbers)

Seasons	Average weight (tons)	Tons per lunar month	Number per lunar month	Ratio	Linkage (Average monthly catch)		Total catch numbers	Total boat months
					Number	Percent		
1	2	3	4	5	6	7	8	9
1932-33	.000208	571.3	2,746,635		2,746,635	100.00	366,379,800	133.4
1933-34	.000212	627.1	2,958,019	1.0770	2,958,126	107.70	489,720,300	165.6
1933-34	.000212	619.7	2,923,113					
1934-35	.000198	867.8	4,382,828	1.4994	4,435,414	161.49	927,373,700	209.1
1934-35	.000198	867.7	4,382,323					
1935-36	.000182	802.0	4,406,593	1.0055	4,459,809	162.38	1,236,598,900	277.3
1935-36	.000182	761.9	4,186,264					
1936-37	.000168	679.5	4,044,643	.9662	4,309,067	156.89	2,232,256,000	518.0
1936-37	.000168	690.8	4,111,905					
1937-38	.000167	351.8	2,106,587	.5123	2,207,535	80.37	1,196,395,200	542.0
1937-38	.000167	369.7	2,213,772					
1938-39	.000141	394.9	2,800,709	1.2651	2,792,753	101.68	1,732,276,600	620.3
1938-39	.000141	380.9	2,701,418					
1939-40	.000137	464.7	3,391,971	1.2556	3,506,581	127.67	1,543,583,900	440.2
1939-40	.000137	449.4	3,280,292					
1940-41	.000133	486.0	3,654,135	1.1140	3,906,331	142.22	885,842,100	226.8
1940-41	.000133	533.4	4,010,526					
1941-42	.000129	649.3	5,033,333	1.2550	4,902,445	178.49	1,441,248,000	294.0
1941-42	.000129	572.4	4,437,209					
1942-43	.000158	490.9	3,106,962	.7002	3,432,692	124.98	731,557,000	213.1
1942-43	.000158	627.4	3,970,886					
1943-44	.000176	623.5	3,542,614	.8921	3,062,305	111.49	716,659,100	234.0
1943-44	.000176	685.7	3,896,023					
1944-45	.000197	396.9	2,014,721	.5171	1,583,518	57.65	692,066,000	437.0
1944-45	.000197	598.7	3,039,086					
1945-46	.000184	453.0	2,461,957	.8101	1,282,808	46.70	453,712,000	353.7

TABLE 9

Average Lunar Month Catch for San Francisco (In Numbers)

TABLE 10

Average Lunar Month Catch for Monterey (In Numbers)

Seasons	Average weight (tons)	Tons per lunar month	Number per lunar month	Ratio	Linkage (Average monthly catch)		Total catch numbers	Total boat months
					Number	Percent		
1	2	3	4	5	6	7	8	9
1932-33	.000180	434.9	2,416,111		2,416,111	100.00	495,872,200	205.2
1933-34	.000183	432.5	2,363,388	.9782	2,363,440	97.82	830,256,800	351.3
1933-34	.000183	400.2	2,186,885					
1934-35	.000171	620.5	3,628,655	1.6593	3,921,656	162.31	1,344,982,500	343.0
1934-35	.000171	604.5	3,535,088					
1935-36	.000165	427.1	2,588,485	.7322	2,871,437	118.84	1,117,868,900	389.3
1935-36	.000165	518.8	3,144,242					
1936-37	.000162	550.6	3,398,765	1.0809	3,103,736	128.45	1,273,018,500	410.2
1936-37	.000162	680.6	4,201,235					
1937-38	.000144	316.0	2,194,444	.5223	1,621,081	67.09	725,444,400	447.5
1937-38	.000144	393.1	2,729,861					
1938-39	.000119	609.3	5,120,168	1.8756	3,040,500	125.83	1,513,361,300	497.7
1938-39	.000119	603.6	5,072,269					
1939-40	.000132	628.0	4,757,576	.9380	2,851,989	118.03	1,721,447,000	603.6
1939-40	.000132	638.4	4,836,364					
1940-41	.000116	496.7	4,281,897	.8854	2,525,151	104.50	1,423,663,800	563.8
1940-41	.000116	574.3	4,950,862					
1941-42	.000105	693.0	6,600,000	1.3331	3,366,279	139.31	2,378,257,100	706.5
1941-42	.000105	553.2	5,268,571					
1942-43	.000137	532.2	3,884,672	.7373	2,481,958	102.71	1,336,919,700	538.7
1942-43	.000137	499.4	3,645,255					
1943-44	.000142	529.8	3,730,986	1.0235	2,540,284	105.12	1,495,654,900	588.8
1943-44	.000142	678.5	4,778,169					
1944-45	.000142	629.3	4,431,690	.9275	2,356,113	97.50	1,652,204,200	701.2
1944-45	.000142	839.7	5,913,380					
1945-46	.000159	487.0	3,062,893	.5180	1,220,467	50.50	894,855,300	733.2
1945-46	.000159	556.9	3,502,516					
1946-47	.000143	120.3	841,259	.2402	293,156	12.13	187,342,700	639.1
1946-47	.000143	123.2	861,538					
1947-48	.000110	66.3	602,727	1.6996	205,092	8.49	131,233,800	639.9
1947-48	.000110	38.5	350,000					
1948-49	.000085	127.7	1,502,353	4.2924	880,337	36.44	474,660,832	539.2

TABLE 10

Average Lunar Month Catch for Monterey (In Numbers)

TABLE 11

Average Lunar Month Catch for San Pedro (In Numbers)

Seasons	Average weight (tons)	Tons per lunar month	Number per lunar month	Ratio	Linkage (Average monthly catch)		Total catch numbers *	Total boat months
					Number	Percent		
1	2	3	4	5	6	7	8	9
1932-33	.000164	335.3	2,044,512		2,044,512	100.00	509,097,600	249.0
1933-34	.000160	452.7	2,829,375	1.3839	2,829,400	138.39	789,776,500	279.1
1933-34	.000160	420.1	2,625,625					
1934-35	.000150	450.9	3,006,000	1.1449	3,239,380	158.44	1,224,708,700	378.1
1934-35	.000150	404.3	2,695,333					
1935-36	.000141	286.4	2,031,206	.7536	2,441,197	119.40	1,053,331,100	431.5
1935-36	.000141	356.5	2,528,369					
1936-37	.000152	271.5	1,786,184	.7065	1,724,706	84.36	936,642,300	543.1
1936-37	.000152	281.8	1,853,947					
1937-38	.000126	172.9	1,372,222	.7402	1,276,627	62.44	866,906,000	679.1
1937-38	.000126	182.3	1,446,825					
1938-39	.000103	231.5	2,247,573	1.5535	1,983,240	97.00	1,437,404,800	724.8
1938-39	.000103	251.1	2,437,864					
1939-40	.000108	197.4	1,827,778	.7497	1,486,835	72.72	862,740,700	580.3
1939-40	.000108	210.2	1,946,296					
1940-41	.000100	307.6	3,076,000	1.5804	2,349,794	114.93	1,712,317,900	728.7
1940-41	.000100	383.8	3,838,000					
1941-42	.000097	314.3	3,240,206	.8442	1,983,696	97.02	1,524,396,400	768.5
1941-42	.000097	331.9	3,421,649					
1942-43	.000106	479.5	4,523,585	1.3220	2,622,446	128.26	1,919,972,000	732.1
1942-43	.000106	541.4	5,107,547					
1943-44	.000109	318.0	2,917,431	.5712	1,497,941	73.26	1,241,122,700	828.6
1943-44	.000109	308.1	2,826,606					
1944-45	.000121	490.3	4,052,066	1.4335	2,147,298	105.02	1,465,636,300	682.5
1944-45	.000121	509.2	4,208,264					
1945-46	.000118	446.3	3,782,203	.8988	1,929,991	94.39	1,444,233,900	748.3
1945-46	.000118	434.5	3,682,203					
1946-47	.000117	283.3	2,421,368	.6576	1,269,162	62.07	1,688,147,800	1,330.1
1946-47	.000117	297.5	2,542,735					
1947-48	.000120	134.2	1,118,333	.4398	558,177	27.30	792,379,900	1,419.6
1947-48	.000120	131.0	1,091,667					
1948-49	.000117	279.4	2,388,034	2.1875	1,221,012	59.72	1,003,782,326	822.1

* Includes numbers delivered at San Diego.

TABLE 11

Average Lunar Month Catch for San Pedro (In Numbers)

4. AVERAGE LUNAR MONTH CATCH

4.1. Tons

The analysis of the average catches of the California fishermen over the 16 seasons indicates certain basic trends at all three ports. (Tables 4–11 For all of California the average monthly catch in tons (Fig. 1) increased from 1932–33 to 1934–35, then decreased until 1937–38. From 1937–38 to 1942–43 there was a general upward trend which was followed by another decline lasting through 1947–48 and bringing the return to the fishermen to the lowest level ever experienced in the California fishery. In 1948–49 the average monthly catch again increased slightly.

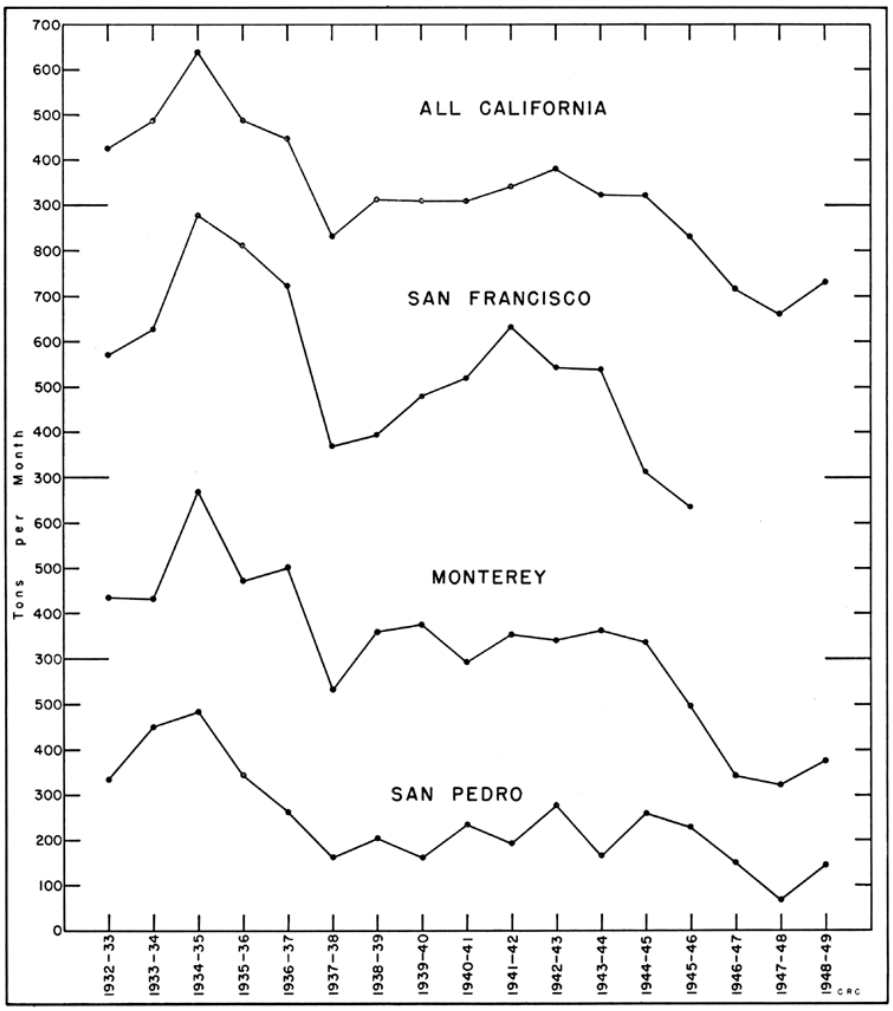

FIGURE 1. Average lunar month catch in tons of sardines, base year 1932-33

FIGURE 1. Average lunar month catch in tons of sardines, base year 1932–33

The average monthly catches at each port follow the same general pattern as that for all California. Because the averages are linked to the base year, 1932–33, caution must be used, however, in a comparison between ports of the tons per month as shown in Figure 1. These averages

are linked to a base year when the sizes of the boats used in the analysis differed from port to port. At San Francisco (see Silliman and Clark, 1945) the boats used in the first seasons of the analysis were larger than those at Monterey and San Pedro. Consequently the use of 1932–33 as a base gives the impression that the success of the fishermen at San Francisco is greater than on the other fishing grounds. A calculation of the average monthly catch based on the 1941–42 season when the fishing vessels were of approximately equal size indicates that Monterey fishermen tended to make the largest monthly catches until 1945–46 and that the San Pedro fishermen were more successful in the last three seasons (Fig. 2). San Francisco monthly averages approximated those of Monterey and San Pedro through 1943–44. After this season they fell off rapidly until the fishery failed in 1946–47. The comparisons in Figures 1 and 2 indicate that there are differences between ports in fishing success from season to season but that no fishing ground will consistently yield greater return per unit of effort expended. The Southern California fishermen, however, have never faced a failure such as occurred off San Francisco and Monterey in 1946–47 and 1947–48.

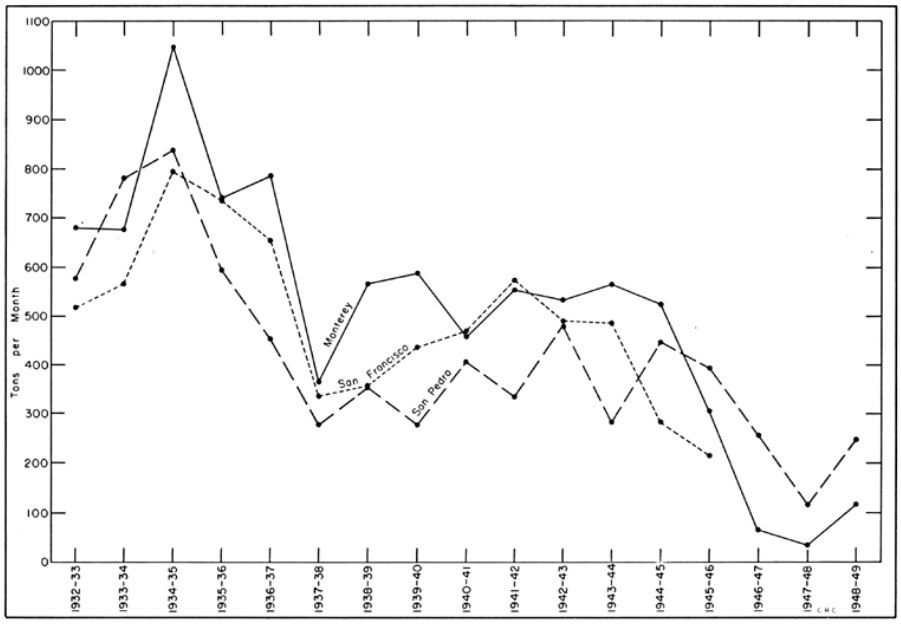

FIGURE 2. Average lunar month catch in tons of sardines, base year 1941-42

FIGURE 2. Average lunar month catch in tons of sardines, base year 1941–42

4.2. Numbers

The monthly catch in numbers differs from the catch in tons in that the fishery experienced a greater recovery after 1937–38 (Fig. 3). At San Francisco and Monterey the monthly average catch in numbers for the seasons 1938–39 through 1943–44 exceeded that of the initial season, 1932–33. For San Francisco also the number of fish in the monthly catch was greater in 1941–42 than in any other season, and at Monterey greater than any season except 1934–35. At San Pedro the averages from 1938–39 through 1945–46 fluctuated around that of 1932–33. For all ports in the

last three seasons the average monthly catch in numbers as well as in tons was less than during any other time in the history of the fishery.

The differences and similarities in variations in monthly catch in tons and in numbers are more readily compared when the averages are

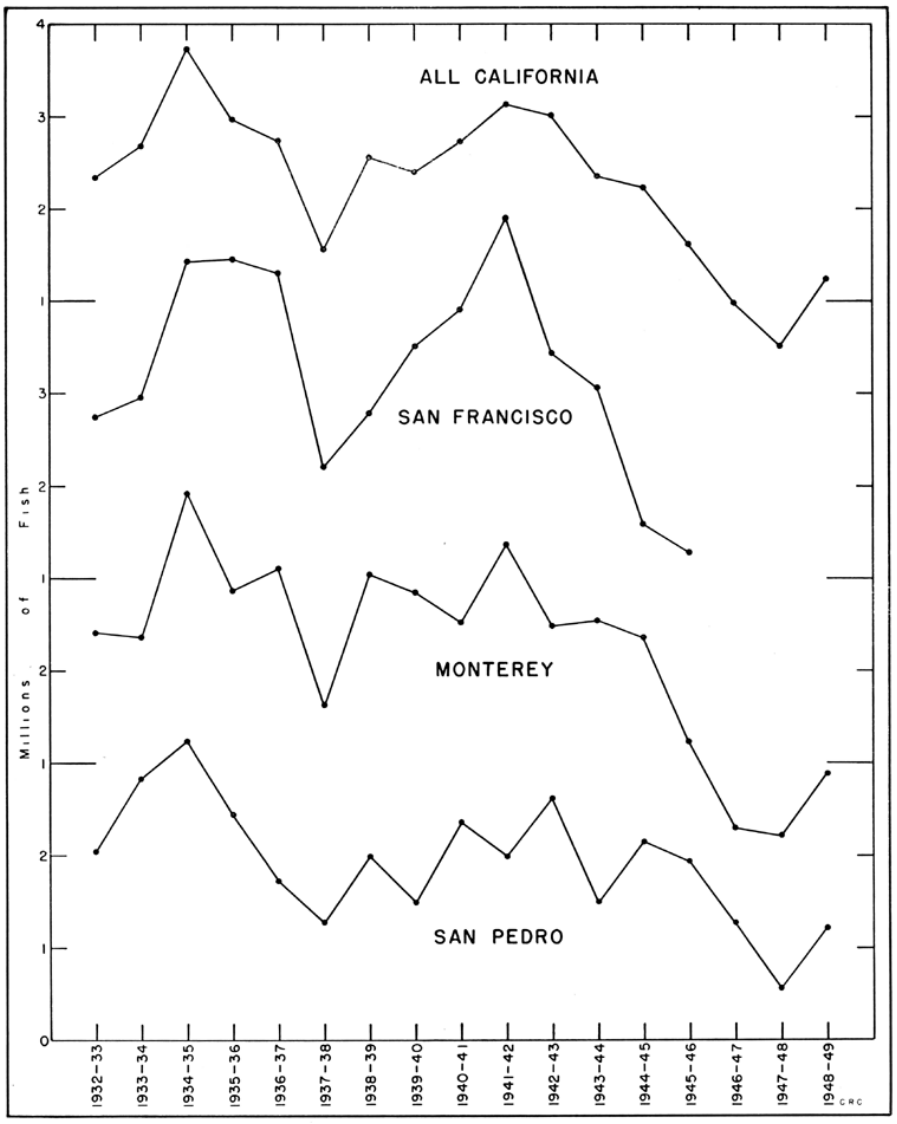

FIGURE 3. Average lunar month catch in numbers of sardines, base year 1932-33

FIGURE 3. Average lunar month catch in numbers of sardines, base year 1932–33

expressed in percentages of the 1932–33 base season (Fig. 4). At all ports the number of fish in each ton showed a general increase from 1937–38 through 1941–42. This indicates that the increase in fisherman's success in these years resulted from a greater abundance of young fish on the

fishing grounds and not from a greater abundance of sardines of all sizes. Presumably the decline in the fishery after 1941–42 resulted from lack of older and larger fish and insufficient replacement by the younger, smaller sardines.

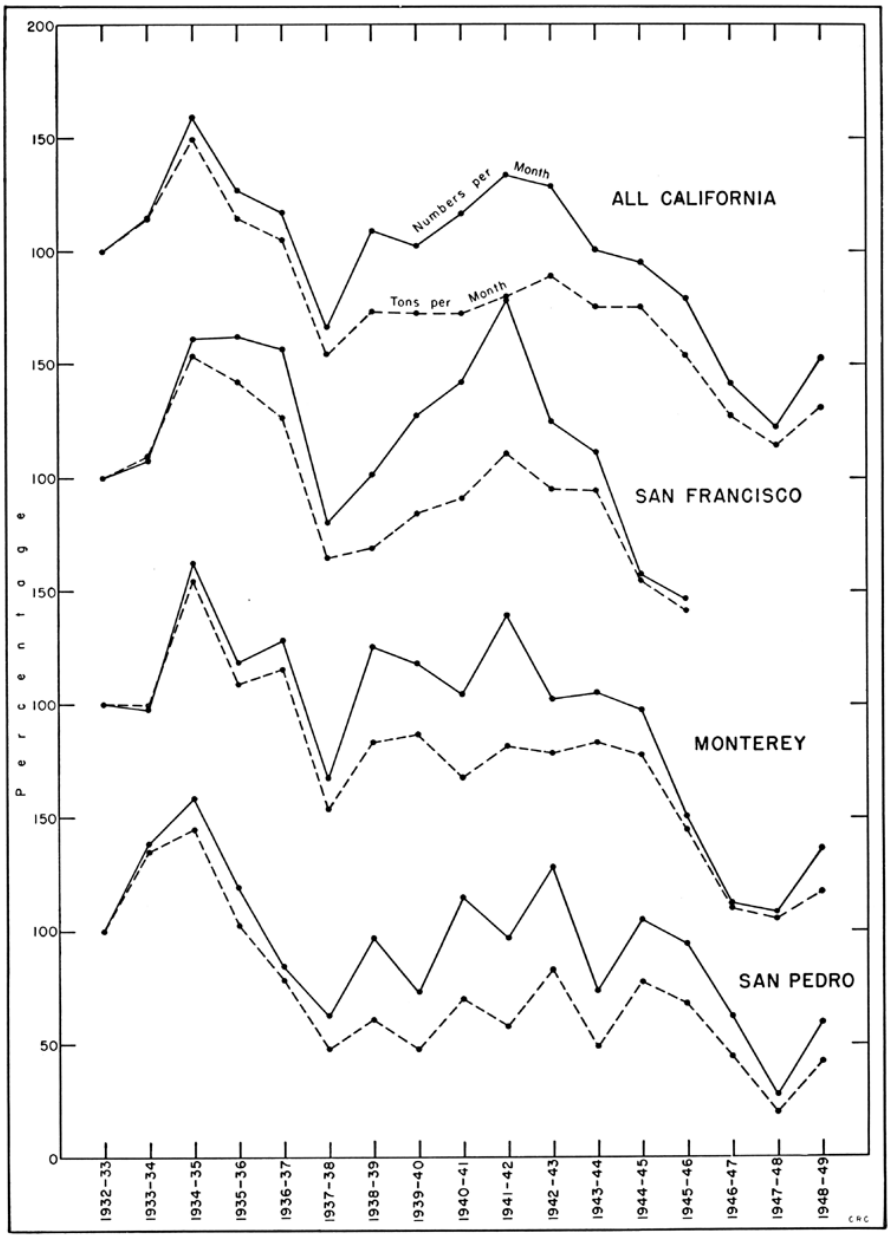

FIGURE 4. Average lunar month catch of sardines in percentage of 1932-33

FIGURE 4. Average lunar month catch of sardines in percentage of 1932–33

4.3. Average Length

This change in the sizes of sardines on the California fishing grounds is further demonstrated in Figure 5 and Table 12 which give the average lengths of the sardines in the catch for the seasons 1924–25 through 1948–49. The average for all California was calculated by weighting the average at each port by the total tonnage delivered to each port. The data for each port were based on the lengths obtained from the regular samples of the fishermen's catch. These figures indicate a general increase in average length of sardines in the catch from 1924–25 to 1932–33 and a decrease from 1933–34 to 1938–39. Prior to 1948–49 the lowest averages in the history of the fishery occurred during the seasons 1938–39 through 1941–42. Average length then increased until 1944–45 but did not regain the average size prevailing prior to 1937–38. After 1944–45 average length again decreased to the all time low in 1948–49.

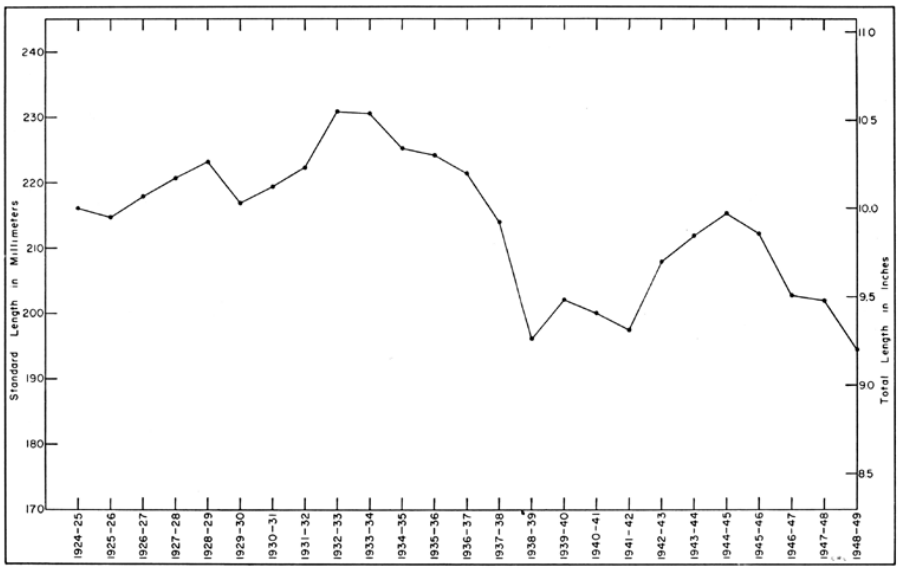

FIGURE 5. Average length of sardines in entire California catch

FIGURE 5. Average length of sardines in entire California catch

Obviously the variations in average length resulted from differences in the proportion of large and small sardines on the fishing grounds. Although these varying proportions might be explained in several ways, the most reasonable is the catching out of the larger and older fish accompanied by differences in the numbers in each new year class at the time that it appears on the fishing grounds. Previous studies of the length distributions of sardines in the California fishery (Clark, 1939) have shown that an abundant year class appeared on the fishing grounds in 1929–30 and dominated the catch until 1933–34. The resulting growth from season to season of the fish in this year class with no great abundance of younger sardines entering the fishing areas caused the average length to reach its greatest value in the 1932–33 and 1933–34 seasons. After 1933–34 this group ceased to play as important a role in the fishery and the average length gradually declined. In 1938–39 and 1939–40 more

TABLE 12

Average Length of Sardines in the Catch

Seasons	San Francisco		Monterey		San Pedro		All California *	
	Standard length (mm.)	Total length (inches)	Standard length (mm.)	Total length (inches)	Standard length (mm.)	Total length (inches)	Standard length (mm.)	Total length (inches)
1924-25			220.5	10.2	213.2	9.9	216.1	10.0
1925-26			219.2	10.2	209.6	9.7	214.7	9.9
1926-27			215.9	10.0	223.4	10.4	217.9	10.1
1927-28			218.6	10.1	223.7	10.4	220.7	10.2
1928-29			227.6	10.6	218.9	10.2	223.2	10.3
1929-30			218.9	10.2	214.7	10.0	216.9	10.1
1930-31			216.5	10.0	220.1	10.2	219.4	10.2
1931-32			219.7	10.2	221.2	10.2	222.3	10.3
1932-33			228.7	10.6	227.9	10.6	230.8	10.7
1933-34			229.8	10.6	225.5	10.4	230.5	10.7
1934-35			223.3	10.4	221.9	10.3	225.2	10.4
1935-36	229.5	10.6	219.9	10.2	221.1	10.2	224.1	10.4
1936-37	221.9	10.3	218.5	10.1	223.5	10.4	221.3	10.3
1937-38	220.8	10.2	209.6	9.7	205.1	9.5	213.8	9.9
1938-39	200.6	9.3	192.0	8.9	192.7	8.9	195.9	9.1
1939-40	204.6	9.5	201.0	9.3	198.4	9.2	202.0	9.4
1940-41	199.6	9.2	204.1	9.5	196.0	9.1	199.9	9.3
1941-42	203.7	9.4	195.2	9.0	194.9	9.0	197.3	9.1
1942-43	218.1	10.1	211.6	9.8	199.7	9.3	207.8	9.6
1943-44	225.9	10.5	212.4	9.8	199.2	9.2	211.8	9.8
1944-45	234.7	10.9	212.3	9.8	204.0	9.5	215.2	10.0
1945-46	224.6	10.4	215.9	10.0	202.8	9.4	212.1	9.8
1946-47	222.5	10.3	202.1	9.4	203.2	9.4	202.7	9.4
1947-48			196.9	9.1	202.7	9.4	201.9	9.4
1948-49			177.9	8.2	200.2	9.3	194.4	9.0

* Weighted average calculated by weighting average length for each port by tons landed at each port. San Francisco included for seasons 1935-36 through 1946-47.

TABLE 12

Average Length of Sardines in the Catch

abundant year classes entered the fishery and in 1940–41 the very numerous 1939 year class first appeared on the fishing grounds (Felin and Phillips, 1948). These groups, still composed of small sized sardines, produced the small average lengths and the large number of fish per ton during the seasons 1938–39 through 1941–42. The growth of the sardines in these year classes during 1942–43, 1943–44 and 1944–45 caused the continuous increase in average length. After 1944–45 these groups supplied fewer and fewer sardines to the fishery and again average length declined.

As happened in the period between 1934–35 and 1937–38, the number of large sardines on the fishing grounds fell off after 1944–45 and no new outstanding year class entered the fishery to replenish the fishable population. Thus there were two periods during the past 17 years, 1934–35 through 1937–38 and 1942–43 through 1947–48, when the abundance of large sardines was reduced to a low level and no great number of younger, smaller fish appeared on the fishing grounds to renew the stock. This brought about, in the first period, a serious decrease in return to the fisherman for his fishing effort and, in the second interval, reached a disaster point for the San Francisco and Monterey fisheries. In 1948–49 some relief was furnished by the appearance of the 1947 year class which gives promise of being more abundant than any occurring on the fishing grounds for several seasons.

4.4. Relation Between Total Catch, Total Effort and Average Lunar Month Catch

The relation between the average monthly catch, the total catch and the total boat months necessary to obtain the total catch is shown for the

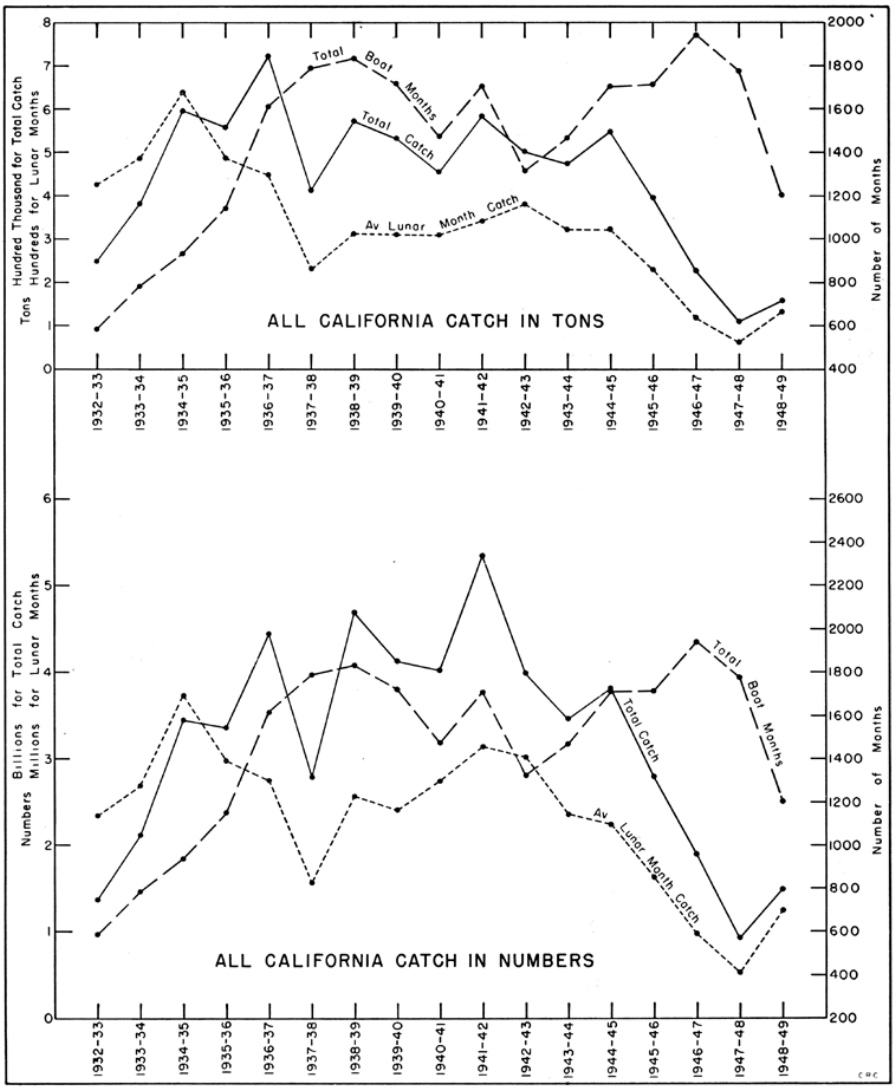

FIGURE 6. Comparison of total sardine catch for all California with average lunar month catch and total boat months

FIGURE 6. Comparison of total sardine catch for all California with average lunar month catch and total boat months

entire California fishery in Figure 6. The total boat months, which represents total fishing effort, was obtained by dividing total catch by average monthly catch. The greatest total catch in tons occurred in 1936–37 when over 700,000 tons were landed. The greatest return to the fisherman for effort expended occurred in 1934–35 when the average lunar month catch was in excess of 600 tons.* The total boat months reached its first peak in 1938–39 and this large fishing effort plus the entrance into the fishery

* * It must be remembered that the average monthly catch figures are linked to the base year, 1932–33, and that the tons and numbers per lunar month as given in Figure 6 represent the catch the fishermen would have made if the fleet had been composed of the same sized boats and had operated at the same efficiency as did the fleet in 1932–33. The actual average catch per lunar month for each season is given in column 2 of Tables 4–7.

of the very abundant 1939 year class maintained the total catch at approximately 500,000 tons until 1944–45. After this season, continued intense fishing effort could not maintain total catch and there resulted a rapid decline in total tons landed as well as in average monthly catch. Finally total effort also declined because it no longer paid the fisherman to try to fish and many boats turned to other fisheries.

A comparison of catch in numbers rather than tons results in a similar picture although the greatest total catch was not reached until 1941–42 at the time that the 1939 year class was fully available but still composed of relatively small sardines.

5. SUMMARY

The analysis of the average lunar month catch of California sardines was based on a summation of the daily catches by individual fishing boats delivered between two full moons. This interval is termed a lunar month.

The monthly catches of boats fishing in paired seasons were compared. If a boat failed to fish in a lunar month of one season its catch in the comparable month of the other season was omitted.

Over a 17-year interval, 1932–33 through 1948–49, many changes in fishing methods and boat sizes have occurred. To eliminate as far as possible the effect of these changes, the seasonal average monthly catches were linked using 1932–33 as the base year.

Average lunar month catch was calculated in pounds and numbers.

For all of California, the average lunar month catch in tons increased from 1932–33 to 1934–35, decreased to 1937–38, increased somewhat until 1942–43 and then began a slight decline which accelerated after 1944–45 and continued through 1947–48. A slight upward trend occurred in 1948–49.

This general trend was also evident in the average monthly catch in numbers but the increase from 1937–38 to 1941–42 was greater.

The total fishing effort was expressed as the total boat months required to make the season's landing. The total number of boat months was determined by dividing total catch by average lunar month catch. A tonnage comparison of average monthly catch with total catch and total effort showed that the average lunar month catch reached its highest point in 1934–35 but a continued increase in total effort carried the total catch to a peak in 1936–37. Total catch, total effort and average monthly catch tended to stabilize from 1937–38 through 1944–45, then both total and monthly catch dropped rapidly in spite of an increased effort. Finally fishing success was reduced to such a low level that fishermen deserted the fishery and after 1946–47 total effort also declined.

Based on numbers of fish caught, the highest peak in total catch occurred in 1941–42 when there was a scarcity of older sardines on the fishing grounds and the fishery depended on the very abundant 1939 year class. This lack of older fish with no new abundant year classes entering the fishery is offered as the explanation of the serious decline in the sardine fishery after 1944–45.

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