Part 2: The Outlook for the Fishery

2) on the basis of these facts to make the best possible estimates of the fluctuations in the abundance and availability of the sardine and to predict the outlook for the fishery;

With the exception of the Department of Fish and Game, which has the dual function of research and management, none of the cooperating research agencies, nor the research-directing Marine Research Committee, is required by law to make management recommendations. The committee was established to sponsor fact-finding research on the State's marine fisheries. It has set as an objective for the cooperating research agencies the extrapolation of known facts into the future, in the form of a prediction of the outlook for the fishery.

This report so far has been concerned solely with picturing the present status of the sardine population as compared to that of several years ago. In this section, we shall attempt to use this information to discover what the immediate future holds for the industry.

Four types of information are required before a reliable prediction can be made:

a) Knowledge of the numerical size of the year classes that have been in the fishery in previous seasons;
b) Knowledge of the numerical size of the year class which will be entering the fishery for the first time;
c) Knowledge of how available the fish of each year class will be during the coming season;
d) Knowledge of the mortality rates.

There are two valid lines of reasoning leading to predictions of the future catch that agree in principle though not in detail. They differ in the weight given the results of separate investigations, the spawning surveys and the young-fish surveys, and in the emphasis placed on the factor of availability.

The first line of reasoning and the evidence upon which it is based can be summarized as follows:

1) The 1951 surveys indicate spawning population almost double the size of that of 1950. This could indicate either that sardines of the 1948 year class did not spawn appreciably in 1950 or that some other year class, presumably the 1949 year class, first spawned in 1951 and did not enter the 1951-52 catch in proportion to its true abundance. Since one-half of all sardines are mature at a length of 8.5 inches and all are mature at about 9.3 inches, one would expect that one-third to one-half of the fish of the 1948 year class would have spawned in 1950 and about three-fourths or more in 1951. If the increase in number of eggs spawned in 1951 was due largely to the increased growth of the fish of the 1948 year class, no increase in catch should be anticipated. If, however, the increase was brought about by fish of the 1949 year class, then this year class is larger than previously thought and apparently up to now has been distributed to the south of the regular fishing grounds.

2) There is little evidence on the size of the 1951 year class.

3) In the 1951-52 season, the 1948 year class made up the bulk of the catch and the 1949 and 1950 year classes appeared to be of below average size. Even assuming that in the 1952-53 season the entering 1951 year class will be of about average size, the outlook for the 1952-53 season is not a good one. This is only a guess, however, since the fish might be less available than in previous seasons and the catch would be even lower than expected, or the fish could be more available and the catch would be greater than might be expected. One indication that the catch statistics do not reflect the total population with full accuracy is the increase in spawning, as mentioned above.

The second line of reasoning and the supporting evidence can be summarized:

1) During 1951-52, the 1948 year class contributed 65 percent of the tonnage taken and older year classes 30 percent. These groups supplied 120,000 tons in the past season, and it is improbable that they will contribute any increased tonnage in the coming seasons. A decrease of 50 percent or more is much more likely. As a result, in the next one or two seasons the fishery will be more and more dependent on the younger year classes, spawned in 1949, 1950, and 1951. Age analysis of the fish in the 1951-52 catch indicates that the 1949 year class is a small one, and this is borne out by the results of the young-fish surveys, which covered Baja California as well as the California fishing grounds. These surveys indicate that the 1949 year class is about one-sixth as abundant as the 1948 group. Since the 1948 year class as it has appeared in the catch is of only average or slightly less than average strength, there is little hope for an improvement in fishing based on the 1949 year-class contribution.

2) The young-fish surveys of abundance of the 1950 and 1951 year classes show approximately equal abundance for each of these groups when about six months old (spawning surveys indicate an egg and larvae abundance of approximately one to two for 1950 and 1951), and that their strength is only slightly greater than that of 1949.

3) There is little hope for improved fishing in the 1952-53 or 1953-54 seasons and the evidence suggests that conditions may be worse. The factors that affect availability are as yet unmeasured. If availability should be exceptionally high it might tend to offset the sparsity of fish.

It will be seen that these two lines of reasoning lead to predictions for the coming season that on the whole are very discouraging.

The consensus is that the industry, if it depends on the sardine alone, and if availability does not operate so as to increase the catch, must for at least the next two seasons subsist upon the smallest catches in more than a generation.

Appendix

TABLE 1. AVERAGE NUMBER OF LARVAE PER STATION PER CRUISE DURING PERIOD MARCH-AUGUST OFF SOUTHERN CALIFORNIA

Species	Year		
	1941	1950	1951
Sardine	30.20	12.30	5.23
Anchovy	50.23	30.46	35.37
Jack Mackerel	1.62	22.50	26.38
Sebastodes	11.61	34.97	44.63
Hake	14.17	8.19	50.38*

* Apparent increase in abundance of hake during 1951 is probably due to deepening our tows, hence getting a more complete sample of this species. Hake larvae tend to be considerably deeper than those of the other fishes in the above list.

TABLE 2. NUMBER OF SCHOOLS OF YOUNG SARDINES FOUND IN VARIOUS LOCALITIES IN YEARS 1938, 1939, 1940, 1950, AND 1951 (see Fig. 2)

Locality	Number of schools by year class				
	1938	1939	1940	1950	1951
Central California (Bodega Head to Pt. Conception)	4	31	62	4	1
Southern California (Pt. Conception to Ensenada)	779	3	79	6	8
Northern Baja California (Ensenada to Pt. San Eugenio)	14	26	60	8	11
Central Baja California (South of Pt. San Eugenio)	21	3	3	6	8
Totals	818	63	204	24	28

TABLE 3. PERCENTAGE OF THE SARDINE CATCH TAKEN IN THE FOUR MAJOR FISHING AREAS DURING ELEVEN SEASONS (see Fig. 3)

Fishing area	Season										
	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51	1951-52
San Francisco (Pt. Montara and North)	25.1	24.7	24.2	13.1	14.7	1.2			1.4	.6	
Monterey (Pt. Montara to South of Pt. Sur)	46.4	32.4	44.0	52.2	42.0	9.4	9.4	21.1	34.9	6.2	.1
Morro (South of Pt. Sur to Pt. Conception)	2.7	2.6	3.0	2.3	.8	2.1		1.0	7.4	8.4	13.2
Southern California (South of Pt. Conception)	25.6	40.2	28.5	32.5	42.5	87.3	90.3	77.7	56.5	84.8	86.6
Totals	99.8	99.9	99.7	100.1	100.0	100.0	99.7	99.8	100.2	100.0	99.9

TABLE 4. SIZE DISTRIBUTION OF 1948 YEAR CLASS SARDINE SAMPLES AT ENSENADA, SAN PEDRO, AND MONTEREY IN THE 1951-52 SEASON (see Fig. 7)

Length (mm.)	PORTS						Length (inches)
	Monterey		San Pedro		Ensenada		
	Number of fish	Percent of total sample for port	Number of fish	Percent of total sample for port	Number of fish	Percent of total sample for port	
185					1.5	3.2	7.3
187							
189					9	19.6	7.4
191	0.5	1	4	1.1			7.5
193					10	21.7	7.6
195			26.5	7.5			7.7
197					9.5	20.7	7.8
199	1.5	3	49.5	14.0			7.8
201					6.5	14.1	7.9
203	3.5	7	62.5	17.7			8.0
205					5	10.9	8.1
207	5	10	58.5	16.5			8.1
209					2.5	5.4	8.2
211	4	8	43.5	12.3			8.3
213					.1	2.2	8.4
215	6	12	34	9.6			8.5
217							8.5
219	9	18	20.5	5.8			8.6
221					0.5	1.1	8.7
223	6	12	22.5	6.4			8.8
225					0.5	1.1	8.9
227	6	12	17	4.8			8.9
229							9.0
231	3.5	7	7	2.0			9.1
233							9.2
235	1.5	3	4	1.1			9.3
237							9.3
239	2	4	3.5	1.0			9.4
241							9.5
243	0.5	1	1	0.3			9.6
245							9.6
247	1	2					9.7
Totals	50.0		354.0		46.0		

TABLE 5. CATCH, MINIMUM INITIAL POPULATION AND MAXIMUM INITIAL POPULATION

(Billions of fish)

Season	Catch	Minimum initial population	Maximum initial population
32-33	1.3	3.1	19
33-34	2.1	4.8	23
34-35	3.5	7.6	35
35-36	3.4	7.2	28
36-37	4.4	8.8	27
37-38	2.8	5.5	16
38-39	4.7	9.0	25
39-40	4.1	8.0	24
40-41	4.0	8.2	27
41-42	5.3	10.6	31
42-43	4.0	8.2	26
43-44	3.5	7.0	22
44-45	3.8	7.2	19
45-46	2.8	5.3	14
46-47	1.9	3.0	5.4
47-48	.9	1.4	2.6
48-49	1.5	2.7	6.5
49-50	2.8	5.2	13.0
50-51	2.6	3.8	6.5
51-52	1.0	----	----

TABLE 6. PERCENTAGE AGE COMPOSITION BASED ON NUMBERS OF SARDINES IN THE CALIFORNIA FISHERY FOR THREE TIME INTERVALS, 1932-33 TO 1937-38, 1941-42 TO 1946-47, 1947-48 TO 1951-52 (see Fig. 10)

Age	Percentage		
	1932-33 to 1937-38	1941-42 to 1946-47	1947-48 to 1951-52
0	.2	----	.3
1	2.4	12.4	11.3
2	19.7	34.2	42.0
3	29.8	29.1	31.3
4	23.0	15.1	10.7
5	12.0	6.3	3.6
6	6.3	2.1	.7
7	2.8	.6	.1
8	1.3	.1	----
9	.8	----	----
10	.7	----	----
11	.5	----	----
12	.8	----	----
Totals	100.3	99.9	100.0

TABLE 7. RELATIVE YEAR-CLASS SIZE OF SARDINES, MEASURED BY THE NUMBER OF THREE-YEAR-OLD FISH CAUGHT PER BOAT-MONTH IN CALIFORNIA (see Fig. 11)

Season	Number of fish caught per boat-month	Year-class measured
1932-33	7,686	1929
1933-34	3,718	1930
1934-35	12,669	1931
1935-36	14,974	1932
1936-37	5,607	1933
1937-38	2,584	1934
1938-39	No data	1935
1939-40	No data	1936
1940-41	No data	1937
1941-42	8,609	1938
1942-43	13,247	1939
1943-44	6,121	1940
1944-45	4,149	1941
1945-46	4,702	1942
1946-47	1,876	1943
1947-48	930	1944
1948-49	1,337	1945
1949-50	6,211	1946
1950-51	4,958	1947

TABLE 8. NUMBERS OF SCHOOLS OF SARDINES BY YEAR CLASS AND REGION PER SCOUTING NIGHT FOR THE 1950 AND 1951 SURVEYS

Locality	Year class						
	1950 survey			1951 survey			
	1950	1949	1948	1951	1950	1949	1948
Central California (Bodega Head to Pt. Conception)	33.3	------	2.8	0.5	4.1	1.4	9.0
Southern California (Pt. Conception to Ensenada)	14.4	8.3	113.0	20.3	7.0	8.4	55.9
Central Baja California (Ensenada to Pt. San Eugenio)	53.8	35.5	150.2	58.4	40.1	31.2	91.0
Southern Baja California (Pt. San Eugenio to Magdalena Bay)	81.7	53.3	48.0	107.0	48.0	14.4	29.4
All regions (averages)	37.7	19.2	88.2	36.3	20.7	14.4	53.4

TABLE 9. FOOD ITEMS IN STOMACHS OF 273 ADULT SARDINES AS COMPARED WITH PLANKTON CONTENT OF WATER SAMPLES TAKEN ALONG WITH SARDINE SAMPLES (see Fig. 31)

Item	In percent of stomachs	In percent of water samples	Average number per fish	Item	In percent of stomachs	In percent of water samples	Average number per fish
Diatoms	75	Not analyzed	1,200,000	Snails (adults and larvae)	49	68	2
Dinoflagellates	71	Not analyzed	13,000	Zoaea larvae	29	44	1
Radiolaria, Silicoflagellates, Tintinnids	46	Not analyzed	1,000	Annelid larvae	36	58	1
Small copepods	100	100	560	Amphipods	19	17	x
Larvaceans	93	96	170	Barnacle nauplii	18	18	x
Copepod nauplii	47	26	130	Fish larvae	17	23	x
Large copepods	70	85	12	Barnacle cypris	16	15	x
Arrow worms	73	90	11	Siphonophores	15	82	x
Euphausiid eggs	32	36	9	Mysids	13	19	x
Fish eggs	79	71	8	Salps	15	15	x
Euphausiid calyptopis and furcilia larvae	50	53	8	Shrimp larvae	8	11	x
Cyphonautes larvae	64	75	7	Ostracods	4	10	x
Cladocera	65	76	6	Brachiopod larvae	4	5	x
Euphausiid nauplii	40	47	4	Megalops larvae	3	8	x
Clam larvae	48	55	3	Doliolids	2	20	x
Euphausiids	24	22	2	Stomatopods	x	0	x
				Octopus	x	0	x
				Isopod	x	0	x

x—Less than one item per fish.

TABLE 10. AVERAGE NUMBER OF FOOD ITEMS PER ADULT SARDINE PER MONTH (WEIGHTED AVERAGES FOR A VOLUME OF 2.0 ML PER FISH)

	November 1949	December 1949	January 1950	February 1950	March 1950	May 1950	August 1951
Diatoms	2,300	50,000	6,400,000	26,500	9,000,000	790,000	212,000
Dinoflagellates	3,300	6,300	26,800	----	104,000	12,000	42,000
Small Copepods	4,700	1,100	400	1,100	300	300	860
Larvaceans	5	100	100	----	28	460	220
Chaetognaths	17	6	34	----	----	15	10
Fish eggs	x	8	4	40	----	19	10
Euphausiids	----	7	----	----	----	4	x
Euphausiid larvae	x	10	x	80	16	20	4
Cyphonautes larvae	5	5	18	15	----	2	24
Cladocera	15	4	8	15	x	11	6
Large Copepods	2	8	12	45	40	31	6
Number of fish	15	39	81	10	4	63	61
Average volume per fish	1.2 ml	2.1 ml	1.0 ml	0.4 ml	1.0 ml	2.1 ml	1.0 ml

x—Less than one item per fish.

TABLE 11. PLANKTON VOLUMES (WET) CC/1000 M^8 (see Fig. 46)

Cruise	Date	Number of stations	Average volume cc. per 1,000 M^3	Percent deviation from seasonal average
	1949			
1	March	69	87.7	—40.1
2	April	92	166	+12.9
3	May	106	208	+41.5
4	June	80	128	—12.9
5	July	110	230	+57.1
6	August	118	175	+19.7
7	September	113	109	—25.8
8	October	104	134	— 8.8
9	November	112	85.7	—42.8
10	Anchor cruise			
Average for 1949=147.1 cc				

Cruise	Date	Number of stations	Average volume cc. per 1,000 M^3	Percent deviation from seasonal average
	1950			
11	February	113	980	+75.0
12	March	101	790	+41.1
13	April	118	928	+67.7
14	May	124	904	+61.4
15	June	107	295	—47.3
16	July	140	361	—35.5
17	August	96	450	—19.6
18	September	129	260	—53.6
19	Anchor Cruise			
20	November	95	69	—87.7
Average for 1950=559.7 cc				

TABLE 11. PLANKTON VOLUMES (WET) CC/1000 M^3 (see Fig. 46)—Continued

	Date	Number of stations	Average volume cc. per 1,000 M^3	Percent deviation from seasonal average
Cruise	**1951**			
21	January	125	165.92	+25.8
22	February	98	99.1	—25.0
23	March	136	86.04	—34.8
24	April	135	147.4	+11.6
25	May	121	135.08	+ 2.6
26	June	121	205.59	+56.0
27	July	105	149.38	+13.17
28	August	118	160.71	+21.9
29	September	102	134.0	+ 1.48
30	October	88	119.1	— 9.8
31	November	88	103.33	—21.7
32	December	64	77.22	—41.5
	Average for 1951=132.0 cc			

TABLE 12. OCCURRENCE OF THE LARVAE OF OTHER FISHES IN HAULS CONTAINING SARDINE EGGS OR LARVAE, JANUARY THROUGH JULY, 1951

	Southern California and adjacent Baja California		Central and Southern Baja California		All areas	
	Number of occurrences	Percent occurrence	Number of occurrences	Percent occurrence	Number of occurrences	Percent occurrence
Sardine	79	100.0	96	100.0	175	100.0
Northern Anchovy	33	42.0	81	84.5	114	65.0
Jack Mackerel	63	80.0	24	25.0	87	50.0
Hake	54	68.5	64	66.7	118	67.5
Rockfish (Sebastodes spp.)	66	83.5	65	68.0	131	75.0

TABLE 13. CONCENTRATION OF THE PRINCIPAL FISHES SAMPLED DURING THE 1950 AND 1951 YOUNG-FISH SURVEYS AS MEASURED BY NUMBERS OF SAMPLES PER SCOUTING NIGHT BY REGION

Region	1950 survey				1951 survey			
	Sardines	Jack Mackerel	Pacific Mackerel	Anchovies	Sardines	Jack Mackerel	Pacific Mackerel	Anchovies
Bodega Head to Cape San Martin	0.33	0.78	0.00	0.67	0.00	0.29	0.00	0.43
Point Piedras Blancas to Point Arguello	0.67	0.67	0.00	0.67	0.50	0.25	0.00	0.50
Point Arguello to Punta Banda (Southern California and Northern Baja California)	2.10	2.00	1.25	2.40	1.06	1.39	0.56	1.39
Punta Banda to Punta Baja	2.50	2.00	0.83	2.00	1.83	1.33	0.00	1.33
Punta Baja to Punta Eugenio (Sebastian Vizcaino Bay)	2.71	0.57	0.29	0.29	2.67	0.56	0.33	0.56
Punta Eugenio to Punta Abreojos	1.80	0.60	0.60	1.40	2.25	1.25	1.75	2.00
Punta Abreojos to Cabo San Lazaro	2.50	0.00	0.00	4.50	1.00	0.00	0.00	2.00
All regions combined	1.83	1.31	0.67	1.65	1.35	0.94	0.41	1.08

About This Report:

3) to make these facts and estimates promptly known to the appropriate management agencies, to the industry, and to the public at large.

Six thousand copies of this report have been printed for distribution to the fishing industry, research institutions, and government agencies in this country and abroad. The report was illustrated by Mr. Robert W. Kirk of the Scripps Institution of Oceanography.

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