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FOOD OF THE PACIFIC SARDINE (*SARDINOPS CAERULEA*)

BY CADET H. HAND AND LEO BERNER, JR.

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ABSTRACT

Stomach contents of adult and juvenile Pacific sardines *(Sardinops caerulea)*, ranging in size from 31 to 285 mm. standard length, were investigated. Crustaceans were found to be the major food item, contributing 89 percent of the organic matter in the stomachs. Size of fish, within the range investigated, had little effect on the food contained in the stomachs, except for a smaller amount of phytoplankton in the juvenile fish.

A very high correlation was found between stomach contents of fish taken from a single school. The stomach contents also showed high correlation with plankton samples taken at the same time and place.

It was concluded that sardines are omnivorous, are filter feeders as well as particulate feeders, and, at least at times, are selective feeders.

FOOD OF THE PACIFIC SARDINE (*Sardinops caerulea*)

By CADET H. HAND and LEO BERNER, JR.

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Studies of the food of the adult Pacific sardine, *Sardinops caerulea* (Girard), have been limited in scope. Lewis (1929) studied the stomach contents of 207 sardines collected in the San Diego area and found a good relation between surface plankton and the stomach contents of these fish. He concluded that phytoplankton was a very important part of the food, although crustaceans and other zooplankters played a major role in the diet of the sardine.

Parr (1930), in a review of Lewis' data, found that zooplankton in the stomachs showed much less variation in numbers than did the phytoplankton. Using these results he suggested that zooplankters might be the object of special pursuit and the phytoplankton was ingested incidentally.

Hart and Wailes (1931) found a high proportion of diatoms in the stomachs of Canadian sardines collected in 1929, a year of very low oil production per ton of fish. The authors suggest that "red feed" (crustaceans), which makes reduction of the fish more difficult, may in the end, actually lead to higher oil production.

Radovich (1952a) examined the stomachs of 42 fish from central Baja California and southern California. He found that the bulk of the food material consisted of crustaceans, with the copepods dominating. He concluded that sardines are both filter and particulate feeders.

In 1949, the present study of the food of the adult Pacific sardine was begun as part of the Marine Life Research Program. This program is Scripps Institution's component of the California Cooperative Oceanic Fisheries Investigations, a broad study sponsored by the California Marine Research Committee and carried out cooperatively by Scripps Institution of Oceanography of the University of California, the Bureau of Marine Fisheries of the California Department of Fish and Game, the South Pacific Fishery Investigations of the United States Fish and Wildlife Service, the Hopkins Marine Station of Stanford University, and the California Academy of Sciences.

The authors are indebted to John Radovich, California Department of Fish and Game, and to Drs. M. W. Johnson and E. W. Fager of Scripps Institution for their critical reading of the manuscript and many helpful suggestions.

METHODS

The fish from which the stomach samples were obtained were collected along the coast of central Baja California and southern California by the California Department of Fish and Game (see figs. 1 to 3 and table 3). Various methods of collection were used: gill net, beach seine, dip net, and dynamite. The majority of the specimens were collected at night by the latter method. The digestive tracts were removed immediately and preserved in formalin for transport to the laboratory. The earlier collections included digestive tracts alone; later samples were accompanied by plankton samples taken as nearly as possible at the same time and place as the fish. The plankton was collected by a net 0.5 meter in diameter, with a mesh opening of approximately 0.6 mm., hauled vertically in a standard manner. On five occasions, plankton samples were collected from various depth layers. A more complete description of the methods and of the various data taken is given by Radovich (1952b).

In the laboratory, the contents of the oesophagus and stomach, including the caecum, were removed and studied. Originally, the stomachs were analyzed separately; all items in each stomach were counted, or if the amount of material

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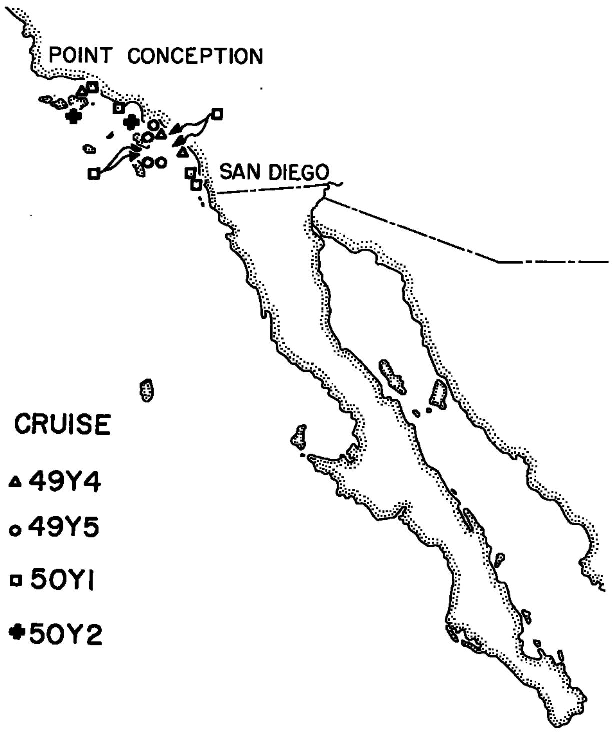

FIGURE 1.—Location of stations occupied on cruises 49Y4, 49Y5, 50Y1, and 50Y2. Arrows indicate closely spaced stations.

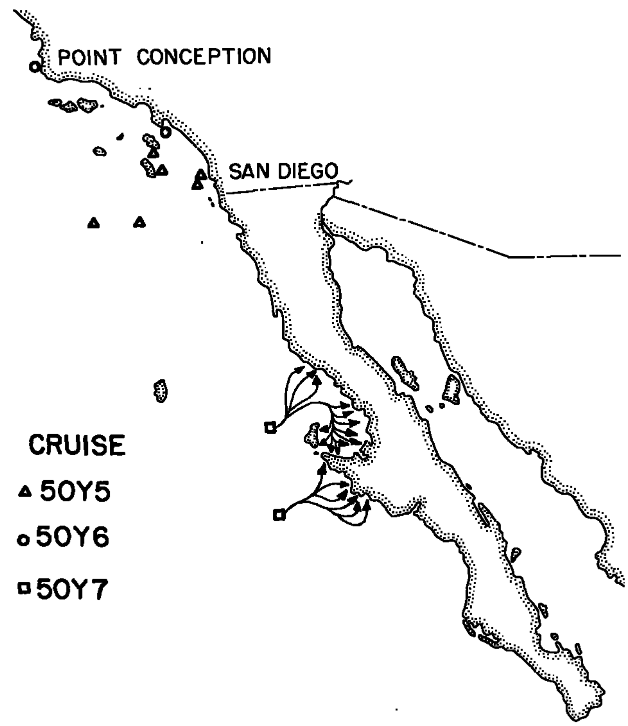

FIGURE 2.—Location of stations occupied on cruises 50Y5, 50Y6, and 50Y7. Arrows indicate closely spaced stations.

was too great, an aliquot of the contents was counted. After it had been established (as discussed in the next paragraph) that there was no significant variation in stomach contents between fish from the same sample (school), the stomach contents from the individual fish in each sample were combined before counting. A total of 585 stomachs was examined. Most stomachs (571) were from adult fish with standard lengths in the range 110 to 235 mm. The following discussion is based largely on these fish. The stomach contents of 14 small fish, 31 to 85 mm. standard length, were not markedly different from the adults, except for an almost complete absence of phytoplankton (appendix table 3).

In the analysis of the data on food content, it was first pertinent to establish whether or not individuals from the same school had been feeding on the same organisms. If this were found to be true, then it would not be necessary to consider each fish individually. Analysis would be facilitated by combining the stomach contents of fish from the same school. The gross appearance, texture, and color, of stomach contents of fish from single schools were similar and suggested that the fish had been feeding on the same organisms. The stomach contents of fish from seven samples (schools) were compared in detail. Six of the samples contained 10 fish, while the seventh contained 9. Data from a typical sample of 10 fish, 49Y5–2, are given in appendix table 1. Kendall's coefficient of concordance (Siegel 1956, pp. 229–239) was used to test for agreement among the 10 fish in regard to the relative abundances of the different organisms found in the stomachs. This method of analysis, using ranks, is distribution free. The chi-square value obtained ($x^2=92.6$ with 12 degrees of freedom) indicates that the probability of the agreement observed between the stomach contents of 10 fish occurring by chance alone is less than 0.001. Comparison of stomach contents within each of the other six samples indicates a similar probability for the agreement to have occurred by chance. On the basis of these data it was decided that stomach samples taken from single schools could be combined and treated as a unit.

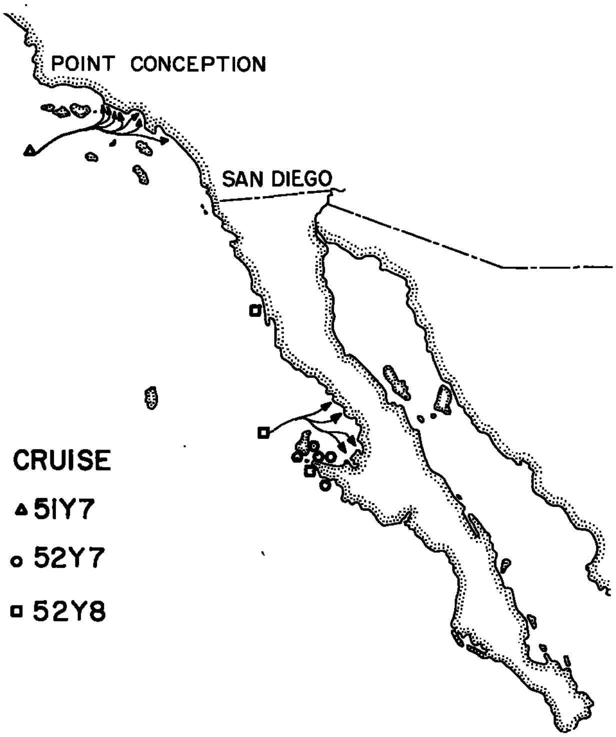

FIGURE 3.—Location of stations occupied on cruises 51Y7, 52Y7, and 52Y8. Arrows indicate closely spaced stations.

FOOD OF THE SARDINE

In all, 34 different groups of organisms were identified in the stomach contents. Owing to the semidigested condition of the material and the time involved, it was not considered practical to carry out specific identification.

The types of organisms and their percentage occurrence in the sardine stomachs are listed in table 1.

There is, in general, good agreement between the occurrence of items found in the sardine stomachs and in the plankton. Some marked differences may have resulted from the softer-bodied organisms, such as plutei, annelid larvae, doliolids, and medusae, being quickly digested in the stomachs and losing their identity, and some fast-moving animals, such as euphausiids, eluding the net. In addition, small items, such as copepod eggs and nauplii, were not properly retained by the coarse-meshed net.

Since the numbers of organisms found in the stomachs and in the plankton hauls were of different orders of magnitude, rank correlation (Kendall's tau; Siegel 1956, pp. 213–223), was used in making comparisons. In every case, correlation was very good between plankton hauls in the upper layers of water and in the stomach contents. At five stations it was possible to compare stomach contents with plankton collected at various depths. As might have been expected, correlation was best between fish collected near the surface and plankton collected in the upper layers. The results of these analyses are summarized in table 2.

TABLE 1.—*Frequency of occurrence of various types of organisms found in the stomachs of 273 sardines*

Organism	Percentage occurrence in stomachs
Small copepods	100
Larvaceans	93
Fish eggs	79
Diatoms	75
Chaetognaths	73
Dinoflagellates	71
Large copepods	70
Cladocerans	65
Cyphonautes larvae	64
Euphausiid furcilia and calyptopis larvae	50
Gastropods (adults and larvae)	49
Lamellibranch larvae	48
Copepod nauplii	47
Radiolarians and silicoflagellates	46
Euphausiid nauplii	40
Annelid larvae	36
Euphausiid eggs	32
Zoea larvae	29
Euphausiid adults	24
Amphipods	19
Barnacle nauplii	18
Fish larvae	17
Barnacle cyprids	16
Siphonophores	15
Salps	15
Mysids	13
Copepod eggs	10
Shrimp larvae	8
Brachiopod larvae	4
Ostracods	4
Foraminiferans	3
Doliolids	2
Cumaceans	1
Isopods	1

TABLE 2.—*Comparison of contents of sardine stomachs and plankton hauls taken at the same time and place*

[Basic data in appendix table 2]

Sample number	Number of items compared	Depth of haul (meters)	Rank correlation coefficient [1]
49Y5-2	16	[2]	+0.508 (p=0.003)
50Y1-16	13	[2]	+0.718 (p=0.0009)
51Y7-2	18	[2]	+0.302 (p=0.038)*
51Y7-12	20	[2]	+0.595 (p=0.0001)
50Y2-4	15	0–22	+0.55 (p=0.002)
		22–49	+0.33 (p=0.041)
		49–77	+0.32 (p=0.046)
50Y2-6	17	0–31	+0.552 (p=0.001)
		31–68	+0.544 (p=0.001)
		68–137	+0.353 (p=0.023)
50Y5-5	16	0–62	+0.500 (p=0.003)
		67–137	+0.416 (p=0.012)
50Y5-9	14	0–28	+0.506 (p=0.006)
		28–47	+0.363 (p=0.034)
		47–140	+0.157 (p=0.215)*
50Y5-13	11	0–62	+0.745 (p=0.0007)
		62–140	+0.411 (p=0.039)*

*Indicates those values in which tau values were corrected for ties.
[1] Significance level.
[2] From various depths; in general, from sea bottom to the surface.

TABLE 3.—*List of stations with dates, times, and locations of sampling*

Station	Date	Time	Location
49Y5-2	21-XII-49	0145	1 mile off center of Catalina Island.
50Y1-16	16-I-50	2225	6 miles south of Point Loma.
50Y2-4	28-II-50	0830	9.2 miles 323° T. from Point Vincente Light.
50Y2-6	1-III-50	0840	5.9 miles 038° T. from W. Point Santa Cruz Island.
50Y5-5	9-V-50	2140	3.5 miles off Ocean Beach.
50Y5-9	11-V-50	0030	60 Mile Bank.
50Y5-13	12-V-50	0245	32°03′ x 119°48′.
51Y7-2	8-VIII-51	0025	2.5 miles southeast of Newport.
51Y7-12	11-VIII-51	2115	1 mile northeast of Point Dume.

This close correlation between stomach contents and plankton would be expected if the sardine is an omnivorous, filter-feeding fish. As stated previously, Lewis (1929) found good correlation between the sardine stomach contents he examined and plankton samples taken in the same area.

Our data do not allow any precise statement as to the degree of selection of specific food particles as opposed to the filter-feeding activities of sardines. Some stomach contents, not included in this study, indicate that sardines use both methods of feeding in nature and observations in aquariums support this view. Davies (1956) found that South African pilchards (*Sardinops ocellata*) could live as long as 6 months as particulate feeders in aquariums from which all plankton had been removed. He later concluded (1957) that the pilchard is mainly a filter feeder on plankton, but at times may be a particulate feeder. Groody (1952) observed the feeding of sardines of 200 mm. standard length in aquariums. The fish fed almost entirely by filtering. They merely oriented toward a cloud of brine shrimp, increased their swimming speed and, while the cloud was dense, did not select but plunged through it with their mouths open, filtering many shrimp from the water by the action of their gill rakers. Only when the shrimp became extremely scattered did the sardines feed on individual shrimp. During this particulate feeding, no selection of shrimp according to size was observed. Sardines accepted dead brine shrimp. This result, combined with others, led Groody to conclude that the fish found their food by reacting to odor.

Adult sardines feed selectively in nature. Samples have been examined in which the stomachs contained almost exclusively a single food item. In this investigation two particularly unusual observations of stomach contents were noted. In one, the stomachs were filled almost entirely with euphausiids; in the other, fish larvae comprised the sole food item.

The total organic content (food value) of the more common items found in the stomachs is probably a better measure of their relative importance than either frequency or abundance alone. The organic matter contained in the following food was determined by ashing:

Organism	Size (mm.)	Average organic matter/specimen (mg.)	Number of specimens ashed
Small copepods	0.9	0.04	100
Large copepods	1.8	0.07	100
Euphausiids	10.0	0.9	10
Anchovy eggs	0.9	0.1	100
Chaetognaths	13.0	0.1	10

From the literature, the following values were obtained for phytoplankton organisms: Dinoflagellates (*Prorocentrum micans*), 2×10^8 cells per gram of dry material (Fox and Coe, 1943); small diatoms 6.75×10^8 cells per gram of organic matter (Fox and Coe, 1943); *Calanus finmarchicus*, 0.27 mg. per individual (Marshall, Nicholls, and Orr, 1934). Using these figures, we may estimate the nutritive role of the more prominent elements of the sardines' diet. The following results are based on average stomach contents of 571 fish:

Organism	Average number in 571 stomachs	Total organic matter (mg.)	Total organic matter (percent)
Diatoms	1.14×10^6	1.77	4.9
Dinoflagellates	33,000	0.7	1.9
Small copepods	666	26.64	74.2
Large copepods	20	*3.4	9.5
Euphausiids	2	1.8	5.0
Chaetognaths	9	0.9	2.5
Fish eggs	7	0.7	1.9

*Average of values determined in this study and by Marshall, Nicholls, and Orr (1934).

The inclusion of the other food items found in the stomachs would not appreciably change these percentages. In the 571 stomach contents examined, small copepods, on the average, supplied about 74 percent of the total organic matter, and all crustaceans supplied nearly 89 percent. Since small copepods are so important in the diet of the sardine, a reduction in their numbers or availability might adversely affect the sardine.

The studies of Hart and Wailes (1931) indicated that the sardine in Canadian waters consumed a much higher proportion of phytoplankton. These observations were supported by the study of 68 stomach samples, collected in the fall of 1940, and supplied the authors by Dr. J. L. Hart, then director of the Pacific Biological Station, Nanaimo, B.C. (Unfortunately, the sizes of these fish were not recorded.) All of the stomachs showed a much greater phytoplankton content than any examined from the Baja or southern California area: 23 fish contained over 90 percent phytoplankton, chiefly diatoms, by volume; 36 fish more than 75 percent; 19 fish from 50 to 75 percent, and 13 fish had less than 25 percent phytoplankton. If we accept Parr's hypothesis that phytoplankton is ingested incidentally during filter feeding, the increase in diatoms in the stomachs would be expected if the numbers of diatoms increase to the north. Davies (1957) indicates an apparent preference for phytoplankton as food by the South African pilchard and suggests that the reason for congregation of schools in St. Helena Bay may be the heavy concentrations of phytoplankton in the area. He finds that phytoplankton is eaten in large quantities whenever it is available, but zooplankton is eaten mainly when phytoplankton is scarce. If this is true, Parr's hypothesis cannot be applied to the pilchard in that area.

Brodski and Jankovskaya (1935) in an investigation of the far eastern sardine, *Sardinops melanosticta*, reached much the same conclusions as Parr (1930). They concluded that the presence of diatoms in the sardine stomachs appears to be incidental to the ingestion of copepods. Further, that zooplankton (mainly copepods) is the principal food of the sardine and that phytoplankton is a so-called forced diet in the absence of zooplankton concentrations.

In our material, a comparison of organisms ingested by sardines during night and day feeding has little meaning because of the small number of samples collected during the day. On the basis of our limited data, there does not appear to be any marked difference in food organisms taken in their night and day feeding.

We found very few sardine eggs in the sardine stomachs. During cruise 52Y8, five samples containing 54 sardines in spawning condition were collected from waters that contained sardine eggs. These fish had empty or nearly empty stomachs. In other instances where samples contained fish that were ready, or nearly ready, to spawn but where spawning had not yet occurred, nearly normal amounts of food were found in the stomachs. From these data it appears that sardines in the act of spawning or in the presence of spawning fish stop feeding. In contrast, Davies (1957) reports that the majority of fish eggs in the stomachs of South African pilchard were pilchard eggs.

SUMMARY

The stomach contents of sardines ranging in size from 31 to 285 mm. standard length were examined. Crustaceans were found to be the major food, and within that group small copepods were the most important item. In 571 fish examined, the crustaceans, on the average, contributed 89 percent of the organic matter in the stomachs; the small copepods contributed 74 percent of the total.

Owing to the lack of data on day-feeding fish, only general comparisons could be made between day and night feeding. There does not appear to be any marked difference between the two groups.

With the exception of the smaller amount of phytoplankton in the 31- to 85-mm. fish, the size of fish, within the range investigated, had little effect on the food contained in the stomachs.

Correlation between the stomach contents of fish taken from a single school was very high. The stomach contents also showed a high correlation with plankton samples taken at the same place and time. When plankton was collected from various depths, the correlation was highest in samples collected in the upper layers. These correlations give credence to the often-made statement that sardines are ominvorous, filter-feeding organisms. They do not, however, rule out particulate feeding by the fish.

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APPENDIX

Appendix Table 1.—*Stomach contents of 10 female sardines taken from one school, by length and age*

[Sample No. 49Y5-2]

Organism	Number of organisms in stomach of fish measuring—										Number found in plankton tow
	235 mm. (4 yr.)	224 mm. (3 yr.)	217 mm. (4 yr.)	224 mm. (3 yr.)	228 mm. (3 yr.)	217 mm. (4 yr.)	217 mm. (3 yr.)	222 mm. (4 yr.)	225 mm. (3 yr.)	223 mm. (3 yr.)	
Large copepods	30	50		4	2		15		10		40
Small copepods	2,180	1,615	16,020	1,005	648	1,510	1,490	596	740	510	2,250
Euphausiids	40	15	80	10		30	25		10	15	
Euphausiid calyptopis larvae	20	30	160	15	8		25	4	10	5	40
Euphausiid furcilia larvae	10		40		4	10	20	2	5	20	
Euphausiid nauplii					4						30
Euphausiid eggs	240	155	220	105	2	220	130	22	90	195	90
Cladocera										5	
Cyphonautes								2			20
Larvaceans	380	145	460	145	138	350	220	148	195	380	1,810
Chaetognaths					2		10	2		20	20
Fish eggs					3		15	12	15	10	30
Gastropods (adult and larvae)					4	10	5	4	5	5	50
Annelid larvae											10

Appendix Table 2.—*Comparison of items in stomach contents of sardine samples and in plankton samples taken at same place and time, by samples*

[Absolute numbers of organisms not compared, but used only to establish rank]

Organism	Number of organisms in—							
	Sample No. 49Y5-2		Sample No. 50Y1-16		Sample No. 51Y7-2		Sample No. 51Y7-12	
	Stomach contents	Plankton sample	Stomach contents	Plankton sample	Stomach contents	Plankton sample	Stomach contents	Plankton sample
Large copepods	11	40	13	90	+	120	+	
Small copepods	2,730	2,250	394	2,170	340	2,140	542	5,270
Copepod nauplii			780	(*)			248	100
Euphausiids	23							
Euphausiid calyptopis larvae	28	40			5	10	4	40
Euphausiid furcilia larvae	11				+		+	10
Euphausiid nauplii	+	30			18	110	2	50
Euphausiid eggs	140	90				120		
Cladocerans	1		9	140	+	10	8	100
Cyphonautes	+	20	2	40	5	30	22	140
Barnacle nauplii			4	30	9	30	4	90
Zoea larvae			2	10	+	20		+
Larvaceans	260	1,810	44	120	388	1,560	180	2,040
Chaetognaths	3	20	6	60	10	30	6	140
Amphipods								
Fish eggs	6	30	6	30	9	60	14	+
Gastropods	3	50				30	12	180
Lamellibranch larvae			1			30	12	40
Annelid larvae		10	3	60	8	10	4	30
Number of fish in sample	10		10		10		10	
Average length of fish	223 mm.		192 mm.		198 mm.		208 mm.	

+ Present, but average number less than 1.
* Not sampled by plankton net because of small size.

APPENDIX TABLE 2.—*Comparison of items in stomach contents of sardine samples and in plankton samples taken at same place and time, by samples*—Continued

Organism	Number of organisms in—						
	Sample No. 50Y5-9				Sample No. 50Y5-13		
	Stomach contents	Plankton (closing-net) sample from—			Stomach contents	Plankton (closing-net) sample from—	
		0-28 m.	28-47 m.	47-140 m.		0-62 m.	62-140 m.
Large copepods	19	130	+	35	2	20	20
Small copepods	52	1, 270	190	155	16	400	90
Copepod nauplii							
Euphausiids	14	10				+	+
Euphausiid calyptopis larvae	77	110	+		1	15	+
Euphausiid furcilia larvae	40	80			2	5	+
Euphausiid nauplii				10	1	5	
Euphausiid eggs	3	30	10	5			
Cladocerans							
Cyphonautes							
Barnacle nauplii							
Zoea larvae							
Larvaceans	28	2, 470	95	20	9	205	45
Chaetognaths	7	100	10	20	3	20	30
Amphipods	+	+	+			5	+
Fish eggs	+	+			26	40	
Gastropods				+			
Lamellibranch larvae							
Annelid larvae		10				5	5
Number of fish in sample	10				10		
Average length of fish	212 mm.				212 mm.		

Organism	Number of organisms in—										
	Sample No. 50Y2-4				Sample No. 50Y2-6				Sample No. 50Y5-5		
	Stomach contents	Plankton (closing-net) sample from—			Stomach contents	Plankton (closing-net) sample from—			Stomach contents	Plankton (closing-net) sample from—	
		0-22 m.	22-49 m.	49-77 m.		0-31 m.	31-68 m.	68-137 m.		0-62 m.	62-137 m.
Large copepods	9	10	5	5	20	90	75	115	672	4, 260	260
Small copepods	209	228	209	257	123	1, 700	875	725		20	
Copepod nauplii	8		1	1	3	120					
Euphausiids				1				5			
Euphausiid calyptopis larvae	7	7	18	12						+	
Euphausiid furcilia larvae	9	4	7	34	1	20	10			10	+
Euphausiid nauplii									48	350	40
Euphausiid eggs					13	800	60	385	38	220	5
Cladocerans	3	4	4		1	60		5		190	
Cyphonautes	3	2	1						12	30	
Barnacle nauplii											
Zoea larvae			2	1						+	5
Larvaceans					14	620	60	15			
Chaetognaths			3	6		10	30	10	24	80	30
Amphipods		3	11	10						+	5
Fish eggs	8	3	3	1					28	100	10
Gastropods		2	4	2		30	5	10		10	
Lamellibranch larvae					1		5		4	+	
Annelid larvae			3	2		10	5				
Number of fish in sample	10				4				10		
Average length of fish	207 mm.				208 mm.				190 mm.		

+ Present, but average number less than 1.

APPENDIX TABLE 3.—*Stomach contents of small (less than 100 mm.) sardines*

A. Sample number, 51Y8-21; time, 0200 PST; date, 30 August 1951; location, 26°58.2′ N., 113°36.2′ W.

Organism	Number of organisms in fish measuring—			
	31 mm.	31 mm.	77 mm.	72 mm.
Small copepods	8	15		4
Large copepods			1	3
Barnacle cypris larvae		2		
Zoea larvae				2
Fish eggs			1	
Moth (Lepidoptera) [1]			1	
Diatoms				([2])
Dinoflagellates	2			([2])

B. Sample number, P44-16; time, 1930 PST; date, 12 January 1953; location, 27°50.2′ N., 114°50.5′ W.

Organism	Number of organisms in fish measuring—				
	46 mm.	46 mm.	51 mm.	49 mm.	55 mm.
Small copepods	3	5	500	12	11
Large copepods		1	4		
Zoea larvae	1	1	7	1	
Chaetognaths		1			
Barnacle nauplius larvae		1			
Barnacle cypris larvae	1	1		1	3
Lamellibranch larvae		2	5		1

APPENDIX TABLE 3.—*Stomach contents of small (less than 100 mm.) sardines*—Continued

C. Sample number, 50Y9-33; time, 2235 PST; date, 11 September 1950; location, 32°47.6′ N., 118°24.3′ W.

Organism	Number of organisms in fish measuring—				
	49 mm.	56 mm.	71 mm.	68 mm.	85 mm.
Small copepods	117	9	260	190	265
Large copepods	12		21	15	18
Cyphonautes larvae	14		48	87	112
Barnacle cypris larvae	3		7	2	16
Fish eggs	1		2	1	
Amphipods	2		1		1
Euphausiids			3	1	2
Zoea larvae			1		2
Diatoms					1, 500
Dinoflagellates			6	+	75

+ Present, but average number less than 1.
[1] This food item cannot be considered natural, but only a very chance occurrence.
[2] Present in very small numbers—not counted.

APPENDIX TABLE 4.—*Summary of items in stomach contents of 571 sardines and in plankton samples, by month, November 1949 to September 1952*

[Asterisk (*)—specimens not properly sampled by net; NS—groups not sampled by net. Values given in each column are average number per month]

Organism	Number of organisms in—							
	Sample No. 49Y4 (Nov. 1949)		Sample Nos. 49Y4 and 49Y5 (Dec. 1949)		Sample No. 50Y1 (Jan. 1950)		Sample No. 50Y2 (Feb. 1950)	
	Stomach contents	Plankton sample [1]	Stomach contents	Plankton sample	Stomach contents	Plankton sample	Stomach contents	Plankton sample
Large copepods*	+		7	36	10	27	9	10
Small copepods	2, 900		1, 203	2, 278	205	2, 903	209	228
Copepod nauplii*	105		314	15	122	78	8	
Copepod eggs*	1		+		125			
Euphausiids*			7	1				
Euphausiid calyptopis larvae*	+		8	19	+	4	7	7
Euphausiid furcilia larvae			4	4	+	6	9	4
Euphausiid nauplii			+	53	+	1		
Euphausiid eggs			40	29	+			
Cladocera	8		3	45	4	108	3	4
Cyphonautes	3		4	24	9	91	3	2
Barnacle nauplii	1				+	4		
Zoea larvae	+				1	2		
Larvaceans	2		107	818	51	450		3
Chaetognaths	10		23	23	8	29		
Gastropods	2		4	45	+	12		2
Lamellibranch larvae	6		2	1	7	16		
Fish eggs	+		7	41	2	7	8	3
Diatoms*	1, 369		27, 246	NS	2. 6 x 10^6	NS	5, 330	NS
Dinoflagellates*	2, 025		6, 739	NS	21, 915	NS		NS
Radiolaria and silicoflagellates*	121		1, 019	NS	1, 540	NS		NS
Average volume of food per fish	1. 2 ml.		2. 1 ml.		0. 9 ml.		0. 4 ml.	
Number of fish	15		38		81		10	

+ Present, but average number less than 1.
[1] No plankton collected.

APPENDIX TABLE 4.—*Summary of items in stomach contents of 571 sardines and in plankton samples, by month, November 1949 to September 1952*—Continued

Organism	Number of organisms in—							
	Sample No. 50Y2 (Mar. 1950)		Sample No. 50Y5 (May 1950)		Sample No. 50Y6 (June 1950)		Sample No. 50Y7 (July 1950)	
	Stomach contents	Plankton sample	Stomach contents	Plankton sample	Stomach contents	Plankton sample [1]	Stomach contents	Plankton sample [1]
Large copepods*	20	90	33	74	80		42	
Small copepods	123	1,700	310	1,324	6,200		390	
Copepod nauplii*	3	120	57	80	122		130	
Copepod eggs*								
Euphausiids*			4	3	1		4	
Euphausiid calyptopis larvae*			14	31	7		11	
Euphausiid furcilia larvae	1	20	8	18	1		9	
Euphausiid nauplii			11	66	1		7	
Euphausiid eggs	13	800	9	45	1			
Cladocera	1	60	12	33	635		41	
Cyphonautes			2	5			7	
Barnacle nauplii							1	
Zoea larvae				2			3	
Larvaceans	14	620	480	1,059	65		104	
Chaetognaths		10	16	58	5		9	
Gastropods		30	+	2			3	
Lamellibranch larvae	1		1	+			2	
Fish eggs			20	37	33		4	
Diatoms*	4.5×10^6	NS	8.3×10^5	NS	21×10^6		97,000	
Dinoflagellates*	52,000	NS	13,000	NS	6.5×10^5		27,000	
Radiolaria and silicoflagellates*		NS	875	NS	7,000		3,307	
Average volume of food per fish	1.0 ml.		2.1 ml.		1.0 ml.		1.0 ml.	
Number of fish in sample	4		63		12		164	

Organism	Number of organisms in—						Average number of organisms per fish	Average number of organisms per plankton tow	Percentage of stomachs containing organism
	Sample No. 51Y7 (Aug. 1951)		Sample No. 52Y7 (Aug. 1952)		Sample No. 52Y8 (Sept. 1952)				
	Stomach contents	Plankton sample	Stomach contents	Plankton sample [1]	Stomach contents	Plankton sample			
Large copepods*	3	102	12		1	2	20	49	61
Small copepods	410	6,676	2,180		167	557	666	2,238	92
Copepod nauplii*	79	15	1,180		188	817	254	161	47
Copepod eggs*							18	NS	10
Euphausiids*	+	1					2	1	21
Euphausiid calyptopis larvae*	2	21					6	12	33
Euphausiid furcilia larvae	+	10	3				4	9	37
Euphausiid nauplii	3	44					4	23	18
Euphausiid eggs	8	129					5	143	15
Cladocera	3	37	48		68	41	39	47	53
Cyphonautes	11	105	2		+	3	6	33	44
Barnacle nauplii	3	39					1	6	12
Zoea larvae	1	9	+			8	1	3	26
Larvaceans	111	1,792	108		11	98	126	691	71
Chaetognaths	5	180	11		5	73	9	53	69
Gastropods	3	100	3		4	3	2	28	37
Lamellibranch larvae	2	24	6		+	7	3	7	35
Fish eggs	5	21	9			6	7	16	51
Diatoms*	1.1×10^6	NS	64,200		71,600	NS	1.1×10^6	NS	65
Dinoflagellates*	20,000	NS	38,000		10^5	NS	33,000	NS	64
Radiolaria and silicoflagellates*	223	NS	504			NS	544	NS	35
Average volume of food per fish	1.0 ml.		0.8 ml.		0.3 ml.		1.1 ml.		
Number of fish in sample	67		67		50				

+ Present, but average number less than 1.
[1] No plankton collected.