REVIEW OF ACTIVITIES
1 April 1955-30 June 1956

During the period 1 April 1955 to 30 June 1956 the research vessels participating in the California Cooperative Oceanic Fisheries Investigations spent 893 days at sea. Figure 1 shows the area covered by the hydrographic-biological cruises; Tables 1 and 2 give the stations occupied and the nature of the work done; Figure 2 shows the cruises made by the *Yellowfin* in its surveys to determine the location and abundance of juvenile and adult fishes.

Most of the time at sea was spent in work similar to that done in the past, but three of the cruises were far from routine: they were CCOFI Cruises 5508 (August, 1955), 5602 (February, 1956), and 5604 (April, 1956).

NORPAC PROJECT

The August, 1955, cruise was part of an international project known as NORPAC (NORth PACific). In terms of ships, manpower and area covered this was the largest oceanographic program ever conducted. Figure 3 shows the western half of the area: the region usually covered by CCOFI cruises in August is shaded in to indicate the vast scale of the NORPAC project.

NORPAC called for a considerable extension of the area usually covered in the CCOFI cruises so that information gathered by the Californian vessels could be tied in with that taken by others.

The project was first formally proposed at the Fifth Pacific Tuna conference of November, 1954, which was attended by representatives of all the agencies which subsequently took part except the Japanese. Distinguished Japanese scientists were asked if their country would participate and they agreed at once to do so.

Participants in the project were, from Japan, the Japanese Hydrographic Office, the Central Meteorological Observatory, the Marine Observatory of Hakodate, the Marine Observatory of Kobe, the Marine Observatory of Nagasaki, the Tokai Regional Fisheries Research Laboratory, the University of Hokkaido, the University of Kagoshima, and the University of Fisheries, Tokyo; from Canada, the Pacific Oceanographic Group of the Fisheries Research Board; from Washington, the University of Washington; from Hawaii, the Pacific Oceanic Fishery Investigations of the U. S. Fish and Wildlife Service; from California, the ships of CCOFI.

Men from these agencies spent all of August and part of July and September making observations in the North Pacific in the areas shown in Figure 4. Nineteen ships comprised the fleet; they sailed approximately 55,000 miles. Eleven of the ships were Japanese. One came from Canada, seven from the United States.

The area explored is about one and one-half times the size of the North American continent. It covers one-sixteenth the surface of the globe. From it are taken every year about 18 billion pounds (almost half the world's total) of commercial food fishes. The catch is worth approximately one billion dollars.

The main features of the oceanography of the region were well known in a general way, and in some areas, such as the CCOFI region, had been extensively explored. On the western side, the warm, narrow, rapid Kuroshio Current sweeps northward from the equator along the eastern shore of Japan. South of the Aleutian Islands it loses much of its warmth and speed. Some of the Kuroshio water eventually descends southward along the Canadian and U. S. coast as the wide, cold, sluggish California Current. South of Baja California it branches and part of it turns westward as the North Equatorial Current which, across the Pacific, feeds into the Kuroshio.

But information about the region as a whole had come from occasional single oceanographic cruises that had lasted for several months at a time—months during which oceanographic conditions at the starting point of the cruise would have changed significantly before the last stations were occupied. What was needed was a rapid, intensive survey over a short period of time. NORPAC provided that, extending to the entire North Pacific Ocean the sort of coverage that has been provided almost monthly for several years over the CCOFI region.

Figure 3 shows one of the first results of the analysis of the NORPAC data, a map of surface temperature over the western half of the North Pacific. Similar charts will be drawn for other oceanographic properties at different depths. Charts, maps, and data will be published, probably in 1957, under the joint auspices of the University of California and the University of Tokyo.

One of the interesting preliminary results of NORPAC was the information that jack mackerel spawning extended to the northernmost part of the CCOFI area and well offshore (see section on Jack Mackerel Larvae).

GULF OF CALIFORNIA CRUISES

Two special cruises (5602 and 5604) were made by the *Black Douglas* into the Gulf of California. The sardine population of the gulf has been inadequately

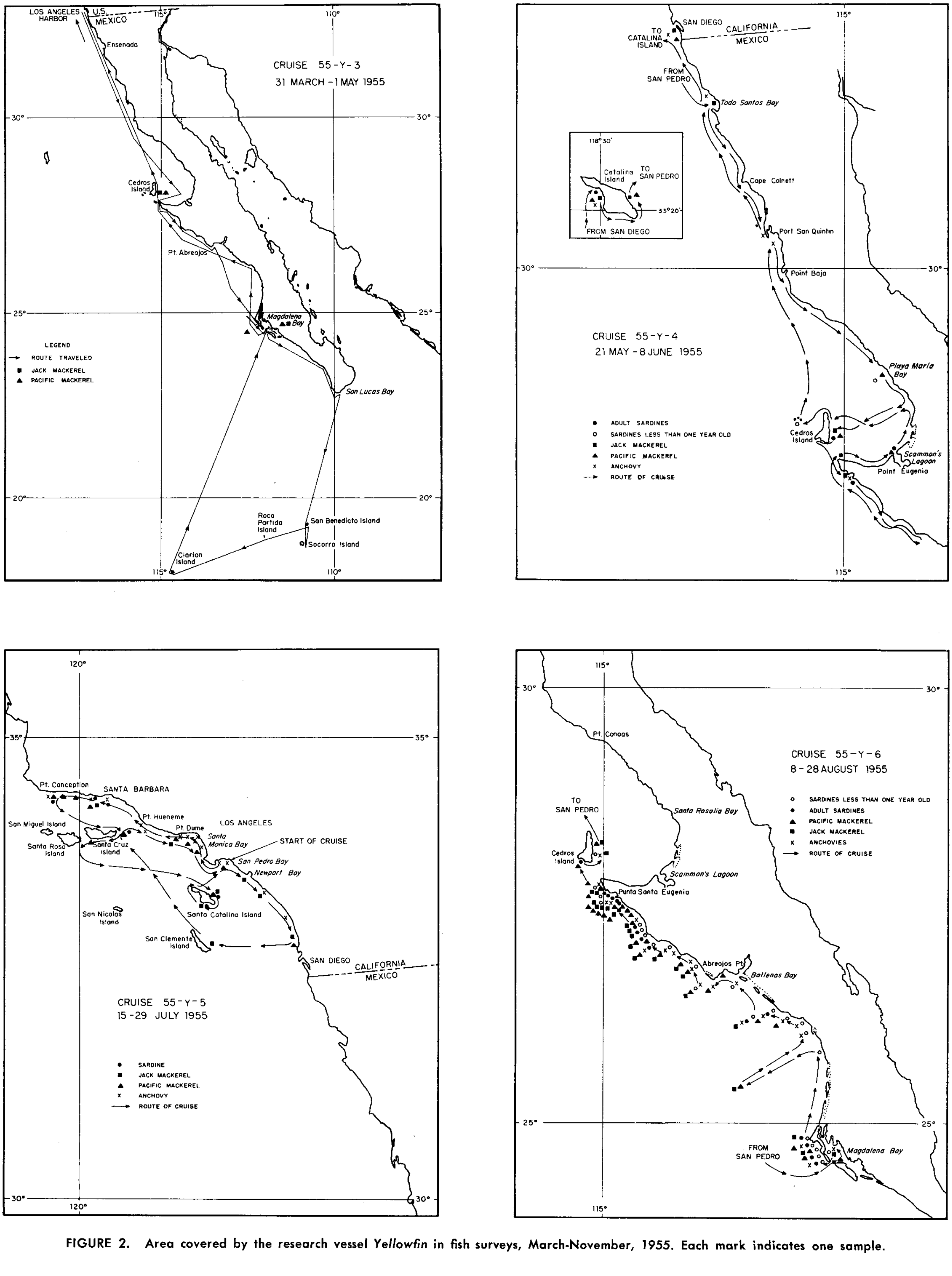
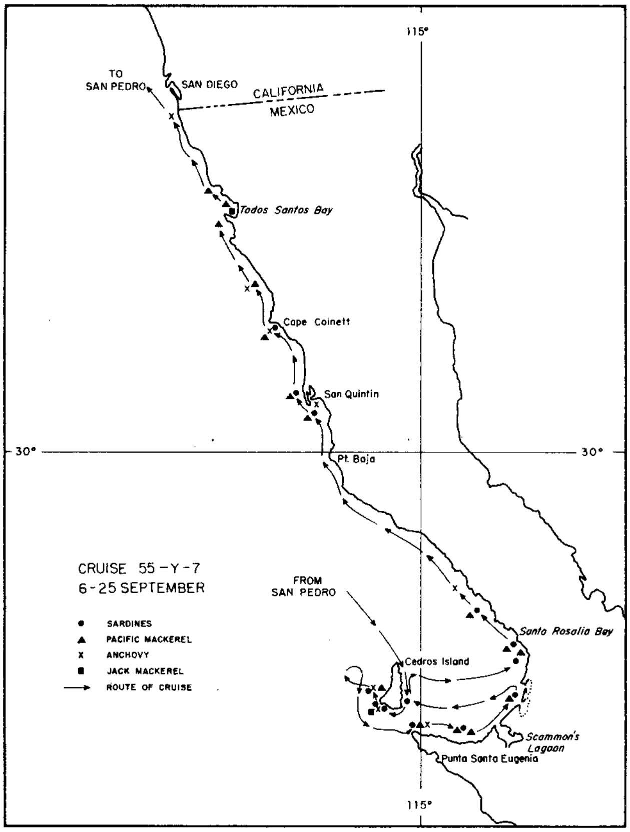
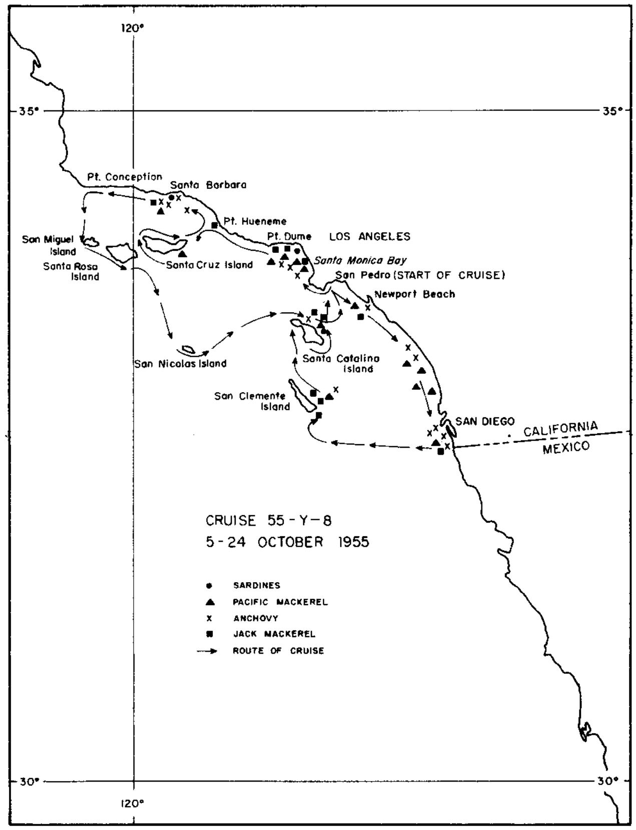
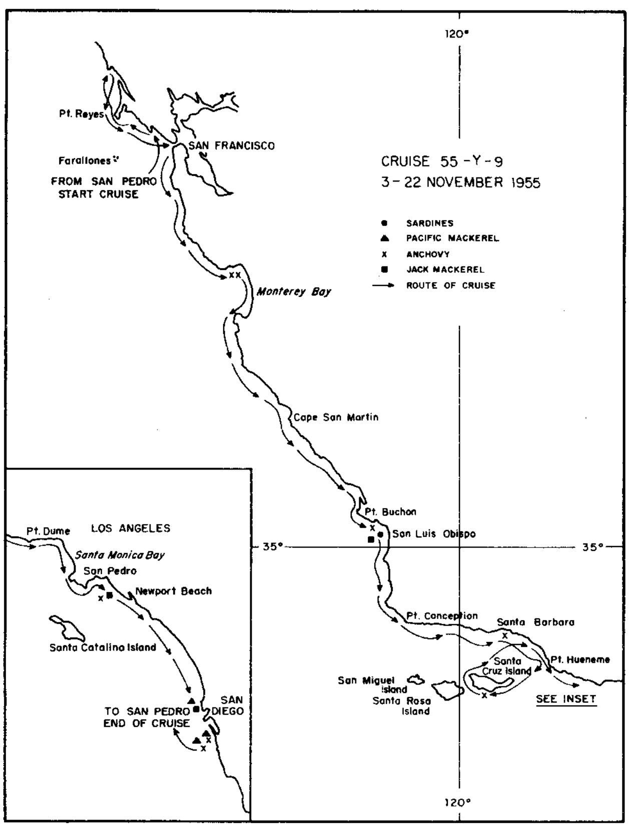


FIGURE 2. Area covered by the research vessel *Yellowfin* in fish surveys, March-November, 1955. Each mark indicates one sample.







studied. It is not known if the fish spawned there ever enter the California fishery, though it is possible that they do.

By the time of writing, the collections from the February cruise had been sorted and identified. They show that in February sardine spawning was widespread. There were sardines all over the gulf, spawning in deep water as well as off the coast. The most eggs were found on line 133G, approximately 80 miles south of Guaymas, the most larvae on line 139G, 60 miles farther south. Larvae were found all the way to the entrance to the gulf.

Since the region is generally considered to be under tropical influence, it was rather unexpectedly that the largest numbers of larvae were found on the Sonora side of the gulf.

Larvae of the Pacific mackerel were extremely abundant. They were found over most of the gulf and in considerable quantities: in this one cruise more Pacific mackerel larvae were collected than are taken in a whole year in the CCOFI area.

YELLOWFIN SURVEYS

The fish surveys, conducted by the California Department of Fish and Game, were curtailed early in 1956 because of the discovery of dry rot in the *Yellowfin*. Results of the surveys are shown in Figure 2.

TABLE 1

STATIONS OCCUPIED BY CCOFI CRUISES, APRIL, 1955 (CRUISE 5504), TO JUNE, 1956 (CRUISE 5606)

Line	Station No.	5504	5505	5506	5507	5508	5509P	5509BD	5510	5511	5512	5601	5602	5603	5604	5605	5606
10	10					x											
	20					x											
	40					x											
	60					x											
	80					x											
	100					x											
20	14					x											
	24					x											
	40					x											
	60					x											
	80					x											
	106					x											
30	30					x											
	40					x											
	60					x											
	80					x											
	106					x											
40	38															x	x
	40					x										x	x
	45															x	x
	46					x											
	50															x	x
	60															x	x
	70					x										x	x
	80															x	x
	90					x										x	x
	110					x											
43	42															x	x
	50															x	x
	60															x	x
47	50															x	x
	55															x	x
	60															x	x
50	47															x	x
	50															x	x
	55					x										x	x
	60															x	x
	70					x										x	x
	80															x	x
	90					x										x	x
	120					x											
53	52															x	x
	55															x	x
	65															x	x
57	51															x	x
	55															x	x
	65															x	x
60	50														x		
	55			x		x			x						x	x	x
	57					x									x		x
	60			x					x						x	x	x
	70			x		x			x						x	x	x
	80			x					x						x	x	x
	90			x		x			x						x	x	x
	120					x											
63	52		x	x	x				x						x	x	x
	55		x	x	x				x						x	x	x
	65		x	x	x										x	x	x
	80														x		
67	50		x	x	x				x						x	x	x
	55		x	x	x				x						x	x	x
	65		x	x	x										x	x	x
	80														x		
70	52		x	x	x				x						x	x	x
	55		x	x	x	x			x						x	x	x
	60		x	x	x				x						x	x	x
	70		x	x	x	x			x						x	x	x
	80			x	x				x						x	x	x
	90			x	x	x			x						x	x	x
	110					x											
	130					x											
73	50			x	x				x						x	x	x
	60			x	x				x						x	x	x
	70			x	x										x	x	x
	80			x	x											x	
	90			x	x												
77	50		x	x	x				x						x	x	x
	55		x	x	x				x						x	x	x
	60															x	x
	65		x	x	x										x		
	70		x	x	x											x	x
	80		x	x	x											x	
	90		x	x	x												
80	51	x	x	x	x				x		x	x	x	x	x	x	x
	55	x	x	x	x	x			x		x	x	x	x	x	x	x
	60	x	x	x	x	x			x		x	x	x	x	x	x	x
	70	x	x	x	x	x			x		x	x	x	x	x	x	x
	80	x	x	x	x				x		x	x	x	x	x	x	x
	90	x	x	x	x	x			x		x	x	x	x	x	x	x
	110					x											
	137					x											
83	40	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
	43	x	x	x	x				x		x	x	x	x	x	x	x
82	47												x	x	x	x	x
	48						x	x		x							
83	51	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
	52.5						x	x		x							
	55			x	x		x	x		x					x	x	x
	57.5						x	x		x							
	60	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
	65			x	x												
	70	x	x	x	x									x	x	x	x
	75			x													
	80	x		x										x	x	x	x
	85			x													
	90	x		x										x	x	x	x
85	39						x	x		x							
	40						x	x		x							
	42.5						x	x		x							
	45						x	x		x							
	47.5						x	x		x							
	50						x	x		x							
	52.5						x	x		x							
	55						x	x		x							
	57.5						x	x		x							
	60						x	x		x							
87	36											x	x	x	x	x	x
	35	x	x	x	x		x	x	x	x	x						
	37.5						x	x		x							
	40	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
	42.5						x	x		x							
	45		x	x	x		x	x	x	x						x	x
	47.5						x	x		x							
	50	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
	52.5						x	x		x							
	55		x	x	x			x		x						x	x
	57.5							x		x							
	60	x	x	x	x			x	x	x	x	x	x	x	x	x	x
	65			x	x											x	x
	70	x		x	x									x	x	x	
	75			x												x	x
	80	x		x										x	x	x	x
	85			x												x	
	90	x		x										x	x	x	
90	28	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
	30	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	32.5						x	x		x							
	35						x	x		x							
	37	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	40						x	x		x							
	42.5						x	x		x							
	45	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
	47.5						x	x		x							
	50	x	x	x	x		x	x		x						x	x
	53					x	x	x									
	55		x	x	x		x	x	x	x	x	x	x	x	x	x	x
	60	x	x	x	x				x		x	x	x	x	x	x	x
	65		x	x	x											x	x
	70		x	x	x	x			x		x	x	x	x	x	x	x
	75		x	x	x											x	x
	80	x	x	x	x				x		x	x	x	x	x	x	x
	85		x		x											x	x
	90	x	x		x	x			x					x	x	x	x
	120					x											
	145					x											
93	27	x	x	x	x				x		x	x	x	x	x	x	x
	30	x	x	x	x				x		x	x	x	x	x	x	x
	35		x	x	x											x	x
	40	x	x	x	x				x		x	x	x	x	x	x	x
	45		x	x	x											x	x
	50	x	x	x					x		x	x	x	x	x	x	x
	55		x	x	x											x	x
	60	x	x	x	x				x				x	x	x	x	x
	65		x	x	x											x	x
	70	x	x	x	x								x	x	x	x	x
	75		x	x	x											x	x
	80	x	x	x	x									x	x	x	x
	85		x		x											x	x
	90	x	x		x									x	x	x	x
	95		x														
97	30	x	x	x	x				x		x	x	x	x	x	x	x
	32	x	x	x	x				x		x	x	x	x	x	x	x
	35		x	x	x												

STATE OF CALIFORNIA
DEPARTMENT OF FISH AND GAME
MARINE RESEARCH COMMITTEE

CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS

Progress Report

1 April 1955 to 30 June 1956

Cooperating Agencies:
CALIFORNIA ACADEMY OF SCIENCES
CALIFORNIA DEPARTMENT OF FISH AND GAME
STANFORD UNIVERSITY, HOPKINS MARINE STATION
U. S. FISH AND WILDLIFE SERVICE, SOUTH PACIFIC FISHERY INVESTIGATIONS
UNIVERSITY OF CALIFORNIA, SCRIPPS INSTITUTION OF OCEANOGRAPHY

1 July 1956

TABLE 1—Continued

STATIONS OCCUPIED BY CCOFI CRUISES, APRIL, 1955 (CRUISE 5504), TO JUNE, 1956 (CRUISE 5606)

Line	Station No.	5504	5505	5506	5507	5508	5509P	5509BD	5510	5511	5512	5601	5602	5603	5604	5605	5606
97	40	x	x	x	x				x		x	x	x	x	x	x	x
	45		x	x	x											x	x
	50	x	x	x	x				x		x	x	x	x	x	x	x
	55		x	x	x											x	x
	60	x	x		x				x				x	x	x	x	x
	65		x		x											x	x
	70	x	x		x								x	x	x	x	x
	75		x		x											x	x
	80	x	x		x									x	x	x	x
	85		x		x											x	x
	90	x	x		x									x	x	x	x
100	29	x	x	x	x	x			x		x	x	x	x	x	x	x
	30	x	x	x	x				x		x	x				x	
	33												x	x	x		x
	35		x	x	x	x										x	x
	40	x	x	x	x				x		x	x	x	x	x	x	x
	45		x	x	x											x	x
	50	x	x	x	x	x			x		x	x	x	x	x	x	x
	55		x	x	x											x	
	60	x	x		x				x		x	x	x	x	x	x	x
	65		x		x											x	x
	70	x	x		x	x			x		x	x	x	x	x	x	
	75		x		x											x	
	80	x	x		x				x		x	x	x	x	x	x	
	85		x		x											x	
	90	x	x		x	x			x					x	x	x	
	120					x											
103	30	x	x	x	x				x		x	x	x	x	x	x	x
	35	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x				x		x	x	x	x	x	x	x
	45		x	x	x											x	
	50	x	x	x	x						x	x	x	x	x	x	
	55		x	x	x											x	
	60	x	x	x	x						x	x	x	x	x	x	
	65		x	x	x											x	
	70	x	x	x	x									x	x	x	
	75		x	x	x											x	
	80	x	x	x	x									x	x	x	
	85		x	x	x											x	
	90		x	x	x									x	x	x	
107	32	x	x	x	x				x		x	x	x	x	x	x	x
	35	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x				x		x	x	x	x	x	x	x
	45		x	x	x											x	x
	50	x	x	x	x						x	x	x	x	x	x	x
	55		x	x	x											x	x
	60	x	x	x	x						x	x	x	x	x	x	x
	65		x	x	x											x	x
	70	x	x	x	x									x	x	x	x
	75		x	x	x											x	x
	80	x	x	x	x									x	x	x	x
	85		x	x	x											x	x
	90		x	x	x									x	x	x	x
110	33	x	x	x	x	x			x		x	x	x	x	x	x	x
	35	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x	x			x		x	x	x	x	x	x	x
	45		x	x	x											x	x
	50	x	x	x	x				x		x	x	x	x	x	x	x
	55		x	x	x											x	x
	60	x	x	x	x	x			x		x	x	x	x	x	x	x
	65		x	x	x											x	x
	70	x	x	x	x				x		x	x	x	x	x	x	x
	75		x	x	x											x	x
	80	x	x	x	x				x		x	x	x	x	x	x	x
	85		x	x	x											x	x
	90	x	x	x	x	x			x					x	x	x	x
	122					x											
113	30	x	x	x	x				x		x	x	x	x	x	x	x
	35	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x				x		x	x	x	x	x	x	x
	45	x	x	x	x									x		x	x
	50	x	x	x	x						x	x	x	x	x	x	x
	55	x	x	x	x									x		x	x
	60	x	x	x	x						x	x	x	x	x	x	x
	65		x	x	x											x	x
	70	x	x	x	x						x	x	x	x	x	x	x
	75		x	x	x											x	x
	80		x	x	x									x	x	x	x
117	26	x	x	x	x				x		x	x	x	x	x	x	x
	30	x	x	x	x				x		x	x	x	x	x	x	x
	35	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x				x		x	x	x	x	x	x	x
	45	x	x	x	x									x		x	x
	50	x	x	x	x						x	x	x	x	x	x	x
	55	x	x	x	x									x		x	x
	60	x	x	x	x						x	x	x	x	x	x	x
	65		x	x	x											x	x
	70	x	x	x	x						x	x	x	x	x	x	x
	75		x	x	x											x	x
	80		x	x	x									x	x	x	x
118	39											x	x	x	x	x	x
119	33											x	x	x	x	x	x
120	25	x	x	x	x				x		x	x	x	x	x	x	x
	27		x	x	x				x								
	30	x	x	x	x				x		x	x	x	x	x	x	x
	35	x	x	x	x				x		x						
	40	x	x	x	x						x	x	x	x	x	x	x
	45	x	x	x	x	x			x		x	x	x	x	x	x	x
	50	x	x	x	x				x		x	x	x	x	x	x	x
	55	x	x	x	x						x	x	x	x	x	x	x
	60	x	x	x	x	x			x		x	x	x	x	x	x	x
	70	x	x	x	x				x		x	x	x	x	x	x	x
	80	x	x	x	x	x			x					x	x	x	x
	90								x								
	100					x											
	126					x											
123	37	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x				x		x	x		x	x		x
	42												x		x	x	x
	45	x	x	x	x									x			
	50	x	x	x	x				x		x	x	x	x	x	x	x
	55	x	x	x	x						x	x	x	x		x	x
	60	x	x	x	x				x					x	x	x	x
127	34	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x				x		x	x	x	x	x	x	x
	45	x	x	x	x									x		x	x
	50	x	x	x	x				x		x	x	x	x	x	x	x
	55	x	x	x	x						x	x	x	x		x	x
	60	x	x	x	x				x					x	x	x	x
130	30	x	x	x	x				x		x	x	x	x	x	x	x
	35	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x	x			x		x	x	x	x	x	x	x
	45													x			
	50	x	x	x	x	x			x		x	x	x	x	x	x	x
	60	x	x	x	x				x				x	x	x	x	x
	70					x											
	100					x											
133	25	x	x	x	x				x		x	x	x	x	x	x	x
	30	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x						x	x	x	x	x	x	x
	50	x	x	x	x									x		x	x
	60													x			
137	23	x	x	x	x				x		x	x	x	x	x	x	x
	30	x	x	x	x				x		x	x	x	x	x	x	x
	40	x	x	x	x						x	x	x	x	x	x	x
	50	x	x	x	x									x		x	x
	60													x			
140	30										x	x	x		x		
	35										x	x	x		x		
	40					x					x	x	x		x		
	50					x							x				
	60												x				
	70					x											
	100					x											
143	26										x	x	x		x		
	30										x	x	x		x		
	35										x	x	x		x		
	40												x		x		
	50												x				
	60												x				
147	20										x	x	x		x		
	25										x	x	x		x		
	30										x	x	x		x		
	35												x		x		
	40												x		x		
150	19										x	x	x		x		
	25					x					x	x	x		x		
	30										x	x	x		x		
	40					x							x		x		
	60					x											
	80					x											
	110					x											
153	16											x	x		x		
	20											x	x		x		
	30											x	x		x		
	40												x		x		
	50												x		x		
	60												x		x		
99G	15														x		
	25														x		
	40														x		
	55														x		
	70														x		

TABLE 1—Continued

STATIONS OCCUPIED BY CCOFI CRUISES, APRIL, 1955 (CRUISE 5504), TO JUNE, 1956 (CRUISE 5606)

Line	Station No.	5504	5505	5506	5507	5508	5509P	5509BD	5510	5511	5512	5601	5602	5603	5604	5605	5606
100G	11														x		
101G	07														x		
102G	04														x		
103G	02														x		
	10														x		
	25														x		
	40														x		
	55														x		
	70														x		
	80														x		
104G	00														x		
105G	00														x		
	70														x		
106G	00														x		
107G	02														x		
	70														x		
108G	06														x		
109G	12														x		
	25														x		
	40														x		
	55														x		
	68														x		
110G	14														x		
111G	14														x		
112G	15														x		
113G	18														x		
114G	20														x		
115G	20														x		
	25														x		
	40														x		
	50														x		
116G	20														x		
117G	25												x		x		
	35												x				
	50												x		x		
	65														x		
	66												x				
118G	20												x		x		
	66												x				
119G	16												x		x		
	66														x		
120G	13												x		x		
	66												x				
121G	13												x				
	20												x		x		
	40												x		x		
	55												x		x		
	70												x		x		
	74												x		x		
122G	16												x		x		
123G	30												x		x		
124G	21												x		x		
125G	30												x		x		
126G	24												x		x		
	101												x		x		
127G	22												x				
	30												x		x		
	40												x		x		
	55												x		x		
	70												x		x		
	90												x		x		
	94												x		x		
128G	27												x		x		
129G	31												x		x		
	89												x		x		
131G	31												x		x		
	94												x		x		
132G	29												x		x		
133G	27												x		x		
	40												x		x		
	55												x		x		
	70												x		x		
	85												x		x		
	100												x		x		
	105												x		x		
134G	20												x		x		
	40												x		x		
135G	35												x		x		
136G	20												x		x		
137G	30												x		x		
138G	20												x		x		
139G	22												x		x		
	40												x		x		
	55												x		x		
	70												x		x		
	85												x		x		
	100												x		x		
140G	20												x		x		
141G	29												x		x		
	96												x		x		
142G	24												x		x		
143G	15												x		x		
	100												x		x		
144G	15												x		x		
145G	30												x		x		
	40												x		x		
	55												x		x		
	70												x		x		
	85												x		x		
	100												x		x		
	115												x		x		
147G	32												x		x		
	42												x		x		
149G	34												x		x		
	40												x		x		
151G	37												x		x		
	40												x		x		
	55												x		x		
	70												x		x		
	85												x		x		
	100												x		x		
	115												x		x		
	130												x		x		
153G	35												x		x		
	137												x		x		
154G	15												x		x		
155G	144												x		x		
157G	25												x		x		
	40												x		x		
	55												x		x		
	70												x		x		
	85												x		x		
	100												x		x		
	115												x		x		
	130												x		x		
	150												x		x		
157	10					x						x	x		x		
	20											x	x		x		
	30					x						x	x		x		
	40												x		x		
	50					x							x		x		
	60												x		x		
	70					x											

TABLE 2

OCEANOGRAPHIC-BIOLOGICAL CRUISES MADE DURING THE PERIOD 1 APRIL 1955 TO 30 JUNE 1956

Cruise number	Ship	Date	Number stations	Hydrographic stations	Plankton collections	Phytoplankton collections*	GEK observations	Bathythermograph observations	Drift bottles released
5504	*Horizon*	4–19 April (1955)	73	73	73	x	81	233	--
	Crest	6–22 April	54	54	54	x	101	235	647
5505	*Black Douglas*	11 May–8 June	102	--	102	x	59	172	384
	Crest	17 May–2 June	85	--	85	x	101	184	144
5506	*Horizon*	10–28 June	98	63	33	x	112	195	--
	Paolina-T	16–24 June	37	18	37	x	--	44	336
	Crest	10–28 June	57	42	57	x	52	158	356
5507	*Paolina-T*	7–21 July	74	--	74	x	29	63	312
	Crest	7–18 July	44	--	44	x	5	154	299
	Black Douglas	6–22 July	79	--	79	--	92	234	--
5508	*Horizon*	3 August–8 September							
	Black Douglas	3 August–7 September							
	Stranger	9 August–6 September; 14–21 September	162	162	197	x	819	1,162	1,944
	Spencer F. Baird	8 August–19 September							
5509	*Paolina-T*	10–23 September	83	--	83	x	--	202	504
	Black Douglas	13–25 September	86	--	86	x	--	183	589
5510	*Stranger*	14–29 October	56	56	56	--	85	165	--
	Black Douglas	11–30 October	53	53	53	--	80	161	140
5511	*Black Douglas*	8–19 November	76	--	76	--	--	28	504
	Paolina-T	8–20 November	84	22	84	--	--	99	480
5512	*Black Douglas*	2–16 December	42	42	42	--	--	136	--
	Stranger	29 November–16 December	64	63	64	--	96	201	240
5601	*Stranger*	7–19 January (1956)	66	--	66	--	11	177	--
	Horizon	4–14 January	47	--	47	--	82	167	336
5602	*Black Douglas*	2–21 February	93	22	93	--	--	308	174
	Stranger	2–19 February	63	51	63	--	86	184	336
	Spencer F. Baird	2–19 February	69	53	16	x	12	353	--
5603	*Stranger*	2–20 March	82	--	82	--	105	278	--
	Black Douglas	6–19 March	59	--	59	--	--	209	360
5604	*Black Douglas*	4–27 April	128	38	128	x	--	335	228
	Stranger	5–26 April	90	73	90	--	139	403	565
	Spencer F. Baird	5–27 April	89	70	88	--	114	366	432
5605	*Spencer F. Baird*	4–17 May	53	--	53	--	29	278	--
	Black Douglas	4–22 May	94	--	94	--	97	281	432
	Stranger	4–19 May	84	--	84	--	66	262	--
5606	*Paolina-T*	28 May–16 June	67	38	67	--	39	163	276
	Black Douglas	30 May–16 June	85	49	85	--	93	278	--
	Spencer F. Baird	26 May–25 June	62	45	62	--	71	230	444
	Totals		2,640	1,087	2,556	--	2,656	8,281	10,462

* Total number of collections not available. "x" indicates collections were taken.

AIRPLANE SPOTTING

For the third year, the Department carried out a program of aerial spotting of fish schools. The results are shown in Figure 5. The most striking phenomenon is of course the appearance of masses of anchovies off the coast in the spring months of 1956: no such concentrations have been seen before. Spawning studies corroborate the apparent increase in anchovies by indicating that the population may have doubled in the period 1951 to 1955.

Methods of spotting and measuring fish schools from the air are still being worked out. Within the past few months, a method much less subjective than that used before has been tested and it has now become possible to estimate with considerable confidence the total area covered by fish schools. Methods of determining from the air the density of fish within a school have not yet been developed.

ELECTRICAL FISHING

The loss of the *Yellowfin* to the program has meant that the State's very promising experiments with electrical fishing gear have been cut short. The department has contracted with the inventor of a specially designed switch which has been attached to collecting gear of various designs. Results of one of the most successful tests are shown in Figure 6. The aim of the experiments has been to develop gear that would work at sea by dragging or by attracting fish with a light. The fish in the photograph were attracted by a light.

It has long been known (see previous progress reports) that in the presence of an electrical field established by a pulsating direct current, fishes are impelled toward the positive pole. But implementation of that theory in the field has lagged, so far as marine fishes are concerned. The best results achieved so far

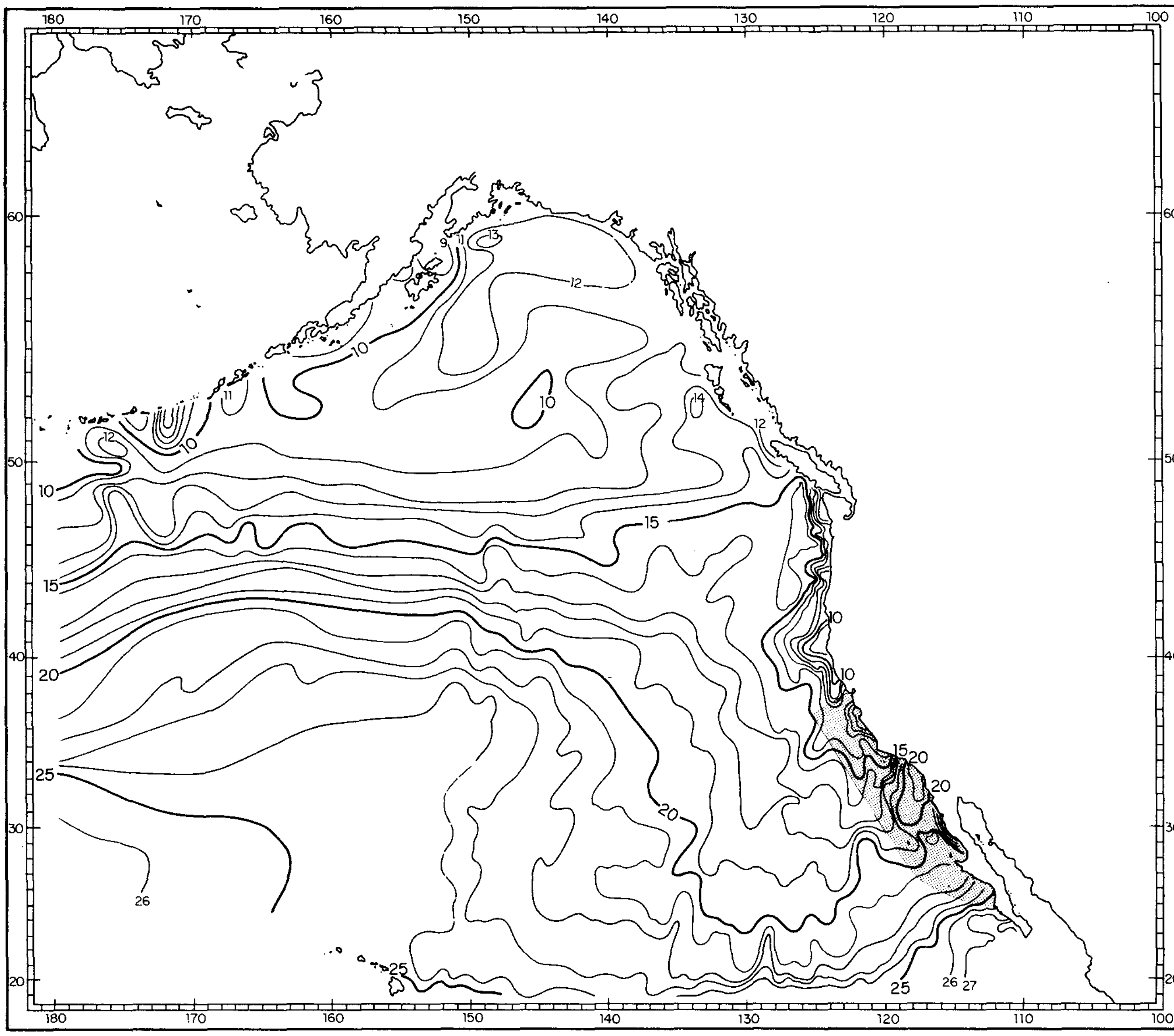


FIGURE 3. Surface temperature of the eastern half of the North Pacific, August, 1955, as shown by NORPAC project. Data for western half were not available at time of drafting, but will be published. Shaded in is the area usually covered by CCOFI surveys during August.

are those obtained by the Department of Fish and Game. Fishery biologists who have worked with the present gear believe it can attract fish of any size at any depth. So far, however, it has been used on small fish (anchovy, sardine, jack mackerel, and Pacific mackerel) close to the surface.

OCEANOGRAPHY OF MONTEREY AREA

The Hopkins Marine Station of Stanford University has continued its studies of the oceanography of the Monterey region. Waters off Monterey are cooler now than they were five years ago and the data suggest that this is the expression of a fairly well-defined long-term trend. The subnormal temperatures cannot be the result of anomalous local weather conditions since they are not limited to the superficial layers but are noticeable to a depth of 500 meters or about 250 fathoms. Practically all of the water mass normally occupied by the great majority of the commercially important fishes in this region is becoming progressively colder.

Since ocean temperatures are characterized by a vertical gradient, the changes in the marine climate may be expressed by plotting the depths below the surface of the various isotherms. The jagged solid line in Figure 7, based on approximately 250 sets of observations taken at weekly intervals off the mouth of Monterey Bay, shows the average depth of the 8° C. (46.4° F.) isotherm by months during the five-year period 1951-55. While there appears to be a general upward trend of the line toward the right (meaning that cold water is nearer the surface), its

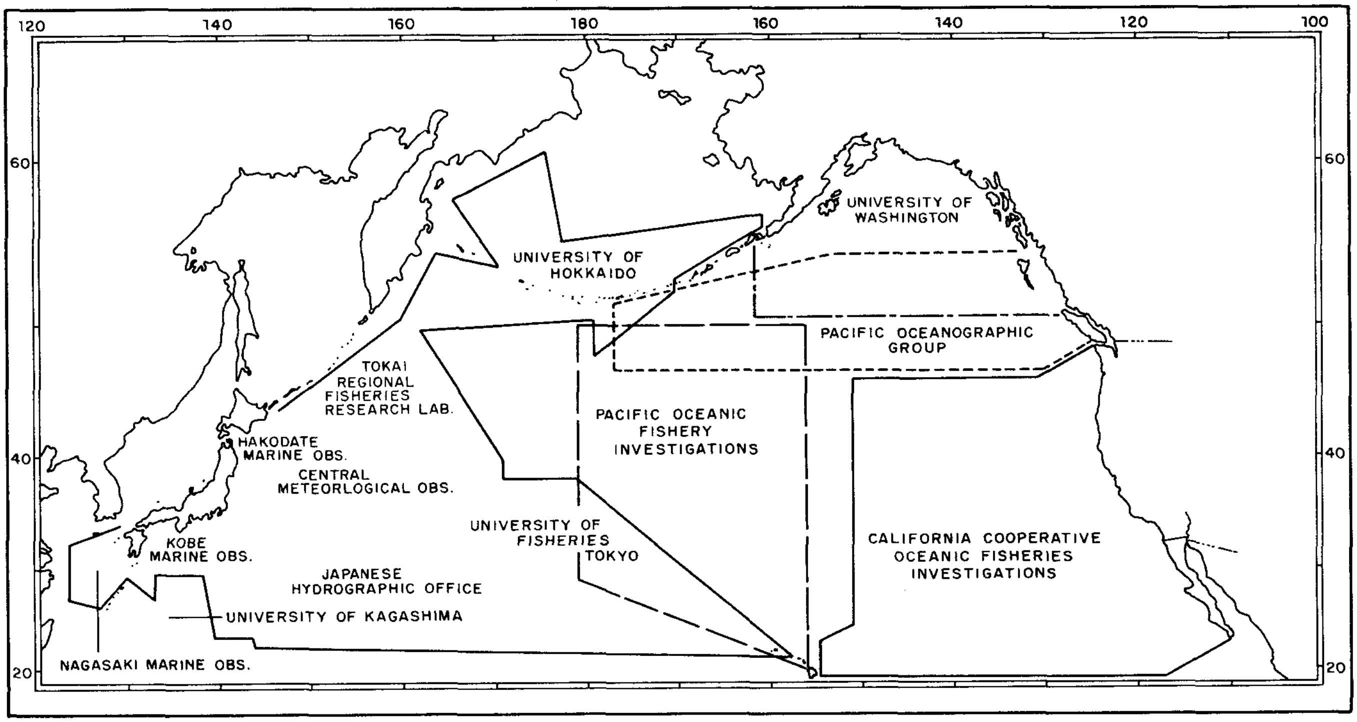


FIGURE 4. Areas covered by different agencies participating in NORPAC project.

magnitude is difficult to estimate because of the irregularities of seasonal fluctuation. The magnitude does, however, become clear if the values are expressed in yearly averages. These are shown by the dashed line extending from the 250-meter level in 1951 to the 220-meter level in 1955. The progressive elevation of the 8° C. water traces a practically straight line between these levels. The almost perfect linear relationship is probably fortuitous, but that the slope of the line is significant is indicated by similar general slopes of the other more irregular isotherms depicted in the same figure.

Marine organisms in general are restricted to specific depths. In some cases the bathymetric range is narrow, in others it is wide, but no organism can occupy all depths. Within the fixed vertical limits of its habitat each organism is restricted in its horizontal distribution by biological, chemical and physical factors, among which temperature is considered to be of prime importance. The northern and southern limits of distribution are usually not marked by sharp physiographic features, but by critical points on gradual temperature gradients—points which fluctuate in latitudinal position from year to year. While other factors such as varying intensity of population pressure may be responsible, it is possible that invasions of new territories, or retreat from old ones previously occupied, may be due to responses to slight changes in ocean climates such as those indicated above. Recent southern extension of the ranges of such fishes as the cod (*Gadus microcephalus*) which are now occasionally being taken in the Monterey area, is correlated with and may be due to the apparently insignificant temperature changes noted. It is possible, although by no means proved, that the apparent shift of the sardine population toward the south has been influenced in some degree by the still more subtle changes in the more superficial layers.

Enrichment of surface waters by upwelling and its effect on the production of phytoplankton, the primary basic food source in the sea, is illustrated by a comparison of Figures 8A and 8B. The latter figure also shows how the physical characteristics of the water and the quantity of plankton production may be used to interpret the patterns of water flow.

During the winter, when upwelling is at a minimum, temperature and salinity are comparatively uniform. On 4 February 1955, at the six stations in Monterey Bay which are indicated by the histograms in Figure 8A, the temperature (dotted bars extending above a base line of 10° C.) showed a range of only 0.69° C., while that of the salinity (white bars extending above a base line of 33°/oo) was only 0.18°/oo. The phytoplankton production (black bars representing wet volume in cc), as indicated by similar net hauls at each station, was low and relatively uniform throughout the area. This particular day yielded volumes approaching the minimum but represents and stresses the conditions found in winter, not only in Monterey Bay but along the entire coast.

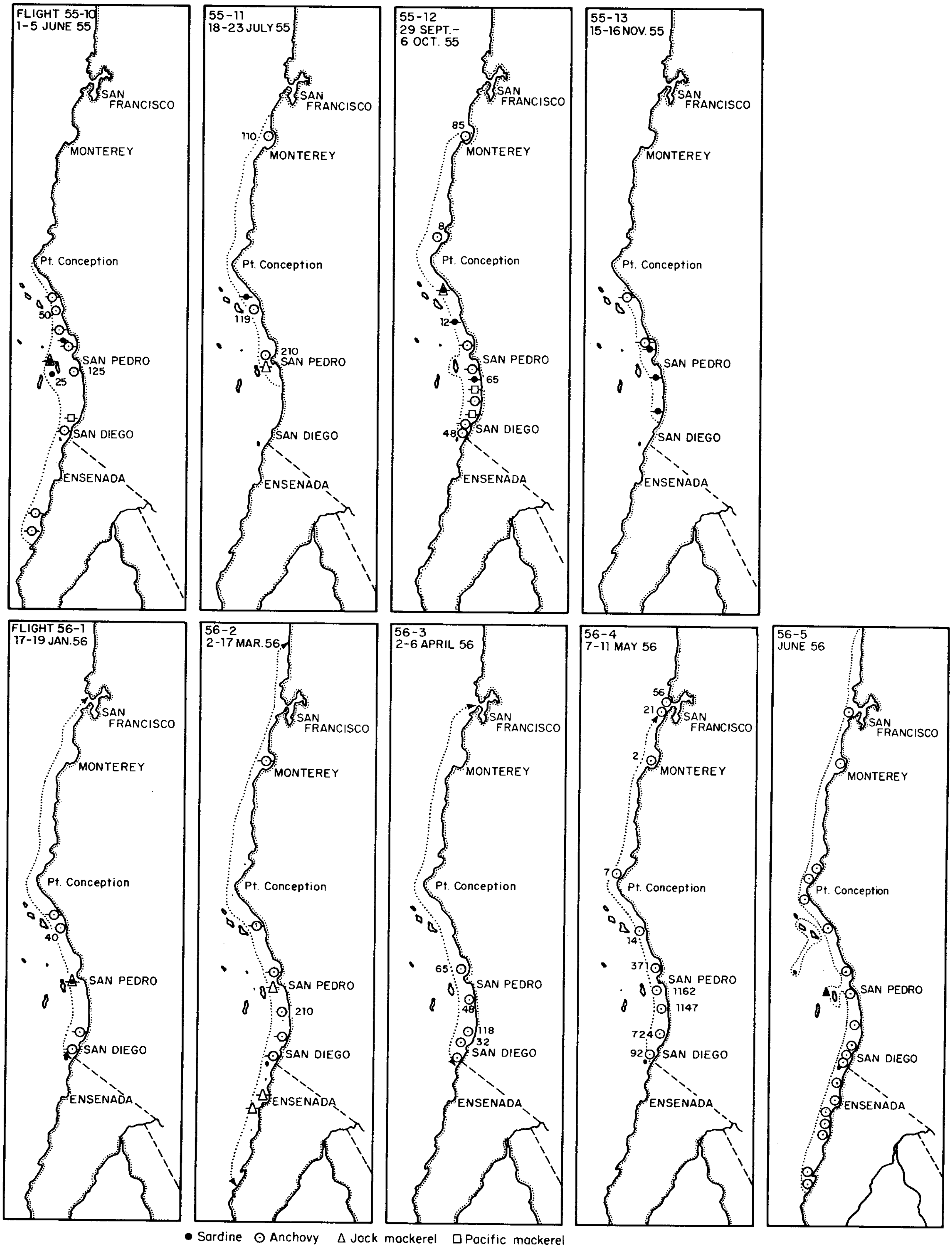


FIGURE 5. Results of airplane spotting surveys of fish schools. Numerals indicate estimated numbers of schools of fish. A crossbar through a symbol denotes that no estimate was made. Dotted line shows north-south extent of area, but greatly exaggerates distance from shore.

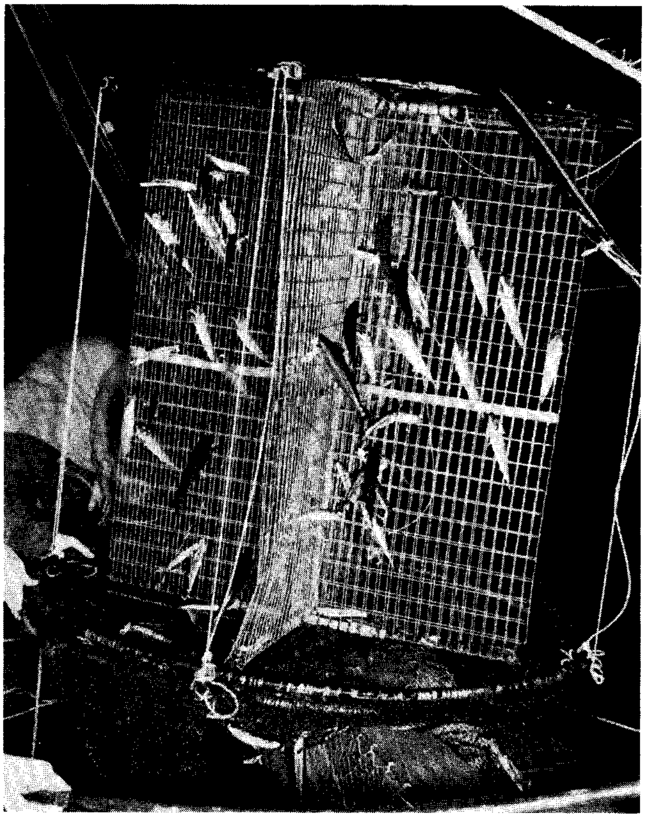


FIGURE 6. Result of an experiment with electrical fishing gear. In this test Pacific mackerel and anchovies were attracted with sufficent force to firmly lodge themselves in the wire mesh of the electrode. The majority of the captured fish are in the webbing at the bottom of the device. In use, a movable ring draws this webbing from bottom to top to completely enclose any fish attracted to the electrode.

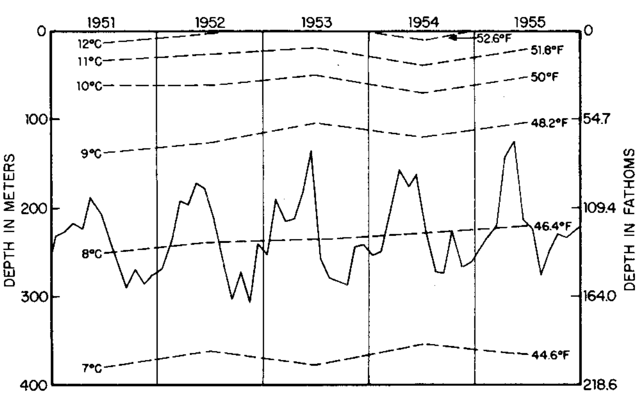


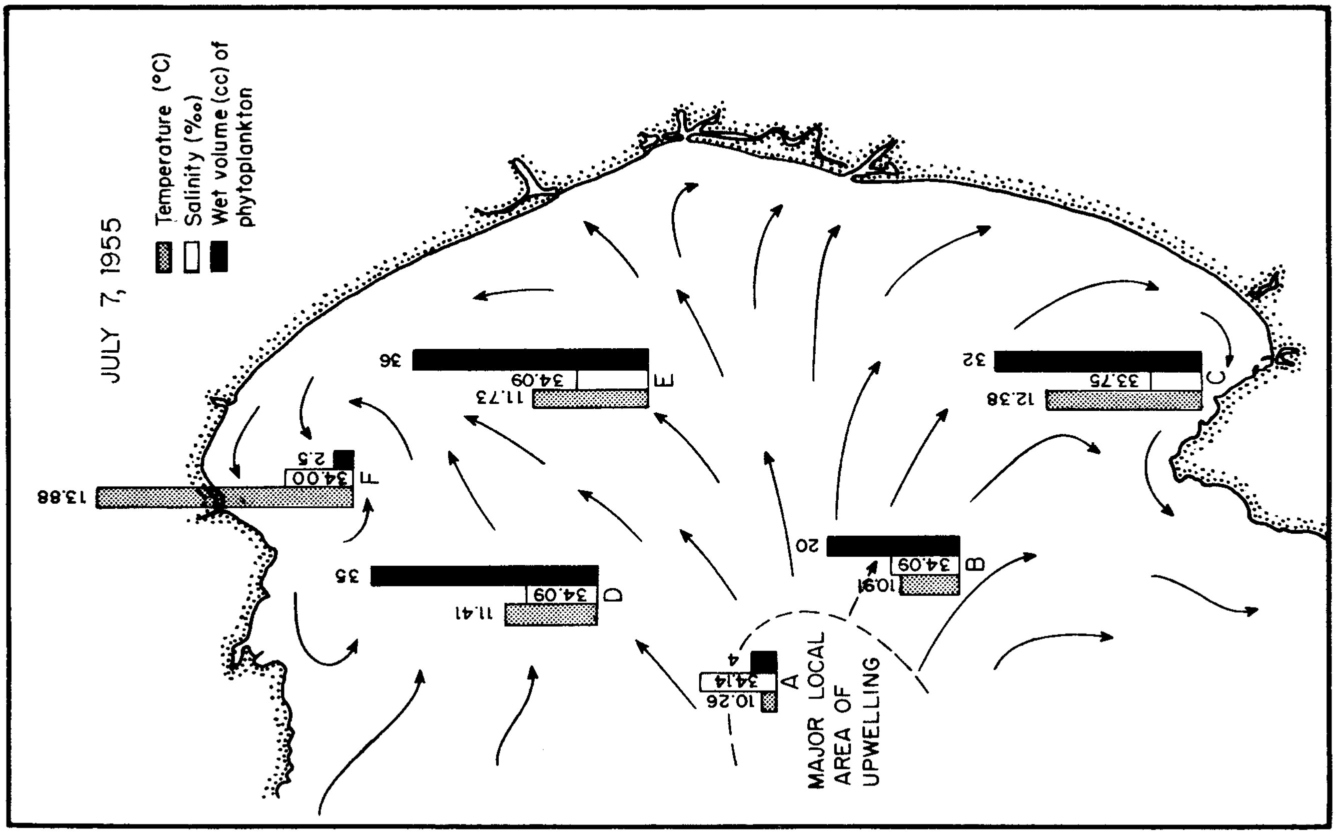
FIGURE 7. Average depth of isotherms, Monterey Bay, 1951-55. The solid line shows monthly values of 8° C. isotherms, the dashed lines, annual averages.

The strikingly different picture presented by Figure 8B shows the situation in summer. During this season the Monterey Submarine Canyon serves to channel the strongly upwelling water which comes to the surface along its course and, depending on local conditions, at various distances from shore. On 7 July 1955, station A, in the major local area of upwelling, gave low temperature and high salinity values indicating water of recent subsurface origin. As the upwelled water spreads over the surface it becomes warmer, owing to solar radiation, and less saline, as a result of mixing with surface layers. The degree of temperature rise and salinity decline provides an index by means of which the comparative length of time which has elapsed since the water reached the surface can be roughly deduced. Stations B and C show a progressive increase in temperature and decline in salinity toward the south and, correlated with these, an increase in phytoplankton volumes; the value of 32 cc at station C indicates rapid growth of the plankton over a considerable period of time. Toward the north, the water at stations D and E, with salinities equal to that at station B, has probably been subjected to the same degree of mixing as that at the latter station, but the higher temperatures indicate that it has been on the surface for a longer period and has had more time to absorb solar energy. This conclusion is strengthened by the rich phytoplankton which surpasses even that found at station C. The physical characteristics of the water at station F, particularly the high temperature, show that it has been on the surface for a comparatively long time. In this case, however, the phytoplankton production is low. The explanation lies in the fact that the water at the extreme northern end of the bay revolves in a relatively permanent eddy and has been at the surface so long that the nutrients derived from the depths have been depleted. As a result the phytoplankton has passed the peak of its bloom and declined.

BEHAVIOR STUDIES

Investigations at the California Academy of Sciences have centered about two problems: (1) whether or not the color of a light is a factor in its attractiveness to sardines, and if so what preference the fish show between various colors; and (2) whether sardines exhibit preference for a definite temperature. If sardines show a marked color preference, this fact should be useful in collecting at sea with a night light. If they show a marked temperature preference, this should be related to where they are most likely to be found at sea.

Experiments were made with white, green, blue, and red lights (all of equal intensity), in which the sardines were given a chance to swim freely from one lighted area into another. The fish showed a definite preference for blue or green light rather than white, but there was no difference in the attractiveness of blue or green. Red light was definitely avoided except when the choice was between red light and darkness. To sum up, the sardines preferred blue and green light to white; blue, green, and white were preferred to red; and all colors tested were preferred to total darkness.



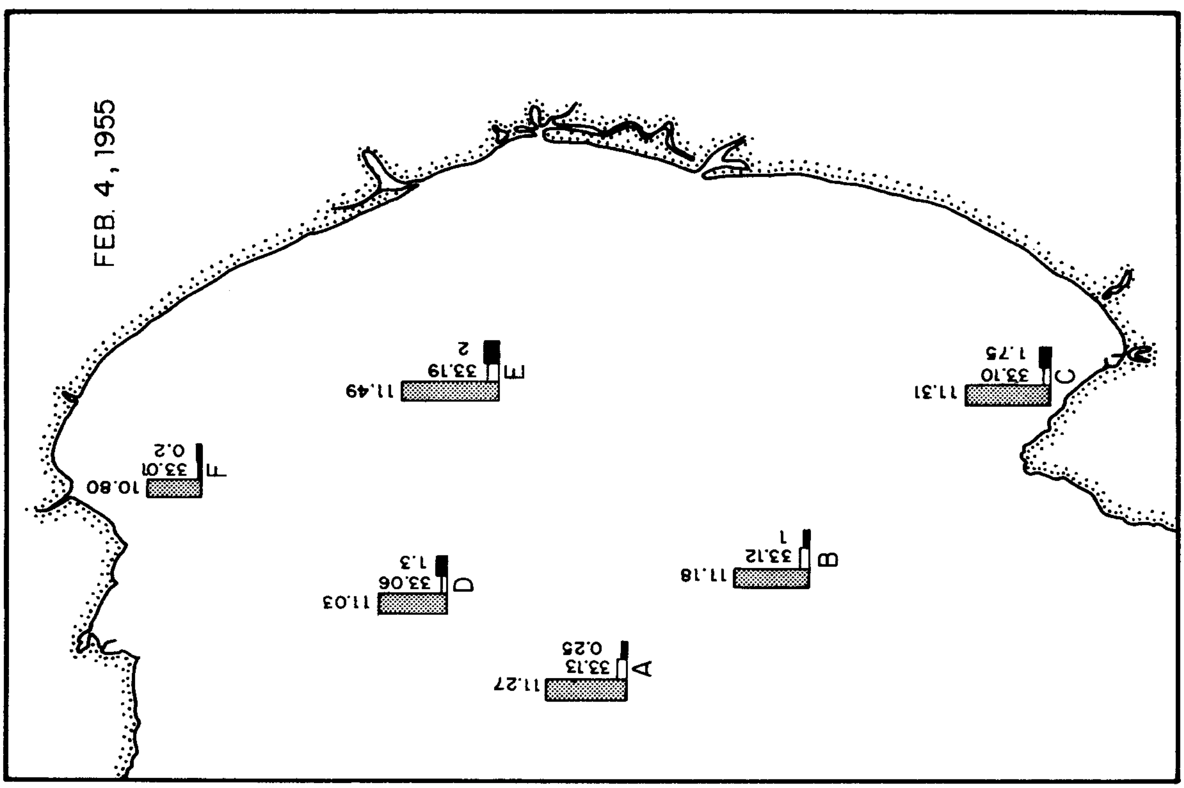


FIGURE 8. Phytoplankton production, Monterey Bay. (A) 4 February 1955; (B) 7 July 1955.

Equipment set up in the laboratory to determine temperature selection consisted of a tank one meter deep in which the temperature varied from 4° C. at the bottom to 34° C. at the top. When placed in this test tank sardines most frequently occupied the 18° C. to 22° C. region. These fish were from aquarium holding tanks where the temperature ranged from 17° C. to 19° C.

Attempts to acclimate sardines to lower temperatures were inconclusive because of a shortage of fish for the experiment, but the role of acclimation in temperature selection was successfully investigated in a similar study of several thousand young anchovies. Anchovies which were acclimated to a temperature of 12° C. most frequently occupied an area in the test tank of 12° C. to 14° C. Those which had become accustomed to a temperature of 17° C. in holding tanks were observed most frequently in the 15° C. to 18° C. area of the test tank, while those which were acclimated to a temperature of 22° C. selected the 18° C. to 20° C. portion of the test tank.

The results indicate that both sardines and anchovies tend to avoid abrupt changes in temperature.

FORECAST FOR 1955-56 SARDINE SEASON

Meeting at La Jolla on 29 June, one day before the end of the reporting period, the Marine Research Committee heard from members of its Technical Advisory Committee that preliminary results on the 1956 sardine spawning indicated widespread spawning off Southern California as far north as San Pedro, in a pattern resembling that of 1955, and that on 25 June, one day later than last year, schools of adult sardines had appeared off Point Hueneme, just as they did in 1955, when a total of 77,000 tons was taken. (Table 3 gives the monthly landings of sardines, anchovies, jack mackerels, and Pacific mackerels in California for the years 1952 to 1955.) It was too early to forecast the results of the coming season in any but the most general terms; however, experts were agreed that none of the year-classes since 1948 has equalled the one of that year, with the weak 1952 year-class the most prominent since.

TABLE 3

LANDINGS OF SARDINE, ANCHOVY, JACK MACKEREL, AND PACIFIC MACKEREL IN CALIFORNIA, 1952-55, INCLUSIVE, IN TONS

	1952	1953	1954	1955
Sardine				
January	1,437.9	458.0	318.4	525.8
February	212.7	137.7	39.0	46.7
March	133.7	91.1	35.6	61.2
April	230.2	73.3	51.0	32.2
May	220.9	20.7	94.6	85.9
June	166.1	136.3	151.6	101.0
July	177.2	212.1	257.9	115.6
August	294.1	174.1	423.9	206.4
September	260.9	577.3	897.4	312.6
October	2,264.8	2,004.5	29,101.2	13,807.8
November	1,033.6	751.0	28,838.9	37,072.5
December	733.1	98.3	8,042.5	20,436.1
Total	7,165.2	4,734.4	68,252.0	72,803.8
Anchovy				
January	9.6	3,113.8	1,810.0	2,670.2
February	44.4	4,908.6	2,531.2	2,324.0
March	0.9	2,485.2	809.4	3,510.8
April	313.1	3,711.9	2,063.5	2,960.2
May	663.7	7,755.5	2,044.5	3,820.4
June	1,809.8	7,881.4	829.0	1,402.7
July	3,134.1	1,999.0	1,752.5	1,479.0
August	3,009.2	1,818.4	2,558.3	1,659.7
September	1,264.1	3,205.1	2,994.1	436.9
October	9,778.8	1,793.0	1,271.9	234.7
November	5,852.8	2,618.2	1,086.4	967.0
December	2,010.5	1,627.6	1,454.3	879.9
Total	27,891.0	42,917.7	21,205.1	22,345.5
Jack Mackerel				
January	2,745.8	701.3	31.8	53.0
February	277.3	121.6	136.6	647.0
March	1,191.2	2,037.2	444.0	512.0
April	3,842.3	7,685.6	427.1	578.5
May	2,922.1	2,448.8	279.8	237.8
June	2,548.2	5,145.1	98.5	134.4
July	4,209.5	5,819.5	3,454.4	4,096.4
August	8,612.4	548.8	2,462.2	2,049.7
September	19,180.0	1,647.9	804.6	316.3
October	9,645.2	1,001.7	0.5	720.0
November	16,486.6	675.1	158.2	3,601.6
December	1,600.2	42.8	369.1	4,930.6
Total	73,260.8	27,875.4	8,666.8	17,877.3
Pacific Mackerel				
January	198.7	53.2	47.7	48.5
February	9.4	31.8	10.8	524.4
March	25.6	0.2	383.9	1,011.5
April	51.8	7.1	313.3	80.1
May	463.7	3.8	188.7	577.5
June	962.9	12.4	144.4	770.7
July	3,142.0	65.3	1,614.7	1,436.4
August	1,797.5	91.8	2,201.6	1,827.4
September	1,108.9	190.6	2,518.0	850.3
October	1,603.9	1,233.6	527.8	1,188.9
November	861.6	1,915.5	3,314.9	1,368.3
December	76.3	145.8	1,430.5	1,971.1
Total	10,302.3	3,751.1	12,696.3	11,655.1