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CALIFORNIA FISH AND GAME

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EXPLORATORY LONGLINE FISHING FOR TUNAS IN THE EASTERN TROPICAL PACIFIC, SEPTEMBER, 1955 TO MARCH, 1956[1]

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INTRODUCTION

The eastern tropical Pacific Ocean is the site of an extremely productive surface tuna fishery, as many as 300 million pounds having been caught in a single year. "Tunas" are taken with live bait (hook and line) and by purse seines near continental land masses and around offshore banks and islands. Yellowfin tuna, *Neothunnus macropterus*, and skipjack, *Katsuwonus pelamis*, predominate in the catch while bigeye tuna, *Parathunnus sibi*, are of minor importance. The fishery extends from Baja California to Chile and is exploited mainly by California vessels. Each year these vessels contribute a major portion of the State's fish landings.

An exploratory longline fishing cruise with the California Department of Fish and Game research vessel *N. B. Scofield* during early 1953 revealed large yellowfin and bigeye tunas inhabiting depths well below the surface (Wilson and Shimada, 1955). Most of these weighed well in excess of 100 pounds. They are relatively unavailable to the surface fishery and very little is known of their abundance, distribution and environment. Such information is vitally important to an understanding of the population structure of the total tuna resource. Two additional exploratory fishing and oceanographic cruises were made with the *N. B. Scofield* in 1955 and 1956 in an effort to learn more about these large, unexploited tunas. The first (Cruise 55-S-5, September 29 to November 30, 1955) in conjunction with expedition EASTROPIC[2] was designed to study the tuna catches in relation to fall oceanographic conditions. The second (Cruise 56-S-1, January 10 to March 10, 1956) was designed to study tuna catches in relation to winter oceanographic conditions.

The results of these two cruises are described herein and a discussion has been included concerning the relationship of certain oceanographic features to the distribution of large subsurface tunas in the central and eastern tropical Pacific as inferred from longline catches.

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[1] Submitted for publication October 1959.

[2] An oceanographic survey of the eastern tropical Pacific Ocean conducted jointly by Scripps Institution of Oceanography of the University of California, the Inter-American Tropical Tuna Commission, the Pacific Oceanic Fishery Investigations of the U.S. Fish and Wildlife Service, the Peruvian Naval Hydrographic Office, and the California Department of Fish and Game.

PROCEDURE

Station Plan

Longline fishing stations were planned to include the four major current systems in the eastern tropical Pacific: north equatorial, equatorial countercurrent, south equatorial, and Peru. In addition a highly productive surface tuna fishing area off Costa Rica was included. This area is characterized by a "doming" of the thermocline to within a

FIGURE 1. Longline stations and areas of highest yellowfin and bigeye tuna catches in the eastern tropical Pacific as determined on *N. B. Scofield* Cruises 55-S-5 and 56-S-1, September 1955 to March 1956.

few meters of the surface. Fifty-eight longline stations were occupied at various localities during the two cruises (Figure 1). In all, 129 stations were occupied at which longlining, nightlighting, trolling, or plankton tows, or a combination of these were accomplished (Tables 1 and 2). The scientific names of the various species captured with longline and troll gear have been listed in Table 3. Throughout the remainder of the text only the vernaculars will be used.

Gear and Methods

The longline fishing gear was similar to that developed by the Pacific Oceanic Fishery Investigations (Shomura and Murphy, 1955). The basic unit or "basket" consisted of a 210-fathom mainline made of No. 261 hard-lay cotton line. Eleven detachable hook droppers, each consisting of one fathom of line joined to a one-fathom leader of galvanized cable wire, were spaced along the mainline. Five- and 15-fathom floatlines attached to flagged buoys suspended each unit in the water (Figure 2). Frozen sardines 9 to 10 inches long were used as bait. Fishing depths were estimated by using chemical sounding tubes instead of hooks on predetermined droppers.

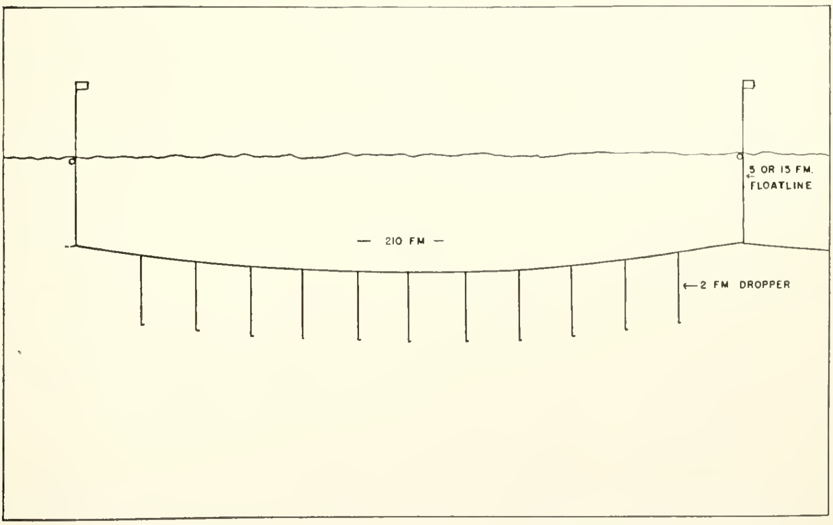

FIGURE 2. One basket; longline gear used by *N. B. Scofield*, 1955 and 1956.

In practice, a string of 40 baskets was fished at each station—fewer were used during foul weather. Half were equipped with five-fathom float lines and half with 15-fathom lines. Setting the gear usually began at 6 a.m. and was completed by 7.40 a.m. Retrieving started at 12.30 p.m. and was finished in three or four hours. Detailed catch records were kept for all fishing operations, and hooked fish that were identified but escaped, were included. Surface trolling was conducted near each longline set and while cruising between stations during daylight hours.

Biological and Oceanographic Operations

Length, sex, stomach contents and gonad development were recorded for each yellowfin, bigeye, sailfish and marlin caught.

TABLE 1

Station Data N. B. SCOFIELD Cruise 55-S-5, September 29 to November 30, 1955

Station no.	Date	Locality		Activity[1]	Water surface temp. (degrees F)	Water depth (fathoms)
		Latitude	Longitude			
1	October 4	18° 17′ N	110° 49′ W	P	80.1	1,900
2	October 4	18° 44′ N	111° 00′ W	N	--	1,901
3	October 5	16° 10′ N	110° 03′ W	L, P, T	81.7	1,739
4	October 5	15° 06′ N	110° 05′ W	N, P	81.7	1,800
5	October 6	14° 10′ N	109° 59′ W	L, P, T	82.2	2,600
6	October 6	13° 13′ N	109° 58′ W	P, N	83.3	--
7	October 7	12° 03′ N	110° 00′ W	L, P, T	81.3	--
8	October 8	10° 27′ N	109° 11′ W	P, N, T	81.7	400
9	October 9	09° 57′ N	110° 02′ W	L, P, T	81.1	2,000
10	October 10	08° 00′ N	110° 01′ W	L, T	79.9	--
11	October 14	01° 58′ N	105° 32′ W	N	66.7	--
12	October 16	01° 55′ N	101° 28′ W	L, P, T	75.4	--
13	October 17	00° 07′ N	100° 15′ W	L, P, T	65.8	1,800
14	October 18	02° 03′ S	99° 57′ W	L, P, T	66.2	1,800
15	October 18	02° 54′ S	99° 37′ W	N, P	67.5	2,000
16	October 19	03° 57′ S	99° 03′ W	L, P, T	67.6	1,900
17	October 21	02° 04′ S	93° 02′ W	N, P	64.9	2,000
18	October 22	02° 02′ S	92° 58′ W	L, P, T	64.0	2,000
19	October 22	01° 45′ S	92° 56′ W	N, P	62.8	1,895
20	October 23	00° 01′ N	92° 59′ W	L, P, T	61.9	1,680
21	October 23	01° 09′ N	93° 04′ W	N, P	65.5	--
22	October 24	01° 58′ N	92° 58′ W	L, P, T	72.3	1,525
23	October 25	05° 44′ N	91° 25′ W	T	78.6	2,050
24	October 26	07° 23′ N	90° 36′ W	L, T	78.1	1,725
25	October 26	08° 26′ N	90° 31′ W	P	76.8	1,942
26	October 27	09° 25′ N	90° 29′ W	L, P, T	77.5	--
27	October 27	10° 16′ N	90° 31′ W	N, P	77.4	1,888
28	October 28	11° 26′ N	90° 33′ W	L, P, T	78.3	2,105
29	October 28	11° 31′ N	89° 39′ W	N	77.7	2,080
30	October 29	11° 31′ N	88° 35′ W	L, P, T	77.7	2,220
31	October 30	09° 31′ N	88° 38′ W	L, P, T	77.9	1,960
32	October 30	09° 25′ N	88° 31′ W	T	78.3	1,960
33	October 30	08° 44′ N	88° 31′ W	N, P	78.3	1,860
34	October 31	07° 30′ N	88° 35′ W	L, P, T	78.4	1,870
35	October 31	07° 29′ N	87° 35′ W	N, P	78.4	--
36	November 1	07° 28′ N	86° 35′ W	L, P, T	78.6	1,822
37	November 1	07° 24′ N	86° 30′ W	N	78.6	1,800
38	November 2	09° 30′ N	86° 38′ W	L, P, T	78.8	1,908
39	November 2	09° 30′ N	85° 35′ W	N	79.3	2,320
40	November 5	08° 00′ N	85° 36′ W	T	78.3	1,582
41	November 6	05° 55′ N	86° 21′ W	L, P, T	78.4	--
42	November 6	05° 32′ N	87° 00′ W	N	78.3	200
43	November 7	05° 29′ N	87° 24′ W	N, P, T	78.6	--
44	November 8	05° 27′ N	88° 30′ W	L, P, T	78.4	--
45	November 10	00° 04′ S	87° 02′ W	L, P, T	74.4	1,400
46	November 10	01° 00′ S	87° 04′ W	N, P	73.6	--
47	November 11	02° 04′ S	86° 56′ W	L, P, T	70.7	1,332
48	November 11	03° 02′ S	87° 00′ W	N, P	66.7	--
49	November 12	03° 59′ S	86° 57′ W	L, P, T	66.9	--
50	November 13	03° 59′ S	84° 19′ W	L, P, T	64.6	1,933
51	November 13	03° 15′ S	83° 52′ W	P	64.0	--
52	November 14	02° 03′ S	83° 05′ W	L, P, T	63.9	--
53	November 14	00° 55′ S	83° 01′ W	N, P	66.6	1,053
54	November 15	00° 02′ S	82° 59′ W	L, P, T	73.4	1,353
55	November 15	00° 07′ N	82° 58′ W	N, P	75.2	1,300

TABLE 1

Station Data N. B. SCOFIELD Cruise 55-S-5, September 29 to November 30, 1955—Continued

Station no.	Date	Locality		Activity[1]	Water surface temp. (degrees F)	Water depth (fathoms)
		Latitude	Longitude			
56	November 16	01° 57′ N	83° 04′ W	L, T	77.0	--
57	November 17	05° 25′ N	88° 46′ W	T		
58	November 18	06° 13′ N	89° 22′ W	T		
59	November 19	08° 45′ N	92° 20′ W	T		1,800
60	November 22	15° 30′ N	99° 15′ W	T		1,060
61	November 22	15° 55′ N	99° 30′ W	T		2,920
62	November 23	17° 26′ N	101° 50′ W	T		1,000
63	November 23	17° 42′ N	102° 20′ W	T		587

[1] L—longline, N—nightlight, P—plankton tow, T—troll.

Quantitative zooplankton collections were made at each fishing station and approximately midway between stations by making oblique net hauls with a one-meter plankton net. An Atlas-type flow meter mounted in the mouth was used for determining amount of water strained. The net was lowered to a calculated depth of 300 meters at a rate of 50 meters per minute and retrieved at a rate of 20 meters per minute while the vessel proceeded slowly under way. Upon completion of a tow, the net would be suspended out of water and hosed down; next, the end would be removed and the contents transferred to a quart jar containing a solution of 10 percent buffered formalin.

A one-hour night light collecting station was occupied after each evening plankton tow.

Bathythermograph casts and surface salinity collections were made at fishing stations and approximately every 40 miles between stations. A mechanical breakdown of the bathythermograph winch reduced the number of casts during the fall cruise, however.

Finally, surface water temperatures and weather observations were regularly recorded.

RESULTS

Longline Catch

Tunas comprised 18 percent of the longline catch for both cruises. Catches of small tuna (under 90 cm. fork length) have not been included in the calculations because they were captured near the surface while setting and retrieving gear.

In general, yellowfin tuna were concentrated within a 120-mile radius of Lat. 09° 30′ N., Long. 88° 30′ W. while bigeye tuna were most abundant between latitudes 02° N. and 04° S. (Figure 1). The fall cruise produced an average of 0.21 yellowfin and 0.73 bigeye tuna per 100 hooks while the winter cruise produced a slightly higher yellowfin (0.35 per 100 hooks) and a lower bigeye catch (0.35 per 100).

Sharks, spearfishes, tunas, and dolphinfishes, in order of abundance, comprised over 95 percent of the total catch for both cruises (Figure 3). Carcharhinid sharks were the most numerous while hammerheads and bonito sharks were caught in small numbers.

TABLE 2

Station Data N. B. SCOFIELD Cruise 56-S-1, January 10 to March 10, 1956

Station no.	Date	Locality		Activity[1]	Water surface temp. (degrees F)	Water depth (fathoms)
		Latitude	Longitude			
1	January 15	20° 39′ N	106° 56′ W	T	80.1	--
2	January 17	16° 40′ N	100° 00′ W	T	79.0	--
3	January 17	16° 28′ N	99° 31′ W	T	79.0	--
4	January 17	16° 18′ N	99° 22′ W	T	81.0	--
5	January 19	13° 21′ N	92° 41′ W	T	77.2	--
6	January 20	13° 30′ N	92° 30′ W	L, N, T	79.2	3,500
7	January 20	13° 34′ N	92° 32′ W	P, N	--	--
8	January 20	12° 53′ N	92° 32′ W	N, P	79.1	2,100
9	January 21	11° 55′ N	92° 28′ W	L, P, T	75.6	2,500
10	January 21	11° 58′ N	91° 30′ W	N, P	78.6	2,000
11	January 22	12° 10′ N	90° 33′ W	L, P, T	77.4	2,100
12	January 23	10° 04′ N	90° 38′ W	L, P, T	76.5	2,100
13	January 23	09° 14′ N	90° 33′ W	P	76.1	1,950
14	January 24	07° 58′ N	90° 38′ W	L, P, T	78.3	--
15	January 24	07° 01′ N	90° 30′ W	N, P	77.0	--
16	January 25	06° 08′ N	90° 29′ W	L, P, T	76.1	--
17	January 25	05° 47′ N	89° 31′ W	N, P	76.8	1,970
18*	January 26	05° 38′ N	88° 26′ W	L, P, T	78.1	410
19	January 26	06° 27′ N	88° 31′ W	N	77.4	1,850
20	January 27	07° 27′ N	88° 24′ W	L, P, T	80.6	1,850
21	January 27	08° 26′ N	88° 26′ W	N	76.8	2,000
22	January 28	09° 37′ N	88° 29′ W	L, T	72.9	1,900
23	January 29	10° 54′ N	86° 26′ W	N	75.9	300
24	January 29	10° 54′ N	86° 15′ W	T	--	--
25*	January 30	10° 03′ N	86° 09′ W	N, P	78.6	550
26	January 31	09° 04′ N	86° 22′ W	L, P, T	81.1	1,750
27*	January 31	08° 10′ N	86° 25′ W	N, P	79.3	1,750
28*	February 1	07° 12′ N	86° 25′ W	L, P, T	82.0	1,675
29*	February 1	06° 09′ N	86° 27′ W	N, P	79.0	800
30	February 2	04° 58′ N	86° 21′ W	L, P, T	81.7	800
31	February 2	04° 59′ N	86° 38′ W	T	--	--
32*	February 2	04° 57′ N	85° 31′ W	N, P	79.5	1,050
33	February 3	05° 00′ N	84° 30′ W	L, P, T	80.2	1,800
34*	February 3	05° 54′ N	84° 29′ W	N, P	81.5	1,550
35	February 4	06° 52′ N	84° 36′ W	L, P, T	81.3	850
36	February 4	07° 38′ N	84° 36′ W	N, P	80.1	900
37	February 5	08° 26′ N	84° 32′ W	L, P, T	81.5	1,375
38	February 5	07° 55′ N	83° 50′ W	N	82.2	800
39	February 6	07° 03′ N	82° 32′ W	L, P, T	82.6	1,800
40	February 6	06° 11′ N	82° 09′ W	N	81.7	1,450
41	February 7	05° 12′ N	81° 40′ W	L, P, T	81.0	2,100
42	February 7	05° 15′ N	81° 36′ W	T	--	--
43	February 7	05° 52′ N	80° 56′ W	N	79.7	1,650
44	February 8	06° 25′ N	80° 06′ W	L, P, T	79.2	1,900
45	February 10	Balboa, Panama C. Z.		N	--	5
46	February 12	07° 06′ N	79° 50′ W	T	80.1	--
47	February 15	01° 53′ S	82° 59′ W	L, P, T	78.4	1,250
48	February 15	01° 00′ S	82° 58′ W	N, P	78.4	800
49	February 16	00° 02′ S	83° 03′ W	L, P, T	79.3	1,950
50	February 16	00° 52′ N	83° 03′ W	N, P	79.9	1,770
51	February 17	01° 58′ N	83° 09′ W	L, P, T	80.8	1,900
52	February 17	01° 59′ N	84° 15′ W	N, P	80.2	1,725
53	February 18	01° 55′ N	85° 06′ W	L, P, T	81.7	2,000
54	February 18	01° 55′ N	86° 00′ W	N, P	80.6	1,750
55	February 19	02° 04′ N	87° 04′ W	L, P, T	81.7	1,510

TABLE 2

Station Data N. B. SCOFIELD Cruise 56-S-1, January 10 to March 10, 1956—Continued

Station no.	Date	Locality		Activity[1]	Water surface temp. (degrees F)	Water depth (fathoms)
		Latitude	Longitude			
56	February 19	01° 02′ N	87° 04′ W	N, P	81.1	1,500
57	February 20	00° 03′ N	87° 03′ W	L, P, T	79.0	1,500
58	February 20	01° 02′ S	87° 03′ W	N, P	79.5	1,150
59	February 21	01° 45′ S	86° 59′ W	L, P, T	79.2	1,550
60	February 24	01° 56′ S	92° 03′ W	L, P, T	78.1	1,850
61	February 24	01° 02′ S	92° 18′ W	N, P	77.5	1,850
62	February 25	00° 08′ N	92° 30′ W	L, P, T	75.6	1,850
63	February 25	01° 10′ N	92° 27′ W	N, P	80.1	1,350
64	February 26	01° 59′ N	92° 29′ W	L, P, T	80.8	1,280
65	February 26	03° 00′ N	92° 49′ W	N, P	81.0	1,400
66	February 27	03° 56′ N	93° 05′ W	L, P, T	82.6	1,115

[1] L—longline, N—nightlight, P—plankton tow, T—troll.
* Plankton collections lost overboard.

TABLE 3

List of Species Taken on Longline and Troll Gear During N. B. SCOFIELD Cruises 55-S-5 and 56-S-1, September 29, 1955 to March 10, 1956

Family name	Scientific name	Common name
Chelonidae	*Chelonia mydas*	green turtle
Alopiidae	*Alopias* sp.	thresher
Lamnidae	*Isurus glaucus*	bonito shark
Carcharhinidae	*Carcharhinus longimanus*	whitetip shark
	Carcharhinus malpeloensis	
	Carcharhinus platyrhynchus	
	Carcharhinus sp.	
	Prionace glauca	blue shark
Sphyrnidae	*Sphyrna* sp.	hammerhead
Dasyatidae	*Dasyatis violacea*	pelagic ray
Mobulidae	*Manta* sp.	manta
Alepisauridae	*Alepisaurus borealis*	lancetfish
Coryphaenidae	*Coryphaena hippurus*	dolphinfish
Katsuwonidae	*Auxis* sp.	bullet mackerel
	Euthynnus lineatus	black skipjack
	Katsuwonus pelamis	skipjack
Thunnidae	*Neothunnus macropterus*	yellowfin tuna
	Parathunnus sibi	bigeye tuna
Istiophoridae	*Istiophorus greyi*	sailfish
	Makaira audax	striped marlin
	Makaira marlina	black marlin
Xiphiidae	*Xiphias gladius*	swordfish

Sharks were found in greatest numbers off Nicaragua and Costa Rica. They destroyed 13 percent of the longline yellowfin and 4.5 percent of the bigeye catch.

Central American waters produced catches of Pacific sailfish as high as nine per 100 hooks. Pacific striped marlin, black marlin and broadbill swordfish were less abundant. Dolphinfish were caught in most areas and comprised 14 percent of the total catch. Twenty species of cartilaginous and bony fishes and one kind of turtle were taken on longline gear. These 21 species comprised 1,106 individual specimens and were taken on 24,634 hooks set at 58 localities during the two cruises (Tables 4 and 5).

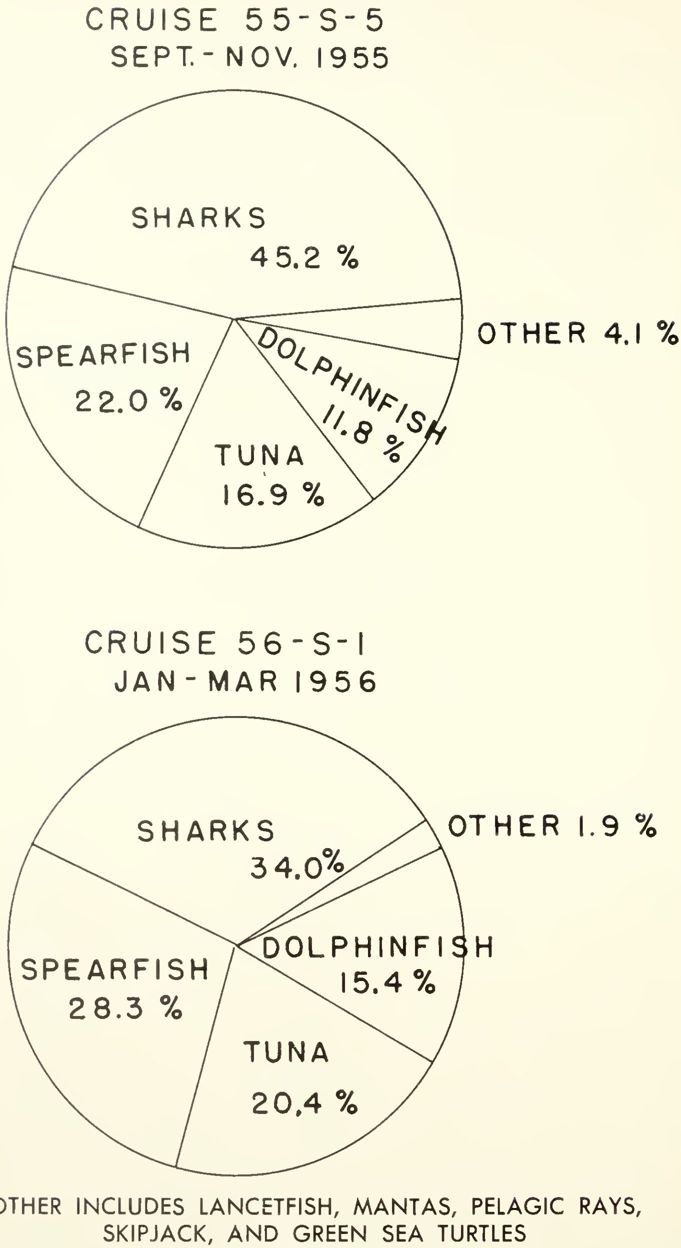

FIGURE 3. Longline catch composition in the eastern tropical Pacific, *N. B. Scofield* Cruises 55-S-5 and 56-S-1.

Longline Catch Data for N. B. SCOFIELD Cruise 55-S-5, September 29 to November 30, 1955

Station no.[1]	Number of hooks	Catch								
		Yellowfin	Bigeye	Sharks	Sailfish	Striped marlin	Dolphin-fish	Lancet-fish	Miscellaneous	Total
3	428	0	0	7	0	2	9	0	0	18
5	432	0	0	8	0	0	0	0	0	8
7	437	0	0	16	1	2	3	0	0	22
9	436	3	0	17	0	5	0	0	1 skipjack	26
10	337	0	0	11	0	1	2	0	1 pelagic ray	15
12	427	0	2	4	0	1	0	9	4 pelagic rays	20
13	434	0	2	0	0	0	0	6	0	8
14	435	0	0	2	0	0	1	1	0	4
16	436	0	0	1	0	1	2	0	0	4
18	435	0	6	0	0	0	0	0	0	6
20	436	0	1	1	0	0	0	2	0	4
22	432	0	14	2	0	5	2	2	0	25
24	436	1	0	14	4	2	1	0	0	22
26	434	3	0	10	8	3	0	0	0	24
28	425	9	0	7	11	1	0	0	0	28
30	419	0[2]	0	40	26	6	12	0	1 swordfish	85
31	435	3	0	3	6	3	0	0	1 swordfish	16
34	437	0	0	7	3	1	0	0	0	11
36	438	2	0	25	11	1	2	0	1 manta	42
38	435	5	0	34	12	4	2	0	0	57
41	438	0	0	10	1	0	0	0	0	11
44	434	0	0	40	0	3	1	0	0	44
45	306	0	3	1	1	1	0	0	0	6
47	431	0	26	0	0	2	0	0	0	28
49	434	0	1	0	0	0	40	0	0	41
50	320	0	0	0	0	0	2	0	0	2
52	437	0	17	0	0	0	0	0	0	17
54	436	0	0	15	2	9	4	0	0	30
56	403	0	17	32	4	7	0	0	1 skipjack	61
Totals	12.203	26	89	307	90	60	83	20	10	685

[1] See Table 1 for locations and dates.
[2] Nineteen small yellowfin caught at surface while retrieving gear.

TABLE 5

Longline Catch Data for N. B. SCOFIELD Cruise 56-S-1, January 10 to March 10, 1956

Station no.[1]	Number of hooks	Catch								
		Yellowfin	Bigeye	Sharks	Sailfish	Striped marlin	Dolphin-fish	Lancet-fish	Miscellaneous	Total
6	418	0	0	24	40	0	2	0	0	66
9	446	2	0	1	5	2	1	0	0	11
11	435	2	0	15	0	0	0	0	1 manta	18
12	437	17	0	7	4	1	1	0	0	30
14	436	9	0	1	1	1	0	0	0	12
16	436	0	0	5	3	0	0	0	0	8
18	434	0	0	7	1	3	1	0	0	12
20	436	0	0	5	1	0	0	0	0	6
22	217	4	0	0	0	0	0	0	0	4
26	437	5	0	6	2	0	1	0	0	14
28	436	0	0	2	1	0	0	0	0	3
30	437	0	0	6	2	0	0	0	1 green turtle	9
33	437	0	0	3	3	0	0	0	0	6
35	437	0	0	16	11	0	1	0	0	28
37	430	0	0	10	10	0	37	0	1 bullet mackerel	58
39	437	0	0	5	12	0	9	0	0	26
41	435	3	0	3	4	0	0	0	0	10
44	433	0[2]	0	4	0	0	11	0	0	15
47	436	0	0	0	0	1	0	0	0	1
49	436	0	0	0	0	1	0	0	0	1
51	436	1	29	4	0	0	0	0	1 black marlin	35
53	437	0	0	0	1	0	1	0	0	2
55	437	0	0	5	1	1	0	1	1 green turtle	9
57	436	0	0	1	0	1	0	0	0	2
59	433	0	11	1	0	2	0	0	1 black marlin	15
60	435	0	2	1	0	1	0	0	0	4
62	430	0	1	6	0	1	0	0	1 pelagic ray	9
64	435	0	0	2	0	0	0	0	0	2
66	436	0	0	3	0	2	0	0	0	5
Totals	12,431	43	43	143	102	17	65	1	7	421

[1] See Table 2 for locations and dates.
[2] One small yellowfin caught on surface while retrieving gear.

Vertical Distribution of the Tuna Catch

Because of differences in the amount of slack in the mainline, current, occasional fouling of droppers, and other complications, exact fishing depths could not be determined for most of the hooks. As a result, detailed studies could not be made of the vertical distribution of the catches, either within a given set or between sets. It is possible, however, to compare the catch rate for the hooks fishing shallow with that for the hooks fishing deep.

During the fall cruise it was found that the gear fished at depths ranging from 24 to 85 fathoms. Hooks fishing in 24 to 35 fathoms have been arbitrarily designated "shallow," while those fishing in 42 to 85 fathoms have been designated as "deep." On tuna producing stations, 2,004 shallow hooks yielded 0.1 yellowfin and 1.0 bigeye per 100, while 1,610 deep hooks averaged 0.4 yellowfin and 1.4 bigeye. The deep hooks were the most productive of both species and bigeye were the major contributor at both depths.

On the winter cruise the gear fished between 20 and 90 fathoms. Hooks fishing between 20 and 42 fathoms were arbitrarily designated "shallow" and those between 48 and 90 fathoms were listed as "deep." The 1,361 shallow hooks yielded 1.2 yellowfin and 0.4 bigeye per 100, and the 1,142 deep hooks averaged 0.4 yellowfin and 1.7 bigeye. The shallow hooks caught the most yellowfin and the deep hooks the most bigeye.

Data from both cruises indicate that deep hooks were the most productive in total catch; however, the shallow hooks produced a slightly larger number of yellowfin (Figure 4).

Troll Catch

Surface trolling produced 129 yellowfin and 12 skipjack—over half from visually located schools. Trolling near longline stations was relatively unproductive, except on one occasion when 23 yellowfin were caught. Dolphinfish, black skipjack, and sailfish were taken in smaller numbers (Table 6).

Size Composition and Sexual Maturity of Tuna Catches

Commercial fishing methods in the eastern tropical Pacific draw primarily upon yellowfin tuna under 90 cm. in fork length. During both cruises tuna caught on longlines were considerably larger than 90 cm. (Figure 5). The Pacific Oceanic Fishery Investigations operating in the central Pacific also found that longline gear took larger individuals than were caught surface fishing in the same area (Murphy and Shomura, 1953). They concluded this was due to ecological preference on the part of tunas rather than gear selection.

Observations for sexual maturity revealed little evidence of imminent spawning. A 145 cm. fork length yellowfin taken at Clipperton Island was in an advanced stage of development and would have spawned in the near future.

Few yellowfin were taken with ovaries in advanced developmental stages, and these only during the winter cruise. Schaefer and Orange (1956) believe winter and spring are the periods of peak spawning off Central America.

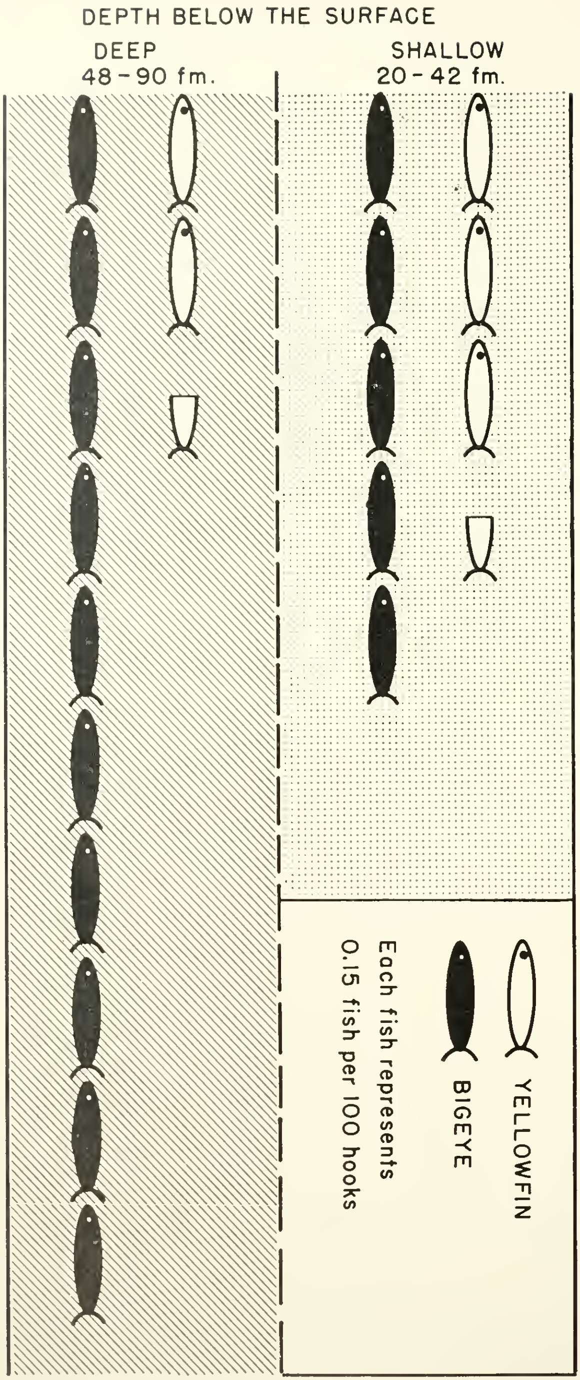

FIGURE 4. Distribution of tuna catches by depth beneath the surface, N. B. Scofield Cruises 55-S-5 and 56-S-1.

TABLE 6

Troll Catch Data for N. B. SCOFIELD Cruises 55-S-5 and 56-S-1, September 29, 1955 to March 10, 1956

Cruise no.	Station no.	Catch					
		Yellowfin	Skipjack	Black skipjack	Dolphin	Sailfish	Total
55-S-5	3	0	0	0	1	0	1
	5	0	0	0	1	0	1
	7	5	0	0	1	0	6
	8	24	4	0	0	0	28
	18	0	3	0	0	0	3
	23	0	0	0	1	0	1
	24	3	0	0	0	0	3
	28	2	0	0	0	0	2
	30	23	0	0	0	0	23
	32	1	0	0	0	0	1
	40	0	0	0	1	0	1
	41	0	1	0	0	0	1
	47	0	2	0	0	0	2
	57	0	0	0	4	0	4
	58	0	0	0	5	0	5
	59	1	0	0	0	0	1
	60	3	0	0	0	0	3
	61	12	0	0	0	0	12
	62	0	1	0	0	0	1
	63	24	0	0	0	0	24
Totals		98	11	0	14	0	123
56-S-1	1	1	0	0	0	0	1
	2	25	0	0	0	0	25
	3	4	0	0	0	0	4
	4	0	0	20	0	0	20
	5	0	0	0	0	1	1
	23	0	0	0	1	0	1
	31	0	1	0	0	0	1
	37	0	0	0	2	0	2
	42	0	0	0	1	0	1
	44	1	0	0	0	0	1
	46	0	0	0	1	0	1
Totals		31	1	20	5	1	58
Grand totals		129	12	20	19	1	181

No ripening bigeye tuna were taken on either cruise. A few were classified as spent and one large individual, 173 cm. fork length, taken near the Galapagos Islands, had just completed spawning. Remnant mature ova from this fish were turgid and translucent, measuring between 1.0 and 1.38 mm. in diameter. Mature ova from bigeye tuna taken in the central equatorial Pacific range between 0.88 and 1.1 mm. in diameter (Yuen, 1955).

Night Light Collections

Fish and other marine life attracted to a night light were collected with a fine mesh dipnet. There was no apparent relationship between abundance of organisms attracted to the light and tuna catches. Inshore

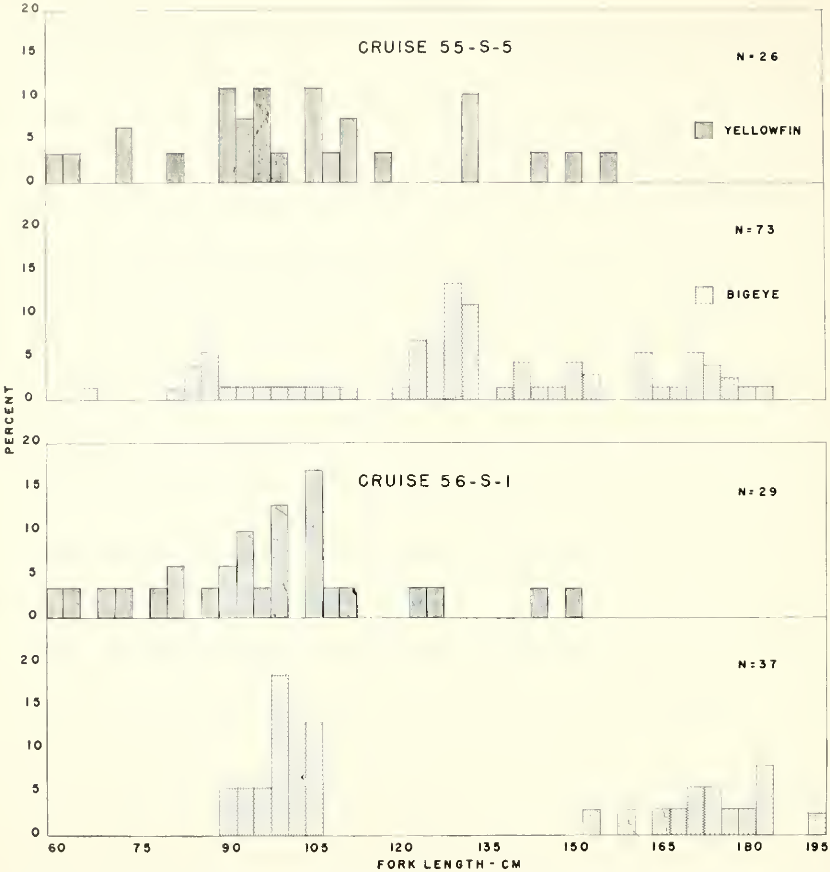

FIGURE 5. Length frequencies of longlined yellowfin and bigeye taken in the eastern tropical Pacific, *N. B. Scofield* Cruises 55-S-5 and 56-S-1.

stations between latitudes 05° N. and 15° N. yielded the greatest diversity of species. Collections in the equatorial area between the Galapagos Islands and the South American coast showed large variation between cruises in number of species and quantities of individuals. During the winter cruises the quantity of individuals and number of species almost doubled over the fall cruise. Offshore stations yielded comparatively few individuals and species.

Lanternfish (Myctophidae) and flyingfish (Exocoetidae) were the most numerous although considerable quantities of mullet (*Mugil* sp.) and bullet mackerel (*Auxis* sp.) were taken during both cruises. Squid frequently appeared under the light, but were difficult to capture except when very near the surface. All specimens collected have been systematically listed in Tables 7 and 8.

TABLE 7

List of Specimens Collected During N. B. SCOFIELD Cruise 55-S-5, September 29 to November 30, 1955

Codes refer to method, station, and number of items, respectively

Alopiidae—threshers
Alopias sp. L3(1), L7(1), L26(2), L30(2), L31(1), L34(1), L38(4), L41(1), L56(4).

Lamnidae—mackerel sharks
Isurus glaucus—bonito shark L20(1), L38(1), L44(1).

Carcharhinidae—requiem sharks
Carcharhinus longimanus—white tip shark L5(1), L7(1), L9(4), L10(1), L54 (3), L56(2).
Carcharhinus malpeloensis L36(1).
Carcharhinus platyrhynchus L45(1).
Carcharhinus sp. L5(5), L7(13), L9(13), L10(6), L12(3), L22(2), L24(13), L26(7), L28(7), L30(38), L31(2), L34(3), L36(20), L38(28), L41(7), L44(38), L54(12), L56(23).
Prionace glauca—blue shark L3(3), L5(1), L7(1), L9(1), L10(4), L12(1), L14(2), L16(1), L24(1), L26(1), L34(3), L36(3), L38(1), L41(2), L44(1), L56(3).

Sphyrnidae—hammerheads
Sphyrna sp. L3(1), L5(1).

Dasyatidae—stingrays
Dasyatis violacea L10(1), L12(4).

Mobulidae—mantas
Manta sp. L36(1).

Clupeidae—herrings
Clupeid P52(3).

Argentinidae—deepsea-smelts
Bathylagus sp. P51(1).
Nansenia sp. P51(1).
Argentinids P18(1), P27(6), P33(4), P43(1), P46(1), P53(1).

Gonostomidae
Maurolicus sp. P12(7), P13(4), P15(2), P22(2), P27(1).
Gonostomatid larvae P2(1), P4(1), P5(1), P7(1), P16(1), P20(1), P22(6), P45(?).

Sternoptychidae—lightfishes
Argyropelecus lynchus P12(1), P15(2), P18(2), P22(4), P25(1), P27(1), P33 (6), P48(3).
Argyropelecus sp. P12(1), P15(2), P18(2), P22(4), P25(3), P31(1), P34(1), P35(4), P38(1), P41(1), P43(3), P45(2), P46(7), P49(2), P51(5), P52(1), P53(2), P55(2).
Cyclothone signata P52(10).
Cyclothone sp. P9(1), P12(5), P13(12), P14(2), P15(1), P16(8), P17(3), P18(1), P20(2), P21(15), P22(5), P25(1), P26(1), P27(1), P33(3), P34(5), P38(3), P41(4), P43(1), P44(2), P45(12), P46(15), P47(6), P48 (1), P49(9), P50(18), P51(6), P53(3), P54(3), P55(5), P62(1).
Vinciguerria lucetia P3(12), P4(7), P5(3), P6(2), P7(1), P8(3), P9(2), P22(8), P26(1), P28(4), P30(3), P31(2), P36(2), P55(1).

Astronesthidae—snaggletooths
Astronesthes sp. N55(1).

Idiacanthidae—blackdragons
Idiacanthus sp. P7(2), P8(1), P9(1).

Scomberesocidae—saury
Scomberesocid N15(6).

TABLE 7—Continued

List of Specimens Collected During N. B. SCOFIELD Cruise 55-S-5, September 29 to November 30, 1955

Codes refer to method, station, and number of items, respectively

Exocoetidae—flyingfishes
- Exocoetids N1(5), N4(1), N8(2), N25(2), N33(2), N35(3), N43(2), N46(1), N55(2).
- *Oxyporhamphus micropterus* N1(4), N4(1), N6(1), N8(11), N25(1), N29(6), N33(4), N35(7), N43(9), N46(2).

Synodidae—lizardfishes
- *Synodus* sp. N42(11).

Myctophidae—lanternfishes
- Myctophid larvae P4(3), P7(6), P8(4), P12(1), P15(1), P17(6), P20(1), P21(7), P25(183), P27(52), P28(3), P30(5), P31(2), P33(54), P34(5), P35(32), P36(2), P38(15), P41(1), P43(52), P44(1), P45(15), P46(50), P47(5), P48(6), P49(1), P50(2), P54(1), P55(1).
- *Gonichthys tenuiculus* N11(8), P,N15(9), N,P17(6), N21(2), N33(5), N35(13), N46(9), N53(4), N55(1).
- *Hygophum reinhardti* N8(1).
- *Myctophum affine* N4(1), N11(4), N15(8), N17(4), N21(5), N43(3), N46(2), P48(2), P52(1), N55(4).
- *Myctophum aurolaternatum* N35(1), N55(4).
- *Myctophum evermanni* N6(1).
- *Myctophum* sp. P3(4), P6(1), P33(2), P55(1).

Bregmacerotidae—threadfin codlings
- *Bregmaceros* sp. P53(2).

Holocentridae—squirrelfishes
- Holocentrid larvae P30(1).
- *Myripristis occidentalis* N42(2).

Paralepidae—barracudinas
- Paralepids P5(1), P20(4), P25(4), P27(1), P34(1), P35(2), P43(6), P44(1), P45(3), P46(4), P47(1), P48(1), P51(10), P52(1), P53(8).

Alepisauridae—lancetfish
- *Alepisaurus borealis* L12(9), L13(6), L14(1), L20(2), L22(2).

Congridae—congers
- Leptocephali P4(1), P34(1), P35(2), P43(2), P45(1), P53(1), P54(1), P55(6).

Melamphaidae—bigscales
- Melamphids P8(2), P27(2), P46(1).

Apogonidae—cardinalfishes
- *Apogon* sp. N42(1).

Mullidae—goatfishes
- *Pseudupeneus* sp. N42(4).

Atherinidae—silversides
- *Mugilops* sp. N42(17).

Mugilidae—mullets
- *Mugil* sp. N15(1), N21(2), N29(10), N39(5), N53(16), N55(1).

Polynemidae—threadfins
- *Polydactylus approximans* N29(1).

Stromateidae—harvestfishes
- *Cubiceps* sp. P7(2), P12(1), P14(2).
- Stromateid larvae P2(4), P6(1), P16(1), P21(2), P28(1), P30(2), P38(1), P47(1), P48(1), P51(1), P53(1).

Coryphaenidae—dolphinfishes
- *Coryphaena equiselis* N1(2), N43(3).
- *Coryphaena hippurus* L,T3(10), T5(1), T,L7(4), N8(2), L10(2), L14(1), L16(2), L22(2), T23(1), L24(1), L30(12), L36(2), L38(2), T40(1), L44(1), L49(40), L50(2), L54(4), T57(4), T58(5).
- *Coryphaena* sp. P4(1), P9(1).

TABLE 7—Continued

List of Specimens Collected During N. B. SCOFIELD Cruise 55-S-5, September 29 to November 30, 1955

Codes refer to method, station, and number of items, respectively

Scombridae—mackerels
Scombrids N8(1), P5(1).

Katsuwonidae—skipjacks
Auxis sp. N6(2), N8(42), N29(16).
Katsuwonus pelamis T8(4), L9(1), T19(3), T41(1), T47(2), L56(1), T62(1).

Thunnidae—tunas
Neothunnus macropterus T7(5), T8(24), L9(3), T,L24(4), L26(3), T,L28(11), T,L30(42), T,L31(4), L36(2), L38(5), T59(1), T60(3), T61(12), T63(24).
Parathunnus sibi L12(2), L13(2), L18(6), L20(1), L22(14), L45(3), L47(26), L49(1), L52(17), L56(17).

Istiophoridae—sailfishes
Istiophorus greyi L7(1), L24(4), L26(8), L28(11), L30(26), L31(6), L34(3), L36(11), L38(12), L41(1), L45(1), L54(2), L56(4).
Makaira audax L3(2), L7(2), L9(5), L10(1), L12(1), L16(1), L22(5), L24(2), L26(3), L28(1), L30(6), L31(3), L34(1), L36(1), L38(4), L44(3), L45(1), L47(2), L54(9), L56(7).

Xiphiidae—swordfishes
Xiphias gladius L30(1), L31(1).

Pomacentridae—damselfishes
Pomacentrus rectifraenum N42(1).
Pomacentrus sp. N42(5).

Labridae—wrasses
Labrid P8(5).

Fistulariidae—coronetfishes
Fistularia sp. N42(1)

Callionymidae—dragonets
Callionymid P46(1).

Blenniidae—blennies
Ophioblennius steindachneri N8(1).
Blenniid N42(4).

Brotulidae—brotulas
Brotula sp. P52(8).

Ceratiidae—anglers
Ceratiid P12(1).

TABLE 8

List of Specimens Collected During N. B. SCOFIELD Cruise 56-S-1, January 10 to March 10, 1956

Codes Refer to Method, Station, and Number of Items, Respectively

Alopiidae—threshers
Alopias sp. L6 (2), L11(7), L12(1), L14(1), L16(1), L20(2), L26(6), L41(1).

Lamnidae—mackerel sharks
Isurus glaucus—bonito shark L11(1), L18(1), L37(2), L44(2), L64(1), L66(1).

Carcharhinidae—requiem sharks
Carcharhinus longimanus—white tip shark L60(1).
Carcharhinus sp. L6(22), L9(1), L11(7), L12(3), L18(4), L30(6), L33(3), L35(16), L37(8), L39(5), L41(2), L44(2), L51(4), L55(5), L57(1), L62 (1), L66(2).
Prionace glauca—blue shark L12(3), L16(4), L18(1), L20(2), L28(2), L59(1), L62(3).

Sphyrnidae—hammerheads
Sphyrna sp. L18(1), L20(1), L62(1), L64(1).

TABLE 8—Continued

List of Specimens Collected During N. B. SCOFIELD Cruise 56-S-1, January 10 to March 10, 1956

Codes Refer to Method, Station, and Number of Items, Respectively

Dasyatidae—stingrays
Dasyatis violacea L62(1).

Mobulidae—mantas
Manta sp. L11(1).

Clupeidae—herrings
Clupeid larvae N6(1), N7(1), N34(1), N40(1).

Alepocephalidae—slickheads
Alepocephalid P62(1).

Gonostomidae
Gonostomatids P8(2), P9(4), P13(9), P15(1), P20(1), P30(3), P33(4), P35(2), P36(16), P39(1), P41(1), P44(2), P47(9), P48(6), P49(4), P50(17), P51(10), P52(7), P53(3), P54(2), P57(4), P58(9), P59(4), P64(1), P65(1), P66(2).
Maurolicus sp. P41(1), P47(2), P48(5), P50(4), P54(1), P57(1), P58(1).

Sternoptychidae—lightfishes
Argyropelecus lynchus P13(2).
Argyropelecus sp. P7(1), P14(1), P16(1), P17(4), P20(5), P26(3), P30(1), P33(1), P36(1), P41(1), P44(1), P48(1), P49(1), P50(3), P51(2), P52(3), P53(1), P57(2), P58(8), P59(1), P63(3), P65(3), P66(2).
Cyclothone sp. P14(3), P15(3), P16(3), P20(5), P30(3), P35(2), P47(1), P49(2), P50(9), P52(1), P55(3), P57(3), P58(1), P59(3), P62(2), P65(7), P66(6).
Vinciguerria lucetia P7(1), P9(7), P10(2), P14(1), P20(1), P26(1), P33(1), P35(2), P36(2), P47(4), P48(7), P49(5), P52(2), P57(1), P58(4), P59(1), P61(3), P63(1), N,P65(6), P66(1).

Stomiatidae—scaly dragonfishes
Stomiatids P12(2), P15(1).

Idiacanthidae—blackdragons
Idiacanthus sp. P12(1), P17(1), P36(1), P51(2), P52(1), P61(1), P64(1).

Exocoetidae—flyingfishes
Exocoetids N34(4), N48(2), N56(1).
Fodiator acutus N6(1).
Oxyporhamphus micropterus N7(1), N10(1), P,N15(6), P20(6), N21(1), N27(1), N29(3), N32(1), N34(6), N38(1), N40(2), P49(1), P51(4), N56(2), P57(1), N58(1).
Parexocoetus sp. N34(1).

Synodidae—lizardfish
Synodus sp. N40(2), N50(2), N52(2), N63(3).

Myctophidae—lanternfishes
Myctophid larvae P7(1), P8(10), P9(8), P10(19), P12(5), P13(253), P14(4), P15(35), P16(5), P17(3), P20(18), P26(16), P30(2), P33(5), P35(10), P36(531), P39(5), P41(11), P44(4), P47(4), P49(2), P50(1), P51(11), P53(1), P54(2), P57(5), P58(10), P63(2), P65(1), P66(2).
Gonichthys tenuiculus N15(4), N19(2), N21(7), N25(1), N29(2), N34(1), N36(2), N48(2), N50(3), N52(2), N54(2), N56(2), N58(1), N65(1).
Lampanyctus sp. P58(1).
Myctophum affine P10(1), N19(1), N27(1), N32(2), P,N36(4), N38(2), N48(3), P,N50(4), N52(3), N54(1), N56(1), P58(1), P61(2), N65(2).
Myctophum aurolaternatum N29(2), N34(1), N48(6), N50(5), N58(2).
Myctophum evermanni N29(1), N32(9), N34(2), N38(2), N54(1).
Myctophum sp. P9(1), P13(1).

Bregmacerotidae—threadfin codlings
Bregmaceros sp. P7(1), P8(2), P39(1), P47(1).

Holocentridae—squirrelfishes
Holocentrid larvae N34(2), N52(23), N58(1).

TABLE 8—Continued

List of Specimens Collected During N. B. SCOFIELD Cruise 56-S-1, January 10 to March 10, 1956

Codes Refer to Method, Station, and Number of Items, Respectively

Paralepidae—barracudinas
Paralepid larvae P17(1), P20(1), N34(2), P41(1), P44(1), P48(4), P50(5), P57(3), P58(2), P61(1).

Omosudidae
Omosudis sp. P26(1), P53(2).

Alepisauridae—lancetfish
Alepisaurus borealis L55(1).

Congridae—congers
Leptocephali P9(1), P10(1), P11(5), P16(1), P26(1), P41(1), P50(1), P51(1), P52(1), P53(4), P57(1), P58(1), P66(1).

Trachipteridae—ribbonfishes
Trachipterids P30(1), P50(1).

Serranidae—sea basses
Serranids P39(2).

Apogonidae—cardinalfishes
Apogonids N45(4).

Mullidae—goatfishes
Pseudupenus grandisquamis N6(4), N7(1), N34(1), N38(7).

Atherinidae—silversides
Atherinids P8(1), P10(1), P13(2), P14(1), P36(2), P41(1), P50(1), P52(4), P61(1).
Mugilops sp. N34(1).

Polynemidae—threadfins
Polydactylus approximans N6(29), N10(8), N21(2), N40(2), N43(1).
Polydactylus opercularis N6(4).

Nematistiidae—roosterfishes
Nematistius pectoralis N40(1).

Carangidae—jacks
Carangids P47(1), P50(3), P57(1), P58(2), P59(1), P63(1), P66(1).
Naucrates ductor N38(1), P65(1).

Stromateidae—harvestfishes
Cubiceps sp. P7(2), P44(2), P47(1), P57(1), P65(1).
Stromateid larvae P11(2), P13(1), P39(1).

Coryphaenidae—dolphinfishes
Coryphaena equiselis N6(1), N19(1), N40(1).
Coryphaena hippurus L6(2), L9(1), L12(1), P15(1), L18(1), T24(1), L26(1), N29(2), N32(1), L35(1), L,T37(37), L39(9), T42(1), L44(1), T46(1), L53(1).

Scombridae—mackerels
Scombrid larvae P10(1), P15(1), N27(1), N38(1), P48(2), P50(7), P52(2).

Katsuwonidae—skipjacks
Auxis sp. N6(6), P8(5), P9(1), N15(1), N21(7), N27(3), N34(20), N36(1), L37(1), N38(20), N40(11), N43(9), N50(31), N52(11), N54(3), N56(4), N58(4), N63(1).
Euthynnus lineatus T4(20).
Katsuwonus pelamis T31(1).

Thunnidae—tunas
Neothunnus macropterus T1(1), T2(25), T3(4), L9(2), L11(2), L12(17), L14(9), L22(4), L26(5), L41(3), T,L44(2), L51(1).
Parathunnus sibi L51(29), L59(11), L60(2), L62(1).

Gempylidae—snakemackerels
Gempylus serpens P48(1), P55(1).
Gempylid P51(1).

TABLE 8—Continued

List of Specimens Collected During N. B. SCOFIELD Cruise 56-S-1, January 10 to March 10, 1956

Codes Refer to Method, Station, and Number of Items, Respectively

Istiophoridae—sailfishes
Istiophorus greyi T5(1), L6(40), L9(5), L12(4), L14(1), L16(3), L18(1), L20(1), L26(2), L28(1), L30(2), L33(3), L35(11), L37(10), L39(12), N40(1), L41(1), L53(1), L55(1).
Makaira marlina L51(1), L59(1).
Makaira audax L9(2), L12(1), L14(1), L18(3), L47(1), L49(1), L55(1), L57(1), L59(2), L60(1), L62(1), L66(2).

Pomacentridae—damselfishes
Chromis atrilobatus N52(2).
Pomacentrus rectifraenum N40(2), N43(3).

Labridae—wrasses
Labrid P13(1).

Kyphosidae—rudderfishes
Kyphosus sp. N6(1), N38(1).

Scorpaenidae—rockfishes
Scorpaenids P7(1), P10(1), P37(1), P39(2), P41(1), P44(1).

Fistulariidae—coronetfishes
Fistularia sp. P14(1).

Blenniidae—blennies
Blenniids N32(1), P58(1).

Brotulidae—brotulas
Brotula sp. P8(1), P10(2), P11(2), P14(1).

Ceratiidae—anglerfishes
Ceratiids P11(1), P12(1), P20(1), P39(1), P65(1).

Balistidae—triggerfishes
Canthidermus maculatus N34(1).

Abundance of Zooplankton

Comparatively low volumes, ranging between 16 and 164 cc. per 1,000 cubic meters of water strained were taken at offshore stations west of Long. 101° W. and at several stations north of the Galapagos Islands. Higher volumes, between 59 and 622 cc., were found off Central America and in the region between Ecuador and the Galapagos Islands (Figure 6).

A comparison with plankton volumes collected in the eastern tropical Pacific by other vessels indicated that our volumes were consistently high. Holmes et al. (1957) found that although variability existed between zooplankton volumes collected by the SPENCER F. BAIRD and the HORIZON during expedition EASTROPIC, the yield in the region of the Peru Current, along the equator, and off Central America was uniformly high. High volumes in the area of the Peru Current and in localized localities off Central America are evident in data presented by Wilson and Shimada (1955). Previous expeditions found a relatively high standing crop of zooplankton for the eastern tropical Pacific. The abundance in this area, as measured by recent expeditions, ranged from 0 to 622 cc. per 1,000 cm. (Table 9). These values are higher than have been recorded for the central tropical Pacific where better tuna longline catches are made. King and Demon (1953) reported an average of 27 cc. per 1,000 cubic meters of water strained in the central Pacific area.

TABLE 9

Zooplankton Abundance in the Eastern Tropical Pacific Ocean, 1953 to 1956

Vessel	Expedition	Dates	Plankton values cc. per 1,000 cubic meters			Reference
			Minimum	Maximum	Average	
N. B. Scofield	Cruise 53-S-1	Jan.-Mar. 1953	19	202	114	Wilson and Shimada (1955)
Charles H. Gilbert	Cruise 15[1]	Feb.-Mar. 1954	12	156	51	King and Hida (1957)
Spencer F. Baird	Eastropic	Oct.-Dec. 1955	14	605	165	California Scripps Institution of Oceanography (1956)
Horizon	Eastropic	Oct.-Dec. 1955	0	286	95	California Scripps Institution of Oceanography (1956)
N. B. Scofield	Eastropic (55-S-5)	Oct.-Nov. 1955	16	489	141	
N. B. Scofield	Cruise 56-S-1	Jan.-Feb. 1956	47	622	159	

[1] Stations 2 to 35 only.

TABLE 10

Major Constituents in Zooplankton Collections From N. B. SCOFIELD Cruise 55-S-5, September 29 to November 30, 1955, Expressed as a Percentage of the Total Per Station

Station No.	Copepoda		Chaetognatha		Tunicata		Euphausiacea		Siphonophora		Ostracoda		Amphipoda		Decapoda		Medusae		Miscellaneous	
	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.
1	**63**	8	**7**	5	**2**	29	**0**	0	**9**	6	**1**	1	**2**	2	**0**	0	**3**	24	**13**	25
3	**62**	20	**14**	11	**7**	7	**7**	18	**2**	3	**<0.5**	T	**1**	1	**5**	1	**<0.5**	T	**1**	38
4	**50**	14	**13**	15	**7**	16	**18**	21	**<0.5**	2	**0**	0	**3**	5	**5**	6	**<0.5**	2	**3**	19
5	**8**	1	**1**	1	**89**	92	**<0.5**	T	**<0.5**	1	**<0.5**	T	**1**	1	**<0.5**	T	**<0.5**	T	**<0.5**	3
6	**66**	13	**9**	2	**2**	52	**15**	3	**1**	1	**1**	T	**3**	1	**1**	15	**1**	1	**1**	12
7	**75**	36	**13**	12	**4**	4	**2**	8	**3**	9	**1**	T	**1**	1	**<0.5**	T	**<0.5**	9	**<0.5**	21
8	**69**	20	**6**	12	**1**	9	**9**	17	**1**	2	**1**	T	**4**	3	**1**	10	**<0.5**	3	**8**	24
9	**73**	19	**17**	16	**2**	6	**3**	6	**1**	3	**1**	1	**2**	5	**0**	0	**<0.5**	1	**<0.5**	12
12	**64**	14	**22**	15	**4**	6	**2**	3	**3**	19	**1**	T	**2**	2	**1**	3	**<0.5**	4	**1**	33
13	**41**	T	**15**	1	**12**	88	**11**	T	**7**	1	**3**	T	**6**	T	**<0.5**	T	**<0.5**	T	**4**	9
14	**83**	3	**4**	1	**1**	79	**3**	T	**2**	1	**1**	T	**4**	1	**<0.5**	T	**2**	1	**3**	14
15	**68**	3	**7**	9	**1**	5	**16**	13	**<0.5**	1	**1**	T	**1**	3	**1**	1	**2**	25	**3**	40
16	**70**	5	**8**	4	**3**	73	**5**	2	**4**	3	**1**	T	**4**	1	**0**	0	**1**	1	**4**	11
17	**81**	13	**6**	5	**3**	63	**7**	7	**1**	6	**1**	T	**<0.5**	T	**<0.5**	T	**<0.5**	1	**1**	4
18	**84**	3	**6**	1	**3**	87	**3**	T	**<0.5**	T	**1**	T	**<0.5**	T	**<0.5**	T	**<0.5**	T	**2**	8
19	**43**	10	**8**	15	**<0.5**	T	**41**	21	**<0.5**	15	**2**	T	**1**	1	**<0.5**	1	**2**	5	**3**	32
20	**88**	48	**4**	4	**1**	15	**4**	2	**1**	4	**1**	T	**<0.5**	2	**<0.5**	T	**<0.5**	1	**<0.5**	24
21	**91**	9	**5**	1	**<0.5**	67	**1**	1	**1**	12	**<0.5**	T	**<0.5**	T	**<0.5**	2	**<0.5**	T	**1**	7
22	**12**	18	**2**	24	**<0.5**	1	**<0.5**	2	**<0.5**	T	**<0.5**	T	**<0.5**	3	**0**	0	**<0.5**	1	**85**[1]	51
25	**65**	45	**14**	14	**1**	1	**4**	6	**1**	6	**2**	1	**<0.5**	T	**2**	4	**<0.5**	2	**10**	21
26	**7**	15	**6**	17	**<0.5**	2	**1**	1	**<0.5**	14	**1**	1	**<0.5**	1	**<0.5**	1	**<0.5**	4	**84**[2]	44
27	**16**	6	**2**	2	**<0.5**	T	**1**	2	**<0.5**	1	**<0.5**	T	**<0.5**	T	**<0.5**	1	**<0.5**	1	**80**[3]	86
28	**78**	43	**11**	8	**7**	5	**1**	1	**1**	3	**<0.5**	T	**<0.5**	T	**<0.5**	1	**<0.5**	1	**1**	38
30	**72**	22	**22**	17	**1**	1	**2**	2	**<0.5**	1	**0**	0	**<0.5**	T	**<0.5**	1	**<0.5**	1	**2**	54
31	**68**	33	**29**	16	**<0.5**	27	**<0.5**	1	**1**	4	**1**	T	**<0.5**	T	**<0.5**	2	**<0.5**	16	**<0.5**	1

33	71	16	9	7	<0.5	2	13	14	1	18	2	T	<0.5	1	1	3	<0.5	1	2	38
34	85	24	10	11	<0.5	3	1	1	1	1	1	T	1	2	<0.5	1	<0.5	2	1	54
35	69	18	23	19	<0.5	5	2	5	1	4	1	T	1	2	1	2	<0.5	2	2	43
36	54	20	29	18	1	2	1	2	1	11	2	1	<0.5	1	1	2	<0.5	1	1	42
38	88	38	8	15	0	0	2	4	<0.5	1	1	T	<0.5	2	<0.5	1	<0.5	1	1	38
41	49	19	35	18	2	10	2	4	1	4	3	T	<0.5	1	<0.5	3	<0.5	1	6	40
43	50	12	31	15	6	10	4	5	2	12	2	T	1	1	1	8	<0.5	1	3	36
44	57	13	20	9	14	20	2	2	2	12	3	T	<0.5	T	1	1	<0.5	T	1	43
45	86	24	10	11	1	3	<0.5	1	<0.5	4	<0.5	T	<0.5	T	2	1	<0.5	T	<0.5	56
46	60	19	13	13	15	10	2	3	1	11	3	1	<0.5	1	3	2	1	5	2	35
47	83	37	7	9	2	2	1	1	<0.5	3	3	1	1	T	1	2	1	8	1	37
48	72	16	4	3	<0.5	18	13	5	2	22	3	T	3	1	2	2	<0.5	1	1	32
49	70	5	6	6	1	3	6	4	6	30	<0.5	T	3	3	1	1	<0.5	T	7	48
50	94	59	4	7	<0.5	1	<0.5	1	<0.5	6	<0.5	1	<0.5	1	<0.5	1	<0.5	1	<0.5	22
51	63	18	28	53	4	5	2	3	<0.5	1	1	T	<0.5	T	1	2	<0.5	T	1	18
52	51	9	14	40	9	9	<0.5	T	1	5	2	T	0	0	<0.5	1	12	7	<0.5	29
53	57	15	4	4	17	16	2	2	1	10	1	T	<0.5	1	<0.5	2	17	11	1	39
54	76	28	14	11	3	6	2	2	2	14	1	T	<0.5	T	<0.5	1	<0.5	3	1	35
55	6	6	2	3	1	2	1	3	<0.5	6	0	0	<0.5	1	<0.5	1	<0.5	1	89[4]	77

[1] Fish eggs and larvae 84 percent.
[2] Radiolarians 84 percent.
[3] Radiolarians 80 percent.
[4] Polychaets 89 percent.

TABLE 11

Major Constituents in Zooplankton Collections from N. B. SCOFIELD Cruise 56-S-1, January 10 to March 10, 1956, Expressed as a Percentage of the Total Per Station

Station No.	Copepoda		Chaetognatha		Tunicata		Euphausiacea		Siphonophora		Ostracoda		Amphipoda		Decapoda		Medusae		Miscellaneous	
	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.
7	56	33	27	19	4	5	12	10	<0.5	1	0	0	<0.5	T	<0.5	1	<0.5	T	1	31
8	74	29	12	7	2	2	8	8	3	17	0	0	<0.5	T	<0.5	T	<0.5	T	<0.5	36
9	69	20	27	12	<0.5	1	0	0	<0.5	2	0	0	<0.5	T	3	4	<0.5	T	<0.5	61
10	46	15	6	13	1	4	2	8	<0.5	1	2	T	1	2	2	3	<0.5	2	40[1]	52
11	58	19	16	8	8	4	10	3	5	17	0	0	1	T	1	1	<0.5	1	1	47
12	83	24	6	6	1	4	7	4	<0.5	2	0	0	2	1	1	2	<0.5	3	<0.5	54
13	72	20	15	9	1	2	7	3	2	18	0	0	1	2	<0.5	1	<0.5	3	2	42
14	66	34	17	13	3	2	5	T	1	10	1	T	3	6	1	2	1	6	2	27
15	51	16	20	9	1	8	19	5	<0.5	22	3	1	5	5	<0.5	1	1	3	1	31
16	58	26	26	12	<0.5	1	9	4	<0.5	16	3	1	<0.5	T	<0.5	T	<0.5	1	1	39
17	72	25	16	6	0	0	4	5	<0.5	3	5	2	<0.5	1	<0.5	2	<0.5	3	2	53
20	87	16	9	6	<0.5	2	1	1	1	14	0	0	<0.5	T	0	0	<0.5	2	1	58
26	80	55	16	11	<0.5	3	<0.5	3	<0.5	T	2	1	<0.5	T	<0.5	1	<0.5	1	<0.5	25
30	14	10	4	8	81	44	<0.5	1	<0.5	5	1	T	<0.5	T	<0.5	T	<0.5	2	<0.5	30
33	75	40	15	7	1	2	2	1	<0.5	T	5	1	<0.5	1	<0.5	2	<0.5	1	1	45
35	67	40	5	3	25	13	1	2	<0.5	8	2	1	<0.5	1	0	0	<0.5	1	<0.5	31
36	44	23	8	7	37	12	4	5	1	12	3	1	1	1	<0.5	1	<0.5	2	2	36
37	82	39	13	8	0	0	2	5	<0.5	4	1	T	<0.5	1	1	2	0	0	<0.5	41
39	19	15	11	18	67	50	2	2	1	2	0	0	0	0	0	0	0	0	<0.5	13
41	87	36	7	5	0	0	<0.5	T	2	11	3	2	<0.5	1	0	0	<0.5	T	<0.5	45
44	56	17	12	15	28	35	1	2	<0.5	6	2	T	0	0	<0.5	1	<0.5	2	<0.5	22
47	92	50	5	20	1	7	1	4	<0.5	3	0	0	<0.5	T	<0.5	T	<0.5	3	<0.5	13
48	54	9	14	11	8	6	15	7	2	20	0	0	1	1	1	3	3	5	2	38
49	74	20	14	14	5	5	4	4	<0.5	13	0	0	1	1	<0.5	1	1	7	1	35
50	73	15	10	10	2	2	11	12	1	5	0	0	1	1	<0.5	2	1	5	1	48

51	51	14	37	16	6	14	1	1	<0.5	9	2	1	<0.5	1	1	1	1	6	1	37
52	57	16	27	16	<0.5	1	4	4	1	18	1	1	0	0	<0.5	T	1	4	9	40
53	42	8	33	20	0	0	2	1	11	21	2	T	1	2	0	0	<0.5	1	9	47
54	70	19	19	12	0	0	6	13	<0.5	8	2	T	1	2	2	4	<0.5	2	<0.5	40
55	73	21	24	19	0	0	3	3	<0.5	2	0	0	0	0	0	0	<0.5	1	<0.5	54
56	61	18	21	15	0	0	10	10	4	18	2	1	0	0	<0.5	4	1	5	1	29
57	59	22	36	31	<0.5	3	1	1	0	0	2	1	<0.5	1	0	0	1	7	1	34
58	72	23	15	14	0	0	11	13	<0.5	10	0	0	0	0	<0.5	2	1	3	1	35
59	54	16	40	27	<0.5	1	1	1	<0.5	3	2	1	<0.5	T	<0.5	T	1	5	1	46
60	61	5	34	9	<0.5	68	3	1	1	2	0	0	0	0	0	0	<0.5	2	<0.5	13
61	61	12	24	13	0	0	11	10	3	23	0	0	<0.5	T	<0.5	7	<0.5	3	<0.5	32
62	78	20	13	11	0	0	2	1	3	20	0	0	4	5	0	0	<0.5	2	<0.5	41
63	79	4	8	1	<0.5	66	8	4	1	8	0	0	4	1	<0.5	1	<0.5	1	<0.5	14
64	39	10	54	26	<0.5	8	3	2	2	9	0	0	<0.5	1	0	0	1	4	1	40
65	86	9	5	2	<0.5	68	7	5	<0.5	3	0	0	<0.5	T	<0.5	2	1	1	1	10
66	59	15	33	18	1	1	2	2	1	3	2	1	0	0	0	0	1	1	1	59

[1] Radiolarians 40 percent

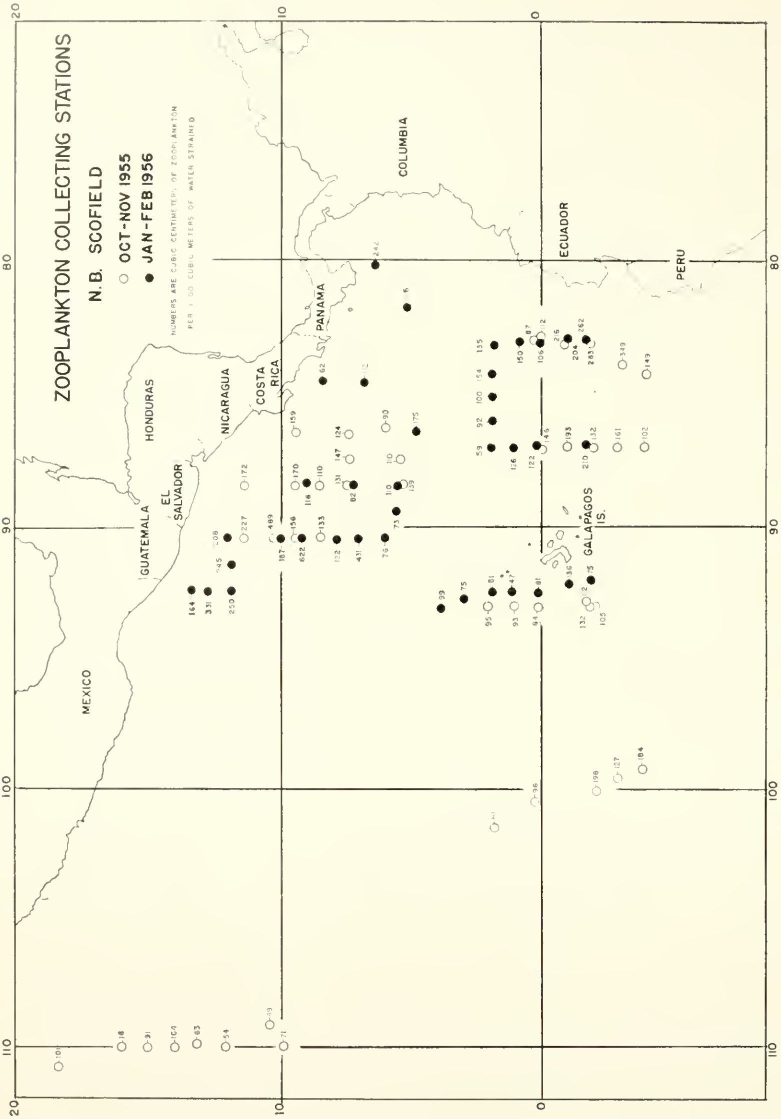

FIGURE 6. Zooplankton collecting stations and volumes taken on *N. B. Scofield* Cruises 55-S-5 and 56-S-1.

Composition of Zooplankton

The percentage composition by number and volume of major components in the zooplankton was determined for both cruises (Tables 10 and 11). Although variation is present between cruises and differences occur from station to station within a cruise, there is a general homogeneity in the zooplankton composition.

Numerically, copepods comprised the highest percentage with chaetognaths second. Tunicates, euphausiids, siphonophores, ostracods, amphipods, and decapods followed in order of abundance. Radiolarians, fish eggs, and fish larvae, which were generally present in low numbers, were found in large quantities at a few stations. An unusually large number of fish eggs, and larvae was present at one station (22) near the Galapagos Islands, during the fall cruise. Radiolarians comprised 85, 80 and 41 percent of the total number of items taken at Stations 26 and 27 of the fall cruise and Station 10 of the winter cruise.

On the average, copepods also contributed the highest volumetric percentages of major components. Tunicates, chaetognaths, siphonophores, euphausiids, medusae, decapods, and amphipods followed. Small percentages of annelids, ctenophores, radiolarians, heteropods, pteropods, cephalopods, ostracods, and stomatopods were also found. A slight distortion exists in the volumetric data due to the varying percentages of miscellaneous material.

Oceanographic Observations

Surface water temperatures observed along the vessel's track ranged in degrees F. from the low 60's to the mid 80's (Figure 7). On the winter cruise, temperatures south of Lat. 02° N. had increased appreciably over those of the fall.

A shallow thermocline and cool water near the surface were characteristic of the region investigated (Figure 8). Temperatures warmer than 60 degrees F. were rarely encountered below 250 feet. The thermocline was shallowest along the equator and between Lat. 08° N. and 10° N. near Costa Rica. At the latter location, thermocline readings as shallow as 15 feet were made on the winter cruise, and a temperature of 65 degrees F. was recorded at a depth of 20 feet (surface temperature 77 degrees F.).

Data on the vertical distribution of dissolved oxygen collected by EASTROPIC have been summarized (Figure 9). High oxygen concentrations, ranging between four and five ml. per liter, existed in the upper 100 feet of water. Oxygen concentrations lower than one ml. per liter were recorded within 100 feet of the surface off Costa Rica. Between Lat. 02° S. and 02° N. oxygen in concentrations of one to two ml. per liter was found in much greater depths—sometimes more than 700 feet beneath the surface.

DISCUSSION

Occurrence of Subsurface Tunas

The yellowfin catch was associated with the shallow thermocline area off Costa Rica. The surface water there was warm, rich in oxygen and high in biological productivity. By contrast, the subsurface layers were cooler, deficient in oxygen, and low in biological productivity. Longline gear fished in the cool subsurface layers yielded a poor catch.

The bigeye catch was associated with the area lying between Lat. 02° N. and 04° S. where low surface temperatures prevail during most of the year. Oxygen concentrations are higher here at greater depths than in waters to the north.

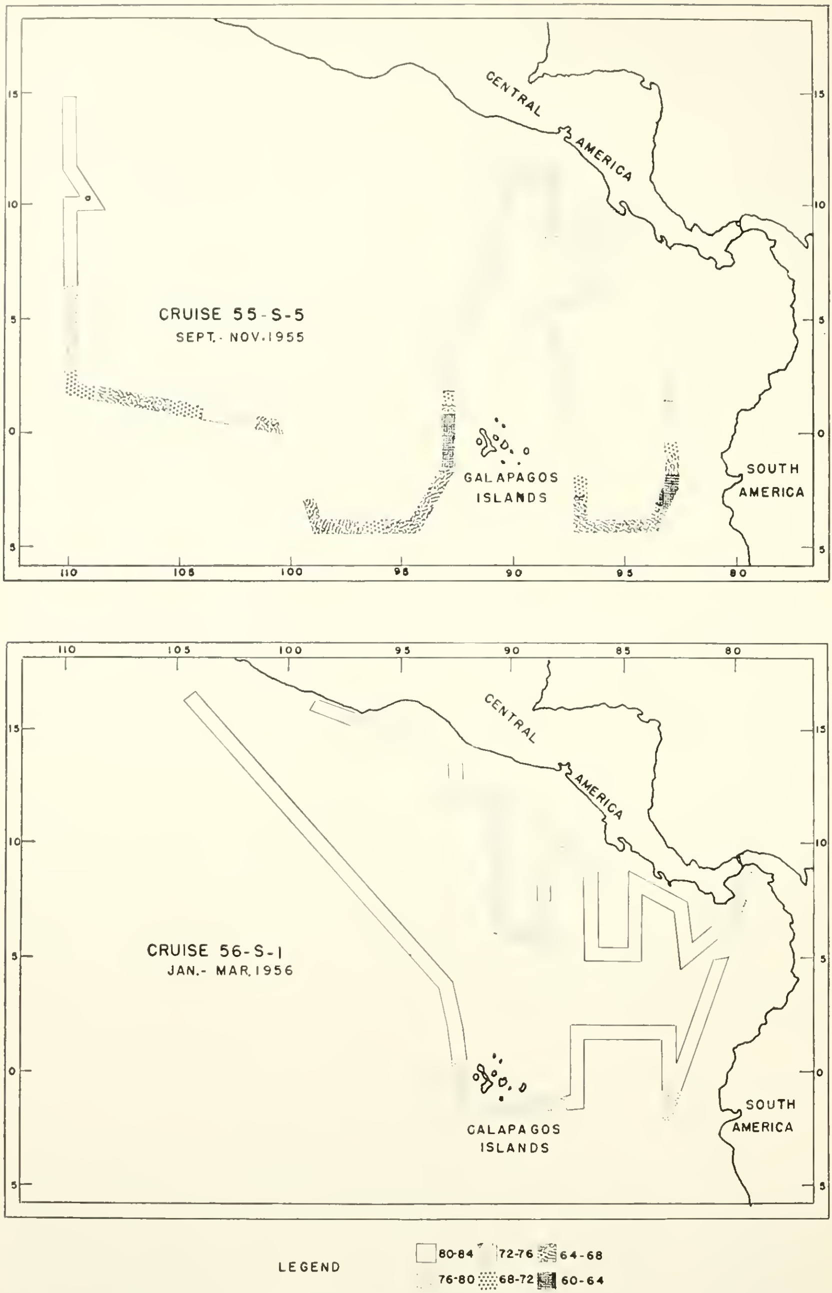

FIGURE 7. Surface water temperature ranges along the track of the *N. B. Scofield* Cruises 55-S-5 and 56-S-1.

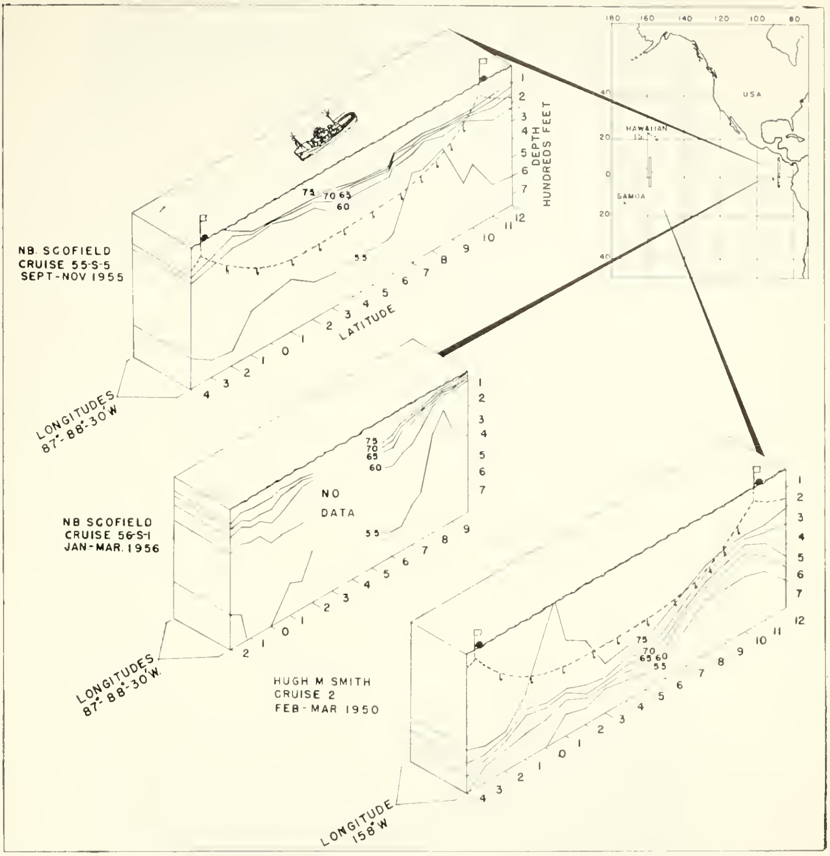

FIGURE 8. Temperature depth profiles of the eastern and central tropical Pacific from *N. B. Scofield* Cruises 55-S-5 and 56-S-1 and Pacific Oceanic Fisheries Investigations Cruise 2 of the Hugh M. Smith, 1950 (Central Pacific data from Cromwell, 1950).

Latitudinal separation of these two species (Figure 10) may be explained by the yellowfin's preference for warmer water. Tester (1956) reported a relationship between surface temperatures and yellowfin longline catches in the central Pacific. Temperatures cooler than 77 degrees F. resulted in a marked drop in the catch. If the deep swimming yellowfin in the eastern Pacific are also associated with surface temperatures, the cool waters of the equatorial area probably have an effect on their occurrence throughout much of the year.

Tuna catches were centered in general areas of high zooplankton abundance, but no correlation was evident at individual stations.

The absence of bigeye in the longline catches north of Lat. 02° N. is difficult to explain. The absence is also conspicuous in the commercial surface fishery of this area. Nakamura (1949) states that bigeye are thought to occur at deeper levels than the other tunas. Based on this concept, low oxygen concentrations in the deep water north of

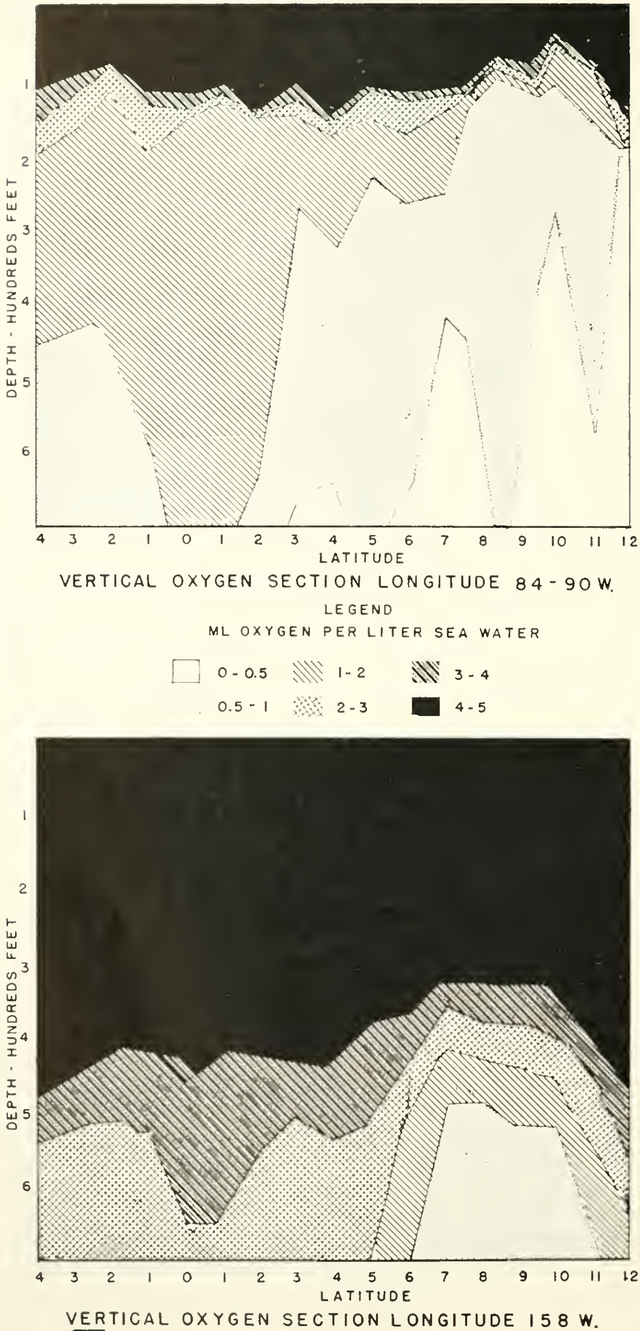

FIGURE 9. Comparison of vertical dissolved oxygen sections between the eastern tropical Pacific (Longitude 84° - 90° W.), and the central tropical Pacific (Longitude 158° W.). Derived from data of Cromwell, 1950 and Scripps Institution of Oceanography, 1956.

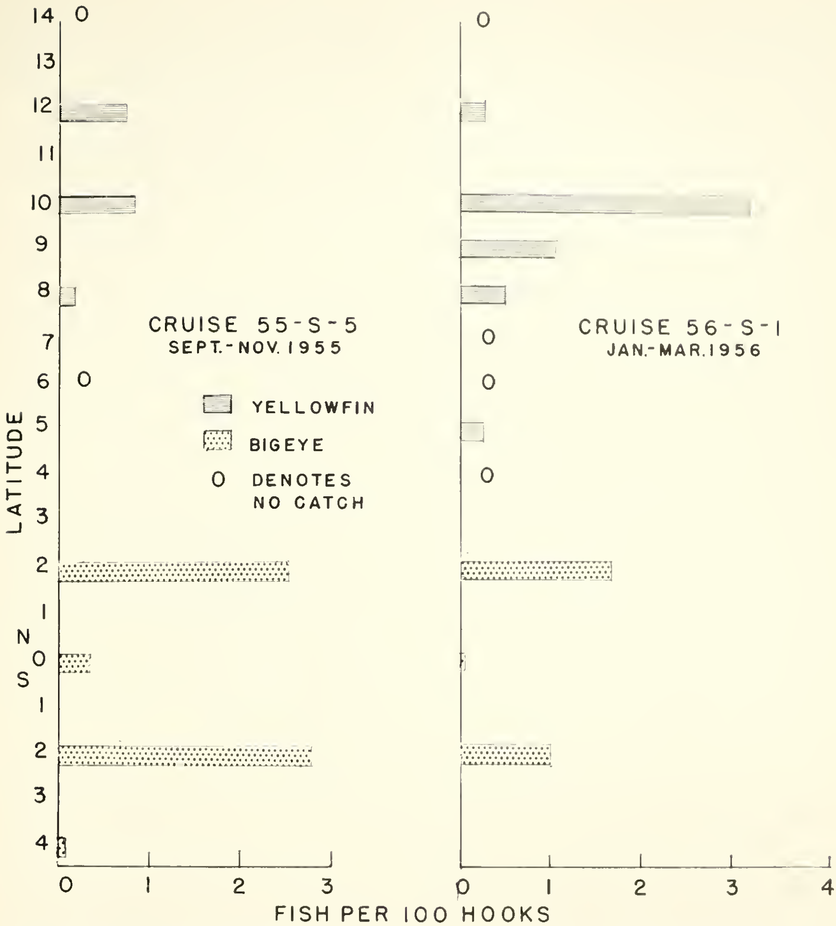

FIGURE 10. Longline tuna catches by latitude in the eastern tropical Pacific taken on the *N. B. Scofield* Cruises 55-S-5 and 56-S-1.

Lat. 02° N. may pose a barrier to them. Wilson and Shimada (1955) found no spatial difference in the distribution of the two species although they had difficulty in assessing the true significance of their data because of abnormal oceanographic conditions (El Nino) existing in the equatorial area at that time.

Abundance of Subsurface Tunas

Yellowfin

Eighty-six percent of the total yellowfin catch came from the Costa Rica area (Figure 1). Catch rates per 100 hooks in this area were 0.67 fish on the fall cruise and 1.34 on the winter cruise. The highest yellowfin catch rate for a single station (No. 12) was 3.89 during the winter cruise.

Very few yellowfin were taken in the equatorial countercurrent area lying between Lat. 02° N. and 07° N.

A comparison of longline catch rates from various parts of the world indicates a relatively low abundance of yellowfin in the eastern tropical Pacific. The central tropical Pacific has produced six to nine fish per 100 hooks (Sette, 1954), the Indian Ocean 12 to 14 (Pan American Fisherman, 1956), and longlining off the coast of Brazil has yielded as many as 20 yellowfin per 100 hooks (Nagi and Nakagome, 1957).

Bigeye

Fourteen of the stations fished produced bigeye. Good catches were made within the area encompassed by Lat. 02° N. and 04° S. and Long. 82° W. and 93° W. An average catch rate within this area of 2.02 fish per 100 hooks was attained during the fall cruise. The average winter rate fell to 0.99, but one station (51) produced a record for both cruises of 6.64. Best catches were made along Lat. 02° N. and 02° S. (Figure 10). No bigeye were taken north of Lat. 02° N.

Longline catch records of bigeye tuna made by Japanese and POFI investigators indicate they are widely distributed in the central and western Pacific, but nowhere abundant. In other tropical areas yellowfin catches have been far greater than bigeye. By contrast, results of our two eastern Pacific cruises indicate an equal or greater abundance of bigeye. The bigeye catch rate during the fall cruise was over three times as great as that for yellowfin. The catch rates of bigeye on these two cruises were as good as most of the better catches made in the central and western Pacific.

Oxygen and Water Temperature

Relatively low longline catches of yellowfin tuna in the eastern tropical Pacific may be caused by a diminished oxygen supply and cold temperatures in the subsurface waters.

A maximum oxygen concentration of only two ml. per liter was found at fishing depths between 144 and 510 feet on the fall cruise. At these depths in the central Pacific during the winter, oxygen concentrations of 1.5 to 5.0 ml. per liter were found (Cromwell, 1950). By comparison, much of the area north of Lat. 02° N. in the eastern Pacific contained 0.5 to 1.0 ml. per liter at the depths fished (Figure 9). These concentrations may be below the minimum requirements of tuna.

Nakamura (1943) gave minimum temperature tolerances of 60 degrees F. for yellowfin and 55 degrees F. for bigeye. Ban (1941) stated temperatures below 68 degrees F. in subsurface waters of the western Pacific result in reduced longline catches.

A comparison of our vertical temperature distributions with those for corresponding latitudes in the central Pacific, where longline fishing is more productive, revealed cooler water nearer the surface in the eastern tropical Pacific.

Our fishing gear placed hooks in a temperature range of 55 to 60 degrees F. much of the time. This is below the minimum indicated for yellowfin tuna.

Surface dwelling yellowfin are not generally found in waters cooler than 68 degrees F.; and, although it is thought larger fish can withstand cooler temperatures, a range of 55 to 60 degrees F. may be too cold for them.

SUMMARY

The Marine Resources Operations of the California Department of Fish and Game conducted two exploratory tuna longline fishing and oceanographic cruises in the eastern tropical Pacific from September, 1955 to March, 1956. On both cruises yellowfin tuna catch rates (0.28 per 100 hooks over all) were low compared to those made in other parts of the world. In certain areas the catches of bigeye tuna ranged from fair to good (1.0 to 2.0 per 100 hooks). A distinct latitudinal separation (2°N to 5°N) of the two species was found. Oceanographic data indicated environmental conditions were unfavorable for tunas at subsurface levels (oxygen less than 2.0 ml. per liter below 150 ft.) throughout much of the area investigated.

ACKNOWLEDGMENTS

We are indebted to members of the tuna staff of the California State Fisheries Laboratory for planning the exploratory cruises and subsequent aid in the preparation of the final report. Acknowledgements are due to Dr. Donald Abbott of Hopkins Marine Station for helpful suggestions toward a work plan for plankton sorting and Miss Galen Howard and Mr. Mataoka Kimura, formerly of our staff, who carried out the tedious task of sorting. Lastly, we extend our appreciation to the master and crew of the *N. B. Scofield*.

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A COMPARATIVE STUDY OF UNSTABLE AND STABLE (ARTIFICIAL CHANNEL) SPAWNING STREAMS FOR INCUBATING KING SALMON AT MILL CREEK[1]

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INTRODUCTION

King salmon *(Oncorhynchus tshawytscha)* originating in the Sacramento River are a valuable resource for the sport and commercial fisheries in the State of California. The Sacramento River also contributes to the coastal salmon fisheries of Oregon, Washington, and British Columbia (Fry and Hughes, 1951). A decline in abundance of the resource has caused concern among sportsmen as well as commercial fishermen *(Commercial Fisheries Review*, 1958, Ryan, 1959). Decreases in numbers of salmon returning to the Sacramento River were explained by the California Department of Fish and Game as being caused by pollution, predation, fishing pressure (river catch and expanding ocean troll), loss of spawning area by construction of dams, direct stream damage by various man-created activities, and streamflow and temperature change from water diversion *(Outdoor California*, 1958).

The United States Bureau of Commercial Fisheries, in cooperation with the California Department of Fish and Game, has been investigating the causes of limited production of salmon in the spawning streams of the Sacramento River area. Measurement of spawn losses determined from experimental sampling indicates an average mortality to fry stage of 96 percent from natural causes. It was hypothesized that if man created the unfavorable conditions for salmon production listed above he might also alter conditions in spawning streams to produce larger yields of salmon. The prospect of increasing the numbers of adult salmon by controlling the natural factors that limit production of young salmon made improvement of spawning streams well worth investigating. Studies therefore were undertaken to determine the principal factor limiting natural production, to show how it operates, and to describe means by which production could be improved.

PROCEDURES

Sampling techniques were established to provide measurements of environmental conditions and of salmon egg survival during the incubation period. The progress of survival was followed by planting known quantities of eggs in plastic containers of .07-inch mesh in simulated redds 12 to 14 inches under the streambed (Gangmark and Broad,

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1955). A systematic recording of the environment was made possible by placing two plastic standpipes (Gangmark and Bakkala, 1958) in each artificial redd.

Selection of a site in the natural stream for planting eggs was confined to those areas where natural spawning had occurred, and in addition, involved consideration of two conflicting factors. On one hand we preferred to plant the salmon eggs under swift water where the possibility of siltation and suffocation of the eggs was minimized. On the other hand, the stream velocity at the planting site must be moderate to afford protection against streambed erosion during periods of fast runoff that are normally expected in Mill Creek, a tributary of the Sacramento River. We, therefore, compromised by choosing a site for deposition of test eggs in moderately fast-flowing water but also a site that afforded some protection from high velocities. In previous experiments severe losses of the test eggs were caused by erosion or siltation of the streambed. In addition, the planted eggs became inaccessible for sampling during periods of high water. Consequently, in recent years, these Mill Creek plants have been reduced to 3,000 eggs planted in 30 plastic containers divided equally among three redds. Many times this number are planted in a control-flow stream where access is assured at all times and where equipment is safe from floods.

An unsolved weakness in the method of testing survival of eggs is our inability to observe or record the fate of the eggs that are eroded from the streambed.

Another aspect of the Mill Creek procedures deserving consideration is the influence on survival of artificially fertilizing and planting the test eggs in plastic containers. Reasonable confidence that these procedures do not adversely affect the test eggs is gained from a comparison of survival between naturally spawned and artificially planted eggs from the same environment. Although results of the natural spawning experiments are not included here, production of young salmon has been comparable to, but not as successful as production from the artificially planted eggs. Further confidence in these planting methods is gained from results already obtained which show production of salmon fry in individual containers ranging from 0 to 99 percent. Thus, survival has not been restricted to certain levels by our test procedures and it has been demonstrated that the maximum possible range of survival can be obtained.

CAUSE OF LIMITED NATURAL PRODUCTION

Experiments at Mill Creek Fisheries Station during the last six years, show that mortality of king salmon to fry stage ranges from 85.2 to 100 percent and averages 95.8 percent. It is quite obvious that the incubation stage is the most critical period in the life history of king salmon. From these studies it was determined that unstable streamflow was the principal cause of the losses. This became increasingly apparent after recent floods in California and after the incubation seasons that produced the poor 1956 and 1957 returns (*Commercial Fisheries Review*, 1958). These studies indicated a consistent mortality-freshet relationship over a period of five years.

Effect of Recent Floods in California

In December 1955 and February 1958, floods occurred in most streams of Northern California including Mill Creek. They caused losses of 100 and 98.2 percent respectively of incubating eggs which had been planted in Mill Creek. Personnel of the California Department of Fish and Game, who count adult upstream migrants and sample downstream migrants by trapping at Mill Creek, captured only two and ten downstream migrants during the winters of 1955-56 and 1957-58 respectively (personal communication with R. Hallock, W. Cunningham, J. Riggs, and W. Van Woert). As indicated in Table 1 these counts entailing 2,440 hours of trapping contrast sharply to the count of 1,942 fry intercepted in 1954. Although the Fish and Game Department's installations are some distance upstream from our operations on Mill Creek and the effectiveness of their downstream trap varies somewhat with the volume of flow, the department's counts substantiate data obtained by our sampling methods. The count of adults moving upstream shows that even 1953-54 may not have been a good incubation season, since 1,339 adults were counted at the station in 1957 from 3,743 parent king salmon counted in 1953.

TABLE 1

Survival of King Salmon Spawn in Mill Creek as Determined by Egg-Planting and Migrant Enumerating Methods

Incubation season*	Survival of spawn to fry stage (USBCF data)	California Fish and Game Counts: Total number of upstream adults	Downstream migrant sampling: Length of sampling period	Downstream migrant sampling: Number of migrants
	Percent		*Hours*	
1953-54	8.7	3,743	1,992	1,942
1955-56	0.0	1,704	1,274	2
1957-58	1.7	1,339	1,166	10

* No downstream migrant counts available for 1954-55, and 1956-57 incubation seasons.

Reasons for Poor Production in Other Years

Experiments indicate that stream runoff of less than disaster level can create conditions lethal for spawn. The influence of freshets on spawn in five seasons is depicted in Figure 1, which shows that in every instance survival dropped with the appearance of the first freshet of the season. The significant factor in Figure 1 is the strikingly different records noted in 1952-53 and 1956-57 when the first freshets occurred in later stages of development than in the other three seasons shown. In Figure 1 the slope of decline in survival does not necessarily correspond to the intensity of the freshet occurring before the decline. This is explained by the relationship of the time of the freshet to the phase of development of the incubating salmon egg. An extremely "tender" phase extends from the time of fertilization until

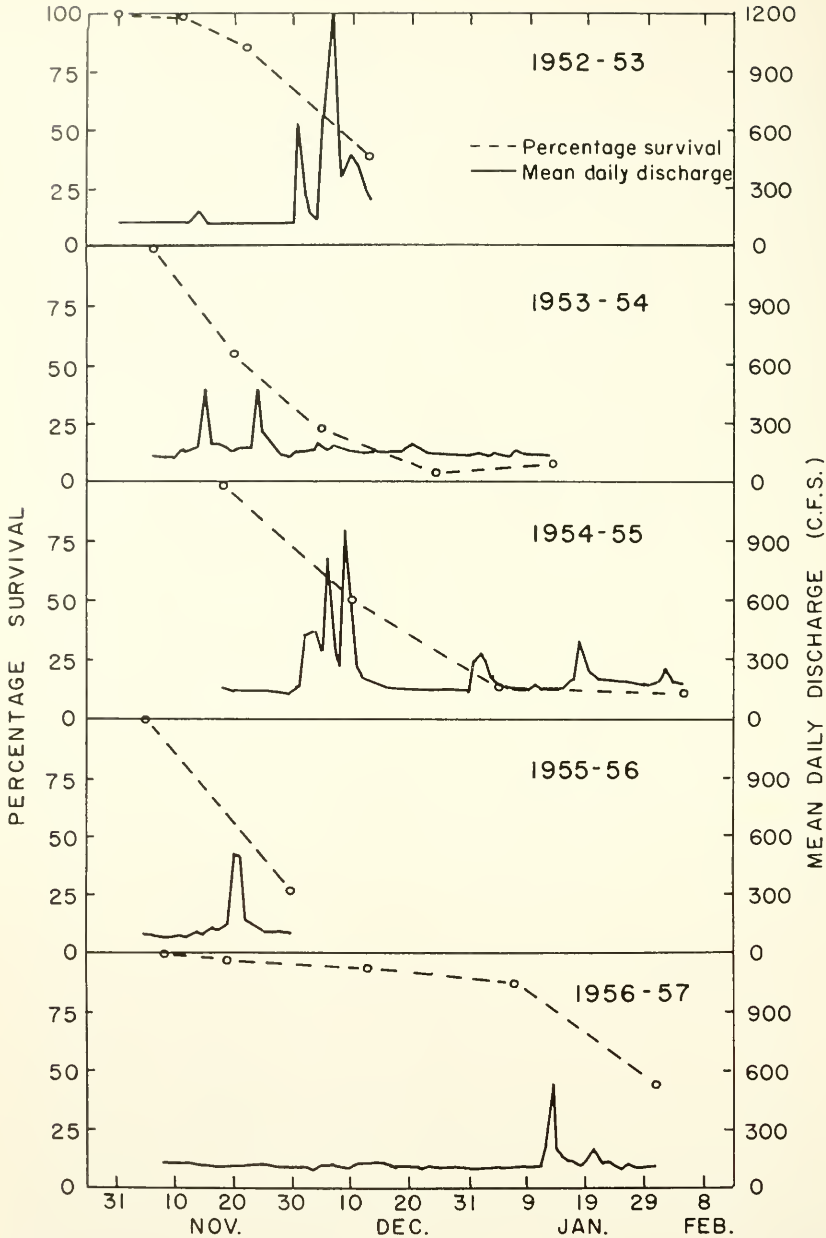

FIGURE 1. Influence of fluctuations in mean daily discharge on king salmon egg survival in Mill Creek, California, 1952-57. Flow records provided by the State of California Division of Water Resources and United States Geological Survey.

the closing of the blastodisk around the yolk. Another period that may be marked by sudden losses occurs when the young salmon emerges from the outer chorion or shell of the egg (Wolf 1957).

During the incubating seasons of 1952-53 and 1953-54 heavy freshets occurred in Mill Creek (Gangmark and Broad, 1955 and 1956). Since king salmon of the Sacramento River area are predominantly four-year-cycle fish, the 1956 and 1957 runs originated from the 1952 and 1953 brood years. As expected, returns were poor in both 1956 and 1957 (*Commercial Fisheries Review*, 1958).

When compared with other tributaries of the upper Sacramento system and with the Sacramento River proper, Mill Creek is not unique in its severe fluctuation in discharge. Table 2 shows the average flow records of some of the important tributaries in this area listed in order of severity of fluctuation. It is noteworthy that this order approximates the order of importance of the streams as salmon producers.

TABLE 2

Flow Rates During the Salmon Spawning and Incubation Season (November 1 to March 31) of the Sacramento River and Some of its Tributaries Located Below Shasta Dam. Flow Rates from U.S. Geological Survey Papers

Stream	Years considered to 1954-55		Flow rate for extreme days during seasons considered			Ratio of maximum to minimum
	From	Total years	Average maximum	Average minimum	Average mean	
			Cubic feet per second			
Battle Creek	1940-41	15	3,603	231	550	16:1
Sacramento River (Near Red Bluff)	1939-40	16	80,350	4,153	14,191	19:1
Mill Creek	1939-40	16	3,392	111	382	31:1
Deer Creek	1939-40	16	4,389	103	465	43:1
Antelope Creek	1940-41	15	2,634	40	215	66:1
Big Chico Creek	1939-40	16	2,824	28	262	101:1
Cottonwood Creek	1940-41	15	12,310	92	1,417	134:1
Cow Creek	1949-50	6	13,043	88	1,205	148:1
Thomes Creek	1939-40	16	4,686	16	441	293:1
Paynes Creek	1949-50	6	1,810	4.4	159	411:1
Elder Creek	1949-50	6	2,314	0	165	.

Based on the relative stability of its flow, the Sacramento River rates higher than most of its tributary streams, for natural reproduction of salmon. In both the 1957 and 1958 incubation seasons, 30 plastic sacks each containing 100 eggs were buried in three experimental redds. Prior to hatching of the fry all of the sacks were eroded away from under 12 to 14 inches of Sacramento River gravel. In the vicinity of the site of planting and downstream from it we found evidence that egg samples may have been plowed out of the Sacramento River gravel by large uprooted trees.

From these data, the role that rapid stream runoff played in limiting natural reproduction of salmon in Mill Creek became evident. Other sources of possible losses at Mill Creek include pollution, high water temperature during spawning, various types of infestation such as saprolegnia, oligochaetes, insect nymphs and larvae, and mechanical damage from trampling by fishermen or cattle. Effects of stream runoff, however, completely overshadowed other causes of egg mortality.

HOW CAUSES OF LIMITED NATURAL PRODUCTION OPERATE

With the knowledge that fast stream runoff was significant in the mortality of spawn, effort was directed toward finding exactly how severe runoff caused these losses. It was determined that mortalities were caused by both direct and indirect factors.

Direct Spawn Losses

Direct losses of spawn were due primarily to erosion of the streambed by high velocities of water. Information as to the fate of spawn washed out is not available, but it is reasonable to assume that once the eggs are washed from the protecting gravel bed out into the stream of violent water flow and shifting gravel, their chance of survival is low. Dead eggs found floating in eddies after periods of fast runoff bear this out.

Indirect Spawn Losses

Indirect losses of spawn occurred from a series of events of diverse and complex nature involving loss of spawning gravel and erosion of soil.

Loss of Spawning Gravel

In streams of the Sacramento River system, loose gravel is constantly washed out and piled high on vast bars where it is no longer available to salmon for spawning purposes. The effect is that adult female salmon must compete for limited spawning areas. This often results in crowding, and causes the later spawners to dislodge the eggs of earlier spawners.

TABLE 3

Mortality Rate of King Salmon Spawn in Relationship to the Dissolved Oxygen in the Gravel Adjacent to Eggs Planted in Mill Creek During the 1956-57 and 1957-58 Incubation Seasons

Dissolved oxygen		Average mortality	
Number of determinations	Amount of oxygen	Number 100-egg tests	Extent of mortality
	P.P.M.		*Percent*
10	< 5	16	37.8
21	5 - < 7	34	13.6
43	7 - < 9	62	12.2
40	9 - < 11	52	9.6
43	11 - < 13	50	10.8
6	> 13	6	3.9

Soil Erosion

Another series of events causing indirect loss of salmon spawn starts with soil erosion and subsequent deposit of silt and sand that clogs the redd. This blockage leads to:

1. Inadequate oxygen: when seepage of water is retarded in the gravel of a stream bed, there generally is a loss of oxygen from the water due to decomposition of humus (Pollard, 1955). Ellis, Westfall, and Ellis (1948) concluded that five p.p.m. (parts per million) is the minimum oxygen concentration for survival of freshwater salmonoids. Table 3 shows the relationship between dissolved oxygen and egg mortalities found during the 1956-57 and 1957-58 tests at Mill Creek. Large mortalities occurred at levels of less than five p.p.m. of oxygen.

TABLE 4

Mortality Rate of King Salmon in Relation to Velocity of Seepage in Gravel Adjacent to Planted Eggs

Seepage velocities		Average mortalities of spawn	
Number of readings	Velocity of seepage water	Number of 100-egg tests	Average mortality
	Feet per hour		*Percent*
21	.5	34	40.0
8	.5 - < 1.0	14	33.1
7	1.0 - < 1.5	14	24.0
3	1.5 - < 2.0	6	10.1
16	2.0 - < 2.5	24	12.9
14	2.5 - < 3.0	20	13.0
25	3.0 - < 3.5	26	10.8
29	3.5 - < 4.0	34	5.3
20	4.0 - < 4.5	20	2.9
4	4.5 - < 5.0	4	3.8
6	> 5.0	6	5.8

2. Poor delivery of oxygen to the eggs (Wickett, 1954) and poor cleansing of metabolic waste products (Wolf, 1957): from the 1956-57 and 1957-58 data taken at Mill Creek, the rate of seepage was related to the survival of eggs. The data are presented in Table 4. It can be seen that the mortality rate of eggs was dependent in large measure upon the rate of seepage of water through the gravel. The data indicate that the optimum velocity is roughly 4.0 to 4.5 feet per hour.

IMPROVEMENT IN NATURAL SPAWNING CONDITIONS

As a result of the studies at Mill Creek, effort has been directed toward reducing or eliminating the principal causes of mortality of salmon spawn by establishing a flow-control area similar to the experimental area at Nile Creek on Vancouver Island (Wickett, 1952).

Experimental Test Area at Mill Creek

The Mill Creek experimental area, previously described by Broad and Gangmark (1956), consisted of a section of an old streambed through which a channel has been bulldozed and from which silt has been flushed to provide an area suitable for tests on incubating salmon

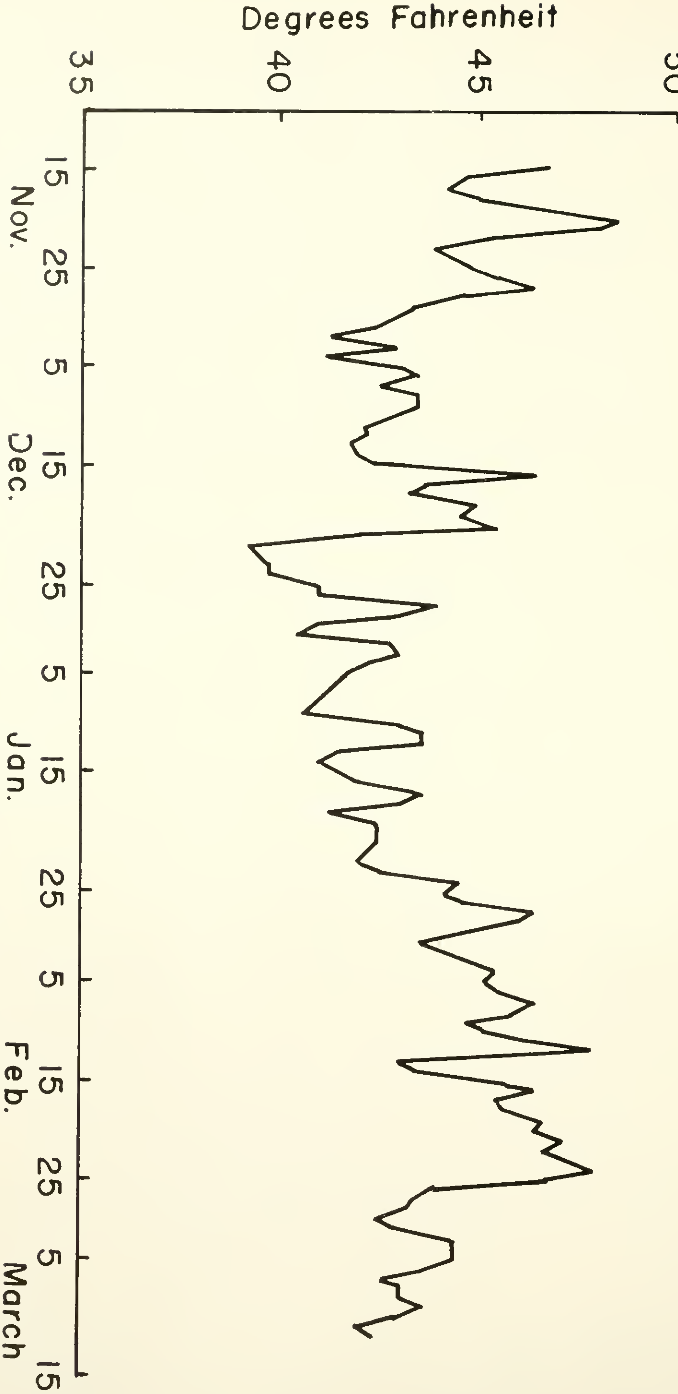

FIGURE 2. Mean daily water temperatures in Mill Creek during the 1957-58 incubation season.

eggs. Two pipes, each 30 inches in diameter and equipped with gate valves, provide for a controlled-flow of water to the area. The amount of silt in the water is reduced before it reaches the test section of the stream by filtering the water through gravel and passing it through a settling basin. A dike protects the area from severe run-off from the main stream of Mill Creek. Adjacent to this controlled-flow area, Mill Creek proper provided an uncontrolled-flow area for comparison.

Comparison of Factors

Testing survival of salmon spawn in the controlled-flow area and in Mill Creek has provided fundamental information on the effect of rapid stream runoff. Stream erosion, temperatures, dissolved oxygen, and seepage rates were compared and measured in these two areas during the 1957-58 incubation season.

Erosion

Rapid runoff eroded out one-half of the planted egg samples in Mill Creek, but no eggs were eroded out in the control area.

Temperature

Temperature was not a factor in differential survival in the 1957-58 tests since the temperature was the same in both areas (Figure 2).

Dissolved Oxygen

In Figure 3 the values obtained during the 1957-58 incubation season reveal a greater concentration of oxygen in the stream gravel in the controlled-flow area than in the open stream. The average level remained above five p.p.m. in both environments. In Mill Creek, however, the concentration of dissolved oxygen at hatching stage, was slightly below the seven p.p.m. considered to be a critical minimum, just prior to hatching, for the chum salmon *Oncorhynchus keta* (Alderdice, Wickett, and Brett, 1958). Nevertheless, in Mill Creek concentrations of

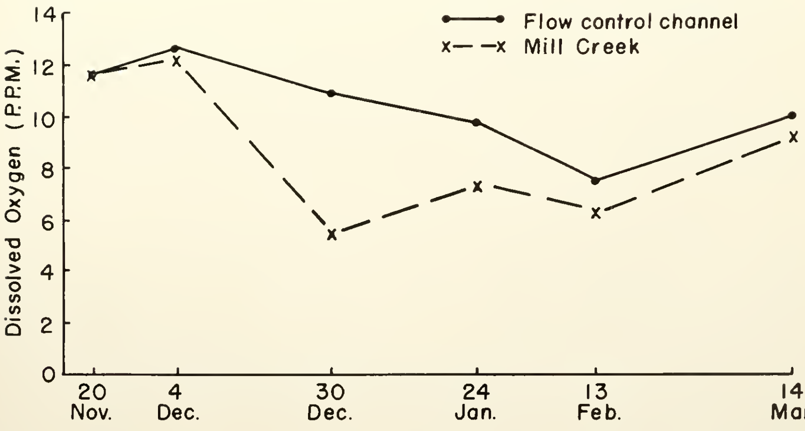

FIGURE 3. Comparison of average dissolved oxygen levels from planted redds in Mill Creek and in the flow-control channel determined at intervals throughout the 1957-58 incubation season. Oxygen samples were obtained in the immediate vicinity of the developing eggs.

oxygen were well above the range of 1.0-1.4 p.p.m. that Alderdice et al. found as the median lethal level (50 percent mortality) for chum salmon spawn just before hatching.

Seepage Rate

Comparing seepage velocities in the gravel in the control area with those in the gravel of the uncontrolled stream provided the most impressive difference between the two areas. The average velocity was 3.5 feet per hour in the controlled area during the 1957-58 season. In contrast, the seepage rate was only 0.3 foot per hour in the uncontrolled stream during a greater part of the season (Figure 4).

Survival

The superiority of stabilized streamflow to the natural stream conditions in Mill Creek was clearly demonstrated during the 1957-58 incubation season by the production of young salmon in the control-flow area. Based on sampling techniques which indicated a 1.7 percent fry survival of one-half of the originally planted samples, it was calculated that one female produced only 50 surviving young salmon in Mill Creek. The other half of the samples were eroded from under 12 to 14 inches of gravel in the main stream. In sharp contrast, it was calculated that one female produced 3,450 surviving young salmon in the controlled-flow area where conditions of optimum flow and reduced silt prevailed. Survival in the control area was thus 69 times $\left(\frac{3,450}{50}\right)$ better than in the uncontrolled stream.

DISCUSSION

Production of salmon in the Sacramento River area is limited by a variety of complex factors affecting the incubation of eggs, principal of which is the silt deposit left by heavy runoff of water that is typical of streams in this area. The means for alleviating damage resulting from heavy stream runoff appears to be control of the natural stream. In the assessment of factors that caused the superior production of salmon in the experimental controlled stream, the most impressive relationship in 1958 was the one associated with seepage rate in the gravel (Figure 4). Wickett (1954) points out that poor seepage may be the cause of failure to deliver an adequate amount of oxygen to the eggs. Wolf (1957) states that inadequate seepage fails to cleanse the eggs of metabolic waste.

Mortality to fry stage was 98.3 percent in the 1957-58 Mill Creek plants. This high mortality was obviously associated with reduced seepage in the gravel, which averaged only 0.3 foot per hour during most of the incubation season. In the controlled-flow area, with seepage rates in the gravel averaging 3.5 feet per hour, survivals were either very good or very poor. Seventy-two percent of the samples averaged 75 percent production of salmon and were associated with good seepages. In the other extreme, 22 percent of the 100-egg samples were all dead—a result of poor seepages that were not always detected by the standpipes.

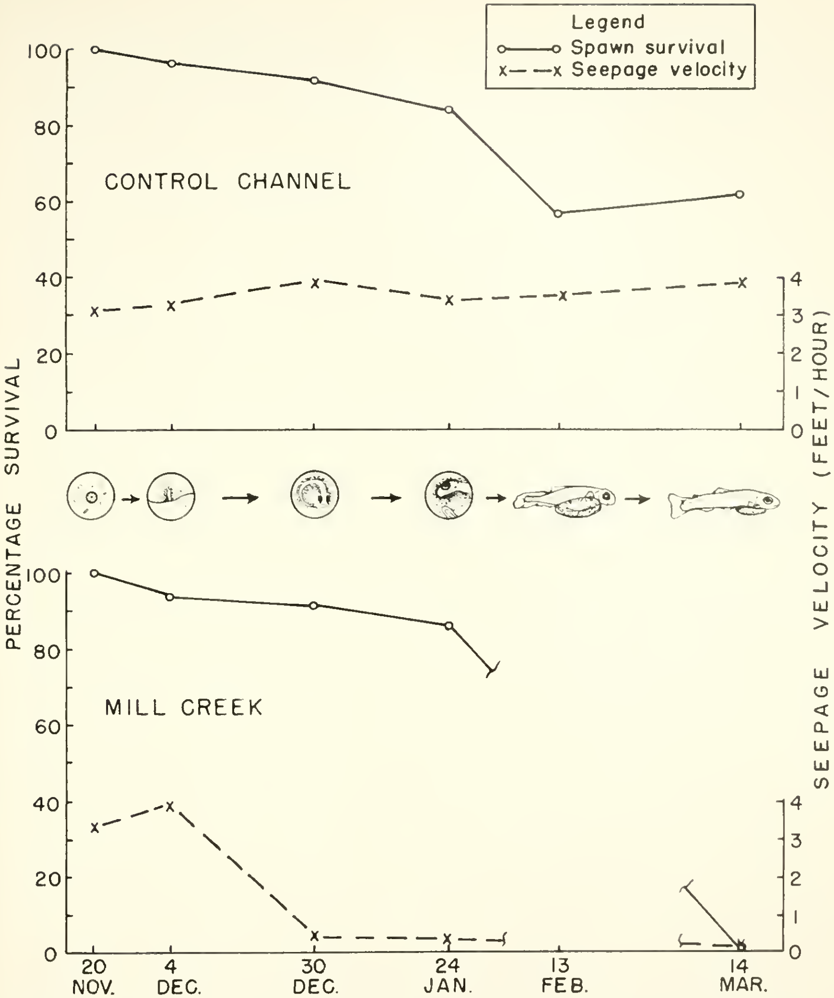

FIGURE 4. Relation of average king salmon egg survival to average seepage velocity in planted redds in Mill Creek and in the flow-control channel during the 1957-58 incubation season. Data for Mill Creek at hatched stage was unobtainable because of high water.

Specific Advantages of Improved Spawning Streams

The experiments at Mill Creek indicate the practicality of increasing the production of salmon by stabilizing stream-flow. Increased production would result from:

(1) Protection to incubating salmon eggs from erosion of the streambed by high velocities of flood water.

(2) Conservation of spawning gravel areas, which are critically depleted in the Sacramento River and its tributaries through flood action.

(3) Reduced smothering of eggs by silt.

Other anticipated advantages of flow-control methods include:

(1) Facilitation of predator control (Wickett 1952).
(2) Retention of nutrients (Briggs 1950).
(3) Easier measurement of production for more efficient management of the fishery.

Immediate Plans at Mill Creek

Since production of salmon to the fry stage in this experiment was 69 times greater under stable streamflows than under unstable streamflow in uncontrolled stream areas, the greater part of an old channel of Mill Creek is being rehabilitated for 9,000 feet from where it branches from Mill Creek to where it enters the Sacramento River. The 1958 returning mature king salmon are to be trapped and introduced into this area. Production will be measured by trapping migrants. Of particular interest in this expanded experiment will be the counts of fry after the adults have selected their own spawning site.

Application to Future Management of the Fishery Resource

As a result of the information we have gained at Mill Creek, we are considering the application of flow-control as a management measure for improving production of salmon in California. One suggestion is the establishment of more controlled-flow salmon producing sanctuaries such as the one presently in use at Mill Creek.

Another suggestion is the establishment of new habitats in the Sacramento River tributaries that presently do not qualify as salmon streams. Briefly the ideas under consideration for improving present salmon streams and creating new salmon streams in California embody the following:

(1) That flood waters be impounded in the headwaters of streams by numerous earthfilled or other dams with automatic self-adjusting gates that will permit stabilized flow of water;

(2) That the water-management program be based on the recommendations of all water users and controllers of water. This should assure best use of the water;

(3) That the impoundments be remotely situated so that they will not interfere with the migration of salmonoids; the water be released throughout the year; and the discharge from impoundments be from a stratum of water that provides suitable oxygen and temperature for salmonoids.

SUMMARY AND CONCLUSIONS

1. It has been determined that production of king salmon in the Sacramento River system in California is limited by a series of factors which result from the unstable stream flow found in that area.
2. Direct losses of spawn are caused by erosion of spawn from stream gravel. Fifty percent of planted egg samples observed were washed out and lost in this manner during six years of tests.
3. Indirect losses result from deposit of silt and sand in salmon redds. This deposition reduces seepage rate and leads to poor delivery of oxygen to incubating eggs, low dissolved oxygen levels from humus decomposition, and poor cleansing of metabolic waste products.

4. Indirect losses result from a critical shortage of suitable spawning gravel eroded from the streambed.
5. The effects of flooding were successfully dealt with in a controlled-flow stream at Mill Creek.
6. Settling and filtering methods, made possible by controlled streamflow, reduced siltation in the controlled-flow area.
7. As a result of reduced siltation, seepage velocities averaged 3.5 feet per hour in the controlled-flow area during the 1957-58 incubation season. In comparison, seepage velocities in Mill Creek proper were only 0.3 foot per hour during the greater part of the incubation season.
8. Advantages from controlled-flow resulted in a 69-fold improvement in production of fry.
9. Of the factors that might affect the survival of spawn, erosion and reduced seepage were critical during the incubation season investigated.
10. The demonstration of improved survival by the controlled-flow method has led to expansion of the experimental area. A 9,000-foot section of controlled-flow channel for spawning, where production of young salmon can be measured, is being developed.
11. An extensive and far-reaching consideration for improving existing conditions for production of salmonoids and for creating entire new areas for this purpose is suggested as a result of the work at Mill Creek. This improvement would entail impoundment of flood waters in the headwaters of tributaries and release during dry seasons to stabilize flow.

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NORTHERLY OCCURRENCES OF THE SCORPID FISH *MEDIALUNA CALIFORNIENSIS* (STEINDACHNER), WITH MERISTIC DATA, LIFE-HISTORY NOTES, AND DISCUSSION OF THE FISHERIES[1]

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INTRODUCTION

Although the halfmoon, *Medialuna californiensis* (Steindachner)–the only scorpid fish of the Californian fauna—has long been reported from as far north as Tomales Bay, most authors have indicated that it ranges northward only to Point Conception. Recent captures in Tomales Bay and near Redding Rock verify its occurrence north of that faunal break and suggest that the northerly occurrences of this species may be correlated with periods of warm ocean temperatures.

RECORDED RANGE

The earliest record of this species from Tomales Bay is that of Lockington (1879, p. 102), who said, "This is another of those species which only occur in our [San Francisco] markets on rare occasions. The individuals described by Dr. Steindachner were collected at San Diego, and, as a very large proportion of the fish fauna of that locality is different from that of San Francisco, it was with a great deal of interest and a little surprise that I found, upon comparison of the single specimen of this little fish with Dr. Steindachner's [1875, p. 47] description of *Scorpis californiensis*, that they agreed in every particular. The example mentioned, now in our museum [California Academy of Sciences], came from Tomales Bay, in a box of Embiotocidae or viviparous perch, and the dealer who saved it for me stated that he sometimes received two or three in a similar way from the same locality. I have since procured a larger specimen."

The only other early record from north of Point Conception is that of Lockington (1881, p. 47): "The few that have been taken in Monterey and even in Tomales bays must be regarded only as stragglers from the crowd."

Jordan and Gilbert (1881, p. 47) appear to have doubted Lockington's records, since, in referring to the range of this species, they wrote as follows: "Santa Barbara Islands and southward. . . . Rare at Santa Cruz Island, and probably not found northward. One in the Museum of the California Academy said to come from Tomales Bay."

[1] Submitted for publication November, 1959.

Most authors, ignoring Lockington's records, have regarded this species as confined to Southern California (and southward): Jordan and Gilbert (1883, p. 562), Goode (1888, p. 100), Jordan and Fesler (1893, p. 537), Jordan and Evermann (1896, p. 393; 1898, p. 1391; 1902, p. 453), Jordan (1905, p. 350), Starks and Morris (1907, p. 197), Starks (1919, p. 68), Ulrey and Greeley (1928, p. 22), Jordan, Evermann, and Clark (1930, p. 358), Walford (1931, p. 112), Barnhart (1936, p. 45), LaMonte (1945, p. 74, and 1952, p. 153), Roedel (1948, p. 91).

A few authors, however, appear to have accepted one or both of Lockington's records: Eigenmann and Eigenmann (1892, p. 353), "San Diego" to "Monterey"; Cannon (1953, p. 262), "Monterey to Turtle Bay"; Roedel (1953, p. 119), "Central California (Tomales Bay) to the Gulf of California (Muertos Bay); rare in Central California."

NORTHERLY OCCURRENCES

On the basis of the following occurrences of this species it is now possible not only to corroborate Lockington's records from Monterey Bay and Tomales Bay but to extend the recorded range northward to Humboldt County, California:

1. A 284-mm. specimen (Stanford Nat. Hist. Mus. No. 35304), taken during September, 1938, by a party of sport fishermen, about 20 miles off Point Sur, Monterey County.

2. A specimen approximately nine inches in total length, caught by an angler about July 24, 1958, from the Santa Cruz municipal wharf, Santa Cruz County, and now alive in the aquarium operated by Vieux Rawls on the same wharf. Another specimen of about equal size, caught at the same place a few days earlier or later, discarded when it died.

3. A 153-mm. specimen (Stanford Nat. Hist. Mus. No. 35303), taken September 24, 1941, by H. Downs, in the vicinity of Halfmoon Bay, San Mateo County.

4. Eight specimens (Calif. Acad. Sci. No. 26356), 161 to 183 mm. in standard length, seined August 10, 1958, by Murray A. Newman, at Young Landing (latitude 38° 08′ 59″ N., longitude 122° 54′ 15″ W.), Tomales Bay, Marin County. Mr. Newman said that about 50 were collected on this occasion.

5. Two specimens taken June 19, 1958, in the vicinity of Redding Rock, Humboldt County. One of these (Figure 1), 163 mm. in standard length and 8 inches in total length, is deposited in the California Academy of Sciences (No. 26362); the other, 153 mm. in standard length and $7\frac{7}{16}$ inches in total length, is deposited at Humboldt State College. Both were taken by Chester L. Hall, aboard the shrimp trawler *Sunset*, about 10 miles offshore (latitude 41° 15′ N., longitude 124° 20′ W.), in 65 fathoms. The most abundant fish taken in the same haul was the slender sole, *Lyopsetta exilis* (Jordan and Gilbert). Other species were petrale sole, *Eopsetta jordani* (Lockington); Dover sole, *Microstomus pacificus* (Lockington); "red rockfish," probably *Sebastodes pinniger* (Gill), *Sebastodes saxicola* (Gilbert), and *Sebastodes diploproa* (Gilbert); and sablefish, *Anoplopoma fimbria* (Pallas). The capture of these two halfmoons extends the recorded range of this species more than 200 miles northward in a general coastwise direction.

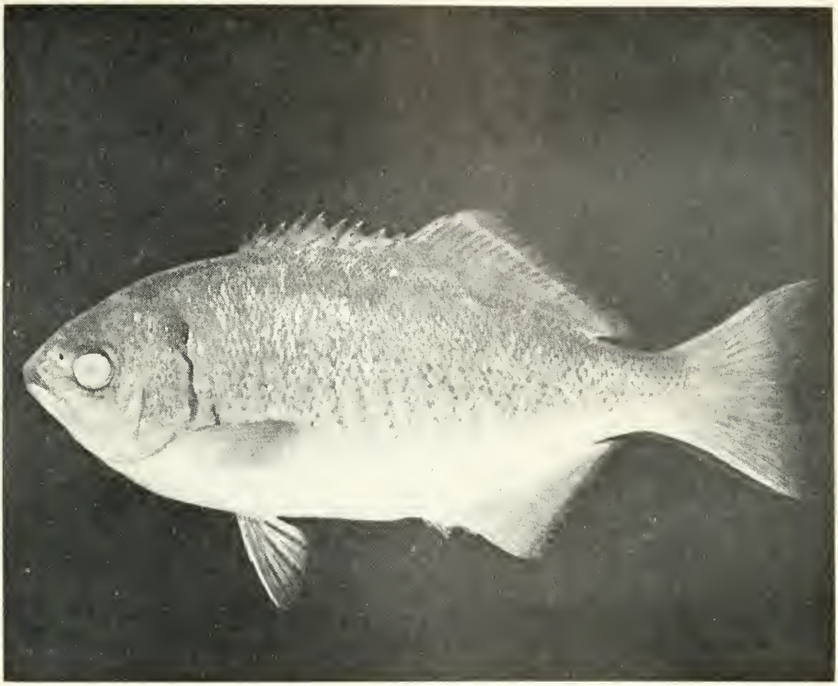

FIGURE 1. Halfmoon, *Medialuna californiensis* (Steindachner), standard length 163 mm., total length eight inches, Calif. Acad. Sci. No. 26362, from off Redding Rock, Humboldt County, California. *Photograph by W. I. Follett.*

It is not surprising that this species should occur in Tomales Bay, which, for its latitude and position, is a relatively warm-water bay, with several other southern elements in its fauna (Hubbs, 1948, p. 461). The halfmoon is particularly liable to fortuitous dispersal; it often occurs pelagically far from land, especially when young (Carl L. Hubbs, personal communication). Possibly, the halfmoon may range far northward during all warm periods and warm seasons. The northward occurrences of 1941 and 1958 were during seasons of unusually high ocean temperatures (Isaacs and Sette, 1959, p. 788). It should be mentioned, however, that no halfmoons have been reported from Tomales Bay during 1959 (Frank Spenger, personal communication), although certain evidence suggests that 1959 is another warm-water year.

HABITAT

The halfmoon occurs in comparatively shallow water along rocky shores (Starks and Morris, 1907, p. 197; Holder, 1912, p. 83; Starks, 1919, p. 68; Walford, 1931, p. 112; LaMonte, 1945, p. 74, and 1952, p. 153; Roedel, 1948, p. 91, and 1953, p. 119; Cannon, 1953, p. 262). In open spaces between kelp beds, it has been observed swimming leisurely in small schools near the surface of the water (Croker, 1935, p. 263). It has been caught occasionally among the piles of the ferry-slips and wharves in San Diego Bay (Eigenmann, 1892, p. 152).

Follett has collected this species off Hermosa Beach from a barge anchored in water 105 feet deep, over sand bottom. The halfmoons were foraging among the algae and invertebrates attached to the hull of the barge, which provided an environment somewhat resembling that of a rocky shore. The specimen recorded by Croker (1931, p. 339) as having been caught from a barge in Santa Monica Bay may similarly have been taken while foraging about the hull. Halfmoons have been found, although rarely, in commercial hauls of Pacific mackerel, *Pneumatophorus diego* (Ayres). taken off San Pedro (Croker, 1933, p. 90).

Halfmoons have been collected at some distance from land: about 20 miles off Point Sur; about 10 miles offshore in the vicinity of Redding Rock; and approximately nine miles offshore, in the San Pedro channel (about 200 half-grown individuals under a cluster of floating kelp, July 8, 1955. Kenneth S. Norris, personal communication).

LIFE HISTORY

The breeding season of this species is suggested by the presence of ripe milt in a male collected on May 3 (Eigenmann, 1892, p. 152).

When very young the halfmoon is pelagic. In that stage it is blue above and silvery below, its pectorals and caudal hyaline, and its other fins blotched with black (Roedel, 1953, p. 119).

SIZE

The size attained by the halfmoon has long been a matter of uncertainty. Confusion on this subject appears to have originated with Jordan and Gilbert (1881, p. 47), who wrote, "It reaches a length of about a foot and a weight of three pounds." A specimen about a foot in length would weigh much less than three pounds; among the halfmoons collected by Follett, a $12\frac{1}{4}$-inch specimen weighed only $1\frac{1}{4}$ pounds. If this species reaches a length of only about a foot (as stated by Jordan and Gilbert, 1883, p. 562; Jordan and Fesler, 1893, p. 537; Jordan and Evermann, 1898, p. 1391, and 1902, p. 453; Starks, 1919, p. 68; Walford, 1931, p. 112; Barnhart, 1936, p. 45; LaMonte, 1945, p. 74, and 1952, p. 153; Roedel, 1948, p. 91, and 1953, p. 119; Cannon, 1953, p. 262), then the statement by Holder (1912, p. 83) that the halfmoon attains a weight of "four or five pounds" would certainly be an exaggeration. Holder's statement is substantiated, however, by two specimens that have recently come to our attention. The first of these was collected July 4, 1954, about two miles offshore, near Corona del Mar, Orange County, California. It measured $16\frac{1}{2}$ inches in total length and weighed "just under four pounds." Scales from this specimen indicated that its age was probably eight years. (John E. Fitch, personal communication.) The second large specimen (Calif. Acad. Sci. No. 26390) was collected in the vicinity of Santa Catalina Island, California, during 1956. It was then about a foot in length. It lived in a fish tank at Marineland of the Pacific until April 6, 1959, when it was speared and then frozen and sent to the California Academy of Sciences for this study. On April 7, after the specimen had been thawed in cold water, it was found to be 391 mm. in standard length and 19 inches in total length, and 4 pounds $12\frac{1}{2}$ ounces in weight.

TABLE 1

Meristic Data from 50 Specimens of **Medialuna californiensis**

All counts were taken as by Hubbs and Lagler (1958, pp. 19-24). Counts of all median elements were determined from radiographs. All specimens counted are half-grown to adult (152-284 mm. in standard length). The 12 "Northern" specimens comprise 2 from Redding Rock, 8 from Tomales Bay, and 1 each from Halfmoon Bay and off Point Sur; the 28 "Southern" specimens, 1 each from Balboa and Laguna Beach, 10 from La Jolla, 15 from San Diego, and 1 from South Coronado Island; 10 are from Guadalupe Island.[1]

The following counts were invariable: branchiostegals, 7; auxiliary interneurals[2], 3; anal spines, III; pelvic rays, I,5; vertebrae, 10 + 15 = 25[3]; and principal caudal rays, 9 + 8.

Region	Dorsal spines			Dorsal soft-rays				Anal soft-rays				Pectoral rays (both sides)			Procurrent caudal rays									Gillrakers (both sides)							Lateral-line pores (both sides)			
															Upper					Lower				Upper limb			Lower limb							
	9	10	11	22	23	24	25	17	18	19	20	17	18	19	10	11	12	13	14	10	11	12	13	7	8	9	16	17	18	19	50	51	52	53
Northern	1	11	--	4	4	1	3	1	6	5	--	4	18	2	--	2	4	6	--	--	6	4	2	15	9	--	11	13	--	--	10	11	3	--
Southern	--	27	1	6	12	8	2	1	15	10	2	20	30	6	1	1	12	13	1	2	14	11	1	17	34	5	12	34	9	1	26	16	8	6
Guadalupe I.	--	10	--	--	6	4	--	1	3	6	--	5	13	2	--	1	5	3	1	2	3	5	--	12	8	--	7	10	3	--	8	6	5	1
Totals	1	48	1	10	22	13	5	3	24	21	2	29	61	10	1	4	21	22	2	4	23	20	3	44	51	5	30	57	12	1	44	33	16	7

[1] The halfmoon is particularly abundant about Guadalupe Island (Carl L. Hubbs, personal communication).
[2] Interneurals anterior to those that bear dorsal spines. (Cf. Starks, 1904, p. 613.)
[3] Corroborating Clothier ([1951], p. 65).

MERISTIC DATA

Meristic data from 50 individuals suggest no significant latitudinal differentiation of the northern specimens (Table 1). These data indicate that certain counts generally ascribed to this species in the literature—notably those of the dorsal soft-rays, anal soft-rays, gillrakers of the upper limb, and lateral-line pores—are atypical. Counts here presented that do not appear to have been mentioned in the literature are those of the pectoral rays, auxiliary interneurals, and caudal rays (both procurrent and principal).

FOOD

The halfmoon has been said to feed chiefly on crustaceans (Jordan and Gilbert, 1881, p. 47; Lockington, 1881, p. 47; Goode, 1888, p. 100). It has also been said to feed chiefly on algae (LaMonte, 1945, p. 74; 1952, p. 153). As we have found algae in the stomachs of our specimens and as Follett has taken this species on several kinds of animal baits, it is apparent that both kinds of food are sought by the halfmoon. On this subject, the following information appears significant: About 20 halfmoons were placed in a large fish tank at Marineland of the Pacific. After being fed animal food for about six months, these fish, apparently suffering a loss of equilibrium, tended to lie on one side, with the body arched and the head and tail downward. In this position they fluttered about at all depths, frequently drifting toward the surface. When kelp—principally *Macrocystis pyrifera* and *Egregia laevigata*—was placed in the tank, the halfmoons ate it ravenously. Two or three days later, apparently having recovered their equilibrium, they were swimming in a normal position. (Kenneth S. Norris, personal communication.)

COLOR CHANGE

When a half-grown harbor seal escaped from its tank at Marineland of the Pacific and entered the large tank occupied by the fish, a number of adult halfmoons suddenly displayed a striking change in color, apparently as a fright reaction. They developed a dark-gray longitudinal band along the middle third of the side, and above it a narrower, whitish band, contiguous to the normal bluish gray color of the back. This color change may be a cryptic device to obliterate the outline of the fish either from above or from below. (Kenneth S. Norris, personal communication.)

"FLOATING LEAF" POSTURE

On several occasions the halfmoon has been seen lying on its side near the surface of the water, in a "floating leaf" posture, somewhat like that observed by Breder (1942, p. 267) in *Oligoplites saurus* (Bloch and Schneider) and by Breder (1949, p. 237) and Caldwell (1955, p. 153) in *Lobotes surinamensis* (Bloch).

A $3\frac{1}{2}$-inch halfmoon was seen floating in water 18 feet deep, over a sand bottom, at about 9 p.m. It was lying on its side with the body flexed, the anal region nearest the surface of the water, and the head and tail turned downward—the head farther down than the tail. The fish floated nearly motionless in this position for at least 15 minutes, except when swimming back into the field of the night light after drifting away from it. Occasionally the halfmoon reversed its flexure, so that the opposite side was exposed to the light. At such times only the motion of the caudal fin showed that the fish was alive. These observations were made on March 4, 1959, from the pier at Marineland of the Pacific, Los Angeles County, California, by John Prescott, who collected the specimen in a dipnet.

A halfmoon between one and two inches in length was observed lying motionless in the floating-leaf posture under a night light on the lee side of Todos Santos Island, off Ensenada, Baja California, in 1952 or 1953. It was collected by Kenneth S. Norris, who did not recognize it as a fish until it began flopping in the dipnet.

As many as six small adult halfmoons were to be seen lying in the floating-leaf posture during the warm part of the day when this species was present in Tomales Bay in 1958. This behavior was observed from day to day during a warm-weather period of about three weeks in October. When too closely approached by a flying gull, the floating halfmoon would suddenly dart beneath the surface. None was ever seen caught by a gull, and none was found dead. (Frank Spenger, personal communication.)

USE AS FOOD

The high quality of the halfmoon as a food fish has been mentioned by Jordan and Gilbert (1881, p. 47; 1883, p. 562), Goode (1888, p. 100), Jordan and Fesler (1893, p. 537), Jordan and Evermann (1898, p. 1391; 1902, p. 453), Jordan (1905, p. 350; 1907, p. 564), Starks (1919, p. 68), and Cannon (1953, p. 96). We regard these favorable comments as well justified. The flesh of this species is fine-grained and has a remarkably good flavor.

COMMERCIAL FISHERY

Catch

More than three-quarters of a century ago, the halfmoon supported a commercial fishery of some importance. This species was then especially abundant about Santa Catalina Island, where it was one of the principal food fishes (Jordan and Gilbert, 1881, p. 47). The great bulk of the fish taken by the Wilmington fishermen off Santa Catalina Island, for the supply of Los Angeles, consisted of this species, according to Jordan (see Lockington, 1881, p. 47).

During the present century, most records of the commercial catch of the halfmoon, having been combined with those of other species, are not informative. The following records, however, purport to indicate the catch of this species alone: 27,791 pounds, worth $832, in 1922 (Sette, 1926, p. 277); 36,765 pounds, worth $2,720, in 1930 (Fiedler 1932, pp. 367, 377); approximately 45,227 pounds in 1947 (Young, 1949, p. 110); 50,007 pounds, worth $11,727, in 1954 (Marine Fisheries Branch, 1956, p. 87); 34,410 pounds, worth $8,410 in 1955; 15,108 pounds, worth $3,774, in 1956 (Marine Resources Operations, 1958, pp. 59, 93); and 12,900 pounds, worth $3,036, in 1957 (Power, 1959, p. 275).

Gear

The earliest mention of a commercial-fishing method for the halfmoon appears to be that of Jordan and Gilbert (1881, p. 47), who stated that in the vicinity of Santa Catalina Island this species was taken in great numbers in gill nets.

Gill nets accounted for 8,000 pounds of the commercial catch in 1922 and 19,951 pounds in 1930; lampara nets, for 42 pounds in 1922 and 13,894 pounds in 1930; lines, for 12,936 pounds in 1922; trammel nets, for 7,353 pounds in 1922; and purse seines, for 2,920 pounds in 1930 (Sette, 1926, pp. 327, 329, 331; Fiedler, 1932, pp. 367, 377); seines and lampara nets, for 15,100 pounds, and lines, for 19,300 pounds, in 1955 (Anderson and Power, 1957, p. 312); lines, for 15,100 pounds in 1956 (Power, 1958, p. 304); and lines, for 12,900 pounds in 1957 (Power, 1959, p. 275).

A miniature purse seine was used in taking halfmoons in the vicinity of San Clemente Island during the winter of 1934-1935 (Croker, 1935, p. 262; Clark, 1937, p. 93). This seine was approximately 100 fathoms long and 10 fathoms deep, with tanned webbing of three-inch stretched mesh and with purse rings of much smaller diameter than those used on ordinary purse seines. The largest single haul made with this seine was somewhat over one ton.

Gill nets designed for the taking of halfmoons accounted for most of the 1947 commercial catch (Young, 1949, p. 110).

A lift net with an inner trap, or fyke, was used in shallow rocky areas near Santa Catalina Island several years ago by a commercial fisherman. This net sat upright on the sea bottom. Chum (ground fish) was thrown into the water over the net. When a fair number of fish had been attracted by the chum, the fisherman winched the net upward rapidly. The sudden motion alarmed the fish, and their fright reflexes caused them to sound. In sounding, they entered the lower compartment of the net, where they were trapped. When the net was raised, the fish were removed by the release of a purse string. This fisherman was so successful that he surfeited the available market and had to seek other species as a means of earning a living. (John E. Fitch, personal communication.)

ANGLING METHODS

When taken on hook and line, the halfmoon is a surprisingly vigorous fighter. It is caught most frequently by those anglers who fish from rocks or breakwaters or from skiffs over sheltered rocky reefs. Methods of angling for this species have been described by Holder (1910, p. 369; 1912, p. 83; 1913, p. 172) and Cannon (1953, pp. 67, 262), who recommended spiny lobster, clam, abalone, mussels, shrimp, rock worms, or bits of fish as bait. Occasionally halfmoons are taken on streamer flies or other artificial lures (John E. Fitch, personal communication). Follett has found rock worms (Nereidae) or pieces of scallop effective baits for this gamy fish.

SUMMARY

Specimens of the halfmoon, *Medialuna californiensis* (Steindachner), collected (1) approximately 20 miles off Point Sur, Monterey County, (2) from the Santa Cruz municipal wharf, Santa Cruz County, (3)

in the vicinity of Halfmoon Bay, San Mateo County, and (4) in Tomales Bay, Marin County, corroborate old records from Monterey Bay and Tomales Bay that appear to have been doubted by most authors.

The capture of two specimens near Redding Rock, Humboldt County, extends the recorded range more than 200 miles northward in a general coastwise direction.

Although the halfmoon has generally been said to obtain a length of only about a foot, two specimens of greater length are here recorded: One of these was $16\frac{1}{2}$ inches in total length, "just under four pounds" in weight, and probably eight years of age; the other was 19 inches in total length and at least 4 pounds $12\frac{1}{2}$ ounces in weight.

Habitat, life history, use as food, commercial catch and gear, and angling methods are discussed.

The food of the halfmoon consists of algae, as well as crustaceans and other animals.

A color change, apparently induced by fear, has been observed.

A "floating leaf" posture, somewhat like that recorded for *Oligoplites saurus* (Bloch and Schneider) and *Lobotes surinamensis* (Bloch), has been reported.

Meristic data from 50 specimens suggest no significant latitudinal variation but indicate that certain counts generally ascribed to this species are atypical.

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OBSERVATIONS ON THE GROWTH RATE OF THE SPINY LOBSTER[1]

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INTRODUCTION

The spiny lobster, *Panulirus interruptus* (Randall), is of considerable importance in Southern California, not only as the object of a commercial fishery but also as a highly prized sport species among skin divers. Unfortunately, data on the population density, growth rate, etc. of the lobster are meager, making it difficult to determine the maximum fishing pressure the species can tolerate. The present paper attempts to establish quantitatively the growth rate of the lobster.

MOLTING FREQUENCY AND GROWTH RATE

Lindberg (1955) has the most comprehensive summary to date of the known information on the spiny lobster. On p. 211, he summarizes, "Sexually mature lobsters molt twice a year, with an annual length increment of approximately 2 cm.," and in the next paragraph, "Frequency distribution plots of overall length and weight increments of mature lobsters suggest an annual growth of approximately 3 cm."

The statement regarding molting frequency is based on the following:

a. A generalization (p. 199) that the family Palinuridae molts twice yearly. This may or may not be true of *P. interruptus.*

b. A graph (p. 208) derived from earlier tables, plotting the molt frequencies against month of molt for two samples, one a group of 49 captive lobsters molting once each, and the other a pair of small captive lobsters molting a number of times over a period of a few years. Both curves show two peaks, but the peaks do not coincide. The numbers involved are quite small for statistical reliability.

c. The statement (p. 209): "It would seem that mature females molt at least once a year, once soon after the eggs are hatched (August-September) and possibly once just before the deposition of the sperm case (November-January)."

The generalization from the above information that sexually mature lobsters molt twice yearly does not agree with the present author's observations. Of his total catch of 233 lobsters over a nine-year period, 36 were taken in the month of October, of which eight were either ready to molt or had the soft shell indicative of recent molting. Of

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33 taken in the month of November, only two were in molting condition, and of 127 taken in the months December through July, none. The earliest catch of a lobster ready to molt was August 1. Conversely, of 23 lobsters observed in September, 17 were in molting condition.

Fish dealers at the wharf in Redondo Beach, California, keep live lobsters for sale in tanks of circulating sea water. Batches of as many as 500 may be kept for a week or two. The dealers state that occasional casts are found in the tanks, numbering perhaps two dozen in the course of the open season October 1 to March 15. If lobsters molted regularly in November and December, say during a 10-week period, the number of casts found would be roughly 10 percent of the number of lobsters held, or 50 per week during this period. Since the number observed averages about two per week, we may conclude that those lobsters molting outside the usual summer period comprise only some 4 percent of the total. These exceptional individuals may molt more than once during the year, but the other 96 percent molt only once.

Lindberg's conclusions quoted above on the yearly growth rate of the lobster are derived from charts shown on p. 206 of his publication, in which are plotted the number of lobsters in each one-centimeter length increment for each of three samples, the sample sizes being 276, 206 and 62, respectively. The results are inconclusive; the two-, three- and four-centimeter groups which can be picked out are not well defined and are more likely to be due to random fluctuations than to any real size grouping. This result is not surprising in view of Lindberg's Table 14 (p. 200) which shows the length increases after molting of 49 captive lobsters. Of these, 32 individuals showed increases spread practically uniformly over the range —0.1 cm. to 2.1 cm. Variations of this magnitude occurring in the field would certainly obscure any yearly size groups which were of the same magnitude, *i.e.*, two to three cm.

Overall length of the spiny lobster is neither easily defined nor easily measured, and may be subject to considerable variation in an individual specimen, as Lindberg's Table 14 suggests. This is further corroborated by the work of Dawson and Idyll (1951), who found considerable variation in the measurements of the length of an individual lobster taken at different times.

In view of the above discussion, a much more reliable dimension would appear to be the carapace length from the ridge above the eye socket to the back of the shell; this distance is easily measurable with vernier calipers to 0.1 mm. This measurement is now the basis for legal size determination in California; a lobster may be legally taken if the above measurement is more than 82.5 mm. ($3\frac{1}{4}$ inches). Nakamura (1940) used this measurement to estimate the growth rate of *P. japonicus*. For a species such as *P. interruptus*, which at maturity molts yearly, the growth is of course discontinuous, occurring in discrete increments at each molt. If these increments are reasonably uniform one might expect the carapace lengths to fall into groups corresponding to the age in years of the lobster.

CARAPACE MEASUREMENTS

An experiment was thus undertaken to see if yearly growth groups could be detected in *P. interruptus*. Carapace lengths of a sample of 589 lobsters at a fish market in Redondo Beach, California, were measured to the nearest millimeter. The measurements are plotted in Figure 1. A moving average of groups of three is also shown. There are no obvious growth groups evident.

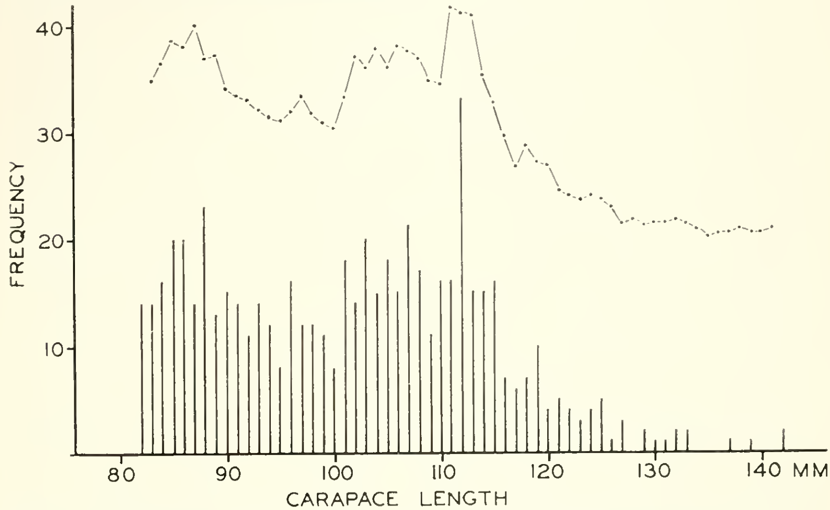

FIGURE 1. Distribution of carapace lengths of a sample of 589 lobsters. The dashed line is a moving average of groups of three, displaced upward 20 units for easier visibility.

In Figure 1 there is no distinction as regards sex, and it is not to be expected *a priori* that both sexes will grow at precisely the same rate. Unfortunately, in the original measurements the sexes had not been distinguished for the greater part of the sample; however, the last 221 had been so distinguished, so that frequency plots could be made for each sex. This last group had a further advantage in that they had been trapped by one fisherman in one location, so that environmental influences on the growth rate should be minimized.

Frequency plots for the two sexes of this last group of lobsters (125 females and 96 males) are shown in Figure 2, together with moving averages of three as before. In both plots groups are fairly evident, indicated by arrows above the moving average curves with group separations of from four to eight mm.

From Figure 2 we see that the female carapace length increases from 89 to 126 mm. in six molts. Assuming a constant growth rate for lobsters in this size range, we get an average increase per molt of 6.2 mm. The corresponding figure for the male is 5.3 mm. per molt.

The author's measurements give the ratio of carapace length to total length (measured from a point between the antennules to the tip of the tail), a value ranging from 0.30 to 0.33, with an average of 0.31. The total length increment for lobsters would thus be 2.0 cm. per molt for females and 1.7 cm. per molt for males. Assuming one molt per year, these numbers are then the yearly length increments of lobsters

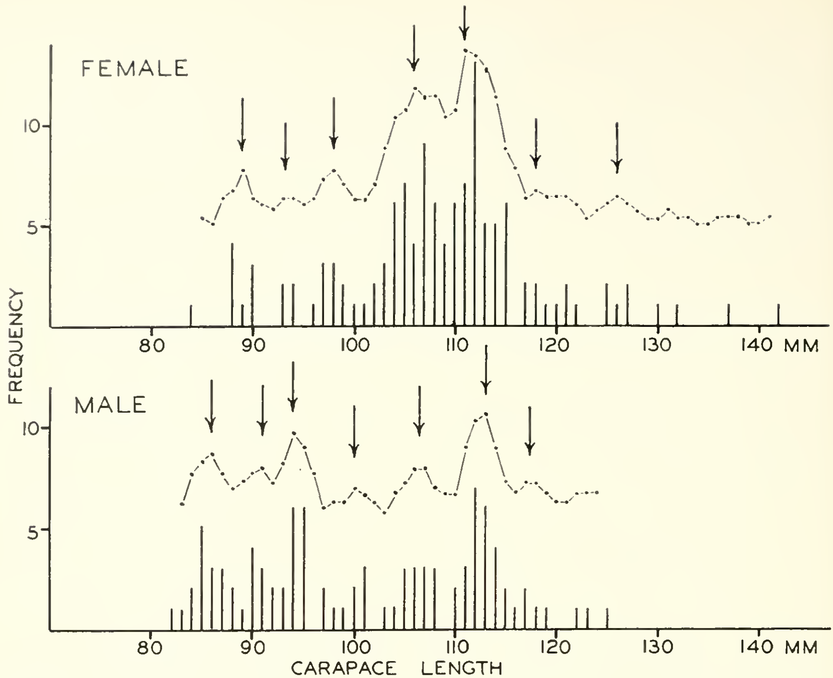

FIGURE 2. Distribution of carapace lengths of a sample of 125 female lobsters and a sample of 96 male lobsters, together with moving averages of three displaced upward five units.

in the range considered, namely, 27 cm. (10½ inches) to 40 cm. (15 inches) in total length. These increments are somewhat smaller than Lindberg's estimates.

It should be noted that the groups for the two sexes fall at sufficiently different locations to obscure any groups if the data are combined into one chart; this would explain the negative result of Figure 1.

The groups shown in Figure 2 may of course be fortuitous. If they are real, they should be even more pronounced at shorter lengths where randomizing influences have been less. It is hoped to extend this work to smaller lobsters to check the present conclusions.

ACKNOWLEDGMENT

The author is indebted to Weddington and McFarlan's Fish Market in Redondo Beach, California, for allowing him the use of their facilities and stock of lobsters for making these measurements.

SUMMARY

1. Observations of lobsters taken by skindiving over a nine-year period show that with very few exceptions lobsters molt only once yearly, during the summer months.

2. Observations of the low molting frequency of captive lobsters held by commercial markets confirm this statement.

3. Frequency distribution plots of carapace lengths of 125 females and 96 males show peaks indicative of grouping by age in years.

4. Analysis of the spacings of the groups shows a yearly length increase for the spiny lobster of 2.0 cm. for females and 1.7 cm. for males.

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AGE COMPOSITION OF THE SOUTHERN CALIFORNIA CATCH OF PACIFIC MACKEREL, *PNEUMATOPHORUS DIEGO* FOR THE 1957-58 SEASON[1]

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The methods used in sampling the commercial catch, making age determinations, and estimating numbers of fish and pounds landed are the same as those used in the six previous reports on the age composition of the Pacific mackerel (Fitch, 1958).

Of the 8,050 fish sampled during the season, 931 pairs of otoliths were read and their ages determined (Table 1). Landings of Pacific mackerel from May 1, 1957 to April 30, 1958 were 56,188,000 pounds consisting of 60,908,000 fish. Fifty percent were two-year-olds, from the 1955 year class (Table 2). This year class by its second year had contributed more to the landings than had the large 1953 year class at the same age. A preliminary analysis of length frequencies available for the 1958-59 season indicates the 1955 year class will surpass the contribution of the 1953's to become the greatest contributor since the 1947 year class, the largest on record (Table 3).

In contrast to the large number of the two-year-old fish there was a notable lack of one-year-olds during 1957-58. A good year class may or may not be evident in its zero year but almost always is in its first. In a parallel manner, a poor year class can usually be forecast by a negligible zero year contribution followed by a modest first year contribution. In its first year an averaged sized year class may be second in percentage contribution to the fishery, or third, if overshadowed by an outstanding year class. The modest 10 percent contribution of the 1956 year class in the 1957-58 fishery and the length frequency data from the 1958-59 season indicate a poorer than average survival in 1956.

The 1957-58 catch was above the average for the past 19 seasons. This was not entirely due to the large 1955 year class. The moderate 1954 and still numerous 1953 year classes helped bolster the catch with heavier three- and four-year-old fish (Table 4).

ACKNOWLEDGMENTS

The author wishes to express his gratitude for the considerable instruction and assistance given him by John E. Fitch in interpreting the ages of Pacific mackerel otoliths. In addition, sincere appreciation is extended to Mrs. Gertrude M. Cutler for performing many of the computations required for this paper and to Bruce M. Dunow and other members of the department's Pelagic Fish Investigations.

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TABLE 1

Fork Length of Pacific Mackerel in Quarter Centimeters at Each Age for the 1957-58 Season, Based on Otoliths Read

¼ cm.	Age group									
	O	I	II	III	IV	V	VI	VII+		Total
82	1	--	--	--	--	--	--	--	--	1
3	--	--	--	--	--	--	--	--	--	--
4	1	--	--	--	--	--	--	--	--	1
85	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--	--
7	--	--	--	--	--	--	--	--	--	--
8	1	--	--	--	--	--	--	--	--	1
9	1	--	--	--	--	--	--	--	--	1
90	--	--	--	--	--	--	--	--	--	--
1	--	1	--	--	--	--	--	--	--	1
2	2	--	--	--	--	--	--	--	--	2
3	3	--	--	--	--	--	--	--	--	3
4	--	--	--	--	--	--	--	--	--	--
95	--	--	--	--	--	--	--	--	--	--
6	2	--	--	--	--	--	--	--	--	2
7	3	--	--	--	--	--	--	--	--	3
8	1	--	--	--	--	--	--	--	--	1
9	1	2	--	--	--	--	--	--	--	3
100	1	2	--	--	--	--	--	--	--	3
1	1	1	--	--	--	--	--	--	--	2
2	4	2	--	--	--	--	--	--	--	6
3	1	3	2	--	--	--	--	--	--	6
4	--	3	--	--	--	--	--	--	--	3
105	1	3	3	--	--	--	--	--	--	7
6	--	4	3	--	--	--	--	--	--	7
7	1	1	3	--	--	--	--	--	--	5
8	--	5	1	--	--	--	--	--	--	6
9	--	7	3	--	--	--	--	--	--	10
110	1	6	12	--	--	--	--	--	--	19
1	--	2	7	--	--	--	--	--	--	9
2	--	5	8	--	--	--	--	--	--	13
3	--	4	14	--	--	--	--	--	--	18
4	--	7	21	--	--	--	--	--	--	28
115	2	5	16	--	--	--	--	--	--	23
6	--	5	13	--	--	--	--	--	--	18
7	--	3	17	1	--	--	--	--	--	21
8	--	2	11	--	--	--	--	--	--	13
9	--	2	21	2	1	--	--	--	--	26
120	1	8	22	3	--	--	--	--	--	34
1	--	2	18	2	--	--	--	--	--	22
2	--	2	17	2	1	--	--	--	--	22
3	--	2	18	3	--	--	--	--	--	23
4	--	2	24	7	--	--	--	--	--	33
125	--	3	13	2	--	--	--	--	--	18
6	--	2	16	5	--	--	--	--	--	23
7	--	1	16	5	--	--	--	--	--	22
8	--	2	18	7	--	--	--	--	--	27
9	--	1	17	3	1	1	--	--	--	23
130	--	1	14	4	2	1	--	--	--	22
1	--	--	12	7	1	--	--	--	--	20
2	--	3	8	3	1	--	--	1	--	16
3	--	2	17	6	2	--	1	--	--	28
4	--	--	5	7	1	--	1	--	--	14
135	--	1	14	8	5	--	--	--	--	28

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TABLE 1

Fork Length of Pacific Mackerel in Quarter Centimeters at Each Age for the 1957-58 Season, Based on Otoliths Read—Continued

	Age group									
¼ cm.	O	I	II	III	IV	V	VI	VII+		Total
6	--	2	4	10	6	2	--	--	--	24
7	--	--	6	9	3	--	--	--	--	18
8	--	2	2	7	4	--	1	--	--	16
9	--	1	6	9	6	1	1	--	--	24
140	--	--	3	5	5	1	1	--	--	15
1	--	--	3	3	13	4	1	1	--	25
2	--	--	1	4	11	3	--	--	--	19
3	--	2	3	6	10	3	1	1	--	26
4	--	--	--	8	3	--	2	--	--	13
145	--	--	--	2	5	2	--	--	--	9
6	--	1	1	7	16	2	--	--	--	27
7	--	--	--	4	6	7	1	--	--	18
8	--	--	1	2	5	4	2	--	--	14
9	--	--	1	--	2	3	--	--	--	6
150	--	--	--	--	1	2	--	--	--	3
1	--	--	--	--	7	2	3	1	--	13
2	--	--	--	3	2	1	2	--	--	8
3	--	--	1	1	2	2	--	--	--	6
4	--	--	--	--	--	1	1	--	--	2
155	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	1	--	1	--	2
7	--	--	--	--	--	1	1	--	--	2
8	--	--	--	--	1	--	--	--	--	1
9	--	--	--	--	--	--	--	--	--	--
160	--	--	--	--	1	--	--	--	--	1
1	--	--	--	--	--	--	--	--	--	--
2	--	--	--	1	--	--	--	--	--	1
3	--	--	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--	--	--
165	--	--	1	--	--	--	--	--	--	1
Totals	29	115	437	158	124	44	19	5	--	931

TABLE 2

Calculated Number of Pacific Mackerel Landed in Age Groups 0 Through VI+ During the 1957-58 Season

	Age group							
	0	I	II	III	IV	V	VI+	Totals
Year class	1957	1956	1955	1954	1953	1952		—
Number of fish	1,386,000	6,228,000	30,487,000	11,332,000	8,160,000	2,302,000	1,013,000	60,908,000
Percentage of fish	2.3	10.2	50.1	18.6	13.1	3.8	1.6	100.0

TABLE 3

Number of Pacific Mackerel Landed by Year Class at Each Age Group from 0 Through V, 1939-40 Through 1957-58

Year class	Age group						
	0	I	II	III	IV	V	Totals
1934						5,340,000	
1935					10,570,000	1,443,000	
1936				35,130,000	13,551,000	970,000	
1937			26,540,000	25,261,000	5,121,000	822,000	
1938		25,200,000	69,322,000	25,661,000	5,271,000	1,082,000	*126,536,000
1939	2,960,000	20,793,000	26,454,000	12,698,000	7,133,000	1,616,000	71,654,000
1940	2,313,000	12,507,000	9,201,000	10,156,000	7,712,000	3,328,000	45,220,000
1941	398,000	29,376,000	54,106,000	33,905,000	10,342,000	2,294,000	130,391,000
1942	0	12,462,000	19,047,000	10,259,000	1,661,000	2,019,000	48,148,000
1943	836,000	16,556,000	10,327,000	11,872,000	5,087,000	429,000	45,107,000
1944	0	11,302,000	25,823,000	10,943,000	1,105,000	584,000	52,757,000
1945	556,000	9,330,000	7,980,000	756,000	688,000	72,000	19,382,000
1946	560,000	1,377,000	3,175,000	1,279,000	937,000	218,000	10,546,000
1947	7,181,000	63,330,000	49,255,000	15,826,000	11,127,000	2,756,000	149,475,000
1948	1,061,000	21,818,000	19,228,000	13,871,000	9,184,000	367,000	65,829,000
1949	136,000	3,854,000	1,428,000	1,286,000	161,000	0	9,865,000
1950	6,000	1,583,000	521,000	583,000	71,000	15,000	2,779,000
1951	769,000	16,000	475,000	208,000	201,000	62,000	1,761,000
1952	86,000	676,000	3,893,000	6,021,000	3,641,000	2,302,000	16,619,000
1953	12,237,000	40,036,000	21,156,000	11,644,000	8,160,000		96,230,000
1954	564,000	3,562,000	11,976,000	11,332,000			30,131,000
1955	1,237,000	19,429,000	30,487,000				84,153,000
1956	21,000	6,228,000					6,249,000
1957	1,386,000						

* No information available on the 0 age group of the 1938 year class

TABLE 4

Pounds of Pacific Mackerel Landed by Year Class at Each Age Group 0 Through V, 1939-40 Through 1957-58

Year class	Age group 0	I	II	III	IV	V	Totals
1934	--	--	--	--		6,851,000	
1935	--	--	--	--	12,141,000	1,885,000	
1936	--	--	--	31,916,000	14,592,000	1,411,000	--
1937	--	--	19,306,000	22,163,000	7,015,000	1,178,000	
1938	--	11,578,000	49,762,000	27,249,000	6,651,000	1,499,000	*96,739,000
1939	961,000	11,609,000	21,747,000	12,898,000	9,058,000	2,331,000	58,607,000
1940	853,000	7,564,000	7,809,000	10,743,000	10,139,000	4,809,000	41,917,000
1941	116,000	15,085,000	40,066,000	36,527,000	13,595,000	3,236,000	108,625,000
1942	0	7,912,000	16,208,000	11,453,000	6,225,000	2,863,000	44,661,000
1943	274,000	9,991,000	9,221,000	12,786,000	6,718,000	638,000	39,628,000
1944	0	7,296,000	22,530,000	13,035,000	1,484,000	852,000	45,197,000
1945	158,000	5,627,000	7,601,000	867,000	899,000	100,000	15,252,000
1946	129,000	1,015,000	2,365,000	4,070,000	1,078,000	290,000	8,947,000
1947	1,477,000	29,643,000	32,320,000	14,692,000	12,819,000	4,058,000	95,009,000
1948	248,000	8,612,000	13,591,000	13,327,000	12,583,000	637,000	48,998,000
1949	47,000	2,155,000	3,547,000	1,509,000	229,000	0	7,487,000
1950	1,000	802,000	474,000	687,000	90,000	24,000	2,078,000
1951	252,000	34,000	483,000	234,000	244,000	94,000	1,341,000
1952	33,000	463,000	3,063,000	6,034,000	4,394,000	3,112,000	17,099,000
1953	4,358,000	23,175,000	16,990,000	14,973,000	10,197,000		69,693,000
1954	94,000	1,964,000	11,722,000	12,294,000			26,074,000
1955	1,270,000	25,940,000	24,552,000	--			51,762,000
1956	5,000	4,222,000	--				4,227,000
1957	466,000	--	--				

* No information available on the 0 age group of the 1938 year class.

AGE AND LENGTH COMPOSITION OF THE SARDINE CATCH OFF THE PACIFIC COAST OF THE UNITED STATES AND MEXICO IN 1957-58[1]

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This is the 12th report on age and length composition of the catch of sardines *(Sardinops caerulea)* off the Pacific Coast of North America. It covers landings of the commercial fishery for the 1957-58 season. Earlier reports give similar data from 1941-42 to the present season (Wolf *et al.*, 1958).

The 1957-58 sardine season opened in Central California on August 1, but no fish were caught in this region during the entire season. In Southern California, the season opened on September 1, a month earlier than for many years preceding, and continued through December 31. The new starting date for the southern region and the new ending dates of December 31 for both regions were set by the 1957 Session of the California Legislature at the request of the fishing industry.

The 1951 California Legislature designated Pt. Arguello as the dividing line between the two sardine fishing regions. Therefore, insofar as sardine fishing is concerned the Southern California region extends from the Mexican border north to Pt. Arguello. The Central California region lies between Pt. Arguello and Pt. Arena. From Pt. Arena north to the Oregon boundary, sardines are not commonly caught.

In Southern California, heavy landings of fish took place at San Pedro and Port Hueneme only.

At Port Hueneme, a small fleet of boats, mostly from Monterey, began fishing immediately after the Southern California season opened. The price was $52.50 per ton (minus about $18 for trucking charges), which was an increase from the $47.50 of the previous year.

In the San Pedro local area, no sardine landings were made in September and few in October due to price disputes. The economic situation there was complicated, with two unions and the canners forming three factions. Two boats delivered fish at one cannery on October 1 and 2, then were stopped. On October 10, one union voted to begin fishing, though many of its members were in strong opposition. On October 14, one boat made a delivery while picketed by members of both unions and under strong police protection. Then fishing ceased until October 28, when two or more large seiners made deliveries. More and more boats allied with one union assembled crews and fished during

[1] Submitted for publication November 1959.

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the following week until interrupted by full moon. At the beginning of the new dark, the night of November 10, the entire fleet went fishing. The prices agreed upon were $55 per ton for sardines, $42.50 for jack mackerel and Pacific mackerel, and $25 for anchovies.

Preseason plane scouting revealed that sardines were not nearly as abundant in the Hueneme area as they had been the season before. Airplane scouting in other parts of the Southern California region also indicated a scarcity of fish.

During the first six nights of September, sardine fishing out of Hueneme was fair. This came to an end with the full moon. When the second dark of the moon began, heavy winds caused poor fishing conditions. This bad weather and apparent fish scarcity continued from September 12 to 21. On one night during this period three boats worked from Oceanside to Hueneme, passing through calm areas, but saw no sardines. Beginning the night of September 21, some sardines were again encountered off Hueneme; however, Pacific mackeral and jack mackerel now dominated the catches. These were accepted by the canners due to the scarcity of sardines.

Most of the catches of the Hueneme fleet were made within a few miles of the mainland between Santa Barbara and Point Dume, and around Santa Cruz Island. The small boats operating out of San Pedro caught most of their fish in the Santa Monica Bay area and between Point Vicente and Point Fermin. For the larger San Pedro boats, the area yielding the greatest number of catches, according to the small sample of interviews obtained, was Cortez Bank. The second greatest number of catches was made in the area from Point Mugu to Malibu Beach. Successful hauls also were reported from Hueneme, Anacapa Island, Santa Barbara Island and Santa Catalina Island. Sardines were rare south of San Pedro.

Up to the time the entire fleet went out in November, about 12,000 tons of sardines had been landed, mostly at Hueneme. The total catch for the season was 21,000 tons. There were no cannery limits on tonnage during most of the season, for the San Pedro boats.

Fish landed at Port Hueneme were trucked to seven canneries in Central California (San Francisco, Moss Landing, Monterey) and one at Oxnard. South of Port Hueneme, fish were landed at Santa Monica, Los Angeles-Long Beach Harbor, and Newport Beach. Nine canneries operated in the Los Angeles-Long Beach area and one at Newport Beach.

The Hueneme fleet of 24 boats consisted of 13 large purse seiners, seven small purse seiners (under 60 feet), and four lampara boats. The entire fleet, including the Hueneme boats, consisted of 76 large purse seiners, 20 small purse seiners, and 36 lampara boats, a total of 132. This contrasts with 160 boats during the preceding season, and 180 in the season before that. During some years, the fleet (for all California) has been made up of as many as 375 boats. In only one season was the total lower than in 1957-58; this was in 1953-54, when it dropped to 123 boats.

Samples were collected at Port Hueneme and in the San Pedro area by personnel of the California Department of Fish and Game, and at Ensenada, Baja California, by personnel of the United States Fish and

TABLE 1

Length Composition of Year Classes in the Southern California Sardine Catch, 1957-58 Season

Age	0	1	2	3	4	5	6	7	8	9	
Year class	1957	1956	1955	1954	1953	1952	1951	1950	1949	1948	Total
Standard length mm.	M&F	M&F	M&F	M&F	M&F	M&F	M&F	M&F	M&F	M&F	M&F
138	--	1	--	--	--	--	--	--	--	--	1
140	1	--	--	--	--	--	--	--	--	--	1
142	--	--	--	--	--	--	--	--	--	--	--
144	--	--	--	--	--	--	--	--	--	--	--
146	--	--	--	--	--	--	--	--	--	--	--
148	1	2	--	--	--	--	--	--	--	--	3
150	1	--	--	--	--	--	--	--	--	--	1
152	--	2	--	--	--	--	--	--	--	--	2
154	--	--	--	--	--	--	--	--	--	--	--
156	--	--	--	--	--	--	--	--	--	--	--
158	--	--	--	--	--	--	--	--	--	--	--
160	1	--	--	--	--	--	--	--	--	--	1
162	--	2	--	--	--	--	--	--	--	--	2
164	--	3	--	--	--	--	--	--	--	--	3
166	--	--	--	--	--	--	--	--	--	--	--
168	--	--	--	--	--	--	--	--	--	--	--
170	--	--	--	--	--	--	--	--	--	--	--
172	--	--	--	--	--	--	--	--	--	--	--
174	--	--	--	--	--	--	--	--	--	--	--
176	--	--	--	1	--	--	--	--	--	--	1
178	--	--	--	--	--	--	--	--	--	--	--
180	--	1	--	--	--	--	--	--	--	--	1
182	--	1	--	--	--	--	--	--	--	--	1
184	--	2	2	--	--	--	--	--	--	--	4
186	--	--	2	--	--	--	--	--	--	--	2
188	--	--	3	2	--	--	--	--	--	--	5
190	--	--	4	3	--	--	--	--	--	--	7
192	--	--	9	6	--	--	--	--	--	--	15
194	--	--	9	6	--	--	--	--	--	--	15
196	--	2	6	6	--	--	--	--	--	--	14
198	--	--	12	13	--	1	1	--	--	--	27
200	--	1	15	10	4	--	--	--	--	--	30
202	--	1	12	14	2	--	--	--	--	--	29
204	--	--	10	9	3	2	--	--	--	--	24
206	--	--	12	8	3	2	--	--	--	--	25
208	--	1	8	13	5	2	--	--	--	--	29
210	--	--	8	11	6	3	1	--	--	--	29
212	--	--	7	14	11	4	1	--	--	--	37
214	--	--	3	13	8	5	--	--	--	--	29
216	--	--	6	12	11	6	2	--	--	--	37
218	--	--	4	18	6	7	--	--	--	--	35
220	--	--	3	17	10	9	2	--	--	--	41
222	--	--	2	12	6	10	--	--	--	--	30
224	--	--	3	12	6	3	2	--	--	--	26
226	--	--	--	6	6	11	3	1	--	--	27
228	--	--	--	2	2	6	--	--	--	--	10
230	--	--	3	1	7	6	2	--	1	--	20
232	--	--	--	4	1	8	1	2	--	--	16
234	--	--	--	5	9	15	1	--	--	1	31
236	--	--	--	3	5	5	--	1	1	--	15
238	--	--	--	2	1	6	1	--	--	--	10
240	--	--	--	4	5	6	3	--	--	--	18
242	--	--	--	3	2	4	1	--	--	--	10
244	--	--	--	1	--	3	2	--	--	--	6
246	--	--	--	3	--	3	1	--	--	--	7
248	--	--	--	1	2	3	1	--	--	--	7
250	--	--	--	--	--	1	--	--	--	--	1
Totals	4	19	143	235	121	131	25	4	2	1	685
Mean lengths	150	173	204	213	221	227	229	232	233	(234)	

TABLE 2

Length Composition of Year Classes in the Baja California Sardine Catch, 1957-58 Season

Age	0	1	2	3	4	5	6	7	
Year class	1957	1956	1955	1954	1953	1952	1951	1950	Total
Standard length mm.	M&F	M&F	M&F	M&F	M&F	M&F	M&F	M&F	M&F
122	--	1	--	--	--	--	--	--	1
124	2	4	--	--	--	--	--	--	6
126	--	4	--	--	--	--	--	--	4
128	1	14	--	--	--	--	--	--	15
130	--	23	--	--	--	--	--	--	23
132	3	30	--	--	--	--	--	--	33
134	2	29	--	--	--	--	--	--	31
136	--	35	--	--	--	--	--	--	35
138	--	16	--	--	--	--	--	--	16
140	2	16	--	--	--	--	--	--	18
142	--	9	--	--	--	--	--	--	9
144	--	4	--	--	--	--	--	--	4
146	--	1	--	--	--	--	--	--	1
148	--	--	--	--	--	--	--	--	--
150	--	2	--	--	--	--	--	--	2
152	--	3	--	--	--	--	--	--	3
154	--	4	1	--	--	--	--	--	5
156	--	1	--	--	--	--	--	--	1
158	--	4	--	--	--	--	--	--	4
160	--	3	1	--	--	--	--	--	4
162	--	1	1	--	--	--	--	--	2
164	--	--	--	--	--	--	--	--	--
166	--	1	--	--	--	--	--	--	1
168	--	1	1	--	--	--	--	--	2
170	--	1	--	--	--	--	--	--	1
172	--	--	1	1	--	--	--	--	2
174	--	--	2	--	--	--	--	--	2
176	--	1	3	--	--	--	--	--	4
178	--	--	6	3	--	--	--	--	9
180	--	--	6	2	1	--	--	--	9
182	--	1	5	4	1	--	--	--	11
184	--	5	9	7	1	--	--	--	22
186	--	3	16	4	1	--	--	--	24
188	--	--	13	9	--	--	--	--	22
190	--	3	11	10	3	--	--	--	27
192	--	--	8	15	4	--	--	--	27
194	--	--	7	11	4	3	--	--	25
196	--	1	8	12	3	3	--	--	27
198	--	1	8	14	4	2	1	--	30
200	--	2	9	8	7	4	--	1	31
202	--	--	4	6	--	1	--	--	11
204	--	--	5	15	6	2	--	--	28
206	--	--	4	9	6	6	--	--	25
208	--	--	2	4	3	6	--	--	15
210	--	--	3	6	1	3	--	--	13
212	--	--	1	8	2	1	--	--	12
214	--	--	--	4	1	3	--	--	8
216	--	--	2	1	--	--	2	--	5
218	--	--	--	2	--	1	1	--	4
220	--	--	--	--	2	--	--	--	2
222	--	--	--	--	--	--	--	--	--
224	--	--	--	--	--	--	1	--	1
Totals	10	224	137	155	50	35	5	1	617
Mean lengths	132	140	190	197	200	205	214	(200)	

TABLE 3

Calendar Dates of Lunar Months for the 1957-58 Sardine Season

Lunar month	Lunar month (number)	Dates*
"August"	468	August 11-September 8
"September"	469	September 9-October 7
"October"	470	October 8-November 6
"November"	471	November 7-December 5
"December"	472	December 6-January 1

* The fishing season began September 1 in Southern California and ended December 31. The same dates have been used for Baja California, where there is no legal restriction on the season.

Wildlife Service. Age determination was continued co-operatively by both agencies.

The 685 fish aged from the Southern California catch include ages zero through nine, with a size range of 138 through 250 mm. (Table 1). Mean lengths were 173 mm. for age-one fish, 204 mm. for age-two fish, 213 mm. for age-three fish, and 221 mm. for age-four. These sizes were appreciably smaller than for fish of comparable ages in the 1956-57 season, but not much different from those in 1955-56. There were 617 fish aged from Baja California. They included ages zero through seven, with a size range of 122 through 224 mm. (Table 2). Mean lengths were 140 mm. for age-one fish, 190 mm. for age-two, 197 mm. for age-three, and 200 mm. for age-four.

A total of 3,500 fish was measured from Southern California. The average length was 213 mm. There were two distinct size groups, one from 128 to 166 mm., with a mode at 146 mm.; and the other from 176 to 256 mm., with a mode at 216 mm. The average weight per fish was 0.28 pounds.

Calendar dates for the lunar months are given in Table 3. The lunar months comprise the periods from one full moon to the next and have been numbered serially since the 1919-20 season.

Tabulation of the age composition of the catch by lunar months (Table 4) showed the 1954 year class to be dominant in Southern California(32.5 percent of the total), with 1955 next (23.3 percent). In Baja California, the 1956 year class was dominant (45.2 percent). For both areas combined, the 1954 year class contributed the most (30.9 percent), with the 1955 year class next (22.4 percent).

REFERENCE

Wolf, Robert S., John MacGregor, Anita E. Daugherty and Daniel J. Miller
1958. Age and length composition of the sardine catch off the Pacific coast of the United States and Mexico in 1956-1957. Calif. Dept. Fish and Game, Fish Bull. 106, pp. 13-17.

TABLE 4

Age (Year-Class) Composition of the Sardine Catch in the 1957-58 Season
(Numbers of Fish are Given in Thousands, i.e. 000 Omitted)

	Catch			Number of Fish by Age (Year-Class)									
				0	1	2	3	4	5	6	7	8	9
	Tons	Percent	Number	1957	1956	1955	1954	1953	1952	1951	1950	1949	1948
Southern California[1]													
"August"	1,410	6.7	9,844	--	118	3,584	2,796	1,102	2,047	118	--	--	79
"September"	5,797	27.5	42,178	--	1,780	12,093	13,779	7,875	5,715	936			
"October"	5,883	27.9	42,203	34	473	9,116	17,386	7,225	6,516	1,047	338	--	68
"November"	6,135	29.0	42,677	1,203	1,396	7,993	11,288	7,528	9,816	2,676	350	427	--
"December"	1,882	8.9	14,341	733	1,371	2,454	3,953	2,677	2,644	509	--	--	--
Total Southern California	21,107	100.0	151,243	1,970	5,138	35,240	49,202	26,407	26,738	5,286	688	427	147
Percent			100.0	1.3	3.1	23.3	32.5	17.4	17.7	3.5	0.5	0.3	0.1
Baja California[2]													
"August"	8	0.3	72	--	--	7	36	15	11	--			--
"September"	731	29.1	6,691	--	311	1,639	3,353	682	475	134	67	--	--
"October"	446	17.7	3,848	--	169	1,475	1,304	535	342	23	--		
"November"	758	30.2	7,346	--	815	2,572	2,512	815	566	66	--	--	--
"December"	570	22.7	13,847	651	13,058	138	--	--	--	--	--		
Total Baja California	2,513	100.0	31,804	651	14,383	5,831	7,205	2,047	1,397	223	67	--	
Percent			100.0	2.1	45.2	18.3	22.7	6.4	4.4	0.7	0.2		--
TOTAL	23,620	--	183,047	2,621	19,521	41,071	56,107	28,451	28,135	5,509	755	427	147
Percent			100.0	1.1	10.7	22.1	30.9	15.5	15.1	3.0	0.4	0.2	0.1

[1] Fish landed and sampled at Port Hueneme and San Pedro.
[2] Fish landed at Ensenada and Cedros Island, sampled at Ensenada.

NOTES ON FOUR SPECIMENS OF THE PACIFIC SARDINE TAKEN IN AUGUST 1957 OFF BRITISH COLUMBIA AND OREGON

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INTRODUCTION

Although the northern limits of the range of the Pacific sardine (*Sardinops caerulea*) extend to the coast of southeast Alaska, there has not been a sustained commercial fishery for this species north of San Francisco since shortly after World War II. The few sardines now taken in the Pacific Northwest, usually fortuitously in other fisheries, are therefore of great biological interest. Herein is a description and discussion of four such sardines taken in 1957, three from British Columbia and one from Oregon. For the purposes of this discussion, the four fish will be treated as one sample.

RESULTS

Length, weight, age, sex, sexual maturity, date, location and method of capture were noted for these four fish (Table 1).

Although the ratio of gonad weight to body weight of the first specimen listed is more than twice that of the remainder, this fact is of little significance when the low ratios of all four fish are considered. The gonad weight/body weight ratio of a fish immediately prior to spawning may reach a magnitude of 20 percent or more.

The markings of the Oregon specimen appeared atypical as compared with fish taken in more southern localities. This specimen (preserved for more than a year in 10 percent formalin) had three lateral rows of prominent dark, oval and round spots, decreasing in size and fading posteriorly, rather than the more common pattern of one or two indistinct rows of lateral spots. The significance, if any, of this pattern is not known.

DISCUSSION

Despite the recent scarcity of the sardine in the northern portions of its range, it is apparent that, in August 1957 at least, individuals were present in that area in sufficient numbers to appear rarely in catches of other species. Since the sardine population is not randomly mixed at all times (Clark and Marr, 1955), it is of interest to attempt to determine whether the four fish of this sample exhibit characters similar to those of fish formerly caught in the Pacific Northwest, or if they are more nearly similar to the fish caught off Central and Southern

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TABLE 1

Length, Weight, Age and Maturity Data on Four Specimens of Pacific Sardine Taken in British Columbia and Oregon

Location	Date Aug. 1957	Standard length in mm.	Weight in gm.	Sex	Gonad weight in gm.	Percent gonad weight body weight	Ova diameter in mm.	State of maturity	K factor	Number of rings	Year-class	Method of capture
British Columbia, 55° N, 135° W	8	220	163	male	1.944	2.2		resting	153	4	1953	2½ inch mesh gill net
British Columbia, 55° N, 135° W	8	222	192	female	2.433*	1.0	0.16	resting	175	5	1952	2½ inch mesh gill net
British Columbia, 55° N, 135° W	8	228	200	male	2.589	1.0		resting	169	6	1951	2½ inch mesh gill net
Winchester Bay, Oregon	1	212	160	male	1.585	1.0		resting	171	5	1952	Herring seine

* Gonads mutilated, weight only approximate.

California. Unfortunately, a sample of such small size does not lend itself to statistical analysis. Thus, only criteria applicable to individual fish may be employed.

The degree of sexual maturity of these specimens is similar to that of fish spawning in the Southern California area. In each case the ratio of gonad weight to body weight was less than 3 percent, which is considered the transition point between the resting and developing stages of gonad development. This is in good agreement with data taken from southern California fish at the same time of year (MacGregor, unpublished data). Had the specimens spawned during the summer months off Northern California, Oregon or Washington, the gonads should have been in either a ripe or a spent stage, since northern spawning (when it occurs) reaches its peak about July-August (the date of capture of the specimens) and follows the period of maximum spawning intensity in the south by about three months. This conclusion is not so clear-cut as could be desired, but does indicate that these fish did not spawn in the Pacific Northwest.

Differences in size at a given age yield more definite evidence. Sardines taken in the Pacific Northwest in the past have shown a definite trend toward greater length at age *n* as compared to southern fish, particularly among three to six ring fish. The difference in standard length between fish taken in the north and those landed at San Pedro may amount to as much as 20 mm. within the above age groups (Clark and Marr, 1955). Average standard lengths of four, five and six ring sardines from Oregon, British Columbia, and San Pedro have been compared to the standard lengths of the sample fish (Table 2). A decreased growth rate, which may result from higher water temperatures or the possible depressing effect of large year-class or stock size (Int. Pac. Halibut Comm., 1954), does not suffice to explain the discrepancy between the 1957 sample and earlier samples from the Northwest. The four fish in question show a greater similarity to the growth pattern of southern California sardines.

Analysis of scale types has been employed previously to differentiate sardines of northern and southern type (Felin, 1954). This technique is of questionable value when applied to only four fish. Examination of

TABLE 2

Average Standard Lengths of 4-, 5- and 6-Ring Sardines From Oregon, British Columbia and San Pedro* in Comparison to the Standard Lengths of the Sample Fish

	Area	Number of rings		
		4	5	6
Average standard lengths	British Columbia	236	242	246
	Oregon	235	243	246
	San Pedro	214	220	226
Sample standard lengths	British Columbia	220	222	228
	Oregon	—	212	—

* After Clark and Marr, 1955, Table 9.

the scales disclosed that the annuli were better defined and that second and third year growth were proportionately greater than is found in scales from southern California fish. Indications of first year's growth and of growth subsequent to the third year were, however, similar to the southern pattern.

The evidence, then, on the basis of sexual maturity and scale types is at best inadequate to determine whether the fish under discussion are typical of those taken in the north or in the south. Age-length relationships tend to agree with the latter.

Another aspect of the problem relates to the length-frequency distributions of the 1957 commercial sardine landings at San Pedro (Wolf, unpublished data). These data indicate a modal progression from relatively smaller fish taken early in the season (mode at 206 mm. SL for the lunar period of August) to larger fish taken near the end of the season (mode at 224 mm. SL for the lunar period of December). This modal progression has been interpreted by various authors (Phillips and Clark, 1935; Clark, 1936 and 1939) as a manifestation of a southward coastal migration of larger sardines during the fall and winter. Thus it may be conjectured that larger fish in the Pacific Northwest area in August could have entered the central and southern California fisheries in the fall and winter of 1957.

SUMMARY AND CONCLUSIONS

In August 1957, four Pacific sardines were taken in Oregon and British Columbia, demonstrating the continued presence (as migrants or residents) of individuals of this species in the northern portions of their range. Observations of sexual maturity, scale type and age-length relationships were made. It may be concluded that, in general, the four fish are more similar to those taken in the south than to those formerly taken in the Pacific Northwest.

ACKNOWLEDGMENT

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AN ECONOMIC EVALUATION OF CALIFORNIA'S SPORT FISHERIES[1]

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INTRODUCTION

A full assessment of the benefits of a sport fishery is yet to be made. However, in order to obtain recognition for game fish resources when conflicts with other uses of land and water occur, it is usually necessary to define the measurable economic benefits in dollars and cents. The resultant figures, frequently referred to as values, are in most cases expenditure figures representing only a fraction of the total worth of the fishery. Expenditure figures do, however, give a definite indication of the economic status of a fishery in relation to other activities and reflect in monetary terms the importance with which the angler considers his sport. These figures are useful, applicable tools of fisheries management and have drawn attention to the impact that sport fishing has on the general economy.

Sport fishing economics is a field of rather recent origin. Evaluations of the economic benefits of angling conducted by and for the conservation agencies of a number of states and by the River Basins Section of the U.S. Fish and Wildlife Service indicated that nationwide the expenditures of anglers and hunters might be of great magnitude. Subsequently, Crossley, S-D Surveys, Inc., was engaged by the U.S. Department of the Interior to conduct the National Survey of Fishing and Hunting (U.S.F.W.S., 1956) to determine the effect on the national economy of these two activities.

A need for similar information on a statewide basis has existed in California. Although evaluations of specific fisheries (Pelgen, 1955) and watersheds have been made, no statewide information on the economic importance of hunting and fishing has been available. Since a national survey was being conducted in 1956, it was decided that this would be an appropriate time to conduct a similar survey in California.

The primary goal of the survey was to obtain the total statewide expenditures for angling and hunting in California in 1955, with a cost breakdown between saltwater and freshwater angling and the average daily and annual expenditures per angler and hunter. The latter figures were particularly sought because of their applicability in determining expenditures for individual fisheries or areas when the number of angler and hunter days are available.

This report contains a description and the results of the economic survey of angling.

[1] Submitted for publication November 1959.
[2] The author is now with the Marine Resources Branch.

SURVEY METHODS

Sampling Procedures

The survey was based on information obtained from a questionnaire mailed to persons selected for the sample. Names of anglers were obtained from the files of angling license stub books in the five administrative regions of the Department of Fish and Game. By selection at regular intervals, 17,500 stubs were drawn; from these, every fifth one was retained for this survey and the remainder were used for the annual angling survey (Calhoun, 1950).

Only buyers of resident citizen licenses (cost $3) and 3-day Pacific Ocean special licenses (cost $1) were sampled. Persons under age 16 and anglers fishing in the ocean from a public pier are not required to have an angling license, and therefore were not contacted. Persons who purchased nonresident and alien licenses were not sampled.

Data on 1955 license sales and the survey sample are presented in Table 1.

TABLE 1

Angling License Sales and Survey Sampling Data, 1955

	Resident citizen	3-day Pacific Ocean special	Non-resident 10-day	Non-resident year	Alien	Total
Licenses sold	1,241,321	43,961	12,336	3,257	2,210	1,303,085
Number sampled	3,289	71	none	none	none	3,360
Percentage sampled	0.26	0.16	--	--	--	0.26

Mailing Procedures

The mailing of questionnaires with accompanying letters of explanation (Forms A-1 and A-2 in Appendix) began February 1, 1956. A franked envelope was provided for the return of the questionnaire. The return envelopes were coded so that a record of individual returns could be kept to facilitate the sending of followup letters. One week after the initial mailing, a postal card followup (Form A-3 in Appendix) was sent as a reminder to those who had not returned the questionnaire. On March 11 a followup letter and a duplicate questionnaire (Form A-4 in Appendix) were sent to the remaining nonrespondents.

Processing the Questionnaires

Questionnaires received through April 1 were used. Table 2 indicates the number and percentage distribution of the returns.

In processing the returns, the expenditures were placed in the general categories listed on the questionnaire. Expenditures for freshwater and saltwater fishing were tabulated separately. When a respondent who fished in both salt water and fresh water reported expenditures expenditures was made between the two fisheries in proportion to the number of days reported for each. The same procedure was followed for fishing equipment, club dues, or publications, a cost division of his in allotting angling license costs.

TABLE 2

Number and Percentage of Questionnaire Returns

	Resident citizen			3-day specials		
	Number	Percentage of total returned	Percentage of total sent	Number	Percentage of total returned	Percentage of total sent
Questionnaires mailed	3,289		100.0	71		100.0
Questionnaires returned prior to mailing of followup letter	1,574	67.9		19	61.2	
Questionnaires returned after mailing of followup letter	746	32.1		12	38.8	
Total returns	2,320	100.0	70.5	31	100.0	43.6
Unusable questionnaires	358	*15.0		6	19.3	
Total usable questionnaires returned	1,962		59.6	25		35.2

* Includes returns from 116 respondents who bought a license but did not fish.

Similarly, in the general purpose equipment category, when an item was reported as having been used for both fishing and other activities, a cost division was based on the number of days the item was used for each.

A figure of 7.5 cents per mile was used to estimate automobile transportation costs.

Returns from 116 respondents (5 percent) who bought a license and did not fish were classed as unusable. Incomplete returns, returns with contradictory statements, and returns from persons other than those to whom the questionnaire was sent were also considered unusable.

TABLE 3

Distribution and Projection of Angling Effort, Resident-Citizen Licensees

	Number of respondents reporting	Percentage of total respondents	Projection to all resident-citizen anglers
Fished both fresh water and salt water	836	42.6	502,362
Fished fresh water only	897	45.7	538,920
Fished salt water only	229	11.7	137,973
Total number of resident-citizen licensees who fished	1,962	100.0	*1,179,255
Total fishing fresh water	1,733	88.3	1,041,282
Total fishing salt water	1,065	54.3	640,366

* The estimated 62,066 licensees who bought a license but did not fish have been deducted from the total number of resident licensees.

Treatment of the Data

Total expenditures for each fishery were obtained by multiplying the estimated number of persons participating in each fishery, as determined from the survey, by the mean annual individual expenditure for that fishery. The data on distribution of angling effort based on the returns from the survey are presented in Table 3.

The mean annual expenditure per angler for each fishery was calculated by obtaining the weighted mean of the initial responding group, the group replying after being contacted with the follow-up letter, and the nonrespondents.

It had previously been determined by Wallace (1956) in a survey of hunters and anglers in Washington that nonrespondents in this type of survey spent less than did the respondents. Since personal interviews with the nonrespondents in the present survey were not possible, nonrespondents were assigned the same expenditure figure as those replying after receiving the follow-up letter and second questionnaire, on the assumption that they would closely resemble this group in their expenditures.

Daily expenditure figures were obtained by dividing the mean annual expenditure per angler by the mean number of days spent fishing annually, as determined by information derived from the questionnaire.

The postal card follow-up a week after the survey started was sent to all persons in the sample, and was designed to spur the return of the questionnaires. A separate expenditure computation for persons replying after this contact was made was not used, because no significant difference between this group and the remainder of the initial responding group was noted.

Expenditures for the two responding groups are presented in Table 4.

TABLE 4

Mean Annual Expenditures of Responding Groups

	Mean annual expenditures initial respondents	Mean annual expenditures late respondents
Fresh water	$272.76	$158.45
Salt water	170.83	109.79
3-day special licenses	39.82	35.06

SURVEY RESULTS

Saltwater Angling

Expenditures of resident-citizen anglers fishing in salt water ranged from less than $1 to $2,600; expenditures of three-day special licensees ranged from $1 to $156. The mean number of days fished in 1955 by resident-citizens in salt water was 11.

An estimated $92,200,000 was spent for saltwater fishing in California in 1955; $90,637,000 by resident-citizen licensees and $1,500,000 by purchasers of three-day special licenses.

TABLE 5

Saltwater Angling Expenditures

	Mean annual expenditure	Mean daily expenditure	Median annual expenditure	Standard error of the mean annual expenditure
Resident-citizen licensees	$141.54	$12.51	$73.24	$5.63
3-day special licensees	36.16	23.49	30.00	3.61

Freshwater Angling

Statewide, freshwater anglers spent an estimated $226,884,935 in 1955. The mean number of days fished by freshwater anglers was 15. The annual expenditures of the respondents ranged from less than $1 to $13,000.

TABLE 6

Freshwater Angling Expenditures

	Mean annual expenditure	Mean daily expenditure	Median annual expenditure	Standard error of the mean annual expenditure
Resident-citizen licensees	$217.89	$14.27	$133.74	$8.04

TABLE 7

Distribution of Expenditures, Resident-Citizen Anglers, 1955

	Freshwater fishing			Saltwater fishing		
Type of expenditure	Total statewide expenditure (in thousands)	Expenditure per angler	Percentage of total	Total statewide expenditure (in thousands)	Expenditure per angler	Percentage of total
Transportation	$65,797	$63.19	29.0	$23,838	$37.23	26.3
Food	53,772	51.64	23.7	18,399	28.73	20.3
General purpose equipment	36,755	35.30	16.2	10,151	15.85	11.2
Fishing equipment	24,050	23.10	10.6	10,423	16.28	11.5
Lodging	11,344	10.89	5.0	3,444	5.38	3.8
Rentals	10,664	10.24	4.7	3,807	5.94	4.2
Bait	9,529	9.15	4.2	3,988	6.23	4.4
Gas and oil (for boats and outboard motors)	4,538	4.36	2.0	2,900	4.53	3.2
Angling license	2,495	2.40	1.1	997	1.56	1.1
Repair and maintenance	2,042	1.96	0.9	1,268	1.98	1.4
Extra vehicles	2,042	1.96	0.9	363	0.57	0.4
Party and charter boat fees	1,588	1.53	0.7	10,243	15.99	11.3
Publications	1,361	1.30	0.6	544	0.85	0.6
Club dues	907	0.87	0.4	272	0.42	0.3
Totals	$226,884	$217.89	100.0	$90,637	$141.54	100.0

The distribution of expenditures according to the major categories on the questionnaire is presented in Table 7.

DISCUSSION

Several major decisions in methodology were required in planning the survey. Initially, it was necessary to determine whether to conduct a personal interview survey or use a mailed questionnaire. Personal interviews have advantages in that a great deal of information can be collected in a relatively short period of time, with little annoyance to the contacted individual; also, the problem of nonresponse is solved to a large extent. The disadvantage is the high cost, which limits the number of contacts that can be made. In the present case, it was decided to use a mailed questionnaire. Although a great deal of information was desired and the questionnaire was long (four pages), it was believed that by pursuing a vigorous follow-up a satisfactory return could be obtained. The subsequent return (70.5 percent) was considered fully satisfactory.

The importance of using a follow-up letter in surveys of this type has been noted by Pelgen (1955) and Wallace (1952). Wallace, as mentioned previously, determined that nonrespondents spent less than did any of the groups responding by mail and therefore applied to the entire nonrespondent group the average expenditure of the portion of nonrespondents contacted personally. Nonrespondents in the present survey were assigned the same expenditures as those of the followup group in an effort to eliminate any upward bias; however, since data on the expenditures of nonrespondents were lacking, a likelihood of some bias does exist.

It has been decided, in preparing the survey, to consider only expenditures made for fishing during 1955. The procedure of amortizing all fishing equipment and related gear owned by the respondents over an expected period of usefulness was discarded in favor of the former method, to facilitate the editing and handling of the questionnaires.

The accuracy of the data collected in the survey is dependent upon the memory of the respondents. Factors of prestige and the memory-bias complex, which were noted by Atwood (1956) to have affected the accuracy of the returns in a survey of duck hunter take, may very well affect the returns on economic surveys as well. On the other hand, these factors may be compensating. In any event, they are unmeasured, and the respondents' answers must be taken at face value.

To those unfamiliar with California's sport fisheries, the expenditure for a recreational pursuit might seem extremely high. However, the vast array of equipment that can be seen on California's waters, ranging from cane poles to custom fly rods and from inner tubes to seagoing yachts, illustrates the tangible effects that sport fishing has on the welfare of the State. Measurement of the intangibles still provides us with a formidable challenge.

ACKNOWLEDGMENTS

I wish to thank Alice Matsuhara, Norma Coates, and Viola Kobriger, who contributed a great deal of assistance with the clerical portion of the survey.

SUMMARY

A statewide economic evaluation of sport fishing in California was conducted by the Department of Fish and Game in 1956.

The survey was based on information obtained from a questionnaire mailed to a random sample of angling license buyers.

Results of the survey indicated that in 1955 saltwater anglers spent an average of $141.54 annually and $12.51 daily for a total estimated expenditure during the year of $92,200,000. This total includes $1,500,000 expended by purchasers of three-day special licenses, who spent an average of $36.16 for their three days of angling.

Anglers fishing in fresh water spent an average of $217.89 annually and $14.27 daily, with an estimated total of $226,884,935 for the year.

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APPENDIX

Form A-1

ECONOMIC SURVEY OF CALIFORNIA FISHERMEN

INSTRUCTIONS

1. In filling out this questionnaire, list only expenditures and fishing trips you made *in California in 1955*. Include days and expenses when taking clams, crabs, abalones, lobsters, frogs, and all kinds of fish.

2. *Consider San Francisco Bay and all other waters inside the Golden Gate as fresh water.*

3. Your best estimate is adequate if you do not remember exactly how much you spent. All information given will be held in confidence.

4. Please complete the questionnaire even if you spent little or nothing.

WHAT WAS THE TOTAL NUMBER OF DAYS YOU FISHED IN *FRESH WATER* IN CALIFORNIA IN 1955? *(INCLUDE SAN FRANCISCO BAY AND ALL OTHER WATERS INSIDE THE GOLDEN GATE.)*

_______ days.

WHAT WAS THE TOTAL NUMBER OF DAYS YOU FISHED IN *SALT WATER* IN CALIFORNIA IN 1955? *(INCLUDE ALL BAYS EXCEPT SAN FRANCISCO BAY AND OTHER WATERS INSIDE THE GOLDEN GATE.)*

________ days.

	Freshwater fishing trips	*Saltwater fishing trips*
About how many miles did you drive your car on California fishing trips in 1955? (Do not include trips in cars of others.)	Miles driven ______	Miles driven ______
What were your other transportation expenses (train, bus, plane, parking, entrance, bridge, and ferry tolls) that may be directly charged to fishing trips? (Exclude gas and oil expenditures.)	$__________	$__________
About how much did you spend for food, restaurant meals, liquor, snacks, candy, ice cream, etc., on your fishing trips in 1955?	$__________	$__________
About how much did you spend for lodging on your fishing trips in 1955?	$__________	$__________
About how much did you spend for oil and gas for your outboard motor or boat on fishing trips in 1955?	$__________	$__________
About how much did you spend for *rentals* of motors, boats, horses, camping gear, and fishing gear for use on your fishing trips in 1955?	$__________	$__________
About how much did you spend for bait on your fishing trips in 1955?	$__________	$__________
About how much did you spend for party boat and charter boat fees on your fishing trips in 1955? (Consider San Francisco Bay and other waters inside the Golden Gate as fresh water.)	$__________	$__________

Form A-1

ECONOMIC SURVEY OF CALIFORNIA FISHERMEN—Continued

FISHING EQUIPMENT

If you *bought or received* in 1955 any of the items on the following list:

1. Give the price paid or approximate value of the item.
2. Give the number of days the item was used in California for each type of fishing.

Item	*Cost or value*	*Number of days used for freshwater fishing*	*Number of days used for saltwater fishing*
Saltwater rods	$____	______	______
Freshwater rods	______	______	______
Saltwater reels	______	______	______
Freshwater reels	______	______	______
Lines	______	______	______
Lures	______	______	______
Hooks, sinkers, etc.	______	______	______
Tackle box	______	______	______
Creel	______	______	______
Landing net	______	______	______
Gaff	______	______	______
Scales (deliars, etc.)	______	______	______
Knives	______	______	______
Other items (please specify)	______	______	______
______________________	______	______	______
______________________	______	______	______

GENERAL PURPOSE SUPPLIES AND EQUIPMENT

If you *bought or received in 1955* any of the items on the following list which may be charged directly to fishing:

1. Give the price paid or approximate value.
2. Give the number of days the item was used in California for each type of fishing.

Item	*Cost or value*	*Number of days used for freshwater fishing*	*Number of days used for saltwater fishing*	*Number of days used for other outdoor activities*
Tents	$______	______	______	______
Sleeping bags	______	______	______	______
Cooking equipment	______	______	______	______
Ice box	______	______	______	______
Packs	______	______	______	______
Tables	______	______	______	______
Lanterns	______	______	______	______
Special fishing clothes	______	______	______	______
Boots and waders	______	______	______	______
Boats	______	______	______	______
Boat accessories	______	______	______	______
Motors	______	______	______	______
Boat trailers	______	______	______	______
House trailers	______	______	______	______
Skin diving equipment	______	______	______	______
Other items (please specify)				
______________________	______	______	______	______
______________________	______	______	______	______

Form A-1

ECONOMIC SURVEY OF CALIFORNIA FISHERMEN—Continued

REPAIR AND MAINTENANCE

How much did you spend for repair and maintenance in 1955 for all items that you own and used for fishing in California in 1955? Specify item and give total cost of repair and maintenance for item.

Item	*Cost for repair and maintenance*	*Number of days used for freshwater fishing*	*Number of days used for saltwater fishing*	*Number of days used for other outdoor activities*
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______

If you purchased an extra vehicle (such as a jeep or pickup) for fishing in 1955, what was its cost? ______ $______

Number of days vehicle used on saltwater fishing trips ______ ______.

Number of days vehicle used on freshwater fishing trips ______ ______.

Number of days vehicle used for other purposes ______ ______.

How much did you spend on books concerning sport fishing in 1955? $______.

Do you belong to a sportsmen's club? ☐ Yes ☐ No

How much did you spend on fishing club dues and donations in 1955? $______

Did you have any other expenditures for fishing in 1955? If so, please list.

Item	*Cost or value*	*Number of days used for freshwater fishing*	*Number of days used for saltwater fishing*	*Number of days used for other outdoor activities*
______	$______	______	______	______
______	$______	______	______	______
______	$______	______	______	______

If you would like to receive a summary of the report on this survey when it is completed, please give your name and address: ______

______

______

COMMENTS: ______

______

______

Form A-2

FELLOW ANGLER:

California's sport fisheries are one of its greatest recreational assets. As such, they must be properly managed to insure fishing for the present and future generations. To accomplish this, we need more information from the individual angler. This is where you come in.

Our angler surveys give us reliable estimates of the total number of days anglers in California spend at their favorite sport. If we can estimate the average cost of a day's fishing, we can determine the total expenditure for sport fishing in the State.

We are therefore asking a selected number of anglers to tell us what they spent on sport fishing in California in 1955. Will you please help? All we ask you to do is:

Give your best estimates of the information requested, and return the questionnaire in the enclosed envelope. Your answer is important, regardless of how little or how much you may have spent.

You need not sign the questionnaire. However, a place is provided for your name and address if you wish to receive a report of this survey when it is completed.

You may rest assured that all information received will be held in strict confidence.

Thank you for your co-operation.

Sincerely yours,
Director

Form A-3

FELLOW ANGLER:

The information we requested from you recently for our economic survey is urgently needed. You are representing 350 other anglers in this survey, so you can see how important it is for us to have your answers.

All information received will be held in confidence.

Director
California Department of
Fish and Game

P.S. If you have already returned your questionnaire, please ignore this notice.

Form A-4

FELLOW ANGLER:

We have not yet received the questionnaire we sent you several weeks ago. Perhaps you did not realize how badly the information was needed in conection with our efforts to maintain and improve angling in California.

You are one of only a few hundred anglers who were included in this statewide survey. Whether you fished a little or a lot, your record will represent an extremely important part of the over-all picture. Will you please provide us with this record by filling in the questionnaire and returning it to us.

Another questionnaire is enclosed just in case the first one did not reach you or has been misplaced.

Thank you for your co-operation.

Sincerely yours,
Director

OBSERVATIONS ON THE SPAWNING OF SACRAMENTO HITCH IN A LACUSTRINE ENVIRONMENT[1]

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The Sacramento hitch, *Lavinia e. exilicauda*, is a large Californian minnow native to the Sacramento-San Joaquin drainage basin and several related basins. It serves as forage for warmwater game fishes during their first year of life, but grows too large for this purpose in its second year.

In at least two instances, unauthorized introductions of hitch have occurred in trout lakes. The hitch competed with trout to such an extent that they had to be eradicated before a trout fishery could be maintained.

Prior to 1959, the hitch commonly was sold in central California as a bait fish. These fish were seined from wild stocks, rather than being raised domestically.

Murphy (1948b) made extensive observations on the biology of the species in Clear Lake[2], California. He concluded from this study that hitch required streams with a gravel bottom for successful spawning. Such a requirement would have important management implications, for it would make the species easy to control by barring spawning access to tributary streams.

More recently, however, there have been indications that hitch can spawn in lakes. Fish rescue crews have found hitch-of-the-year in isolated ponds where the adults apparently had no access to a stream. A large, self-sustaining population of hitch existed in Lake Merced, San Francisco County, before its chemical treatment to remove rough fish in 1949. This population also had no evident access to a spawning stream. Proof of lake or pond spawning was never conclusive, however, because the observations were cursory.

On May 21, 1956, the writer and H. E. Pintler observed hitch in Clear Lake at the Lakeport city park beach engaged in the typical spawning movements of chasing, rapid swimming, and splashing commonly observed on stream riffles. About 50 hitch were involved.

The depth of the water was from one to five inches. The gravel ranged from one-quarter to two inches in diameter. Wave action had cleaned a band of gravel about three feet wide near the shore. The interstices of the gravel in this area contained no silt or other debris. There was moderate wave action, but the water was less turbulent than that of some stream riffles in which hitch have been observed spawning. A school of carp was feeding over the area in which the hitch were active. No attempt was made to collect hitch eggs.

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[1] Submitted for publication October 1, 1959.
[2] For a detailed description of Clear Lake see Murphy, 1951.

During 1956, various local residents were asked if they had seen hitch spawning in Clear Lake. Mr. Nick Miholovich, Clear Lake Oaks, reported that hitch spawned annually along the shores at Clear Lake Oaks. He agreed to advise the writer when activities began in 1957. He did so on April 25, 1957, when a large group of hitch ranging from 6 to 14 inches in length moved into the shallows.

Detailed observations were made by the writer between 11 a.m. and 9 p.m. on May 3, 1957. The water temperature was 64 degrees F. No hitch ventured into the shallows until about 3 p.m., when several small groups of 6 to 10 were seen near the shore. No spawning was noted until 7 p.m. This delay was due apparently to angler activity on the beach. The spawning behavior resembled that observed previously in streams and along the beach at Lakeport. Pairs or groups of fish would force themselves into the shallows until their backs were exposed. They pressed their bodies closely together, and wriggled and splashed vigorously. Some fish became so excited that they dashed onto the bank far enough to become stranded and die.

One haul with a 30-foot, one-half-inch bar mesh beach seine caught 15 hitch, all with flowing eggs or milt.

A stream-type bottom sampler was used in the backwash from the waves in an attempt to collect eggs. The depth of the sampled area ranged from one-half to four inches. The gravel was well washed, with no debris in the interstices, and varied from one-quarter to three inches in diameter. In collecting, the bottom was stirred by hand and anything floating was washed back into the sampler by wave action. Three eggs were collected in this manner. No eggs were found when the sampler was moved offshore to a point where the water was one foot deep, and the influence of the wave action on the bottom somewhat less. No eggs were collected offshore by towing a plankton net.

The collected eggs were identical in appearance with hitch eggs described by Murphy *(op. cit.)*. They were taken to the laboratory and placed with gravel in an aquarium filled with Clear Lake water. The temperature was held at 62 degrees F., with moderate aeration. The stage of development at collection was not noted. The eggs hatched in two days, and the fry were held in aquaria for 54 additional days. At the end of this period they were identified as hitch and preserved. The average length at this time was 11.3 mm. This rate of growth is not comparable with natural growth, since no special effort was made to provide normal food.

The newly emerged fish have a very small amount of yolk. The mouth is not developed. In the aquarium they swam upward rapidly with quick, wriggling movements, became suddenly inactive, and fell head downward to the bottom, where they lay in whatever position they hit for several minutes before repeating the process. It was three days before they were able to maintain a position in the middle layers without falling to the bottom. At this time they were also able to swim in a fairly straight line and appeared to be seeking food.

On May 9, 1957, more sampling at the Clear Lake Oaks beach secured several hundred eggs in various stages of development. These were also hatched in the laboratory, and the larvae were identified as hitch after being reared approximately 50 days.

A plankton net towed near the shore on May 9 captured three newly hatched hitch. However, no schools of fry were seen in the course of an intensive search.

The newly emerged hitch could not have been spawned in a stream, since none exists near the collecting point. The nearest one is Schindler Creek, about one mile from the collection site. Although it was flowing at the Highway 20 bridge during these observations, no hitch were observed there on May 9. Spawning hitch were observed, however, in Middle Creek near Upper Lake and in Lyons Creek, approximately 20 miles from Clear Lake Oaks, on May 3, 1957.

A two-acre farm pond in the N.W. ¼ of Section 30, T. 14 N., R. 7 W., M.D.B. & M. (Figure 1), in the Schindler Creek drainage also was investigated on May 9, 1957, in connection with a reported self-sustaining hitch population.

FIGURE 1. Farm pond in the Schindler Creek drainage with a self-sustaining hitch population. *Photograph by J. B. Kimsey, May 9, 1957.*

This pond had a large population of hitch, reportedly started by a plant from Clear Lake in 1948. No further details on the source are available.

The pond has no established connection with the creek, and plant growth is heavy along the margins. The bottom is mud, with no gravelly areas. Parts of the pond have been either dredged or bulldozed, and the spoil heaps remain around three sides. The source of water is natural runoff from pasture land. Migration of hitch into this pond is unlikely, even if it were to overflow extensively.

The nature of the runoff into the pond is sheet-like rather than occurring in specific small streams. During heavy or sustained rainfall, small tributary streamlets can develop. However, these do not last long enough to serve as spawning tributaries. The apparent streams entering from the left in Figure 1 are remnants of former Schindler Creek channels no longer associated with the creek and without current. The present creek channel lies well beyond the lake in the center background of Figure 1 and passes behind the large spoil heap.

A minnow dealer was harvesting the hitch from the pond. From his statements it was estimated that he collected 60,000 hitch ranging from 1.5 to 5.0 inches fork length in 1956. The operation had been going on for several seasons. It is evident that there was a self-sustaining population of hitch in the pond.

These observations demonstrate that all hitch are not obligatory stream spawners and that populations can be maintained in ponds or lakes without substantial inflow. Stream conditions of gravel, turbulence, and well mixed water can be satisfied on lake shores with moderate wave action and suitable gravel. However, they are not essential. The pond population described is maintaining itself in substantial numbers without gravel shores in an area too small to provide sustained wave action.

During years of short or low tributary flow into Clear Lake, eggbound hitch are regularly found in the lake long after the normal stream spawning season is over. These fish obviously are not going to spawn, even though adequate shore spawning gravels are available. This suggests that one segment of the population is actually obligatory stream-spawning in habit.

There is no morphological evidence to indicate that there are two species of hitch in Clear Lake.

Even though some hitch may spawn in the lake itself, it is possible to have virtually no recruitment in the Clear Lake hitch population during a dry year. Murphy *(op. cit.)* reports such a situation in 1946 and again in 1947. His observations on hitch running into an artificial freshet provided by a pumping operation also indicate that some hitch are obligatory stream spawners.

Why shore spawners are unable to contribute significantly to recruitment in years like 1946 and 1947 is not definitely known. Schools of carp, such as those observed working over the shore spawning area at the Lakeport beach in May, 1957, may consume many of the eggs and larvae. Murphy (1948a) postulated that the predation of introduced species such as the carp, bluegill, and catfish on the unguarded eggs of the Sacramento perch, *Archoplites interruptus*, had been the principal cause of its decrease in numbers. In the intermittent streams where Clear Lake hitch regularly spawn, populations of egg predators do not build up as they do in the lake. This may explain why Clear Lake depends upon stream spawning hitch for recruitment, rather than upon lake shore spawners.

These observations have an important fisheries management implication. Hitch are not obligatory stream spawners, and appropriate precautions must be taken against introducing them into new waters even when there are no tributary streams. The two types of spawners cannot, at this time, be differentiated morphologically, nor can dependence be placed on the premise that either kind of spawning is obligatory for certain individuals.

SUMMARY

The Sacramento hitch, *Lavinia e. exilicauda*, is not an obligatory stream spawner in the Clear Lake, California, drainage basin. Successful spawning along the shore at Clear Lake Oaks was observed in May, 1957. A farm pond population was also observed to be maintaining itself without access to a stream.

The management implication that hitch populations can be controlled by barring access to spawning streams is no longer valid.

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A STUDY OF WATERFOWL NESTING IN THE SUISUN MARSHES[1]

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INTRODUCTION

The Suisun Marshes, an area comprising approximately 140 square miles in Solano County, California, was the locale of a duck nesting study conducted from late April to July 1, 1959.

To all appearances, large sections of the Suisun Marshes possess the requirements essential to waterfowl production, being favored with a sufficiency of food, nesting cover, and water. However, it has been long apparent to investigators that duck nesting in this area falls far below expectations.

This region has been included in the department's annual breeding ground surveys since 1949. These surveys were made from aircraft. A study of production was made on the ground during the nesting season of 1953.

The objectives of the present investigation were to evaluate production as compared with that of 1953, and to determine any factors tending to discourage a normal nesting population.

The Suisun Marshes consist largely of an intricate system of sloughs and channels separating land areas. Some of these land areas are so dry during the spring and summer months that they are of little value as duck nesting habitat. The State Waterfowl Management Areas, Grizzly Island and Joice Island, comprise somewhat over 10,000 acres. A substantial portion of Grizzly Island is planted to waterfowl food crops, mainly barley. The remainder of the Suisun area is for the most part occupied by gun clubs and devoted to waterfowl shooting during the open season. The marsh supports a relatively high wintering population of birds, and the hunting success has compared favorably with that of other California wetlands.

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VEGETATION

The most abundant submerged waterplant in sloughs and ponds was ditch grass *(Ruppia maritima)*, while horned pondweed *(Zannichellia palustris)*, and sego pondweed *(Potomageton pectinatus)* were common in some localities. Extensive stands of the latter species have disappeared because of damage by carp *(Cyprinus carpio)*.

The problem of controlling undesirable climax growth in the Suisun marshes is difficult because of high water tables. Vast flats are covered with pickleweed *(Salicornia pacifica)*. Other marshy areas still have stands of brass button *(Cotula coronopifolia)*, saltgrass *(Distichlis spicata)* and arrow grass *(Triglochin maritima)*, interspersed with alkali bulrush *(Scirpus robustus)*, smartweed *(Polygonum* sp.), dock *(Rumex* sp.), and baltic rush *(Juncus balticus)*. Unfortunately, however, there is a marked tendency for low growing, desirable food plants, as well as, shallow open water areas to be gradually replaced by dense stands of hardstem bulrush or tule *(Scirpus acutus)*, Olney bulrush *(Scirpus olneyi)*, and cattail *(Typha* sp.). Scattered here and there throughout the marsh are clumps of common reed *(Phragmites communis)*, although this species has not become a major pest in this locality.

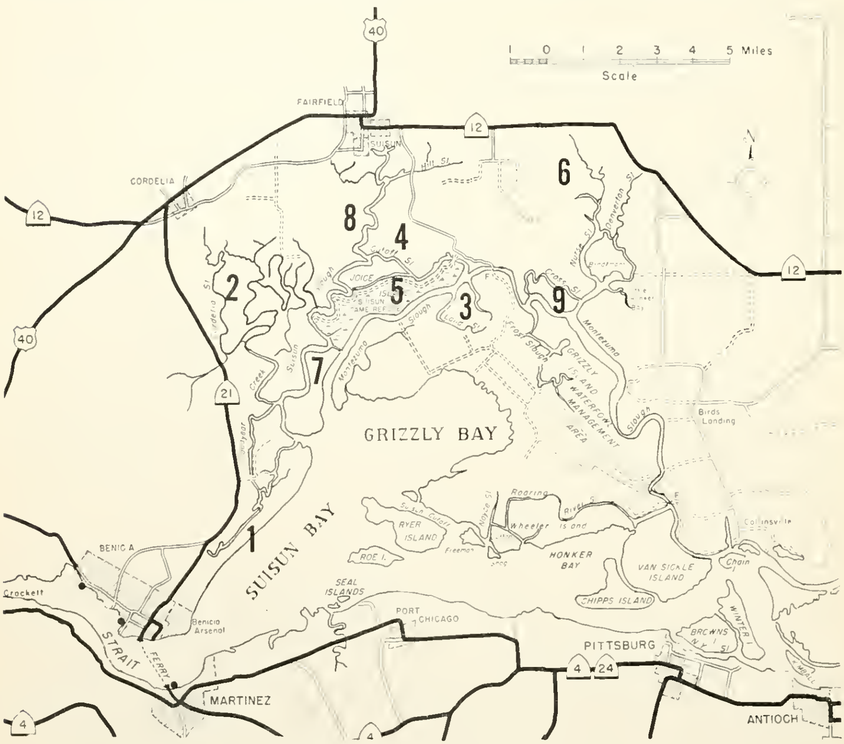

FIGURE 1. Map of study area.

Plant species found growing on ditch banks, levees, and the drier parts of the marshes were too numerous for a complete list to be included in this report. However, this should not be interpreted as an attempt to minimize their importance as a source of food and cover for waterfowl. Among the most prominent of these plants were fat hen saltbush (*Atriplex patula var. hastata*), Australian saltbush (*Atriplex semibaccata*), coyote bush (*Baccharis pilularis*), pigweed (*Chenopodium* sp.), alkali heath (*Frankenia grandifolia*), gum plant (*Grindelia cuneifolia*), silverweed (*Potentilla anserina*), and sand spurry (*Spergularia* sp.)

STUDY PLOTS

From the annual aerial breeding ground survey figures and from the nesting study made on the ground in 1953, it was anticipated that nesting pairs of ducks would be few and scattered. In order to have a large enough sample to determine the degree of nesting success it was necessary to use study areas which showed reasonable promise of fair nest density. But it was also considered desirable to sample representative sections of the region as well as divergent types of habitat, although this meant searching large areas with poor yields or negative results.

TABLE 1

Sample Plots for Suisun Marsh Nesting Study

Area no.*	Name	Size	Number of nests
1	Benicia area	280 acres	5
2	Cordelia area	100 acres	2
3	Grizzly Island	600 acres	5
4	Volanti Club	600 acres	33
5	Joice Island	300 acres	7
6	Denverton area	420 acres	11
7	Joice Island Gun Club	60 acres	--
8	Sheldon Gun Club	20 acres	
9	Can-Can Gun Club	40 acres	--
	Totals	2,420 acres	63

* Area number corresponds to numbers on map (Figure 1).

Table 1 lists the study plots and a map of the area is shown in Figure 1. The Benicia area included approximately 200 acres of Pahl's Gun Club and 80 adjoining acres. This club was favored with abundant shallow water and desirable vegetation, but good nesting sites were somewhat scarce. The Cordelia area comprised a portion of the Cordelia Gun Club and the Scanlon property. This area featured several ponds and sloughs but the vegetative cover consisted mostly of tules and pickleweed.

On Grizzly Island 350 acres of barley and volunteer grasses were investigated on the State Waterfowl Management area and 250 acres of ditch banks and marsh on adjoining club lands.

The Volanti Gun Club had the highest nest density of any area covered. It was characterized by ponds and sloughs bordered by saltgrass, pickleweed, and patches of baltic rush. Stable water levels persisted throughout the study period. The nests on Joice Island were found in dry marsh and on ditch banks. Those in the Denverton area were located in saltgrass and pickleweed surrounding shallow ponds.

Three other areas were searched without revealing any nests (Table 1). The vegetative cover there was largely heavy tules.

PROCEDURES

The methods used to evaluate production were similar to those applied in previous nesting studies conducted by the department (Miller and Collins, 1954, Hunt and Naylor, 1955).

Active nests were usually found by flushing hens from the nests. These were marked to facilitate relocation, given a number, and recorded on IBM Porta Punch cards.

Objections have occasionally been made to this method of determining production on the premise that the activities of the investigators result in biases which impair the value of data. It is probably true that some desertion is caused by flushing the female ducks from the nests, especially in cases where the nests were located before incubation was advanced. However, past experience in different parts of California indicates that the present method is the most practical means of obtaining reliable production data without undue bias.

Suspicions have been voiced that trails made by the investigators may lead mammalian predators to the nests, but it must be remembered that an average of two or a maximum of four visits is sufficient to complete a nest history. Caution is exercised to keep human disturbance at an absolute minimum. A nesting study on the grasslands of the San Joaquin Valley, during 1954 (Anderson 1956), showed that 50 percent of the destroyed nests already had been disrupted before the nests were located.

FIGURE 2. Rank climax vegetation invading pond area. *Photograph by author.*

SPECIES COMPOSITION AND NEST SITES

A total of 63 nests were located, 27 of which were mallard, 33 cinnamon teal, and 3 gadwall. The composition of nesting species indicated by these figures does not correspond with the aerial survey conducted on May 20, 1959, because it is difficult to cover completely such a large and complex area on the ground. The following estimates were made of breeding pairs for the Suisun Marsh from aircraft: mallard *(Anas platyrhynchos)* 760; pintail *(A. acuta)* 30; gadwall *(A. strepera)* 270; cinnamon teal *(A. cyanoptera)* 110; shoveler *(Spatula clypeata)* 30; and ruddy duck *(Oxyura jamaicensis)* 40.

The aerial breeding ground survey tabulated a coot *(Fulica americana)* population numbering 1,080 pairs. Apparently, few of these, if any, remained to breed in this locality since no coot nests were found during the period of the study.

TABLE 2 *

Waterfowl Nest Sites

Species	Dike		Marsh		Uncult. field		Total	
Mallard	6	(22.2)	15	(55.6)	6	(22.2)	27	(100.0)
Cinnamon teal	1	(3.0)	30	(90.9)	2	(6.1)	33	(100.0)
Gadwall			3	(100.0)			3	(100.0)
Totals	7	11.1	48	76.2	8	12.7	63	100.0

* Percent in parentheses.

TABLE 3 *

Nesting Site Cover Types

Species	Juncus		Saltgrass		Pickleweed		Others		Total	
Mallard	15	(55.6)	2	(7.4)	4	(14.8)	6	(22.2)	27	(100.0)
Cinnamon teal	2	(6.1)	29	(87.8)	2	(6.1)	--		33	(100.0)
Gadwall	-	-	2	(66.7)	1	(33.3)	-	-	3	(100.0)
Totals	17	(27.0)	33	(52.4)	7	(11.1)	6	(9.5)	63	(100.0)

* Percent in parentheses.

Tables 2, 3, and 4, showing nest sites, cover types and distance of nests from open water apply to the nests included in the sample. Factors which cannot be shown in these tables may be explained as follows: The mallard nests were thinly scattered throughout this immense area, sometimes in upland fields far from water as evidenced by the presence of broods of downy young in the vicinity of such fields. Their nests, therefore, were not located as readily as those of cinnamon teal. The latter species demonstrated a marked preference for nest sites in matted saltgrass beds within a few yards of water. The three gadwall nests were located near water in a marshy area.

TABLE 4 *

Distance to Water from Nest Site

Species	Within 3 yds.	4–50 yds.	51–100 yds.	Over 100 yds.	Total
Mallard	7 (25.9)	17 (63.0)	1 (3.7)	2 (7.4)	27 (100.0)
Cinnamon teal	18 (54.5)	15 (45.5)			33 (100.0)
Gadwall	1 (33.3)	2 (66.7)			3 (100.0)
Totals	26 (41.2)	34 (54.0)	1 (1.6)	2 (3.2)	63 (100.0)

* Percent in parentheses.

In Table 2 it is shown that nests were located in three main types of sites: Dikes included levees, ditch banks, and roadsides; marsh denoted areas that had been flooded over a long enough period to support typical marsh vegetation; and uncultivated fields consisted of land that was not currently cultivated and which supported upland types of vegetation.

It was believed that some mallards nested in cultivated fields although no nests were found in this type of habitat.

It has been explained earlier that the Suisun Marsh consists of land areas separated by sloughs and channels. However, it was decided that for the purpose of this study the designation "island" should not be applied unless the sites were surrounded by a sufficient water barrier to afford protection from mammalian predators.

FATE OF NESTS

The fate of all nests is shown in Table 5. The habit of cinnamon teal in nesting along sloughs in low cover apparently contributed to the high incidence of predation as indicated in the table.

TABLE 5 *

Fate of Nests by Duck Species

Species	Hatched	Destroyed	Deserted	Total
Mallard	14 (51.9)	8 (29.6)	5 (18.5)	27 (100.0)
Cinnamon teal	12 (36.4)	14 (42.4)	7 (21.2)	33 (100.0)
Gadwall	2 (66.7)	1 (33.3)		3 (100.0)
Totals	28 (44.4)	23 (36.5)	12 (19.1)	63 (100.0)

* Percent in parentheses.

Some nests probably were robbed by skunks *(Mephitis mephitis)* and Norway rats *(Rattus norvegicus)*, but most predation was attributed to raccoons *(Procyon lotor)*, whose tracks in some instances led to recently destroyed nests.

One mallard nest was destroyed by a marsh fire. Another mallard nest was destroyed by a mowing machine and the incubating bird killed.

The admittedly small samples of successful nests showed an average clutch size of nine eggs for each of the three species concerned. In 11 mallard nests all 99 eggs hatched, but three dead young were found in one of the nests. It was not possible to determine the cause of death.

Out of 119 cinnamon teal eggs, 116 hatched, and three contained dead embryos. The two successful gadwell nests hatched all 18 eggs.

TABLE 6

Time of Nesting Activity—(Active Nests Only)

Species	April	May			June		
	20-30	1-10	11-20	21-31	1-10	11-20	21-30
Mallard							
Nests found	1	3	7	2	--	--	--
Nests hatched	1	--	1	3	--	--	--
First week broods			7	3	1	10	--
Cinnamon teal							
Nests found	1	3	8	8	1	--	--
Nests hatched	--	--	--	7	2	2	1
First week broods	--	--	--	1	3	3	2

Table 6 presents the available data pointing to the peak of nesting activity for mallards and cinnamon teal. The small samples tend to show two peaks for mallards, one in the middle of May and another in mid-June, perhaps an indication of renesting. Cinnamon teal reached the hatching peak during late May and early June.

BROODS

Brood observations were incidental to the study, but were made whenever an opportunity presented itself.

A total of 22 mallard broods, one-week-old or less, averaged 6.6 young. Four broods, two-weeks-old, averaged 4.5 each. Three broods, aged three-weeks, averaged two young. Most mallard broods were seen in shallow ditches where they appeared to be vulnerable to predation.

Nine broods of cinnamon teal in their first week of development averaged 5.9 young. Only two broods were seen which were estimated to be two-weeks-old. These averaged 3.5 young.

TABLE 7 *

Comparison of the Fate of Nests Between the 1953 and 1959 Studies

Year	Hatched	Destroyed	Deserted	Total
1953	14 (48.3)	14 (48.3)	1 (3.4)	29 (100.0)
1959	28 (44.4)	23 (36.5)	12 (19.1)	63 (100.0)

* Percent in parentheses.

Although no shoveler nests were located, two one-week-old broods were observed. These averaged six young each.

Comparison With 1953 Study

A comparison between the results of a study of local nesting conditions in 1953 and 1959 (Table 7) reveals little difference in hatching success although predation was somewhat less prevalent and nest desertion occurred more frequently in the present study.

During 1953, 22 mallard nests, five cinnamon teal, one gadwall, and one pintail nest were found as compared to 27 mallards, 33 cinnamon teal and three gadwall in 1959. The most obvious difference here is in the increased cinnamon teal nest sample located in 1959. The breeding ground survey did not show a parallel increase in nesting pairs. Improved conditions on one of the study plots may possibly account for this difference.

DISCUSSION

Results of the present study confirmed earlier concepts regarding the disappointing status of the Suisun Marsh as a waterfowl breeding area. No specific factor could be singled out as a sufficiently important reason why this area should not support a far larger nesting population than it now does.

The unfavorable features encountered in this region include the overwhelming proportion of rank climax vegetation composed largely of hardstem bulrush, Olney bulrush, and cattail. The combination of these extensive stands of coarse vegetation and steep banked tidal sloughs prevailing over large sections of the marsh was obviously incompatible to waterfowl nesting (see Figure 3.)

FIGURE 3. Typical tidal slough in Suisun Marsh. *Photograph by author.*

It is the practice of many gun clubs to drain their lands after the hunting season. The subsequent drying and contracting of the spongy peat soil soon results in the formation of great cracks criss-crossing such areas (see Figure 4.) It is doubtful if many ducklings hatched in this kind of environment would be able to avoid these pitfalls and safely reach open water.

FIGURE 4. Cracked ground on Joice Island, Suisun Marsh. *Photograph by A. W. Miller.*

Predation was shown to be a significant factor, especially among broods of young ducks. Raccoons are known to be abundant. It is suggested that persistent harrassment by these and other predators could have a discouraging effect upon prospective nesting ducks and coots. The insular nature of many areas in the Suisun Marshes makes it entirely feasible to test the effectiveness of predator control on increasing nesting success.

SUMMARY

1. A study of duck nesting in the Suisun Marshes, Solano County, California was conducted from late April to July 1, 1959.

2. Only 63 duck nests were located, 27 of which were mallard, 33 cinnamon teal, and three gadwall. No coots were found to be nesting in the area.

3. Mallards nests were scattered thinly throughout the area. Cinnamon teal showed a preference for nest sites in saltgrass within a few yards of water.

4. Of the 63 nests included in the sample 44.4 percent hatched successfully, 36.5 percent were destroyed and 19.1 percent were deserted.

5. Hatching success in this study approximated that shown in a study made in 1953.

6. Brood observations indicated that there was a poor rate of survival among young ducks.

7. Fluctuating water levels, extensive stands of tules and cattails, and cracks in peat soils are listed along with predation as incompatible to satisfactory nesting conditions.

8. An experiment with predator control on one or more islands is suggested.

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NOTE

THE INTERPRETATION OF THE PROTEIN LEVEL IN THE RUMINAL CONTENTS OF DEER

The recent note of Bissell (1959) on the relationship of the protein content of the browse consumed by deer to the subsequent protein level of their ruminal contents raises some interesting analytical and physiological questions. While it is possible that deer are capable of selecting those parts of the browse plants that have a higher protein content than those selected for analysis by the wildlife biologist, such a conclusion cannot be accepted until a number of alternative possibilities to explain the higher ruminal protein levels can be excluded.

Since it is not stated otherwise, we must assume that the protein figures given were computed from the nitrogen level of the plants and of the ruminal contents using the conventional factor of 6.25 to convert the nitrogen values to protein content. While this assumption is frequently made in the course of feed analysis, it is pertinent to point out that the nitrogen content of plant and bacterial proteins varies considerably (Block and Bolling (1947), Porter (1946)), and as a result the conversion factor for nitrogen to protein must be used with some reservation until the chemical nature of the plant or ruminal protein is known. Furthermore, the use of the factor 6.25 is further complicated by the fact that a greater or lesser amount of the plant or ruminal nitrogen is present in the nonprotein fraction. It is generally accepted that 5 to 20 percent of the total nitrogen of plant material is present in the nonprotein form. The exact level varies with the plant species, its stage of growth, and with the soil nutrient conditions under which it is grown. It would be of interest to carry out a fractionation of the browse plants and ruminal contents to elucidate the chemical nature of their nitrogen containing constituents. The procedure developed by Wasteneys and Borsook (1924) has been used successfully for this purpose by Clarke (1938).

Nonprotein nitrogen in the form of urea, ammonia, amino acids, nucleic acids, purine and pyrimidine bases, choline, betaine, etc. are normal constituents of the ruminal contents. The ammonia may be ingested as ammonium salts or it may arise from the degradation of the amino acids and the various other nitrogenous compounds as a result of microbial activity in the rumen. For example; Pearson and Smith (1943) have shown that net synthesis of protein by the ruminal bacteria proceeds concomitant with the deamination of protein residues and other nitrogenous materials. It appears from the present literature (Arias *et al.* 1951) that the rate of disappearance of ammonia from the rumen contents tends to be a function of the energy available to the rumen microflora. It is tempting to suggest that the browse diet of deer in Lake County, California, with its low protein and high fiber content, is deficient in energy to the point that protein resynthesis does not proceed at an adequate rate to prevent the net accumulation of simpler nitrogenous substances including ammonia in the rumen.

One cannot eliminate the nitrogen contribution to the rumen fluid made by the urea present in the salivary secretions. For example: McDougall (1948) has shown that a single parotid gland of the sheep can secrete in excess of 1,800 ml. per day of saliva containing 20 mgms. percent of nitrogen in the form of urea. Inouye *et al.* (1927) has recorded that nitrogen also reaches the rumen as a constituent of salivary mucinate. In this regard Zolnikova (1941) stated that 86 to 89 percent of the total nitrogen of saliva is mucin nitrogen. Water conservation mechanisms in species with arid environment may also increase the rate of recycling of urea by the salivary route.

With reference to the earlier suggestion that deer select only the high protein parts of the fodder plants, it would be valuable to determine the protein or nitrogen fraction of washed browse material recovered from the rumens of animals immediately after eating. Parallel analyses of the various foliar parts of the browse plants would facilitate the interpretation of findings such as Bissell (1959) has reported. The questions that arise from Bissell's report certainly merit much more intensive examination by the student of wildlife nutrition.

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—*A. J. Wood and W. D. Kitts, Division of Animal Science, The University of British Columbia, B.C., Canada; and I. McT. Cowan, Department of Zoology, The University of British Columbia, B.C., Canada; November, 1959.*

NOTE ON SPRING FOOD HABITS OF THE LAKE TROUT, *SALVELINUS NAMAYCUSH*

The lake trout was first introduced into California in May, 1895, when 65,000 fry were planted in Lake Tahoe. About this time they were also planted in Donner Lake, Nevada County.

During studies of the Donner Lake kokanee salmon, *Oncorhynchus nerka*, fishery in 1949, stomachs were collected from 31 angler-caught lake trout in an effort to determine whether or not the species was a significant predator on kokanee.

The fishing season opened on May 1 in 1949, about two weeks after the ice had thawed. The spring overturn was in progress. The last lake trout known to have been taken from Donner Lake in 1949 was caught on June 6, when stratification was under way. The legal fishing season, however, continued until October 31, 1949.

During the 37-day period that lake trout fishing was productive, 44 lake trout were checked. This was very nearly the total season's catch for the species. The total weight of the catch was approximately 110 pounds or a little more than 0.1 pound per surface acre for the 750-acre lake. (Donner Lake is used as a storage reservoir, and the surface area ranges from 650 to 862 acres.) The average fork length was 17.7 inches, with a range of 11.0 to 28.0 inches.

TABLE 1

Foods Consumed by Lake Trout in Donner Lake

Class of food	Frequency of occurrence	Percentage frequency of occurrence	Percentage of total volume
Fish	27	100	98.2
1. Tui chub, *Siphateles bicolor*	16	59.2	89.2
2. Lahontan redside, *Richardsonius egregius*	1	3.7	2.4
3. Lahontan mountain-sucker, *Pantosteus lahontan*	2	7.4	1.4
4. Piute sculpin, *Cottus beldingi*	1	3.7	1.2
5. Salmonids	2	7.4	0.6
6. Unidentified	11	40.7	5.1
Surface foods (insect)	3	11.1	0.04
Bottom foods	1	3.7	0.24
Miscellaneous (wood)	3	11.1	1.4
Bait	1	3.7	0.12

Four of the 31 stomachs collected were empty. The results of the analysis of the remaining 27 stomachs are shown in Table 1.

Tui chub, comprising 89.2 percent of the total volume, remain in the depths of the lake until stratification is well established and the surface water temperature is about 60 degrees F. Then they move into shallow water to spawn. The surface temperature on June 8, 1949, was 57 degrees F. Tui chub remain in the shallows until about the time of the fall overturn.

During the four months in which tui chub are relatively unavailable to the lake trout, the thermocline-inhabiting kokanee may be used more extensively than these data indicate.—*J. B. Kimsey, Inland Fisheries Branch, California Department of Fish and Game, December, 1959.*

BOOK REVIEW

How to Make Fishing Lures

By Vlad Evonoff; The Ronald Press Company, New York, 1959; v + 108 pp., illus., $3.50.

To the fisherman with a "do it yourself" inclination, this book is an excellent guide to the making of almost every kind of fresh and saltwater fishing lure.

The author has drawn upon a lifetime of fishing and writing experience to make this book easily readable. Commencing with the correct tools and materials, he goes further and tells how to improvise with materials at hand, then takes you step by step through the procedure of completing a lure.

There are about 150 clear line drawings that are large enough and have the detail and measurements that make instructions for making the lures easy to follow.

One whole chapter is devoted to leader knots and how to tie them, and one chapter is devoted to making molds and casting sinkers.

The book is nicely assembled, each chapter dealing with certain groups of lures. The book is indexed simply and directly.

This book has been written for the fishermen who wish to increase their fishing pleasure by catching fish on lures they made themselves, and it will be a "boon" to the fisherman who feels a financial twinge each time an expensive "store bought" lure is lost.—*George Seymour, California Department of Fish and Game.*

Wildlife Conservation—Second Edition

By Ira Gabrielson; The Macmillan Company, New York, 1959; xii + 244 pp., illus., $5.50.

Dr. Gabrielson has revised the First Edition of this book by adding a new chapter on the effect of changing practices in farm wildlife and has, in general, brought the book up to date.

The book is in no way technical. Rather, it gives a general philosophical treatment to a wide range of conservation matters affecting wildlife. A total of 17 chapters are devoted to subjects ranging through general conservation of renewable resources, soil, water, forests, and various phases of wildlife conservation.

Dr. Gabrielson is particularly interested in increasing interest in fur animal management and in renewing the vast grassland plains of the middle portion of the nation. In the final chapter, entitled "Surmounting the Obstacles to Conservation," Dr. Gabrielson puts forth some sound thoughts that should be of interest to anyone in the field. This book could hardly be considered a standard reference on the subject of wildlife conservation, but should serve a very useful purpose in introducing newcomers and in refreshing the thinking of those in the field on the general problems and relationships to other natural resources.—*Fred L. Jones, California Department of Fish and Game.*

Boy's Book of Turtles and Lizards

By Percy A. Morris; The Ronald Press Company, New York, 1959; vi + 229 pp., illus., $4.50.

This is a popular volume for youngsters and beginning naturalists. It treats 61 North American turtles and 72 lizards, including subspecies.

A brief introduction on turtles is followed by a series of sections on individual species, most of them illustrated with excellent photographs. Geographical distribution, size, appearance, habitat requirements, feeding and breeding habits, and subspecies are discussed in these sections.

The second half of the book, on lizards, follows the same general format.

The book is a thoroughly pleasant little volume: readable, attractive, and businesslike. It will be a great help to budding herpetologists and a godsend to their teachers. —*Alex Calhoun, California Department of Fish and Game.*

Hunting Pronghorn Antelope

By Bert Popowski; The Stackpole Company, Harrisburg, Pennsylvania, 1959; 225 pp., illus., $6.50.

This book is devoted entirely, as the title indicates, to the hunting of pronghorn antelope.

Mr. Popowski has many years of experience in the pursuit of the sport and he is a dedicated devotee. In compiling this work, he has drawn heavily on his own extensive experience and has sought the assistance of the Fish and Game Departments of states and Canadian provinces. He has perused reams of PR project reports and has asked the co-operation of many observers and game managers. As a result, his material is truly informative.

The book is organized into nine chapters as follows: History, Habitat and Habits; Antelope Distribution; Pronghorn Hunting Needs; Hunting and Stalking; Hunting by Ambush; Trapping and Transplanting; Predators and Fences; Care of Meat and Heads; and Pronghorn Trophies.

Emphasis is placed on re-establishment of antelope from an estimate of 30,000 in the United States and Canada in the period 1922-24 to an estimated 370,000 prior to the 1957 season.

The State of Montana is credited with an increase from about 3,000 in the period 1922-24 to about 90,000 in 1957. This is felt to be due primarily to a colossal trapping and transplanting program embarked on in 1945 which trebled the antelope population in just seven years.

The author strongly supports the theory that predatory animal control is essential to enhancing pronghorn survival. This is a matter of considerable controversy among pronghorn workers. The author also feels that sheep type fences are extremely detrimental as antelope normally will not jump them and cannot crawl under them. —*Fred L. Jones, California Department of Fish and Game.*

Wildlife of Mexico—The Game Birds and Mammals

By A. Starker Leopold; University of California Press, Berkeley and Los Angeles, 1959; xiii + 568 pp., 194 illustrative sketches and distribution drawings or photographs and two plates in full color, a two-page folded color map of vegetative zones, $12.50.

Dr. A. Starker Leopold is an extremely capable and remarkable person. This excellent book is a good example of that fact. Dr. Leopold is Professor of Zoology and Associate Director of the Museum of Vertebrate Zoology at the University of California at Berkeley. This book not only reflects the high professional capabilities of the author but also his warm personal qualities. His travels and encampments during the more than 12 years this volume was in preparation put him in close association with people of all walks of life throughout Mexico. The warm cooperation and assistance of all these people can readily be noted by the results in this book.

The significance of the book is considerable. It is the first to study and assemble all that is known about the game birds and mammals of Mexico. Individual accounts of over 150 game animals and birds are presented. Included are the salient life history characteristics, the description of the animal, the type of habitat and range in Mexico, and the common and scientific names of each species. Hunting methods are described for many species.

Mr. Charles W. Schwartz, a worthy biologist in his own right, has done a masterful job of illustration. He has produced 130 grease pencil sketches and two full-color paintings for this edition. One hundred and seven illustrations are full-page drawings depicting the wildlife species in their natural habitat. In the mammal illustrations, there are sketches of skull, feet and head of young as well as the adult animal and distribution maps for each species. In addition, Schwartz has contributed some of the fine photographs used in this publication.

The book is divided into three parts. Part II is the species accounts for the game birds and Part III covers the game and fur-bearing mammals. Part I consists of five chapters which present descriptions and evaluations of Mexico's present day wildlife management, its problems and possibilities.

For example, Chapter I, The Mexican Landscape, presents the physiographic regions, rainfall distribution, temperate zones and vegetative types. Chapter II is on Land Use and considers the Mexican human population, agriculture, grazing, forest products, water and wildlife in relation to land use.

The title of Chapter III is Utilization of Wildlife in Mexico. Sport hunting, wildlife as food, commercialization of wildlife and better use of the wildlife resources are discussed. Chapter IV, The Existing Program of Wildlife Conservation, considers present legal basis of administration, hunting regulation problems and an analysis of the game laws and the current wildlife program. This chapter really puts the finger on Mexico's problem in carrying on a wildlife management program. Only $8,000 to $13,000 annually has been set aside for administration and conservation of the country's entire program.

Chapter V is Wildlife in the Future. Herein is a sound evaluation of Mexico's wildlife resources as well as recommendations pointing out what can be done. Topics discussed in this chapter are objectives of a wildlife program, control of hunting, national parks, wildlife refuges, predator control, habitat conservation and improvement, extension and education, research and technical training, the role of organized sportsmen and the future.

This is an outstanding book. Dr. Leopold and those who assisted him in its preparation deserve much credit. It gives the best and most complete picture of Mexico's wildlife available. It is highly recommended to those in the field of wildlife management and anyone else interested in learning about the wildlife of Mexico.—*John B. Cowan, California Department of Fish and Game.*

All About Tropical Fish

By McInerny, Derek and Gerard, Geoffrey; The Macmillan Company, New York, 1959; 480 pp., 300 photos (100 color), 30 diagrams, $15.

Though there have been several good works on the hobby of keeping tropical fish, they must move over and make room for this one. The background of the authors (tropical fish and technical writing) becomes evident in the evenly written chapters.

Should the reader worry about having started the book backwards, don't. The index is in the front—it follows the foreword and table of contents.

The 31 chapters may be divided into two sections. The first 12 deal with the aquarium and the physical principles involved in its success. The second section (chapters 13-31) covers the live-bearing and egg-laying fishes. The egg-laying families are each assigned a chapter, while the live-bearers are described in one chapter.

Insofar as possible, information on each species includes a description, its distribution, water requirements, size, diet, breeding requirements, and temperature requirements.

Occasionally, the British matter-of-fact approach may cause the reader to raise an eyebrow. One paragraph on killing fish (when they are beyond hope) says to anesthetize the fish and, "while still insensible it is picked out of the solution and smashed with full force onto the floor."

The abundant photographs are generally good and some of the color plates are outstanding. The last chapter dealing with marine tropical fish, while short, will be read avidly by those starting in this phase of the tropical fish hobby.

For the beginner, the established hobbyist, and the commercial aquarist this book will be useful and should be within handy reach.—*Harold Wolf, California Department of Fish and Game.*

The Earth Beneath the Sea

By Francis P. Shepard; The Johns Hopkins Press, Baltimore, 1959; 275 pp., 113 figs., $5.

The Earth Beneath the Sea is a technical volume as capable of holding the reader's interest as any modern novel dripping with mystery and intrigue. No previous knowledge of submarine geology is necessary to read and understand this well-written little volume.

Dr. Shepard has drawn upon 35 years of professional experience in relating the many fascinating facts and conjectures about the 72 percent of the earth's surface, that for the most part lies hidden from direct viewing by man. His discussions of various phenomena are brief, yet lucid and complete—many based upon personal experiences.

An introductory chapter is followed successively by sections on waves and currents, catastrophic waves, transient beaches, continental shelves, continental slopes, submarine canyons and the ocean floor. Under the heading of bonuses or added attractions, one can list the final three chapters entitled "Under the Ocean Bottom," "Coral Reefs and Their Undersea Wonderlands," and "Using the Present Sea-floor Deposits to Interpret the Past." A chart of the geological time scale has been strategically placed near the end of the book near a list of suggested additional reading and an index.

The Earth Beneath the Sea should be near the top of the best seller list among oceanographers, marine biologists, sanitary engineers and similar professional workers in the marine environment. Its use should not be restricted to such a limited few, however.—*John E. Fitch, California Department of Fish and Game.*

Methods of Testing Chemicals on Insects. Vol. I.

Edited by Harold Shepard; Burgess Publishing Co., Minneapolis, Minn., 1958; iv + 356 pp., illus., $5.

Since this book has been reviewed in detail, both in the June 1959 Bulletin of the American Institute of Biological Sciences and in California Vector Views for December 1958, the present review will only include personal impressions not fully covered elsewhere.

Bound together in a single volume are a set of 14 collected papers describing various methods of testing chemicals on insects. It is, perhaps, necessary at this point to explain why a book with this title is reviewed in a professional conservation journal. First, the wide and often indiscriminate use of insecticides is increasing to the place where it is becoming a very serious problem for the fish and wildlife worker who is faced with water pollution control. He can meet this problem much better by becoming familiar with literature in the field of insect control. Second, and probably even more important, this book was chosen because it explores the nature of testing problems and suggests methods of approach which are applicable beyond the immediate subject of insects. An example is the electrophysiological study in Chapter IV which might be used by a pollution bioanalyst working with fish or aquatic invertebrates.

The simple, basic approach to problems should be appreciated by all biologists. In Chapter II, "Penetration of Cuticle," this approach is well illustrated by the step by step development of methods for answering particular questions. For the bioanalyst and the worker in the field of economic poisons, probably the most interesting and informative part of the book is Chapter XIV, "Synergism and Antagonism," in which some of the more complex definitions of these phenomena are given.

Although the book's index is quite brief, the 559 titles cited in the list of references should stimulate further reading in the field of insecticides.

For the fish and game biologist, it is unfortunate that there is nothing on insect culture methods and only a minimum on the technique of handling small invertebrate forms. Neither is there much on aquatic insects, although some of these are significant pests and even dangerous vectors. It would also be helpful to the workers in other disciplines if there were a summary at the end of each paper. The most serious criticism, however, is the unevenness in both length and quality of the various articles. The chapter on precision spraying, for example, takes up almost one-third of the book (104 pages), while there are only seven pages devoted to the complex subject of "Radioactive Tracer Methods."

As a reference, this book should be of value in many fields of biological investigation.—*Herbert E. Pintler, Department of Fish and Game.*

A California Flora

By Philip A. Munz; University of California Press, Berkeley and Los Angeles, 1959; 1,681 pp., colored frontis., 134 text figures, 2 maps, $11.50.

This is the first comprehensive manual of the flora of California since 1925 and covers more than 6,000 kinds of native plants. Dr. Munz was even more thorough and meticulous in the treatment of individual species than he was in his earlier work—*Manual of Southern California Botany.*

A 21-page introductory section refamiliarizes the user with the size and topography of California; her climate, geological history, plant communities, and such. The plant community concept is carefully explained and 29 communities are established according to 11 vegetation types. For each of the 29, there are listed the dominant species, topography, elevation, average rainfall, temperature and average height of the vegetative cover.

Dichotomous keys, strategically placed before each division or subdivision aid in identifying plants and plant material. These keys have been thoroughly revamped and overhauled and, where they are not the work of the author, a complete reference citation is given. The illustrations are all new, and although they are not profuse, their numbers are adequate to obtain proper identification.

The descriptions of individual species are brief, yet complete. The authority for the scientific name is given in all cases. This is followed by synonyms, if appropriate; descriptions of flower, fruit and plant components; habitat notations; and the plant community with which it is associated. Other data include information on altitudinal and geographical distribution, flowering dates, use, if economically important, and chromosome numbers where known.

A feature of considerable interest is the list of author's names. Here, one can find the full name, date of birth (and death), field of interest, professional position, major contribution, and so on for every authority listed in the taxonomic section.

A 16-page glossary and an 89-page index to common and scientific names complete the volume.—*John E. Fitch, California Department of Fish and Game.*

How to Hunt Deer and Small Game

By Luther A. Anderson; The Ronald Press Company, New York, N. Y., 140 pp., illustrated with black and white photographs and line drawings, $3.50.

This is another addition to the Ronald Sports Library series that consists of instructional, how-to books.

The book is aimed at the novice hunter. It contains many useful and fundamental facts regarding the selection of the proper firearm, how to use it properly and safely, woodslore and equipment needed.

Most of the information in the hunting of deer and upland game chapters is drawn from author Anderson's personal experiences in the states bordering the Great Lakes. The man who intends to hunt Rocky Mountain mule deer in the west for example, would use different hunting techniques than those described by the author in hunting white-tailed deer in the northwoods.

Some subjects the author expresses an opinion on, have two or more schools of thought. For example, the handling of deer meat, he recommends leaving the hide on for 15 to 20 days; the beagle and coonhound are rated as good pheasant dogs and Japan made binoculars do not compare with French or German makes.

I was happy to see Mr. Anderson stress hunter safety. This is properly the primary and most important instruction for the new hunter.

In the chapter concerning field dressing and hauling, no mention is made of the "buck bike" or the packboard that experienced western hunters find useful in packing deer when distance is involved.

In this 140 page, well illustrated and simply written book, the new hunter will find information that will start him off in the right direction and also give him the benefit of the author's years of experience in the northwoods. *Trevenen A. Wright, California Department of Fish and Game.*

California Natural History Guides

General Editor: Arthur C. Smith; University of California Press, Berkeley, 1959; each with 72 pp. illus. Paper, $1.50 each.

This is a series of four publications:

Introduction to the Natural History of the San Francisco Bay Region, by Arthur C. Smith.

Mammals of the San Francisco Bay Region, by William D. and Elizabeth Berry.

Reptiles and Amphibians of the San Francisco Bay Region, by Robert C. Stebbins.

Native Trees of the San Francisco Bay Region, by Woodbridge Metcalf.

Rarely can one find a natural history field guide for any area which will satisfy the needs of both the layman and the more serious student. Here for the first time, has been created a most useful, well illustrated series of paperback pocket guides to the ten-county region surrounding San Francisco Bay. Prepared by recognized authorities in their respective fields, these booklets are attractive, well organized, and easy to use. They are equally adaptable for use by teachers, youth leaders, students, or parents wishing to keep up with the daily inquiries of their children. Each guide contains eight color plates.

The first of the series sets the stage with a physical description of the region and general comments on nature study. It also contains an excellent review of the biotic communities found in the region, with colored illustrations of each.

The remaining three guides cover their specific subjects in a most scholarly manner. One slight criticism of the guide on mammals is its omission of the marine mammals, which are truly an important feature of the bay region fauna.

All things considered, however, this series represents the best material available as an introduction to the natural history of the bay region, and its popularity is understandable.

Additional volumes on butterflies, birds, and freshwater fish are in preparation.—*Willis A. Evans, California Department of Fish and Game.*

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FISH AND GAME COMMISSION

Notice is hereby given that the Fish and Game Commission shall meet on April 7-8, 1960, in the State Employment Building, 722 Capitol Avenue, Sacramento, California to receive recommendations from its own officers and employees, from the Department of Fish and Game and other public agencies, from organizations of private citizens, and from any interested person as to what, if any, orders should be made relating to birds or mammals, or any species or variety thereof, in accordance with Section 206 of the Fish and Game Code.

FISH AND GAME COMMISSION
Wm. J. Harp
Assistant to the Commission

Notice is hereby given that the Fish and Game Commission shall meet on May 26 and 27, 1960, in the State Building, First and Broadway, Los Angeles, California to hear and consider any objections to its determinations or proposed orders in relation to birds and mammals for the 1960 hunting season, such determinations resulting from hearing held on April 7-8, 1960. This notice is published in accordance with the provisions of Section 206 of the Fish and Game Code.

FISH AND GAME COMMISSION
Wm. J. Harp
Assistant to the Commission