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A SEA URCHIN, A LOBSTER AND A FISH, NEW TO THE MARINE FAUNA OF CALIFORNIA[1]

JOHN E. FITCH
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California Department of Fish and Game

Radovich (1961) reported upon 11 southern species of fish that were new to the marine fauna of California. These had strayed north during the warm-water years 1957, 1958, and 1959. The lobster and the fish being reported in this paper probably arrived in California during the same period and on the same northerly moving currents that brought many of the species discussed by Radovich to our shores. The sea urchin, on the other hand, may have arrived during an earlier influx of warm water from the south.

CLUB-SPINED URCHIN, *EUCIDARIS THOUARSII* (VALENCIENNES) (Figure 1)

During the first week of January 1958, Mr. Al Hanson, an experienced diver from Avalon, Santa Catalina Island, saw a large urchin that he did not recognize while he was diving in 70 feet of water off St. Catherines Bay, just above Avalon. He collected the specimen and took it home where he meticulously tied each spine to its nearest neighbor in such a way that when dried every spine remained erect and evenly spaced. When it no longer smelled, he sent it to the California State Fisheries Laboratory where it was identified as a club-spined urchin, a determination that was later verified by Mr. Fred Ziesenhenne of the Allan Hancock Foundation.

Mortensen (1928) reported that club-spined urchins live in tropical waters between Baja California (Cape San Lucas) and Panama and at the Galapagos Islands, from the intertidal zone to depths of about 150 feet (45 meters). He stated that they are mainly a littoral form, moving into the open at night to feed. At Espiritu Santo Island in the Gulf of California they are considered enemies of pearl oysters. Since Mortensen found mostly mollusk shell fragments in their alimentary tracts he believed the accounts of their predation on pearl oysters and other shelled mollusks were true. Club-spined urchins in turn are sometimes attacked by fishes, probably wrasses, triggerfishes and similar toothsome species. The larvae of these and most other urchins are pelagic and may drift many miles on the prevailing ocean currents before settling down for an adult existence. The test of the largest club-spined urchin encountered by Mortensen was 65 mm across.

Ziesenhenne (personal communication) informed me that among more than 200 lots in the Allan Hancock Foundation collection, the northernmost is from Consag Rock at the head of the Gulf of California.

[1] Submitted for publication January 1962.

FIGURE 1. Club-spined urchin, *Eucidaris thouarsii*, from 70 feet of water off St. Catherines Bay, Santa Catalina Island, California, January 1958. *(Photo by Jack W. Schott.)*

Other lots had come from as far south as La Libertad, Ecuador. He said *Eucidaris thouarsii* had not been reported from the west coast of Baja California but they had material in their collection from Clarion and Socorro Islands in the Revilla Gigedos group and from Guadalupe Island, Baja California, some 270 miles south of Santa Catalina Island. Their largest measured 67 mm, two more than Mortensen's.

The test of the urchin collected by Mr. Hanson (Figure 1) was 72 mm in horizontal diameter by 53 mm deep. It had 10 rows of primary spines with 10 spines in each row, eight long and two short. The longest spine measured 48 by 7 mm. Thus the St. Catherines Bay urchin was not only an extension of the known northerly range for the species and new to the marine fauna of California, it represented a new size record for *E. thouarsii.*

Without knowing their growth rates it would be foolish to assign a definite date for the arrival of Hanson's specimen at Santa Catalina Island as a larva; however, it is interesting to speculate upon two possibilities. If the urchin had arrived during the first year of the most recent warm-water period, 1957, its growth would have had to be phenomenal to say the least. On the other hand, the most likely time of entry prior to 1957 (1940 or 1941) would attribute a highly improbable longevity to the species.

The specimen was retained by Mr. Hanson who has a small, private collection of marine organisms on display at Avalon.

PINTO LOBSTER, *PANULIRUS GRACILIS* STREET
(Figure 2)

On January 17, 1961, Mr. Carl A. Magers, Jr., pulled a lobster trap he had set near the San Diego harbor breakwater and found a lobster in it that differed from any he had caught previously. He took it to the local Department of Fish and Game office where it was identified as a pinto lobster, a species never before taken in California waters.

Pinto lobsters generally have been recorded from tropical waters bounded by southern Baja California and Peru and at such offshore islands as Cocos, the Galapagos, Clipperton, and the Revilla Gigedos; however, definite records for the extremes of their range are difficult to find.

Johnson (1960) showed alongshore distribution of California spiny lobsters *(P. interruptus)* south to Magdalena Bay, Baja California. Although some were found below Magdalena Bay, these were generally offshore, in small numbers, and in late stages of their development. Larvae of *P. gracilis* were intermixed with those of *P. interruptus* along the Baja California coast north to about Pt. Eugenia.

During numerous cruises of Department of Fish and Game research vessels, pinto lobster adults were often noted intermixed with California spiny lobsters between Abreojos Point and Magdalena Bay. South of Magdalena Bay only pinto lobsters have been seen or collected until reaching the vicinity of the upper Gulf of California (Los Angeles Bay, Tiburon Island, Guaymas, etc.) where *P. interruptus* again are encountered. In April 1948, during a survey of the Guadalupe Island area we took fair numbers of *P. gracilis* in traps set at three localities around the island. All were mature and no trap yielded any except pinto lobsters, a situation that has never occurred since 1948. In fact, I can find no record of anyone having taken a pinto lobster there, either before or since 1948; the island's lobster population is typically *P. interruptus.*

If the 1948 pinto lobster population had arrived at Guadalupe Island as drifting larvae from the south (the only plausible explanation for their presence there), they probably were at least seven years old, since the earliest previous warm-water year had been 1941 (Radovich 1961). Johnson (1960) showed that the larval stages of *P. interruptus* drift for seven and three-quarters months before settling to the bottom; those of *P. gracilis* probably drift equally as long. Seven and three-quarters months would allow them more than enough time to drift the 500 miles from their usual nursery grounds off southern Baja California to Guadalupe Island, even on a slow, meandering current (Reid *et al.*, 1958).

Mr. Mager's pinto lobster (Figure 2) was a male, eight and one-quarter inches (209 mm) long from the center of the rostrum to the end of the tail; its carapace length (mid-rostrum to posterior margin)

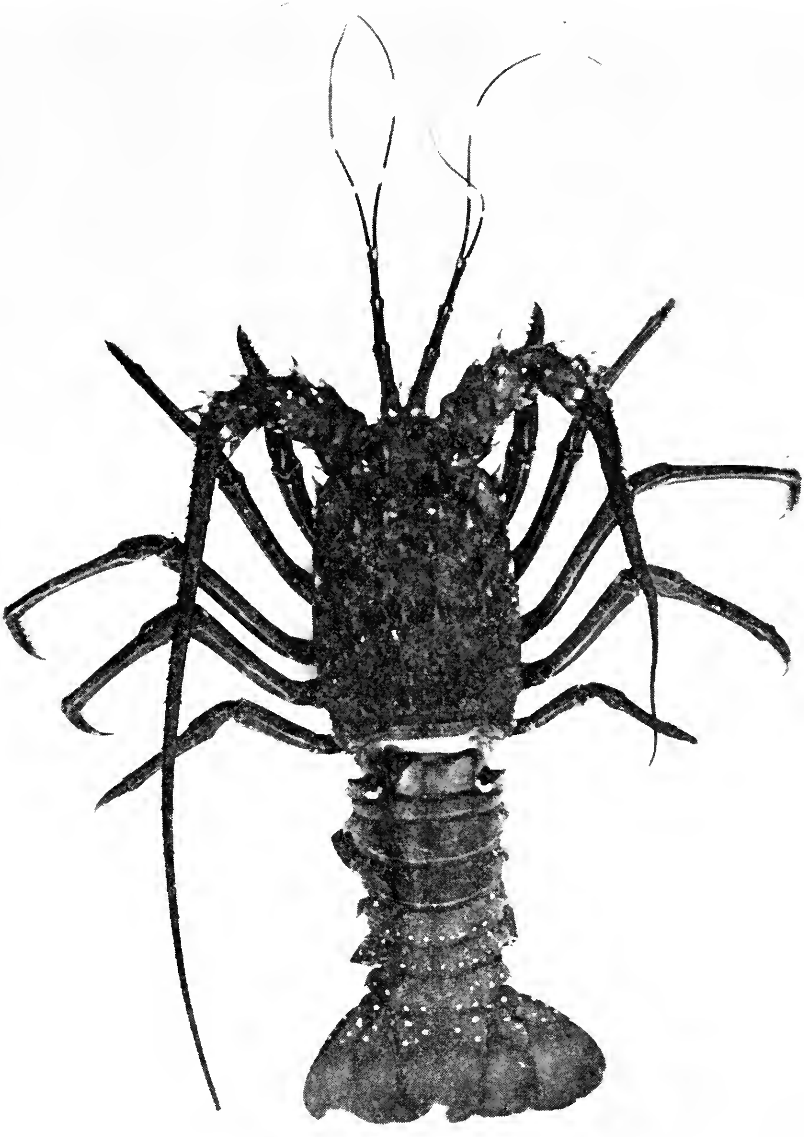

FIGURE 2. Pinto lobster, *Panulirus gracilis,* taken in a lobster trap off the San Diego harbor breakwater January 17, 1961. *(Photo by Jack W. Schott.)*

was 79.5 mm. This catch extended the known northern distribution for the species by some 400 coastwise miles (Abreojos to San Diego) or 220 straight-line miles (Guadalupe Island to San Diego). The specimen was sent to Dr. Martin Johnson, Scripps Institution of Oceanography, who placed it in their collection.

PACIFIC FAT SLEEPER, *DORMITATOR LATIFRONS* (RICHARDSON)
(Figure 3)

Mr. Norm Sherman hooked and landed a Pacific fat sleeper on July 8, 1961, while he was fishing from the rocky shoreline near Palos Verdes (Los Angeles County) using shrimp for bait. Mr. Sherman dropped his catch into a metal ice chest partially filled with water and thought no more of the incident until he was preparing to depart for home and discovered it was still alive. He kept it alive at home for several days, adding fresh water as the level in the ice chest fell. After about a week, the water had become so foul that Mr. Sherman felt it necessary to change it; having no salt water handy he refilled the ice chest from a freshwater tap, expecting to see the fish succumb at any minute. Instead, the fish survived the change and lived for another week when Mr. Sherman took it to Harry's Bait and Tackle, Playa Del Rey, to see if they could identify it for him. Mrs. Harry Edilson, wife of the proprietor, called me and I arranged to have it picked up and identified. With the assistance of Dr. Carl L. Hubbs, Scripps Institution of Oceanography, I was able to inform Mrs. Edilson that it was a Pacific fat sleeper.

Follett (1961) reviewed the status of the species and listed their distribution as Punta Lobos, two miles southwest of Todos Santos, Baja California (770 miles below Palos Verdes, California), south to Guayaquil, Ecuador. They typically inhabit freshwater but move freely into saltwater and vice versa. In discussing finding a close relative, *Eleotris picta*, in a canal off the Colorado River in 1952, Hubbs (1953) speculated that *Dormitator latifrons* might also stray up the river into California but added none had yet been found as far north as the Colorado Delta. That one would stray even a short distance north along the riverless outer coast of Baja California seemed highly unlikely. Mr. Sherman's catch, however, leaves little doubt that such a movement did take place during the recent warm-water period, a logical time for such a trip. Although one cannot exclude the possibility that some well-meaning individual liberated this fish in our ocean waters either as a "joke" or because it had

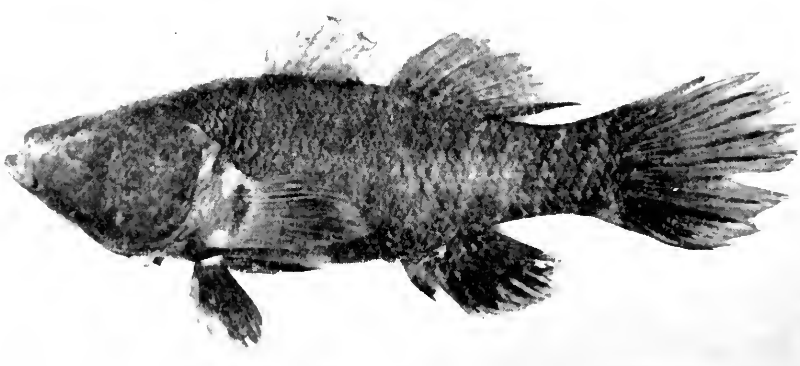

FIGURE 3. Pacific fat sleeper, *Dormitator latifrons,* caught on hook and line at Palos Verdes, California, July 8, 1961. *(Photo by Jack W. Schott.)*

outgrown his aquarium, I prefer to believe it traveled northward with water currents having suitable temperatures.

Mr. Sherman's fish (Figure 3) was an adult male 12 inches long (230 mm s.l., 302 mm t.l.) weighing approximately three-quarters of a pound (345 grams). There were six winter rings on the otoliths, indicating an age of six years if these are annuli. Pacific fat sleepers are supposed to attain lengths of 24 inches but there seems to be no definite record of one that size. The Palos Verdes eleotrid had 35 rows of scales along the lateral line and its radial formula, as determined by Dr. Carl L. Hubbs, was D VIII—I, 8; A I, 9; C 15 (branched rays + 2) or 13 articulated rays; P_1 15—I, 13 (14); P_2 I, 5—I, 5. It was sent to UCLA and eventually will be deposited at Scripps Institution of Oceanography.

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THE SOUTHERN CALIFORNIA MACKEREL FISHERY AND AGE COMPOSITION OF THE PACIFIC MACKEREL CATCH FOR THE 1958-59 SEASON[1]

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This is the eighth report on the age composition of the Pacific mackerel *(Pneumatophorus diego)* catch. It covers landings for the 1958-59 season. The methods used in sampling, making age determinations, and estimating numbers of fish and pounds landed are the same as those used annually since the 1939-40 season (Fitch, 1951). Appreciation is extended to Mrs. Gertrude M. Cutler for her aid on the data computations required for this study.

Commercial landings of Pacific mackerel at southern California ports totaled only 24.2 million pounds during the season from May 1, 1958 to April 30, 1959, which were less than half those of the preceding season (Hyatt, 1960), and less than the 35 million-pound seasonal average since 1947-48. During the 12-season period from 1934-35 to 1946-47 an average of about 85 million pounds was landed annually.

The 1958-59 season began with moderate landings (2.3 million pounds) in May. Landings declined after May, reached a low in September, then rose from October through December when half the season's total was taken. After December, catches dropped off sharply then increased slowly through April (Table 1).

TABLE 1
Pacific Mackerel Monthly Landings During the 1958-59 Season

Month	Pounds	Month	Pounds
May	2,312,000	November	3,909,000
June	1,300,000	December	5,322,000
July	1,216,000	January	919,000
August	1,528,000	February	133,000
September	765,000	March	1,653,000
October	2,775,000	April	2,343,000

From May through August, the canners paid fishermen $42.50 per ton for Pacific mackerel; in September, the price was raised to $50 per ton.

At certain times during the season when the market is good or the backlog of canned fish is low, the catch may be limited by the avail-

[1] Submitted for publication July 1961.

able supply. At other times when the market is slow and inventories build up, canners place limits on the tonnage accepted daily from each boat. Such limits fluctuated from 20 to 90 tons during the 1958-59 season. Since the lower figure is approximately the capacity of a lampara net boat, canner limits tend to favor the operations of these smaller fishing boats over the large purse seiners whose capacities may exceed 100 tons.

Most of the catches were made within a 30-mile radius of Los Angeles Harbor. Moderate catches were made in the vicinity of Santa Cruz and San Clemente Islands, and minor catches along the coast from Oceanside to San Diego, and offshore (Table 2).

TABLE 2
Origin of the Southern California Pacific Mackerel Catch in the 1958-59 Season

Locality	Percent of catch
Santa Catalina Island	29.0
San Pedro to Oceanside	26.5
Santa Monica Bay	25.5
Santa Cruz Island Area	10.0
San Clemente Island	7.8
Oceanside to San Diego and offshore	1.2
Total	100.0

Fishing boats using purse seines or lampara nets caught 63 percent of the tonnage. The remaining 37 percent was caught by scoop boats whose loads varied from a few hundred pounds to several tons.

Lengths and weights were obtained from 6,178 Pacific mackerel sampled during the season, and ages were determined from otoliths removed from 898 of these fish (Table 3).

During the latter half of the season, fish younger than one year were large enough to be caught in great numbers. These fish, the 1958 year-class, contributed 60 percent of the number taken (Table 4).

The second largest age group, comprising 18.5 percent of the numbers caught, was the three-year-old 1955 year-class which had dominated the catch during the preceding two seasons. As two-year-old fish in the 1957-58 season, they had supplied 50 percent of the catch; and had made up 60 percent as one-year-olds during 1956-57. The tonnage landed in each of these seasons was more than twice that of the 1958-59 season.

Only 10.2 percent of the previous season's catch consisted of 1956's, but this was about twice as many individuals from that year-class as were caught in 1958-59 when the contribution was 11.5 percent. It is probable that future contributions of 1956 fish will be of minor importance since the contributions are heaviest from the first to the third year of life (Tables 5 and 6) and percentages of this year-class have been small in the catches of the past two years.

The 1957 year-class (one-year-olds) amounted to only 3.8 percent of the 1958-59 season's landings. This may be one of the poorest year-classes on record.

Fish four years old and older comprised only 5.5 percent of the landings.

TABLE 3

Fork Lengths of Pacific Mackerel in Quarter Centimeters at Each Age for the 1958-59 Season, Based on Otoliths Read

¼ cm.	Age group								
	0	I	II	III	IV	V	VI	VII+	Total
1	1	--	--	--	--	--	--	--	1
2	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--	--
75	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--
7	3	--	--	--	--	--	--	--	3
8	--	--	--	--	--	--	--	--	--
9	4	--	--	--	--	--	--	--	4
80	3	--	--	--	--	--	--	--	3
1	2	--	--	--	--	--	--	--	2
2	3	--	--	--	--	--	--	--	3
3	6	--	--	--	--	--	--	--	6
4	4	--	--	--	--	--	--	--	4
85	9	--	--	--	--	--	--	--	9
6	3	--	--	--	--	--	--	--	3
7	6	--	--	--	--	--	--	--	6
8	9	--	--	--	--	--	--	--	9
9	8	--	--	--	--	--	--	--	8
90	12	--	--	--	--	--	--	--	12
1	4	--	--	--	--	--	--	--	4
2	4	--	--	--	--	--	--	--	4
3	8	--	--	--	--	--	--	--	8
4	15	1	--	--	--	--	--	--	16
95	18	--	--	--	--	--	--	--	18
6	10	--	--	--	--	--	--	--	10
7	10	1	--	--	--	--	--	--	11
8	14	2	--	--	--	--	--	--	16
9	11	--	--	--	--	--	--	--	11
100	13	1	--	--	--	--	--	--	14
1	18	--	--	--	--	--	--	--	18
2	9	--	--	--	--	--	--	--	9
3	16	1	--	--	--	--	--	--	17
4	11	--	--	--	--	--	--	--	11
105	8	--	--	--	--	--	--	--	8
6	19	1	--	--	--	--	--	--	20
7	14	--	--	--	--	--	--	--	14
8	12	1	--	--	--	--	--	--	13
9	9	3	--	--	--	--	--	--	12
110	7	2	--	--	--	--	--	--	9
1	8	--	1	--	--	--	--	--	9
2	7	1	--	--	--	--	--	--	8
3	8	6	1	1	--	--	--	--	16
4	3	1	2	--	--	--	--	--	6
115	3	6	1	1	--	--	--	--	11
6	4	4	--	--	--	--	--	--	8
7	5	2	1	1	--	--	--	--	9
8	8	7	1	1	--	--	--	--	17
9	2	1	2	6	--	--	--	--	11
120	2	4	4	5	1	--	--	--	16
1	--	1	5	2	--	--	--	--	8
2	--	4	4	4	1	--	--	--	13
3	--	1	--	4	--	--	--	--	5
4	1	4	5	11	--	--	--	--	21
125	--	2	5	7	--	--	--	--	14
6	--	1	7	6	--	--	--	--	14
7	--	--	3	3	--	--	--	--	6
8	--	--	8	13	1	--	--	--	22
9	--	1	10	11	1	--	--	--	23
130	--	--	6	10	1	--	--	--	17
1	--	1	6	17	1	1	--	--	26
2	--	1	7	10	1	1	--	--	20
3	--	--	6	10	1	--	--	--	17
4	--	--	3	7	--	--	--	--	10

TABLE 3—Continued

Fork Lengths of Pacific Mackerel in Quarter Centimeters at Each Age for the 1958-59 Season, Based on Otoliths Read

¼ cm.	Age group								
	0	I	II	III	IV	V	VI	VII+	Total
135	--	--	6	8	--	--	--	--	14
6	--	1	3	7	2	--	--	--	13
7	--	--	4	11	2	--	--	--	17
8	--	2	5	9	3	--	--	--	19
9	--	--	1	4	2	--	--	1	8
140	--	--	4	12	3	--	1	--	20
1	--	--	3	6	5	2	1	--	17
2	--	--	4	11	7	1	--	--	23
3	--	--	3	1	4	--	--	--	8
4	--	--	4	5	2	--	--	--	11
145	--	--	2	3	5	--	1	--	11
6	--	--	4	7	4	3	--	1	19
7	--	--	--	4	4	1	--	--	9
8	--	--	2	5	7	2	--	--	16
9	--	--	--	--	2	--	--	--	2
150	--	--	1	1	2	1	--	--	5
1	--	--	--	3	4	2	1	--	10
2	--	--	1	2	--	1	1	--	5
3	--	--	1	2	2	3	--	--	8
4	--	--	--	1	3	1	1	--	6
155	--	--	--	--	--	--	1	--	1
6	--	--	--	3	2	3	--	--	8
7	--	--	--	--	--	--	--	--	--
8	--	--	--	--	--	1	--	--	1
9	--	--	--	2	--	1	--	--	3
160	--	--	--	--	--	--	--	--	--
1	--	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	1	--	--	1
Totals	354	64	136	237	73	25	7	2	898

The Pacific mackerel population seems to be at a low level; the 1956 and 1957 year-classes appear to be below average and the 1955 year-class represents the only mature class of any size in the fishery. The population contains too few older fish to contribute much weight to the catch. Therefore, the main support of the fishery will probably depend on the apparently larger entering 1958 year-class. However, this year-class may only appear numerous in comparison with the other weak classes. In either event, the 1958 fish may not add substantially to the

TABLE 4

Calculated Number of Pacific Mackerel Landed in Age Groups 0 Through VI+ During the 1958-59 Season

	Age group							
	0	I	II	III	IV	V	VI+	Totals
Year-class	**1958**	**1957**	**1956**	**1955**	**1954**	**1953**		
Number of fish	23,922,000	1,511,000	4,533,000	7,300,000	1,687,000	295,000	182,000	39,430,000
Percentage of fish	60.7	3.8	11.5	18.5	4.3	.8	.4	100.00

TABLE 5

Number of Pacific Mackerel Landed of Each Year-Class at Each Age from the 1939-40 Through the 1958-59 Seasons

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	9,204,000	10,156,000	7,712,000	3,328,000	45,220,000
1941	398,000	29,376,000	54,106,000	33,905,000	10,312,000	2,294,000	130,391,000
1942	0	12,462,000	19,047,000	10,259,000	4,661,000	2,019,000	48,448,000
1943	836,000	16,556,000	10,327,000	11,872,000	5,087,000	429,000	45,107,000
1944	0	14,302,000	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	4,279,000	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	9,484,000	367,000	65,829,000
1949	136,000	3,854,000	4,428,000	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	46,000	475,000	208,000	204,000	62,000	1,764,000
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	14,641,000	8,160,000	295,000	96,525,000
1954	564,000	3,562,000	14,976,000	11,332,000	1,687,000	----	32,121,000
1955	4,237,000	49,429,000	30,487,000	7,300,000	----	----	91,453,000
1956	21,000	6,228,000	4,533,000	----	----	----	10,782,000
1957	1,386,000	1,511,000	----	----	----	----	2,897,000
1958	23,922,000	----	----	----	----	----	----

TABLE 6

Pounds of Pacific Mackerel Landed of Each Year-Class at Each Age from the 1939-40 Through the 1958-59 Seasons

Year-class	Age group						
	0	I	II	III	IV	V	Totals
1934	----	----	----	----	----	6,851,000	----
1935	----	----	----	----	12,141,000	1,885,000	----
1936	----	----	----	31,946,000	14,592,000	1,414,000	----
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	2,334,000	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	411,000	70,104,000
1954	94,000	1,964,000	11,722,000	12,294,000	2,117,000	----	28,191,000
1955	1,270,000	25,940,000	24,552,000	8,194,000	----	----	59,956,000
1956	5,000	4,222,000	4,674,000	----	----	----	8,901,000
1957	466,000	897,000	----	----	----	----	1,363,000
1958	7,617,000	----	----	----	----	----	----

broodstock upon reaching maturity at $2\frac{1}{2}$ years of age, after having borne the brunt of the fishery throughout its early life.

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CALIFORNIA SEA LION CENSUS FOR 1958, 1960 AND 1961[1]

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For over three-quarters of a century, sea lions along our shores have created varying degrees of interest in their abundance and behavior. Consequently, these animals have been counted intermittently since the late 1800's.

Coastwide censuses have been made by the Department of Fish and Game since 1927. Counting methods have been modified and the tallies since 1946 do not have the same base as those prior to that time. In fact, the substantial differences in techniques permit direct comparison or evalution of the figures only with caution based upon an understanding of their limitations.

The persistent charge of devastation leveled at sea lions particularly by sportsmen and commercial fishermen has made these animals the subject of extensive criticism on one hand, and indulgent defense on the other. It is our intent to discuss only the records and fluctuations of the counts and to point out some of the factors complicating the tallies but not to relate the details of the controversies.

Prior to 1946, censuses were made only on the larger rookeries, hauling grounds and nearby areas (Bonnot and Ripley, 1948). Generally, the sea lions on the rocks were counted from a boat by at least two observers. In some cases, the observers would land and make their tallies from vantage points. The counts of the two or more observers were averaged. By this system it was possible to determine accurately the species, to count only adults and subadults, and to eliminate pups from the tallies. In the field, subadult males could not always be distinguished from females with accuracy. The species breakdown through 1938 is believed reliable because the counts through that year represented adults and subadults only.

In 1946, the census was made by a variety of observers and methods. Both patrol personnel and marine biologists made direct observations and took photographs from boats, airplanes and blimps. Thus a mixture of surface tallies, which excluded pups, and aerial techniques, which sometimes did not, created an aggregate count not comparable with prior or subsequent ones. Species were not separated in the 1946 census but for general purposes all north of Point Conception were considered Steller sea lions, *Eumetopias jubata,* and those south of that point California sea lions, *Zalophus californianus.*

[1] Submitted for publication May 1962.

The ranges of the two species overlap in central California but detailed studies by Bartholomew and Boolootian (1960) showed less than one-half of one percent Stellers on the southern California islands they surveyed. Similarly, during the censuses when the species were separated the percentage of Californias north of Point Conception was insignificant. However, this does not imply that the population structure remains constant before or after the breeding season. According to Fry (1939), Bartholomew and Boolootian (1960), and Orr and Poulter (1962), the Californias appear to migrate widely and rapidly between breeding seasons.

The 1947 census was made almost entirely from a Navy blimp, which in the 1946 census, had proved excellent for observation. Photographs were taken at slow ground speeds, at relatively low altitudes, and on large, nine- by nine-inch negatives. Although species were not distinguished with precision, the pups were eliminated to a large degree from nearly all counts. Unfortunately, an accident occurred during one flight along the northern coast. The blimp was destroyed in a crash off Cape Mendocino and, although no one was injured, photographs of several rookeries were lost. These areas were resurveyed from a Department plane. Faster ground speeds, higher altitudes and smaller negatives made it impossible to distinguish with accuracy large pups from small adults. Thus the 1947 census figures were a mixture of mainly adult counts for most of the coast, and of adult and pup counts for several northern California rookeries and hauling grounds.

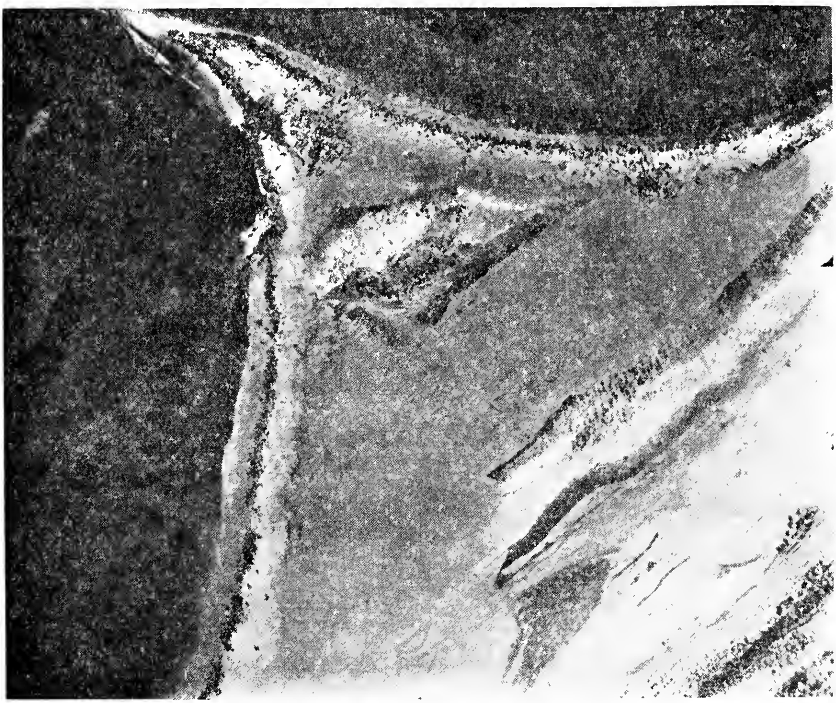

FIGURE 1. Aerial photograph of sea lions and elephant seals on San Miguel Island, 1958. The elephant seals are clustered mainly in the center of the sandspit.

Eleven years elapsed before the next survey in 1958. This and the 1960 and 1961 surveys were made by airplane using comparable techniques (Figure 1). Counts were made from aerial photographs of the larger concentrations while smaller groups were counted visually and added to area totals. Adult and pup sea lions were included and no attempt was made to distinguish species.

NORTHERN CALIFORNIA

Unadjusted sea lion counts made in northern California since 1927 have varied from about 4,000 to slightly over 7,000 per year (Table 1). The apparent increases since 1938 may largely reflect our having included pups plus the more complete coverage we obtained by aerial methods. For the most part, northern California counts were Stellers. The trends reflect a fairly stable population with some minor changes probably associated with emigration out of, or immigration into, the census area.

SOUTHERN CALIFORNIA

The southern California sea lion population has definitely increased, containing over 18,000 animals during the 1961 survey (Table 1). Unfortunately, no counts were possible in southern California in 1960 because of unsuitable weather during the census period. However, the 1958 and 1961 results showed significant increases of California sea lions, particularly in three areas: the rookeries of San Miguel, San Clemente, and San Nicolas Islands.

TABLE 1
Number of Sea Lions Counted on Rookeries and Hauling Grounds 1927-1961

Locality	1927	1928	1930	1936	1938	1946	1947	1958	1960*	1961
St. George Reef to Cape Mendocino	2,400	1,511	1,600	1,452	918	902	825	1,321	1,219	907
To Pt. Arena	300	206	300	142	--	148	40	1,050	464	781
To Pt. Reyes	--	--	--	54	6	111	102	936	625	795
To Pigeon Point	150	42	--	4	2	59	50	90	9	23
Farallon Islands	706	540	928	525	447	950	750	941	1,290	703
Pt. Ano Nuevo	1,500	1,500	2,500	1,200	2,000	1,900	2,050	1,170	1,350	2,342
To Pt. Lobos	--	270	209	338	191	402	403	517	311	230
To Pt. Conception	557	337	357	509	415	696	836	1,028	504	894
Northern Ca ifornia	5,613	4,406	5,894	4,224	3,979	5,168	5,056	7,053	5,772	6,675
To Pt. Loma (Mainland)	--	--	--	--	--	36	30	164	--	33
San Miguel Island	744	1,021	825	1,879	2,706	2,819	1,600	5,192	--	9,512
Santa Rosa Island	49	38	12	52	20	--	--	295	--	--
Santa Cruz Island	233	203	208	200	141	1,075	100	262	--	15
Anacapa Island	34	27	11	11	10	81	--	45	--	15
Santa Barbara Island	125	327	8	600	500	2,056	1,000	1,847	--	1,760
San Clemente Island	265	251	347	435	490	883	250	1,507	--	2,361
Santa Catalina Island	--	--	--	--	15	104	20	233	--	30
San Nicolas Island	Not visited	Not visited	Not visited	Not visited	Not visited	284	660	3,074	--	4,637
Southern California	1,450	1,867	1,411	3,177	3,882	7,338	3,660	12,619	--	18,363
All California	7,063	6,273	7,305	7,401	7,861	12,506	8,716	19,672	--	25,038

* No census of southern California taken.

Excluding the effects of environment, two factors may be related to their increase. The first is associated with seclusion. Several areas where increases have occurred are remote places not normally frequented by the general public. Some are accessible only to military personnel.

The second factor may be related to stress. During and subsequent to World War II many areas frequented by sea lions were used for military training. Air to ground gunnery ranges were established and considerable disturbance took place on the islands in preparation for amphibious activity. Practice gunnery by trainee fighter pilots undoubtedly frightened the sea lions and contributed to a reduction in their numbers on these particular islands. During the 1946 and 1947 surveys, sea lion herds were very jumpy and reacted wildly to the approach of an airplane. Although frightened by the noise and the size of the blimp, they were not nearly as panicky when it approached.

The reaction of the sea lions to an airplane was not so violent during the 1958 and 1961 censuses. Apparently the passage of years since the wartime activity and new generations of sea lions in the population have decreased the intensity of the herd's response to low-flying aircraft. To a lesser degree, in certain isolated northern California areas, the reaction of the Stellers immediately after the war was similar to that of the Californias on the southern California islands. Thus, the activities associated with wartime training may have kept sea lion numbers down during and immediately following World War II. Variations in the environment and food supply also may have affected the population, just how is not known.

SUMMARY

Ten sea lion censuses were made in California between 1927 and 1961. The population has fluctuated, being highest in northern California during 1958. In southern California, the peak of abundance was in 1961 when over 18,000 sea lions were on the southern California offshore islands. Changes in their abundance may have been due to increased immigation into southern California, to a lessening of harassment by man or to environmental factors.

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AGE AND LENGTH COMPOSITION OF THE SARDINE CATCH OFF THE PACIFIC COAST OF THE UNITED STATES AND MEXICO IN 1959-60[1]

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INTRODUCTION

This report, the 14th on age and length composition of the catch of Pacific sardines *(Sardinops caerulea)* off the Pacific Coast of North America, resulted from one phase of the research conducted by the California Cooperative Oceanic Fisheries Investigations. Two CalCOFI agencies, the California Department of Fish and Game and the U.S. Bureau of Commercial Fisheries, have prepared these reports jointly on a seasonal basis since the 1941-42 sardine season (Wolf, *et al.*, 1961).

The assistance of Anita E. Daugherty and Clark Blunt, of the California Department of Fish and Game; and John MacGregor and Makoto Kimura of the U.S. Bureau of Commercial Fisheries, is gratefully acknowledged.

THE FISHERY

During the 1959-60 season, the 128-boat California sardine fleet landed 15,418 tons in central California and 20,335 in southern California for a total of 35,753. Approximately 8,113 of the 22,400 tons landed by the Mexican fleet were netted during a period comparable to the California season making a coastwide season total of 43,866 tons. This was less than half of the 110,414 tons landed the preceding season.

The catch was restricted little by cannery-imposed limits on individual boat trips. Limits, when imposed, ranged from 40 to 100 tons per boat per trip.

Central California

As in the previous year, the legal canning season in central California extended from August 1 through December 31. The seasons are set by California law, with Point Arguello as the central-southern area dividing line (Figure 2).

A price dispute deterred the fleet from fishing through all of August. On September 1, agreement was reached with five of the seven Monterey area canners, setting the price at $35 per ton for sardines and at $50 for mixed loads of sardines and mackerel.

Fishing began the night of September 1, and 1,571 tons were landed during the "September" dark-of-the-moon period. Lunar months are

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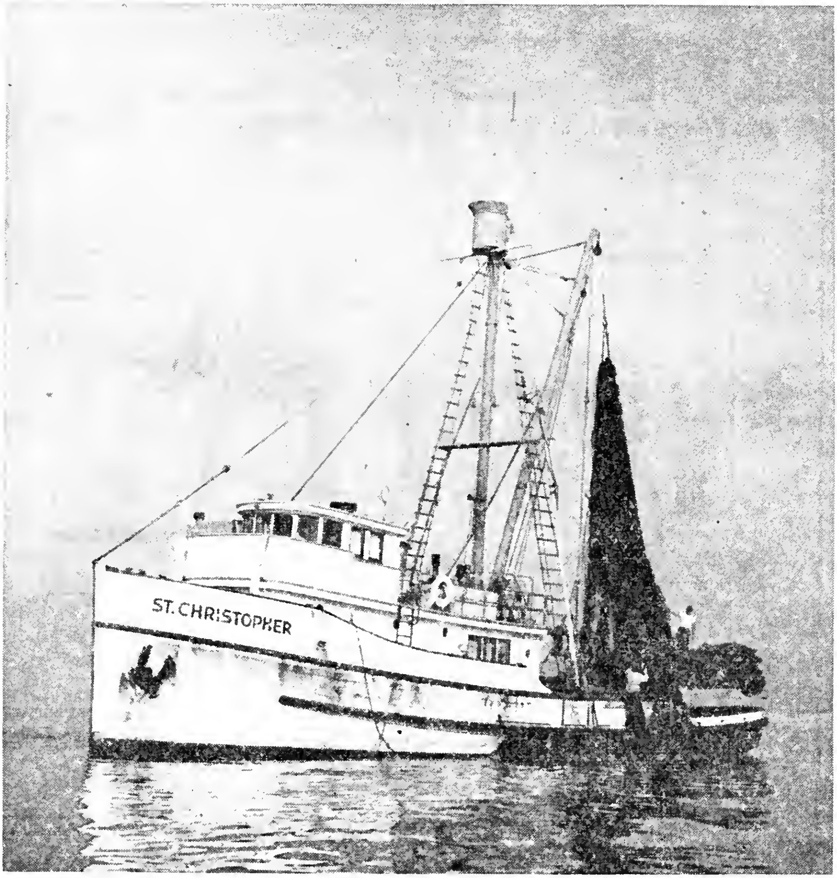

FIGURE 1. A typical California sardine purse seiner that has just completed a haul. *(Photograph by Anita E. Daugherty, October, 1958.)*

set in quotation marks to distinguish them from the calendar months they approximate (Table 1). Almost equal tonnages were landed in "October," "November" and "December"—4,500, 4,000 and 4,400—and 800 in "January" giving a total through December 31 of 15,418, about 9,000 tons less than the preceding season.

The lower catch was caused in part by the late fishing start, and by inclement weather throughout much of September and October.

Ninety-four percent of the central California catch originated in or near Monterey Bay; the remainder was caught in the Morro Bay-Avila area and trucked to Monterey area processing plants. During the previous season, about two-thirds of the catch was netted off Morro Bay and Avila. In 1959, as in 1958, the fishermen paid the cost of shipping sardines from the Morro Bay area to the processing plants.

Seven canners processed the central California catch: five in Monterey, one in Moss Landing, and one in San Francisco. The fleet consisted of 13 large purse seiners (60 feet or over), 5 small purse seiners, and 20 lampara boats.

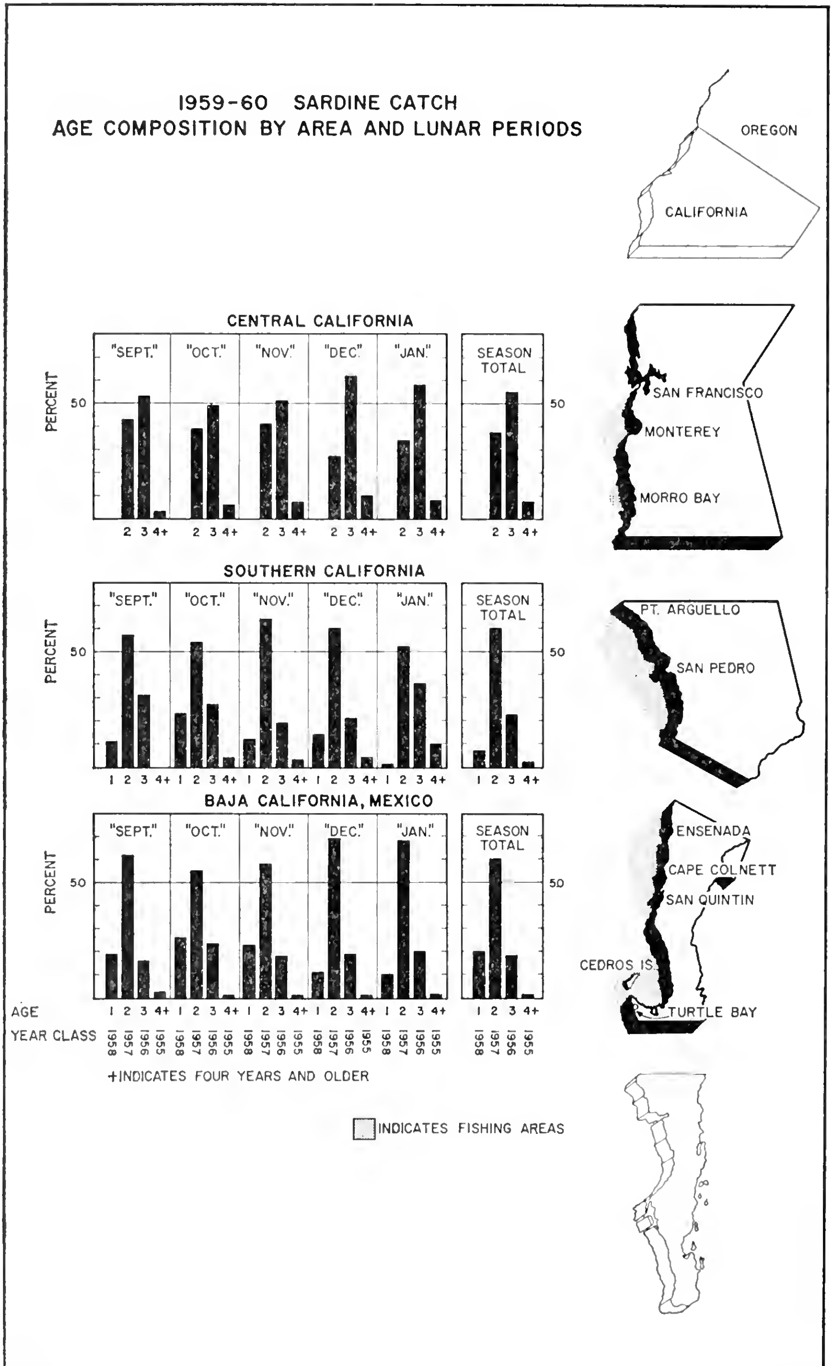

FIGURE 2. The sardine catch age composition by geographical area and lunar month periods. **Major fishing areas are shaded.**

Southern California

The southern sardine region extends from Point Arguello to the U.S.-Mexican border. The legal season began one month later than off the central coast, extending from September 1 through December 31. Although a few boats fished during September, the entire fleet did not fish until the night of October 4 due to price negotiations. At that time, the price was set at $35 per ton, the same as in central California.

For the second consecutive season, sardines were netted in the northwest portion of the region, with a few taken from the coastal area between San Pedro south to San Diego. Forty percent of the catches, as determined by fishermen interviews, originated in the expanse from the City of Santa Barbara to Point Mugu and offshore in the Santa Cruz Island-Anacapa Island area; 34 percent from Point Dume to Point Vicente and in Santa Monica Bay; 22 percent from southern Channel Island waters (Santa Barbara, Santa Catalina, San Clemente, and San Nicolas Islands); and 4 percent from the coastal area south of San Pedro.

Only 844 tons were landed during the "September" dark. Approximately 6,000 were netted in "October" which together with the 9,828 in "November" comprised 78 percent of the southern California total. About 2,500 tons were netted in "December" and 1,200 in "January" for a total southern California catch of approximately 20,335 tons.

Nine canners processed the southern California catch: eight in the Los Angeles-Long Beach Harbor area and one at Oxnard. Ninety boats supplied these processors, a decrease of 29 vessels from the previous season. The fleet consisted of 63 purse seiners (56 large, 7 small) and 27 lampara boats.

Baja California

There is year-round fishing for sardines off the Pacific coast of Baja California. During 1959, approximately 22,400 tons were netted by 20 Mexican purse seiners, 8,113 during the "September" through "January" darks. The catch was processed by eight canneries.

Mexican fishermen, operating cannery-owned boats, received a price equivalent to $15.10 (U.S. currency) per metric ton for sardines and mackerel. A few American seine fishermen from San Pedro and San Diego who delivered to Mexican canneries were paid $32.80 per metric ton for their fish. Sardines and mackerels used for reduction yielded fishermen $10.04 per metric ton.

The Baja California catch was netted in three general fishing areas: Ensenada, San Quintín, and Cedros Island (Figure 2). The six canneries at Ensenada were supplied by 14 boats fishing between Los Coronados Islands and Cape Colnett. A cannery at San Quintín operated two company-owned seiners in and around San Quintín Bay and the Cedros Island cannery took fish from four vessels which netted their catches in the area from northern Sebastián Vizcaíno Bay to Turtle Bay.

AGE AND LENGTH COMPOSITION

Lunar month summaries were used to obtain the year-class composition of the total catch following a method described by Felin and Phillips (1948). Inherent in the method are weight-per-fish factors computed each lunar week for each area. The average weights for this season were: central California 0.2449 pound, southern California 0.2041 pound, and Baja California 0.1487 pound.

The 708 fish aged from the central California catch were 2 through 5 years old and ranged from 194 to 256 mm standard length (Table 2). In southern California, the 657 fish aged were 1 through 6 with lengths of 166 to 238 mm (Table 3). Ages ranged from 1 through 5 for 470 fish from Baja California samples taken during the California season; their lengths ranged from 136 to 236 mm (Table 4). During the Baja California interseason, the 866 fish aged were 1 through 8 years old and 142 through 222 mm long (Table 5).

Two- and three-year-old fish constituted 92 percent of the 115,943,000 sardines caught in central California (Figure 2 and Table 6). The three-year-old 1956 year-class contributed 54 percent and the two-year-old 1957 year-class, 38 percent. There was little change in length or age composition between lunar periods.

In southern California, the 1957 year-class as two-year-olds contributed 60 percent of the 202,095,000 sardines caught, the three-year-old 1956 year-class 23 percent, and the one-year-old 1958's 12 percent (Figure 2 and Table 6).

In Baja California, during the California season, the 1957 year-class supplied 61 percent of the 118,672,000 fish netted (Table 6). One-year-olds, of the 1958 year-class, contributed 20 percent and three-year-olds, the 1956 year-class, 18 percent.

During the interseason, from January 1 to September 1, the Baja California catch of 189,008,000 sardines contained 47 percent three-year-olds, 1956 year-class (Table 7). The two-year-old 1957 year-class contributed 39 percent and the four-year-old 1955's, 8 percent.

TABLE 1
Calendar Dates of Lunar Months During 1959

Lunar month	Lunar period[1]	Dates
"January"	485	December 25–January 23
"February"	486	January 24–February 21
"March"	487	February 22–March 23
"April"	488	March 24–April 22
"May"	489	April 23–May 22
"June"	490	May 23–June 20
"July"	491	June 21–July 20
"August"	492	July 21–August 18
"September"	493	August 19–September 17
"October"	494	September 18–October 16
"November"	495	October 17–November 15
"December"	496	November 16–December 14
"January"	497	December 15–January 12[2]

[1] Lunar periods have been numbered serially since "November" of the 1919-20 season.
[2] All commercial sardine fishing was considered to end on December 31.

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TABLE 2
Length Composition of Year-Classes in Sardine Samples from the Central California Commercial Catch, 1959-60 Season

Age	2	3	4	5	6	
Year-class	1957	1956	1955	1954	1953	Total
Standard length mm						
194	--	1	--	--	--	1
196	5	2	--	--	--	7
198	7	5	--	--	--	12
200	10	9	1	--	--	20
202	11	17	0	--	--	28
204	27	22	2	--	--	51
206	32	24	3	--	--	59
208	40	44	3	--	--	87
210	37	51	7	1	--	96
212	34	48	10	1	--	93
214	27	33	7	--	--	67
216	15	36	1	--	--	52
218	16	29	3	--	--	48
220	7	27	2	--	--	36
222	7	8	2	--	--	17
224	2	8	2	--	--	12
226	4	5	0	--	--	9
228	--	5	0	--	--	5
230	--	1	0	--	--	1
232	--	1	1	--	--	2
234	--	0	2	--	--	2
236	--	0	1	--	--	1
238	--	0	0	--	--	0
240	--	0	0	--	--	0
242	--	0	0	--	--	0
244	--	0	0	--	--	0
246	--	0	1	--	--	1
248	--	0	--	--	--	0
250	--	0	--	--	--	0
252	--	0	--	--	--	0
254	--	0	--	--	--	0
256	--	1	--	--	--	1
Totals	281	377	48	2	--	708
Mean lengths	210	212	215	211	--	211

TABLE 3

Length Composition of Year-Classes in Sardine Samples from the Southern California Commercial Catch, 1959-60 Season

Age	1	2	3	4	5	6	
Year-class	1958	1957	1956	1955	1954	1953	Total
Standard length mm							
166	1	--	--	--	--	--	1
168	0	1	--	--	--	--	1
170	0	2	1	--	--	--	3
172	4	4	0	--	--	--	8
174	0	2	0	--	--	--	2
176	7	13	0	--	--	--	20
178	8	6	1	--	--	--	15
180	3	17	1	--	--	--	21
182	15	24	2	--	--	--	41
184	7	13	1	--	--	--	21
186	4	18	1	--	--	--	23
188	6	16	5	--	--	--	27
190	3	20	3	1	--	--	27
192	4	25	7	1	--	--	37
194	1	19	9	2	--	--	31
196	0	20	4	3	--	--	27
198	2	21	12	1	--	--	36
200	0	16	12	3	--	--	31
202	1	19	8	1	--	--	29
204	0	30	14	2	--	--	46
206	0	25	23	2	--	--	50
208	1	27	17	0	--	--	45
210	--	9	13	1	--	--	23
212	--	17	12	2	--	--	31
214	--	13	8	4	--	--	25
216	--	8	5	2	--	--	15
218	--	1	2	0	--	--	3
220	--	2	2	0	1	--	5
222	--	1	0	1	0	1	3
224	--	--	3	0	0	--	3
226	--	--	1	0	0	--	1
228	--	--	0	0	0	--	0
230	--	--	0	1	0	--	1
232	--	--	1	0	1	--	2
234	--	--	0	0	0	--	0
236	--	--	0	1	0	--	1
238	--	--	1	--	1	--	2
Totals	67	389	169	28	3	1	657
Mean lengths	183	196	204	207	230	222	197

TABLE 4

Length Composition of Year-Classes in Sardine Samples from the Baja California Commercial Catch, 1959-60 ("September" through "December")

Age	1	2	3	4	5	
Year-class	1958	1957	1956	1955	1954	Total
Standard length mm						
136	1	--	--	--	--	1
138	1	--	--	--	--	1
140	0	--	--	--	--	0
142	1	--	--	--	--	1
144	3	1	--	--	--	4
146	0	0	--	--	--	0
148	4	2	--	--	--	6
150	2	3	--	--	--	5
152	6	2	--	--	--	8
154	10	6	--	--	--	16
156	7	7	--	--	--	14
158	15	12	2	--	--	29
160	11	16	3	--	--	30
162	7	18	3	--	--	28
164	7	26	1	--	--	34
166	8	22	3	--	--	33
168	2	16	1	--	--	19
170	0	31	8	--	--	39
172	2	17	4	--	--	23
174	0	16	5	--	--	21
176	0	18	10	--	--	28
178	0	12	13	1	--	26
180	1	12	7	2	--	22
182	--	11	7	0	--	18
184	--	6	8	0	--	14
186	--	6	8	2	--	16
188	--	2	5	0	--	7
190	--	4	5	0	--	9
192	--	2	2	0	--	4
194	--	1	1	0	--	2
196	--	2	0	0	--	2
198	--	1	1	1	--	3
200	--	1	1	0	--	2
202	--	--	0	1	--	1
204	--	--	0	0	--	0
206	--	--	0	1	--	1
208	--	--	0	--	--	0
210	--	--	2	--	--	2
236	--	--	--	--	1	1
Totals	88	273	100	8	1	470
Mean lengths	158	170	179	190	236	170

TABLE 5

Length Composition of Year-Classes in Sardine Samples from the 1959 Baja California Interseason Catch ("January"-"August")

Year-class	1958	1957	1956	1955	1954	1953	1952	1951	Total
Standard length mm									
142	1	--	--	--	--	--	--	--	1
144	0	--	--	--	--	--	--	--	0
146	1	3	--	--	--	--	--	--	4
148	1	1	--	--	--	--	--	--	2
150	3	1	--	--	--	--	--	--	4
152	3	6	1	--	--	--	--	--	10
154	2	3	1	--	--	--	--	--	6
156	6	11	1	--	--	--	--	--	18
158	0	13	5	1	--	--	--	--	19
160	1	20	10	0	--	--	--	--	31
162	0	12	8	1	--	--	--	--	21
164	3	22	9	0	--	--	--	--	34
166	0	14	9	0	--	--	--	--	23
168	1	19	13	1	--	--	--	--	34
170	0	12	11	1	--	--	--	--	24
172	1	18	8	1	--	--	--	--	28
174	0	12	15	1	--	--	--	--	28
176	0	21	12	1	--	--	--	--	34
178	0	16	16	1	--	--	--	--	33
180	1	11	19	2	--	--	--	--	33
182	--	10	12	1	--	--	--	--	23
184	--	19	35	0	--	--	--	--	54
186	--	9	32	7	--	--	--	--	48
188	--	20	35	5	--	--	--	--	60
190	--	19	37	7	--	--	--	--	63
192	--	8	38	4	--	--	--	1	51
194	--	8	38	5	--	--	--	--	51
196	--	4	20	9	--	1	--	--	34
198	--	4	15	5	--	--	--	--	24
200	--	1	12	6	--	--	--	--	19
202	--	2	6	4	--	--	--	--	12
204	--	2	4	5	--	--	--	--	11
206	--	--	3	5	2	--	--	--	10
208	--	--	1	2	1	--	--	--	4
210	--	--	3	4	0	--	--	--	7
212	--	--	0	0	0	--	1	--	1
214	--	--	0	0	0	--	--	--	0
216	--	--	0	4	1	--	--	--	5
218	--	--	0	0	--	--	--	--	0
220	--	--	1	0	--	--	--	--	1
222	--	--	--	1	--	--	--	--	1
Totals	24	321	430	84	4	1	1	1	866
Mean lengths	157	174	185	195	209	196	212	192	181

TABLE 6

Age and Year-Class Composition of the Sardine Catch in the 1959-60 Season

	Catch		Number of fish in thousands by age and year-class						
			1	2	3	4	5	6	7
	Tons	Number	1958	1957	1956	1955	1954	1953	1952
Central California									
"August"	--	--	--	--	--	--	--	--	--
"September"	1,571	11,274	--	4,882	5,998	304	90	--	--
"October"	4,544	34,049	--	15,186	16,684	2,179	--	--	--
"November"	4,068	31,439	--	12,953	16,129	2,106	220	31	--
"December"	4,435	33,083	--	9,065	20,511	3,408	99	--	--
"January"[2]	800	6,098	--	2,122	3,537	341	98	--	--
Total Central California	15,418	115,943	--	44,208	62,859	8,338	507	31	--
Percent	--	100.0	--	38.1	54.2	7.2	0.5	--	--
Southern California									
"September"	844	6,853	774	3,934	2,145	--	--	--	--
"October"	5,942	60,039	8,045	32,661	16,571	2,642	60	60	--
"November"	9,828	100,581	12,372	65,177	19,412	2,917	603	100	--
"December"	2,531	24,473	3,573	14,684	5,188	979	49	--	--
"January"	1,190	10,149	142	5,277	3,715	873	112	--	30
Total Southern California	20,335	202,095	24,906	121,733	47,031	7,411	824	160	30
Percent	--	100.0	12.3	60.2	23.3	3.7	0.4	0.1	--
Total California	35,753	318,038	24,906	165,941	109,890	15,749	1,331	191	30
Percent	--	100.0	7.8	52.2	34.6	4.9	0.4	0.1	--
Baja California[3]									
"September"	1,326	20,051	3,887	12,413	3,220	531	--	--	--
"October"	2,405	35,874	9,354	19,893	6,360	267	--	--	--
"November"	2,017	31,054	7,134	18,059	5,694	167	--	--	--
"December"	1,545	20,721	2,215	14,289	3,951	85	181	--	--
"January"[2]	820	10,972	1,132	7,462	2,224	52	102	--	--
Total Baja California	8,113	118,672	23,722	72,116	21,449	1,102	283	--	--
Percent	--	100.0	20.0	60.8	18.1	0.9	0.2	--	--
TOTAL	43,866	436,710	48,628	238,057	131,339	16,851	1,614	191	30
Percent	--	100.0	11.1	54.5	30.1	3.9	0.4	--	--

[1] Price dispute, vessels did not fish.
[2] December 15 to January 1 only.
[3] Includes data from Ensenada, San Quintín and Cedros Island.

TABLE 7

Year-Class Composition of the 1959 Interseason Sardine Catch for Baja California

Lunar month	Catch		Number of fish in thousands by age and year-class							
			1	2	3	4	5	6	7	8
	Tons	Number	1958	1957	1956	1955	1954	1953	1952	1951
"January"[1]	1,298	19,801	--	9,169	10,535	80	20	--	--	--
"February"	1,147	16,350	--	3,705	10,240	2,405	--	--	--	--
"March"	1,255	17,591	--	4,363	10,550	2,273	289	--	116	--
"April"	1,317	19,407	--	9,845	7,621	1,494	--	447	--	--
"May"	821	12,315	1,296	5,187	5,181	648	--	--	--	--
"June"	4,634	60,207	6,337	25,351	25,349	3,170	--	--	--	--
"July"	1,792	20,680	419	5,869	11,597	2,795	--	--	--	--
"August"	1,646	18,100	786	8,812	6,900	1,155	--	--	--	447
"September"[2]	415	4,554	415	2,168	1,653	318	--	--	--	--
TOTAL	14,325	189,008	9,253	74,469	89,629	14,338	309	447	116	447
Percent	--	100.0	4.9	39.4	47.4	7.6	0.2	0.2	0.1	0.2

[1] From January 1 only.
[2] To September 1 only.

THE NESTING OF *CHROMIS PUNCTIPINNIS* (COOPER) AND A DESCRIPTION OF THEIR EGGS AND LARVAE[1]

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The damselfish family Pomacentridae is represented along our California coast by two commercially unimportant species, the very colorful and pugnacious garibaldi, *Hypsypops rubicunda,* and the less colorful

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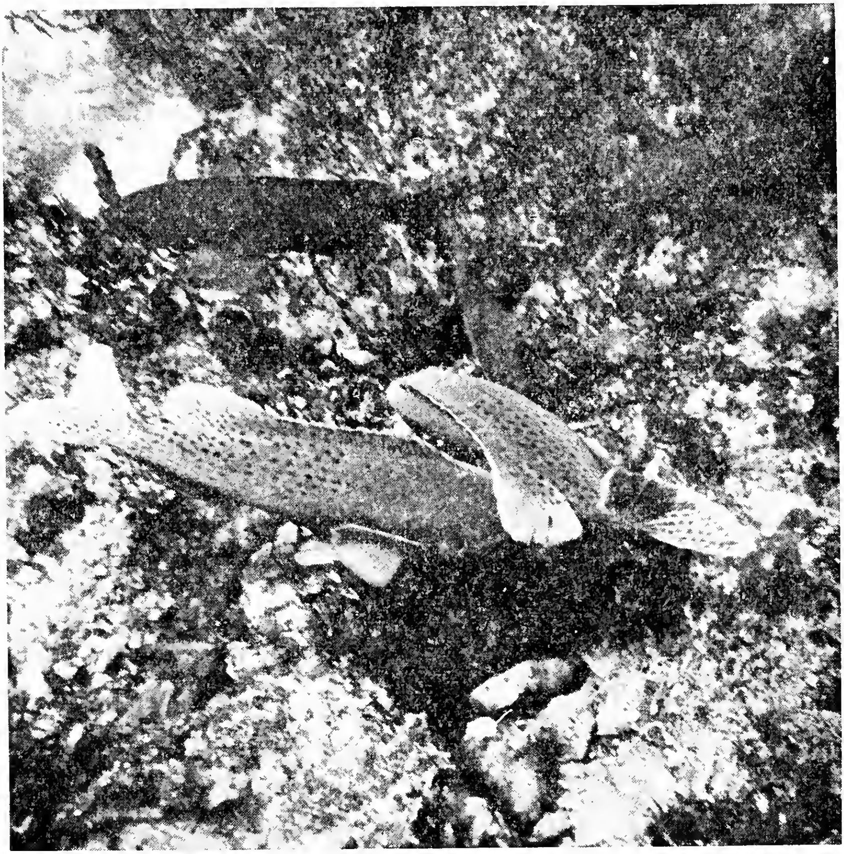

FIGURE 1. A male blacksmith (center left) nudging and biting a gravid female, forcing her into his nest site. *(Photo by Charles H. Turner.)*

FIGURE 2. With the spawned-out female's departure, the male immediately positions himself in the cave entrance, protecting the nest from intruders and fanning the eggs. *(Photo by Charles H. Turner.)*

but equally pugnacious blacksmith, *Chromis punctipinnis.* Garibaldis (sometimes called ocean goldfish) are protected by law but it is legal to take blacksmiths. Although their flesh is good quality, they are taken only incidentally by fishermen; their small mouths make them difficult to catch. Characteristically, pomacentrids are oviparous and construct nests which are closely guarded by the males (Breder, 1933).

While diving at Santa Catalina Island during the summer of 1961, the nesting behavior of *Chromis punctipinnis* was observed—a phenomenon not previously described.

We first noted blacksmith nests at Harbor Reef, Santa Catalina Island in July and August, 1961. This reef, consisting of large shale shelves interspersed with scattered 15- to 30-pound rocks, rises to the surface from depths of over 100 feet. Blacksmiths were building nests under these 15- to 30-pound rocks from 12 to at least 80 feet beneath the surface, but most nesting was between 40 and 50 feet. Several dives were made at other localities along the inshore side of Santa Catalina Island but no other nests were located; however, nesting behavior was

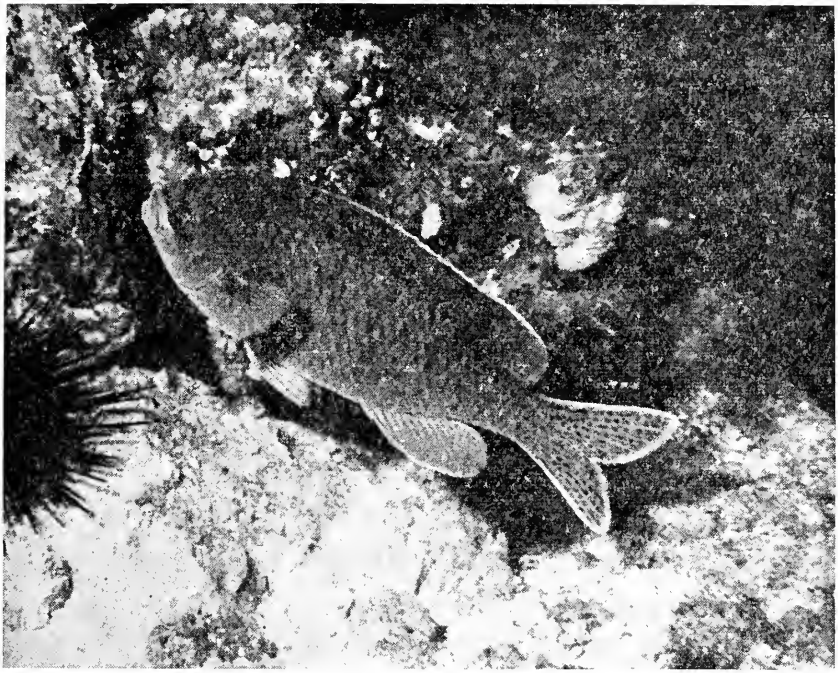

FIGURE 3. A nest-guarding male exhibiting "masking" around the eyes. *(Photo by Charles H. Turner.)*

exhibited by adult male blacksmiths at some of those sites. The bottom around the Harbor Reef is ideally suited for observing the nesting habits of *C. punctipinnis*.

Nests were constructed under rock ledges or under the 15- to 30-pound rocks that provided small caves. A male would first clean an area well back under the cave roof and then force a gravid mature female into the site by nudging and biting her. We could not observe actual egg deposition because the nest entrances were singular and small; however, the eggs were attached by adhesive filaments to the previously cleaned area of the cave roof. After the spawned-out female departed, the male would position himself in the nest opening, fanning the eggs with his tail and keeping out predators by his pugnacious behavior.

Temperatures at the nesting area ranged from 10.0°C to 18.0°C, depending upon depth and day.

The nestguarding males undergo a very conspicuous color change. From their normal bluish-grey with black flecks along the sides, they transform into a very pale, almost white, mottled grey. Two pronounced dark bands, each about one-quarter inch wide, show up dorsal and slightly anterior to the eyes, giving *Chromis* a "masked" appearance (Figure 3). If a male is driven from his nest, he quickly resumes normal coloration.

Whenever a male was driven from a nest site, fish converged on the unguarded nest and devoured eggs in a wild frenzy. Leading the assault were other blacksmiths who seemed to relish the eggs, particularly mature ones. Other fish preying on the eggs were señoritas, *Oxyjulis californica*, sheepheads, *Pimelometopon pulchrum*, and garibaldis. The returning male was very aggressive towards these fish regardless of their size.

Immature eggs were apparently easily guarded by the male; however, when the first hatching larvae swam out of the nest cave they attracted predators to the area. Blacksmiths and other fish then ganged-up on the nesting male. The larvae were eaten as they left the cave and the predators tried to swim down this "food stream," past the guarding male, to its source.

Although Limbaugh (1955) excised cherry red eggs from mature females in June and July, he was unable to locate their nests. We found that the freshly spawned eggs were salmon pink in color, oblong in shape, and had up to seven filaments at one end. The egg filaments attached to each other in such a way they formed a larger central cord which adhered to the substrate. A nest was composed of numerous cords

FIGURE 4. When the rocky roof of the nest site is overturned the strings of eggs (arrow) are easily visible. Blacksmiths "flock" to the unguarded nest to feed upon the eggs. *(Photo by Charles H. Turner.)*

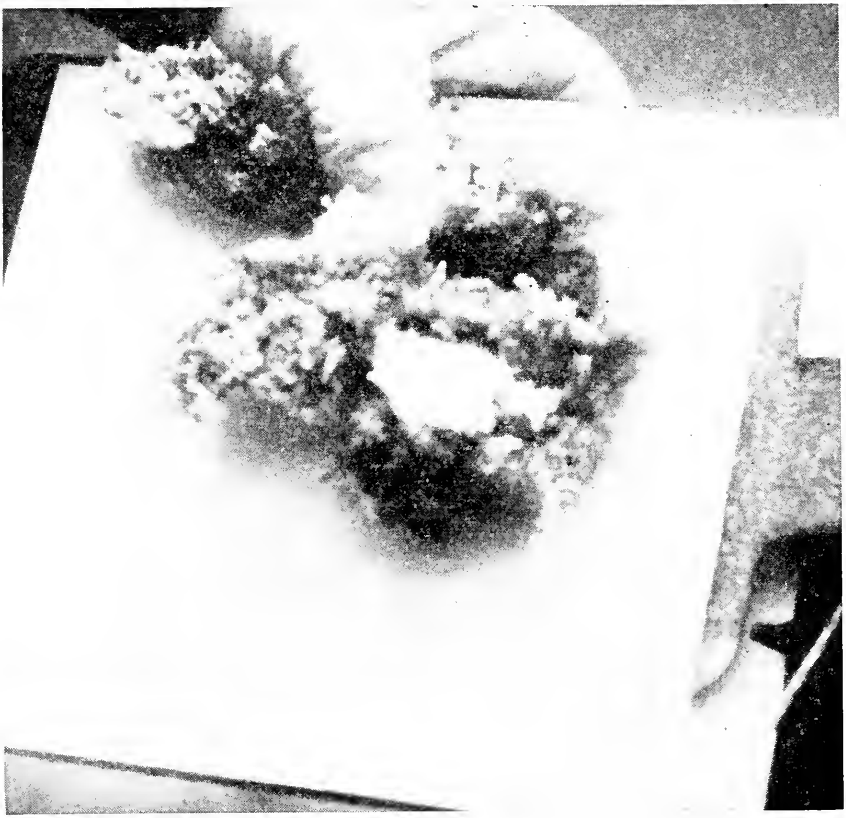

FIGURE 5. An entire egg mass just after its removal from the nest site. For size comparison the white sheet is 8 by 11 inches. *(Photo by Charles H. Turner.)*

and had the appearance of several bunches of tiny grapes. Fifty eggs were randomly sampled from one nest, these averaged 1.22 mm long, ranging from 1.14 to 1.32 mm. We estimated there were 615,000 eggs per nest and because of these numbers and the fact they were in several stages of development we felt that at least two, and probably three or four, females had been induced to spawn at each nest. Such large numbers are usually atypical for nest-building species.

As *C. punctipinnis* eggs mature, they become opaque and whitish; eyes show up as black spots inside each egg. Just prior to hatching the entire egg mass appears greyish because of the eyes and numerous melanophores that have developed along the ventral surface of the embryo. Newly-hatched larvae are about 3.06 mm long. In these, the mouth is terminal, the anal area is well-forward, the yolk sac is almost gone, and the finfold is continuous around the body—only the pectoral fins are differentiated (Figure 7). Blacksmith larvae and juveniles to one-half inch long were noted in the area during all of our observations. The young are bi-colored: anteriorly a bluish-grey and posteriorly a brassy orange. We commonly have observed one-inch long specimens in Santa Monica Bay during October and November where they form loose small schools and remain close to protective cover. Limbaugh (1955) reported that blacksmiths mature at 5.5 inches at a probable age of two years. The largest specimens we have observed were about 12 inches. An 11½ incher taken in Monterey Bay was in its 7th year; it had first spawned in its third year.

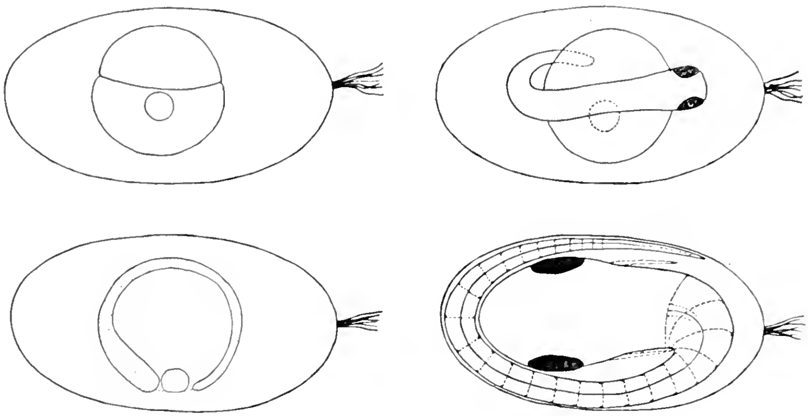

FIGURE 6. Eggs from one nest in four different developmental stages on August 2, 1961.

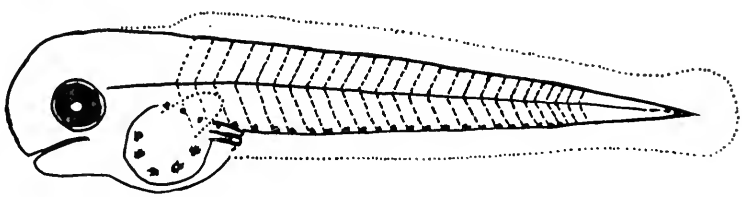

FIGURE 7. Just-hatched larva, 3.06 mm total length.

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THE NESTING BEHAVIOR, EGGS AND LARVAE OF THE BLUESPOT GOBY[1]

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Bluespot gobies, *Coryphopterus nicholsi* (Bean), belong to the widely-distributed fish family Gobiidae, a group inhabiting tropical and temperate waters throughout the world; 12 species of gobies have been recorded from California waters (Roedel, 1953). Gobies are characterized by having their pelvic fins completely joined to each other.

Coryphopterus can be distinguished from other local gobies by its big scales, dark crested dorsal and large black eyes. A fleshy dorsal

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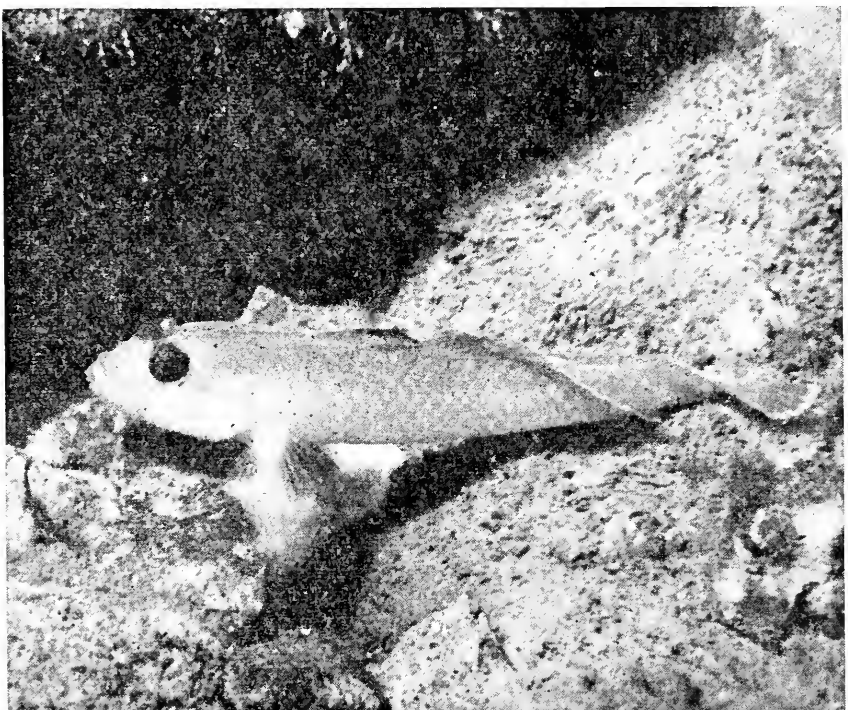

FIGURE 1. A 4-inch adult bluespot goby in its nesting area. *(Photo by Charles H. Turner.)*

ridge extends from just behind the eyes to the insertion of the slightly elongated dorsal fin. Underwater it is grey-white to pale yellow in color. The pelvic fins, usually dusky, darken on the male during the breeding season. Adults attain maximum lengths of about 6 inches.

Bluespot gobies range from San Martin Island, Baja California, to British Columbia and adults live intertidally and to depths over 200 feet (Limbaugh, 1955). Although adults are usually considered bottom dwellers, juveniles are occasionally taken in plankton nets far at sea. One inch-long juvenile was found in the stomach of an albacore caught on Davidson Seamount, 60 miles SW of Point Sur. Although this seamount rises to within 745 fathoms of the surface it is surrounded on all sides by 2000-fathom water.

Apparently *Coryphopterus nicholsi* is an old inhabitant of our waters; fossil otoliths have been identified from the San Diego formation, a Pliocene deposit estimated between 8 and 12 million years old. Additional fossil otoliths, 20 in material screened from Timms Point, San Pedro (Lower Pleistoscene) and 1 from Baldwin Hills, Los Angeles (Upper Pleistocene), attest to its antiquity (John E. Fitch, personal communication).

Although eggs and larvae of some western Atlantic gobiids have been described (Hildebrand, 1938), nothing has been recorded for *Coryphopterus.*

We made all field observations while using SCUBA (self contained underwater breathing apparatus) in Santa Monica Bay while routinely checking artificial reefs placed at strategic localities throughout the bay. Entire nests were brought to the laboratory and the eggs placed in 5 percent formalin. Drawings were made from preserved material.

We observed breeding during the spring, summer and fall and found nests from April through October. These were off Hermosa Beach and Santa Monica in 60 feet of water, attached to the undersides of rocks on our artificial reefs. Water temperatures at the nest sites ranged from 12.9° to 14.6°C.

We noted that males would select a rock for a nest site, hollow out a small depression beneath it, and then clean its underside; later the female would attach her eggs to this cleaned undersurface (Figure 2).

During courtship, the male would rise straight off the bottom a few inches and settle back again, attracting the female's attention by spreading his dorsal and blackened pelvic fins which are quite striking at this time.

In an aquarium, a male frantically rushed across the tank at a female and then returned to his starting place apparently in an attempt to stimulate her and force her into the nest area he had selected. (David Powell, Marineland of the Pacific, pers. commun.)

After the female attaches her eggs, the male remains on guard and fans the nest to keep water circulating around the eggs. When disturbed, he will retreat into the "nest-cave" to protect his family. If the nest site is molested, the male swims away about a yard, becomes quite excited, and will not return to the "nest-cave" for several minutes.

Nests average 4 inches in diameter, are roughly circular, and are made up of a single layer of eggs. The oblong eggs, pointed at both

FIGURE 2. By overturning the nest-cave roof, the single-layered nest of eggs (outlined) is visible. A sheephead and rockfish, upper left, are showing considerable interest in the exposed nest. *(Photo by Charles H. Turner.)*

ends, are attached directly to the rock but do not have adhesive threads. Immature eggs gave the nest a faded-pink appearance while mature nests were greyish due to pigment on the developing embryos.

The earliest stages we observed were of recently differentiated embryos at a time when the yolk filled only a small portion of the egg sac. Excess space is rapidly used as the embryo develops, resulting in the tail curling back on the body in advanced stages. A well-formed embyro, prior to hatching, nearly fills its egg case.

Mature eggs average 2.10 mm long by 0.48 mm wide. The embyro within each mature egg is 2.97 mm long and its head is directed opposite (downward) the pole of attachment.

The larva is released when its enveloping egg sac splits in a median plane. The attached end remains on the substrate, later disolving, and the larva drops out and swims away.

Newly-hatched larvae are 2.97 mm long, have prominent, large eyes and almost transparent bodies (Figure 4). A line of pigment extends posteriorly over the yolk sac then curves downward to the base of the ventral finfold, ending in the caudal region. There is another short line of pigment near the caudal peduncle at the dorsal finfold base. The

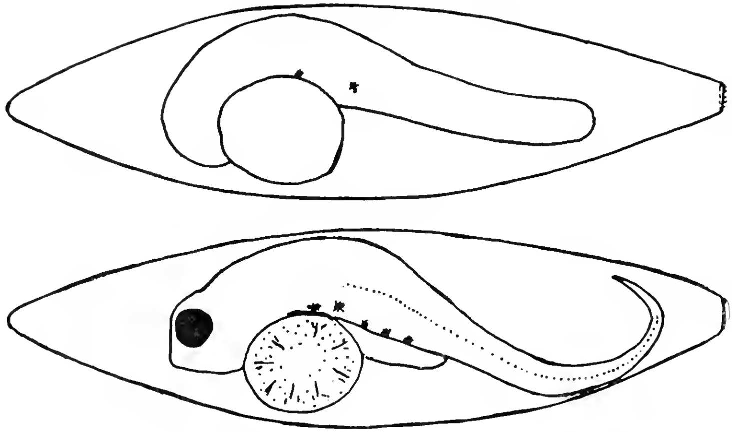

FIGURE 3. Top: Developing embryo. The egg case is 2.10 mm long by 0.48 mm wide; its yolk is 0.30 by 0.42 mm and the embryo is 1.05 mm long. Bottom: Maturing embryo. There are melanophores ventrally and the black eyes are prominent.

air bladder and gut are visible posterior to the yolk which, at this time, is little larger than the eye. The vent is slightly closer to the snout than the tail. The well-developed mouth is terminal, a normal position for this species.

We calculated there were 1,700 eggs per nest and believe that only one female was involved, although fecundity was not determined.

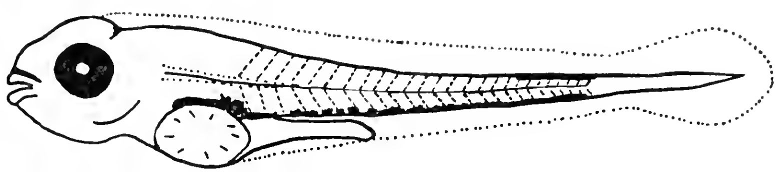

FIGURE 4. Just-hatched larva 2.97 mm total length.

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ESTIMATING THE NUMBER OF ANGLING LICENSE PURCHASERS[1]

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INTRODUCTION

The number of persons purchasing California angling licenses is of particular interest in relation to Federal Aid to Fish Restoration funds which are allocated according to number of license purchasers rather than number of licenses sold. California issues three types of special angling licenses in addition to the regular resident license. Because of the nature of these special licenses (3-day ocean waters only, 10-day nonresident, annual nonresident), some individuals probably purchase more than one of them. The object of this paper is to provide an estimate of the number of distinct persons who bought special licenses during 1961.

ESTIMATION METHOD

The estimation method I applied to the problem utilizes only information obtained by examining a sample of license stubs. This may be likened to solving a problem involving N balls of k different colors in an urn. There are n_1 balls of the first color, n_2 balls of the second color and n_k balls of the kth color,

$$\sum_{j=1}^{k} n_j = N.$$

Assume N is known and estimate k, the number of colors, from a sample of n balls. To see the analogy with the license problem, associate balls with licenses and colors with license purchasers.

A theoretically more efficient method, which involves querying a sample of licensees regarding the number of licenses they purchased, could have been employed. However, such a method would have required either a high-cost field survey or a mail survey with possible large nonresponse error. Furthermore, surveys requiring the respondent to recall events of a past year may produce bias due to memory failure. Mosteller (1949) discussed solutions to the urn problem as well as the survey method and gave some results from experimental sampling.

Goodman (1949) derived the unique unbiased estimator for k in the urn problem. Unfortunately this may give very unreasonable estimates and is too erratic for practical use. He also presented a modification of the unbiased estimator which, though not unbiased, always gives reasonable results. The modified estimator, which was deemed suitable

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for estimating the number of persons purchasing special angling licenses during 1961, is

$$\hat{k}' = \begin{cases} s' = \dfrac{N(N-1)}{n(n-1)} x_2 & \text{if} \quad s' \geq \sum_{i=1}^{n} x_i \\ \\ \sum_{i=1}^{n} x_i & \text{if} \quad s' < \sum_{i=1}^{n} x_i \end{cases}$$

where N is the number of special licenses in the population, n is the number of licenses sampled and x_i is the number of persons in the sample who purchased i licenses. To estimate the ratio of license purchasers to licenses, $\hat{p}' = \hat{k}'/N$ was used.

Raj (1961) derived an unbiased estimator for the variance of $x_2[N(N-1)]/[n(n-1)]$ under the assumption that $n_j \leq 2$ for all j. We have used his formula,

$$\hat{V}(s') = \left[\frac{N(N-1)}{n(n-1)} x_2\right]^2 \left[1 - \frac{n(n-1)}{N(N-1)} \frac{(N-2)}{(n-2)} \frac{(N-3)}{(n-3)}\right] + \frac{N(N-1)}{n(n-1)} x_2 \left[\frac{(N-2)}{(n-2)} \frac{(N-3)}{(n-3)} - 1\right]$$

as an approximation to the variance of s'. The approximation will be close if very few persons purchased more than two special licenses. It should also be noted that the mean square error of $\hat{k}'$ is less than $MSE(s')$. Similarly, the variance of s'/N was approximated by $\hat{V}(s')/N^2$ and $MSE(\hat{p}') \leq MSE(s'/N)$.

ESTIMATES FOR 1961

Of 142,597 special angling licenses sold during 1961, 134,936 license stubs were available for sampling. A sample of 7,500 including seven illegible stubs was randomly selected. Examination of the sample revealed 52 pairs purchased by the same persons and one quadruplicate. Thus, $N = 134{,}936$, $n = 7{,}493$, $x_1 = 7{,}385$, $x_2 = 52$ and $x_4 = 1$. Computing the components of $\hat{k}'$, we obtain $\Sigma\, x_i = 7{,}438$ and $s' = 118{,}070$. Then, because $s' > \Sigma\, x_i$, the estimated number of persons purchasing 134,936 special licenses in 1961 is $\hat{k}' = s' = 118{,}070$. The estimated ratio of license purchasers to licenses is $\hat{p}' = .875$. With respect to the bias of these estimates, it can be shown that for the N and n of this problem, $\hat{k}'$ and $\hat{p}'$ tend to yield underestimates. Further, if the number of persons purchasing three or more licenses is small, the bias will be negligible relative to the estimate.

The approximate standard errors of $\hat{k}'$ and $\hat{p}'$ are 2,305 and .017 respectively.

SUMMARY

An estimated 118,070 persons purchased 134,936 special California angling licenses during 1961. The corresponding ratio of license purchasers to licenses is 0.875. Approximate standard errors of the number of purchasers and the ratio are 2,305 and .017, respectively. Estimates were obtained from a random sample of 7,493 license stubs using a method involving examining the sample for persons purchasing more than one license.

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POTENTIAL PROFITS IN THE CALIFORNIA SALMON FISHERY[1]

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INTRODUCTION

More and more water and power projects are being built in California. Many of these will put dams in the paths of migrating fish, flood out their spawning areas and divert their spawning streams. In such instances, the Department of Fish and Game is legally required to order the construction agency to take appropriate steps to minimize damage to fish life by installing fishways, fish screens or fish hatcheries. Other state and federal statutes require the Department to report on and recommend other protective or compensating measures, including water releases to maintain fish life, and suggest changes in the project's design and operation to maintain and enhance these resources.

The Department is not required to demonstrate the cash value of these fish in order to take steps to save them. Neither is the U.S. Coast Guard required to demonstrate that a sailor on a sinking ship is worth what it will cost to rescue him. In either instance, the victim's death would be apt to occur before the matter could be settled. This does not mean the Department can ignore the species or numbers of fish involved. Often, extensive studies must be carried out in order to determine how best to provide for fish runs, but such studies are based primarily on biology and engineering rather than on economics.

Sometimes when studying a project it becomes evident that not only can runs be maintained but by spending a bit more money they can be increased. At this point, economics become of primary importance. Government agencies are required to regard fish production as one of the beneficial uses of water. If, in a state or federal project, an additional expenditure would increase the run above its former (pre-project) level and the extra fish produced would more than offset the cost of producing them, there is an excellent chance that money to increase the run will be forthcoming. Conversely, if the cost of providing *extra* fish exceeds their value, the project will usually supply finances to maintain the run at its natural level—but no more.

Once the cost of producing extra fish is known, the problem can be settled by determining the value of each fish. Unfortunately there are all too many ways to calculate this, and the answers are ridiculously far apart. For commercially-caught salmon, values from zero to well

[1] An evaluation of the fishery based on a method suggested by Dr. James Crutchfield, Associate Professor of Economics, University of Washington, Seattle. Submitted for publication May 1962.

above the retail cost-per-pound have been seriously suggested. In this paper, I will present a method of evaluating commercial salmon; sport-caught fish pose altogether different problems and will not be discussed.

Quite logically, men who evaluate water projects want to be able to appraise the fisheries involved by methods comparable to those used on other parts of the project. Most values assigned to water, for example, are based on the increased profits that will be realized. A plot of land will ordinarily produce more if irrigated than if dry-farmed, but the costs of farming will be greater. Profits due to irrigating are calculated by deducting the extra expenses from the extra money gained from the larger (or different) crop. Commercial fisheries' values, on the other hand, have usually been expressed by the Department of Fish and Game as the total received for the fish at dockside, or sometimes at the wholesale level, with no deductions for the cost of catching them. On occasion this has led to the fisheries receiving little consideration because no one had calculated the profits involved. Some economists have insisted that, according to economic standards sometimes used in business, many fisheries (including salmon) have no value because the fishermen could have made as much or more at almost any other job—the fishermen were, in effect, running a small business, paying themselves a bare minimum wage for long hours of hard work and, on the average, making no money whatever on their investment.

Some American traditions and laws tend to reduce a fisherman's cash profit (above day wages) to the vanishing point. Truly efficient fishing gear is outlawed in the interests of conservation or to spread employment among as many people as possible. In California, for example, commercial fishermen may take salmon only by trolling—a grossly inefficient method made a trifle less so by a large investment in mechanized gear and electronic fishing aids. There is no limitation on the number of men who may enter this business. If too many do enter it, catches of individual fishermen fall off and the least efficient or most easily discouraged individuals drop out. If the dictates of conservation demand it, the State may hasten the process by shortening the season. Limiting the number of boats and thus letting each make a fair living would be one approach—but our society has not chosen to use it. We *do* use this approach in some businesses such as radio and television stations, liquor stores, and power plants. It is often against the profits of a power-plant monopoly that fisheries' profits are compared.

A farmer is allowed to own or lease land and manage it as efficiently as he is able. His crop is not open to harvest by anyone who comes along. A fisherman has no such protection even though his investment in boat and gear may exceed the cost of a farm. He must share the harvest with everyone who enters the fishery and is often compelled by law to operate very inefficiently.

Obviously, if the net economic yield concept is to be used to compare such differently managed businesses as power generation, farming and commercial fishing, it must be modified. For commercial fishing this could be done by calculating the profits a fishery would realize if it operated as a virtual monopoly, if it used the most efficient gear and if the catch were adjusted to that which the resource could continuously produce under best management practices. For the salmon fishery of California's Central Valley, such profits can be calculated without wandering too far into fields of conjecture.

A HYPOTHETICAL SALMON FISHERY

I will describe a fishery which has been proven efficient. *I am not proposing that such a fishery be created;* it is only used as a method to calculate the potential net benefits of the resource—nothing else is implied.

Assume that all commercial trolling was stopped and all commercial catches were made where they could be taken most efficiently. The Sacramento-San Joaquin Delta would be an excellent area—the fish are still in prime condition (they are mature and have reached their maximum growth). A fishery would get maximum production out of Sacramento-San Joaquin fish. It would not harvest fish from other California rivers, but there is no reason why similar but smaller fisheries could not be established in other streams.

Salmon in inland waters could be caught by many methods. Some of these are proven ones, having been used either in California or other parts of the world. Even electrical fishing could be considered in a study to determine the cheapest way to harvest fish; however, I have chosen proven methods for this model in order to be on firmer ground when calculating costs. Some which might be used are:

Salmon traps similar to those recently used in Alaska were once used in California but were not particularly effective in this State and were gradually being abandoned when the Legislature outlawed them.

A dam with a fishway. This would have to be constructed upstream from the levee system controlling the lower river. Fish taken this far upstream would be approaching spawning condition and their desirability would be greatly reduced. Furthermore, capital investment would be very high, particularly because several streams would have to be dammed.

Fishwheels have not been proven on the Sacramento. In any event, suitable sites are so far upstream that fish quality would have deteriorated badly.

Beach seines once met with moderate success but would never harvest the entire crop. There are not enough suitable seining sites in the Delta or in the lower Sacramento River.

Gill nets were the only gear which proved successful for many decades in the inland waters of the Central Valley. Legislation reduced their effectiveness through the years, and gill-net fishermen had to be content with salmon that had escaped the expanding troll fishery. Finally, in 1957 salmon gill-netting was outlawed completely. A small gill-net fleet could be very effective if it operated to take the maximum sustainable yield for the lowest reasonable cost.

In the last decades of the fishery, many gill-netters operated from Carquinez Strait to Pittsburg—an area with much open water which gave the fish a chance to scatter. Carquinez Strait is narrow but it is deep, has violent tides and such heavy boat traffic that the ship channel must be kept free of nets. In the strait and other downstream areas, the boats had first chance at migrating fish but they were fishing in the large end of the funnel. Farther upstream in the Sacramento River, from Collinsville to Rio Vista and corresponding places on the San Joaquin, the boats were at the small end of the funnel but were catching only those fish that had escaped trollers *and* downstream gill-netters. To make sure they did not catch too many salmon, gill-netters were required to stop fishing on weekends.[2] The season closed September 26—at the peak of the fall migration—and did not open till November 15, by which time the run was down to a dribble. There was another closed season in early summer, but not nearly as many fish were moving at that time. All these restrictive measures (closed seasons, closed areas, etc.) were imposed largely because there were too many boats.

Assume that instead of a large fleet scattered over a wide area, a small fleet fished in the small end of the funnel. Assume that instead of having two lengthy closed seasons, the fleet was kept small enough to permit the necessary escapement. This could be done by restricting the number of boats fishing when salmon were relatively scarce. The weekend closure could be lengthened when more escapement was needed and eliminated in times of excessive abundance. Assume also that this fleet was manned exclusively by competent fishermen. Such a fleet could harvest the Sacramento-San Joaquin at a very low cost.

WHAT WOULD BE THE SIZE OF THE HARVEST?

Obviously if there were no troll fishery, many more salmon would enter the Delta. Tagging and marking experiments have demonstrated that landings of salmon *produced* in the Sacramento-San Joaquin River system exceed the total salmon from all sources which are landed in California. In other words, tonnages of Central Valley salmon taken by trollers off Oregon, Washington, and Canada exceed all California catches of salmon from rivers outside the valley. Extensive additional analysis and possibly some additional marking experiments will be needed to demonstrate the amount of this excess, so for this study total state salmon landings will be used as a measure of how many pounds could be taken in the Delta if there were no troll fishery. This is a minimum figure, not only for the reason given above but because trollers keep many 5-pound salmon that two years later would weigh 20. In some years, the average weights of gill-netted salmon were almost twice those of troll-caught fish. Furthermore, many still-smaller fish are unintentionally killed in the course of being hooked, unhooked, and returned to the water.

Average salmon landings over the 10 years 1952-1961 were 7,895,000 pounds, which will be used as the average catch of our hypothetical gill-net fleet operating in the Delta.

How would the catch be distributed through the year? To determine this, the monthly gill-net catch of each of the last 10 complete years of the fishery (1947 through 1956) was expressed as a percent of that year's total catch and then averaged (column 1, Table 1). During this period, there were closed seasons during all of July and October, half

[2] Weekly closed periods are useful to permit escapement and should probably be retained even with a much smaller fleet.

TABLE 1
Theoretical Catch of a Gill Net Fishery Operating All Year

	Col. 1	Col. 2	Col. 3	Col. 4
	Average percent of yearly catch 1946-1955	Column 1 expanded for closed periods	Calculated average percent of yearly catch	Catch per month calculated from Col. 3
January	.69	.69	.39	31,000
February	2.15	2.15	1.21	96,000
March	1.88	1.88	1.06	84,000
April	3.15	3.15	1.78	141,000
May	5.62	5.62	3.17	250,000
June	1.05	2.10[1]	1.18	93,000
July	--	6.05[2]	3.41	269,000
August	7.10	10.00[3]	5.64	445,000
September	76.53	88.30[4]	49.85	3,935,000
October	--	54.63[5]	30.84	2,435,000
November	.77	1.54[6]	.87	69,000
December	1.06	1.06	.60	47,000
	100.00	177.17	100.00	7,895,000

[1] June—Col. 1 doubled (15 days closed).
[2] July—Interpolated between June and August (after expanding Avg.).
[3] Aug.—x 31/22 (9 days closed).
[4] Sept.—x 30/26 (4 days closed)
[5] Oct.—Used ratio of Sept. to Oct. catches taken by Fish and Game employees in tagging traps operated in the lower Sacramento River 1953-1956.
[6] Nov.—Doubled (15 days closed).

of June and November, the first nine days of August and the last four days of September. To make a somewhat better estimate of the probable catch of a gill-net fleet operating throughout the year, the June and November catches were doubled, the August catch was multiplied by 31/22 and the September catch by 30/26. The July catch is an interpolation between those of June and August since trap catches made by Fish and Game personnel in the lower Sacramento River indicated the run was gradually picking up over this period. The October catch was estimated by averaging our September and October trap catches for four years and using the ratio of the average September to the average October catch (column 2).[3] Since this yielded 177.17 percent, it was reduced to 100 percent by multiplying each month's catch by 100/177.17 (column 3). Finally, the last column contains the theoretical monthly poundages that would be landed, assuming a total catch of 7,895,000 pounds. These figures will be used even though the total catch probably could be greater because only full-grown fish would be harvested.

HOW MANY BOATS WOULD BE REQUIRED?

The Sacramento-San Joaquin gill-net fleet increased from about 100 boats in 1872 to about 750 in 1909 and then gradually declined to about 150 in the mid-30's. In 1946, each of 242 boats landed 1,000 pounds or

[3] *See* Hallock, Fry, and LaFaunce (1957). The traps were fished through September and October in each of four years, but were operated from June through August in only one year.

more for the season.[4] The 1909 fleet, presumably oar or sail powered, covered a much larger area than was legally fishable in later decades, but still overcrowded the fishing grounds. The 242 boats fishing in 1946 were covering a wider area than would be necessary for a smaller fleet—and they too were overcrowded. This fleet was gasoline powered but, with possibly one or two exceptions, nets were pulled by hand. Our hypothetical fleet would have power-driven net rollers and one man could handle a boat except during the height of the fall season. How many such boats, placed in the most strategic areas, would be required to take about 8,000,000 pounds per year?

In 1946, the gill-net catch was 6,463,000 pounds—the highest year in which we have records of catches of individual boats. The September catch in 1946 was 3,674,000 pounds, although the season ended September 26. Had fishing continued through September 30, the catch would almost certainly have exceeded 4,250,000 pounds—more than we would expect from our hypothetical fleet in an average September.

The 1946 fleet had 219 boats fishing in September. There were too many of them; they got in each other's way. Boats and nets drift with the tide, and on the better drifts boats lined up and had to await a turn. Each boat caught some fish, alarmed others, and made fishing worse for the boat behind it. Half as many boats fishing the same drifts would have had a much better average-catch-per-boat. A quarter as many boats fishing only the best drifts would have had still better catches.

The 59 poorest boats took only 283,000 pounds (Table 2). The remaining 160 boats took over 3,390,000 pounds and had they fished at the same rate through September 30 would have taken over 3,900,000 pounds.

Without a troll fishery, salmon in an average year would be more abundant than in 1946—catch-per-boat would be greater and a smaller fleet would suffice. We do not want our small fleet to take as high a proportion of the fish as the old fleet did—we want enough fish to get past the nets to eliminate all need for lengthy closed seasons.

TABLE 2
Sacramento-San Joaquin River Fishery, September 1946
Salmon Boat Catches

Catches in thousands of pounds	*Number of boats*
Under 5,000	30
5,000- 9,999	29
10,000-14,999	30
15,000-19,999	46
20,000-24,999	39
25,000-29,999	29
30,000-34,999	12
35,000-39,999	2
40,000-44,999	1
45,000-49,999	1
	219

[4] From Fry (1949), and unpublished records of the Department of Fish and Game.

The 1946 fleet pulled its nets by hand. Power rollers will bring a net in faster and with less effort and more time can be spent actually catching fish.

The 1946 fleet used linen nets—linen is relatively inefficient, especially in the daytime. When nylon nets were tried in the Delta they took many more fish than linen.[5] Monofilament nets were developed after all net fishing had been outlawed in the Delta. They have been used in other areas and took from two to more than three times as many fish as nylon nets with which they were competing.[6] Monofilament nets have been outlawed in Washington and British Columbia—they are too effective.

The 3,900,000 pounds that the 160 "high" boats in 1946 would have taken had they been allowed to fish through September 30 were about what our hypothetical fleet would be expected to take in September. Without their 59 inefficient competitors, a somewhat smaller fleet could have done the job. Probably fewer than 40 boats would be required to take 3,900,000 pounds if they were using power pullers and fishing in the best places with nets capable of catching several times as many fish, and with salmon at a higher level of abundance. To allow for higher catches in above-average years, I am proposing a hypothetical fleet of 50 boats. These 50 boats would probably be able to take so much fish that weekend closures would be needed in most years to permit adequate escapement. The lengths of these closures could be varied to suit the sizes of the runs.

Thus far I have stressed the fishery as it could be expected to exist in September, since that is the peak month and the one in which, historically, the largest catches were always made. In recent decades, October was always closed. Our hypothetical fishery could expect to make excellent catches in October. Based upon experimental fishing by department employees near the mouth of the Feather River, October catches would average about 62 percent as much as those made in September.

The limiting factor during September and October would not only be the catching capacity of the nets—it would include the fishermen's endurance. During the rest of the year neither of these problems would be serious and fewer boats could do the job. Ten boats would probably be sufficient to harvest the catch during 6 of the 12 months (Table 3). It might be necessary legally to limit the number of boats by law which could fish during months other than September and October, but economics probably would do a fairly good job of regulation. In the past only a small part of the fleet was fishing during poorer months.

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[5] The most comprehensive comparison of nylon and linen gill-net catches I found was that by Davis and Posey (1959). They compare catches made with several mesh sizes and three twine sizes of cotton, two of linen, and five of nylon that could be directly compared with the cotton and linen. Gill nets and trammel nets were among the gear tested. (A trammel net is a highly modified form of gill net—both gill and trammel nets were used in the Delta salmon fishery.) The number of net days of fishing ran into the thousands. Comparing the most effective twine size of nylon with the most effective linen twine size for each mesh size, the weight of fish taken by nylon trammel nets averaged about 2.5 times that taken by linen trammel nets, and nylon gill-net catches averaged about 3.5 times those of linen gill nets. (Cotton ran third.) Monofilament was not included in their tests.

[6] *Pacific Fisherman* (1961) states that in the Japanese high seas salmon fishery of 1961, the catch rate of monofilament nets is reported to have averaged 2.5 times as much as for the conventional multifilament nylon nets.

TABLE 3

Fleet Needed to Harvest Sacramento-San Joaquin Salmon

	Thousands of pounds to be landed[1]	Boats fishing	Fishermen fishing
January	31,000	10	10
February	96,000	10	10
March	84,000	10	10
April	141,000	15	15
May	250,000	20	20
June	93,000	10	10
July	269,000	15	15
August	445,000	20	20
September	3,935,000	50	100
October	2,435,000	50	100
November	69,000	10	10
December	47,000	10	10
	7,895,000	230	330

[1] These are the theoretical catches that would be made if the timing and relative size of the runs averaged the same as they did from 1947-56. Department of Fish and Game men believe that, at present, the winter run would be larger and the spring run smaller than shown above.

COST OF FLEET OPERATION

Because we might want as many as 50 boats fishing at the peak of the best years, costs will be calculated on the assumption there are 50 boats in the fleet and that all are allowed to fish during September and October of every year. During a poor year, it would be necessary to close the season enough days per week to let enough salmon escape to maintain the run. We will assume that in an average year, 25 fishing days per month would be permissible including any lost because of bad weather. (Bad weather rarely is a problem in the Delta.) During September and October, each boat would be operated by two men. During the rest of the year, only one man per boat would be required. Fewer boats would be licensed to fish from November through August in the event smaller catches did not automatically reduce the active fleet.

In any fishery which is at its peak for only two months each year, most of the fishermen would have other jobs during much of the year. Historically, many gill-net fishermen migrated to Alaska to work in other gill-net fisheries. Some entered other seasonal fisheries and still others had nonfishing jobs.

An adequate gill-net boat with engine can be built for as little as $6,000. Because our fleet would have to be in top condition, I am allowing $7,500 per boat—$6,000 for the hull and $1,500 for the motor. The hull would have a useful life of about 20 years and could be sold for about $1,000 at the end of that time, making a net cost-per-year of $250. The motor would have a useful life of only 10 years, and would be worth about $300 on a trade-in, making its net cost-per-year about $120.

Proper maintenance of boat and motor would require a cash outlay of about $300 per year. This is based on the assumption that much of the maintenance (especially hull maintenance) would be done by the fishermen themselves. (It nearly always is.) Using $20 per working day as a fisherman's wages and allowing 20 days per year of maintenance work, would add $400 per year to maintenance.

A nylon net which normally would have a life of about two years can be purchased for about $1,500. To allow for accidents and for heavier usage than normal, I based costs on a useful life of 1½ years at $1,000 per year. Allowing 20 days per year of a fisherman's time for net work adds $400.

All these costs total $2,470 per year per boat exclusive of fuel and oil. Gasoline and oil would probably cost about $6 per day or $150 per 25-day boat month. Fuel and oil costs will, of course, be applicable only when boats are operating.

Fishermen would be making wages if working at nonfishing jobs so, for determining costs and profits, fishermen's wages while fishing were calculated at $20 per day with no allowance for overtime and were then included in the expense of operation. Profits, as used here, would be the amount over and above all expenses, including wages. According to the costs just given and the fishing schedule in Table 3, the calculated cost of operating the entire fleet for a year would be $323,000 (Table 4).

Salmon are high-priced fish. The public has always been willing to buy the entire California catch and usually additional tonnages that are imported into the State as well. Since our hypothetical fishery will be operating in the future and because its costs are all based on current prices, I have used the latest price figures available in detail, i.e., those of 1959. The 1960 prices were higher, but I lack full details.

TABLE 4
Cost of Operating a 50-Boat Fleet

Item		*Cost*
Boat, other than fuel		
Hull $6,000; useful life 20 years; sale value $1,000; cost per year	$250.00	
Motor $1,500; useful life 10 years; turn-in $300; cost per year	120.00	
Boat and motor maintenance, cash outlay per year	300.00	
Fisherman's time on maintenance, 20 days per year at $20 per day	400.00	
Net		
Purchase price $1,500; useful life 1½ years; cost per year	1,000.00	
Fisherman's time spent maintaining net, 20 days at $20 per day	400.00	
Total per boat other than fuel or wages of fisherman while fishing, per year	$2,470.00	
Total cost of fleet of 50 boats, per year		$123,500.00
Fuel, 230 boat-months at $150.00 per boat-month—total per year		34,500.00
Wages of Fishermen (exclusive of maintenance) 330 man-months at $500 per 25-day month		165,000.00
TOTAL COST OF OPERATING FLEET OF 50 BOATS, PER YEAR		$323,000.00

TABLE 5
Income and Profit from the Hypothetical Fishery

Average gross income:	
7,895,000 lbs. of salmon at $0.421 per lb.	$3,324,000
Less: Total cost of operating fleet (*see* Table 4)	323,000
POTENTIAL NET PROFIT	**$3,001,000**
Potential net profit per pound of salmon landed	$0.38
Potential net profit per fish landed	$8.45

The 1959 salmon catch was landed entirely by trollers who, in 1959, received an average of $0.468 per pound for their fish. Traditionally, gill-net caught fish sold for a trifle less than troll-caught fish, because as soon as salmon leave the ocean some begin to lose their silvery color and take on spawning colors. To determine the ratio between troll- and gill-net fish prices, the average received for each was compared during the last five years of the gill-net fishery. Gill-net fish sold for as little as 75.5 percent of the troll fish price-per-pound in 1955 and as much as 99 percent in 1954. The five-year average was 90 percent. At this rate, the 1959 catch would have been worth 0.9 times $0.468, or $0.421 per pound. A 7,895,000-pound catch would have sold for about $3,324,000. The fishermen would have received roughly $3,000,000 over and above their boat operation costs and their wages of $20 per day (Table 5). This is the equivalent of a profit of 38 cents for each pound of salmon landed, or about $8.45 per fish.[7]

These are the profits a 50-boat fleet could have made if the operators had owned and harvested the Sacramento-San Joaquin salmon runs much as a farmer owns and harvests crops grown on his land. With appropriate adjustments as prices change, these figures can be used to calculate net benefits to commercial salmon fisheries if a water or power project is able to enhance existing salmon runs or establish new ones.

This method takes no account of sportfishery values. In making the calculations it was assumed there would be a sportfishery in addition to the hypothetical commercial fishery just as there is a sportfishery in addition to the existing commercial fishery. Sport values would, therefore, be in addition to commercial values.

SUMMARY

When water or power projects might damage a fishery, it is not necessary under California and federal law to determine the dollar value of the threatened fishery, to obtain fishways or hatcheries, or in other ways maintain the fishery at its natural preproject level.

To obtain funds to enhance a fishery, it is necessary to show the value of extra fish produced will exceed the cost of producing them.

The methods presently used to evaluate commercial fisheries are varied, and none is directly comparable with methods used to calculate the value of other beneficial uses of water.

[7] According to Cope and Slater (1957) the average weight of a gill-net caught salmon was 22.23 pounds during 1947-1949.

The net-economic-yield concept is not applicable to a fishery in which everyone can participate and in which efficient methods are outlawed to prevent overfishing. The concept could be applied, however, in a fishery managed for maximum efficiency. The profits that would accrue from such a fishery are calculated.

The troll fishery, now the only legal way to take commercial salmon in California, is very inefficient. Several other fishing methods are briefly considered and costs are calculated for operating a hypothetical gill-net fleet in the Sacramento-San Joaquin Delta. (It is not proposed that gill netting be legalized—the study is strictly for calculating profits.)

In such a hypothetical fishery all trolling would be stopped, all fishing for Sacramento-San Joaquin salmon would be in the Delta. Similar fisheries could be established in other rivers.

The historical gill-net fishery was outlawed in 1957 after its efficiency had been reduced by overcrowding, closed seasons, and closed areas. It could take only those fish which escaped the trollers.

The harvest in the Delta could be at least as large as the total ocean salmon catch off California because landings of Sacramento-San Joaquin salmon presently made off Oregon, Washington, and Canada exceed catches made off California of salmon from all other rivers. California's 7,895,000-pound average annual catch (1952-1961) was used as the normal catch of the hypothetical gill-net fleet.

The probable monthly distribution of the catch was determined from gill-net catch records and from some experimental fishing during the closed season.

The largest gill-net catch for which we have detailed records was made in 1946 when 6,463,000 pounds of salmon were taken. The season closed September 26 when fishing was at its peak. In September, 219 boats were fishing, including a number of unsuccessful ones. The fishing grounds were seriously overcrowded and the fishermen were using linen gill nets which were pulled by hand. By doing away with lengthy closed seasons and by using nylon or monofilament nets (which have been proven much more effective) and mechanical net pullers, a fleet of 50 boats manned by good fishermen could land the same poundage. The 50 boats would be needed only during the peak months of September and October.

The cost of purchasing, maintaining and operating such a fleet would be about $323,000 per year, including $20 per day for time spent by each fisherman either while fishing or doing maintenance work.

The gross income at 1959 prices, about $3,324,000 per year, would yield a net profit of over $3,000,000 which is the equivalent of 38 cents per pound or $8.45 per fish landed.

Thus, 38 cents per pound or $8.45 per fish would be a justifiable amount to allow when calculating net benefits to the commercial salmon fishery that would result from enhancing existing runs or establishing new ones.

Values of the sport catch are not included in these determinations.

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THE RESPONSE OF BROWSE PLANTS TO FERTILIZATION[1]

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INTRODUCTION

The wildland areas serving as game ranges today are covered predominately by shrubs. The browse produced by these plants is a staple item in the diet of game, particularly deer. Thus, shrubs constitute a crop; just as corn, grass, or trees are crops on other land. Fertilization, a technique which has proved its worth in managing other crops, may be useful in managing game ranges as well. Although there is a wealth of knowledge about the response of "cash" crops to fertilization, little information is available on the response of shrubs. This study was undertaken to gain some knowledge of the growth and utilization of browse plants on a deer winter range following fertilization.

The soils of wildland areas in California are often deficient in nutrients. A survey of about 100 upland soils, many associated with a brush cover, showed about two-thirds were low in available nitrogen and phosphorus, indicated by lettuce grown in pot tests (Jenny, 1950). Similar tests of brushland soils from southern California showed nearly all were deficient in nitrogen and phosphorus, especially in the lower horizons (Vlamis, *et al*, 1954). Native brush plants, as well as lettuce, have been used as indicators in pot tests of some common brushland soils from the coast ranges and the central Sierra Nevada. Available nutrients were often low and the brush seedlings used as indicators were much larger and more vigorous when deficiencies were corrected (Schultz, *et al*, 1958; Vlamis, *et al*, 1959). In the semiarid San Gabriel mountains of southern California, soil nutrition, as well as water, was a controlling factor in the growth of shrubs and trees, both for seedlings in pots and for mature plants in the field (Hellmers, *et al*, 1955). Thus it seems that fertilization might prove valuable for increasing the quantity, and possibly the quality, of browse on game ranges.

The effect of fertilizers was investigated in conjunction with other brush manipulation studies on the San Joaquin deer winter range. The winter range lies on the west side of the San Joaquin river in Madera County. The topography is rough, ranging from precipitous slopes to relatively level benches. Soils vary from deep to shallow and rocky, with frequent granite outcrops. The vegetation is predominately mixed chaparral, but ponderosa pine and oak woodland, with grass or brush understory, are also present. The study area is at an elevation of about

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3,800 feet. The average annual precipitation is 34 inches, but during 1959 and 1960, when the studies were conducted, rainfall was only 24 and 28 inches, respectively.

The winter range is occupied by a large population of migratory deer from November to the middle of May each year. Browse plants are utilized very heavily during this period. Pellet counts made on brushy areas manipulated by mashing and burning showed as many as 200 deer days of use per acre. Livestock also use portions of the winter range at various seasons.

RESPONSE OF BRUSH SEEDLINGS

To determine the effect of fertilization on brush seedlings, two areas were selected on which the original cover had been manipulated by mashing and burning. One, the Lion Point area, was mashed and burned in the fall of 1955. When the fertilization studies were started in the fall of 1958, this area had a dense stand of three-year-old wedgeleaf ceanothus seedlings (*Ceanothus cuneatus*), an abundant and important source of browse.

Eight plots, each 60 x 33.5 feet, were laid out in two contiguous rows on a gentle slope. In each plot, 100 seedlings were marked by tagging every one encountered in transects 1 foot wide until all the tags were used. Heights of the plants were recorded when they were tagged; the plants were remeasured each spring and fall until the study was terminated.

Another series of eight plots, each 50 x 37.5 feet, was laid out on Kinsman Flat which had been mashed and burned in the spring of 1957. Wedgeleaf ceanothus seedlings were not so abundant here as at Lion Point and only 50 seedlings were tagged and measured in each plot. These seedlings were one and two years old in the fall of 1958, with one-year-olds predominating. At the start of the study, there were 2.26 seedlings per sq. ft. on the Lion Point plots and 0.14 per sq. ft. on the Kinsman Flat plots.

On both the Lion Point and Kinsman Flat plots, herbaceous cover consisted primarily of annual grasses and filaree. There were scattered perennial grasses on the Lion Point plots. Shrubs, other than wedgeleaf ceanothus, were thinly scattered on the plots.

Ammonium phosphate (20-20-0) was applied to alternate plots in both groups at the rate of 150 pounds of N and 150 pounds of P_2O_5 per acre in October 1958 and March 1959. During the second year, fertilizer applications were repeated, so the final treatment was 600 pounds of N and 600 pounds of P_2O_5 per acre.

All of the plots were browsed by deer from November 1st to the middle of May. Two fertilized and two nonfertilized plots in each group were fenced to exclude cattle. Cattle grazed the Lion Point area during March, April, and May and the Kinsman Flat area during August and September.

Mortality

The mortality of seedlings was greater on fertilized plots than on the control plots; this was true of both age groups (Figure 1). Losses were much greater on the Kinsman Flat plots where the seedlings were younger. Fertilization resulted in almost complete annihilation of small

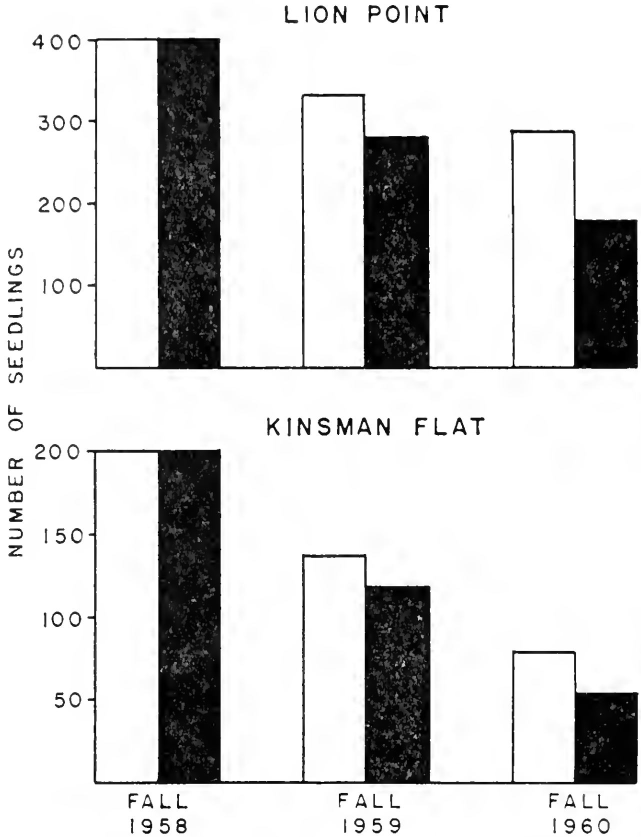

FIGURE 1. Number of wedgeleaf ceanothus seedlings surviving on fertilized plots (black bars) and control plots (white bars). Seedlings on Lion Point plots three years old when fertilizers applied, those on Kinsman Flat plots one and two years old.

seedlings. Most of the seedlings which died on control plots were also small. Virtually none of the largest seedlings died on either treatment.

The stimulation of the growth of herbaceous vegetation was probably a prime factor in increasing mortality of the brush seedlings on fertilized plots. The yield of herbaceous vegetation was determined in 1959 on both Lion Point and Kinsman Flat plots. Production did not exceed 600 pounds per acre, due to the very dry growing conditions which prevailed during the spring. However, yields were significantly higher on fertilized plots on both areas. Production of herbaceous vegetation was not measured in 1960, but better moisture conditions resulted in an obvious increase in yield on fertilized plots as compared to control plots (Figure 2).

Growth

By using only the tagged seedlings which were alive at the end of the experiment, it was possible to determine if fertilization caused an increase in height. The heights recorded for surviving seedlings at the start of the study did not differ significantly between fertilized and control plots. In the fall of 1960, when the final measurements

FIGURE 2. Stand of five-year-old wedgeleaf ceanothus seedlings on the Lion Point plots in the fall of 1960. Plots in upper left and lower right were fertilized in each of the two preceding years. This area has not been grazed by cattle and grasses on the fertilized plots obscure most of the seedlings.

were made, there was no significant difference in seedling heights on the two treatments. The fall measurements included a season increment not yet browsed, but evidently the heavy use during previous winters suppressed any measurable response to fertilization. A few seedlings protected from browsing by exclosures made more growth when fertilized than those not fertilized but similarly protected.

Utilization

Each fall 200 twigs were tagged and measured on fertilized and nonfertilized seedlings. In the winter of 1958-59, deer removed 27 and 28 percent of the twig length on fertilized and control seedlings, respectively. The average reduction in twig length was 33 percent on fertilized plants and 36 percent on control plants in 1959-60. The difference in amount removed was not significant in either winter. The reduction in seedling heights during the winter, another measure of utilization, was not significantly different on fertilized and control plants. Reduction in height is a rather poor measure of utilization because the tallest living portion is often a group of leaves on an old twig, instead of a new leader which may be bitten off.

Deer exhibited a preference for the herbaceous growth on fertilized plots. This was especially evident on the Kinsman Flat plots in April 1960. At this time, grazing by deer had kept large portions of the fertilized plots mowed off, while the control plots showed little use.

Livestock also preferred the forage on fertilized plots, but they used nonfertilized plots heavily too, as forage was scarce during both years. No differences were found in the growth or mortality of seedlings between plots protected from livestock and those which were grazed, but there was a greater accumulation of mulch and litter, since the herbaceous vegetation was not grazed by cattle.

RESPONSE OF MATURE WEDGELEAF CEANOTHUS PLANTS

A series of plots was established on a portion of the winter range burned by wildfire in 1939. The area studied has a stand of heavily-hedged wedgeleaf ceanothus plants 2 to 4 feet high (Figure 3). In November 1958, ammonium phosphate (10-20-0) was applied to about 4 acres with a mechanized spreader at about 100 pounds of N and 200 pounds of P_2O_5 per acre. On small plots, 50 x 75 feet, fertilizers were applied in the following amounts and kinds: ammonium nitrate, at 80 pounds of N per acre; ammonium sulfate, 80 pounds N and 90 pounds S; treble superphosphate, 140 pounds of P_2O_5. These applications were made in combination so that the following treatments were obtained; control; nitrogen (N); nitrogen-phosphorus (NP); nitrogen-sulfur (NS); and nitrogen-sulfur-phosphorus (NSP).

After ammonium phosphate was applied to the 4-acre plot, four plants in each of the following vigor categories were selected: 75 percent decadent; 50 percent decadent; and healthy or nondecadent. Two plants in each category were on the fertilized area and two on an adjacent nonfertilized area. These plants were protected by individual

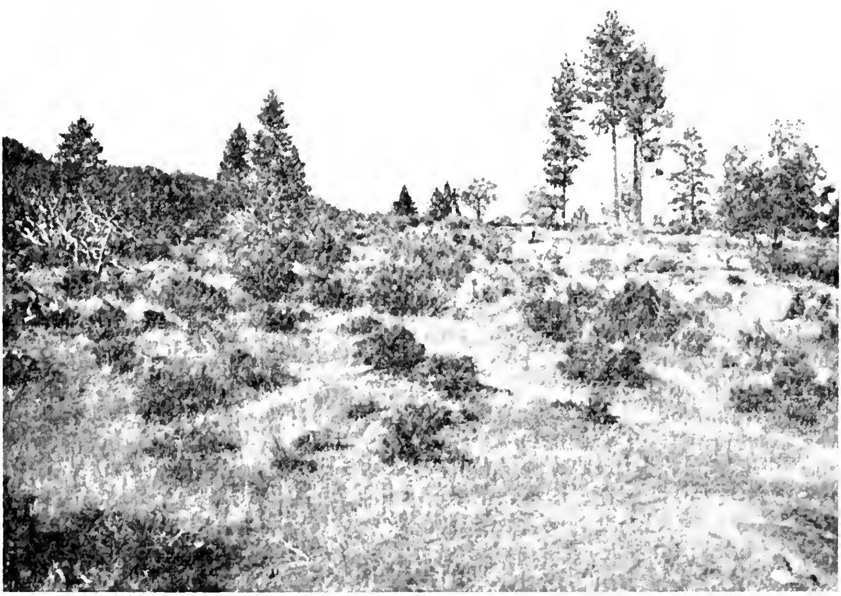

FIGURE 3. A portion of the stand of heavily-hedged wedgeleaf ceanothus plants used in the fertilizer trials. Picture taken in the fall of 1958 when the plants were 19 years old.

exclosures from the fall of 1958 to the fall of 1959. On each plant, 20 twigs were tagged and measured at intervals during the spring and summer to determine the amount and rate of growth. A shortage of fencing material limited the protection on the small plots to a single plant on the NSP treatment.

Due to similarity of response and subjective nature of selection, the 75 and 50 percent decadent plants were combined when analyzing the data. One decadent plant on the control area and scattered twigs on other plants died. Only twigs still living in the fall of 1959 were used in computing growth. As the tagged leaders were selected at random, twigs of different lengths were marked. The twigs with the longest original length made the most growth, probably because of a more favorable location on the plant. The differences among twig lengths on the various treated plots were significant. Consequently, the seasonal increment of each leader was adjusted by using the regression coefficient of seasonal increment on original twig length. Adjusted seasonal increment for the treatments could be compared by a "t" test, since the influence of original twig length on growth had been equalized. Seasonal increment included the length of lateral branches which developed on the twigs and the increase in length of the central, dominant branch.

Fertilization failed to stimulate leader growth on the healthy plants sampled (Table 1). The nonfertilized, healthy plants produced significantly more growth than the fertilized ones. However, the decadent plants which were fertilized produced significantly more growth than those which were not fertilized. Twig growth on all of the plants was largely confined to the period from April 15 to June 19. Only fertilized decadent plants grew appreciably in the latter part of the season. Since the spring of 1959 was extremely dry, moisture was probably more limiting to plant growth than nutrient supply. There were no visible differences in herbaceous growth on the plots during the season. A 3-inch rain which fell on September 18 did not initiate measurable twig growth.

In the fall of 1959, additional ammonium phosphate (20-20-0) was applied on a portion of the 4-acre plot fertilized the previous year. Hand broadcasting was used to spread the fertilizer at a rate of 200 pounds of N and 200 pounds of P_2O_5 per acre on a plot 100x300 feet.

TABLE 1
Seasonal Increment of Wedgeleaf Ceanothus Twigs During the 1959 Growing Season

Treatment	Number of plants	Number of twigs	Average twig increment (inches)	Adjusted twig[1] increment (inches)
NP	2—healthy	40	3.78	2.84^{bc}
NSP	1—healthy	20	4.19	3.58^{ab}
Control	2—healthy	40	4.52	4.34^{a}
NP	4—decadent	72	3.94	3.94^{ab}
Control	3—decadent	55	1.64	2.67^{c}

[1] There is a significant difference ($P < .05$) between adjusted means of treatments having different letters for superscripts, and no significant difference where the same letter occurs in the superscript. For example, in Table 1 the NP treatment with a mean of 2.84^{bc} is significantly different from the control (4.34^{a}) because the superscripts have no letter in common. The NP treatment is not different from any other treatment because either b or c appears in all other superscripts. The superscript letters should be read individually and not as terms.

TABLE 2
Twig Increment of Fertilized Plants During the 1960 Growing Season

Treatment[1]	Number of plants	Number of twigs	Average twig increment (inches)	Adjusted twig[2] increment (inches)
Wedgeleaf ceanothus (large plots)				
NP (1958 and 1959)	5	100	9.71	10.26[a]
NP (1958)	5	100	8.98	8.94[a]
Control	5	100	7.71	7.20[b]
Wedgeleaf ceanothus (small plots)				
NP (1958)	1	20	8.18	8.82[a]
NSP (1958)	1	20	8.73	7.30[a b]
N (1958)	1	20	7.27	6.69[b]
NS (1958)	1	20	6.74	5.61[b]
P (1958)	1	20	2.57	4.73[b]
Control	1	20	5.00	5.32[b]
Mariposa manzanita				
NP (1959)	3	60	8.38	8.90[a]
NS (1959)	3	60	5.83	7.35[a]
NSP (1959)	3	60	7.69	7.08[a]
P (1959)	3	60	8.60	7.00[a]
Control	3	60	4.87	5.02[b]

[1] Symbol of element and year applied.
[2] See Table I footnote for explanation.

On each of the following areas five healthy plants were protected by exclosures: fertilized in 1958—100 pounds of N and 200 pounds of P_2O_5 per acre; fertilized in 1958 and 1959—total treatment 300 pounds of N and 400 pounds of P_2O_5 per acre; and a control area. Vigor was not considered in this experiment because an adequate sample of decadent plants could not be found on each area. Twigs were tagged and measured on each fenced plant to determine growth during the spring and summer of 1960.

Seasonal increments were adjusted in the same manner as before. Both fertilizer treatments produced significantly more twig growth of wedgeleaf ceanothus than the control (Table 2). There was no significant difference in twig growth between the two fertilizer treatments, although twigs on plants receiving the second application of fertilizer were longer.

On the small plots fertilized in 1958, one representative plant was protected by an exclosure during the winter of 1959-60. No additional fertilizer was applied to these plots. Again, differences in the original length of twigs among treatments made it necessary to adjust seasonal increment before comparisons could be made. The NP treatment produced significantly more twig growth than the control (Table 2). The other fertilizer treatments did not increase twig growth over the control although the NSP treatment approached significance. Thus, pronounced carry-over effect was evident only when N and P were in combination. This conforms to the effects observed in agricultural crops.

Better moisture conditions in the spring of 1960 resulted in a seasonal increment nearly double that of 1959. From 75 to 95 percent of the season's growth was completed by June 15. There were no apparent relationships between fertilization and the length of growing period.

RESPONSE OF MARIPOSA MANZANITA

In the fall of 1959, plots were laid out on a portion of the 1939 wildfire burn occupied by low, hedged mariposa manzanita (*Arctostaphylos mariposa*) plants (Figure 4). This species was selected because it is abundant, but low in palatability. Fertilizers were applied by hand broadcasting on plots 50x75 feet. Single superphosphate, ammonium sulphate and ammonium phosphate were used to give the following treatments: 100 pounds of N and 114 pounds of S per acre; 100 pounds of P_2O_5 per acre; 100 pounds of N, 100 pounds of P_2O_5, and 114 pounds of S per acre; and 200 pounds of N and P_2O_5 per acre. Growth response was measured by tagging and measuring 20 twigs on each of three plants on each treatment. The plants were protected by exclosures when the fertilizers were applied and twig growth for the 1960 growing season determined.

The seasonal increments in twig length were adjusted for differences in original twig length in the same manner as those of wedgeleaf ceanothus. All of the fertilized plants had significantly more twig growth than the control plants (Table 2). There were no significant differences among the fertilizer treatments, although the NP treatment produced slightly longer twigs; note the heavier rate of N fertilization. Mariposa manzanita completed a large part of the season's growth by June 15.

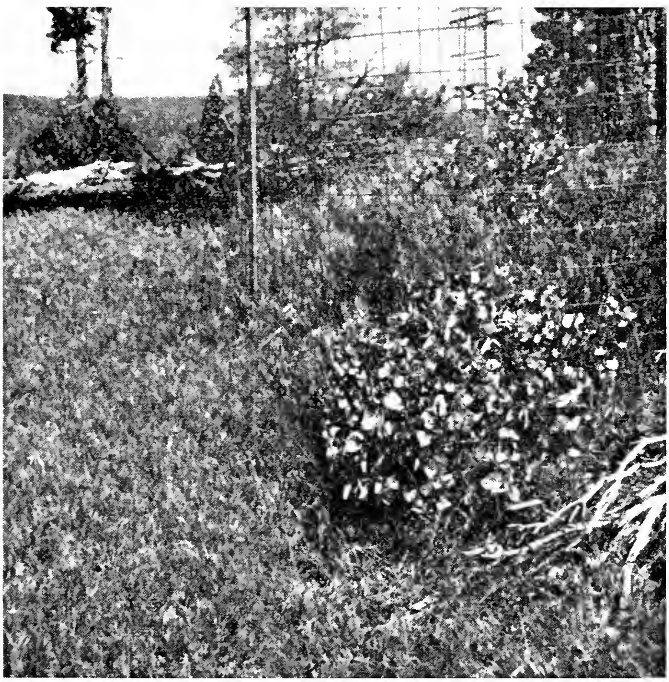

FIGURE 4. Mariposa manzanita plants on plot fertilized with NSP. Grasses outside exclosure were grazed by deer earlier in the season and consequently are much shorter than those inside the exclosure.

DEER UTILIZATION OF FERTILIZED PLANTS

Mature wedgeleaf ceanothus and mariposa manzanita plant utilization was determined by tagging and measuring large numbers of current twigs in the fall and remeasuring the same twigs in the spring after the deer had left. The reduction in twig length caused by browsing was used as an index to utilization. No leaf-use measurements were made, but leaf utilization probably would be in the same proportion as twig use. Since the deer were present until the middle of May, utilization and growing periods overlapped. Tagged leaders of the previous season gave no indication of use during this period. However, when tagged leaders were measured in the spring, a record was made of the number having new axillary leaders and the number browsed. Less than 5 percent of the new leaders were browsed, indicating little use of new twig growth during the spring.

During the winter of 1958-59, small aluminum tags were used to mark twigs. Deer liked to chew these tags, resulting in an unplanned reduction in sample size. Consequently, small lengths of electrical hook-up wire with insulation of different colors were used the second winter. This method was very successful. The deer did not chew the wire and a great deal of time was saved when making measurements, as it was not necessary to look for, and read, a number. Ten color patterns were used as this was the number of twigs marked on an individual bush. The number of bushes used varied with the size of the plots.

Deer removed more from longer twigs than they did from shorter ones. Also, the original length of twigs differed significantly among treatments. Thus, to compare the amount removed from twigs on various treatments, it was necessary to adjust the amount removed from each twig with the overall regression coefficient of amount removed on original length. This adjustment equalized the influence of original twig length. Treatment differences could then be determined by the "*t*" test. This procedure had not been necessary for the twigs measured on the seedlings because the original lengths were not significantly different between treatments.

In the fall of 1958, wedgeleaf ceanothus twigs were tagged on the following treatments: control, NP, P, NS, and NSP. Comparison of the

TABLE 3
Reduction in Twig Length by Deer on Fertilized Wedgeleaf Ceanothus Plants During the Winter of 1958-59

Treatment[1]	Number of twigs measured	Percent of twigs browsed	Percent of twig length removed	Average amount of twig removed (inches)	Adjusted amount[2] of twig removed (inches)
NS (1958)	94	96	33	1.15	1.10[a]
NSP (1958)	96	99	32	1.45	1.02[a]
NP (1958)	546	98	23	0.79	0.79[b]
P (1958)	99	98	15	0.47	0.55[c]
Control	567	99	21	0.66	0.74[b]

[1] Symbol of element and year applied.
[2] See Table I footnote for explanation.

TABLE 4
Reduction in Twig Length of Fertilized Plants by Deer During the Winter of 1959-60

Treatment[1]	Number of twigs measured	Percent of twigs browsed	Percent of twig length removed	Average amount of twig removed (inches)	Adjusted amount[2] of twig removed (inches)
		Wedgeleaf ceanothus			
NSP (1958)	98	98	54	1.20	1.07 [a]
NS (1958)	97	100	60	0.89	1.00 [ab]
P (1958)	98	99	56	0.79	0.92 [bc]
NP (1958)	98	100	54	0.70	0.86 [c]
N (1958)	100	97	44	0.64	0.76 [d]
NP (1958 and 1959)	300	100	42	0.73	0.75 [d]
NP (1958)	293	99	36	0.75	0.66 [d]
Control	300	100	37	0.75	0.68 [d]
		Mariposa manzanita			
NP (1959)	96	99	32	1.44	1.35 [a]
NSP (1959)	100	89	33	1.22	1.17 [ab]
NS (1959)	99	96	36	0.92	1.01 [bc]
P (1959)	94	61	15	0.56	0.52 [d]
Control	97	74	30	0.84	0.93 [c]

[1] Symbol of element and year applied. Large plots have more than 100 measured leaders.
[2] See Table I footnote for explanation.

adjusted values of amount removed revealed that the NS and NSP treatments were browsed significantly more than the control, NP, and P treatments (Table 3). These data indicate deer actually consumed more of the twigs of the sulphur-fertilized plants since there was very little difference in the percent of twigs browsed among the treatments (column 3 of Table 3).

During the winter 1959-60, wedgeleaf ceanothus utilization was measured on the following treatments: control; fertilized with NP in 1958 and 1959; and fertilized with NP in 1958 only. On the small plots fertilized in 1958 the NP, N, P, NS, and NSP treatments were included (Table 4).

The percent reduction in leader length on all treatments indicated utilization was heavier than during the previous winter (column 4 of Tables 3 and 4). The deer did not browse the large plot NP treatments, even the one fertilized in 1958 and 1959, more than the control. But the treatments containing sulfur were browsed significantly more than the control and most of the other treatments (Table 4). The consistent preference by deer for the sulphur-fertilized plants indicates that sulphur may help increase the palatability of the plants.

While wedgeleaf ceanothus is a preferred browse species, mariposa manzanita is low in palatability. Consequently, utilization of the fertilized mariposa manzanita plants was measured to see if fertilization increased its attractiveness to deer. All of the treatments previously described for this species were used. As with wedgeleaf ceanothus, it was necessary to adjust the amount removed before making comparisons.

The NP treatment received the heaviest use, probably reflecting the heavier rate of fertilization (Table 4). The NPS treatment was used more than the control but the NS treatment was not. Utilization on the P treatment was significantly lower than on the other treatments. Besides having larger amounts browsed from twigs, plants in the NP, NS, and NSP treatments also had a higher percentage of twigs browsed (Table 4). This indicates they were more attractive to deer than the control or phosphorus-fertilized plants. Why the P treatment received less use than the control is not clear. This phenomenon also occurred on the wedgeleaf ceanothus treatments the first season after fertilization.

NITROGEN AND PHOSPHORUS CONTENT OF WEDGELEAF CEANOTHUS LEAVES

Leaves were analyzed to determine how soon fertilizers were taken up by the mature wedgeleaf ceanothus plants and how the nitrogen and phosphorus content of leaves was affected. Leaves furnish the bulk of usable browse and can be collected and analyzed more readily than twigs. Composite leaf samples from mature wedgeleaf ceanothus plants were collected from the area fertilized with ammonium phosphate at the rate of 100 pounds of N and 200 pounds of P_2O_5 per acre in the fall of 1958. Collections were made for five different months during 1959. Total phosphorus determinations were made colorimetrically after wet digestion with ternary acid as described by Johnson and Ulrich (1959). Total nitrogen was determined by the micro-Kjeldahl method.

The total nitrogen and phosphorus content of the leaf samples is given in Table 5. Analysis of variance showed a highly significant difference ($P < .01$) among dates and between treatments for both nitrogen and phosphorus. The nitrogen content of the leaves from fertilized bushes was consistently higher than that from the leaves of control bushes. This difference was less pronounced for June than for other months. However, fertilizing apparently had a depressing effect on the phosphorus content of the leaves. The phosphorus content was consistently lower for the fertilized plants than for the control plants. One possible explanation for the lower phosphorus content in the leaves of fertilized plants is a dilution effect resulting from stimulation by nitrogen.

Contrary to data of Gordon and Sampson (1939), the content of both nitrogen and phosphorus increased from June to October. This increase is probably related to an unusually heavy rain which fell on September 18, 1959.

TABLE 5
Total Nitrogen and Phosphorous Content of Wedgeleaf Ceanothus Leaves Collected from Fertilized and Control Plots During 1959

Treatment	January	April	June	July	October
			Percent Nitrogen*		
Fertilized	1.80	2.52	1.87	1.67	2.10
Control	1.70	2.25	1.83	1.43	1.90
			Percent Phosphorus*		
Fertilized	0.153	0.229	0.150	0.120	0.173
Control	0.156	0.245	0.183	0.140	0.200

* Each figure is an average of three composite samples collected for each date and treatment. Averages were made after arc sine transformations (Snedecor, 1956).

DISCUSSION

Although the fertilizer trials were conducted during years of below normal rainfall, they showed that fertilization will significantly increase the growth of browse plants, even when moisture becomes limiting early in the growing season. The magnitude of response would undoubtedly be greater in years of higher rainfall.

Since fertilization increased the mortality of wedgeleaf ceanothus seedlings, even when well-established, it would not be advisable to fertilize areas where manipulation results in a poor stand of seedlings, or where natural thinning will provide the desired density. But by increasing the growth of herbaceous plants, fertilizers could be used to thin a stand of seedlings if they were too thick. Such a practice might be desirable on areas where livestock are more important users than deer. Even when growing in competition with grasses, brush seedlings will respond to an increase in fertility level (Gartner, *et al,* 1957). Thus, the growth of surviving seedlings in a thinning operation would be increased.

There was no measurable growth response to fertilization by the heavily browsed wedgeleaf ceanothus seedlings, but a response could be expected under lighter use levels. Since browse production on manipulated areas dominated by nonsprouting species is low until the plants attain a fair size, an accelerated growth rate is desirable. Fertilizers could be used to increase growth while allowing a higher level of use than would otherwise be possible.

Mortality of mature wedgeleaf ceanothus and mariposa manzanita plants was not affected during the study period. The increased growth of partially decadent plants indicates that fertilization might be effective for restoring plant vigor on over-utilized areas.

Deer exhibited some preference for plants which were fertilized, especially those receiving sulphur. It is quite possible that, if more browse were available and the deer had more freedom of choice, a greater preference would be displayed. Even though it seems logical to assume leaf use is proportional to twig use, a measure of the amount of leaves utilized, especially in the spring; might show a higher preference for fertilized plants. Mariposa manzanita, for example, has very large leaves which are easily picked off without biting the twig. Reduction in the length of twigs is not the best measure of preference. The basal portions of twigs become progressively more woody, and harder to bite off, regardless of how they taste to a browsing animal.

On areas such as winter ranges, where use of preferred browse species is extremely heavy, it might not be advisable to increase utilization of the plants by making them more attractive to deer. The increased use could cause excessive mortality. However, many of the preferred browse plants grow rapidly and can readily escape the deer (Gibbens and Schultz, 1961). On areas receiving moderate to light use, fertilization could be used to increase the utilization of preferred browse species and prevent them from growing out of reach.

The preference shown by deer for the fertilized mariposa manzanita plants indicates that the utilization of less preferred species may be increased. In this case nitrogen, phosphorus, and sulphur in combination were effective. Other combinations and rates need to be tested. Browse species low in palatability occupy vast areas and tend to increase at the expense of their more preferred neighbors. An effective means of changing palatability would result in a manyfold increase in range area and quantity of usable forage.

The quality of browse may be equally as important as quantity. If protein is a critical constituent, nitrogen fertilizer may improve the quality of browse. Since the uptake is very rapid, there would be little time lag in the application of such a management practice. However, if phosphorus is critical, nitrogen fertilization may actually decrease the phosphorus content of the leaves and phosphorus may become deficient. Certainly the nutritional requirements of deer and the amounts of nutrients supplied by browse need further investigation.

The use of fertilizers on game ranges would have desirable effects in aspects other than quantity or quality of browse. Maintaining a grass-brush ratio adjusted to the relative needs of livestock and game on particular areas would permit fuller use of the land. The inability of many brushland areas to support a maximal growth of plants due to low fertility levels leads to a high erosion rate and further depletion of soil nutrients. Interruption of this cycle by fertilizers would greatly increase the watershed value of the land (Hellmers et al., 1955).

While no argument is being presented concerning the economic feasibility of fertilizing game ranges at this time, it is quite conceivable that such a practice may be desirable, and readily financed, in the future. This study indicates that fertilizers could supply the game manager with a valuable tool for habitat manipulation on brush ranges where soil fertility levels are low. Further study of the effect of fertilizers on browse plants, particularly on palatability, is recommended.

SUMMARY

The effect of fertilization on the growth and utilization of browse plants was studied on a deer winter range in Madera County, California. The effect of N, P, and S, in various combinations, on seedlings and mature plants of wedgeleaf ceanothus and mature plants of mariposa manzanita was investigated. The studies were conducted in 1959 and 1960. During both years precipitation was far below normal.

Fertilization with NP increased the mortality of wedgeleaf ceanothus seedlings, especially those only one and two years old. Deer did not utilize fertilized seedlings more than nonfertilized seedlings. Fertilized seedlings did not increase in height more than those not fertilized, probably because of the heavy utilization.

Despite the extremely dry conditions, mature, heavily hedged wedgeleaf ceanothus plants on an old wildfire burn responded to fertilizers by increased twig growth. Carryover effect was evident only when N and P were in combination. Growth response of mariposa manzanita was measured for only one season. All of the fertilized plants produced significantly more twig growth than those not fertilized.

The reduction in twig length by deer was used as an index to utilization of the mature plants. Sulphur-fertilized plants of wedgeleaf ceanothus were browsed significantly more than control plants and most of the other fertilizer treatments. Fertilized plants of mariposa manzanita, a species low in palatability were utilized more than control

plants. The rather consistent preference by deer for fertilized plants indicates that fertilization may be an effective means of increasing palatability.

Analyses of leaves collected from wedgeleaf ceanothus plants showed a consistently higher nitrogen content in leaves of ammonia-phosphate-fertilized plants. Phosphorus content was consistently lower for the fertilized plants, possibly due to a dilution effect resulting from stimulation by nitrogen.

Since fertilizers may be used to increase growth and palatability, cause selective thinning and browsing, and improve watershed values, they offer the game manager an effective tool for habitat manipulation on brush ranges where soil fertility is limiting.

ACKNOWLEDGMENT

The authors thank Drs. A. M. Schultz and H. H. Biswell of the University of California, and Dr. George R. Hawkes, Agronomist, California Spray-Chemical Corporation, for their advice and assistance.

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NOTE

THE OCCURRENCE AND DISTINCTION OF THREADFIN SHAD IN SOUTHERN CALIFORNIA OCEAN WATERS [1]

A threadfin shad, *Dorosoma petenense* (Günther), was caught February 13, 1962, in a 10-minute tow with a shrimp try-net approximately 75 yards off Belmont Shore, Long Beach, in three fathoms of water. This specimen, 80 mm standard length, was taken while trawling for juvenile white seabass. Although introduced into many freshwater areas of California by the Department of Fish and Game, this is the first known record from southern California ocean waters. Pos-

[1] A contribution of Federal Aid to Fish Restoration, California Project F 16 R, "Barracuda-White Seabass Management Study."

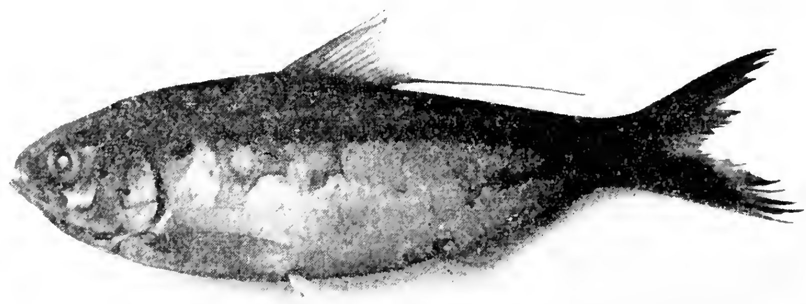

FIGURE 1. Threadfin shad *Dorosoma petenense*, 113 mm standard length. *(Photo by Jack W. Schott.)*

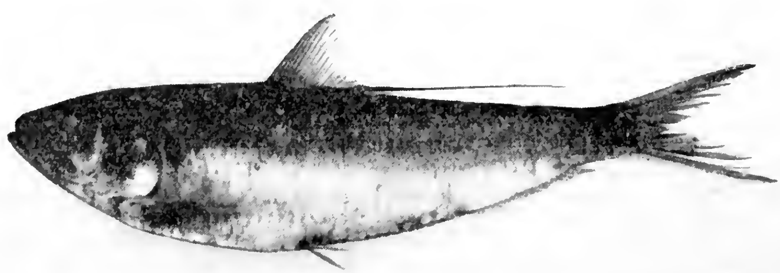

FIGURE 2. Thread herring, *Opisthonema libertate*, 111 mm standard length. *(Photo by Jack W. Schott.)*

TABLE 1

Characters for Distinguishing Threadfin Shad and Thread Herring

Species	Characters			
	Mouth	Pectoral fin	Dorsal-pelvic fin relationship	Total ventral scutes
Threadfin shad	inferior	extends at least to pelvic fin insertion	dorsal origin nearly vertical to pelvic insertion	25 to 27
Thread herring	terminal	does not reach pelvic fin insertion	dorsal origin well in advance of pelvic insertion	31 to 33

sibly the heavy rains during January and early February 1962 flushed this individual from the Los Angeles or San Gabriel River drainages.

This occurrence demonstrates a possible need for a simple means of differentiating this species (Figure 1) from the thread herring, *Opisthonema libertate* (Günther) (Figure 2), a similar clupeid reported in California ocean waters (Radovich, 1961). The characters I have listed will enable the field biologist to distinguish between the two species easily (Table 1).

Characters were determined from 10 threadfin shad, 105 to 165 mm standard length, from the Salton Sea and 10 thread herring, 82 to 176 mm standard length, from the Gulf of California.

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—— *James C. Thomas, Marine Resources Operations, California Department of Fish and Game, June 1962.*

RETIREMENTS

RICHARD S. CROKER

Richard S. Croker, Chief of Marine Resources, retired from the Department of Fish and Game on August 31, 1962, after 33 years of service.

His interest in the marine resources and fish and game work was kindled by summer employment with the California Fish and Game Commission while working toward his degree in zoology at Stanford University. In 1927 he worked as a fish car messenger, transporting fish from Mt. Shasta hatchery. In 1928 he worked as a student biologist on albacore studies.

Croker commenced his permanent career with the Department of Fish and Game in July 1929 following graduation from Stanford. From July 1929 to 1942 he worked at Terminal Island as a biologist. The results of his scientific investigations and research are published in numerous bulletins. It was at this time that he was also editor of *California Fish and Game.* He went on military leave from 1942 to 1946 where he served in the U.S. Army Air Force, attaining the rank of captain with specialized training and served nine months as fisheries officer for the occupation forces in Japan. Croker was reinstated in the Department in 1946 and was promoted to chief of the Marine Resources Branch. His broad and comprehensive knowledge of marine resources and the problems involved in their management brought international recognition to both himself and the Department of Fish and Game. As chief of Marine Resources Branch his unique ability to foresee into the far future of resources, plus his unselfish recommendations for scientific management, is reflected in many of the present-day policies.

Duties and responsibilities in addition to that of chief of Marine Resources Branch included serving since 1947 as member of Pacific Marine Fisheries Commission; since 1947 to date, as secretary of the California Marine Research Committee; 1953 to date, member of Advisory Committee to U.S. Section of the International North Pacific Fisheries Commission; 1946 to date, member of Fisheries Advisory Committee for the Department of State; October 1950 to January 1951, visiting expert assigned to Fisheries Division to investigate and analyze the fisheries administration of Japan for the Supreme Commander of Allied Powers in Tokyo; January to March 1952 as instructor, Fisheries Training Center, FAO Valparaiso, Chile; March to April 1960, consultant and adviser for U.S. Senate Committee on Interstate and Foreign Commerce at second United Nations Conference on Law of the Sea, Geneva, Switzerland; February 1961, member of Governor Egan's Inter Agency Conference on Salmon, Juneau, Alaska.

Croker belongs to the following professional societies: American Fisheries Society (president); American Institute of Fisheries Research Biologists (fellow); American Society of Ichthyologists and Herpetologists (member); Pacific Fisheries Biologists (member).

He is also a member of the Sierra Club and the Air Force Association.

From 1931 to 1962 his career was further enriched by numerous trips in the interests of marine resources to Canada, Mexico, and Japan. Vacation travels took him to Panama, Central America, and Europe.

The following inscription was found on a wall in Croker's office: "No life is more satisfactory than one of service to your country and humanity, with the courage to stand up unflinchingly to your convictions" (Dag Hammarskjold). Croker believes this and it seems to epitomize his 33 years' service with the Department of Fish and Game.

Croker's retirement will not take him from the field of marine resources for he has accepted the position of Executive Director of the Pacific Marine Fisheries Commission. With his wife Annie he will move to Portland, Oregon, headquarters of the Pacific Marine Fisheries Commission. There, it is hoped, he can continue to pursue his hobbies of fishing, hunting, photography, stamp collecting, radio, and travel.

His numerous friends and colleagues at home and abroad wish him well.—*W. T. Shannon, Director, California Department of Fish and Game.*

WILLIAM LaMARR

William LaMarr, Chief of Wildlife Protection Branch retired from the Department of Fish and Game on May 2, 1962, after 26 years of service. He is a native of Colorado.

Prior to his service with the State, LaMarr served in the U. S. Army Cavalry, San Mateo County Sheriff's Office and the Palo Alto Police Department.

He began his State service as a fire-suppression crewman with the Division of Forestry in 1935. He advanced to Forest Fire Lookout in 1936. Later the same year he joined the old Division of Fish and Game as an Assistant Fish and Game Warden. In 1938 he was appointed Fish and Game Warden. LaMarr went on military leave from 1942 to 1943. In 1947 he was promoted to Fish and Game Patrol Captain. In 1953 he was promoted to Wildlife Protection Supervisor and in 1955 was elevated to Chief Wildlife Protection Branch.

During his career in Fish and Game, LaMarr was assigned to Shasta, Los Angeles, Monterey, Oakland, Nevada City, Truckee, Angels Camp, Colfax, Auburn and Sacramento.

His co-workers and many friends in the Department extend best wishes for a long and happy retirement.—*W. T. Shannon, Director, California Department of Fish and Game.*

BOOK REVIEWS

The Physiology of Crustacea. Volume II—Sense Organs, Integration and Behavior

Edited by Talbot H. Waterman, Academic Press, Inc., New York, 1961; v + 681 pp., 22 tables, 142 figures. $22.

Volume II continues the fine work begun in its predecessor (Vol. 1, Metabolism and growth). The text is a review of crustacean physiology written by selected western world authorities. They cover a wide range of material as indicated by the following 14 chapter headings: "Light Sensitivity and Vision," "Mechanoreception," "Chemoreception and Thermoreception," "Pigmentary Effectors," "Light Production," "The Neuromuscular System," "Reflexes and the Central Nervous System," "Neurohumors and Neurosecretion," "Locomotion," "Kinetic and Tactic Responses," "Physiological Rhythms," "Migrations," "Complex Behavior," and "Comparative Physiology."

The authors should be complimented for using excellent photographs and drawings and for their extensive list of up-to-date world-wide references. Also worthy of note are the author, systematic and subject indexes.

Although little attention has been given the commercially important species of the Pacific West Coast (two references to *Cancer magister* Dana), it can be a valuable source book to the crustacean biologist. Because of this value, and because of its expense ($22) it should be available in libraries.

The only error noted was one of binding: pages 659-674 of the subject index were inserted between pages 352 and 353 of the text. No confusion resulted however since these pages were repeated in their proper place.——*J. D. Messersmith, California Department of Fish and Game.*

Fishes of the Pacific Coast of Canada

By W. A. Clemens and G. V. Wilby; Fisheries Research Board of Canada, Ottawa, 1961; 443 pp., 281 black and white figures, 6 color plates; $5.

This is the second or revised edition of the only recent complete work on Canadian Pacific Coast fishes. The first edition, published in 1946, had been out-of-print for nearly three years.

The general arrangement of this book is quite similar to that of the first edition; however, the 39-page key to families and species has been greatly improved and made easier to use. Also, with revision the total pagination went up from 368 to 443 and the number of species from 245 to 272. A new feature is the six pages of color plates at the center of the book.

Since the first edition was so well-known and well-used by fishery workers, students and educators everywhere, it would be superfluous on my part to describe in detail the content of this edition. It should be mentioned, however, that the authors have followed closely the vernacular nomenclature proposed by the American Fisheries Society in 1960.

The only "big" complaint I would like to register is that the authors have limited the range for each species, "to that portion of the Pacific coast of North America from Southern California to the Alaskan coast of the Bering Sea."

As with any undertaking of this magnitude, a few inaccuracies and erroneous statements have crept in—a few are original but others have been carried in various published works for years.

Regardless of these problems, the volume is an outstanding contribution to the literature and the field of fishery biology and should grace the book shelves of every student of fishes or fisheries whether amateur or professional.——*John E. Fitch, California Department of Fish and Game.*

Illustrated Dictionary of Tropical Fishes

By Hans Frey; (translation from the German), T.F.H. Publications Inc., Jersey City, N.J., 1961; 768 p., over 1,000 illustrations incl. 24 color plates. $7.95.

Dictionary form is used in this unique volume listing virtually every known species of tropical fish and a number not tropical. Subjects pertinent to fish rearing are also included: aquatic plants and insects, snails, and diseases.

The original edition, *Das Aquarium von A biz Z*, a popular book in communist East Germany, has been revised to include well over 1,000 excellent illustrations including line drawings, photographs and 24 full-page color plates. The color plates in a few cases are somewhat exaggerated.

Fin formulas are given for many of the fishes along with brief descriptions of other anatomical features.

A pictorial catalogue featuring microphotographs of various forms of algae and other aquatic organisms is on the last several pages.

Minor technical errors were encountered, e.g., page 42, referring to *Ampullarius*, "Aquatic plants cannot be kept with them." This is true for *Ampullarius* with the exception of *Ampullaria cuprina*, a popular aquarium snail; page 97, "The fishes in these regions feed preponderantly on the larvae of *Chironomus* and other mosquitoes . . ." This error in classification and other technical errors are probably the result of the author's endeavor to cover too large a field. Mistakes commonly incurred in translation are present but do not detract from the technical value of the book.

The naturalist as well as the most experienced biologist will find this a very worthwhile reference manual for his library.——*J. A. St. Amant, California Department of Fish and Game.*

All About Camping

By W. K. Merrill, The Stackpole Company, Harrisburg, Pa., 1962; 262 pp., illustrations by Dick Pargeter and Luis M. Henderson; $3.95.

When one sees the colloquial phrase of comparison, "all about—something," his first reaction is usually one of doubt. Admittedly, this was my first reaction. But like most first reactions, mine changed after reading this book. If it is not "all about camping" it is about as close as is presently available between the covers of a single volume. Everything from an extensive list of camping areas within the United States to details for the care of pack animals is discussed. Some subjects are dealt with in a sentence or two, while an entire chapter is devoted to others. A rather extensive bibliography refers the reader to more exhaustive literary works on specific subjects.

Three chapters covering three separate but related subjects are particularly noteworthy. These are: "Pathfinding by compass" (how to make practical use of a compass);"Pathfinding with maps" (how to read and use topographic maps); and "Outdoor measurement" (how to determine height and distance in the field without the customary measuring aids). All three technical subjects are amazingly clear and complete.

The author has drawn upon knowledge gained during nearly a half century of experience in the wilderness. His youth was spent on the Colville Indian Reservation and most of his adult life has been with the National Park Service as a park ranger, primarily in California. Sometime between 1922 and 1927 he was an employee of the California Fish and Game Commission.

All About Camping is appropriately summarized by a short quote from the "Foreword," written by Secretary of the Interior Steward L. Udall. "Here, in a volume small enough to be tucked into a knapsack, is a ready reference filled with camping hints and woodlore gleaned from W. K. Merrill's years of experience as a park ranger—covering all those numerous details that make camping a comfortable and rewarding experience instead of a bedraggled comedy of camping errors."——*William L. Craig, California Department of Fish and Game.*

California Desert Wildflowers

By Philip A. Munz, University of California Press, Berkeley, 1962; 122 p., 96 color photos, 172 line drawings, 2 maps; $2.95 paperbound.

California Desert Wildflowers is the second of three little books on California flowering plants that Dr. Munz has undertaken to produce for the person with no particular botanical training but with an avid interest in our native flora.

For ease of use, the book has been arranged into five sections, four according to flower color with ferns and conebearers in the other.

The illustrations are all excellent, whether line drawings or color plates, and are the backbone of the publication. There are no "keys" other than flower color so identification is a matter of recognition and remembrance. The two indexes (one to color plates and the other to common and scientific names) speed the task of finding a species for which one recalls the name but little else.

The brief species descriptions include details on plant size, blooming season, general appearance of the flowering plant, geographical distribution, habitat preferences, and distinguishing characters or peculiarities.——*John E. Fitch, California Department of Fish and Game.*

Manual of Ski Mountaineering

Edited by David Brower; Sierra Club, San Francisco, California, 1962; xxii + 224 pp., 32 pp. of photographs, many diagrams; cloth $3.75.

This book represents the third edition (revised and brought up to date) of a work that has long been out of print. Two editions with two printings of the second attest to its previous popularity. Although the name of the book implies it is for the ski mountaineer, its contents have wide application. It has useful information to the cold weather camper, the fisherman rock climbing to that "inaccessible" spot or to the hiker on the top of a mountain in a lightning storm who has an "overwhelming desire to be back in camp."

This manual is not designed to condense all that is known on the subject but does a masterful job in presenting the basic fundamentals of how to make a safe and sane winter excursion.

The following chapter titles give an idea of the subjects covered: 1. Warmth; 2. Equipment; 3. Climbers and Waxes; 4. Water; 5. Food; 6. The Technique of Travel; 7. Selecting a Campsite; 8. Shelter; 9. Miscellaneous Notes on Camping; 10. Snow Formation and Avalanches; 11. Compass and Map; 12. First Aid; 13. Transportation of the Injured; 14. The Ski Mountaineering Test; 15. Mountaineering Routes; 16. Rock-Climbing; 17. Ice-Climbing; and the appendix—Check List of Equipment.

This is a valuable reference book of the subject and is highly recommended for those planning cold weather or snow trips or for others just wanting to be prepared in case an emergency does arise.——*Jack L. Hiehle, California Department of Fish and Game.*

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Notice is hereby given, pursuant to Section 206 of the Fish and Game Code, that the Fish and Game Commission shall meet on October 5, 1962 at 9:30 a.m. in the 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, regulations should be made relating to fish, amphibia, and reptiles, or any species or subspecies thereof.

FISH AND GAME COMMISSION
Monica O'Brien, Secretary

Notice is hereby given, in accordance with Section 206 of the Fish and Game Code, that the Fish and Game Commission shall meet on December 7, 1962 at 9:30 a.m. in Room 115, State Building, 217 West First Street, Los Angeles, California, to hear and consider any objections to its determinations and proposed regulations in relation to fish, amphibia, and reptiles for the 1963 angling season, such determinations and orders resulting from hearing held on October 5, 1962.

FISH AND GAME COMMISSION
Monica O'Brien, Secretary