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VOLUME 47 JULY, 1961 NUMBER 3

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SURVIVAL, MORTALITY, AND MOVEMENTS OF WHITE CATFISH AND BROWN BULLHEADS IN CLEAR LAKE, CALIFORNIA[1]

GEORGE W. McCAMMON and CHARLES M. SEELEY
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Clear Lake is a large, seminatural lake situated in the central portion of Lake County in northern California. It lies at an elevation of 1,325 feet, the average surface area is approximately 40,000 acres, and the maximum depth is about 50 feet. The lake is exceedingly fertile and its large populations of warmwater game fish maintain a sport fishery of considerable magnitude.

The sport fishery of Clear Lake has been the subject of several investigations. Murphy (1951) presented data on the history of the fishery through 1949 and some general information on the ecology of the lake. Pintler (1956, 1957a, 1957b) reported the results of a limited creel census of boat fishermen for the years 1954, 1955, and 1956. Kimsey (1957) tagged largemouth bass (*Micropterus salmoides*) in the lake in 1953 and 1954, and obtained data on their movements and mortality rates. Limited data on the mid-summer food of fingerling largemouth bass were obtained in 1948, 1956, 1957, and 1958 (Murphy, 1949; McCammon, 1957; McCammon and LaFaunce, 1958; LaFaunce, 1959).

The white catfish (*Ictalurus catus*) and the brown bullhead (*Ictalurus nebulosus*) are the only ictalurid species present in the lake, and both are important constituents of the game fish catch. An analysis of boat fishermen catch records showed that white catfish made up nearly 80 percent of the total catch sample in 1948 and 1949, 12 percent in 1953 and 1954, and almost 40 percent in 1956 (Pintler, 1957b). Brown bullheads were less important in the boat catch. During the years 1947 to 1956, the contribution of brown bullheads to the boat catch sample ranged from 0.4 percent in 1954 to 9.7 percent in 1955.

The boat catch statistics are not necessarily indicative of either the relative abundance of the fish or their relative contribution to the total catch. For instance, large numbers of bullheads are caught during late winter and early spring at the mouths of the major tributaries, while relatively few white catfish are caught from shore at any time of year. Also, compulsory records maintained for a commercial seine fishery for carp (*Cyprinus carpio*) and Sacramento blackfish (*Orthodon microlepidotus*) have indicated consistently for many years that the brown bullhead is considerably more abundant than the white catfish.

[1] Submitted for publication October 1960. This work was performed as part of Dingell-Johnson Project California F-2-R, "A Study of the Catfish Fishery of California," supported by Federal Aid to Fish Restoration funds.

A broad investigation of the major catfish fisheries of California was begun in 1951, with the aid of Dingell-Johnson funds. As part of this investigation, both white catfish and brown bullheads were tagged in Clear Lake in the summer of 1952 and in the late fall and winter of 1954-55. The objectives were to (1) obtain reliable estimates of survival and mortality rates, and (2) define the movements of the fish. The relative efficiency of three types of tags was tested in the 1952 study. The results of these experiments are presented in this paper.

METHODS

Tagging Operations

1952 Study

Both species were captured for tagging in unbaited fyke nets of the type described by Pelgen and McCammon (1955). The nets were fished at "The Narrows", a constriction between the eastern and western portions of the lake (Figure 1). The most successful sets were at depths of 15 to 30 feet, and were left undisturbed for at least five days.

Three previously described tags were compared: the disk-dangler tag, the staple tag, and the hydrostatic capsule tag. Pelgen (1954) used disk-dangler and staple tags on white catfish in the Sacramento-San Joaquin Delta, and McCammon (1956) used disk-dangler and hydrostatic tags on channel catfish (*Ictalurus punctatus*) in the lower Colorado River. The construction and method of attachment of these tags in the present study were identical to those described by the above authors.

Between August 13 and September 24, 1952, 722 white catfish and 724 brown bullheads were tagged and released at The Narrows, for a

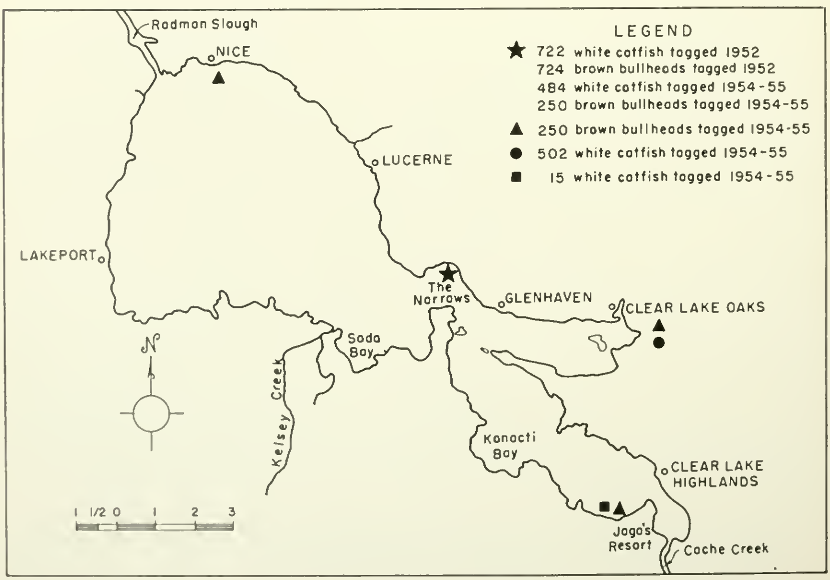

FIGURE 1. Map of Clear Lake, showing areas where white catfish and brown bullheads were tagged in 1952 and 1954-55.

total of 1,446 tagged fish. Staple tags were placed on 247 white catfish and 248 brown bullheads; disk-dangler tags were affixed to 248 white catfish and 247 brown bullheads; and hydrostatic tags were attached to 227 white catfish and 229 brown bullheads (Table 1).

Figure 2 presents the length frequencies of both species for each type of tag. The white catfish ranged from 6.3 to 18.5 inches in fork length, with a mean of 10.4 inches. The brown bullheads in the sample ranged from 6.6 to 13.9 inches, with a mean fork length of 9.8 inches.

FIGURE 2. Length frequencies of white catfish and brown bullheads tagged in Clear Lake in 1952.

TABLE 1

Clear Lake, 1952 Study: Summary of Tag Return Data

	Tags attached		Tags returned							
Species	Type of tag	Number of tags	First year	Second year	Third year	Fourth year	Fifth year	Sixth year	Seventh year	Totals
White catfish	Staple	247	4	6	7	10	10	2	5	44
	Disk-dangler	248	4	7	10	6	8	3	1	39
	Hydrostatic	227	5	7	6	7	1	0	1	27
	Totals	722	13	20	23	23	19	5	7	110
Brown bullheads	Staple	248	3	4	3	2	1	2	0	15
	Disk-dangler	247	3	3	2	3	0	1	0	12
	Hydrostatic	229	13	1	1	1	2	1	1	20
	Totals	724	19	8	6	6	3	4	1	47

1954-55 Study

A second experiment was begun in the fall of 1954 to check the results of the 1952 experiment. Tagging operations were carried on during the period November 10, 1954, to January 11, 1955. Tagging was carried out during the cold months to test the hypothesis that the low rate of tag return during the first two years of the 1952 experiment resulted from a high extra mortality among the tagged fish, caused by summer tagging. Subsequent tag returns from the 1954-55 experiment failed to support this hypothesis.

The disk-dangler tag was used exclusively in the second study. The success of this tag in other catfish tagging experiments then in progress indicated that it was the best available tag.

Four tagging stations were established. They were: (1) The Narrows; (2) Clear Lake Oaks, four miles east of The Narrows; (3) the town of Nice, nine miles northwest of The Narrows; and (4) Jago's Resort, seven miles southeast of The Narrows (Figure 1). It was originally planned to trap, tag, and release 250 fish of each species at each of the four stations. However, due to difficulty in trapping white catfish, only 15 were tagged at Jago's Resort and none were tagged at Nice. The remaining quota was filled at the other stations: 484 at The Narrows and 502 at Clear Lake Oaks. The total number of tagged white catfish was 1,001.

No difficulty was encountered in trapping brown bullheads. Two hundred and forty-nine were tagged at The Narrows, and 250 were tagged at each of the remaining stations, for a total of 999 tagged bullheads.

The mean fork lengths of white catfish tagged at Clear Lake Oaks and The Narrows were 8.9 and 8.8 inches, respectively. The 15 fish tagged at Jago's Resort had a mean fork length of 10.9 inches. The fish in the entire sample ranged from 6.3 to 15.8 inches in fork length, with a mean of 8.9 inches.

The mean fork lengths of brown bullheads at each of the locations were as follows: Clear Lake Oaks, 11.5 inches; Nice, 11.8 inches; Jago's Resort, 11.8 inches; The Narrows, 12.1 inches. The range in length for the entire sample was 7.0 to 14.0 inches, with a mean of 11.8 inches.

Figure 3 presents length frequency distributions for both species.

Mortality Computations

Tag recoveries are grouped according to the number of months elapsed since the date of tagging, divided into 12-month periods. For instance, a fish tagged on August 12, 1952, and recaptured on September 15, 1956, had been at liberty 49+ months, and is thus designated a fifth-year return.

The calculations and notations of mortalities follow Ricker (1958).

Publicity

Several techniques of stimulating voluntary tag returns by anglers were employed in both studies. Posters that explain the State's catfish tagging program and the procedure for returning tags were displayed prominently around the lake. Press releases were directed to those

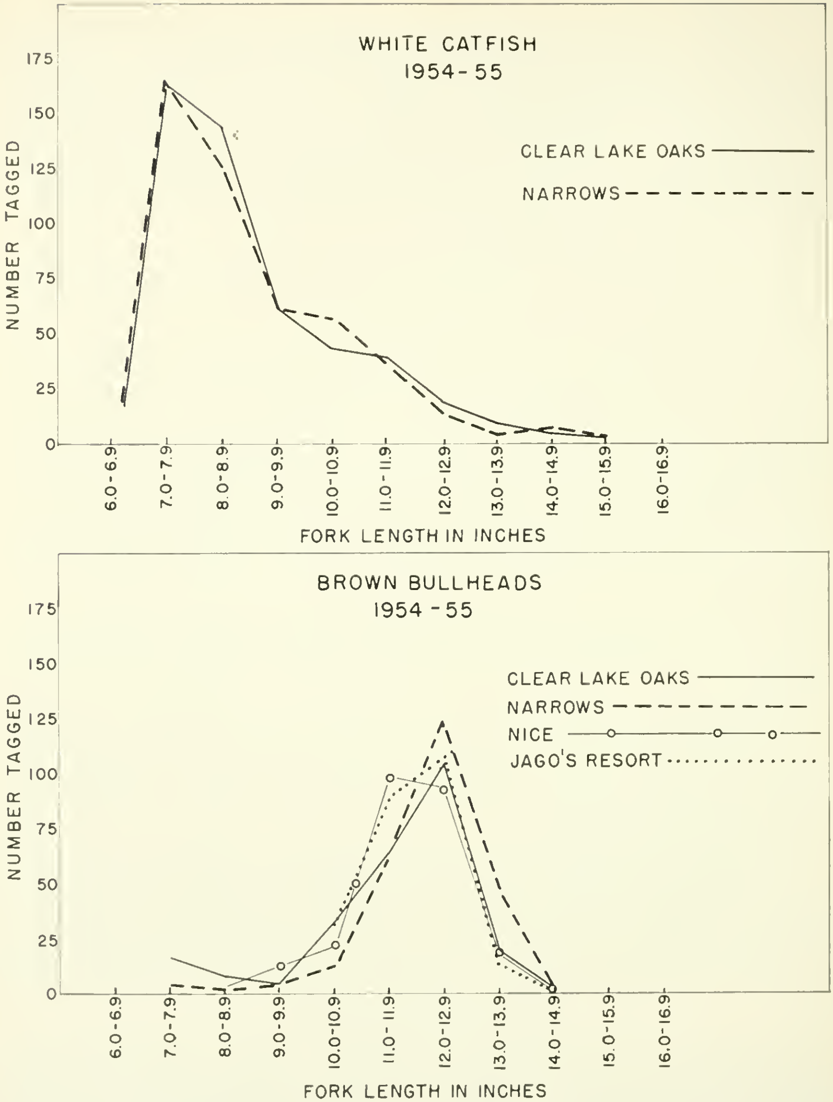

FIGURE 3. Length frequencies of white catfish and brown bullheads tagged in Clear Lake in 1954-55.

newspapers that served the majority of the anglers that use the lake, and talks were presented to local sportsmen's organizations. Each person who returned a tag was awarded a commendation card that carried a brief history of the recaptured fish. In addition, tag returnees were eligible for well-advertised prize drawings sponsored by the Foothill Sportsmen's Club of Oakland and the Lake County Sportsmen's Association.

RESULTS

1952 Study

General Data

Anglers returned 110 tags (15.2 percent) from white catfish and 47 tags (6.5 percent) from brown bullheads over a seven-year period from 1952 to 1959. Additional returns from white catfish are anticipated; however, it is unlikely that they will appreciably affect the present results. They will serve primarily to demonstrate the length of time that the tags will remain attached to white catfish, and to emphasize the low mortality rates operating on the stock.

Recoveries of brown bullhead tags are considered complete.

The breakdown of tag returns by tag type and year of recovery is shown in Table 1. These data exhibit some singular characteristics, the most conspicous being the pattern of annual returns from white catfish. Annual recoveries of tags from white catfish were: First year, 13; second year, 20; third year, 23; fourth year, 23; fifth year, 19; sixth year, 5; and seventh year, 7.

The pattern of tag recoveries from brown bullheads is more typical, showing a general decrease after the first year. Annual tag recoveries from brown bullheads were: first year, 19; second year, 8; third year, 6; fourth year, 6; fifth year, 3; sixth year, 4; and seventh year, 1.

Comparison of Tags

The differences in total returns of each type of tag from both species were not significant at the 5 percent level, as determined by chi-square tests (white catfish, $X^2 = 3.29$, 2 d.f., $P > 0.10$; brown bullheads, $X^2 = 3.05$, 2 d.f., $P > 0.20$). Thus, from a statistical viewpoint only, staple, disk-dangler, and hydrostatic tags were equally efficient in this study.

However, close scrutiny of the recovery data, coupled with information from comparable experiments, indicates that the hydrostatic tag may be less effective in studies that extend over periods of more than one year. It will be noted that of the 20 hydrostatic tags returned from brown bullheads, 13 were returned during the first 12 months (Table 1). The remaining seven hydrostatic tag returns were spread fairly evenly over the next six years. On the other hand, both staple and disk-danglers were returned at a relatively constant rate throughout the seven years. The abrupt decline in hydrostatic tag returns after the first year is a common symptom of tag detachment. Shedding of these tags from catfish has been observed previously (McCammon, 1956).

Possible direct evidence of hydrostatic tag shedding was detected during the course of this study. Three detached tags, one from a white catfish and two from brown bullheads, were found by project personnel in the vicinity of The Narrows within the first 14 months of the study. The possibilities exist that the fish involved died from natural causes or that the tags were discarded by disinterested anglers; however, it appears more likely that the tags were shed.

Recoveries of hydrostatic tags from white catfish maintained a constant level until the fifth year, when they declined appreciably. Staple and disk-dangler tag returns did not decline to the same extent, further supporting the evidence of shedding of hydrostatic tags.

The higher return of hydrostatic tags from brown bullheads during the first year is attributable to more complete reporting by anglers of recaptures. The message enclosed in the hydrostatic tag is believed to be more effective in eliciting angler response than the printed disk of the staple and disk-dangler tags.

There was no clear evidence of the superiority of either the staple or disk-dangler tag in remaining attached to the fish.

Survival and Mortality Estimates

It is apparent from the data in Table 1 that simple procedures for estimating the mean annual survival rate of white catfish are not applicable in this case. The increase in annual recoveries through the fourth year precludes survival calculations by means of ratios of one years's returns to the preceding year's returns, or by the rate of decline of the logarithms of the numbers of tags returned in successive years.

An indication of the cause of the annual increase in white catfish tag returns, and a possible approach to a reasonable estimate of survival, are provided by a statistical comparison of returns from different-sized fish. A chi-square test demonstrated that all tags from fish that were 10 inches long, and longer, when tagged, returned at a significantly (5 percent level) higher rate during the seven years than tags from fish less than 10 inches long ($X^2 = 9.79$, 1 d.f., $P < 0.01$). This comparison was made under the assumption that the percentage of nonreponse from anglers was the same for both size groups and for all recovery periods.

The size differential in returns indicates that a large percentage of the tagged white catfish were not fully vulnerable to the fishery when tagged. To clarify this, an approximation of the age distribution of the tagged fish was determined from limited, unpublished data on white catfish growth rates in Clear Lake. Annual returns from each age group were then noted (Table 2).

The resultant data still present an irregular pattern, with no distinct indication of the age, size, and survival of the fish when completely recruited. These data suggest that recruitment occurs at about Age IV; however, several factors obscure this possibility. These factors are the following: (1) the obvious increased chance for variability in returns in different years, due to the very small numbers of returns, (2) the inhibitory effect of the tags upon the growth of the fish, which might delay recruitment for one or more years, (3) possible differences in the rate of fishing between years, and (4) a lower rate of return during the first year, due to non-random distribution of the tagged fish during that year (Type C error).

Despite the deficiencies of the recovery data, it is apparent that survival of the white catfish was high. An estimate of the general level of magnitude of this parameter can be computed; however, it should be accepted with caution.

By using recoveries of age IV and older fish during the second through seventh years, the ratio 47/58 is obtained. The apparent mean annual survival rate of fully vulnerable fish is $s = 0.81$. The apparent mean annual total mortality is $a = 0.19$, and the apparent instantaneous mortality rate is $i = 0.21$.

TABLE 2

Clear Lake, 1952 Study, White Catfish: Age Groups Tagged and Recaptured

Fork length when tagged (inches)	Approximate age when tagged	Number tagged	Annual recaptures							Totals
			First year	Second year	Third year	Fourth year	Fifth year	Sixth year	Seventh year	
6.0- 7.9	II	71	--	2	1	2	1	--	1	7
8.0- 9.0	III	271	1	3	8	8	6	1	2	29
10.0-11.9	IV	217	7	10	6	10	11	3	4	51
12.0-13.9	V	122	4	2	8	2	1	1	--	18
14.0+	VI+	38	1	3	--	1	--	--	--	5
Totals		722	13	20	23	23	19	5	7	110

To obtain estimates of the general magnitude of the apparent rate of fishing, it is necessary to make corrections for Type A and C systematic errors. The effect of Type C error is eliminated by using only the returns from age IV fish from the second and later years, and applying appropriate correction methods from Ricker (1958). The apparent mean rate of exploitation, uncorrected for Type A error, is $u = 0.06$ and the apparent mean rate of fishing is $p = 0.07$. Corresponding natural mortality values are $v = 0.13$, and $q = 0.14$.

Nonresponse by anglers who caught tagged white catfish is believed to be the primary source of Type A error, although it is strongly suspected that shedding of hydrostatic tags was responsible for a minor amount of the error. No estimate of the magnitude of nonresponse is available for this study; however, McCammon and LaFaunce (1961) estimated about 40 percent nonresponse in a similar tagging experiment with channel catfish in the Sacramento Valley of California. The application of this nonresponse estimate to the present data results in the following final estimates of mortality in the fully recruited age groups:

$$u = 0.10$$
$$v = 0.09$$
$$p = 0.11$$
$$q = 0.10$$

While the above parameters are merely approximations of the true parameters, it is nevertheless apparent that the white catfish stock of Clear Lake was lightly exploited during the period 1952-59.

A chi-square analysis of the total returns from brown bullheads that were less than 10 inches when tagged and brown bullheads 10 inches long and longer, also demonstrated significantly greater returns from the larger fish ($X^2 = 16.79$, 1 d.f., $P < 0.0005$). However, due to the low number of returns and lack of growth rate data, a satisfactory estimate of the survival rate of fully recruited fish cannot be derived from the return data. It appears from the magnitude and pattern of brown bullhead tag recoveries that the survival and fishing rates are slightly lower than for white catfish, and the natural mortality rate is slightly higher.

Movements of Tagged Fish

Of the 110 total white catfish tag returns, 87 were usable for determining the recapture location with reasonable accuracy (Figure 4A). No suggestion of a regular migration or movement was detected when the locations of seasonal and annual recoveries were plotted (not shown in Figure 4A). These data did not necessarily demonstrate the absence of a regular movement, however, since tag returns within any single season or year were too few to provide sufficent evidence of such migrations.

The scattered distribution of recapture locations of all usable white catfish tag returns indicates extensive movement away from the release point in The Narrows, with no evidence of discrete sub-populations. The concentrations of recaptures in specific areas, such as Clear Lake Oaks, Soda Bay, and Glenhaven, are believed to reflect greater angling pressure in those areas.

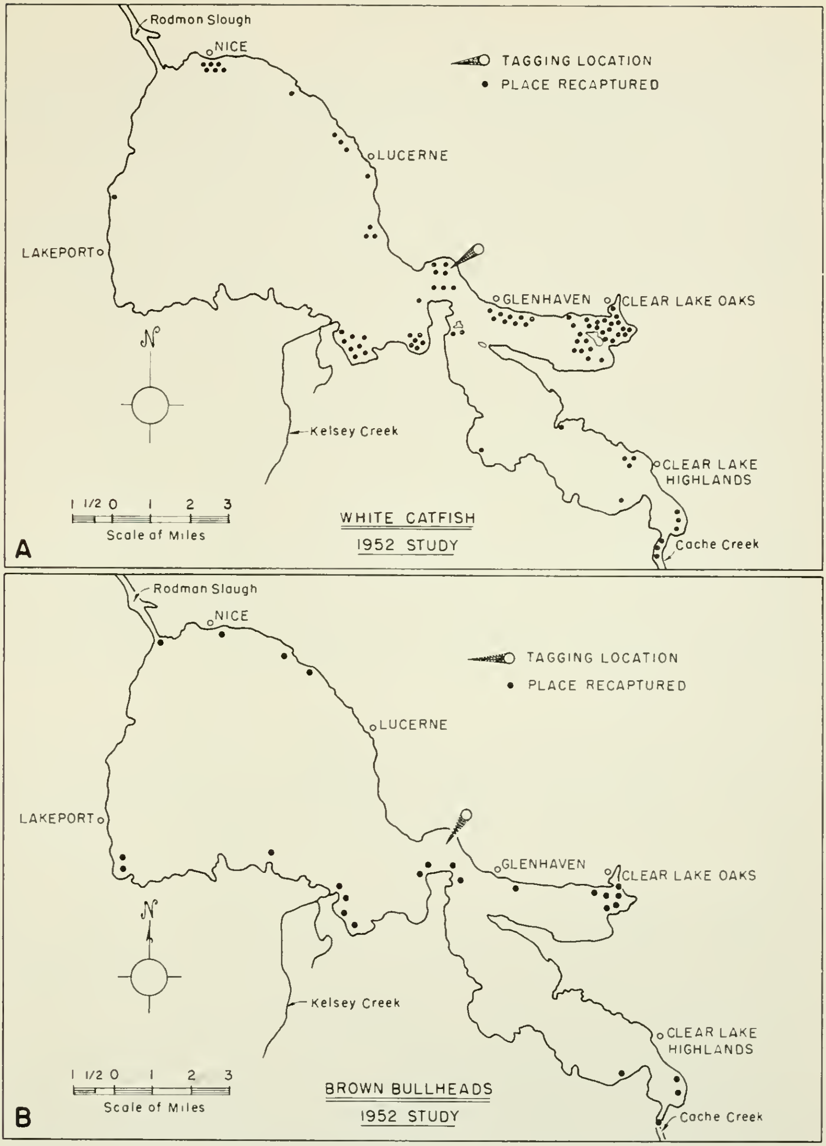

FIGURE 4. Locations of recaptures of white catfish and brown bullheads tagged in Clear Lake in 1952.

Twenty-six brown bullhead tag returns provided data on specific recapture locations (Figure 4B). The reported distribution of recaptures over the entire seven-year period was similar to that of the white catfish.

1954-55 Study

General Data

During the first five years following tagging operations, 96 (9.6 percent) tags from white catfish and 122 (12.2 percent) tags from brown bullheads were returned voluntarily by anglers. Additional returns from both species are expected; however, it is doubtful that they will modify or contradict conclusions based on the present data.

Annual tag recoveries from both species and from each of the four tagging locations are presented in Table 3. Total recoveries from white catfish were: first year, 20; second year, 18; third year, 18; fourth year, 27; and fifth year, 13. Total brown bullhead recoveries were: first year, 37; second year, 29; third year, 36; fourth year, 9; and fifth year, 11.

Total returns from white catfish tagged at Clear Lake Oaks and The Narrows were approximately the same, with 48 returns (9.6 percent) from the 502 fish released at Clear Lake Oaks and 44 returns (9.1 percent) from the 484 fish tagged at The Narrows. The 15 white catfish released at Jago's Resort produced a return of 4 tags (26.7 percent); however, the small number of fish involved precludes any comparison with the other locations.

Brown bullhead tag returns from each of the four tagging stations varied in number; however, the differences were not significant at the 5 percent level. Total recoveries from each station were: Clear Lake Oaks, 34 (13.6 percent); The Narrows, 25 (10 percent); Jago's Resort, 41 (16.4 percent); and Nice, 22 (8.8 percent).

Rates of Exploitation

As in the 1952 study, the anomalous pattern of annual recoveries from white catfish prevents simple computations of survival and mortality rates. Thus, the same methods used to approximate these parameters in the 1952 study were utilized in the treatment of the 1954-55 data.

Similarly, returns from white catfish 10 inches long and longer were significantly greater than returns from smaller fish ($X^2 = 4.79$, 1 d.f., $P < 0.05$), indicating only partial vulnerability of the smaller fish. However, the breakdown of returns by assumed age groups failed to provide a clear indication of survival (Table 4). No attempt to approximate the survival rate of fully vulnerable fish was made.

It appears that the only parameter obtainable from these data is the apparent definitive rate of exploitation during the first recovery period. By taking returns from age IV and older fish during the first year and correcting for an assumed rate of nonresponse of 40 percent, the ratio 12/238 is obtained. Thus, the apparent exploitation rate is $u = 0.05$. No correction for Type C error is necessary, since the fish were tagged at the start of the fishing season.

Although the estimate of the apparent rate of exploitation of completely recruited white catfish is only half of the 1952 estimate, both are in the same order of magnitude. The previous conclusion that the Clear Lake white catfish stock is greatly underexploited is confirmed by the 1954-55 data. The hypothesis that an appreciable tagging mortality was responsible for the low returns of both species in the 1952 study is rejected.

TABLE 3

Clear Lake, 1954-55 Study: Summary of Tag Return Data

Species	Tagging location	Number of tags attached	Annual recoveries					Totals
			First year	Second year	Third year	Fourth year	Fifth year	
White catfish	Clear Lake Oaks	502	10	8	9	12	9	48
	The Narrows	484	9	9	9	13	4	44
	Jago's Resort	15	1	1	--	2	--	4
	Totals	1,001	20	18	18	27	13	96
Brown bullheads	Clear Lake Oaks	250	13	9	9	1	2	34
	The Narrows	249	4	7	9	2	3	25
	Jago's Resort	250	15	7	10	4	5	41
	Nice	250	5	6	8	2	1	22
	Totals	999	37	29	36	9	11	122

TABLE 4

Clear Lake, 1954-55 Study, White Catfish: Age Groups Tagged and Recaptured

Fork lengths when tagged (inches)	Approximate age when tagged	Number tagged	Annual recaptures					Totals
			First year	Second year	Third year	Fourth year	Fifth year	
6.0- 7.9	II	365	4	3	3	4	3	17
8.0- 9.9	III	398	9	8	7	17	7	48
10.0-11.9	IV	176	5	4	6	3	2	20
12.0-13.9	V	45	2	3	1	--	--	6
14.0+	VI+	17	--	--	1	3	1	5
Totals		1,001	20	18	18	27	13	96

There was no difference, at the 5 percent level of significance, between the lengths of brown bullheads tagged and the lengths, at time of tagging, of the recaptures. Evidently most of the tagged sample was fully vulnerable, which is not surprising, since the length frequency distribution was skewed negatively, with a mean of 11.8 inches.

With the effect of recruitment eliminated from consideration, an estimate of survival can be computed directly and simply, despite the slightly irregular pattern of annual recoveries. The ratio of one year's recoveries to the preceding year's recoveries results in the mean ratio 85/111. Thus, the weighted estimate of mean annual survival is $s = 0.77$, and its complement mean annual total mortality is $a = 0.23$. The instantaneous total mortality rate is $i = 0.27$.

Estimates of mortality components, corrected for an assumed, uniform rate of angler nonresponse of 40 percent, are:

$$p = 0.08$$
$$q = 0.19$$
$$u = 0.07$$
$$v = 0.16$$

As in the case of the estimates of white catfish parameters derived from the 1952 data, the above estimates must be considered as approximations of the true values, due to the large sampling error.

The greater total percentage return from brown bullheads in the 1954-55 study (12.2 percent) as compared with the total seven years return in the 1952 study (6.5 percent) is believed to reflect the virtually complete vulnerability of the tagged sample in 1954-55, rather than an increased rate of fishing.

Movements of Tagged Fish

The general locations of 65 white catfish recaptures were determined from voluntary information provided by tag returnees in the 1954-55 study (Figure 5A). Their distribution was essentially the same as the distribution of recaptures from the 1952 tagging. Recaptures tended to be concentrated in those areas where the angling use is known to be relatively high; however, a few returns were recorded from scattered areas around the entire lake.

No suggestion of a regular migration was revealed in these data. The extensive movement of the fish is apparently without direction, a characteristic that has also been noted in the Sacramento-San Joaquin Delta (Pelgen, 1954; Pelgen and McCammon, 1956).

Forty-seven brown bullhead tag returns were usable for spotting recapture locations (Figure 5B). The distribution of total recaptures demonstrated that bullheads tagged in any one of the three major arms of the lake has a tendency to remain in that arm, while bullheads tagged in The Narrows dispersed into one or more of the adjacent arms. The 1952 data also provided evidence of a general dispersion of bullheads away from The Narrows.

Bullhead recaptures were highly concentrated in the Clear Lake Oaks area and in, or near, the outlet to Cache Creek. Angling use is relatively high at both localities, and is probably the primary determinant of

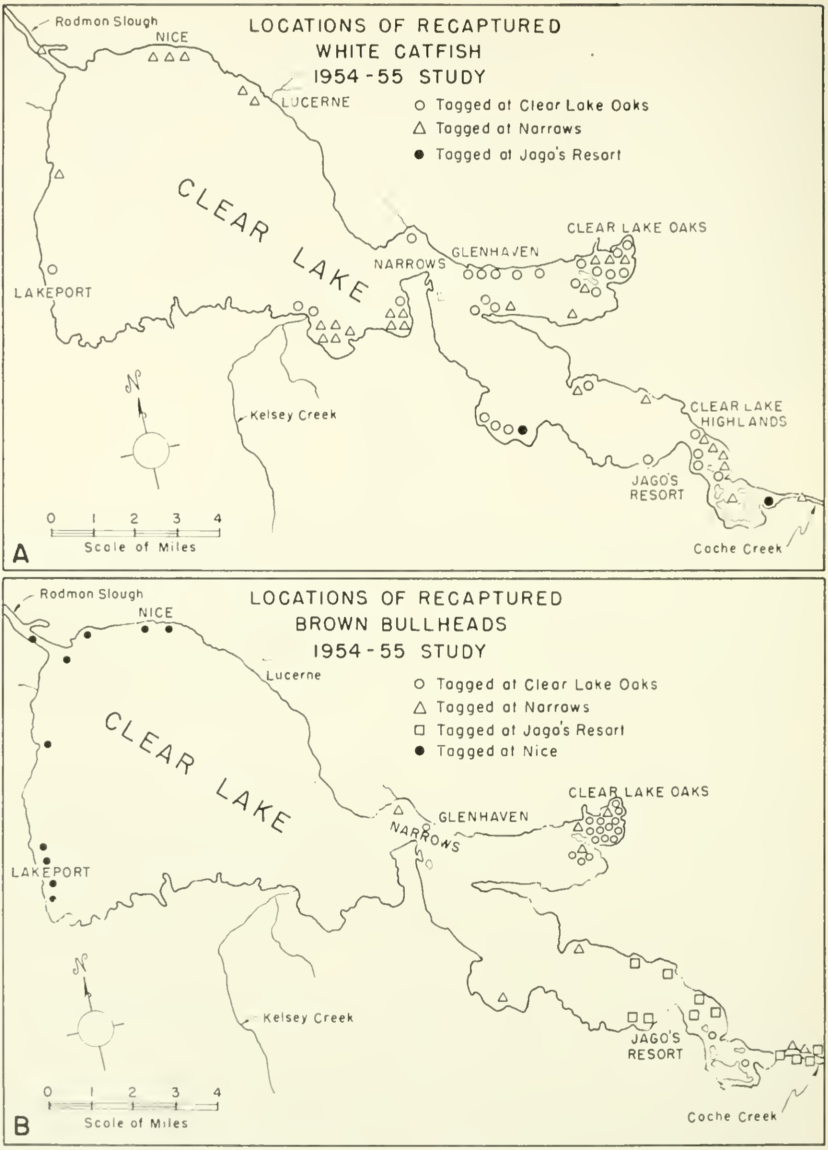

FIGURE 5. Locations of recaptures of white catfish and brown bullheads tagged in Clear Lake. in 1954-55.

the greater number of recoveries. The recapture of at least six tagged bullheads in Cache Creek, below the Clear Lake Impoundment Dam, suggests that substantial numbers of bullheads may pass through that structure under high runoff conditions. Runoff during the winters of 1955-56 and 1957-58 was considerably above average.

MANAGEMENT IMPLICATIONS

Despite the large sampling error, due to the small numbers of tag recoveries from both species, it is palpable that huge, underexploited stocks of white catfish and brown bullheads exist in Clear Lake. Relaxation of restrictions on the bag limit and type and quantity of angling gear would be an obvious approach toward increasing the low yield. There is no closed season or minimum size limit.

In 1959, the daily bag limit at Clear Lake was raised from 15 to 20 white catfish and brown bullheads in combination. The effect of this change on the rate of fishing is a matter of conjecture. Judging from the low catch per unit of effort for the period 1947 to 1956 for both species (Pintler, 1957b), it is doubtful that the increased limit will influence the yield measurably.

The development and promulgation of more effective catfish angling techniques should not be overlooked as a means of increasing the yield appreciably. It has been observed that the average tourist angler experiences difficulty in capturing either species, despite their abundance.

Current gear restrictions limit the angler to one line, with a maximum of three hooks. Conceivably, liberalization of this regulation might have a positive influence on catfish angling success; however, such a move would create difficult law enforcement and biological problems with respect to the largemouth bass fishery. It is questionable whether the benefits from more lenient catfish gear restrictions (e.g., trot lines) would be worth the ensuing social conflict and the additional enforcement effort necessary to protect the largemouth bass population. Similarly, a limited, controlled, commercial fishery is virtually out of the question for the same reasons, even though the evidence suggests that present catfish stocks could support such a fishery.

SUMMARY

White catfish and brown bullheads constitute a substantial portion of the sport catch of warmwater game fishes in Clear Lake, a 40,000-surface acre, fertile, seminatural lake in central Lake County, California. Samples of both species were tagged and released in the summer of 1952 and the winter of 1954-55 to provide data on their mortality and movements. Both studies were terminated in 1960.

In August and September of 1952, approximately equal numbers of 722 white catfish and 724 brown bullheads were single-tagged with disk-dangler, staple, or hydrostatic tags. All fish were trapped and released in The Narrows, a constriction separating the three major arms of the lake.

Anglers voluntarily returned 110 tags (15.2 percent) from white catfish and 47 tags (6.5 percent) from brown bullheads during the ensuing seven years. Annual recoveries were:

	White catfish	*Brown bullheads*
First year	13	19
Second year	20	8
Third year	23	6
Fourth year	23	6
Fifth year	19	3
Sixth year	5	4
Seventh year	7	1
Totals	110	47

No significant difference among the total returns from both species of disk-dangler, staple, and hydrostatic tags was revealed. However, collation of these and other tagging data indicates that the hydrostatic tag is unsuitable for long-term mortality studies.

The low number and atypical pattern of annual white catfish tag recoveries prevents the computation of reliable survival and mortality estimates. Gross estimates of the survival and mortality of completely recruited white catfish, corrected for an assumed 40 percent nonresponse, were as follows:

Mean annual survival	= 0.81
Mean annual total mortality	= 0.91
Mean instantaneous mortality rate	= 0.21
Mean instantaneous fishing mortality rate	= 0.11
Mean instantaneous natural mortality rate	= 0.10
Mean annual expection of deaths from fishing	= 0.10
Mean annual expection of deaths from natural causes	= 0.09

The brown bullhead recovery data were insufficient for estimating population parameters; however, the quantity and pattern of returns suggests that survival and fishing rates were lower and natural mortality higher than for white catfish.

The locations of recaptures of both species demonstrated nondirectional dispersal throughout the lake.

In the 1954-55 study, 1,001 white catfish and 999 brown bullheads were tagged with disk-dangler tags only, and released in approximately equal numbers at four widely-separated locations.

During the following five years, annual returns were as follows:

	White catfish	*Brown bullheads*
First year	20	37
Second year	18	29
Third year	18	36
Fourth year	27	9
Fifth year	13	11
Totals	96	122

The differences in returns of both species from different release locations were not significant.

The only parameter obtainable from the white catfish tag recovery data was the rate of exploitation. During the first recovery year, $u = 0.05$.

Approximate survival and mortality values for brown bullheads were as follows:

Mean annual survival	= 0.76
Mean annual total mortality	= 0.23
Mean instantaneous mortality rate	= 0.27
Mean instantaneous fishing mortality rate	= 0.08
Mean instantaneous natural mortality rate	= 0.19
Mean rate of exploitation	= 0.07
Annual expection of natural deaths	= 0.16

It is concluded that huge, underfished stocks of white catfish and brown bullheads exist in Clear Lake. Several possible approaches to more effective management of the stocks are discussed briefly.

ACKNOWLEDGMENTS

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SALMO EVERMANNI A SYNONYM OF *SALMO CLARKII HENSHAWI*[1]

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After finding a record that cutthroat trout from Lake Tahoe had been planted in the stream from which *Salmo evermanni* Jordan and Grinnell, 1908, was later obtained, and aware that specimens of *evermanni* resembled specimens of cutthroat trout from Lake Tahoe, we closely compared the type and two "cotypes" of *evermanni* with specimens of *Salmo clarkii henshawi* Gill and Jordan, 1878, from Lake Tahoe to determine if *evermanni* was actually a distinct form. We found no significant differences in the specimens. It is especially important that they were alike in distribution, size, and shape of the dark spots and in having a high number of gill rakers. These characters distinguish *henshawi* from other kinds of cutthroat trout. From these circumstances, and because the presence of a cutthroat endemic to the San Bernardino Mountains seems unlikely to us on distributional grounds, we have concluded that the specimens upon which the name *evermanni* was based were derived from a plant of cutthroat trout whose origin was Lake Tahoe.

The record concerning the plant and its source is contained in the Fourteenth Biennial Report of the Fish Commissioners of the State of California for the years 1895-1896. Operations of the Sisson Hatchery are described on pages 25-27. The cutthroat trout reared at the Sisson Hatchery in those years were from spawn obtained in Taylor and Blackwood creeks which are tributaries to Lake Tahoe. The places where cutthroat fry were liberated are listed beginning on page 64 for 1895 and on page 65 for 1896. On July 30, 1895, 6,000 cutthroat trout fry were liberated in the Santa Ana River, San Bernardino County. On July 26, 1896, 2,500 fry were planted in the "Santa Ana River" and 15,000 in the "Santa Ana River, above falls". It is obvious from the records of plants in tributaries of the Santa Ana River and in nearby streams that cutthroat trout fry were planted in most, if not all, streams of the higher parts of the San Bernardino Mountains. It is highly probable that "Santa Ana River, above falls" refers to the same part of the Santa Ana River from which the specimens of *evermanni* were obtained eleven years later. Whether or not cutthroat trout were planted in the stream after 1896 we do not know, for subsequent biennial reports are not detailed as to localities planted with cutthroat.

[1] Submitted for publication July, 1960.

The fact that the validity of *Salmo evermanni* has not been previously questioned rests, we think, on the reputation of the describers as authorities and on the scarcity of specimens. One factor is that the authors did not know that cutthroat had been introduced into the area and for some reason not apparent to us did not directly compare their material with cutthroat. This may rest on their notion that *evermanni* was a relict which had been derived from a coastal form, although they did not state the relationships of that form. Jordan (1919; p. 369) stated later: "Another species of trout, perhaps derived from the coastwise rainbow, perhaps older, but at any rate very distinct, occurs at San Gorgonio Mountain in southern California where it has only lately been found by Professor Joseph Grinnell. A little trout, plain colored, with large black spots, and very small scales, like a cutthroat. It lives at a height of seventy-five hundred feet and is shut off from the lower rainbow trout of the lower Santa Ana River by a series of waterfalls. This species has been called *Salmo evermanni* by Doctors Jordan and Grinnell." The original description by Jordan and Grinnell (1908, p. 31) of *evermanni* is detailed and accurate with regard to the characters listed. They mentioned, without comment, the presence of hyoid (= basibranchial) teeth, a character which distinguishes cutthroat from rainbow. They referred to the absence of red on the throat in these words, ". . . fresh tints unknown, but no red in the throat region shown in the specimens." The lack of red is not significant, since the cutthroat mark usually disappears in specimens preserved, as these were, in alcohol. In all, there is nothing in the description which indicates difference from *henshawi* preserved in similar fashion.

Whether or not the reference of *evermanni* to the rainbow series by Evermann and Bryant (1919; p. 108) has a relation to Jordan's statement "perhaps derived from the coastwise rainbow," we do not know. At any rate, later authorities—until Miller (1950)—referred *evermanni* to the rainbow series. We have found no definite indication in the literature that anyone except Miller ever examined any of the original specimens critically, if at all; and it seems significant to us that he recognized them as belonging in the cutthroat series. He did not know, however, that cutthroat had been planted in the area. As far as we can determine, only the five original specimens exist, three in the Stanford collection and two in the U. S. National Museum collection. Miller's reference of *evermanni* to the cutthroat series was based on the specimens in the National Museum.

It is now established that the population of *evermanni* is extinct. Gard (M.S. thesis, 1953) after a careful search, concluded it was extinct before 1952. When it became extinct is uncertain as the evidence is incomplete and inconsistent, but it may have happened quite early. For instance, Bryant (1929; p. 392) stated: ". . . trout at the head of the Santa Ana River in southern California have been named a separate variety. In more recent years pack train loads of rainbows and steelhead trout have been placed in the habitat of the San Gorgonio trout and as a consequence the native stock has been replaced by a hybrid fish which is certain to be of less interest and value."

We gratefully acknowledge the help of Dr. George S. Myers and the late Miss Margaret Storey in permitting us to examine the type and two paratypes of *evermanni* and specimens of cutthroat trout from Lake Tahoe in the Stanford University collection.

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THE USE OF THE SEDIMENT BOTTLE COLLECTOR FOR MONITORING POLLUTED MARINE WATERS[1]

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INTRODUCTION

With increased interest in oceanic waters for recreation, shipping channels, a source of food, receiving domestic and industrial waste discharges, and as a source of fresh water, the problem of pollution becomes more acute, particularly of coastal waters. With this increase in the utilization of marine waters, it becomes of greater importance to protect this natural resource. A conflict of interests exists with regards to the use of these marine waters: the use of the ocean for receiving waters for domestic and industrial waste discharges is in opposition to the use for recreation, source of food, future fresh water source, and esthetic values.

In recent years, research investigations have been undertaken in many states bordering marine waters to determine whether or not pollution exists. The most extensive investigation undertaken thus far has been a study of southern California offshore waters by the Allan Hancock Foundation of University of Southern California (Allan Hancock Foundation, 1959). This study, supported by the State of California, involves a survey of bottom-dwelling plants and animals, hydrography and marine geology of the 250 miles of coastline from Santa Barbara to the Mexican border. Regardless of the size of the area involved, the majority of these pollution studies have been concerned primarily with descriptions of existing conditions and interpretations as to whether or not a state of pollution exists. Other marine pollution studies have dealt with the effect of industrial discharges, such as wastes from pulp mills or oil companies on fish and shellfish (Galtsoff, *et al.*, 1935; 1947, for example).

The U. S. Public Health Service recently initiated a monitoring program for collecting basic data on water quality at 50 stations on the Great Lakes and interstate streams of the United States (Palange and Megregian, 1958). At each of these stations, samples have been collected periodically and analyzed as to bacteriological, biological, chemical, and physical characteristics. No such program exists for marine waters. In fact, it was not until a few years ago that any marine area had been monitored. Marine monitoring programs generally have been associated with new installations (Pimentel, 1959; Rawn and Bacon, 1957).

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The present study was undertaken to determine whether or not the sediment bottle collector, described below, could be utilized for monitoring an area or outfall. The sediment bottle collector was chosen because it represented a means of capturing bottom-dwelling organisms. The importance of bottom-dwelling organisms to the study of water quality has been stressed by Patrick (1949) and Gaufin and Tarzwell (1952) for the fresh water environment and by Reish (1955; 1959) in marine waters. Coincident to this study considerable data were collected on the seasonal settlement of bottom-dwelling organisms, notably the polychaetous annelids. This information has been included since the settlement of these organisms has not been studied previously from Pacific waters. The work of Thorson (1946) and Smidt (1944; 1952) dealt in part with the settlement of bottom-dwelling animals in Danish seas, and represent the most extensive studies undertaken thus far.

MATERIALS AND METHODS

A wide-mouth, glass, gallon jar, similar to a device described by Thorson (1946) for collecting early stages of marine invertebrates in Danish waters, was suspended by rope (Figure 1) into 15 feet of water. Leaving the bottle in the water for 28 days divided the year into 13 equal periods. The first 28-day period extended from December 21, 1955 to January 18, 1956. The last sediment bottle was picked up at the termination of the 28-day period, November 20, 1957 to December 18, 1957. Sediments and marine invertebrates settled in the bottles and were analyzed as to species present and their abundance, odor of the substrate, if any, and percentage of organic carbon of the sediments.

The bottles were attached to harbor installations, generally either pilings or cleats on docks. At the end of each 28-day interval a series of bottles was removed and replaced by different jars. The bottles were brought to the laboratory and after the odor of the sediments was noted, the material was transferred onto a Tyler screen having 60 openings to the inch (openings equal to 0.0097 inch or 0.246 mm.) and washed. The organisms retained on the screen were preserved in formalin for later sorting and identification.

The material which passed through this screen was dried for later organic carbon analysis. The potassium dichromate method was used to determine the percentage of organic carbon (Emery and Rittenberg, 1952).

Dissolved oxygen of the water was determined at the 15-foot depth utilizing the modified Winkler method (American Public Health and American Water Works Associations, 1955).

STATION DESCRIPTIONS

Los Angeles-Long Beach Harbors were divided into five ecologic areas on the basis of bottom fauna and degree of pollution (Reish, 1955; 1959). Sediment bottle collectors were suspended at seven stations (Figure 2), two in the healthy zone (LA 7, LB 11), three in the semi-healthy zones (LA 28, LA 31, and LA 54), and two in the polluted zone (LA 39, LA 43A). The station numbers employed follow those used in previous studies of pollution in Los Angeles-Long Beach Harbors (California Regional Water Pollution Control Board No. 4, 1952;

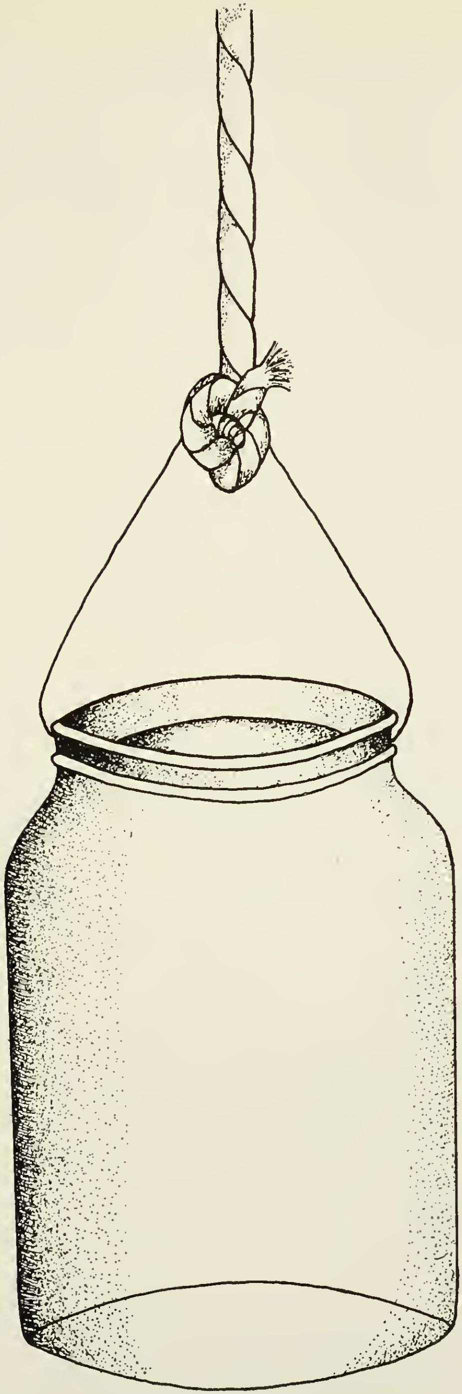

FIGURE 1. One-gallon sediment bottle collector showing method of attachment.

Reish, 1955, 1959); LA denotes those stations in Los Angeles Harbor, and LB denotes the one station in Long Beach Harbor. These stations may be characterized from the data in Reish, 1959, as follows:

Health Zones

LA 7, Watchorn Basin. The substrate at this station consisted of either gray or black muds and contained a diversity of fauna in 1954. Waste discharges into the area included cooling waters from industry and private raw sewage disposal, but neither of these was of major significance.

LB 11, Pontoon Bridge. The bottom dwelling organisms were sparse until late 1954; this was because of dredging operations within the area in 1953-1954. Pollution was not serious in the vicinity of this station: wastes included small amounts of discharge from oil well operations, cooling waters from steam generating plants and minor amounts of raw domestic sewage.

Semi-healthy Stations

LA 28, Main Channel. This station was not studied in 1954, (Reish, 1959) but stations located nearby were characterized by black muds, with or without a sulfide odor. Only minor amounts of wastes were emptied nearby, but the area was influenced by large amounts of oil refinery wastes discharged into nearby West Basin.

LA 31, Main Channel. The substrate consisted of either gray clays or black muds; the fauna was characteristic of one of two types of semi-healthy bottoms. The data for waste discharges are similar to LA 28, since the two stations are in close proximity.

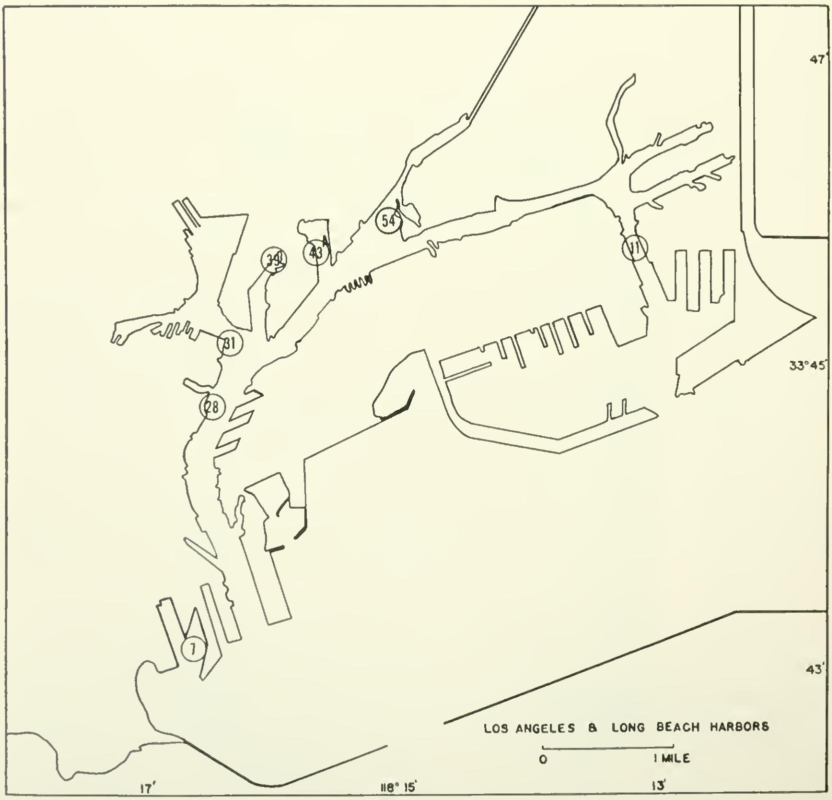

FIGURE 2. Map of Los Angeles-Long Beach Harbors indicating the station locations. Station 11 was in Long Beach Harbor; all others were in Los Angeles Harbor.

LA 54, East Basin. The substrate was either a gray clay or a black sulfide mud possessing a sulfide odor. Bottom conditions became progressively worse during 1954 because dredging activities in 1953 had removed the accumulated pollutants from the bottom, thus exposing unpolluted substrate (Reish, 1957b). Large amounts of oil refinery wastes emptied into the Consolidated Slip (Figure 2) influence this station.

Polluted Bottom

LA 39, Slip 1. The substrate consisted of black muds possessing a sulfide odor. Only a few species of animals were encountered in this area. No major contributors of waste discharges were found in the vicinity; however, the station was located at the end of a slip and water circulation was limited.

LA 43A, Slip 5. Fish scales were always present in the substrate, the fauna was diminished, and the sample generally had a sulfide odor. A vegetable processing plant and a fish cannery emptied their wastes nearby.

THE RELATIONSHIP OF SETTLEMENT OF SPECIES TO DEGREES OF POLLUTION

The sediment bottle data for the seven stations for the 1956-1957 period have been summarized in Tables 1 and 2 and Figure 3. Table 1 compares some of the biological, chemical, and physical characteristics of the three different ecologic areas. Table 2 lists 45 species, according to station, that were encountered during the two-year period. Figure 3 is a graphic summary of the seasonal settlement of the 14 more commonly encountered species (an anthozoan, 10 polychaetes and three crustaceans).

The five most frequently encountered species for each ecologic area are included in Table 1. The polychaetes *Capitella capitata* and *Podarke pugettensis* were present as dominants in the sediment bottles suspended in all zones. Many species settled, to some extent, in the bottles in all three areas, but the combinations of the different species are

TABLE 1

Comparisons of the Biological, Chemical, and Physical Data from the Three Ecologic Areas

Characteristic	Zone: Healthy	Zone: Semi-Healthy	Zone: Polluted
Dominant Species (in order of importance)	*Corophium acherusicum* *Capitella capitata* *Polydora paucibranchiata* *Armandia bioculata* *Podarke pugettensis*	*Capitella capitata* *Podarke pugettensis* *Epinebalia* sp. *Dorvillea articulata* *Corophium acherusicum*	*Capitella capitata* *Polydora paucibranchiata* *Dorvillea articulata* *Epinebalia* sp. *Podarke pugettensis*
Number of Animal Species			
Range	5-24	1-13	1-9
Average	10.7	6.5	4.6
Percent Odorous substrate	33	56	92
Percent Organic Carbon of Substrate			
Range	2.3-7.3	2.7-8.8	0.9-5.4
Average	5.3	5.3	5.8
Dissolved oxygen (ppm) of water mass			
Range	2.0-8.2	0.0-5.5	0.0-5.4
Average	4.7	2.1	2.0
Number of bottles analyzed	50	73	49

TABLE 2

Occurrence of Animals Settling in the Sediment Bottle Collectors, 1956-1957

Species	Zone							Totals
	Healthy		Semi-Healthy			Polluted		
	LA7	LB11	LA54	LA31	LA28	LA39	LA43A	
Phylum Coelenterata								
Class Anthozoa								
Diadumene leucolena (Verrill)	7	22				3		32
Phylum Platyhelminthes								
turbellarians, unidentified	4	5						9
Phylum Nematoda								
nematodes, unidentified		1	2					3
Phylum Nemertea								
nemerteans, unidentified	3	8				1		12
Phylum Phoronidea								
phoronids, unidentified	2	3	1	5	1		1	13
Phylum Annelida								
Class Polychaeta								
Paleonotus chrysolepis Schmarda	2	6	1	3	5	3		20
Halosydna johnsoni (Darboux)	8	7	3	4	6	1	1	30
Eumida sanguinea (Oersted)	6	16	5	2		1	1	31
Leocrates sp.	1							1
Podarke pugettensis Johnson	19	14	17	22	25	21	8	126
syllids, unidentified	8	12	3	8	4	2	1	38
Neanthes caudata (delle Chiaje)	1			1	1			3
Nereis latascens Chamberlin		1						1
Nephtys caecoides Hartman	1	3						4
Lumbrineris minima Hartman		1						1
Dorvillea articulata (*Hartman*)	17	9	15	21	20	18	14	114
Ophryoptrocha puerilis Claparede & Metschnikow	3		1					4
Haploscoloplos elongatus (Johnson)	1	1						2
Polydora paucibranchiata Okuda	22	22	13	10	13	19	15	114
Prionospio cirrifera Wiren	3	2			2			7
Magelona californica Hartman							1	1
Cirriformia luxuriosa (Moore)	1	10	5	6	2	4	2	30
Cossura candida Hartman	1							1
Tharyx parvus Berkeley	2							2
Ctenodrilus serratus (Schmidt)	5	5	1					11
Pherusa inflata (Treadwell)		1						1
Capitella capitata (Fabricius)	23	21	20	22	24	20	19	149
Armandia bioculata Hartman	20	16	3	2	2	1		44
sabellid, unidentified	1							1
Class Oligochaeta								
oligochaetes, unidentified	1		4	3		2	14	24
Phylum Arthropoda								
Subphylum Crustacea								
Class Ostracoda								
ostracods, unidentified	2							2
Class Malacostraca								
Subclass Leptostraca								
Epinebalia sp.	4	2	20	12	25	17	14	95
Subclass Peracarida								
Order Cumacea								
cumaceans, unidentified	3	1	1					5
Order Amphipoda								
Corophium acherusicum (Costa)	23	25	16	12	20	3	7	106
amphipods, unidentified	14	19	4		3		1	41
Caprella sp.	12	11	3					29
Order Isopoda								
isopods, unidentified	1	4						5
Subclass Eucarida								
Order Decapoda								
Cancer sp.		1						1
Hemigrapsus oregoniensis (Dana)	1	2	2	2		3	1	11
shrimp, unidentified	7	1	1	1		2	1	13

TABLE 2—Continued

Occurrence of Animals Settling in the Sediment Bottle Collectors, 1956-1957

Species	Zone							Totals
	Healthy		Semi-Healthy			Polluted		
	LA7	LB11	LA54	LA31	LA28	LA39	LA43A	
Phylum Arthropoda—Continued								
Subphylum Chelicerata								
Class Pycnogonida								
pycnogonid, unidentified	1	--	--	--	--	--	--	1
Phylum Mollusca								
Class Pelecypoda								
clams, unidentified juveniles	3	9	3	2	3	--	--	20
Class Gastropoda								
snails, unidentified juveniles	2	3	--	--	--	--	--	5
nudibranchs, unidentified juveniles	4	5	3	3	7	5	2	29
Phylum Echinodermata								
Class Holothuroidea								
holothurian, unidentified	--	1	--	--	--	--	--	1
Total number of species	38	35	24	19	17	18	17	45
Number of bottles suspended	24	26	23	24	26	26	23	172

useful as indicators of water quality. In addition to the dominant species listed in Table 1, other invertebrates, not as frequently encountered, may be of use as indicators. Utilizing only those species observed on five occasions or more, four species: an anemone, two polychaetes, and an amphipod, limited, or nearly so, to the healthy stations LA 7 and LB 11 (Table 2), were *Diadumene leucolena, Prionospio cirrifera, Ctenodrilus serratus,* and *Caprella* sp. Additional species were limited, or nearly so, to the healthy and semi-healthy zones but not the polluted area; these include the three polychaetes *Paleonotus chrysolepis, Halosydna johnsoni,* and *Eumida sanguinea.* An unidentified oligochaete was more frequently limited to the polluted zone than the other areas.

A reduction in the number of species was observed in the more polluted areas (Table 1). The average number of species encountered in the bottles suspended in the healthy areas was more than double the number taken from the polluted zone. Substrates with either a sulfide or petroleum odor were more prevalent in the more polluted areas.

The differences in the percent of organic carbon from the three areas were not so striking; an average of 5.8 percent was measured from the very polluted areas as compared to 5.3 at the other two zones. Higher values were obtained in the sediments collected in the more polluted areas. Several low values, measured at station LA 39, were related to the presence of sands, rather than muds, as is generally encountered in the bottles.

The average dissolved oxygen content of the water mass in the vicinity of the sediment bottles was highest at the healthy stations and about the same at the semi-healthy and polluted stations (Table 1).

SEASONAL VARIATIONS

The seasonal settlement for the 14 more frequently occurring animals has been summarized in Figure 3. All the data for each period of the two-year interval have been considered as a unit. The majority of these species, notably, the anthozoan *Diadumene leucolena*, seven polychaetes *Eumida sanguinea*, *Podarke pugettensis*, *Platynereis bicanaliculata*, *Dorvillea articulata*, *Polydora paucibranchiata*, *Armandia bioculata*, *Capitella capitata*, and two crustaceans *Epinebalia* sp. and *Corophium acherusicum* settle throughout the year. Among the more commonly encountered species only the three polychaetes *Paleonotus chrysolepis*, *Halosydna johnsoni*, *Cirriformia luxuriosa*, and the amphipod *Caprella* sp. did not settle in the sediment bottles throughout the year.

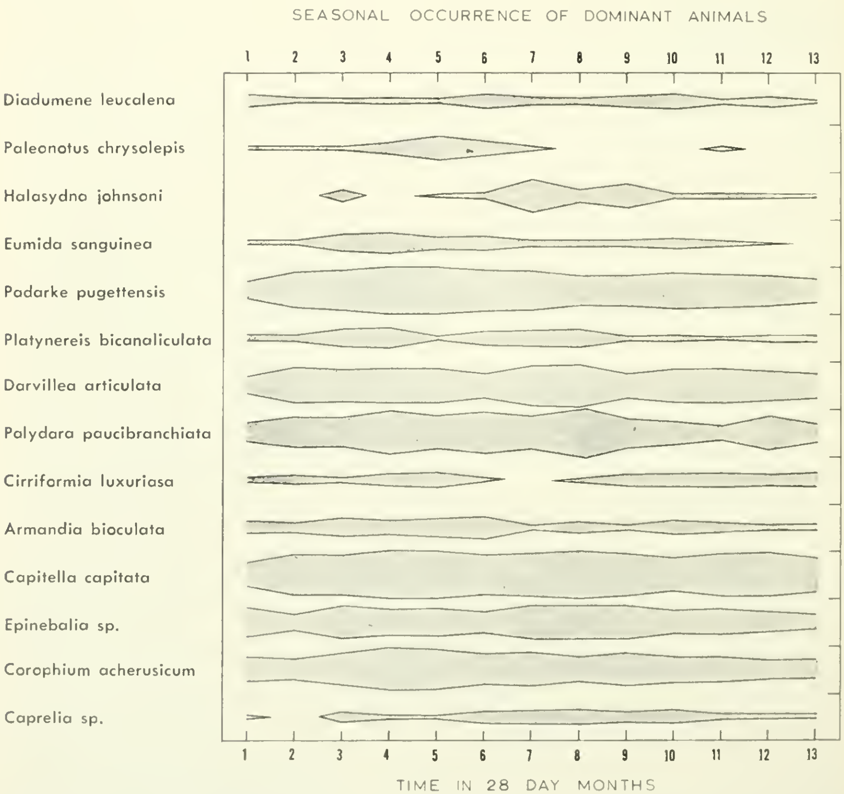

FIGURE 3. The seasonal occurrence of the more frequently encountered marine invertebrates taken from the sediment bottle collectors suspended in Los Angeles-Long Beach Harbors for 28-day intervals during 1956-1957. The subdivisions along the vertical margins indicate 100 percent occurrence for each species for each period of exposure. Data for each 28-day month are based on 12 to 14 suspensions.

While most of the larvae of the dominant species settled throughout the year, reflecting reproduction by the adults throughout the year, most of them showed seasonal peaks. *Diadumene leucolena* and *Epinebalia* sp. were the only major species lacking seasonal peaks. The majority of the peaks occurred during the spring months. The polychaetes *Podarke pugettensis* and *Cirriformia luxuriosa* were characterized by having both a spring peak and a fall peak. In terms of number of species settling in the bottles, the peak occurred in the spring to early summer months or during the third to seventh 28-day intervals. A gradual decrease followed, and the smallest number of animals settled during periods 13 and 1.

Odorous substrates, generally either a sulfide- or petroleum-type, were more prevalent during periods 6 and 7 and less prevalent during 3 and 4. Warmer water temperatures were noted during the summer (periods 7 to 10), and the reverse during periods 13 and 1. Highest dissolved oxygen values were obtained during the spring, and the low amounts were noted in the late fall and early winter.

DISCUSSION

Application of the Sediment Bottle Collector

Use of the sediment bottle collector for monitoring an outfall may be illustrated as follows. Prior to constructing a new marine outfall, sediment bottle collectors could be suspended in the region, preferably at monthly intervals for a year, in order to ascertain the number and kinds of animals settling in the area. In addition, it would be desirous to sample the benthic fauna. By noting what animals settle within the bottles after waste discharge commences, it would be possible to ascertain whether or not the effluent was altering the environment. Degrees of contamination, if they exist, would be indicated not only by the number of species settling, but also by the species composition. The majority of the identified species listed in Table 2 are limited in their geographical distribution so these particular species may or may not be of value as indicators, if they even occur, in other geographical areas. Presumably, another species complex would exist.

Sediment bottles may be suspended from marine structures in bays and harbors. In the absence of such constructions, they may be tied to buoys or suspended in much the same manner as lobster or crab pots. It may be necessary to attach a weight to the bottle in offshore waters, and substitute a plastic container for the glass bottle. During the course of this study only about five percent of the bottles were lost or broken.

Seasonal Settlement

The seasonal settlement of fouling organisms and wood borers on test blocks in Los Angeles—Long Beach Harbors was studied in 1950-51 by Barnard (1958). The dominant animals were the amphipods, and polychaetes. The greatest numbers of amphipods, of which *Corophium acherusicum* was the most prevalent, were observed in the spring months especially at stations where turbidity and dissolved oxygen content were high. This seasonal peak of the fouling amphipods corresponds to the data presented herein for animals settling in the sediment bottles. Three polychaetes, *Podarke pugettensis*, *Polydora (C.) paucibranchiata*, and *Capitella capitata*, important fouling organisms, were also frequently encountered in the bottles.

Since most of the species listed in Table 2 have limited distributions in the Eastern Pacific Ocean and since little work has been done on their development and life histories, comparisons of these data to other studies are limited.

Thorson (1946) collected larvae of *Capitella capitata* in plankton hauls throughout the year in Oresund Sound, Denmark. He encountered four larvae in two sediment bottles suspended in the same area; one had attained the length of 6.5 mm. in 20 days. Thorson concluded that *C. capitata* seems to spawn throughout the year in Oresund Sound and that development was very rapid after the larvae settled. Additional data, but not as complete, on the larval occurrence of *C. capitata* in Danish waters are given by Rasmussen (1956) and (Smidt) (1952).

The findings reported herein indicate *Capitella capitata* settles throughout the year in Los Angeles-Long Beach Harbors, and development is rapid. In fact, females have been observed incubating eggs in sediment bottles suspended for a 28-day period. Since these bottles were suspended in the water mass, presumably *C. capitata* arrived during their pelagic larval life. These sexually mature females were observed more frequently in the summer months than the remaining times of the year. Additional data for the rapid development of this polychaete are the observations by Reish and Barnard (1960) that *C. capitata* completed its life cycle in about 54 days at temperatures ranging from 14.9 to 17.9 degrees C. Development undoubtedly proceeds at a faster rate in Los Angeles-Long Beach Harbors than Oresund Sound because of higher water temperatures; temperatures ranged from 13.0 to 24.0 degrees C in 1956-1957 in the two harbors; whereas, the range was 0.0 (sometimes negative) to 17.0 degrees C in Oresund Sound (Thorson, 1946).

Value of the Sediment Bottle Collector

The advantages of the sediment bottle collector for monitoring areas surrounding marine outfalls may be summarized as follows: (1) inexpensive to construct, (2) the data may be analyzed rapidly, (3) the animals will not be too difficult for the non-specialist to identify, (4) the instrument is adaptable and may be altered to fit the particular situation, and (5) the results will be indicative of conditions over the entire period of exposure and not limited to the time of taking the sample. Several additional advantages of particular interest to the invertebrate zoologist are (1) it will yield valuable data on the early development and seasonal settlement of bottom funa, (2) it is a means of collecting subtidal bottom fauna in good condition for laboratory studies, and (3) it may yield animals not previously encountered; for example, the first occurrence of the polychaete *Neanthes caudata* in the Pacific Ocean was collected in Los Angeles Harbor in this way (Reish, 1957a).

SUMMARY

1. The use and application of a one-gallon jar for monitoring marine areas or outfalls are discussed.

2. The results of a two-year study in different ecological regions of Los Angeles-Long Beach Harbors, California, are presented.

3. The species, the number of species, and some chemical and physical characteristics are related to varying degrees of pollution.

4. The seasonal occurrences of the more prevalent species are discussed.

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AGE AND LENGTH COMPOSITION OF THE SARDINE CATCH OFF THE PACIFIC COAST OF THE UNITED STATES AND MEXICO IN 1958-59[1]

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INTRODUCTION

This is the thirteenth report on age and length composition of the catch of California sardines (*Sardinops caerulea*) off the Pacific coast of North America. These reports have been prepared on a seasonal basis since 1941-42.

Previous to the 1957-58 report (Daugherty and Wolf, 1960), this series was devoted almost entirely to presenting basic age and length data of the seasonal catch of the sardine fishery. Beginning with the above mentioned report a more comprehensive picture of the fishery has been presented.

The assistance of Leighton G. Claussen, formerly of the U.S. Bureau of Commercial Fisheries, and of Doyle Gates of the California Department of Fish and Game is gratefully acknowledged.

THE FISHERY

During the 1958-59 season 102,621 tons of sardines were landed in central and southern California. This was the largest seasonal catch there since 1951-52 when 127,000 tons were caught. It is possible that sardines were more plentiful than in recent years and that except for economic limitations[2] the landings might have exceeded the 1951-52 level.

Central California

In the central California region, which lies north of Point Arguello, the sardine season opened on August 1, 1958. During the first dark-of-the-moon period, "August",[3] 4,599 tons of sardines were landed. This was the first major catch of sardines in the region since the more than 15,700 tons landed there during the 1951-52 season. During "September" another 9,174 tons of sardines were taken. In "October" 5,450 tons were caught, and in "November" 2,917 tons. In "December" 2,460 tons were landed and in "January" 14 tons, which brought the total for central California to 24,614 tons for the season which ended on January 1, 1959.

[1] Submitted for publication December 1960.
[2] See pages 274 and 275 for information on limits.
[3] Lunar months are always referred to in quotation marks to distinguish them from the calendar months they approximate. Calendar dates for lunar months during 1958 are presented in Table 1.

Central California fishermen were paid $60 per ton for their fish at the beginning of the season. Where necessary, however, they were obliged to pay the charges of transporting the fish to the cannery. After "September" and for the remainder of the season, the price paid was $50 per ton, still exclusive of trucking charges.

Thirty boats were involved in the central California sardine fishery. These included 13 large purse seiners (60 ft. or over), 4 small purse seiners, and 13 lampara boats. They were on nightly cannery-imposed limits of 35-40 tons. On some nights no limits were set.

Approximately two-thirds of the total tonnage was landed at either Morro Bay or Avila and trucked to processors in Monterey or San Francisco. The remainder of the catch was landed at Monterey Bay plants. There were seven cannery plants in operation: five in Monterey proper, one in Moss Landing, and one in San Francisco. Approximately 3,300 tons of sardines were processed in San Francisco and 21,300 tons in the Monterey Bay area.

Southern California

The sardine season in southern California opened on September 1, 1958, and closed coincident with the central California season on January 1, 1959. This fishing region includes the waters between Point Arguello and the Mexican border.

During the season, 78,007 tons of sardines were landed in the southern California region—72,932 in the Los Angeles-Long Beach area. At Port Hueneme 5,075 tons were landed, of which 4,429 tons were trucked to a cannery at nearby Oxnard or to the canneries of the Los Angeles-Long Beach area. The remaining 646 tons were trucked north to the Monterey Bay area. During "September" 25,677 tons of sardines were landed in southern California, in "October" 29,972 tons, in "November" 16,470, in "December" 5,731, and in the first and only week of the "January" dark (which commenced on December 25) 157 tons.

Southern California fishermen, like those in central California, received $60 per ton during "September". When fishing resumed in "October" the price was renegotiated at $50 per ton where it remained until the end of the season.

The fleet in southern California consisted of 119 boats: 67 large purse seiners, 16 small purse seiners, and 36 lamparas. In recent years the number of large purse-seine vessels has decreased through the loss of some and the sale of others.

Throughout the season sardines remained in the vicinity of Santa Rosa, Santa Cruz and Anacapa Islands. The major part of the southern California catch came from this area, although some fish were taken along the adjacent mainland shore and as far east as Malibu Beach. This season differed from most recent ones in that fishing operations did not extend appreciably towards the Mexican border.

During "September" southern California boats were on individual nightly catch limits up to 100 tons. Before fishing resumed in "October" processors agreed to take a minimum of 40,000 tons during the remainder of the season concurrent with the ex-vessel price drop.

This was in addition to the 25,677 tons already landed. Each boat was guaranteed a minimum nightly catch limit of 40 tons until the 40,000 tons were landed. Nightly limits held at 40 to 50 tons until the middle of "November" when the 40,000-ton quota was achieved. From then until the end of the season, nightly limits ranged from 20 to 40 tons.

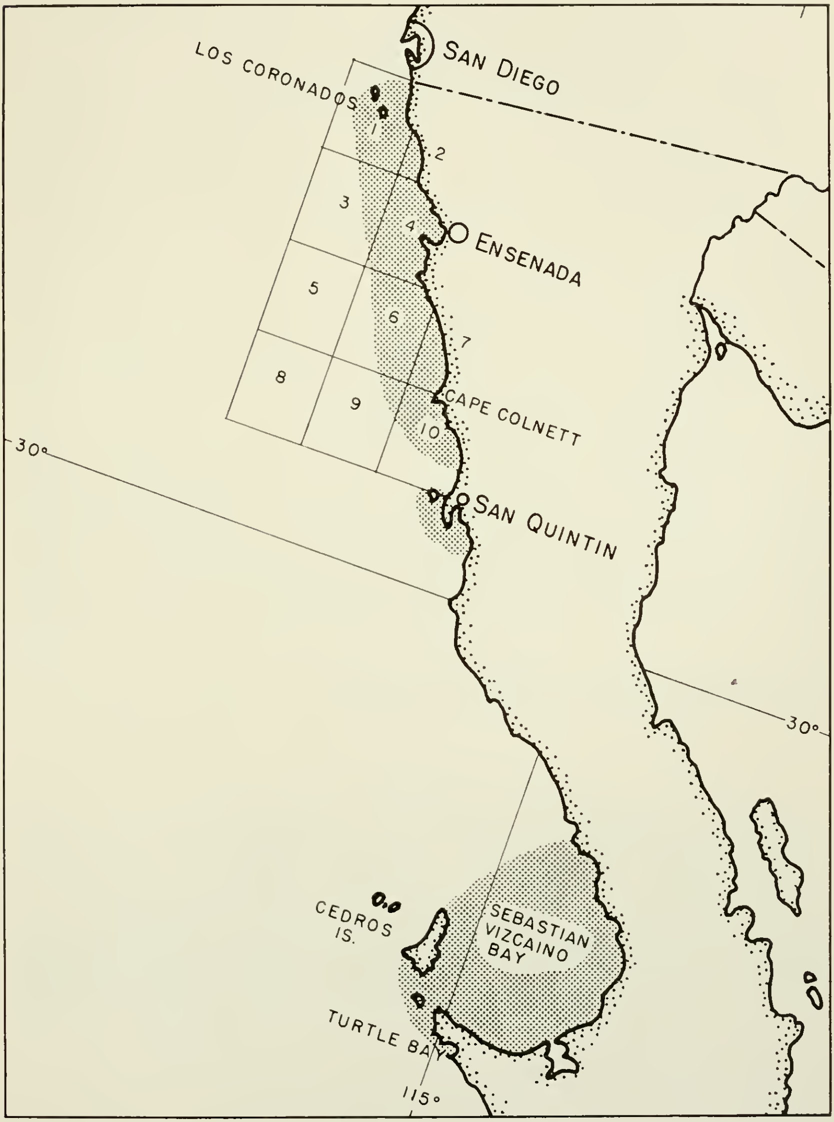

FIGURE 1. Upper Baja California showing sardine fishing areas (shaded) and ports of landing. Statistical subareas for the Ensenada fishery are superposed (taken from Oficina de Cartografia, Julio de 1954).

Weather conditions during the season were considered good. Except for the usual fog, and a bad storm the night of November 14 resulting in the loss of one lampara boat, no great amount of time was lost due to weather.

Baja California

To augment information obtained from sampling California landings, the sampling program in Baja California, Mexico, was considerably expanded in 1957. In 1958-59 sardine landings were sampled at Ensenada, San Quintin and Cedros Island (Figure 1).

Sardines are taken commercially throughout the year in upper Baja California. In 1958 the total catch in Baja California was 19,383 tons. Of these, 7,793 tons were taken during the period of the California fishery and 11,590 tons during the interseason. Baja California fishermen received an ex-vessel price equivalent to $40 in U. S. currency per ton for their sardines. In cases where the canner supplied fuel for the boat the price was $30.

Currently there are about 30 boats in the Baja California fishery, but the number varies according to the abundance of pelagic species and market conditions. Contrary to the situation in California, the jack and Pacific mackerels are preferred species when they are available. When fishing becomes an unprofitable venture, the boats may be used in other pursuits or may be tied up.

Ensenada, located 60 miles below the U. S.-Mexico border, is the largest fishing port in Baja California. Five canneries there processed sardines. These were supplied by boats that operated between Los Coronados Islands and Cape Colnett. The cannery at San Quintin was supplied by one or two boats operating in and around San Quintin Bay. A cannery at Cedros Island was supplied by three to six boats that operated between northern Sebastian Vizcaino Bay and Turtle Bay.

No information is available as to whether nightly catch limits are ever imposed on Baja California fishermen.

TABLE 1

Calendar Dates of Lunar Months During 1958

Lunar month	Lunar period[1]	Dates	Lunar month	Lunar period	Dates
"January"	473	January 5-February 3	"August"	480	July 31-August 29
"February"	474	February 4-March 4	"September"	481	August 30-September 27
"March"	475	March 5-April 3	"October"	482	September 28-October 26
"April"	476	April 4-May 3	"November"	483	October 27-November 25
"May"	477	May 4-June 1	"December"	484	November 26-December 24
"June"	478	June 2-July 1	"January"	485	December 25-January 23[2]
"July"	479	July 2-July 30			

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

AGE AND LENGTH COMPOSITION

In central California all but five of the 716 fish aged were one to three years old. Lengths ranged between 166 and 248 mm. standard length (Table 2). Eight age groups were separated in the 1,044 fish, 166 to 252 mm. in standard length, from southern California (Table 3). A total of 958 fish were aged from Baja California samples during

TABLE 2

Length Composition of Year-classes in Sardine Samples from the Central California Commercial Catch, 1958-59 Season

Age	0	1	2	3	4	5	6	
Year class	1958	1957	1956	1955	1954	1953	1952	Total
Standard length mm.								
166	--	--	1	--	--	--	--	1
168	--	--	--	--	--	--	--	--
170	--	1	8	--	--	--	--	9
172	--	5	7	--	--	--	--	12
174	--	5	23	1	--	--	--	29
176	--	10	29	2	--	--	--	41
178	--	9	40	2	--	--	--	51
180	--	17	65	10	--	--	--	92
182	--	13	47	14	--	--	--	74
184	--	10	73	19	--	--	--	102
186	--	8	63	16	--	--	--	87
188	--	2	48	16	1	--	--	67
190	--	1	44	18	--	--	--	63
192	--	2	28	10	--	--	--	40
194	--	1	12	10	--	--	--	23
196	--	--	5	7	--	--	--	12
198	--	--	4	3	1	--	--	8
200	--	--	1	--	--	--	--	1
202	--	--	--	--	--	--	--	--
204	--	--	1	--	--	--	--	1
206	--	--	--	--	1	--	--	1
236	--	--	--	--	--	--	1	1
248	--	--	--	--	1	--	--	1
Totals	--	84	499	128	4	--	1	716
Mean lengths	--	181	184	187	210	--	--	184

the period that corresponded to the California fishery. The age range was one through five, and the length range was 110-206 mm. (Table 4). In Baja California interseason six year-classes were represented in the catch. Because the annulus was formed during this period with an accompanying age change, these fish were tabulated by year-class only. A length range of 118-232 mm. was observed from 696 fish (Table 5). Mean lengths at each age are also shown in the tables.

Length and age compositions by year-class are shown by lunar month for each region in Figure 2. Although length composition during the regular season differed among regions, it remained fairly stable within

TABLE 3

Length Composition of Year-classes in Sardine Samples from the Southern California Commercial Catch, 1958-59 Season

Age	0	1	2	3	4	5	6	7	8	9	
Year class	1958	1957	1956	1955	1954	1953	1952	1951	1950	1949	Total
Standard length mm.											
166	--	1	--	--	--	--	--	--	--	--	1
168	--	--	3	--	--	--	--	--	--	--	3
170	--	--	--	--	--	--	--	--	--	--	--
172	--	5	3	--	--	--	--	--	--	--	8
174	--	5	3	2	--	--	--	--	--	--	10
176	--	4	9	--	--	--	--	--	--	--	13
178	--	4	16	--	--	--	--	--	--	--	20
180	--	10	27	5	--	--	--	--	--	--	42
182	--	9	36	8	--	--	--	--	--	--	53
184	--	12	40	11	1	--	--	--	--	--	64
186	--	10	47	10	--	--	--	--	--	--	67
188	--	8	58	12	--	--	--	--	--	--	78
190	--	8	74	19	1	--	--	--	--	--	102
192	--	6	61	17	3	--	--	--	--	--	87
194	--	3	53	32	2	--	--	--	--	--	90
196	--	5	42	18	1	--	--	--	--	--	66
198	--	4	39	16	--	--	--	--	--	--	59
200	--	2	24	22	--	1	--	--	--	--	49
202	--	1	19	13	1	--	--	--	--	--	34
204	--	3	24	10	3	--	--	--	--	--	40
206	--	1	13	7	1	--	--	--	--	--	22
208	--	3	7	6	--	--	--	--	--	--	16
210	--	--	6	8	1	1	--	--	--	--	19
212	--	--	6	2	5	--	--	--	--	--	13
214	--	--	3	2	3	3	--	--	--	--	11
216	--	--	2	4	3	1	1	--	--	--	11
218	--	--	1	2	2	--	--	1	--	--	6
220	--	--	1	1	--	--	--	--	--	--	2
222	--	--	--	3	--	1	--	--	--	--	4
224	--	--	--	--	3	1	1	--	--	--	5
226	--	--	--	1	2	1	1	--	--	--	5
228	--	--	--	2	1	2	1	--	--	--	6
230	--	--	--	1	2	4	--	--	--	1	8
232	--	--	--	1	--	--	--	--	--	--	1
234	--	--	--	2	1	--	--	--	--	--	3
236	--	--	--	--	1	--	1	--	--	--	2
238	--	--	--	1	1	--	1	--	--	--	3
240	--	--	--	--	3	3	1	--	--	--	7
242	--	--	--	--	1	1	2	--	--	--	4
244	--	--	--	--	1	--	1	--	--	--	2
246	--	--	--	--	1	--	3	--	--	--	4
248	--	--	--	--	--	1	--	1	--	--	2
250	--	--	--	--	--	--	--	--	--	--	--
252	--	--	--	--	1	1	--	--	--	--	2
Totals	--	104	617	238	48	21	13	2	--	1	1044
Mean lengths	--	187	191	197	216	227	237	233	--	230	195

them. The only major change occured in southern California where the size range decreased from 160-255 in "September" to 165-220 in "December". The 1956 class dominated in all regions during these months, and it is obvious from inspection that variations in the length curves are matched by similar variations in year-class composition.

TABLE 4

Length Composition of Year-classes in Sardine Samples from the Baja California Commercial Catch, 1958-1959 Season ("September" through "December")

Age	0	1	2	3	4	5	
Year class	1958	1957	1956	1955	1954	1953	Total
Standard length mm.							
110	--	--	1	--	--	--	1
130	--	1	--	--	--	--	1
132	--	--	--	--	--	--	--
134	--	--	--	--	--	--	--
136	--	--	1	--	--	--	1
138	--	--	3	--	--	--	3
140	--	1	6	1	--	--	8
142	--	3	7	--	--	--	10
144	--	3	14	1	--	--	18
146	--	2	15	--	--	--	17
148	--	11	25	3	--	--	39
150	--	11	39	2	--	--	52
152	--	7	64	2	--	--	73
154	--	11	58	7	--	--	76
156	--	12	61	5	--	--	78
158	--	11	82	--	--	--	93
160	--	7	59	9	--	--	75
162	--	8	82	10	--	--	100
164	--	4	53	9	--	--	66
166	--	3	36	4	--	--	43
168	--	1	47	5	--	--	53
170	--	4	21	3	--	--	28
172	--	2	16	--	--	--	18
174	--	2	10	3	--	--	15
176	--	1	12	3	--	--	16
178	--	--	6	2	--	--	8
180	--	--	10	4	--	--	14
182	--	--	3	3	1	--	7
184	--	--	3	5	--	--	8
186	--	--	3	2	--	--	5
188	--	--	1	2	2	--	5
190	--	--	3	4	--	--	7
192	--	--	--	6	--	1	7
194	--	--	1	--	1	--	2
196	--	--	--	--	3	1	4
198	--	--	--	2	--	--	2
200	--	--	--	3	--	--	3
202	--	--	--	--	1	--	1
204	--	--	--	--	--	--	--
206	--	--	--	--	1	--	1
208	--	--	--	--	--	--	--
Totals	--	105	742	100	9	2	958
Mean lengths	--	156	160	170	194	194	161

During the Baja California interseason length composition was more varied. The primary modes shifted from 125 mm. in "February" and "March" to 190 mm. in "April" and "May". It went down to 170 mm. in "June" and "July", then up to 180 mm. in "August". Again the variations in length composition were reflected in differences in year-class composition. All months of the interseason were dominated by the 1956 class except "April" and "May", when the 1955 class was dominant.

Lunar month summaries of the year-class composition of catch samples were used to obtain the year-class composition of the total catch.

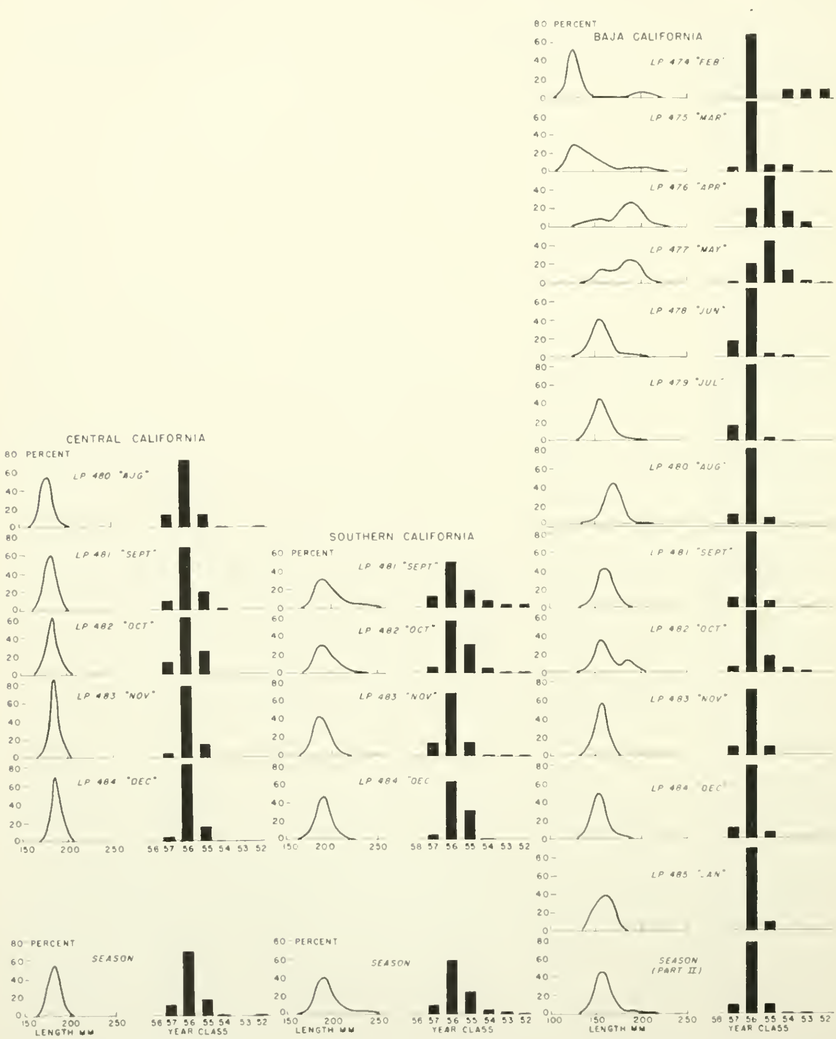

FIGURE 2. Percentage length and year-class composition of all samples of the 1958-59 commercial sardine catch. Length data are summarized by 10 mm. intervals.

TABLE 5

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

Year class	1958	1957	1956	1955	1954	1953	1952	Total
Standard length mm.								
118	--	--	1	--	--	--	--	1
120	--	--	4	--	--	--	--	4
122	--	--	4	--	--	--	--	4
124	--	1	11	--	--	--	--	12
126	--	--	12	--	--	--	--	12
128	--	2	13	--	--	--	--	15
130	--	--	14	--	--	--	--	14
132	--	2	6	--	--	--	--	8
134	--	1	10	--	--	--	--	11
136	--	1	4	--	--	--	--	5
138	--	2	7	--	--	--	--	9
140	--	2	4	--	--	--	--	6
142	--	2	11	1	--	--	--	14
144	--	1	16	--	--	--	--	17
146	--	3	15	--	--	--	--	18
148	--	2	11	--	--	--	--	13
150	--	2	8	1	--	--	--	11
152	--	2	18	--	--	--	--	20
154	--	7	13	--	--	--	--	20
156	--	8	25	1	--	--	--	34
158	--	6	15	1	--	--	--	22
160	--	7	24	1	--	--	--	32
162	--	5	23	1	--	--	--	29
164	--	1	17	1	--	--	--	19
166	--	3	19	2	--	--	--	24
168	--	4	10	2	--	--	--	16
170	--	--	23	4	--	--	--	27
172	--	1	15	1	--	--	--	17
174	--	1	25	1	--	--	--	27
176	--	1	16	6	--	--	--	23
178	--	1	11	11	--	--	--	23
180	--	--	9	6	1	--	--	16
182	--	--	4	8	--	--	--	12
184	--	1	4	8	1	--	--	14
186	--	--	2	12	--	--	--	14
188	--	--	4	8	1	--	--	13
190	--	--	2	8	2	--	--	12
192	--	--	2	6	4	--	--	12
194	--	--	1	14	2	1	--	18
196	--	--	2	5	1	1	--	9
198	--	--	--	11	8	1	--	20
200	--	--	--	3	3	--	--	6
202	--	--	--	1	2	--	--	3
204	--	--	--	4	4	1	--	9
206	--	--	1	1	6	1	1	10
208	--	--	--	--	7	--	--	7
210	--	--	--	1	3	1	--	5
212	--	--	--	--	--	1	--	1
214	--	--	--	--	2	--	1	3
216	--	--	--	--	--	--	--	--
218	--	--	--	--	1	1	--	2
220	--	--	--	--	--	1	--	1
222	--	--	--	--	--	--	--	--
224	--	--	--	--	--	1	--	1
226	--	--	--	--	--	--	--	--
228	--	--	--	--	--	--	--	--
230	--	--	--	--	--	--	--	--
232	--	--	--	--	--	--	1	1
Totals	--	69	436	130	48	10	3	696
Mean lengths	--	154	156	186	201	208	--	166

TABLE 6

Age and Year-class Composition of the Sardine Catch in the 1958-59 Season

	Catch		Number of fish in thousands by age and year-class									
			0	1	2	3	4	5	6	7	8	9
	Tons	Number	1958	1957	1956	1955	1954	1953	1952	1951	1950	1949
Central California												
"August"	4,599	52,711	--	7,095	37,789	7,664	121	--	42	--	--	--
"September"	9,174	101,471	--	11,771	70,137	18,914	568	81	--	--	--	--
"October"	5,450	58,739	--	8,141	36,248	14,268	82		--	--	--	--
"November"	2,917	30,992		1,240	25,413	4,339				--	--	--
"December"	2,460	27,842	--	1,114	23,610	3,118	--	--	--	--	--	--
"January"	14	159	--	6	135	18	--	--	--	--	--	--
Total Central California	24,614	271,914	--	29,367	193,332	48,321	771	81	42	--	--	--
Percent	--	100.0	--	10.8	71.1	17.8	.3	--	--	--	--	--
Southern California												
"September"	25,677	218,655	--	30,021	111,820	43,731	17,055	10,211	5,095	722	--	--
"October"	29,972	284,435	--	18,204	161,957	85,700	13,653	3,214	939	569	--	199
"November"	16,470	169,792	--	22,497	116,206	27,387	1,902	1,596	204	--	--	--
"December"	5,731	60,756	--	2,710	38,136	18,974	936		--	--	--	--
"January"[1]	157	1,558	--	69	978	487	24			--	--	--
Total Southern California	78,007	735,196	--	73,501	429,097	176,279	33,570	15,021	6,238	1,291	--	199
Percent	--	100.0	--	10.0	58.4	24.0	4.6	2.0	.8	.2	--	--
Total California	102,621	1,007,110	--	102,868	622,429	224,600	34,341	15,102	6,280	1,291	--	199
Percent	--	100.0	--	10.2	61.9	22.3	3.4	1.5	.6	.1	--	--
Baja California[2]												
"September"	653	9,490	--	1,148	7,738	589	--	15	--	--	--	--
"October"	2,213	28,327	--	2,588	19,376	4,925	1,258	180	--	--	--	--
"November"	2,955	37,080	--	4,694	28,272	4,114	--	--	--	--	--	--
"December"	1,821	34,463	--	4,561	28,261	1,641	--	--	--	--	--	--
"January"[1]	151	2,535	--	--	2,281	254	--	--	--	--	--	--
Total Baja California	7,793	111,895	--	12,991	85,928	11,523	1,258	195	--	--	--	--
Percent	--	100.0	--	11.6	76.8	10.3	1.1	0.2	--	--	--	--
TOTAL	110,414	1,119,005	--	115,859	708,357	236,123	35,599	15,297	6,280	1,291	--	199
Percent	--	100.0	--	10.4	63.3	21.1	3.2	1.4	.5	.1	--	--

[1] December 24 to January 1 only.
[2] Includes data from Ensenada, San Quintin and Cedros Island.

Details of the method are given by Felin and Phillips (1948, p. 11). Necessary to the method are weight-per-fish factors. This season's averages of these factors were: central California 0.1784 pounds; southern California 0.2091 pounds; and Baja California 0.1212 pounds. The age and year-class compositions of the catches of central and southern California and Baja California (for the corresponding California season) are presented in Table 6.

The 1956 class was the most abundant in the fishery in all regions. It contributed almost two-thirds of the total number of sardines landed during the season. The 1955 class, which contributed almost one-quarter of the southern California catch, was second in the total landings, contributing over one-fifth. About one-tenth of the total were fish of the 1957 class. Fish older than the 1955 class made up only one-twentieth of the total catch.

During the Baja California interseason the 1956 class made up almost three-quarters of the total catch (Table 7).

TABLE 7

Year-class Composition of the 1958 Interseason Sardine Catch for Baja California [1]

Lunar month	Catch		Number of fish in thousands by year-class						
	Tons	Number	1958	1957	1956	1955	1954	1953	1952
"Jan" [2]	1,851	44,911	--	--	36,557	1,078	3,054	2,695	1,527
"Feb"	715	17,335	--	--	14,111	416	1,179	1,040	589
"Mar"	869	20,478	--	914	16,278	1,854	1,210	173	49
"Apr"	1,160	14,196	--	241	2,917	8,632	2,045	361	--
"May"	920	11,548	--	490	4,279	5,052	1,289	309	129
"Jun"	832	13,097	--	2,822	9,880	291	104	--	--
"Jul"	2,360	35,408	--	5,004	29,213	1,096	95	--	--
"Aug"	2,883	35,880	--	4,160	28,808	2,912	--	--	--
Total	11,590	192,853	--	13,631	142,043	21,331	8,976	4,578	2,294
Percent	--	100.0	--	7.1	73.6	11.1	4.6	2.4	1.2

[1] Tonnage figures from Ensenada and Cedros Island; sampling of commercial catch for age composition at Ensenada only.

[2] No fish were sampled at Ensenada during "Jan". Number of fish and age composition derived from "Feb" sampling.

DISCUSSION

The most interesting feature of the 1958-59 season was the dominant role of the 1956 class of sardines. This class had been primarily responsible for the resumption of the central California fishery after a seven-year lull, and for making this season's total catch from all regions the largest in those seven years. This dominance is surprising in that there was little advance notice of it. During the 1957-58 season in southern California the 1956 class did not contribute an unusual proportion of age-one fish to the commercial catch (Daugherty and Wolf, *op. cit.*, Table 4). Only in the relatively minor Baja California fishery, and then only in "December", did it show evidence of being of more than usual abundance.

The 1956 class fish have been smaller than average. They were relatively small as age-one fish in Baja California during the 1957-58 season (Daugherty and Wolf, *op. cit.*, Table 2). During the 1958-59 season they were still relatively small as age-two fish. In central California mean lengths of age-two fish during 19 earlier seasons ranged between 195 and 213 mm. and averaged 204 mm. This average is 20 mm. greater than the mean of 184 mm. observed in this region during the 1958-59 season. In southern California the range of mean lengths was 194 to 224 mm. over 24 seasons with an average of 204 mm. This average is 13 mm. larger than the 1958-59 seasonal mean of 191 mm. The Baja California means ranged from 193 to 207 mm. and averaged 200 mm. for four seasons. This was 40 mm. greater than the 160 mm. mean observed during the 1958-59 season. In all regions this season's mean for age-two fish was not only lower than the long-time average, but was also the lowest mean length so far observed.

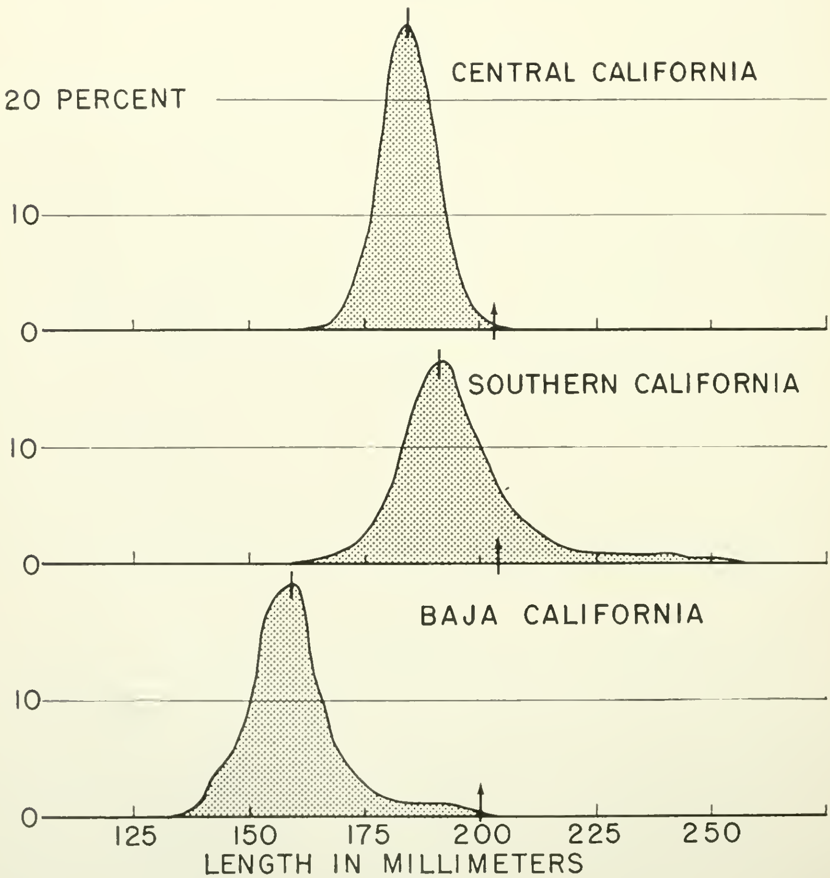

FIGURE 3. Percentage length composition of the sardine catch by region during the 1958-59 commercial season. Marks near modes are average length of age-two fish during this season. Arrows on length scale lines locate average length of age-two fish over earlier seasons.

In Figure 3 the length composition of the total catch in each region is shown. The peaks of the curves represent 1956 class fish almost entirely, however. Marked on the curves are the mean lengths of 1956 class fish in each region for the season. On the length scale line, the long-term means of age-two fish have been entered. The figure illustrates the differences between means within a region, and in addition shows that fish of the same year-class also vary considerably in length between regions.

SUMMARY

1. The 1958-59 season began on August 1 and ended on January 1 in central California and on September 1 and January 1 in southern California. Sardine fishing in Baja California occurred throughout the year but, for purposes of this paper, the time was divided into two periods, one comparable to the southern California season and the other an interseason period.

2. The California commercial catch of Pacific sardines during the 1958-59 season was 102,621 tons of which over 24,600 tons were from central California and over 78,000 tons from southern California. During the same season in Baja California almost 7,800 tons were taken. This added to an interseason total of almost 11,600 tons made the Baja California landings total approximately 19,400 tons during 1958.

3. California fishermen received $60 per ton for their fish through "September"; thereafter they received $50 to the end of the season. Baja California fishermen received the equivalent of $40 per ton all year.

4. Around 180 boats were involved in the season's sardine fishery: 30 from central California, 119 from southern California, and about 30 from Baja California.

5. Length composition data, by age, based on samples from the commercial catch are presented for central California, southern California and Baja California.

6. Age composition estimates for the entire season's catch are presented for central and southern California and Baja California. Age composition data from the Baja California interseason's catch are also given.

7. The dominance in this season's catch of the 1956 class of sardines in all regions is pointed out and briefly discussed.

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THE DISTRIBUTION OF THE CALIFORNIA SEA OTTER [1]

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INTRODUCTION

The California sea otter, *Enhydra lutris nereis* (Merriam), occurred off the coast of California in considerable numbers prior to the twentieth century. Heavy exploitation reduced it to virtual extinction, and the last individual was supposedly killed in 1911 south of Fort Ord, California (Merton E. Hinshaw, personal communication).

On March 19, 1938, the existence of sea otters off the mouth of Bixby Creek, Monterey County (Mill Creek on most maps), became a matter of common knowledge. An investigation on March 25 revealed a group of approximately 50 of these animals at the stated locality, Lat. 36° 22′ 15″ N., Long. 121° 54′ 15″ W. (Bolin, 1938).

The survival of this species in fair numbers was not surprising considering the rugged character of the central California coastline. The region has been comparatively inaccessible and was first opened to motor traffic during the summer of 1937. Sheer cliffs and very steep slopes rise directly from the sea to a height of several hundred feet, making access to the beach difficult if not impossible. The shore, studded with massive projecting rocks and almost continuously hammered by heavy surf, affords no protected anchorage and is usually given wide berth by coastwise shipping and by the Monterey fishing fleet.

It has therefore been a region where sea otters could live unmolested by man, the major factor in their near-extermination.

One reason for the presumed disappearance of the California sea otter is that they may have been mistaken for harbor seals, *Phoca vitulina*, or sea lions, *Zalophus californicus* and *Eumetopias jubata*, which they resemble from a distance. Published reports and fish and game wardens' records show the continual presence of a small herd throughout the early part of this century. Popular recognition of their presence off the California coast dates from March 19, 1938, when Bolin (1938) published an account of these historically important and biologically interesting animals.

Not only were the otters rigidly protected by the California State Department of Fish and Game, but ranchers along the coast took an active interest in enforcement of the laws prohibiting their killing and many times have reported poachers to the Department.

Adequate data on the precise number of sea otters and of their distribution are still lacking; however, Bolin (1938) reported counting 50 animals and described their distribution as being from Bixby Creek

[1] Submitted for publication, November 1960.

to "some southern point." Donald McLean of the California Department of Fish and Game informed me that in 1938 approximately 300 sea otters were noted. Following publication of the "rediscovery", counts were made by the California Department of Fish and Game at periodic intervals for approximately 10 years. On the basis of these counts, the total population was thought to be about 500 (McLean, personal communication). These tallies were made from an automobile and therefore should be considered as estimates. A small herd may be readily counted from the coastal highways, but when the herd exceeds 25 animals, it is difficult to resolve each individual with binoculars.

Gilmore (1956) estimated 500 sea otters were inhabiting waters between Monterey and San Miguel Island, but gave no basis for this figure.

The distribution and numbers of California sea otters is of paramount importance to Federal and State agencies since the animals are rigidly protected by law. An accurate assessment of their numbers required a more suitable counting technique than had been used in the past. With the generous cooperation of the United States Military Services it was possible to develop such a technique by using helicopter aircraft.

METHODS AND MATERIALS

Preliminary observations were made from a fixed-wing airplane in order to locate the herds. Subsequently, a helicopter was used while taking photographs of each specific herd. Aerial cameras bearing the military designations K-20 and K-25 were employed. The film consisted of super-double XX $5\frac{1}{4}''$ x $20'$ aerial film. It produced $4''$ x $5''$ negatives. Photographs were made of all herds containing more than five otters. Herds with fewer than five animals were counted visually. Contact prints were made, and the numbers were counted and recorded from such photographs. All photographs were made between 10:00 a.m. and 4:00 p.m. when the majority of the otters were rafting.

RESULTS

In 1957, California sea otters were restricted to a narrow zone extending from north of Santa Barbara to Carmel Bay, California (Figure 1). The number of individuals in each herd varied considerably, the largest herd being found at Carmel Bay, and the smallest at Point Conception. In all, 638 animals were counted in 14 different herds, the largest of which contained 144 individuals (Table 1). Part of a herd of 15 otters residing at Lopez Rocks, Monterey County, was observed floating on a dense mass of kelp, *Macrocystis*, (Figure 2); and 12 of the 18 otters belonging to the Rocky Point, Monterey County, herd were photographed while two females, numbers one and two, were carrying their pups (Figure 3).

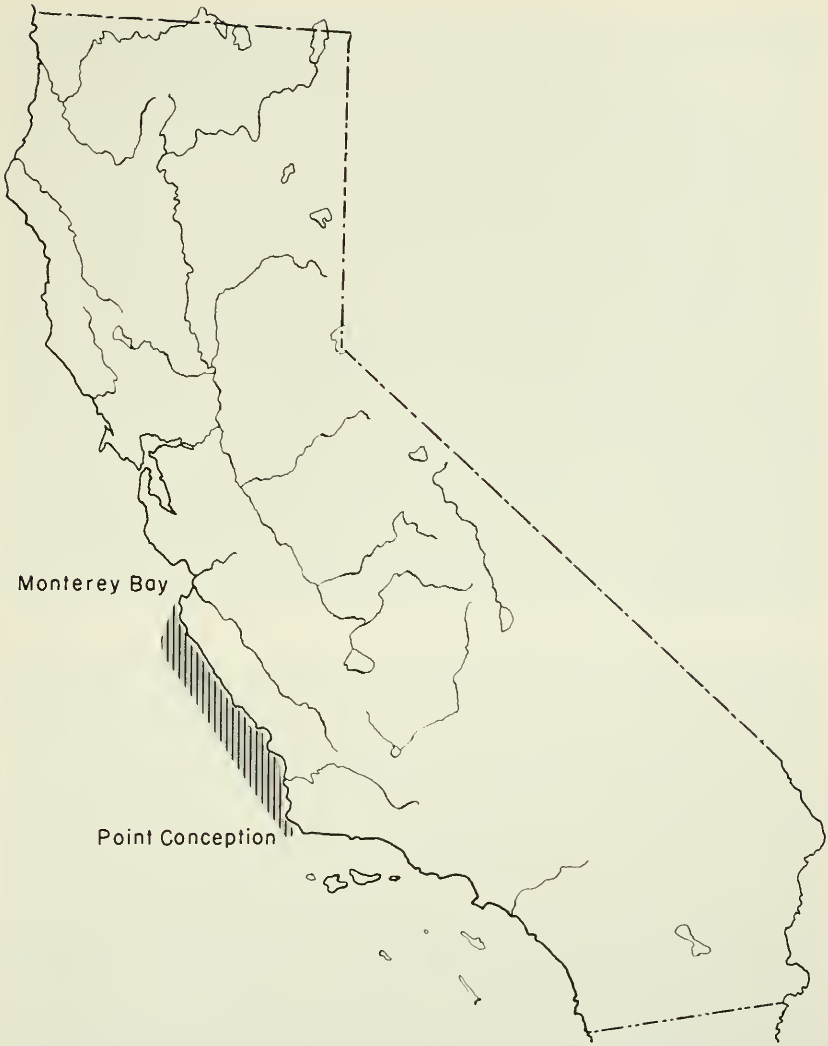

FIGURE 1. The range of *Enhydra lutris* in California, August 27, 1957.

DISCUSSION

In 1957, an aerial survey of the California coastline from Humboldt County to San Diego revealed 638 sea otters between Cypress Pt. and Pt. Conception. Although the distribution of the otter populations, (herds) seems to be in discrete colonies, individuals have been recorded between herds, particularly in the area between Carmel Bay and Cape San Martin. Thus, it is reasonable to conclude their distribution is actually continuous.

Although otter herds have been reported by various individuals from Santa Cruz and San Mateo County coastal waters our systematic

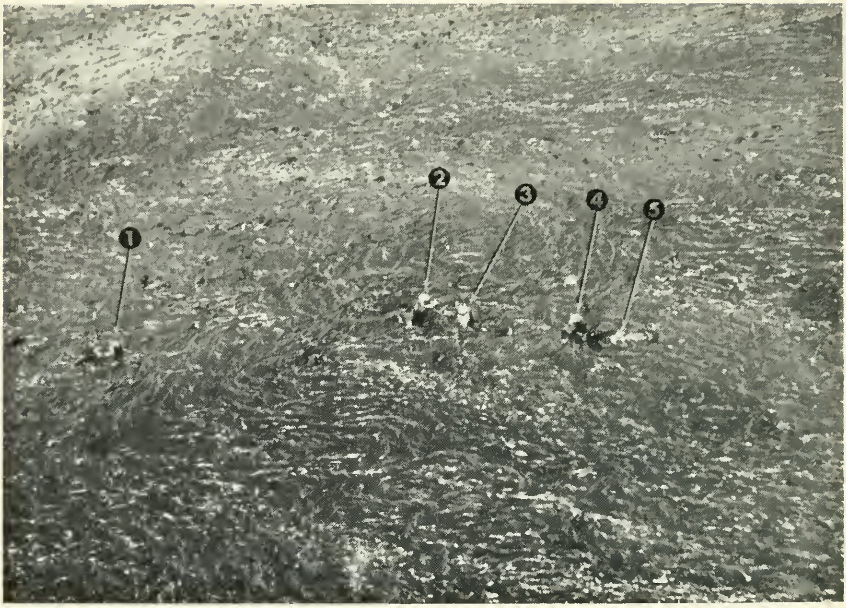

FIGURE 2. Five sea otters floating on *Macrocystis* near Lopez Pt. Photo by R. A. Boolootian.

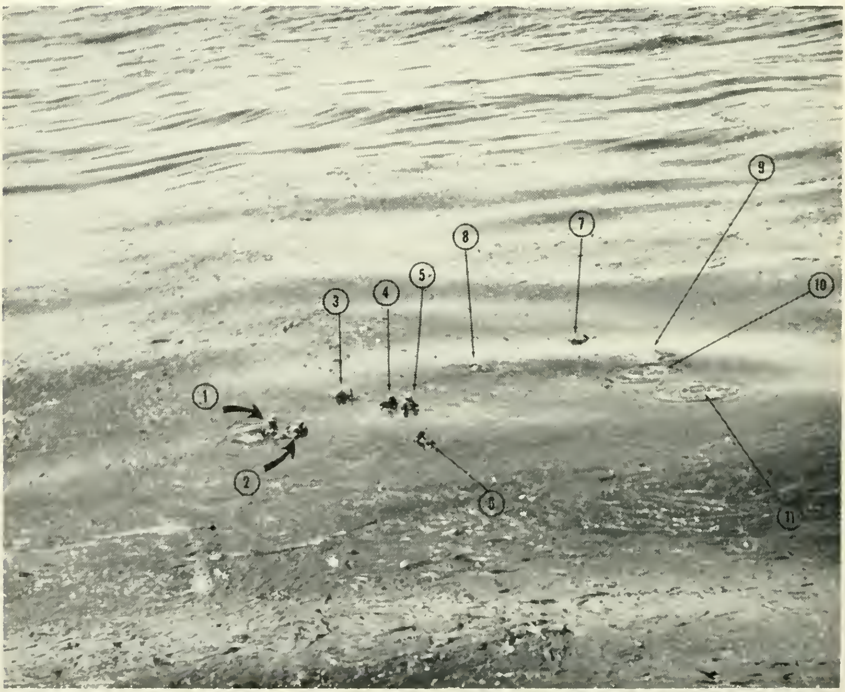

FIGURE 3. A herd of otters at Rocky Pt., California. Numbers 8, 9, 10, and 11 point to the wakes of submerged otters. Numbers 1 and 2 show females with pups. Photo by R. A. Boolootian.

surveys of these areas revealed no sea otters. Many harbor seals were observed, however, and since these seals are known to live and feed among the larger kelp beds they were probably incorrectly identified as sea otters.

Otters have also been reported from Westport, Mendocino Co.; Redwood Creek, Humboldt Co.; Tomales Head, Marin Co.; Russian River, Sonoma Co.; Cape Vizcaino, Mendocino Co.; Punta Gorda, Humboldt Co.; and Point Delgada, Humboldt Co. Each of these localities has been carefully surveyed from the air on three separate occasions. To this date it has not been possible to establish the presence of a single sea otter in these areas. It should be emphasized that otters are difficult to identify when they are floating on kelp beds, although a single animal can readily be identified if the characteristic behavior patterns of sea otters are known to the observer.

TABLE I

Number of Otters at Various Localities in California as of August 27, 1957

Locality	Longitude (W)	Latitude (N)	Numbers
Carmel Bay	121° 58′ 00″	36° 32′ 30″	144
Pt. Lobos	121° 58′ 20″	36° 31′ 25″	29
Yankee Point	121° 56′ 50″	36° 29′ 30″	12
Malpaso Creek	121° 56′ 25″	36° 28′ 25″	15
Lobos Rocks	121° 55′ 50″	36° 27′ 5″	18
Rocky Point	121° 54′ 25″	36° 22′ 50″	18
Pt. Sur	121° 54′ 5″	36° 18′ 25″	7
Big Sur	121° 51′ 30″	36° 16′ 55″	23
Anderson Canyon	121° 39′ 58″	36° 9′ 13″	48
Lopez Rocks	121° 34′ 48″	36° 1′ 35″	15
Cape San Martin	121° 27′ 40″	35° 53′ 12″	100
San Simeon	121° 11′ 40″	35° 38′ 10″	17
Salmon Creek	121° 21′ 44″	35° 48′ 25″	96
Piedras Blancas	121° 17′ 10″	35° 39′ 55″	93
Pt. Conception	120° 28′ 20″	34° 27′ 00″	3
Total			638

Among the habits characteristic of the otter, a few are especially useful guides to a ready identification. For example, he has a unique habit of extending his head, neck, and part of the chest above the surface of the water for several seconds while the head is being turned from side to side. He then immediately dives for food. The body is highly arched during the dive. Upon surfacing, the otter rolls over on his back and quite frequently "paws" at his mouth. If food was collected, it is placed on the otter's chest during the pawing activity. Also characteristic are the numerous rolls made while swimming forward and their motionless floating with tail arched and hindlegs extended flat out over the water's surface. Conceivably, this could be mistaken for the California sea lion which also floats in a similar manner. But the sea lion has a short tail and flippers. The harbor seal also swims with its head above water, so a careful examination is still needed to insure an accurate identification.

Allanson (1955) reported two otters at the western end of Cuyler Harbor, San Miguel Island. In February, and June, 1958, Dr. George A. Bartholomew, Department of Zoology, U.C.L.A., and the author, flying in an Air Force helicopter at an altitude of 100 feet, carefully surveyed the coastline of each of the four northern channel islands for sea otters. None was observed. Recently, however, a record of sea otters at Anacapa Island was made by observers on the California Department of Fish and Game Patrol Boat, YELLOWTAIL (Carol M. Ferrel, personal communication). Bentley (1959) noted in 1956 two sea otters in the vicinity of Trinidad Head, however subsequent observations by him in this area through the spring months of 1957 did not reveal their presence.

Several dead otters have been recovered from the Carmel Bay area. Death, in several instances was due to bullet and spear wounds. In two cases, teeth of the great white shark, *Carcharodon carcharias*, were removed from the abdominal region. These are the first reported incidences of shark attacks on sea otters (Orr, 1959). The animals with bullet and spear wounds bear witness to the fact that man is still taking a toll in spite of rigid State, Federal, and International laws protecting them and that there still is an acute need for the sharpest vigilance to insure the survival of these animals.

ACKNOWLEDGMENTS

I am grateful to Captain Charles W. Fielder, Commanding Officer, Monterey Naval Auxiliary Air Station, Monterey, California, for his kindness in making available to me the facilities of this air station. Thanks are also extended to Lt. Commander Joseph Cullota for his skillful piloting of the naval helicopter made available to me. I should also like to acknowledge the kindness of Major General Gilman C. Mudget, former Commanding General and Brigadier General William Breckinridge, Commanding General, of Fort Ord, California, for making the facilities of their military base available to me. The necessary administrative assistance which expedited the use of military facilities was in large measure the efforts of Colonel Thomas N. Sibley, Chief of Staff, Fort Ord, California, to whom I am deeply indebted.

The scheduling of flights was competently handled by Major Harold D. Flynn, Aviation Officer, Fort Ord, California. I should also like to extend my gratitude to First Lieutenants Gerald Beekman, Riley Walker, and Peter Mutty for their continued interest in this project and for their skillful piloting of the aircraft used. I am also indebted to Dr. L. R. Blinks and Dr. Rolf Bolin for their advice and for permission to use the facilities of the Hopkins Marine Station of Stanford University, Pacific Grove, California.

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MULTIPLE PURULENT ABSCESS *(CORYNEBACTERIUM PYOGENES)* OF DEER[1]

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INTRODUCTION

In California approximately 400,000 deer hunters move through the mountainous regions in the fall of the year and bag about 75,000 deer. Some of the animals show evidence of abnormalities or outright infection. The Disease Section of the Wildlife Investigations Laboratory is called upon to examine some of these deer, particularly, when an infection is easily discernible. This is especially true when an individual may discover that the deer has multiple purulent abscesses within the body cavities. However, it is known that many hunters will merely abandon the carcass when they find that it is infected.

The laboratory personnel have maintained deer in captivity for scientific study. In addition, they have collected authorized numbers of deer from certain herds within California as a part of investigations aimed at determining biological information, e.g. food habits, reproductive data, and disease and parasite incidence. Several cases of suppurative abscess were observed in these deer.

The cause of the abscesses has been determined. There have been enough encounters with this disease to describe and evaluate the different pathological manifestations that have been observed. In addition, an indication of its importance in the economy of California deer herds may be assessed. It is with these aspects of suppurative multiple abscesses in deer that this paper is concerned.

BACTERIOLOGY

There are many bacterial species that may be responsible for an infectious process that results in disseminated suppurative abscesses within the body of an animal. Those that have been isolated from California deer include *Corynebacterium pyogenes*, *Streptococcus* sp., *Staphylococcus aureus*, and *C. pseudotuberculosis* in order of frequency of occurrence. Some of the abscesses have yielded mixed cultures in which it was impossible to determine the particular organism that was responsible for initiating the infection. On the other hand, there have been frank cases of foot rot caused by *Spherophorus necrophorus* wherein secondary invaders which probably were *C. pyogenes,* have produced purulent abscesses that were distinctly different from the necrotic type of abscess that characterizes necrobacillosis.

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The organisms isolated by Seghetti and McKenny (1941) from deer in Washington were classified as *C. ovis*, which according to the latest accepted taxonomy would be *C. pseudotuberculosis* (Table 1). Several isolations have been made from deer in California by Biberstein (personal communication) at the University of California and these have been identified as *C. pyogenes*.

TABLE 1

Growth Characteristics of Corynebacterium pyogenes and C. pseudotuberculosis

	C. pyogenes			California deer	Washington deer	*C. pseudotuberculosis*		
	Bergey	Hagan	Merchant			Bergey	Hagan	Merchant
Glucose	A*	A	A	A	A	A	A	A
Sucrose	A	A	A	A	NC	A	NC	A
Lactose	A	A	A	A	NC	A	NC	NC
Xylose	A	A	NC	A	--	V	--	NC
Raffinose	NC	NC	--	NC	--	--	NC	NC
Inulin	NC	NC	NC	NC	--	--	NC	NC
Mannitol	NC	NC	NC	NC	A	--	--	NC
Salicin	NC	NC	NC	NC	A	--	--	NC
Fructose	--	--	A	A	A	A	--	A
Galactose	--	A	A	A	--	A		V
Mannose	--	--	A	A	--	A	--	A
Maltose	--	A	A	A	--	A	A	A
Dextrin	--	--	A	A	--	A	NC	V
Litmus milk	ACP	ACP	ACP	ACP	NC	NC	NC	NC
Gelatin	L	L	L	L	NL	NL	--	NL
Indol	Neg.	Neg.	Neg.	Neg.	--	--	--	Neg.
Nitrate reduction	Neg.	Neg.	Neg.	Neg.	--	Neg.	--	Neg.

*A—acid; NC—no change; V—variable; ACP—acid, coagulation, peptonization; L—liquefaction; NL—no liquefaction.
Blank space indicates no data available.

Microscopically, *C. pyogenes* may be observed readily in smears prepared from the suppuration when treated with Gram's stain. They are small pleomorphic organisms 0.2 to 0.3 μ wide by 0.5 to 2.0 μ long. Generally they are clumped or form palisades. Although they are Gram-positive, on rare occasion they stain unevenly displaying granulation.

Initial cultures have been prepared on blood agar plates and incubated in reduced oxygen tension at 37 degrees C. The colonies form a small zone of beta hemolysis on this medium. At pH 6.0 coccoid forms are produced on blood agar, but when the pH is raised to 7.6-8.2 there is optimal growth (Nordberg, 1947).

The biochemical reactions of *C. pyogenes*, *C. pseudotuberculosis*, isolates from the Washington deer (Seghetti and McKenny, *op. cit.*), and those organisms cultured from California deer are listed in Table 1. An indication of the conflicting opinions on the cultural reactions and differentiation of *C. pyogenes* and *C. pseudotuberculosis* may be observed in this tabulated data. This disagreement extends throughout the literature on the subject (Brooks and Hucker, 1948; Brown and Orcutt, 1920; Hagan and Bruner, 1951; Ryff and Browne, 1954). Since Bergey (Breed *et al*, 1957) is the standard source for taxonomy, the organisms isolated from California deer were classified as *C. pyogenes*. This was substantiated by reference to Verge and Senthille

(1941a.) who stated that one of the principal differentiating characteristics is the liquefaction of gelatin. Our cultures liquefied gelatin uniformly. An additional criterion that is evident in Table 1 is the positive reaction in litmus milk.

PATHOLOGY

Pathogenesis

The normal mucous membranes of the mouth, nose, throat, and vagina of animals harbor many bacteria capable of infecting wounds or abrasions, among which is *C. pyogenes* (Lovell, 1943). Since this bacterium is found most often in the suppurative lesions of deer, it is probably the most common pyogenic organism inhabiting the mucous membranes. In addition, it may be more readily adapted for growth in a wound. The tendency of deer as well as other animals to lick an abrasion or wound is probably one of the factors by which the infecting bacteria gain entrance. Also, it has been found as a contaminant of skin (Merchant, 1951). Barley and oat awns, or other sharp plant projections that puncture the mucous membranes of the mouth or throat provide another portal of entry (Cameron and Britton, 1943). Humphreys and Gibbons (1942) determined that the portal of entry could be either by abrasion or ingestion. They rubbed a suspension of bacteria on the scarified legs of deer and drenched other deer. In both cases the deer died about one month after initial infection. They felt that contamination of wounds was the most likely route of infection. In cattle it has been shown to be transmissible by coition (Merchant, *op. cit.*). This may account for endometritis, abortion, and perhaps mastitis in deer. Roach (1946) reported that *C. pyogenes* would remain alive 19 days in cow's milk taken from a case of summer mastitis.

In addition to being a primary invader, it may assume a role in secondary infection, e.g. simple pneumonia complicated by *C. pyogenes* changes the pathology to purulent pneumonia, (Lovell, 1945a., 1945b.). In a study of bighorn sheep *(Ovis canadensis)*, Packard (1946) indicated that lung worm infection may be complicated by secondary invasion with *C. pyogenes*. This was substantiated by Marsh (1953). Although California deer and elk often have lung worm, complications with *C. pyogenes* have not been observed. This bacillus frequently complicates the pathological picture in foot rot.

Maddy (1953) reported that ticks may harbor the organism. Humphreys and Gibbons *(op. cit.)* found infected ticks on deer. The ova of the ticks weren't infective, but the larvae were. They also reported that deer were much more susceptible to infection than sheep.

Symptomatology

The effect of pyobacillosis is probably a reflection of the condition of the individual deer. If the animal is in good health its resistance may require considerable time for the infectious process to become evident. Bucks taken during hunting season have been magnificent physical specimens, but within the pleural cavity large abscesses were found. On the other hand, if the deer is in poor condition when the infection occurs, the development of metastatic abscesses would be accomplished more quickly and the animal soon would become lethargic and the cachexia could be seen easily. If the suppuration is under the skin the swelling may be noted. In one deer with a brain abscess the animal was blind, stood lethargically and there was an incessant drooling.

Pathological Findings

The most common finding at autopsy is a series of pockets of pus in the thoracic cavity usually adherent to the inner surface of the sternum (Figure 1). These mediastinal abscesses may be the only pathological process discernible, or there may be involvement of the pericardium, or occasionally purulent pneumonia. The pneumonia can be the only site of infection.

FIGURE 1. Abscesses in the pleural cavity adherent to the sternum.

In purulent pneumonia due to *C. pyogenes* there may be small or large multiple abscesses in the lungs filled with yellowish green pus. The abscesses have been walled off in some cases resembling the nodules of tuberculosis. Hammersland and Joneschild (1937) examined two deer in Montana that had abscesses along the trachea, flank, and on the pleura in both cases. Later they found a buck with multiple abcesses on the pleura of the ribs and nodules in the lungs that contained greenish yellow pus with calcified centers. They attributed the infections to *C. pseudotuberculosis.*

Occasionally subphrenic abcesses have been encountered, some of which have extended to form adhesions with the rumen. In these cases the hosts' reactions have resulted in fibrous tissue walling off the infectious process. At other times specimens have been submitted for examination in which the abscesses were distributed in the peritoneal cavity usually along the dorsal region. A few cases have been observed in which abscesses have been found imbedded in the liver. There have been cases of jaw involvement with abscesses extending into the neck. Butler (1938) reported similar cases in Montana.

Two cases of mastitis have been found in deer, one of which also had endometritis and the dead embryos were being aborted. The inoculation of a pregnant heifer with *C. pyogenes* produced an abortion in two weeks and the heifer died a month later (Nordberg, *op. cit.*). Brown and Stuart (1943) reported that summer mastitis in dry cows is common.

Septicemia has been found in some instances. Nordberg observed that 9 of the 20 strains he tested produced an exotoxin in young cultures. In those cases where septicemia has been encountered there have been inflammatory edematous swellings probably as a result of the toxins elaborated by the bacteria, or by the absorbtion of the large amounts of tissue breakdown products.

Since bacteremia has been encountered it is evident that the abscesses may localize almost anywhere within the animal body. Brain abscesses have been observed. The purulent mass in one case eroded part of the brain itself.

OCCURRENCE IN CALIFORNIA DEER

During the past 13 years there have been 24 deer infected with *C. pyogenes* submitted to the laboratory for examination. Sixteen of these specimens, or approximately 66 percent of the total, were sent in during the hunting season. Undoubtedly there were a number of cases found by hunters who left the carcasses in the field when they discovered that the animals were infected. Reports of such abandoned hunter-killed deer have been received each year. However, with no material to verify the cause of the abscesses, only a conjecture that *C. pyogenes* was responsible can be made. It is impossible to estimate how many cases are found or the total incidence of the disease.

Some of the remaining cases of infected deer were from those being held in captivity for various other studies such as an investigation on nutrition. The rest were animals that had been taken during an authorized collection of specimens for scientific study. One indication of the incidence of disease may be obtained from this latter group wherein two deer were found to be suffering from pyobacillosis in a group of 66 deer that had been examined.

Although the greatest incidence of infection seems to occur during August, September, and October—the regular hunting season in California—this is not the case. It is merely a reflection of a greatly increased number of observers in the field, the hunting public. Those cases that have been recorded from other than the hunting season are evenly distributed throughout the balance of the year.

The records would seem to indicate that bucks are more susceptible than does. This sex differentiation is not valid on the basis that during the past 13 hunting seasons predominantly bucks were taken. Nevertheless, there are more females in the total deer population of California and this may account for the fact that about half of the specimens were females. The same factor of hunting probably is the reason that only one fawn in the wild was found to be suffering from an infection of *C. pyogenes*. Two fawns of the captive experimental animals died from this disease.

The distribution of morbidity throughout the state is also based on hunting. Those counties with the heaviest sport kill also had the highest number of cases of this disease. *C. pyogenes* has been found in deer in El Dorado, Amador, Madera, Modoc, Inyo, Mono, Humboldt, Mendocino, Napa, Sonoma, Marin, Santa Cruz, and San Bernardino Counties.

The four subspecies of deer which have been affected with pyobacillosis in California are: Rocky Mountain mule deer *(Odocoileus hemionus hemionus)*, California mule deer *(O. h. californicus)*, Inyo mule deer *(O. h. inyoensis)*, and Columbian blacktail deer *(O. h. columbianus)*. There is no way to determine any differential susceptibility in the subspecies, but from the available evidence there would not seem to be any difference.

DISCUSSION

Infection with *C. pyogenes*, unlike many other diseases is not contagious. It does not appear as an epizootic but rather assumes the character of individual malady. Nevertheless, it poses a potential threat to the deer in that the organism is harbored in the mucous membranes and contaminates the skin so that a wound, abrasion, or scratch suffered by a deer going through a barbed wire fence, has a good chance of becoming infected. Deer superficially wounded during the hunting season may become infected, although they would have recovered ordinarily. Those deer add to the normal crippling loss.

Mastitis has been encountered in California deer with subsequent abortion. This type of infection provides another drain on the population that might be considered as a multiple effect in that the reproductive potential has been decreased.

Although the indications are that pyobacillosis is not too important in the overall economy of the California deer herds, nevertheless it is one more factor to be considered in the composite picture of disease as it affects the deer populations. There are many diseases that affect deer. Some of these such as foot rot (Rosen, *et al*, 1951) and infection with stomach worms (Longhurst, *et al*, 1952) assume serious proportions at times.

There are four reports in the literature of this bacterial species causing infection in man (Ballard, *et al*, 1947; Lodenkamper, 1948; Moser, 1952; Verge and Senthille, 1941b.) two of which were traceable to direct animal contact. The conclusion must be that such an infection in man is rare.

SUMMARY

Over a period of 13 years, 24 deer have been found to have an infection with *C. pyogenes*. Other pyogenic bacteria have been identified including staphylococci, streptococci, and *C. pseudotuberculosis*. Many deer that have been killed during the hunting season were abandoned when they were found to contain multiple purulent abscesses. Therefore, actual incidence of the disease in the wild is unknown.

The mucous membranes and skin of normal deer may harbor the causative organism of pyobacillosis. The portal of entry may be a superficial abrasion or other type of wound, and there is the possibility of tick transmission.

A deer in excellent condition as judged by external appearance may contain large abscesses within the body cavities. The most common

location for the suppurations is in the pleural cavity either as mediastinal abscesses or as a purulent pneumonia, or a combination of both conditions in a single animal. Some of the abscesses have been localized in the peritoneal cavity with an occasional involvement of the liver. Endometritis, abortion, and mastitis have been encountered in some cases. Some deer that have been examined had abscesses in the brain.

There seems to be no age, sex, geographic, or seasonal difference as far as susceptibility is concerned. The four subspecies of deer that have been found to be affected, the Rocky Mountain, California, and Inyo mule deer, and the Columbian blacktail deer have no differential incidence relative to this disease.

Multiple abscess is a potential threat to the individual animal rather than to a herd inasmuch as it is not contagious. Although it may not be too important *per se*, nevertheless, it must be considered when added to all of the factors that tend to diminish a population.

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NOTES

SHOVELERS NESTING IN HUMBOLDT COUNTY, CALIFORNIA

Gabrielson and Jewett (1940) do not list nesting records for shovelers *(Spatula clypeata)* west of the Cascade Mountains in Oregon. Jewett, Taylor, Shaw and Aldrich (1953) show that shovelers nested in small numbers in the Puget Sound Region west of the Cascades, in Washington, and Jewett saw them near Copalis, Grays Harbor County, Washington, about small ponds just back from the beach, where he assumed that they were nesting. Grinnell and Miller (1944) present no records of shovelers nesting along the northwest coast of California.

During the evening of May 20, 1960, I saw a pair of shovelers feeding in a marshy area supporting *Eleocharis macrostachya, Scirpus paludosus, Scirpus americanus* and other marsh plants adjacent to grass land pasture on the Arcata bottom land near the old Mad River Channel, Humboldt County, California. These birds acted as though they were feeding hurriedly, especially the female. The actions of this pair reminded me of pairs observed on the nesting grounds in Eastern Washington when the female had come off of her nest to feed after incubating. I was unable to flush the female or locate the nest on subsequent visits; however, on June 11, in the same area, I flushed a male shoveler in partial eclipse plumage with a flock of 13 cinnamon teal males. Nearby a female shoveler flushed from a small marsh containing an abundance of *Hippuris vulgaris, Typha latifolia* and *Scirpus acutus.* Her feigning actions successfully attracted my dog from the area; I was unable to locate young birds that certainly must have been concealed in the vegetation.

At 7:30 p.m. on June 21 a female was flushed from the same pond and two young shovelers were observed attempting to hide in the thick vegetation. Feathers on the young ducks were appearing in the scapular area in front of their wings.

On July 12, I flushed one young shoveler, Class III (fully feathered) from the same area; others easily could have been in the dense cover.

It is possible that these observations of shovelers with young in the Humboldt Bay area represent the only nesting records for this species along the immediate coastal areas of California, Oregon and Washington south of Grays Harbor.

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—*Charles F. Yocom, Division of Natural Resources, Humboldt State College, Arcata, California, December 1960.*

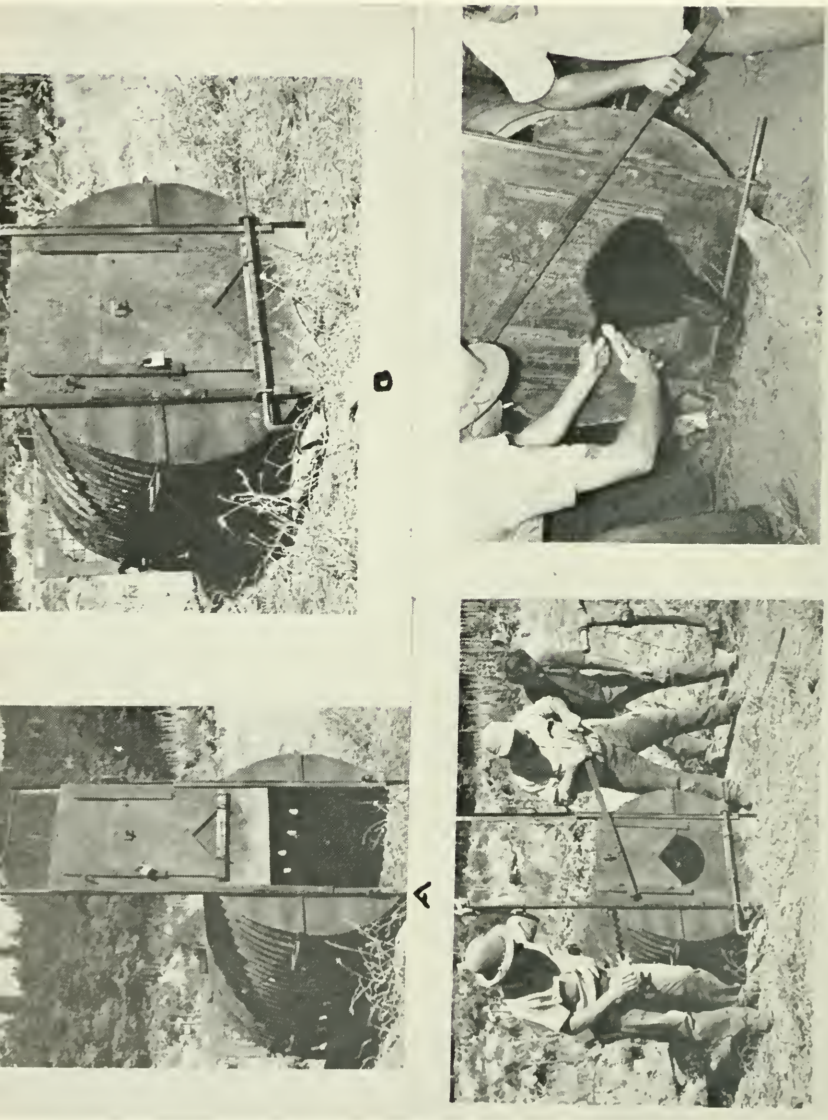

FIGURE 1. (A) Squeeze door locked to main door when trap is first set; (B) safety bar in place to hold the main door secure; (C) lever bar in place and door opened slightly larger than bear's head; (D) bear's head held motionless while ear tagging.

A METHOD OF IMMOBILIZING BEAR FOR EAR TAGGING

A method of immobilizing bear in a culvert trap without the use of drugs was developed in California by unit game manager Jack Slosson and game assistants Walter George and Jesse Foster. This method was devised to facilitate ear tagging bears with safety.

The principle of the holding device is a squeeze door which is forced down on the bear's neck when the animal sticks its head through an opening in the main trap door.

The squeeze door consists of a steel plate with an inverted V-shaped bottom which slides across a twelve inch circular opening on the main door of the trap. A $4\frac{1}{2}$ foot lever that can be slipped over a peg on the main trap door and a peg on the squeeze door (by use of a short linkage) is used to open and to clamp the squeeze door on the bear's neck.

In operation, the squeeze door is locked to the main door with a padlock when the trap is first set. This makes the two doors a single operating unit during trapping (Figure 1-A).

When a bear is trapped, a safety bar to hold down the main door is inserted (Figure 1-B). The squeeze door is then unlocked from the main trap door and the lever bar is put in place on the pegs. The door is then lifted open to a height slightly larger than the bear's head (Figure 1-C). If opened too wide, a bear up to 250 pounds in weight can escape through the opening. The operators should be very careful to be as quiet as possible. The bear is allowed to stick its head through the opening on its own accord. If the bear is uncooperative, a noise is made at the rear of the trap. When the bear has both ears beyond the opening, the squeeze door is brought down sharply by use of the lever and the bear is held securely. By applying enough pressure to the animal's neck, the head can be held motionless (Figure 1-D). The man tagging the bear is in no danger as long as the head is held tightly. After tagging, the door is lifted quickly above the ears to prevent the bear from ripping them when it withdraws its head back into the trap.—*Jack L. Hiehle and Jack R. Slosson, Game Management Branch, California Department of Fish and Game, March 1961.*

PARTY BOAT LOGS SHOW HOW SKINDIVERS FARED DURING 1958 AND 1959

Divers often charter sportfishing boats with the idea that distant and secluded areas can be reached en masse with comfort and precision. California law requires the operators of such boats to keep records of the catch, similar to those they maintain for the usual angler party.

During 1958 and 1959, 97 acceptable records were sent the department for diving charters. The data from several charters were not usable.

In the central part of the state, Carmel Bay and the Farallon Islands were the most popular charter-diving locations. Here, 112 divers bagged approximately 3.6 fish and shellfish per diving day. Only four marine species were reported (Table 1), but among the rockfish there probably was more than one kind.

TABLE 1

Marine Species Taken by 112 Charter-divers in the Monterey and San Francisco Bay Areas, 1958 and 1959

Species	Scientific name	Number reported
Abalone	*Haliotis rufescens*	209
Lingcod	*Ophiodon elongatus*	132
Rockfish[1]	*Sebastodes* spp.	54
Cabezon	*Scorpaenichthys marmoratus*	7
Total		402

[1] Probably more than one variety.

In southern California, most diving activity was at Santa Rosa, Santa Cruz, Anacapa, Santa Barbara, Santa Catalina and San Clemente Islands. At these localities 1,725 divers bagged 3.3 fish and shellfish per diving day. Eighteen kinds were reported, but only seven of these were important numerically (Table 2).

TABLE 2

Marine Species Taken by 1,725 Charter-divers Off Southern California, 1958 and 1959

Species	Scientific name	Number reported
Abalone[1]	*Haliotis* spp.	2,450
Kelp bass	*Paralabrax clathratus*	1,199
Sheephead	*Pimelometopon pulchrum*	564
Spiny lobster	*Panulirus interruptus*	512
Opaleye	*Girella nigricans*	413
Perch[1]	species of embiotocids	366
Rockfish[1]	*Sebastodes* spp.	124
Yellowtail	*Seriola dorsalis*	16
Bonito	*Sarda chiliensis*	14
Cabezon	*Scorpaenichthys marmoratus*	10
White seabass	*Cynoscion nobilis*	9
Lingcod	*Ophiodon elongatus*	7
Barracuda	*Sphyraena argentea*	4
Misc.		15
Total		5,703

[1] Probably more than one variety.

In southern California, the miscellaneous species (Table 2) included 5 unidentified sharks, 4 unidentified flatfish, 3 California halibut, *Paralichthys californicus*, 2 jacksmelt, *Atherinopsis californiensis*, and 1 moray eel, *Gymnothorax mordax*.

Abalone were obviously the prime target for most divers. However, speargun experts showed sufficient skill (or luck) and stamina to bring in white seabass, yellowtail, bonito and barracuda. These catch figures indicate there is practically no competition between skindivers and hook and line fishermen.

Most of the species taken in southern California waters (Table 2) are amply protected by bag limits, size limits, closed seasons or combinations of these. Among the few not so protected, only sheephead appear to warrant future consideration. They are not abundant and grow rather slowly. Their bright coloration and bold habits make them exceptionally vulnerable to spearing. Black seabass and groupers, which apparently were not taken by charter boat divers, are also exceptionally vulnerable to spearmen.—*Parke H. Young, Marine Resources Operations, California Department of Fish and Game, August 1960.*

BOOK REVIEWS

Traite de Pisciculture—third edition (in French)

By Morcel Huet; Editions Ch. De Wyngaert, Bruxelles, Belgium, 1960; XII + 369 pp., 280 fig. $7.50.

For all practical purposes this edition is the same as the first two, with the exception of the revision of Article IV, "Pisciculture des regions intertropicales africaines" in Chapter V, formerly titled "Pisciculture des Tilapia". The new title implies a wider coverage of tropical fishculture problems. This, however, is not the case. Genera such as *Haplochromis*, *Hemichromis*, and *Serranochromis* are very briefly mentioned. The material on Tilapia culture is more brief than before. This is the result of better organization and improved knowledge rather than less information. The illustrations are better than those in the second edition, and some new ones have been added.

As before, however, the French Text precludes the manual's effective use by many American fish culturists.—*J. B. Kimsey, California Department of Fish and Game.*

Under the Deep Oceans, Twentieth Century Voyages of Discovery

By T. F. Gaskell; W. W. Norton & Co., New York, 1960; 239 pp., 8 figs., $3.95.

An interesting non-technical report by the Chief Scientist of the Challenger Oceanographic Expedition. Beginning by describing the technique of seismic exploration to obtain the characteristics of the substrate, the author then describes in broad generalities the structure of the sea bottom as determined by experiments carried out aboard the Challenger as the vessel proceeded across the Atlantic, passed through the Panama Canal, and continued working in the Pacific and Indian Oceans, Mediterranean Sea, before returning to England.

Particular studies were made of volcanic islands such as Hawaii, coral atolls of the southwestern Pacific Ocean, and the "Challenger Deep." Discussion of the continental-drift theory, echo sounding, Mohorovicic discontinuity, and the "Mohole Project" add some interesting reading.

One short paragraph reports the disposal of radioactive waste in sealed containers in deep water off the California coast. Subsequent sampling of water and sea bed near the dump indicate the containers were not leaking. [However, actual tests carried out by the California Department of Fish and Game indicated these containers would rupture at depths considerably less than those of the dumping grounds.]

This is a very readable book containing much information about the sea bottom and the earth beneath that is enlightening to those whose work is with the sea.—*E. A. Best, California Department of Fish and Game.*

Conetca Commercial Fishing Gear Manual, Volume 1

By Vincent A. Plancich; Consolidated Net and Twine Co., Inc., Seattle, 1961; 28 pp., illus., $2.50.

An illustrated catalog of the types and sizes of netting material available for use by commercial fishermen, research agencies, and hatchery operators. Schematic drawings of several types of commercial fishing nets and specially designed experimental nets (from plankton nets to otter trawls) are included. One page is devoted to the correct method of ordering material for the do-it-yourself fan. A single diagram illustrates net mending of the simplest type, enlargement of this section would greatly increase the usefulness of this booklet.—*E. A. Best, California Department of Fish and Game.*

Guide to Marine Fishes

By Alfred Perlmutter; New York University Press, New York, 1961; 431 pp., illus., $6.50.

This book presents a new and rather novel approach to the age-old problem of fish identification that should prove rewarding to those who take a moment to thumb the pages. The author has applied the pictorial method used so successfully by the Armed Forces to teach technical information to troops during World War II. In this case, distinguishing characters have been effectively illustrated in silhouettes of the fishes. Thus, by following the simple dichotomous key on the even-numbered pages (which is illustrated with silhouettes on the odd-numbered pages), the user can readily identify over 200 species of marine fish including sharks, rays, skates and even the lamprey. At the conclusion of each identification a page reference directs the reader to a separate section of the book that illustrates and gives general ecological information about each species found in the key. Notes on color, distribution, size, economic importance, etc., are presented for those who wish to know more about their prize specimen. All of this has been accomplished with the barest minimum of technical terminology. A glossary of eight words and eleven anatomical terms is included in the brief introduction.

Unfortunately specific use of the handbook is not as general as the title implies. It includes only the marine fishes commonly found along the shores of the western Atlantic Ocean between Cape Cod (Massachusetts) and Cape Hatteras (North Carolina). Since most of the fishes described in this book have close relatives or counterparts in the eastern Pacific Ocean the key could be used to identify, at least to a general group, many fishes found off the California coast.

Dr. Perlmutter is not just another self-taught authority on fish. Among his qualifications are many years of experience with the New York Conservation Department and the U.S. Fish and Wildlife Service. These, together with his present status as Professor of Biology at New York University, have led to an understanding of the problems involved as well as the knowledge necessary for preparing this guide.

If this silhouette key is an indication of a new trend in presenting taxonomic information, there is hope for the scientist to get his message to the layman in a readily understandable fashion.—*William L. Craig, California Department of Fish and Game.*

Land for the Future

By Marion Clawson, R. Bernell Huod and Charles H. Stoddard; John Hopkins Press, Baltimore, 1960; 570 pp., $8.50.

In "Land for the Future," the authors present a well-organized story of how our land has been used, is being used, and will probably continue to be used up to the year 2000. Unless we plan wisely, this "spacious land" of which Secretary Udall speaks, may not be too spacious by 2000 when there will probably be 300 plus millions of people to use it. The authors, however, are not pessimistic as "some 15 percent of all cultivated land in the world lies within the borders of the United States."

With a total investment in urban property of perhaps $40 billion annually between now and the year 2000, a scientific knowledge of land uses becomes absolutely necessary to make sure that all the needs of the population would be met. The fact that $12 billion or more are being spent annually for recreation makes the use of land for recreational purposes of great concern to all of us.

Agricultural use of land will continue to be of basic importance. The authors predict that we shall continue to be able to afford the expensive diet we now enjoy if we make proper use of available land. Surpluses will probably be a greater problem than shortages.

"In the USA 25 percent of the total land area is used for commercial forestry." Attention must be given to halting our depletion of forest and to making proper provision for our future. Decisions must be made far enough in advance. This is true also for our grazing land and land used on a smaller scale for miscellaneous purposes.

"Land for the Future" is an objective study by a group of experts of "the conflict between an expanding economy and a fixed area of land." It is through the use of land for various purposes that this study addresses itself. Comprehensive treatment, section by section is given to: urban uses of land, lands for recreation, agricultural land use, forestry, grazing and miscellaneous uses. Accompanying charts and graphs plus an abundance of statistics make this book a package for planning commissions and governmental officials who will make the decisions on the uses to which our land will be put. The layman who wishes to have a comprehensive background for understanding his land problems will benefit greatly from a careful reading of this book. It provides an excellent background reference on the subject for fish and game administrators and managers.—*Willis A. Evans, California Department of Fish and Game.*

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