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VOLUME 60 JULY 1974 NUMBER 3

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# CALIFORNIA FISH AND GAME

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## CONTENTS

## CHANGE OF EDITORSHIP

With this issue Robson A. Collins of Operations Research Branch assumes the duties of Editor-in-Chief of *California Fish and Game.*

Mr. Collins' assumption of the editorship follows the Department's policy of rotating the editorship between staff members representing Marine Resources, Inland Fisheries, and Wildlife Management.

For three years Mr. Collins, Associate Marine Biologist, has served as Marine Resources Editor of the Quarterly. Through this service he has gained a knowledge of editorial policies and procedures of the Journal.

Under his guidance, the Journal will continue its policy of presenting to the public the results of scientific investigations as they relate to management programs and the conservation of California fish and wildlife resources.

Mr. Collins will be ably assisted in his duties by five associate editors: Kenneth A. Hashagen, Inland Fisheries; Carol M. Ferrel, Wildlife Management; Robert N. Tasto, Marine Resources; and Harold K. Chadwick and Paul M. Hubbel, Anadromous Fisheries.

To Mr. Ferrel, Editor-in-Chief the past 4 years, we wish to express our appreciation for a job well done.—*G. Ray Arnett, Director California Department of Fish and Game.*

*Calif. Fish and Game*, 60(3): 109–127. 1974.

# AN EXPERIMENTAL ARTIFICIAL REEF IN HUMBOLDT BAY, CALIFORNIA[1]

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**In October 1968, an artificial reef constructed of used truck tires was placed in Southport Channel of Humboldt Bay, California, by the Eureka Kiwanis Club. Studies were conducted to determine floral and faunal species composition and relative abundance, and to measure fishing success on the reef.**

**A "rocky habitat fish fauna" was attracted to the reef. Between April 13, 1969, and May 13, 1970, 15 species were captured by hook and line. Seven species were tagged with Petersen disc tags. Estimates of fish populations revealed that the most abundant fishes were kelp greenling, followed by copper and black rockfish. No tagged fish were captured away from the reef. The reef did not attract large fish from other reef areas. Nearly all fish captured on the reef during spring, 1969, were of the 1968 year class. During dives, 9 species of fish, 25 species of invertebrates and 3 species of algae were observed on or near the reef. Lingcod and pile perch were the only species of fish observed by divers but not captured by hook and line.**

**Fishing success was measured to better understand the effectiveness of the reef. The most successful fishing was from May to October. During perods of extremely turbid water or heavy tidal currents, fishing success tended to decrease.**

## INTRODUCTION

In October 1968, the Eureka Kiwanis Club constructed an artificial reef with used truck tires in Humboldt Bay, California. The purpose of the reef was to test the use of old tires as habitat for reef-dwelling fishes and to establish a new sportfishery inside Humboldt Bay.

Artificial reefs have been utilized successfully in California near-shore waters since 1958 (Carlisle, Turner and Ebert 1964; Turner, Ebert and Given 1969). All artificial reefs previously studied were composed of old automobiles or street cars, which have a short life, or longer-lasting quarry rock or concrete shelters. In addition, all of the reefs were constructed south of Point Conception. The Humboldt Bay reef is the first artificial reef constructed in northern California and the first in California constructed with old tires.

The establishment of an experimental reef in Humboldt Bay was recommended in a survey of northern California sportfishing (Miller and Gotshall 1965). Humboldt Bay lacks reef areas, except for jetties at the entrance, which are fishable only on very calm days. The objectives of this study were to determine species attracted to the reef, their relative abundance, and factors affecting fishing success on the reef.

[1] Accepted for publication November 1973.

## METHODS

The reef was placed in Southport Channel at lat 40°41′10″ N and long 124°13′40″ W, approximately 900 m (2,950 ft) south of channel buoy number six and 820 m (2,690 ft) west of the entrance to King Salmon (Figure 1). At mean low tide the reef is at a depth of 7.3 m (24 ft).

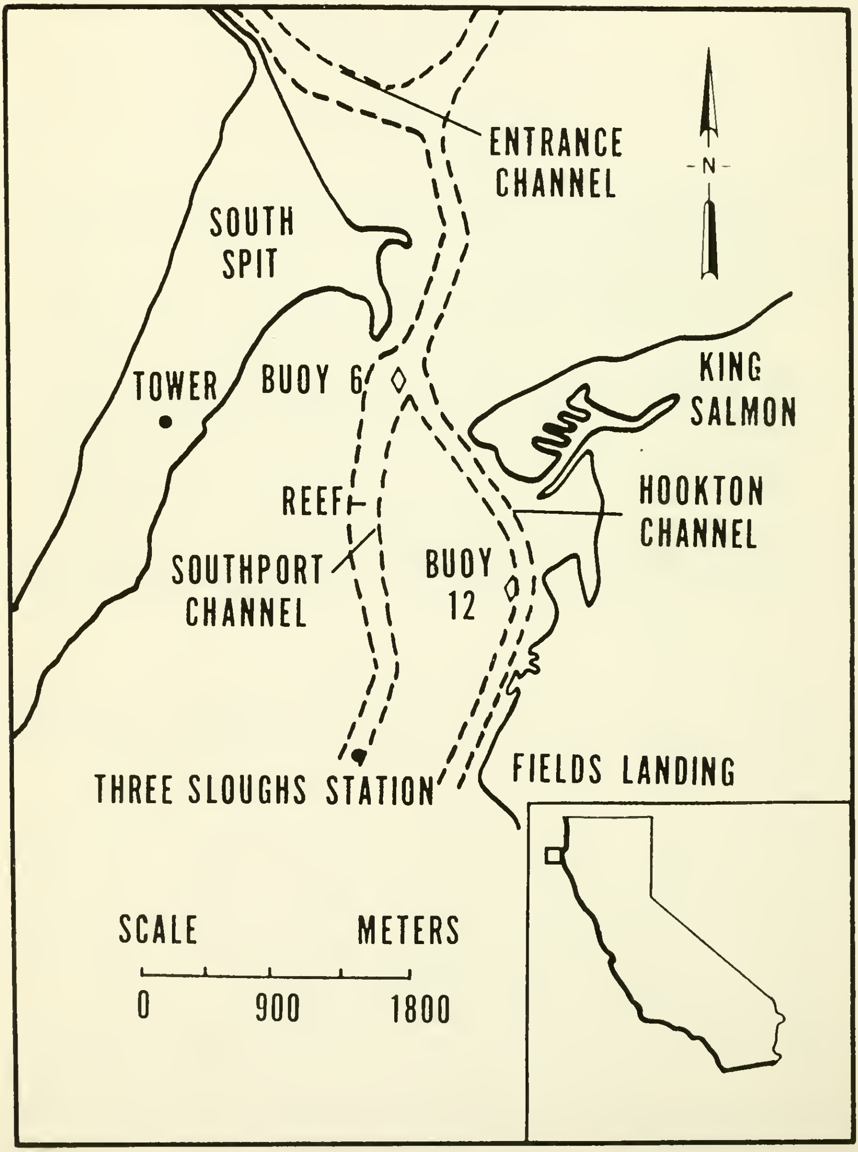


FIGURE 1. Tire reef location in South Humboldt Bay, California.

Southport Channel was chosen as the site because: (i) it is not used by large, deep-draft commercial vessels; (ii) the site is easily accessible from nearby boat launching facilities at King Salmon and Fields Landing; (iii) the site is not close to any other reef area; (iv) the channel is deep (6 to 9 m) (20 to 30 ft); and finally, (v) weather seldom limits accessibility to the reef.

Discarded truck tires, 45 kg and larger, were used to build the reef. Eight hundred tires were set out singly and in groups of three and four. The groups were banded together with plastic straps and all tires were strung on a polypropolene line to prevent straying. Holes were drilled in all tires to allow them to sink. Most of the tires were placed in an upright position which provides a shelter area for fish and larger surface area for encrusting organisms. The finished reef has an area of approximately 230 $m^2$ (2,473 $ft^2$) and is approximately 30 m (98 ft) long, 8 m (26 ft) wide and 1 to 2 m (3 to 7 ft) high.

Tagging was used to obtain information on population size, individual growth, and movements of the fish on the reef. Fish were collected by hook and line. Attempts to catch juvenile fish in a 76 cm by 48 cm by 41 cm triangular trap failed. Fishing was usually conducted from a skiff with one to three anglers, although several trips were made with the *R. V. Sea Gull* with six to ten anglers. Shrimp was the major bait used, because diving observations showed that when shrimp was used as bait a more representative sample of the reef population was captured than when other common baits were used.

Captured fish were unhooked and placed in a container of sea water containing one part tricain methanesulphonate (MS 222) per 15,000 parts water to calm the fish (McFarland 1960; Miller, Odemar and Gotshall 1967). The fish were identified, measured (TL), tagged, and placed in a container of sea water to recover. Any weakened or injured fish were noted. Fish caught before September 1969 were identified and measured but not tagged. After September 1969 numbered red and blank white Petersen disc tags of 1.27 cm (½ inch) diameter were attached to fish with stainless steel pins inserted under the first dorsal spine. All tag recaptures were identified, the tag numbers recorded, the fish measured and re-released. Any injury caused by the tag was noted. All fish were examined for evidence of tag shedding. We did not consider the problem of shedding and increased vulnerability to nets encountered in other studies with Petersen discs (Calhoun 1953) to be significant because of the short duration of the study and the fact that nets were not used around the reef. However, several tagged fish were captured in crab traps set near the reef by sportfishermen.

Population estimates were made from tagging data on copper rockfish, black rockfish and kelp greenling using the modified Schnabel estimate (Table 4; Ricker 1958). Additional population estimates were made by SCUBA divers from California State University, Humboldt and California Department of Fish and Game. These estimates were compared to the tag and recapture population estimates. The divers also made observations of the condition of the reef, fish behavior, and species composition of fish and invertebrates.

Information was collected on fishing success (catch-per-unit-of-effort) in an attempt to correlate fishing success with environmental factors.

Information on date, baits, tide, total time fishing, time of day, number of anglers, weather, wind direction and wind speed was noted. Any unusual occurrences, such as a plankton bloom, were noted. By December 1969, it was suspected that turbidity might be an important factor in fishing success. From December 1969 through May 1970, readings were made with a 30.5 cm diameter white Secchi disc.

## RESULTS

### Species Composition

Between April 13, 1969, and May 14, 1970, 640 fishes of 15 species were captured by hook and line (Table 1). The most common species were copper rockfish, *Sebastes caurinus* (297), black rockfish, *S. melanops* (129), and kelp greenling, *Hexagrammos decagrammus* (122). Ninety-one percent of the reef catch consisted of fish expected in rocky areas of Humboldt Bay (Allen, Delacy and Gotshall 1960). In otter trawling during 1964 in Southport Channel only 15.7% of the catch was of the rocky habitat fish (Table 2).

**TABLE 1—Nomenclature and Catch Totals of Artificial Reef Fishes *.**

| Scientific name | Common name | Total captured |
|---|---|---|
| *Anarrhichthys ocellatus* Ayres | wolf-eel | 1 |
| *Atherinopsis californiensis* Girard | jacksmelt† | 3 |
| *Citharicthys stigmaeus* (Jordan & Gilbert) | sand dab† | 1 |
| *Cymatogaster aggregata* Gibbons | shiner perch† | 30 |
| *Embiotoca lateralis* Agassiz | striped seaperch | 2 |
| *Enophrys bison* (Girard) | buffalo sculpin | 11 |
| *Hexagrammos decagrammus* (Pallas) | kelp greenling | 122 |
| *Leptocottus armatus* Girard | staghorn sculpin† | 1 |
| *Phanerodon furcatus* Girard | white seaperch† | 6 |
| *Platichthys stellatus* Pallas | starry flounder† | 1 |
| *Scorpaenichthys marmoratus* (Ayres) | cabezon | 2 |
| *Sebastes auriculatus* (Girard) | brown rockfish | 20 |
| *S. caurinus* (Richardson) | copper rockfish | 297 |
| *S. melanops* (Girard) | black rockfish | 129 |
| *Triakis henlei* (Gill) | brown smoothhound† | 14 |

* The scientific and common names are those accepted by the American Fisheries Society (1970).
† Not expected to be in reef areas of Humboldt Bay (Allen, Delacy and Gotshall 1960).

We expected grass rockfish, *Sebastes rastrelliger*, and striped seaperch, *Embiotoca lateralis*, to be common on the reef since they are common in rocky areas and along jetties in Humboldt Bay (Allen, et al. 1960; Smith 1967). The reason for the lack of these two species is unknown, but the depth and low profile of the reef could be important factors.

### Tagging

Between September 7, 1969, and May 14, 1970, 236 fishes of seven species were tagged. Thirty-six tagged fish were recovered and rereleased for a recovery rate of 15.3% (Table 3). Thirteen tagged fish were recovered more than once. Two copper rockfish were recaptured three times. Copper rockfish had the highest percentage of recaptures, 24.8% (Table 5). Black rockfish and kelp greenling had 9.1% and 7.1% recapture rates, respectively (Tables 6 and 7). No tagged fish were reported from any area away from the reef.

## Population Estimates

The calculated population for copper rockfish in May 1970, was 294 fish (Table 4). Black rockfish numbered 185. Contrary to the capture data and diver observations (Table 8), the calculated population for the kelp greenling was the highest of the three species, 515 fish.

**TABLE 2—Percent of Catch by Species on Artificial Reef, 1969–70, and by Otter Trawl in Southport Channel of Humboldt Bay, 1964***

| Species | Percent of reef catch | Percent of 1964 trawl catch |
|---|---|---|
| *Citharichthys stigmacus* | 0.1 | 6.3 |
| *Cymatogaster aggregata* | 4.6 | 39.7 |
| *Embiotoca lateralis*† | 0.3 | 0.1 |
| *Enophrys bison*† | 1.7 | 4.0 |
| *Hexagrammos decagrammus*† | 19.0 | 5.7 |
| *Hyperprosopon argenteum* | 0.0 | 2.6 |
| *Ophiodon elongatus*† | 0.0 | 1.9 |
| *Parophrys vetulus* | 0.0 | 29.8 |
| *Phanerodon furcatus* | 0.9 | 4.7 |
| *Scorpaenichthys marmoratus*† | 0.3 | 0.4 |
| *Sebastes auriculatus*† | 3.1 | 0.0 |
| *S. caurinus*† | 46.4 | 0.0 |
| *S. melanops*† | 20.1 | 1.2 |
| *Triakis henlei* | 2.1 | 0.0 |
| Other | 0.7 | 3.1 |

* Dr. George H. Allen, pers. comm., unpublished Humboldt Bay trawl reports, California State University at Humboldt, Arcata, California.
† Fish expected to be captured in rocky areas of Humboldt Bay (Allen, Delacy and Gotshall 1960).

**TABLE 3—Summary of Fish Tagged and Recaptured on Humboldt Bay Artificial Reef, September 1969–May 1970.**

| Species | Number tagged | Number of individual fish recaptured | Total tags recaptured* | Percent recaptured |
|---|---|---|---|---|
| *Enophrys bison* | 4 | 1 | 1 | 25.0 |
| *Hexagrammos decagrammus* | 70 | 5 | 5 | 7.1 |
| *Phanerodon furcatus* | 4 | 0 | 0 | 0.0 |
| *Scorpaenichthys marmoratus* | 1 | 0 | 0 | 0.0 |
| *Sebastes auriculatus* | 12 | 1 | 1 | 8.3 |
| *S. caurinus* | 101 | 25 | 40 | 24.8 |
| *S. melanops* | 44 | 4 | 4 | 9.1 |

* Includes multiple recaptures.

**TABLE 4. Modified Schnabel Population Estimates for Copper Rockfish, Kelp Greenling, and Black Rockfish on Humboldt Bay Artificial Reef, May 1970.***

| *Copper Rockfish* | | *Kelp Greenling* | | *Black Rockfish* | |
|---|---|---|---|---|---|
| N | 95% range | N | 95% range | N | 95% range |
| 294 | 268–326 | 515 | 326–1223 | 185 | 127–343 |

Modified Schnabel Population Estimate

$$N = \frac{(C_t M_t)}{R_t + 1}$$

N=population estimate
$M_t$=total marked fish at large at start of sample period $_t$
$C_t$=total sample taken during period $_t$
$R_t$=number of recaptures in sample $C_t$

* Black rockfish estimate—November, 1969.

## Age Determination and Composition

Length frequencies and scale examination were used to determine the age of the fish. Studies have shown that the embryos of copper rockfish, black rockfish and kelp greenling are released during the winter and spring (Delacy, Hitz and Dryfoos 1964; Dunn and Hitz 1969; Daniel Miller pers. comm.). Based on these data, nearly all copper rockfish, black rockfish, and kelp greenling captured on the reef in the spring of 1969 were 1968 year class fish (Figure 2). By late fall, 1969, the 1969 year class of these three species became vulnerable to the fishing gear. One 1967 year class copper rockfish and several 1967 year class kelp greenling were captured.

## Growth

Fish were measured to determine monthly growth rates. Mean lengths of copper rockfish, black rockfish, and kelp greenling of the 1968 year class increased approximately 70 mm, 60 mm, and 70 mm TL, respectively, during the 13 month study period (Figure 2). Growth was most rapid during the spring and summer months. During these months the strongest coastal water upwelling occurs and the greatest plankton concentrations are found along the northern California coast (Bolin and Abbott 1963; Magoon 1965). A similar growth pattern occurs with blue rockfish, *S. mystinus*, during and after periods of upwelling in Monterey Bay (Miller, Odemar, and Gotshall 1967).

## Diving

Six successful observation dives were completed on the reef. Estimates of numbers of fish were made on two of the dives. Several other dives were unsuccessful because of poor visibility. Underwater visibility ranged from zero to 2.5 m. Twenty-five species of invertebrates, three species of algae, and nine species of fishes were observed on or near the reef (Tables 8 and 9, Figure 3), all known to occur in other parts of the bay. The most common invertebrates were crabs, particularly

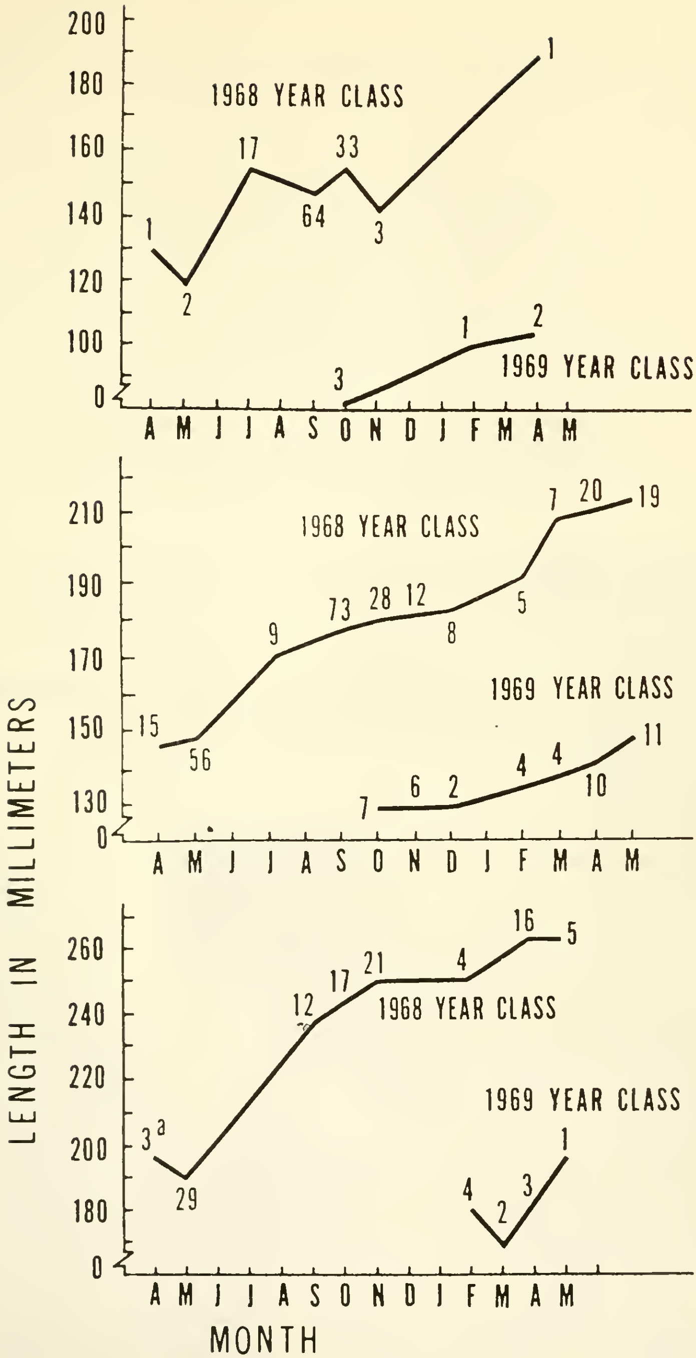


FIGURE 2. Mean lengths of black rockfish, copper rockfish, and kelp greening from the Humboldt Bay artificial reef, April 1969 to May 1970.

*Cancer antennarius* and *C. productus*, and the starfish *Pisaster brevispinus*. *C. productus* and *C. anthonyi* observed on the September 8, 1969, dive were mating. Copper and black rockfish, kelp greenling and white seaperch were the most numerous fish species. Lingcod and pile perch were the only two species observed by the divers not captured by hook and line. Population estimates made by the divers were generally lower than the estimates made by tag and recapture (Table 5). Many fishes utilized the interior of the tire casings for protection. The copper rockfish, brown rockfish, kelp greenling and cabezon were never observed more than a few feet away from the tires, rarely above them. Conversely, the black rockfish and surfperch tended to form loose-knit schools 2 or 3 ft from the tires. During periods of strong tidal currents and turbid water most fishes observed were inside the tire casings. During periods of slack water the fishes moved out of the tires. In July 1969, we noted that the tires had become partially silted in, up to one half of their height, but no increase in siltation was observed on later dives. In several cases tires previously silted in were again exposed.

FIGURE 3. Copper rockfish (*Sebastes caurinus*) near Humboldt Bay reef. Photograph by Daniel W. Gotshall.

TABLE 5—Summary of Tags and Recaptures for Modified Schnabel Population Estimates for Copper Rockfish on Humboldt Bay Artificial Reef, September 1969–May 1970.

| Date | Number caught | Recaptures | Number marked | Marked fish at large | | | | |
|---|---|---|---|---|---|---|---|---|
| | $C_t$ | $R_t$ | | $M_t$ | $C_tM_t$ | $M_tR_t$ | $C_tM_t^2$ | $R_t^2/C_t$ |
| 9/7/69 | 53 | 0 | 1 | 0 | 0 | 0 | 0 | 0.0000 |
| 9/11/69 | 20 | 0 | 20 | 1 | 20 | 0 | 20 | 0.0000 |
| 10/ 4/69 | 9 | 0 | 9 | 21 | 420 | 0 | 3,969 | 0.0000 |
| 10/12/69 | 9 | 1 | 8 | 30 | 270 | 30 | 8,100 | 0.1111 |
| 10/30/69 | 17 | 5 | 11 | 38 | 646 | 190 | 24,548 | 1.4706 |
| 11/16/69 | 14 | 3 | 9 | 49 | 686 | 147 | 33,614 | 0.6429 |
| 11/25/69 | 4 | 0 | 2 | 58 | 232 | 0 | 13,456 | 0.0000 |
| 12/31/69 | 10 | 2 | 5 | 60 | 600 | 120 | 36,000 | 0.4000 |
| 2/26/70* | 3 | 0 | 3 | 65 | 195 | 0 | 12,675 | 0.0000 |
| 2/26/70† | 6 | 2 | 3 | 68 | 408 | 136 | 27,744 | 0.6667 |
| 3/ 3/70* | 5 | 1 | 3 | 71 | 355 | 71 | 25,205 | 0.2000 |
| 3/20/70 | 3 | 1 | 2 | 74 | 222 | 74 | 16,428 | 0.3333 |
| 3/25/70 | 3 | 1 | 2 | 76 | 228 | 76 | 17,328 | 0.3333 |
| 4/ 9/70 | 2 | 0 | 1 | 78 | 156 | 0 | 12,165 | 0.0000 |
| 4/18/70 | 1 | 0 | 1 | 79 | 79 | 0 | 6,241 | 0.0000 |
| 4/21/70 | 14 | 5 | 7 | 80 | 1,120 | 400 | 32,000 | 1.7857 |
| 4/23/70* | 2 | 1 | 1 | 87 | 174 | 87 | 15,138 | 0.5000 |
| 4/23/70† | 11 | 1 | 10 | 88 | 968 | 88 | 85,184 | 0.0909 |
| 5/ 5/70 | 4 | 2 | 0 | 98 | 392 | 196 | 38,416 | 1.0000 |
| 5/ 7/70 | 20 | 6 | 1 | 98 | 1,960 | 588 | 192,080 | 1.8000 |
| 5/14/70 | 6 | 1 | 0 | 99 | 594 | 99 | 58,806 | 0.1666 |
| Total | 216 | 32 | 99 | 1,318 | 9,725 | 2,302 | 659,117 | 9.5011 |

* Morning trip.
† Afternoon trip.

TABLE 6—Summary of Tags and Recaptures for Modified Schnabel Population Estimates for Kelp Greenling on Humboldt Bay Artificial Reef, September 1969–May 1970.

| Date | Number caught | Recaptures | Number marked | Marked fish at large | | | | |
|---|---|---|---|---|---|---|---|---|
| | $C_t$ | $R_t$ | | $M_t$ | $C_tM_t$ | $M_tR_t$ | $C_tM_t^2$ | $R_t^2/C_t$ |
| 9/11/69 | 9 | 0 | 9 | 0 | 0 | 0 | 0 | 0.0000 |
| 10/ 4/69 | 6 | 0 | 6 | 9 | 54 | 0 | 486 | 0.0000 |
| 10/12/69 | 5 | 0 | 2 | 15 | 75 | 0 | 1,125 | 0.0000 |
| 10/30/69 | 6 | 0 | 6 | 17 | 102 | 0 | 1,734 | 0.0000 |
| 11/16/69 | 10 | 0 | 9 | 23 | 230 | 0 | 5,290 | 0.0000 |
| 11/25/69 | 12 | 0 | 10 | 32 | 384 | 0 | 12,288 | 0.0000 |
| 2/26/70* | 4 | 0 | 4 | 42 | 176 | 0 | 7,056 | 0.0000 |
| 2/26/70† | 4 | 0 | 4 | 46 | 184 | 0 | 8,464 | 0.0000 |
| 3/ 3/70* | 3 | 0 | 3 | 50 | 150 | 0 | 7,500 | 0.0000 |
| 3/ 3/70† | 1 | 0 | 1 | 53 | 53 | 0 | 2,809 | 0.0000 |
| 3/20/70 | 2 | 0 | 2 | 54 | 108 | 0 | 5,832 | 0.0000 |
| 4/ 9/70 | 1 | 0 | 1 | 56 | 56 | 0 | 3,136 | 0.0000 |
| 4/18/70 | 3 | 0 | 2 | 57 | 171 | 0 | 9,747 | 0.0000 |
| 4/21/70 | 1 | 0 | 1 | 59 | 54 | 0 | 3,481 | 0.0000 |
| 4/23/70* | 3 | 1 | 2 | 60 | 180 | 60 | 10,800 | 0.3333 |
| 4/23/70† | 11 | 2 | 9 | 62 | 682 | 124 | 42,284 | 0.3636 |
| 5/ 7/70 | 6 | 2 | 0 | 71 | 426 | 142 | 30,246 | 0.6666 |
| Total | 87 | 5 | 71 | 706 | 3,090 | 326 | 152,274 | 1.3635 |

* Morning trip.
† Afternoon trip.

**TABLE 7—Summary of Tags and Recaptures for Modified Schnabel Population Estimates for Black Rockfish on Humboldt Bay Artificial Reef, September 1969–May 1970.**

| Date | Number caught | Recaptures | Number marked | Marked fish at large | | | | |
|---|---|---|---|---|---|---|---|---|
| | $C_t$ | $R_t$ | | $M_t$ | $C_tM_t$ | $M_tR_t$ | $C_tM_t^2$ | $R_t^2/C_t$ |
| 9/ 7/69 | 55 | 0 | 1 | 0 | 0 | 0 | 0 | 0.0000 |
| 9/11/69 | 9 | 0 | 9 | 1 | 9 | 0 | 9 | 0.0000 |
| 10/ 4/69 | 17 | 0 | 17 | 10 | 170 | 0 | 1,700 | 0.0000 |
| 10/12/69 | 9 | 1 | 8 | 27 | 243 | 27 | 6,561 | 0.1111 |
| 10/30/69 | 11 | 3 | 4 | 35 | 385 | 105 | 13,475 | 0.8112 |
| 11/16/69 | 1 | 0 | 1 | 39 | 39 | 0 | 1,521 | 0.0000 |
| 11/25/69 | 2 | 0 | 2 | 40 | 80 | 0 | 3,200 | 0.0000 |
| 2/26/70 | 1 | 0 | 0 | 42 | 42 | 0 | 1,764 | 0.0000 |
| 4/ 9/70 | 1 | 0 | 1 | 42 | 42 | 0 | 1,764 | 0.0000 |
| 4/23/70 | 2 | 0 | 1 | 43 | 86 | 0 | 1,849 | 0.0000 |
| Total | 108 | 4 | 44 | 279 | 1,096 | 132 | 31,843 | 0.9223 |

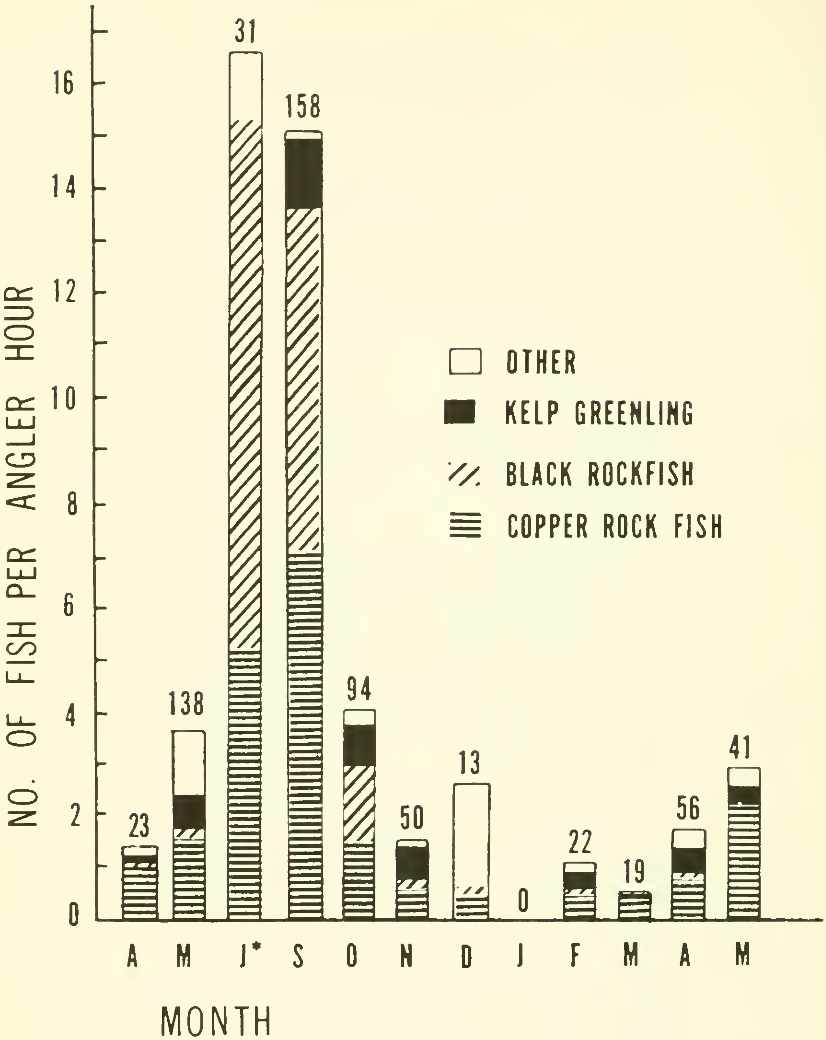


FIGURE 4. Catch per angler hour by species and total monthly catch of fish on the Humboldt Bay artificial reef (June, July and August combined).

## Fishing Success

The reef was sampled with hook and line on 32 trips between April 13, 1969, and May 14, 1970. Eight of these trips were on the *R. V. Sea Gull* and 24 were by skiff. The catch per angler per hour, all species combined, averaged 2.82 fish (Figure 4). This compares with a catch per angler per hour at the South Jetty and Buhne Point Jetty in 1958 of 0.45 and 0.66, respectively (Miller and Gotshall 1965). The most successful fishing was May to October and the least successful January to March. Copper rockfish and black rockfish followed this pattern while the monthly catch rates for kelp greenling showed little variation.

TABLE 8—**Population Estimates by Divers of Fishes on Humboldt Bay Tire Reef, Summer 1969.**

| Species | Date: July 27, 1969 | | Date: September 8, 1969 | |
|---|---|---|---|---|
| | Nos. | Remarks | Nos. | Remarks |
| Copper rockfish | 100+ | very easy to approach | 100–200 | growth very evident, tagged fish observed |
| Black rockfish | 100 | schools 2 to 3 ft. above tires, some fish under 100 mm TL | 100–150 | blacks less dominant, saw tagged fish |
| Kelp greenling | 25+ | inside and near tires | 25–50 | up to 12 inches |
| Brown rockfish | 25+ | | 50–100 | |
| Cabezon | 5+ | | 2–5 | |
| Buffalo sculpin | ---- | | 2 | |
| White perch | 25+ | well above reef | 100–200 | |
| Lingcod | ---- | | 3 | about 3 lb. each |
| Pile perch | ---- | | 2 | |

**TABLE 9—Algae and Invertebrates Identified on Humboldt Bay Artificial Reef, April, 1969–May, 1970***

| Phylum or major group | Common name | Phylum or major group | Common name |
|---|---|---|---|
| Chlorophyta | | Arthropoda (continued) | |
| *Enteromorpha micrococca* | green weed | Brachyura | |
| *Ulva* sp. | sea lettuce | *Cancer antennarius* | red rock crab |
| Rhodophyta | | *Cancer anthonyi* | yellow crab |
| *Porphyra lanceolata* | foliose red | *Cancer gracilis* | slender crab |
| Coelenterata | | *Cancer magister* | dungeness crab |
| Hydrozoa | | *Cancer productus* | red crab |
| *Campanularia integra* | hydroid | *Pugettia producta* | kelp crab |
| *Obelia surcularis* | hydroid | Amphipoda | |
| *Plumularia lagenifera* | hydroid | *Caprella californica* | amphipod |
| *Thuiaria similis* | hydroid | *Caprella laeviuscula* | amphipod |
| *Tubularia marina* | hydroid | Mollusca | |
| Anthozoa | | Opisthobranchia | |
| *Metridium senile fiombriatum* | anemone | *Dirona albolineata* | nudibranch |
| Annelida | | *Hermissenda crassicornis* | nudibranch |
| Polychaeta | | Gastropoda | |
| *Platynereis bicanaliculata* | nereid worm | *Tegula pulligo* | dusky top snail |
| Arthropoda | | Pelecypoda | |
| Pycnogonida | | *Tresus nuttalli* | gaper clam |
| *Achelia chelata* | sea spider | *Tresus capax* | gaper clam |
| *Achelia echinata* | sea spider | Echinodermata | |
| Cirripedia | | Asteroidea | |
| *Balanus crenatus curviscutum* | white barnacle | *Pisaster brevispinus* | pink sea star |
| | | *Pycnopodia helianthoides* | sun star |

* Most of the identifications were made by Robert Hardy, Assistant Marine Biologist, California Department of Fish and Game, on dives made September 9, 1969.

The most successful fishing for kelp greenling was during fall months. Allen, Delacy and Gotshall (1960) recorded a similar pattern for kelp greenling in the sport catch in Humboldt Bay.

The effect of water clarity and tidal difference on catch rates was studied to better understand the factors influencing fishing success on the reef. Fishes tended to remain inside the tire casings during turbid water and strong tidal flow. Secchi disc readings are plotted against fishing success (Figure 5). The low correlation coefficient ($r=0.221$, 15 degrees of freedom) indicates that a relationship between fishing success and water clarity cannot be demonstrated. However, no fishes were caught when the water was extremely turbid (30 to 40 cm Secchi readings). This indicated that there may be some threshold of visibility below which the fishes are not vulnerable to the fishing gear. The differences between high and low tides are plotted against fishing success (Figure 6). The correlation coefficient ($r=0.377$, 30 degrees of freedom) indicates that as the distance in meters between high and low tide increases, the catch-per-unit-of-effort tends to decrease ($P=0.036$).

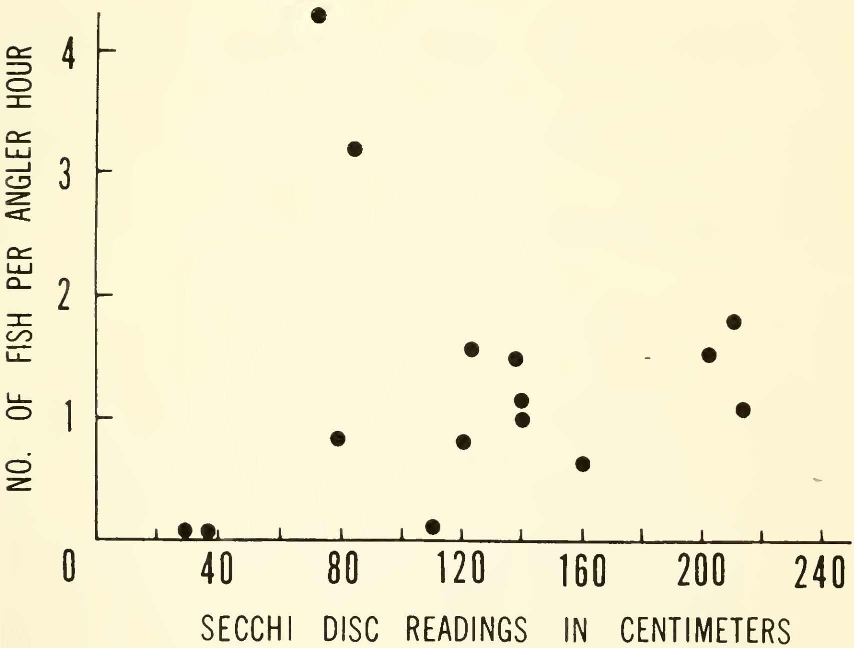


**FIGURE 5.** Secchi disc readings versus catch per angler hour on Humboldt Bay artificial reef, December 1969 to May 1970.

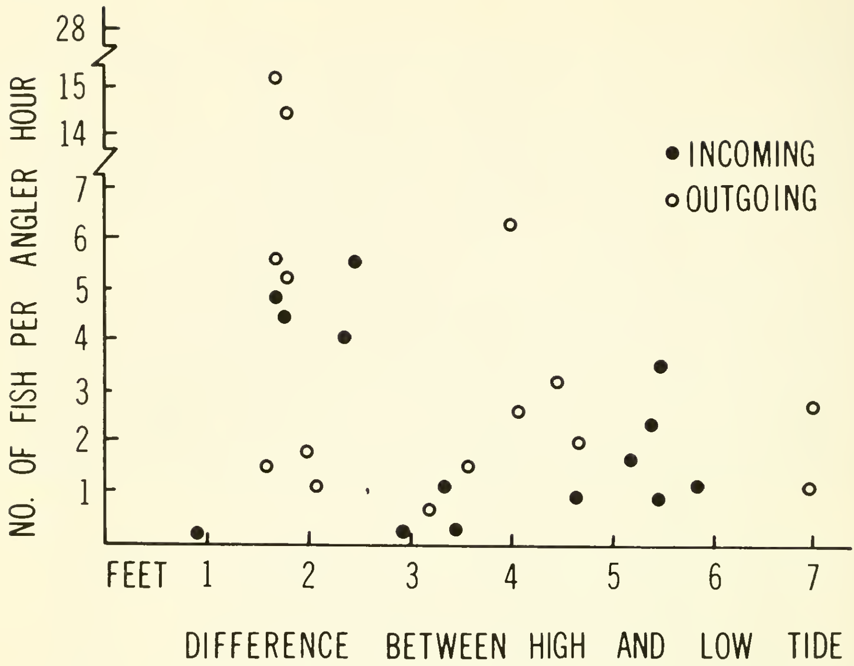


FIGURE 6. Tidal difference versus catch per angler hour on Humboldt Bay artificial reef, April 1969 to May 1970.

## DISCUSSION AND CONCLUSIONS

### Limitations of Data

Hook and line sampling is very selective. Allen, Delacy and Gotshall (1960) stated that all gear is selective, but hook and line, although selective, is effective in sampling rocky shore areas. Gear selectivity was not an important factor in this study because the species composition observed by divers was similar to the species composition of the hook and line catch (Tables 1 and 5). However, the hook and line gear did not collect all of the species present on the reef. Lingcod and pile perch were not captured and there probably were other fish species on the reef not observed by divers and not susceptible to hook and line fishery, such as small cottids. The hook and line gear was also selective to size. Although divers observed black rockfish under 100 mm, few were captured by hook and line, and all attempts to capture the small fish in traps failed.

Daniel J. Miller (pers. comm.) reported that all individuals of a population of blue rockfish, *Sebastes mystinus*, were not equally vulnerable to hook and line sampling; some fish refuse to bite baited hooks. These observations were made by diving during fishing operations. If all of the fishes in the reef population are not equally vulnerable due to their refusal to bite baited hooks, the population estimates would be lower.

There are several factors which could result in higher population estimates. Tag loss and tagging mortality probably were not significant in this study due to the short duration (9 months). Ten tagged reef fishes were held for 120 days in a 500-gallon aquarium and no death, injury or tag loss was observed. Only one fish, a 280 mm kelp greenling, was observed with a tag loss scar. Secondly, increased predation by seals and lingcod caused by increased vulnerability due to the bright red disc tags could have affected the population estimates. On October 12, 1969, a harbor seal was observed feeding on rockfishes on the reef. Two fishes were taken off of our lines by the seals. Finally, unreported tag recoveries would also increase the population estimates. No tagged fish were reported away from the reef area. Few fishermen were observed fishing on the reef. The catch rates and species composition of the catch by fishermen using the reef are unknown. This is probably because the presence of the reef and the tagging program were not publicized. The number of unreported tags, if any, is unknown.

Fishing success data were collected to better understand the productivity of the reef. The difference in our fishing ability and that of other anglers sampling the reef affected the catch-per-unit-of-effort data. The biggest differences occurred on the *R. V. Sea Gull* trips with six to ten inexperienced anglers when we often caught approximately 30–50% of all fish captured. These trips took place February 26, 1970, March 3, 1970, and April 23, 1970 (Tables 5, 6, and 7). As anglers learned how to fish the reef, they increased their catch-per-unit-of-effort. Another factor biasing the data was the improvement of angling techniques throughout the study period. The very high catch rates during June, July, and August (Figure 6) might have been lowered by fishing for longer time periods which included non-optimum fishing conditions (e.g. strong tidal currents).

There are many interrelated environmental factors which could affect fishing success on the reef. Tide and water clarity were chosen because they appeared to be of primary importance and easily measured. Other environmental factors could change the significance of the effects of tide and water clarity on fishing success. On several occasions high winds and cold air temperature lowered the efficiency of the fishermen. Time of year could be important. An abundance of natural food could lower the fishing success as found by Gotshall, Smith and Holbert (1965) for Monterey Bay blue rockfish. The major problem with the tidal data is that the tide often changed direction during the fishing time. The points on Figure 6 are plotted for the direction in which the tide flowed for the majority of the fishing time. But several times the majority of the fish were caught at high and low slack water and during the time the tide flowed, a minority of the fishing time. The major limitation in the Secchi disc data is the lack of readings.

In conclusion our studies indicate that: (i) the artificial reef attracted a rocky habitat fish fauna; (ii) the reef attracted juvenile rockfish and greenling rather than adults, as far as is known, these fish did not move away from the reef; (iii) black rockfish were vulnerable to fishing during the summer and early fall months only, copper rockfish and kelp greenling were captured throughout the year; (iv) diving observations of fish behavior and fishing success data suggest that during periods of heavy tidal current flow or extremely turbid water (Secchi readings of 30 to 40 cm) the reef fish are less vulnerable to hook and line gear; (v) the most successful fishing was from May to October; (vi) rapid growth of the copper rockfish, black rockfish, and kelp greenling took place during spring and early summer months (periods of strong upwelling of coastal waters). From our studies we feel that old tires can be highly successful as reef building material. We suggest the following be considered as future projects in Humboldt Bay:

1) The artificial reef should be expanded to provide more sportfishing potential. The present size of the reef is not sufficient to support a sizable sportfishery. Additional tire reefs should be placed in suitable sites inside and possibly outside of Humboldt Bay.
2) As fishing pressure increases on the reef, a creel census should be made. The value of the reef to the local sportfishing should be determined.
3) The factors affecting fishing success on the reef, such as tide and water clarity, should be studied further. The effects of location, shape, and profile on the species composition and abundance of fish on the reef need to be examined.
4) The life histories of the important fish species on the reef should be studied, especially that of the kelp greenling.
5) Any mariculture possibilities of artificial reefs should be investigated.

## ACKNOWLEDGMENTS

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# ACUTE TOXICITY OF TWENTY INSECTICIDES TO STRIPED BASS, *MORONE SAXATILIS*[1]

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**The acute toxicity of twenty insecticides to juvenile striped bass was determined in saline water. All bioassays were four-day tests using proportional diluters as described by Mount and Brungs (1967).**

**Endrin, Endosulfan, DDT, and Dursban were the most toxic with Median Lethal Concentration ($TL_{50}$) values of less than 1 $\mu$g/l. Carbaryl and Abate were the least toxic with $TL_{50}$ values over 1,000 $\mu$g/l. DDD, Heptachlor, Methoxychlor, Toxaphene, Aldrin, Lindane, Chlordane, Malathion, Parathion, Dieldrin, E.P.N., Fenthion, Dibrom, and Methyl Parathion were also tested and are listed in order of decreasing toxicity. Some advantages of intermittent versus static bioassay testing are discussed.**

## INTRODUCTION

The San Francisco Bay and Delta region represents the most important striped bass habitat on the west coast. It is also an area which receives large amounts of pesticides from drainage systems, primarily the Sacramento-San Joaquin Rivers. Insecticides in this study were selected because measurable quantities of 14 out of the 20 have been reported in the waters of this region (Water Resources Control Board, 1971). Earnest and Benville (1971) found DDT levels in bay water in Tiburon, California to vary from 3 to 21 ng/l during 1969. The other insecticides were selected because mosquito control districts and others indicated these compounds were either now being used or had potential for use in the bay-delta area.

This study was an effort to provide intermittent flow bioassay data for insecticides on striped bass. Information of this type is useful to screen out the more toxic compounds from those in use or being considered for application. The determination of acute toxicity is the first of a logical sequence of evaluative steps leading to the determination of chronic sub-lethal effects of compounds potentially harmful to aquatic organisms.

## METHODS

Striped bass (14–83 mm SL, 0.06–4.8 g) were obtained from the fish diversion facility operated by the Bureau of Reclamation at the Tracy pumping plant, Tracy, California. Fish were transported in fresh water to our facility where they were acclimated over a 3 day period to bay water. The fish were further acclimated to test water conditions in

[1] Accepted March, 1974

1,000 liter fiberglass tanks for at least 1 week before testing. Frozen brine shrimp were fed to the fish once daily to saturation.

The test water during the acclimation and test periods was filtered through a sand filter and salinity (Kahlsico salinity hydrometer), turbidity (Hach 2100 turbidimeter) and temperature were determined daily (Table 1).

**TABLE 1—Toxicity of Insecticide to Striped Bass Listed in Descending Order.**

| Insecticide | Mean length (mm) | Mean weight (g) | Temp mean (C°) | Salinity mean (°/₀₀) | Turbidity mean (J.T.U.) | $TL_{50}$ (95% C.I.) (ug/1) |
|---|---|---|---|---|---|---|
| Endrin | 70 | 2.7 | 17±1* | 28±2* | 2 | 0.094 (0.045–0.19) |
| Endosulfan | 33 | 0.3 | 16±1 | 30±1 | 1 | 0.1 (0.048–0.21) |
| DDT | 70 | 2.7 | 17±1.5 | 28±1 | 2 | 0.53 (0.38–0.84) |
| Dursban | 36 | 0.6 | 13±0.5 | 30±2 | 1 | 0.58 (0.35–0.97) |
| DDD | 40 | 0.6 | 17±1 | 30±2 | 1 | 2.5 (1.6–4) |
| Heptachlor | 33 | 0.5 | 13±1 | 28±1 | 1 | 3 (1–6) |
| Methoxychlor | 70 | 2.9 | 15±0.5 | 28± | 2 | 3.3 (2.1–5.1) |
| Toxaphene | 60 | 2.3 | 17±1.5 | 30±2 | 1 | 4.4 (2–9) |
| Aldrin | 70 | 4.3 | 13±1.5 | 28±2 | 2 | 7.2 (3.4–15.2) |
| Lindane | 65 | 2.4 | 13±1 | 28±1 | 2 | 7.3 (4.5–11.9) |
| Chlordane | 83 | 4.8 | 15±0.5 | 28±2 | 2 | 11.8 (5.7–24) |
| Malathion | 34 | 0.4 | 13±1 | 30±1 | 1 | 14 (13–15) |
| Parathion | 83 | 4.8 | 15±1 | 27±2 | 2 | 17.8 (4.8–65.7) |
| Dieldrin | 78 | 4.3 | 14±0.5 | 28±2 | 3 | 19.7 (9.8–33.4) |
| E.P.N. | 37 | 0.36 | 18±1.5 | 30±1 | 1 | 60 (25–150) |
| Fenthion | 35 | 0.33 | 13±1 | 29±1 | 1 | 453 (216–955) |
| Dibrom | 46 | 0.8 | 13±1 | 30±1 | 1 | 500 (100–2400) |
| Methyl Parathion | 34 | 0.4 | 13±1 | 30±2 | 1 | 790 (170–1400) |
| Carbaryl | 31 | 0.42 | 17±0.5 | 30±1 | 1 | 1000 |
| Abate | 14 | 0.6 | 13±1 | 30±1 | 1 | 1000 |

* Range

Water temperature was not controlled. Previous Winkler oxygen determinations with intermittent flow devices at this facility indicate that satisfactory oxygen levels are maintained with the biomass per tank used in these tests. We did not exceed 1g of fish per liter of water.

All bioassays were 4-day tests (96-hour) using proportional diluters as described by Mount and Brungs (1967). Stock solutions were prepared by dissolving the insecticides in ethanol. Fish were sorted for size and placed 10 per concentration in 80 liter aquaria. The fish were not fed the day before bioassays started or during bioassays. Mortalities were recorded daily, but only the 96-hour results are reported. The $TL_{50}$ (tolerance limits for 50% of the test animals) values were determined by converting the data to logs and probits and calculating a linear regression according to a modification of the Litchfield and Wilcoxin (1949) method. Technical information on insecticides used is listed in Table 2.

## RESULTS

Endrin, Endosulfan, DDT, and Dursban proved to be the most toxic to striped bass with $TL_{50}$ values of less than 1 μg/l. Carbaryl and Abate were at the other end of the scale proving to be relatively nontoxic with $TL_{50}$ values over 1000 μg/l (Table 1).

TABLE 2—**Technical Insecticides Used for Striped Bass Bioassays**

| Pesticide | | Activity* % | Source |
|---|---|---|---|
| Endrin | 1,2,3,4,10,10-Hexachloro-6,7-epoxy 1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo*-*endo*-5,8-dimethanonaphthalene | 99 | City Chemical Co. |
| Endosulfan | 6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide | | |
| DDT | 1,1,1-Trichloro-2,2-bis(p-chlorophenyl) ethane | 77.2 | City Chemical Co. |
| Dursban | 0,0 Diethyl-0-3,5,6-Trichloro-2-pyridyl phosphorothioate | 99+ | Dow Chemical Co. |
| DDD | 1,1-Dichloro-2,2,-bis(p-chlorophenyl) ethane | 99 | City Chemical Co. |
| Heptachlor | 1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene | 99+ | City Chemical Co. |
| Methoxychlor | 1,1,1-Trichloro-2,2-bis-(p-methoxyphenyl) ethane | 89.5 | City Chemical Co. |
| Toxaphene | Chlorinated camphene with 67–69% chlorine | 100 | City Chemical Co. |
| Aldrin | 1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo exo*-5,8-dimethanonaphthalene | 90 | City Chemical Co. |
| Lindane | 1,2,3,4,5,6-Hexachlorocyclohexane | 100 | City Chemical Co. |
| Chlordane | 1,2,4,5,6,7,8,8-Octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindan | 60 | City Chemical Co. |
| Malathion | 5,(1,2-dicarbethoxyethyl)0,0-dimethyldithiophosphate ethyl phosphorodithioate | 95 | American Cyanamid Co. |
| Parathion | 0,0-Diethyl-0-p-nitrophenyl phosphorothioate | -- | American Cyanamid Co. |
| Dieldrin | 1,2,3,4,10,10-Hexachlor-6,7-epoxy 1,4,4a,5,6,7,8,8a-octahydro-*endo*-*exo*-1,4:5,8-dimethanonapthalene | 85 | City Chemical Co. |
| E.P.N. | 0-Ethyl-0-p-nitrophenyl phenylphosphonothioic acid | 87.7 | Du Pont |
| Fenthion | 0,0-Dimethyl-0-[4-(methylthio)-m-tolyl] phosphorothioate | -- | Chemagro Corporation |
| Dibrom | 1,2-Dibromo-2,2-dichloroethyl dimethyl phosphate | 90 | Chevron Chemical Co. |
| Methyl Parathion | 0,0-Diemthyl 0-p-nitrophenyl phosphorothioate | 80 | American Chemical Co. |
| Carbaryl | 1-Naphtyl-N-methylcarbamate | 98 | Union Carbide |
| Abate | 0,0,0′,0′-Tetramethyl 0,0′-thiodi-p-phenylene phosphorothioate | 90 | American Cyanide |

* % of pure compound

## DISCUSSION

It is realized that toxicity values may vary with fish size, temperature and salinity (Eisler 1970). Therefore, the order of descending toxicity presented in Table 1 may be altered with a more uniform size of fish and more controlled environmental conditions. The high variability in the results from certain tests was due to few data points being obtained. This would also affect the order of toxicity. Previous bioassay data in salt water to compare with this study is lacking. Wellborn (1971) reported 96-hour $TL_{50}$ values for malathion and lindane on striped bass in fresh water under static conditions to be 0.24 and 0.40 mg/l, respectively. Our results were much lower, 0.015 and 0.007 mg/l, respectively. This can be explained in part due to the characteristics of static and intermittent bioassays.

All of our results were intermittent flow tests which are more meaningful than static tests. Under static conditions, oxygen and waste products can be stress-inducing factors (Lincer, Solon and Nair 1970). Also, pesticides may be absorbed by fish and glass resulting in higher $TL_{50}$ values (unpublished data, Fish Pesticide Research Laboratory, Columbia, Mo.). Earnest and Benville (1972) found static bioassays generated higher $TL_{50}$ values than intermittent flow tests with two species of fish and four organochlorine insecticides. Since many of the $TL_{50}$ values in the past have been based on static tests, we feel more studies comparing static and intermittent flow tests are warranted. The actual toxicity of other pesticides currently being used in the San Francisco Bay Area may in fact be much higher than expected since toxicities were determined under static conditions.

## ACKNOWLEDGMENTS

The laboratory research was conducted while the Bureau of Sportfisheries and Wildlife maintained a Fish Pesticide Research Laboratory at their Tiburon field station. Under terms of Administration Reorganization Plan No. 4, which became effective October 3, 1970, this field facility at Tiburon was transferred from the Department of Interior to the Department of Commerce. Data analysis and manuscript preparation were completed after the senior author's transfer to the National Marine Fisheries Service.

We are grateful to Doctors Robert Brocksen and Jeannette Struhsaker for reviewing the manuscript.

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# AERIAL CENSUS OF GRAY WHALES IN BAJA CALIFORNIA LAGOONS, 1970 AND 1973, WITH NOTES ON BEHAVIOR, MORTALITY AND CONSERVATION[1]

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**Aerial counts and observations of gray whales, *Eschrichtius robustus* (Lilljeborg), were conducted during the winters of 1970 and 1973 at important calving and mating grounds in Baja California, Mexico. Although the total number of whales on four wintering grounds did not change appreciably between 1964, the year of the last published census, and 1973, there was a decided shift in local distribution. Abundance of whales decreased in Scammon Lagoon, probably due to increased boating activity, but increased in Guerrero Negro Lagoon after commercial shipping terminated in 1967. It is recommended that (1) boating activity on the whale calving grounds be strictly regulated in winter, (2) the present whale refuge consisting of Scammon Lagoon be expanded to include Guerrero Negro and San Ignacio lagoons, and (3) the distribution and abundance of whales on their wintering grounds be assessed annually.**

## INTRODUCTION

California gray whales, *Eschrichtius robustus* (Lilljeborg)[3] return each winter from their summer feeding grounds in the Bering Sea to lagoons of Baja California, Mexico, where they calve and mate (Figure 1). Concentration of whales in and near these shallow lagoons permits convenient enumeration by airplane, as well as ready observation of behavior and mortality. Aerial census of wintering gray whales was initiated by Carl L. and Laura C. Hubbs and Gifford C. Ewing in 1952 and repeated by these and other investigators during most years through 1964. Gilmore (1960) and Hubbs and Hubbs (1967) reported on these censuses.

Since 1964, the year of the last published aerial census, human disturbance on the wintering grounds has generally increased and has shifted among the lagoons. To detect changes in distribution and abundance of whales associated with human activities, the aerial censuses reported here were conducted at the most important calving and mating grounds, namely Scammon, San Ignacio and Guerrero Negro lagoons and Magdalena Bay. Whales in the three lagoons were censused in 1970 and 1973, but whales in Magdalena Bay were enumerated in 1973 only. Additionally, observations of behavior and mortality of whales were made in Scammon Lagoon.

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[1] Information presented here was acquired during biological surveys sponsored by the Belvedere Scientific Fund.

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[3] Following nomenclature proposed by Rice and Wolman (1971).

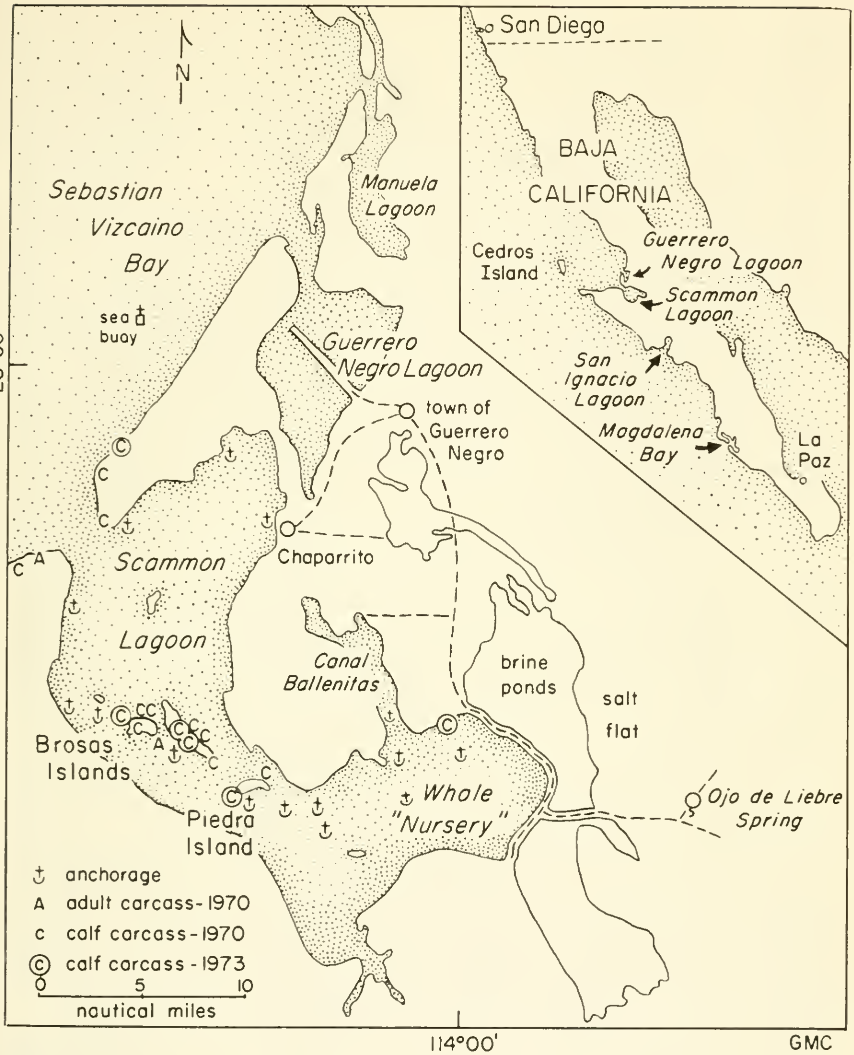


**FIGURE 1.** Reference map of Scammon Lagoon showing location of whale carcasses and anchorage sites. Insert map is of Baja California.

## PHYSICAL FEATURES OF THE CENSUS AREAS

Scammon Lagoon, or Laguna Ojo de Liebre as it is called locally, is situated on the west coast of Baja California approximately 507 km (315 miles) south of the U.S. border (Figure 1). The crescent-shaped lagoon extends from its mouth (lat. 27° 53′ N, long. 114° 18′ W) at the eastern end of Bahia Sebastian Vizcaino to its termination in extensive tidal flats about 48 km (30 miles) to the southeast. A shallow finger of water, Canal Ballenitas, runs from this southeastern bay some 13 km (8 miles) to the north. Another section of the lagoon extends 14 km (9 miles) from its mouth to the northeast where a new barge harbor, Chaparrito, is located. The lagoon covers an area of approximately 466 $km^2$ (180 $miles^2$).

Guerrero Negro Lagoon lies immediately to the north of Scammon Lagoon (Figure 1). It has a length of about 21 km (13 miles), a width of 11 km (7 miles), and an area of about 104 $km^2$ (40 $miles^2$). A narrow causeway extends about 8 km (5 miles) from the southeast shore to an abandoned deep-water dock.

San Ignacio Lagoon is located about 113 km (70 miles) southeast of Scammon Lagoon (Figure 1). It extends from its entrance at lat. 26° 45′ N, long. 113° 15′ W to a tidal flat about 26 km (16 miles) to the north. Varying in width from 3 to 6 km (2 to 4 miles), the lagoon covers and area of perhaps 78 to 130 $km^2$ (30 to 50 $miles^2$) (Gilmore 1960). La Laguna, a small village of fishermen and turtle hunters, is situated on the eastern side of the lagoon.

Within each lagoon are small islands and vast shoal areas coursed by tortuous channels in which strong tidal currents occur. Underwater topography of the lagoons has not been adequately charted and is constantly changing. Visibility to the bottom is poor with the result that navigation is hazardous.

Climate at the lagoons is generally dry, windy and cool. A few inches of rain may fall in winter. The prevailing wind is from the northwest, blowing stronger in the afternoon than in the morning. Considerable fog or low cloud cover occurs in early morning and evening, which with the afternoon winds, tend to keep temperatures cool even in summer. Mean monthly maximum temperatures at Guerrero Negro Lagoon vary from 20 to 35 C (68 to 95 F) while mean monthly minimum temperatures range from —1 to 9 C (30 to 48 F) (Eberhardt 1966).

Because of the dry, windy climate, the lagoons are suitable for the commercial production of salt. This potential is being realized in the diked tidal flats adjacent to Scammon Lagoon. Approximately 5 million tons of salt are harvested annually by residents of the nearby town of Guerrero Negro (population 2 600). Between 1957 and 1967 salt was shipped in deep-draft vessels from Guerrero Negro Lagoon. However, since 1967 salt has been barged from Chaparrito in Scammon Lagoon to Cedros Island where it is transferred to freighters. New navigational aids, installed to facilitate barging of salt, now permit many types of vessels to make the formerly dangerous approach to the lagoon.

The huge Magdalena Bay complex of esteros and bays extends both north and south of its main entrance located at lat 24° 32′ N, long. 112° 04′ W (Figure 1). It is the largest of the gray whale wintering grounds with an area of between 518 and 648 $km^2$ (200 and 250 $miles^2$) (Gilmore 1960). Most of the complex is deeper and more easily navigated than are the lagoons. Several burgeoning fishing villages and a naval base border the complex, and boat traffic has been increasing steadily over the past two decades.

## METHODS

My wife and I conducted a biological survey of Scammon Lagoon from our ketch, BLUE WATER, during the periods January 15–March 6 and June 13–28, 1970 (Gard & Gard 1970). Observations of distribution and behavior of whales were made from the deck of the vessel. We also explored the islands and beaches of the lagoon to locate whale carcasses, collect tympanoperiotic (ear) bones, and evaluate the role of man in the ecology of the gray whale. During February, 1970 we made a brief visit to San Ignacio Lagoon by car.

Two aerial censuses of gray whales were carried out over Scammon, Guerrero Negro, and San Ignacio Lagoons in 1970. The first census, on the afternoons of January 31 (Scammon and Guerrero Negro lagoons) and February 1 (San Ignacio Lagoon) was accomplished in a Cessna 182. Both lagoons were flown between about 1500 and 1615 hours in partly cloudy weather with fresh northwest winds. Flying at an elevation of 122 m (400 ft) and a speed of 129 km.p.h. (80 m.p.h.), we crossed back and forth over the lagoons so that a new strip of water was censused during each crossing. Counts of adult and calf whales from the right and left sides of the plane were summed to give the total number observed. Only the whales within the entrance of Scammon and Guerrero Negro lagoons were censused, but whales both inside San Ignacio Lagoon and in a semicircle of water outside the lagoon (within 3 or 5 km (2 or 3 miles) of the entrance) were censused. A second census was conducted from a Cessna 185 on March 4, 1970, between 0945 and 1310 hours with procedures and weather similar to those of the first census. During this census the whales outside Scammon Lagoon between the entrance and the sea buoy were also counted.

During the winter of 1973, whales were enumerated from a Cessna 185 in a manner similar to that of 1970. San Ignacio Lagoon was censused between 1200 and 1300 hours on 27 February and Guerrero Negro and Scammon lagoons were censused between 0700 and 1000 hours on 28 February. The Magdalena Bay complex was censused on 4 March between 1030 and 1200 hours. Light to moderate northwest winds prevailed throughout the census. An attempt was made to conduct censuses during the morning when winds were lighter and visual conditions better than in the afternoon. Hubbs and Hubbs (1967) reported obtaining substantially lower counts in Scammon Lagoon on a windy afternoon than they obtained the following calm morning.

Each census figure was obtained during only one flight over each wintering ground. Hence it is impossible to compute a mean or a variance or to determine if counts from 2 years or areas are significantly different. During future censuses, I suggest that counts be made for several consecutive mornings on one or two lagoons. The series of observations thus obtained would permit a more meaningful evaluation of census figures.

## RESULTS

### Census

Total counts of gray whales on the major calving and mating grounds increased during the 1950's, but changed very little after about 1960 (Figure 2). These counts should be considered as indices of abundance rather than estimates of total populations because at any given time an unknown portion of a population is beneath the surface where it is not visible from the air.

Although the total population of whales varied only moderately over the years, counts in individual lagoons varied substantially (Figure 3), suggesting that whales moved from one lagoon to another. Shifting of whales between lagoons was probably a response to a changing pattern of boat traffic as indicated in the paragraphs that follow.

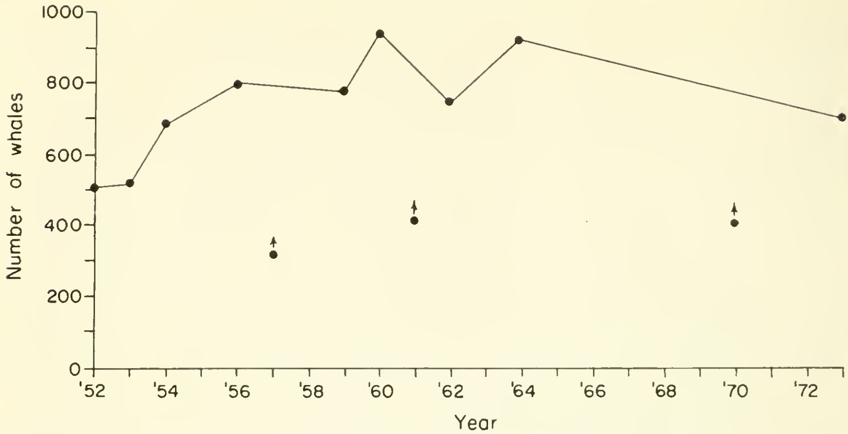


FIGURE 2. Total number of gray whales censused in Guerrero Negro, Scammon (inside only) and San Ignacio lagoons and the Magdalena Bay complex (inside only) during complete census years between 1952 and 1973. Counts for 1957, 1961 and 1970 are not included in the trend line because they are too low due to a late census date, unavoidable haste or poor weather.

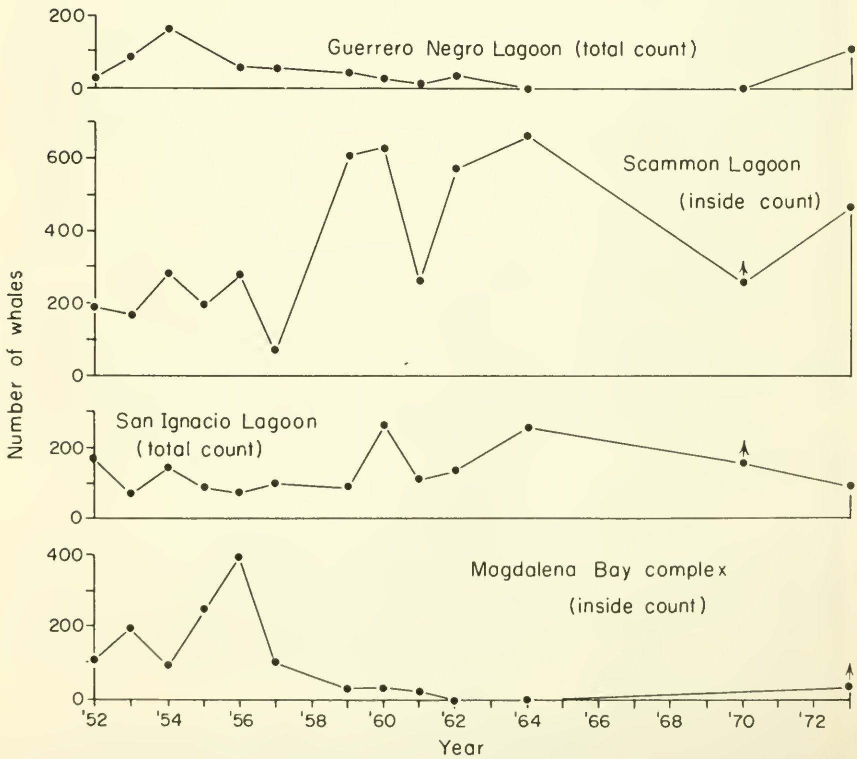


FIGURE 3. Number of gray whales censused on their major wintering grounds of Baja California, 1952–73. Arrows indicate that counts are probably too low due to poor weather (1970) or a late census date (1973).

Abundance of whales in Guerrero Negro Lagoon increased in the early 1950's but then decreased to zero in 1964 and probably remained at that level at least through 1970 (Figure 3). Local residents who were interviewed in 1970 said that only an occasional whale had been seen in the lagoon during recent years. However, 104 whales were counted in the lagoon and just outside the mouth in 1973. Shipping of salt from this lagoon between 1957 and 1967 apparently drove out the whales, but they reinvaded the lagoon in substantial numbers after shipping was eliminated.

In Scammon and San Ignacio lagoons, the number of whales censused generally increased from 1952 to 1964, but subsequently declined (Figure 3). Decrease in whales in Scammon Lagoon after 1964 was probably the result of barging of salt from that lagoon beginning in 1967, coupled with an increase in excursion and pleasure boat traffic (see section cn Conservation). The apparent decline in abundance of whales in San Ignacio Lagoon is not explainable in terms of human activity which has remained nearly constant.

The number of whales in the large Magdalena Bay complex was high during the mid 1950's, but subsequently declined to zero in 1962 (Figure 3). Whales reinvaded the complex some time prior to 1973. Although only 33 were counted, this number was too low because of the late census date (March 4). Norris and Gentry (MS) reported that approximately 86 whales were in residence in the northern part of the complex in late January of 1973. The exodus of whales from the Magdalena Bay complex during the 1960's was probably due to ever increasing fishing boat traffic. When the whales returned, they located in the northern esteros and the extreme southern tip of the complex where human activity is minimal. During the period of peak population, many whales were counted in Magdalena Bay near the main entrance (C. L. Hubbs personal communication), but no whales were seen in this area in 1973.

In summary, although the number of whales wintering in Baja California has remained more or less stable for the past 13 years, the use of individual lagoons and bays has varied as an inverse function of disturbance. The implications of this situation are discussed in a later section of the paper.

## Behavior

Social structure of the populations differed between the inside of the lagoons, and the coast just outside the entrances. Cows with calves were observed inside the lagoons while few calves were recorded on the outside (Table 1). Single adults or breeding pairs or trios were most frequent outside the entrances. In Scammon Lagoon, cows with calves were especially numerous between Brosas Islands and the eastern border including the southern part of Canal Ballenitas.

Although we had no physical encounters with whales while underway, whales did swim into the anchored vessel or the anchor chain on several occasions. Twice they hit the bow with a moderate thump when we were anchored in the inner channels at night. Another whale ran into our stern on a sunny morning with such violence that we were jostled in the cabin. At least six other times whales hit our anchor chain, but veered off before they actually made contact with the vessel. I observed one such encounter from the mainmast: A cow and calf

TABLE 1—Aerial Censuses of Gray Whales in Baja California Lagoons, 1952–1973

| Year | Date | Age group | Scammon Lagoon | | | San Ignacio Lagoon | | | Guerrero Negro Lagoon | Magdalena Bay Area |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Outside | Inside | Total | Outside | Inside | Total | Outside plus inside | Inside |
| 1952 [1] | Feb. 16–20 | adults | 246 | 158 | 404 | 152 | 17 | 169 | 35 | 71 |
| | | calves | 1 | 35 | 36 | 2 | 2 | 4 | 1 | 35 |
| | | all | 247 | 193 | 440 | 154 | 19 | 173 | 36 | 106 |
| 1953 [2] | Feb. 25–27 | adults | 86 | 129 | 215 | 21 | 41 | 62 | 77 | 151 |
| | | calves | 5 | 39 | 44 | -- | -- | 8 | 10 | 42 |
| | | all | 91 | 168 | 259 | -- | -- | 70 | 87 | 193 |
| 1954 [1] | Feb. 14–21 | adults | 189 | 194 | 383 | 69 | 53 | 122 | 142 | 90 |
| | | calves | 14 | 92 | 106 | 12 | 8 | 20 | 22 | 0 |
| | | all | 203 | 286 | 489 | 81 | 61 | 142 | 164 | 90 |
| 1955 [3] | Feb. 26–Mar. 4 | adults | -- | 121 | -- | 20 | 34 | 54 | -- | 214 |
| | | calves | -- | 69 | -- | 4 | 28 | 32 | -- | 37 |
| | | all | -- | 190 | -- | 24 | 62 | 86 | -- | 251 |
| 1956 [2] | Feb. 14–17 | adults | 67 | 214 | 281 | 26 | 37 | 63 | 38 | 363 |
| | | calves | 1 | 65 | 66 | 3 | 10 | 13 | 16 | 30 |
| | | all | 68 | 279 | 347 | 29 | 47 | 76 | 54 | 393 |
| 1957 [2] | Feb. 27–Mar. 8 | adults | 215 | 56 | 271 | 55 | 26 | 81 | 47 | 74 |
| | | calves | 27 | 14 | 41 | 2 | 14 | 16 | 11 | 23 |
| | | all | 242 | 70 | 312 | 57 | 40 | 97 | 58 | 97 |
| 1959 [1] | Feb. 20–26 | adults | 377 | 432 | 809 | -- | -- | 69 | 35 | 21 |
| | | calves | 16 | 180 | 196 | -- | -- | 22 | 10 | 5 |
| | | all | 393 | 612 | 1,005 | -- | -- | 91 | 45 | 26 |
| 1960 [1] | Feb. 18–21 | adults | 124 | 493 | 617 | -- | -- | 219 | 17 | 24 |
| | | calves | 2 | 141 | 143 | -- | -- | 42 | 9 | 3 |
| | | all | 126 | 634 | 760 | -- | -- | 261 | 26 | 27 |
| 1961 [1] | Feb. 25–27 | adults | 140 | 188 | 328 | -- | -- | 79 | 7 | 26 |
| | | calves | 22 | 77 | 99 | -- | -- | 29 | 5 | 1 |
| | | all | 162 | 265 | 427 | -- | -- | 108 | 12 | 27 |
| 1962 [4] | Feb. 18–21 | adults | 104 | 451 | 555 | -- | -- | -- | 31 | 0 |
| | | calves | 2 | 124 | 126 | -- | -- | -- | 2 | 0 |
| | | all | 106 | 575 | 681 | -- | -- | 140 | 33 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1964 [5] | Feb. 20–24 | adults | 252 | 498 | 750 | -- | -- | 242 | 0 | 0 |
| | | calves | 0 | 173 | 173 | -- | -- | 16 | 0 | 0 |
| | | all | 252 | 671 | 923 | -- | -- | 258 | 0 | 0 |
| 1970 [6] | Jan. 31–Feb. 1 | adults | -- | 192 | -- | 23 | 89 | 112 | 0 | -- |
| | | calves | -- | 60 | -- | 4 | 42 | 46 | 0 | -- |
| | | all | -- | 252 | -- | 27 | 131 | 158 | 0 | -- |
| 1970 [7] | Mar. 4 | adults | 39 | 133 | 172 | 31 | 89 | 120 | 0 | -- |
| | | calves | 7 | 42 | 49 | 5 | 31 | 36 | 0 | -- |
| | | all | 46 | 175 | 221 | 36 | 120 | 156 | 0 | -- |
| 1973 [8] | Feb. 27–28, Mar. 4 | adults | 42 | 271 | 313 | 29 | 40 | 69 | 69 | 25 |
| | | calves | 0 | 204 | 204 | 8 | 17 | 25 | 35 | 8 |
| | | all | 42 | 475 | 517 | 37 | 57 | 94 | 104 | 33 |

[1] Censused by C. L. and Laura C. Hubbs and G. C. Ewing.
[2] Censused by R. M. Gilmore, and G. C. Ewing.
[3] San Ignacio Lagoon censused by R. M. Gilmore and G. C. Ewing; Scammon Lagoon censused by F. B. Phleger, R. Langford and G. C. Ewing on February 4.
[4] Censused by C. L. and Laura C. Hubbs, G. C. Ewing, L. C. Kuebler, G. E. Lindsay, E. S. Gardner and Eva Ewing.
[5] Censused by C. L. and Laura C. Hubbs, G. C. Ewing, T. J. Walker, R. W. Elsner and Jean Filloux.
[6] Censused by R. and Sylvia S. Gard, M. Rueda, J. F. Castillo and W. Swan (pilot).
[7] Censused by R. and Sylvia S. Gard, J. F. Castillo and F. Morales (pilot).
[8] Censused by R. and Sylvia S. Gard, M. Rueda, C. Sweeney and F. Morales (pilot).

swimming a few feet underwater ran into the anchor chain causing the boat to lurch and necessitating my clutching the mast to keep from being thrown from the boatswain's chair. In most cases, closely-approaching whales veered away from the vessel or sounded as soon as they became aware of its presence. All the collisions occured within several hours after the boat was anchored in a new area, indicating that the whales quickly learned the location of a vessel and avoided the area.

Physical contact between gray whales and the anchor chain of a vessel was reported by Huey (1928) in San Ignacio Lagoon. A skiff was actually holed by a whale during an expedition to Scammon Lagoon to implant electrodes in whales for studies of the heart beat (White and Matthews 1956). Also, Scammon (1874) vividly reported incidents of small boats being smashed by gray whales pursued by whalers. I believe that physical encounters between gray whales and vessels are accidental unless the whales are angered by harassment. Despite their huge size, they are remarkably timid. Inadvertent collisions probably resulted from the whales' inability to see well directly ahead through the murky lagoon waters. Regardless of the active or passive nature of encounters, they do occur and it is unwise to pursue or closely approach gray whales in a skiff.

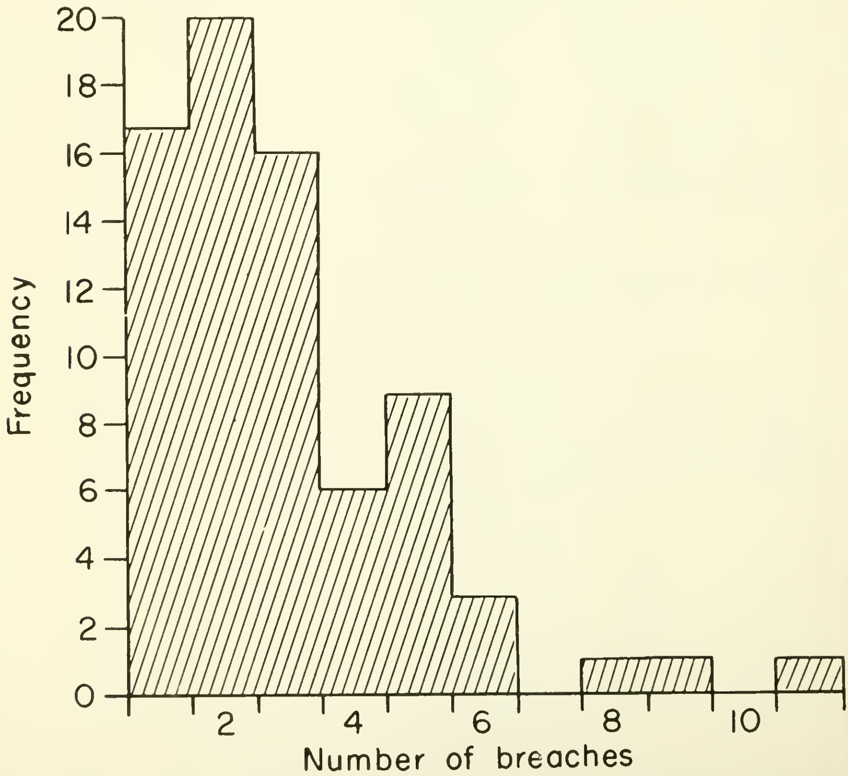


FIGURE 4. Frequency of number of breaches in sequence for 74 gray whales in Scammon Lagoon, 1970.

In the lagoons, gray whales often jump (breach) nearly clear of the water and crash back into the water sometimes on their backs. Often they jump two or more times in sequence with periods of 10 or more seconds separating breaches. I recorded the number of breaches in sequence in Scammon Lagoon on 74 occasions and found that the grays usually jumped one to three times in sequence though one individual jumped 11 times (Figure 4). This propensity for jumping has been an important factor in attracting a large clientele of whale watchers.

## Mortality

Relative mortality of calf and adult whales was estimated from samples of carcasses. Remains of 12 whales that died in 1970 were located on the islands in the lagoon or on beaches immediately outside the entrance. Ten of the 12 carcasses (83%) were calves. In 1973, only six fresh carcasses (all calves) were found. Approximately the same areas were surveyed during 1970 and 1973. When samples from the 2 years were combined, 16 of 18 carcasses (89%) were calves.

Size and texture of tympanoperiotic bones collected in 1970 and 1973 were used to separate calves from adults and provided a second method of determining relative mortality. Length was defined as the maximum dimension with the long axis of the bone held parallel to the shaft of the calipers. Ear bones attached to skeletons could be grouped in pairs, but the majority of the bones were collected singly and could not be paired. Therefore, the length of each bone was recorded. Adult bones are large and rough compared to calf bones. Twenty-two bones in the sample of 224 were 101 mm (3.97 inches) in length and longer and were judged to be adult on the basis of size and texture (Figure 5). All of the 202 bones 100 mm in length and shorter (90% of the sample) were considered to have come from calves, although a few may have been adult bones diminished in size by erosion.

The two methods indicate that calves account for about 90% of the total mortality in Scammon Lagoon. However, only 21% of all whales censused in and near Scammon Lagoon since 1952 were calves (Table 1). Clearly mortality of calves was much higher than mortality of

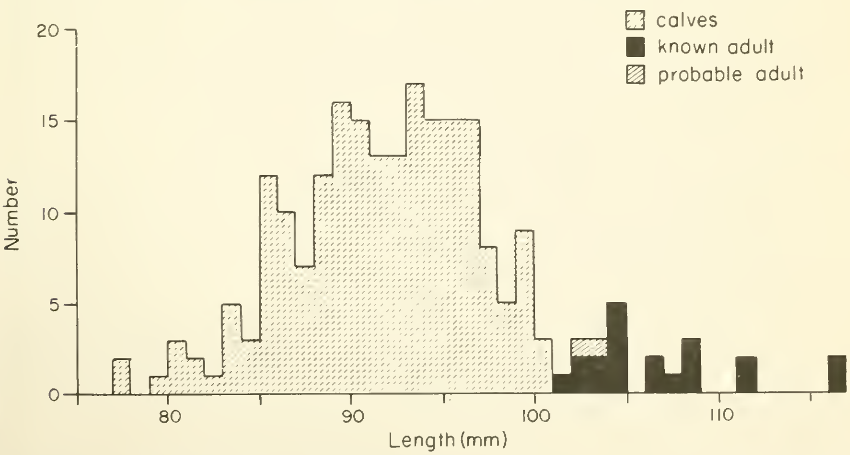


FIGURE 5. Length—frequency of 224 tympanoperiotic bones of gray whales from Scammon Lagoon, 1970 and 1973.

adults. Eberhardt and Norris (1964) also noted high infant mortality in gray whales.

## CONSERVATION

In the fall of 1971 the Mexican government established a National Whale Refuge at Scammon Lagoon—the first preserve of its kind in the world. This highly commendable act came none too soon as most evidence indicates that gray whales are greatly disturbed by human activity which has been increasing at the lagoon. Continuing improvement of road and airport systems in Baja California has brought yearly increases in air- and land-based whale watching, but the most serious threat to the whales has arrived from the sea. In 1970 the first excursion boat entered Scammon Lagoon for the purpose of observing and photographing whales (Gard and Gard 1970). This successful venture was followed by about 8 excursions in 1971 and 16 excursions in 1972. Approximately 30 trips were made during the 1973 season. As each vessel remained in the lagoon for about $2\frac{1}{2}$ days, an average of about 1.7 excursion vessels plus their small outboard boats were in the lagoon each day during the height of the 1973 whale-watching season (January 15 to March 1). All this boat traffic superimposed on the twice daily round trips by the salt barges and increasing visits by seagoing yachts and trailable vessels could be a serious disturbance to the gray whales during the critical phase of life history, namely, the period of calving and mating.

As a result of the recent increase in boat traffic, the following recommendations are suggested for preserving the tranquility of the whale calving grounds:

(1) Regulation of boat traffic in the Scammon Lagoon whale refuge during the calving season is imperative. It would be best to prohibit boats from entering the lagoon in winter, but if they are permitted to enter, a fee should be charged. The income from such fees would defray in part the cost of patrol.

(2) Vessels that are permitted to enter, except those engaged in authorized research projects, should be excluded from the inner portions of Scammon Lagoon southeast of the Brosas Islands. This is the ''nursery'' area where most of the cows and calves occur. Protection of this area is especially important because calves have a much higher mortality rate than do adults.

(3) A refuge manager should be on duty during the winter months to enforce the regulations concerning boat traffic.

(4) Consideration should be given to adding Guerrero Negro and San Ignacio lagoons to the whale refuge. Protection should be extended to these lagoons because both now accommodate sizeable populations of whales and human disturbance of these areas will surely increase.

(5) An aerial census of the whales should be conducted annually on the wintering grounds to monitor changes in numbers and distribution of whales as they relate to changing human activities.

Twice in the past 100 years the gray whale has been brought to the point of extinction by whaling. With protection since 1937 the whales have prospered, but there is evidence that the population has leveled off. The key to the well-being of the gray whale today is the undisturbed lagoons of Baja California. We must not permit human activity, however well intentioned, to precipitate a third decline of this valuable and interesting species.

## ACKNOWLEDGMENTS

I am most grateful to Mr. Kenneth Bechtel and the Belvedere Scientific Fund for two grants covering expenses of the 1970 and 1973 investigations. Carl and Laura Hubbs and Raymond Gilmore graciously permitted me to use their earlier census figures for the lagoons. Robert Eberhardt provided charts and background information. Messrs. Charles Sweeney, John Bremmer, Felix Urquizu, Mario Rueda and Jose Castillo of Exportadora de Sal S. A. furnished information and field assistance. Willis Swan provided his airplane for one of the censuses and Louis Henrich advised on sampling techniques. George Lindsay permitted me to use a California Academy of Sciences camper during the 1973 investigation. A. Starker Leopold and my wife, Sylvia S. Gard assisted with many phases of the study. To all these people and organizations I extend my sincere thanks.

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# NOTES

## MISSISSIPPI SILVERSIDES AND LOGPERCH IN THE SACRAMENTO-SAN JOAQUIN RIVER SYSTEM

The Mississippi silversides, *Menidia audens* Hay, and the logperch, *Percina caprodes* (Rafinesque), are two species of fish recently introduced into California that are rapidly expanding their ranges in the Sacramento-San Joaquin River system. The logperch was accidently introduced in 1953, into three ponds on Beale Air Force Base, Yuba County, which overflow into tributaries of the Yuba River (McKechnie 1966). Farley (1972) collected a logperch from the San Joaquin River near Mendota, indicating their range in California had greatly expanded. Mississippi silversides were introduced into Clear Lake and upper and lower Blue lakes, Lake County, in 1967, largely to help control the Clear Lake gnat, *Chaoborus astictopus* (Cook and Moore 1970). The population in Clear Lake has exploded. Recent collections indicate that they are now the single most abundant littoral zone species. They have not previously been recorded in California outside the Clear Lake Basin. This paper reports recent collections of the two species in the main Sacramento-San Joaquin River system and their introduction into reservoirs in Alameda and Santa Clara counties, in drainages that are part of the Sacramento-San Joaquin system.

Between August, 1972 and November, 1973 numerous fish collections were made with small mesh seines in sloughs and creeks flowing into the lower Sacramento River and the Sacramento-San Joaquin Delta as part of various research projects on the native fishes. These collections show the logperch to be abundant and widely distributed and the Mississippi silversides to be present in Putah and Cache creeks, Yolo County (Figure 1). On 2 August 1972, a collection was made in a large pool on Cache Creek near Capay, about 25 miles upstream from the Sacramento River and about 55 miles downstream from Clear Lake. Along with numerous white catfish (*Ictalurus catus*), several species of centrarchids, carp (*Cyprinus carpio*), and goldfish (*Carassius auratus*), the collection contained hundreds of Mississippi silversides and one logperch. The collection indicates that the Mississippi silversides has access to the main Sacramento-San Joaquin River system, because the logperch could only have moved upstream from the Sacramento River and the silversides downstream from Clear Lake. A similar conclusion can be reached from Putah Creek collections made on 20 July and 9 October 1973, in which a total of six Mississippi silversides and three logperch was taken from the creek on the University of California, Davis campus, about 15 miles upstream from the Sacramento River. Additional logperch have been collected there at other times. Fifteen other species were collected from the same area. Since Putah Creek below the dam at Winters (upstream from Davis) was completely dry in September 1972, these fish must either have moved upstream from the Sacramento River (including the logperch) or downstream via irrigation canals from Clear Lake (Mississippi silversides).

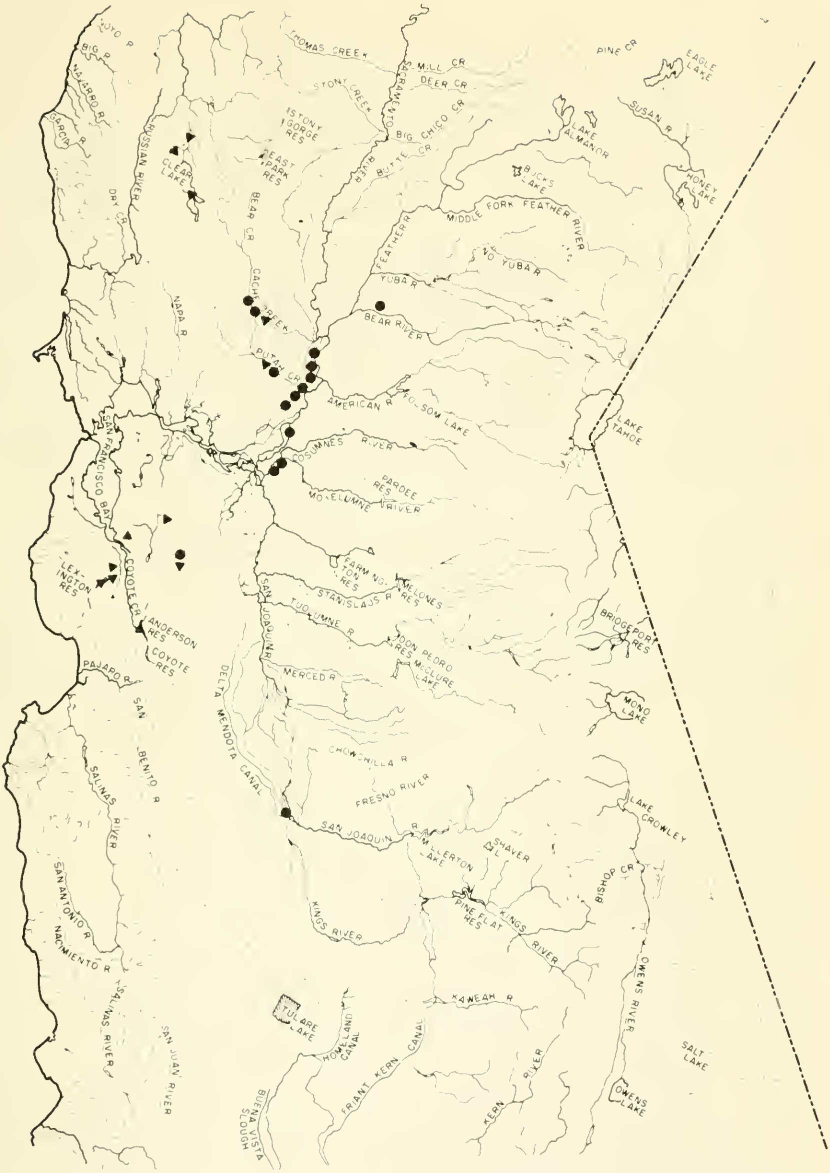


**FIGURE 1. Recent records of Mississippi silversides (triangles) and logperch (circles) in California.**

Both species are also found in reservoirs which drain into south San Francisco Bay. Logperch have been found thus far only in Del Valle Reservoir, Alameda County, where they are abundant. They presumably were pumped into the reservoir from the Sacramento-San Joaquin Delta via the Tracy pumping plant and South Bay Aqueduct. Mississippi silversides are now found in at least eight reservoirs and ponds in Alameda and Santa Clara counties. All the fish apparently originated from an authorized experimental introduction into three ponds near Dell Avenue in Campbell, Santa Clara County, on 5 January 1968. The introduction consisted of 750 fish from Clear Lake. On 29 April 1969, 1,500 silversides were seined from the ponds and planted in Lake Elizabeth, in the Central Park of Fremont, Alameda County. On 27 May 1970, 1,000 fish were taken from Lake Elizabeth and planted in Shadow Cliffs Lake, Alameda County. Populations are now established at all three localities.

Although the above three introductions were authorized by California Department of Fish and Game personnel, a number of unauthorized introductions have been made into other reservoirs in the area, presumably by bait fishermen using fish from the original introduction sites. Silversides were collected from Lexington Reservoir, Santa Clara County, a large impoundment on Los Gatos Creek, in 1969. From Lexington Reservoir they have spread downstream to Vasona Reservoir and a series of ponds along Camden Avenue, Campbell. In September 1972, silversides were collected in Del Valle Reservoir, presumably the result of an unauthorized introduction. The numbers and size classes of silversides collected indicate they have been in the reservoir since at least 1971. Finally, on 12 October 1973, numerous silversides were taken from Anderson Reservoir, Santa Clara County, on Coyote Creek. Method and date of introduction are unknown, but the size classes present indicate they have been there at least one year.

Our information indicates that the logperch is well established and widespread in the lower Sacramento-San Joaquin River system, and that Mississippi silversides probably soon will be. The effect these two species may have on the fishes and invertebrates of the system, especially the Sacramento-San Joaquin Delta, is not known but neither is likely to be beneficial. The bottom living logperch has low value as a forage fish (Applegate, Mullan, and Morais 1966) and the presence of eggs in the stomachs of logperch collected from one slough (Moyle, unpublished data) indicates they can be significant predators on fish eggs, especially those of centrarchids. The effect of the Mississippi silversides on the Clear Lake ecosystem is controversial and has yet to be properly evaluated. However, as it is both a littoral and pelagic zooplankton feeder (Saunders 1959) and tolerant of brackish water (Hubbs, Sharp, and Schneider 1971), it could develop large populations in the Sacramento-San Joaquin Delta, adversely affecting the ecologically-similar Delta smelt (*Hypomseus transpacificus transpacificus*) and, perhaps, juvenile striped bass (*Morone saxatilis*). Although they can be important as forage fish in reservoirs (Mense 1967), they are unlikely to provide additional forage for game fishes but only replace species already present.

## ACKNOWLEDGMENTS

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# CHUM SALMON OBSERVATIONS IN FOUR NORTH COAST STREAMS

The reported occurrence of chum salmon, *Oncorhynchus keta* (Walbaum), in California waters is uncommon. They have been taken from the San Lorenzo River, Santa Cruz County (Scofield, 1916), and are occasionally seen in the Klamath River (Snyder, 1931). A minor run has been reported in the Sacramento River (Hallock and Fry, 1967). A single chum was caught in the ocean off Del Mar in 1955 by the purse seiner *Saint Louis* (Messersmith, 1965) and a troll caught specimen was landed at Bodega Bay in 1966 (Wild, 1967).

On September 13, 1973, a 69.9 cm (27.5 inch) FL gravid female chum salmon was captured during salmon trapping operations in Freshwater Creek, A Humboldt Bay tributary. This fish was taken to the California Department of Fish and Game's Eureka field office and positively identified by L. B. Boydstun and John B. Robinson of the Department's Anadromous Fisheries Branch.

The capture of this fish prompted inquiries regarding the occurrence of chum salmon in other north coast streams. As a result, unpublished reports of their presence in three more streams were brought to light.

In December of 1951, loan chum salmon were observed on two occasions in the Mad River drainage, Humboldt County (Elton D. Bailey and Leroy T. Mongold, pers. comm.). The first was seen December 13 in Canyon Creek 91 m (100 yards) above its confluence with Mad River and 26.5 km (16.5 miles) from the ocean. The second was observed December 19 in the North Fork Mad River 3.2 km (2 miles) above its confluence with the main stem and 20.9 km (13 miles) from the ocean. This fish was captured and found to be a nearly spent female 70.5 cm (27.75 inches) long, FL.

In late November 1970, an unidentified angler caught a male chum salmon in spawning condition about 11.2 km (7 miles) above tidewater in the Smith River. A photograph of this fish is on file in the Department's Eureka field office. The photograph was taken by Larry Lammers, Route 1, Box 420, Crescent City, in the presence of Warden Albert L. Clinton, at Saxton's Tackle Shop. Mr. Saxton, the proprietor of the shop, said, "Two other chum salmon were caught in the Smith River that year but the anglers were never identified".

## REFERENCES


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Messersmith, J. D. 1965. Southern range extensions for chum and silver salmon. Calif. Fish Game 51(3):220.

Scofield, N. B. 1916. The humpback and dog salmon taken in San Lorenzo River. Calif. Fish Game 2(1):41.

Snyder, John O. 1931. Salmon of the Klamath River, California. Calif. Div. Fish and Game, Fish Bull. (34):1–130.

Wild, Paul W. 1967. An occurrence of a chum salmon, *Oncorhynchus keta* (Walbaum), in the California troll fishery. Calif. Fish Game 53(4):299–300.



*David W. Rogers, Region 1, Inland Fisheries, Department of Fish and Game.*


*Accepted January 1974.*

## RANGE EXTENSION OF THE CHINA ROCKFISH

On 24 September 1972 Vucci found a China rockfish, *Sebastes nebulosus*, 289 mm SL, in a trash can of filleted rockfish carcasses aboard the party boat *China Clipper*. Skipper Jon Ward stated that the specimen was caught by hook and line near Castle Rock, San Miguel Island (lat. 34°03'N, long. 120°26'W) in 20 fm of water. Mr. Ward remembered having seen about 10 China rockfish caught in the same area. Because the fish had been filleted, we could not determine its weight. However, except for the lateral musculature, most of the fish was intact. This allowed us to make a positive identification and length measurements.

Previously, the southernmost China rockfish reported came from Diablo Cove, where five were taken (Burge and Schultz 1973). The San Miguel specimen represents a range extension of about 70 miles. It was deposited at the California Academy of Sciences.

### REFERENCES

Burge, Richard T. and S. A. Schultz (1973) Marine environment in the vicinity of Diablo Cove with special reference to abalones and bony fishes. Calif. Dep. Fish and Game, Mar. Res. Tech. Rept. 19: 1–433.

*Milton S. Love, Department of Biology, University of California, Santa Barbara and John Vucci, Santa Barbara Underseas Foundation, Santa Barbara, California 93017.* *Accepted January 1974.*

# BOOK REVIEW

***Hawaiian Reef Animals***

**By Edmund Hobson and E. H. Chave, The University Press of Hawaii, 1972; 135 p., illustrated in color. $7.50.**

Anyone who intends to visit the Hawaiian Islands for snorkeling or SCUBA diving should have a copy of this beautiful book. The fine color photographs and text cover the major groups of fish and invertebrates found on Hawaiian reefs. Each family is discussed in terms of the more common species one would expect to encounter. The authors have endeavored to obtain and present information regarding the Hawaiian legends, myths, and importance of each species to the Hawaiian fishermen.

The narrative also includes life history data, Hawaiian, English, and scientific names. The color photographs show 66 species of sharks and bony fish, and 20 species of invertebrates.

I was disappointed in the text's lack of distinguishing characters for most species, particularly in the case of animals that are very difficult to identify on sight. For example, the authors point out that recent studies indicate that the common long-nosed butterfly fish is actually *Forcipiger flavissimus* and that *F. longirostris* is the rarer form; yet no information is given as to how to separate these two species.

Diving laymen, as well as scientists, should find this book a highly useful introduction to Hawaiian fauna, and the price is right.—*Daniel W. Gotshall*

***Fishes of the Western North Atlantic—Part 6, Order Heteromi, Suborder Cyprinodontoidei, Orders Berycomorphi, Xenoberyces, and Anacanthini in part (Macrouridae).***

**Daniel M. Cohen, Editor-in-chief; Sears Foundation for Marine Research, Yale Univ., New Haven, Conn., 1973; xix + 698 p., illustrated; $27.50.**

At long last, 25 years after Part 1 was published and 7 years after Part 5, Part 6 of FWNA has become available for purchase. At that rate, few of us who were budding ichthyologists when this series was first spawned will still be alive when the last volume emerges.

The present format encompasses two radical departures from that of previous volumes, and since both are capable of accelerating production, they obviously are welcome changes for that reason alone. With Part 6, FWNA no longer follows a phylogenetic arrangement—henceforth, we are informed, the included material will depend upon "availability of completed works on coherent taxonomic units." Also with this volume, "descriptions of un-named species and other categories" are included for the first time. These new-to-science items have been noted with boldface type in the table of contents and index so they are easily spotted. Hopefully, they have not been superceded in the interim between manuscript submission and publication.

Contributors to Part 6 are: S. B. McDowell (Order Heteromi); D. E. Rosen (Suborder Cyprinodontoidei); L. P. Woods and P. M. Sonoda (Order Berycomorphi); A. W. Ebeling and H. W. Weed, III (Order Xenoberyces), N. B. Marshall and D. M. Cohen (Order Anacanthini) and N. B. Marshall and T. Iwamoto (Family Macrouridae).

Some of the keys are real nightmares of complexity and contain such an assortment of internal and skeletal characters, that to check each item as presented would completely destroy the specimen at hand before a specific name could be assigned. For such rare fishes as halosaurs, and notacanths, there should be a better system.

Rosen's illustrated keys to brackish and salt-tolerant killifishes offer a refreshingly useful approach to identifying the critters which belong to this confusing group of sexually dimorphic ambiguities. I still anticipate that I'll have problems, however, especially in identifying females and young.

I was surprised to find that broad geographic ranges had been ascribed for several beryciform fishes when the "study material" was comprised only of Atlantic specimens. In my otolith collection, I have sagittae from Madeiran and eastern north Atlantic *Beryx splendens* and *B. decadactylus* (type localities) which are significantly distinct from sagittae removed from the supposed same two species from central and western north Pacific waters. The same is true of otliths from a New Zealand *Diretmus* af. *aureus*, which in FWNA is synonymized with *D. argenteus*, apparently without having examined the type of *aureus*. In attempting to check out a trachichthyid, I found that the "two supramaxillae" given as a family character on p. 298 should read "one," but generally typos, erroneous statements, and other anomalous items are noticeably lacking.

In their brief treatment of Order Anacanthini (confined to characterizing families) Marshall and Cohen place *Steindachneria* in its own family for the first time, and show that Eretomophoridae (Jordan, 1923) takes precedence over Moridae (Svetovidov, 1937).

As with previous volumes of FWNA, the information contained in Part 6 has long been needed and is extremely useful. Neither content nor treatment has suffered since the inception of the series, and fortunately, the purchase price has not increased since Part 3 appeared in 1963. I would not anticipate this latter statement to apply in the future, however. Since these various accounts are by "the experts," I would like to see subsequent synopses contain an occasional evaluation of the fossil record, which until now has been neglected for the most part. I would also like to see noted a date of submission or acceptance for each account. As it is, one has to search references, lists of synonyms, and other places in order to determine the time lapse between submission and publication—*John E. Fitch.*

***Toward Global Equilibrium:*** **Collected Papers. Edited by Dennis L. Meadows and Donalla H. Meadows. Copyright Allen Press, Inc. 238 Main St., Cambridge, Mass. 02142; 1973. ix + 358 p. $18.**

This book is a technical sequel to the *Limits of Growth* and the earlier work of Jay Forrester entitled *World Dynamics. Toward Global Equilibrium* is the second volume published by the systems dynamics group at M.I.T. under the sponsorship of the Club of Rome.

The heart of the book consists of papers which describe in detail, models of pollution, resource, and population problems. The first paper deals with DDT in the global environment. This model will be of great interest to anyone studying the long range trends of an environmental contaminator such as DDT. Based on available data the model indicates that DDT will persist in ocean food webs long after the cessation of application.

The second paper, "System simulation to identify environmental research needs: Mercury contamination" points out how modeling can assist in formulation for control of mercury pollution.

Fishery biologists will find the third paper, "The eutrophication of lakes" of interest. The model's principle components are oxygen, detritus, nutrients, and biomass.

The next three papers deal with resource utilization. The titles are: (1) "The dynamics of natural resource utilization", (2) "The dynamics of solid waste generation" and (3) "The discovery life cycle of a finite resource: A case study of U.S. natural gas". The latter paper focuses on what effects various policies will have on the production and consumption of natural gas. The life expectancy of this resource is only 15 years.

The last paper of this section, "Population control mechanisms in a primitive society", focuses on the natural means of population control which keeps the *Tsembagas* of New Guinea below the carrying capacity of their environment. This system is extremely vulnerable to adverse changes. The encroachment of Western cultural values and/or technology would likely cause growth and an overshoot of carrying capacity.

The final section of the book is comprised of four interpretive papers. The first is "Determinants of long-term resource availability". This paper presents the life expectancy estimates for 19 non-renewable resources and advocates better long-term resource management policies.

The other paper of interest is "The carrying capacity of our global environment: A look at the ethical alternatives". This paper indicates global disaster on an unprecedented scale unless population growth and the growth of industrial capital are halted soon. Essentially a classical overshoot of carrying capacity and a crash to a lower level is predicted given the assumptions in the model.

The authors advocate the attainment of the equilibrium state. While not being completely utopian they do seem overly optimistic that a long-term "golden age" can be sustained well into the future if we can just stabilize world population and industrial capital soon.

In reality it would appear that such a prognostication has to rest on technological breakthroughs that cannot be predicted from their models because even a stationary population and economy will eventually exhaust non-renewable resources unless the second law of thermodynamics is circumvented. Nonetheless a speedy transition to an equilibrium state is our best hope for long range survival. The authors advocate a world where quality supercedes quantity. Lifting out time horizons, changing attitudes, and bringing about greater material equality in the world are some of the steps we must take to bring about the equilibrium state. The current "do nothing" attitude toward overpopulation and overindustrialization indicates that a good many politicians and leaders could benefit by reading this book.—*Lee W. Miller*

## ERRATA

Sunada, John S. 1974. Age and growth of the Pacific Saury, *Cololabis saira*. Calif. Fish Game. 60(2):64-73.

Figures 2 and 4 are transposed. The captions are correct in their present location.

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State of California

# FISH AND GAME COMMISSION

Notice is hereby given that the Fish and Game Commission will meet on June 28, 1974, at 9:00 a.m. in the City Council Chambers of the City Hall, 3300 Newport Boulevard, Newport Beach, California, to receive recommendations from its own officers and employees, from the department, and other public agencies, from organizations of private citizens, and from any interested persons as to what, if any, orders should be made relating to resident game birds for the 1974–75 hunting season.

Notice is hereby given that the Fish and Game Commission shall meet on August 16, 1974, at 9:00 a.m. in Room 1194 of the State Building, 455 Golden Gate Avenue, San Francisco, California, to hear and consider any objections to regulations proposed for resident game birds for the 1974–75 hunting season.

This notice is published in accordance with the provisions of Section 206 of the Fish and Game Code.

LESLIE F. EDGERTON
*Executive Secretary*

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