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THE RIBBONFISHES (FAMILY TRACHIPTERIDAE) OF THE EASTERN PACIFIC OCEAN, WITH A DESCRIPTION OF A NEW SPECIES[1]

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INTRODUCTION

Although ribbonfishes are widely distributed in most world seas, being known from the Arctic Ocean, Atlantic Ocean, Pacific Ocean, Indian Ocean and Mediterranean Sea, they are poorly-understood as a group. All undergo allometric growth, some changing rather radically in body shape, fin length, etc. between their larval stages and adulthood (Hubbs, 1926). They are quite delicate, and among some species, intact individuals are the exception rather than the rule. Probably fewer than half of the ribbonfishes captured or found each year reach the hands of trained biologists or are deposited in museums.

As a result of these various circumstances, more than 30 different specific names have been assigned to ribbonfishes throughout the world, perhaps three times as many as are valid. Often a single species has been given 10 or more scientific names, particularly a cosmopolite which undergoes a radical series of morphological changes. On the other hand, some species have remained unrecognized and thus undescribed.

Four species are known in the eastern Pacific, but probably only one of these is endemic. Three are taken fairly frequently by California commercial and sport fishermen. Many individuals are captured at night in purse seines or lampara nets set for sardines, tunas, and other pelagic schooling species; perhaps equal numbers are brought in by albacore trollers who have found them on deck where albacore have spit them up. Occasionally a large individual is caught in an otter trawl being fished along the bottom in several hundred fathoms of water, and other large individuals sometimes are found floundering in the surf or are picked up on the beach where they were flung by the waves. Larvae, juveniles, and adults are not unusual in plankton tows or midwater trawls; and one specimen was even caught from a dock on a baited hook. Wherever and whenever they are found, questions arise as to their identity, origin, habits, life-history, importance, etc. Even before Californa was settled by the white man, ribbonfishes were known among the coastal Indians. Our commonest species, *Trachipterus altivelis,* was called King-of-the-salmon by Indians of the Pacific Northwest because they believed these beasts led salmon runs into the rivers each year. This same fish has been given four different scientific names (unintentionally) in the eastern Pacific during the last 105 years—two off South America, and two off California.

[1] Submitted for publication June 1964.

In recent years, Walters and Fitch (1960) published a review of the genera belonging to the ribbonfish family, and Palmer (1961) reviewed and revised the species found in the Mediterranean and eastern north Atlantic. However, until now, there has never been a critical review or an attempt to understand the ribbonfishes of the eastern Pacific. In this paper, I have attempted to cover all aspects of their systematics and biology that are presently known.

Most of the specimens I examined were deposited in the fish collections of the University of California, Los Angeles (UCLA), but some were sent to the United States National Museum (USNM), the Chicago Natural History Museum (CNHM), Stanford University (SU), and the Los Angeles County Museum (LACM).

SYSTEMATIC ACCOUNT

The eastern Pacific ribbonfishes comprise three genera and four species, as presented in the following key and descriptive material.

Key to the Eastern Pacific Ribbonfishes, Family Trachipteridae

1. Ventral profile scalloped between pelvic fin bases and the anus. Lateral line wavy on tail. Color pattern of dark vertical bars or bands. Scales deciduous, imbricated, cycloid. Dorsal rays 135 to 145. Vertebrae 63 to 69_____ Scalloped ribbonfish, *Zu cristatus* (p. 229)

   Ventral profile entire. Lateral line straight on tail. Color pattern uniform, polka-dotted, or a few large dark spots or longitudinal blotches. Scales absent or modified ctenoid. Dorsal rays 160 or more. Vertebrae 80 to 109____________________________________ 2

2. Color pattern uniform or polka-dotted. Tubercles along midventral line never sharp-tipped. Scales deciduous, nonoverlapping, modified ctenoid. Two or more pairs of lateral line plates per postanal vertebra. Caudal rays always parallel to body axis. Vertebrae 104 to 109 _______Polka-dot ribbonfish, *Desmodema polysticta* (p. 231)

   Color pattern uniform or with several equidistant, very large black spots and one or more longitudinal blotches. Tubercles along midventral line sharp-tipped. Scales absent. One pair of lateral line plates per postanal vertebra. Upper caudal fin lobe upturned and perpendicular to body axis. Vertebrae 69 to 94_________________3

3. Ventral body contour straight for entire length. Dorsal contour descending in a straight line from nuchal crest to caudal fin origin. Vertebrae 90 to 94______King-of-the-salmon, *Trachipterus altivelis* (p. 233)

   Ventral and dorsal body contours converge behind the anus (to within about an eye's diameter of each other) and continue posteriorly nearly parallel to each other, forming an elongate strap-like tail. Vertebrae 69 to 72_______Tapertail ribbonfish, *Trachipterus fukuzakii* sp. nov. (p. 236)

Scalloped ribbonfish, *Zu cristatus* (Bonelli, 1820)

Distribution: Known from all tropic and temperate world seas, but rare in the eastern Pacific, having been found off Newport Beach, California, off Cedros Island, Baja California, and east of the Galapagos Islands, Ecuador.

Material Examined: Three larvae (8.0 to 10.0 mm SL), one juvenile (213 mm SL), and one adult (535 mm SL) were examined, but only the juvenile (Figure 1) and adult were used to compose my description.

Standard length (mm)	*Date of capture*	*Method of capture*	*Locality of capture*
8.0	8 Nov. 1955	plankton net	lat. 05°28′N., long. 88°26′W.
10.0	24 Oct. 1955	plankton net	lat. 02°06′N., long. 93°03′W.
10.0	20 Feb. 1956	plankton net	lat. 01°02′S., long. 87°03′W.
213.0	18 Jan. 1947	dip net	Cedros Isl., Baja Calif.
535.0	22 Nov. 1906	?	Idzu, Japan

Description: D 6, 132-138 (50-55 to vertical of anus); P_1 11-12; P_2 6; C 9 + 2; gill rakers 11; lateral line scales 114-118; vertebrae 63 (24 precaudal).

The general body form is apparent in the photograph (Figure 1). The ventral profile is scalloped between the pelvic fin bases and the beginning of the tail, being straight (horizontal) from there to the caudal fin (the curvature seen in Figure 1 was caused by preservation).

The dorsal profile descends in a relatively straight line from the nuchal crest to the upturned caudal rays. Juveniles and adults have about six wavy dark vertical bars on the dorsal part of the trunk, and four on the ventral part. The tail has about six complete vertical dark bars, and the terminal four-fifths of the caudal fin is darkly pigmented. The lateral line commences on the nuchal crest about half-way between the eye and the dorsal contour, curves downward to just over the opercle and then progresses posteriorly in a relatively straight line, reaching the ventral contour about one-half head length behind the anus. From that spot to the caudal fin, the lateral line undulates as

FIGURE 1. Juvenile scalloped ribbonfish, *Zu cristatus*, 213 mm SL, captured at Cedros Island, Baja California, January 18, 1947. *Photograph by Jack W. Schott.*

scales from opposite sides of the body alternately align along the ventral contour. The body is covered with cycloid, imbricated, deciduous scales.

Natural History: No information was obtained on the natural history of this species, which apparently does not attain the lengths reported for other ribbonfishes. The largest known seems to be a specimen 1,105 mm TL from the Mediterranean (Tortonese, 1958).

Discussion: *Trachypterus cristatus* was first described by Bonelli (1820) from the Mediterranean. *T. semiophorus* described by Bleeker (1868) from the Indo-Pacific, and *T. ijimae* described by Jordan and Snyder (1901) from Japan, seem to be the only Pacific forms that are conspecific. Walters and Fitch (1960) erected the genus *Zu* for this ribbonfish, briefly discussing its relationship with other genera in the family. Palmer (1961) gives a fairly complete account of *Zu cristatus*, including Atlantic synonyms.

Polka-dot ribbonfish, *Desmodema polysticta* (Ogilby, 1897)

Distribution: Known from all tropic and temperate world seas, being abundant offshore in the eastern Pacific where it has been recorded at many localities between Monterey, California, and the Galapagos Islands, Ecuador.

Material Examined: One larva (11 mm SL), nine juveniles (57.5 to 191 mm SL), and four young and adults (>450 to 1,106 mm SL) from the eastern Pacific were used to compose my description. In addition, I examined 10 other specimens from the eastern Pacific, one juvenile 110 mm SL from Sagami Bay, Japan (SU 23783 labeled *T. misakiensis*), and the 50.4 mm holotype of *T. deltoideus* from Rurutu Island (CAS 5532).

Standard length (mm)	Date of capture	Method of capture	Locality of capture
11.0	9 Oct. 1956	plankton net	lat. 09° 56′ N., long. 109° 59′ W.
57.5	30 July 1953	midwater trawl	lat. 37° 06′ N., long. 140° 11′ W.
60.5	2 Dec. 1955	plankton net	lat. 11° 48′ N., long. 88° 25′ W.
>73.0	21 Jan. 1954	lancetfish stomach	lat. 28° N., long. 132° W.
>80.0	1 Dec. 1954	albacore stomach	200 miles off Monterey, Calif.
117.0	18 Jan. 1954	lancetfish stomach	lat. 34° N., long. 132° W.
167.0	18 May 1955	lancetfish stomach	lat. 33° 39′ N., long. 135° 00′ W.
179.0	2 Feb. 1954	lancetfish stomach	lat. 35° N., long. 137° W.
191.0	2 Feb. 1954	lancetfish stomach	lat. 35° N., long. 137° W.
–	16 Oct. 1955	lancetfish stomach	lat. 01° 58′ N., long. 110° 39′ W.
>450	13 Apr. 1962	midwater trawl	220 miles SW of Ensenada, Mexico
>750	15 Apr. 1953	purse seine	60 miles SE of Cape San Lucas, Mexico
>790	2 Dec. 1958	midwater trawl	lat. 16° 01′ N., long. 100° 54′ W.
1106	Sept. 1962	midwater trawl	520 miles SW of San Pedro, California

Description: D. 187-215 (45-70 to vertical of anus); P_1 12-14; P_2 9-10; C 5-8; gill rakers 11-14; lateral line scales 262-306 (88-120 to vertical of anus); vertebrae 104-109 (20-25 precaudal).

FIGURE 2. Juvenile polka-dot ribbonfish, *Desmodema polysticta*, 191 mm SL, taken from lancetfish stomach caught on longline gear February 2, 1954, at lat. 35° N., long. 137° W. *Photograph by Jack W. Schott.*

The general body form is apparent in the photographs (Figures 2 and 3), which illustrate the extreme changes between the juvenile and adult stages. Posterior to the anus the body tapers rapidly into an extremely long, filamentous tail, terminating in a caudal fin having rays which are on the same axis as the body (various terminal portions of the tail are usually missing, resulting in unrealistic counts and measurements). The lateral line progresses posteriorly in a relatively straight line along the midside, and there are more than two pairs of lateral line scales per postanal vertebra. The anus is often situated on the right or left side of the body instead of on the ventral midline. Through about 300 mm SL the head and trunk are covered with numerous large, dark polka-dots, but these are absent in adults. The body is covered with non-imbricate, elliptical scales each with two slightly divergent spinose ridges. The gill chambers of adults are very darkly pigmented, and the dorsal fin is quite black along the entire rat-like tail.

Natural History: Almost every year, albacore fishermen bring in from 1 to 10 or more juvenile polka-dot ribbonfish that were spit up by fish they caught. Most of these apparently were ingested while the albacore were feeding far beneath the surface. Numerous other juveniles were found in the stomachs of lancetfish, *Alepisaurus borealis,* caught on longline gear fishing 500 to 1,000 feet beneath the surface (Figure 2). Only two of the *Desmodema* I examined had any food in their stomachs and these contained (i) an unidentified squid, and (ii) one blackdragon, *Idiacanthus antrostomus,* two amphipods, *Phronima sed-*

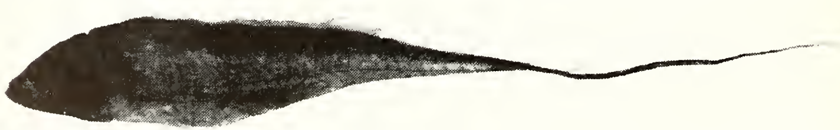

FIGURE 3. Adult polka-dot ribbonfish 750 mm long captured at night in a purse seine 60 miles southwest of Cape San Lucas, Baja California, June 15, 1953. At least 250 mm is missing from the tail of this fish. *Photograph by Jack W. Schott.*

entaria, and two arrowworms, *Sagitta* sp. Only the large adult (> 750 mm) taken southwest of Cape San Lucas in April 1953 (Figure 3), showed any indications of the onset of maturity, and its eggs were barely commencing to enlarge. The largest individual I have seen was 1,106 mm SL; it weighed 340 grams. I have no information on *Desmodema* growth rates or ages.

Discussion: *Desmodema polysticta* was first described from New South Wales by Ogilby (1897) as *Trachypterus jacksoniensis polystictus*. Walters and Fitch (1960), in reviewing the ribbonfishes, erected the generic name *Desmodema* for this species. Among the Pacific ribbonfishes, *T. misakiensis* Tanaka (1908) from Japan and *T. deltoideus* Clark (1938) from Rurutu Island are conspecific with the polka-dot ribbonfish, *Desmodema polysticta*.

King-of-the-salmon, *Trachipterus altivelis* Kner, 1859

Distribution: Eastern Pacific Ocean from Chile to Alaska and offshore halfway to the Hawaiian Islands.

Material Examined: Over 100 individuals were examined during the course of this study, but only 9 larvae (7 to 28 mm SL), 7 juveniles (54 to 270 mm SL), and 10 young and adults (340 to 1,565 mm SL) were used in composing my diagnostic and descriptive accounts.

Standard length (mm)	Date of capture	Method of capture	Locality of capture
7.0	12 June 1951	plankton net	lat. 34° 13′ N., long. 125° 54′ W.
8.4	17 June 1950	plankton net	lat. 38° 40′ N., long. 126° 21′ W.
10.4	12 June 1951	plankton net	lat. 29° 32′ N., long. 116° 37′ W.
10.7	17 June 1950	plankton net	lat. 38° 40′ N., long. 126° 21′ W.
11.0	7 June 1949	plankton net	lat. 37° 51′ N., long. 129° 03′ W.
12.8	17 June 1950	plankton net	lat. 38° 40′ N., long. 126° 21′ W.
14.0	5 May 1950	plankton net	lat. 33° 53′ N., long. 126° 35′ W.
17.0	15 May 1951	plankton net	lat. 33° 14′ N., long. 121° 26′ W.
28.0	3 April 1950	plankton net	lat. 36° 45′ N., long. 123° 00′ W.
53.5	25 Aug. 1955	albacore stomach	off San Nicolas Island, California
69.0	25 July 1955	albacore stomach	off San Clemente Island, California
106.0	18 May 1955	lancetfish stomach	lat. 33° 39′ N., long. 135° 00′ W.
197.0	19 Dec. 1955	purse seine	Cortez Bank
232.0	1 April 1954	lampara	Los Angeles Harbor
255.0	Sept. 1957	albacore stomach	60 miles off Point Arguello, California
270.0	3 Sept. 1952	purse seine	off Pt. Fermin, Calif.
>300.0	27 Jan. 1963	lancetfish stomach	lat. 34° 55′ S., long. 92° 43′ W.
340.0	20 May 1958	lampara	Horseshoe Kelp, Calif.
355.0	17 Oct. 1949	purse seine	Point Dume, California
525.0	17 Oct. 1949	purse seine	Point Dume, California
535.0	May 1953	dip net	Santa Catalina Island, California
560.0	17 Oct. 1949	purse seine	Point Dume, California
630.0	17 Oct. 1949	purse seine	Point Dume, California
1,350.0	5 Jan. 1962	otter trawl	Eureka, Calif.
1,562.0	24 May 1958	lampara	Pacific Grove, California
>1,565.0	14 Nov. 1963	otter trawl	Eureka, California

Description: D 5-6, 160-178 (72-80 to vertical of anus); P_1 10-11; P_2 6-7; C 7-8 + 6; gill rakers 12-16; lateral line scales 106-122 (66-81 to vertical of anus); vertebrae 90-94 (35-40 precaudal, 50-55 preanal).

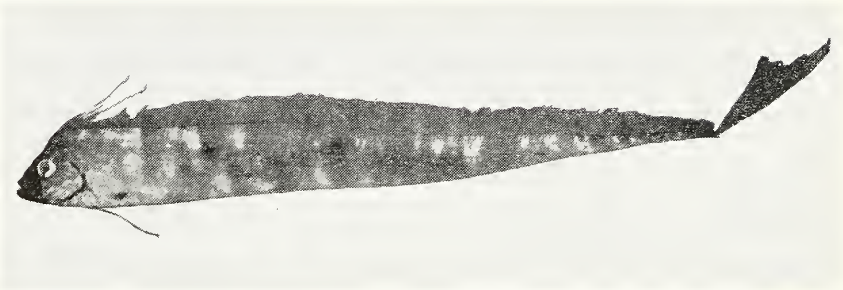

FIGURE 4. Young king-of-the-salmon, *Trachipterus altivelis,* 560 mm SL, caught in a purse seine off Point Dume, California, on October 17, 1949. *Department of Fish and Game photo by Al Johns.*

The general form of the body is apparent in the photograph (Figure 4). The ventral contour is approximately straight (parallel with the body axis) for its entire length, while the dorsal contour descends evenly and in a straight line from the nuhcal crest, above the eye, to the caudal attachment. The upper caudal lobe has well-developed rays set at a right angle to the body axis; the rays of the lower lobe usually persist as spine-like protuberances. Juveniles and young adults of both sexes usually have two rows of dark blotches along each side. The upper row normally contains four blotches; the anteriormost of these is the smallest and always at the dorsal contour beneath the 18th to 28th dorsal rays. The succeeding three blotches are evenly-spaced along the side, midway between the lateral line and the dorsal contour. The lowermost row normally contains a single blotch at the ventral contour, one eye diameter behind the pelvic insertion. A juvenile, 197 mm SL, captured at Cortez Bank off southern California had five blotches in the upper row and two in the lower. Scales are absent at all sizes (except along the lateral line). There are enlarged, sharp-tipped fleshy tubercles along the midventral contour.

Natural History: King-of-the-salmon ribbonfishes, while not common, are unquestionably more abundant than records of their occurrence indicate. They often are captured at or near the surface (four were taken in a single purse seine haul), but equal numbers have been found in the stomachs of deep-feeding albacore and lancetfish, or have been taken in trawl nets fished as deep as 350 fathoms.

The stomachs of many *T. altivelis* have contained an assortment of small fishes, cephalopods, and crustaceans, and a polychaete worm. A fish netted off Point Dume, California, in October 1949 had eaten five small pelagic octopi and several amphipods. A large adult trawled in 200 fathoms outside of Eureka had in its stomach two euphausiids (each $1\frac{1}{2}$ inches long), a 1-inch long rockfish (*Sebastodes* sp.), two, 4-inch lanternfish (*Lampanyctus* sp.), a 1-inch long squid, six sets of cephalopod beaks, and a seamouse (*Aphrodite* sp.) 2 inches long. Identifiable fish remains in others were (i) two Mexican lampfish, *Lampanyctus mexicanus,* and three blacksmelt, *Bathylagus* sp., (ii) one blue lanternfish, *Tarletonbeania crenularis,* and (iii) one hatchetfish, *Argy-*

ropelecus sp., and one smoothtongue, *Leuroglossus stilbius.* A small ribbonfish spit up by an albacore had eaten 11 euphausiids, *Euphausiia pacifica,* and the only king-of-the-salmon caught on a baited hook, bit on a small strip of fresh queenfish, *Seriphus politus,* fillet.

Ripe adult females (1,562 and > 1,565 mm SL) were captured in May and November, but spawning probably takes place throughout the year. Plankton hauls, made by the various agencies of the California Cooperative Oceanic Fisheries Investigations (CalCOFI), have yielded numerous eggs and larvae. E. H. Ahlstrom, Bureau of Commercial Fisheries, La Jolla (pers. commun.) said, "We routinely list *Trachypterus* larvae from our hauls, but not eggs." He further stated that, "*Trachypterus* larvae have been collected throughout the year, but the largest number of larvae and most occurrences fall in June and July. The larvae are not common, as is apparent from the few occurrences per year." During four years for which records were available (1950, 1951, 1952, and 1955), 88, 32, 39, and 14 *Trachipterus* larvae, respectively, were taken in 965, 1,440, 1,475, and 1,375 samples (plankton tows). Ahlstrom stated that, "The higher frequency of occurrence in 1950—in about 9% of the stations occupied—probably results from our more northerly coverage of that year. Of the 88 occurrences, 55 were off central and northern California (to the north of Pt. Conception), 28 were off Southern California, and 5 were off Baja California."

The larvae of *T. altivelis* are sufficiently developed at small sizes that they can be identified by counting their vertebrae. All 91 vertebrae of a specimen 28 mm SL were well-enough calcified to take a stain (alizarin), and the position of the first haemal spine was readily determinable. On the other hand, in a specimen 11 mm long only the anteriormost 41 vertebrae would stain, and none of these had haemal processes.

The largest individual previously reported was the 1,520 mm holotype of *T. seleniris;* however, three of my specimens exceeded that size. My largest was a ripe female exceeding 1,565 mm (at least three terminal vertebrae were missing which would have added more than 100 mm to its standard length). This fish had been caught in an otter trawl on November 14, 1962, by the boat *Ina* which was fishing on the bottom in 270 to 330 fathoms off Eureka, California. It weighed slightly less than 9 pounds (4,035 grams), but no attempt was made to determine its age.

Mr. Harry Turver, Yucaipa, informed me (pers. commun.) he sent a huge specimen (over 5½ feet long) to the U. S. National Museum that was taken at Santa Cruz, California, a number of years ago. I did not see this specimen (USNM 119655) but it is said to be about 1,750 mm SL in its present condition, which would make it the largest known.

The otoliths (sagittae) of several *T. altivelis* were examined during my study, and although they were quite small, they did show good "growth rings" under high magnification. Standard lengths, weights (when available), and ages for these were (i) 405 mm, 60 g, 1 year, (ii) 575 mm, 150 g, 2 years, (iii) 845 mm, 360 g, 3 years, (iv) 1,350 mm, 5 years, and (v) 1,550 mm, 2,740 g, 7 years. One other large individual (1,090 mm SL) was weighed (1,220 g) but its age was not determined. Hognestad (1962) believed the otoliths of *Trachipterus arcticus* did not show clear growth zones, but was able to count 12 annuli on stained vertebral sections of a 220 cm specimen.

Parasitic roundworms were found in the stomachs of several individuals, but these remain unidentified at this time. Tapeworms occasionally were noted in the intestinal tracts of large specimens. Nishimura (1963) reported upon two species of parasitic helminths in the Japanese *T. ishikawai,* a close relative of *T. altivelis.*

Discussion: *Trachipterus altivelis* Kner 1859, was described from a specimen 20½ inches long, taken off Valparaiso, Chile. Kner's figure shows the typical black blotching of the species, tubercles on the midventral line, and enlarged lateral line scales each with a central antrorse spine. The figure is rather poorly drawn; however, and most of the characters are out-of-proportion. As the specific name indicates, the rays of the dorsal fin of this particular fish were quite long and the drawing tends to over-emphasize this feature. In the figure (Kner, 1859), the dorsal rays about at the fish's midlength are equal in length to the body depth at that point. Several California specimens of similar length showed similar tendencies, while California fish 53.5 to 355 mm SL had dorsal rays at that point that were half again as long as the body depth at the anus.

The king-of-the-salmon ribbonfish was next described as *Trachypterus weychardti* by Philippi in 1874, again from Chile, and not until 20 years later was the species described from California waters as *Trachypterus rexsalmonorum* by Jordan and Gilbert. Their description was based upon an immature fish 285 mm long from San Francisco. Fourteen years later, in 1908, Snyder described *Trachypterus seleniris* from a 1,520 mm ribbonfish taken off Monterey, California. Hubbs (1925) showed that Snyder's fish was merely the adult of *T. rexsalmonorum,* but neither he nor earlier workers associated the California ribbonfish with that found in Chilean waters. My study has shown that in the eastern Pacific *weychardti, rexsalmonorum,* and *seleniris* are synonyms of *altivelis.*

Tapertail ribbonfish, *Trachipterus fukuzakii* sp. nov.

Distribution: Eastern Pacific Ocean from central Baja California to Ecuador.

Differential Diagnosis: This species can be distinguished from all other members of the family in the eastern Pacific by the body shape and vertebral count. It has 69 to 72 vertebrae of which 25 to 28 are precaudals and 40 to 42 preanals. It may be distinguished from the

FIGURE 5. Holotype of tapertail ribbonfish, *Trachipterus fukuzakii,* 674 mm SL, captured in a purse seine south of Ceralbo Island, Gulf of California, May 6, 1955. *Photograph by Jack W. Schott.*

South African *T. nigrifrons* (which closely resembles it in body shape) by the vertebral count. *T. nigrifrons* has 82 or 83 vertebrae of which 37, 38, or 39 are precaudal and about 48 preanal.

Material Examined: Holotype: USNM 175344, an immature female 674 mm SL (Figure 5) from Ceralbo Island, Gulf of California, caught the night of May 6, 1955, by the San Pedro purse seiner *Defense* with a school of yellowfin tuna, *Thunnus albacares*. **Paratypes:** USNM 175345, a mature female 1,061 mm SL and CNHM 62162, sex unknown, 716 mm SL, both caught during the night of June 15, 1953, by the San Pedro purse seiner *Stella Maris* 60 miles SW of Cape San Lucas, Baja California; SU 50172, an immature female 1,088 mm SL caught in June 1955 by the San Pedro purse seiner *Western Star* 160 miles SW of Cape San Lucas, Baja California. **Other Material Examined:** one badly damaged specimen longer than 1,530 mm SL removed from the stomach of a bigeye tuna, *Thunnus obesus*, taken on longline gear by the California Department of Fish and Game research vessel *N.B. Scofield* off Ecuador at lat. 02° 04′ N., long. 83° 02′ W., November 16, 1955; a fragmentary adult spit up by a yellowfin tuna off Guatemala at lat. 13° 21′ N., long. 92° 55′ W., October 4, 1956; a ripe female longer than 1,110 mm SL (tail missing) caught by the San Pedro purse seiner *Anthony M* 20 miles west of Turtle Bay, Baja California, during July 1956 (three or four others captured in the net at the same time were not saved).

Description: D 5-6, 157-168 (68-73 to vertical of anus); P_1 11-13; P_2 ?; C 7-9 + 6-7; gill rakers 11-12; lateral line scales 91-105 (60-72 to vertical of anus); vertebrae 69-72 (25-28 precaudal, 39-42 preanal).

Description of Holotype: D 5 + 169 (5 + 68 to vertical of anus); P_1 12; P_2 ?; C 8 + 7; gill rakers 11; lateral line scales 101 (70 to vertical of anus); vertebrae 69 (26 precaudal, 41 preanal).

The general form of the body is apparent from the photograph (Figure 5). Greatest depth is about one head-length in advance of the anus, and from about this point, the dorsal and ventral contours gradually converge posteriorly forming an elongate tapered tail that makes up slightly more than one-third of the total length. The fish, an immature female, measures 674 mm in standard length. Head length 8.6, maximum body depth 9.0, preanal length 2.3, in standard length. Maximum body depth 3.9 in preanal length. Eye diameter 3.9 in head length. Longest pectoral ray 2.6 in head length.

There are several, strong, incurved canine-like teeth in each jaw and one strong backcurved tooth on the head of the vomer.

The scaleless body is everywhere covered with oval-shaped, osseous pads. On the ventral contour these form several rows of stiff, pointed, fleshy papillae which diminish in size caudally.

The lateral line commences midway between the eye and the first ray of the crest, curves downward and backward to a point just over the pectoral fin and then runs posteriorly in a straight line until it is just above and parallel to the ventral contour on the distal part of the tail. The lateral line consists of separate, short, bony plates in the anterior part of the body. From a point slightly in advance of the anus the lateral line scales (plates) increase in length successively until just before the caudal fin, where they are again reduced. Each plate bears a sharp antrorse spine in the middle of its length, those on the posterior part of the body being the strongest.

The rays of the pennant (crest-like anteriormost dorsal rays) are short and scarcely distinguishable from the succeeding rays of the dorsal fin. The dorsal rays are granular and each ray has a pair of strong outward-pointed spines at its base. The pelvic fins have become obsolescent and are indicated only by a bristle-like protuberance at the ventral contour. The upper lobe of the caudal fin has well-developed rays which are perpendicular to the body axis.

When fresh, the dorsal and caudal fins were bright crimson. The pectorals were semi-transparent but flushed with a pinkish hue. The entire body was metallic silver and there was an ovate, black blotch at the dorsal contour under rays 23 to 27. Another ovate black blotch occurred at the ventral contour about one eye diameter behind the pelvic insertion. The tail region was darkly pigmented from the vicinity of dorsal ray 121 to the base of the caudal fin at dorsal ray 174. There was considerable dusky to black pigmentation in the head region and under the opercles.

The following data are presented in tabular form on the holotype and three paratypes. All measurements are in millimeters.

	Holotype	*Paratypes*		
	USNM 175344	USNM 175345	CNHM 62162	SU 50172
Standard length	674	1,061	716	1,088
Preanal length	293	476	314	456
Head length	78	132	82	140
Head width	18	32	19	31
Body depth at occiput	69	110	78	114
Body depth at anus	53	84	56	86
Body width at occiput	13	19	12	21
Eye diameter	20	38	23	36
Longest pectoral ray	30	46	--	--
Anus to pectoral insertion	216	345	243	320
Branchiostegal rays	6	6	6	6
Sex	♀	♀	--	♀
Maturity	immat.	ripe	unk.	immat.

Natural History: Judging by the great number of specimens caught by purse seiners while fishing for tuna, primarily *Thunnus albacares,* the species is probably quite abundant throughout its range. (Many of the ribbonfishes caught by purse seiners are discarded because they have no commercial value.) They are usually taken at night, often several in a single set of the net, indicating they are somewhat gregarious, and that they do approach the surface, at least at night. Their presence in the stomachs of deep-feeding tunas also would indicate they probably live part of their lives at depths of 500 to 1,000 feet or more. A diurnal migration is suggested.

The ovaries of a large female 1,061 mm SL captured 60 miles southwest of Cape San Lucas by the seiner *Stella Maris* on June 15, 1953, contained thousands of large, apparently gravid eggs. Another large female captured in mid-July off Turtle Bay, Baja California, was also gravid. This would suggest mid-summer spawning, at least in the northern part of their distribution.

The stomach of a large female netted 60 miles southwest of Cape San Lucas contained a pelagic galatheid crab, *Pleuroncodes planipes,* as did the stomach of a 1,088 mm specimen captured 160 miles southwest of Cape San Lucas. These crabs are extremely abundant in the eastern tropical Pacific Ocean where they live at or near the surface most of the year. The stomach of a badly mangled specimen spit up by a yellowfin tuna at lat. 13° 21′N., long. 92° 55′W. contained the remains of eight mantis shrimp, *Squilla* sp. There were five parasitic roundworms in the stomach of one of the large adults.

The largest tapertail observed to date was 1,530 mm long, even with one to three terminal vertebrae missing. A specimen 1,300 mm long weighed 2,045 grams, and its otoliths had 5 winter rings on them.

It is with a great deal of pleasure that I name this species in honor of Mr. Ben Fukuzaki, a San Pedro boat owner and fisherman whose keen interest in the creatures of the sea has led him to save and donate to science most of the animals he captures that are either unknown to him or which he recognizes as rare or unusual. As a result, in the past 20 years, he has given the California Department of Fish and Game more than 15 young and adult ribbonfish of three species including the first two known specimens of the species which now honors his name.

ACKNOWLEDGMENTS

Many individuals have helped me immeasurably during the nearly 20 years I have been accumulating information on eastern Pacific ribbonfishes. Unfortunately, I have delayed publishing this account for so many years (but not all of the delay was of my doing) that some colleagues to whom I owe a debt of gratitude have died in the interim.

E. H. Ahlstrom, U.S. Bureau of Commercial Fisheries, La Jolla, loaned me numerous larval specimens, and sent me a great deal of information on egg and larval occurrence and abundance off California; Frederick H. Berry, U.S. Bureau of Commercial Fisheries, Brunswick, Georgia, loaned me several adult *Desmodema* and offered helpful suggestions; Charles R. Clothier (deceased) spent many hours clearing and staining material from which I made meristic counts and obtained other information; W. I. Follett, California Academy of Sciences, San Francisco, permitted me to examine the holotype of *T. deltoideus;* Carl L. Hubbs, Scripps Institution of Oceanography, La Jolla, loaned me numerous specimens and made available some very rare references from his personal library; W. L. Klawe, Inter-American Tropical Tuna Commission, La Jolla, loaned me some Chilean specimens; Jack W. Schott, California State Fisheries Laboratory, took the excellent photographs I used to illustrate this paper; Bell Shimada (deceased) sent me material he had collected off Central America; J. L. B. Smith, Rhodes University, South Africa, loaned me X-rays of the holotype of *T. nigrifrons;* Margaret Storey (deceased) spent many hours attending to my ribbonfish needs from the Stanford University collection; Harry Turver, Yucaipa, furnished me with details on the largest known king-of-the-salmon; and Vladimir Walters, University of California, Los Angeles, worked with me during the middle stages of this project but eventually became too involved in other chores to finish the job.

Innumerable fishermen went out of their way to save preserved and frozen material at every opportunity, and many additional colleagues at California State Fisheries Laboratory gave a great deal of their time and knowledge, particularly J. L. Baxter and P. Patricia Powell.

If I have failed to acknowledge some special assistance, it has not been intentional, and I hope I will be forgiven the oversight.

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AGE AND LENGTH COMPOSITION OF THE SARDINE CATCH OFF THE PACIFIC COAST OF THE UNITED STATES AND MEXICO IN 1961-62[1]

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INTRODUCTION

This is the 16th report in a series giving age and length composition of the catch of Pacific sardines, *Sardinops caeruleus* (Girard), off the Pacific coast of North America. These have been prepared on a seasonal basis since 1941-42.

We wish to acknowledge the assistance given by Harold Hyatt of the California Department of Fish and Game and by Makoto Kimura of the U.S. Bureau of Commercial Fisheries.

THE FISHERY

During the 1961-62 season, 2,200 tons of sardines were landed in central California, August 1, 1961, through March 2, 1962, and 21,498 tons in southern California, September 1 through March 2. During the interseason, January 1 to the beginning of the respective seasons, landings totaled 1,896 tons. The 1961-62 period total for all California was 23,698 tons. For several prior years the season in both central and southern California had ended December 31. In 1961 it was extended to March 1, of the following year, making March 2 the last delivery date. This report, therefore, covers sardine landings of the period January 1, 1961, through March 1, 1962.

Landings during the season include both cannery and fresh fish market deliveries. Most of the latter are iced or frozen and sold for bait, chiefly in the San Francisco region, where sardines are regarded as the best bait in the striped bass sportfishery.

Interseason sardine landings include not only fish sold for bait but also a special summer pack. This pack, first permitted in 1929, gives canneries an opportunity to develop packs in small cans which might compete with imported "sardines." This privilege was suspended by the Legislature in 1949 as the result of the decline in sardine landings. On June 1, 1961, the special pack again became legal, and one processor, taking advantage of this, purchased sardines during June through August for a 6½-ounce fillet pack.

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TABLE 1

Calendar Dates of Lunar Months During 1961-62

Lunar month	*Lunar period*	*Dates*
"January"	510*	January 2—January 31
"February"	511	February 1—March 1
"March"	512	March 2—March 30
"April"	513	March 31—April 29
"May"	514	April 30—May 28
"June"	515	May 29—June 27
"July"	516	June 28—July 27
"August"	517	July 28—August 25
"September"	518	August 26—September 24
"October"	519	September 25—October 23
"November"	520	October 24—November 22
"December"	521	November 23—December 22
"January"	522	December 23—January 21 (1962)
"February"	523	January 22—February 19
"March"	524	Febrary 20—March 20 †

* Lunar months have been numbered serially since "November" 1919.
† 1961-62 period ended March 1.

In Baja California, cannery fishing is permitted throughout the year. For this report, the period is divided into two parts, season and interseason, the dates coinciding with those of southern California. Season and interseason landings were 8,551 tons and 11,752 tons respectively, a period total of 20,303 tons.

Central California

The season opened August 1 in central California (Point Arguello northward), but for the most part the boats remained in port until the latter part of the month because fish were scarce. Landings at Monterey, Moss Landing, and Morro Bay during the first dark (Table 1) were 197 tons. During "September," 349 tons were landed; during "October," 524 tons; during "November," 324 tons; during "December," 104 tons; during "January," 485 tons; and during "February," 217 tons. The total for the region was 2,200 tons.

A sardine price of $50 per ton was agreed upon at Monterey well in advance of the season. Southern California fishermen subsequently agreed upon the same price, an increase of $15 over the preceding season. Mixed sardines and mackerels brought $45, straight mackerel $42.50. In addition to the fish actually caught in central California, about 2,000 tons were trucked there from southern California.

Two Monterey canneries closed shortly after the beginning of the season, leaving five plants operating in central California: one at San Francisco, one at Moss Landing, and three at Monterey.

One large (60 feet or over) and one small purse seiner and 15 lampara boats fished in central California only, while an additional nine large and two small purse seiners fished both in central and in southern California.

Southern California

In southern California, the season opened September 1, and the fleet began fishing the night of September 4. The union-cannery agreement, which accepted the central California prices, further stipulated that there be a minimum limit of 40 tons on sardines and 20 tons on mackerels. In actual practice, the sardine limit was either higher than this or most of the time, non-existant, while the mackerel limit remained at 20 tons, and limits on mixed mackerels and sardines were usually 30 to 40 tons.

Southern California landings were highest in the opening dark, "September," with 7,612 tons. In "October" they were 3,754 tons; in "November," 2,555 tons; in "December," 3,884 tons; in "January," 1,664 tons; in "February," 1,987 tons; and in "March," 42 tons. The total was 21,498 tons, of which 29 tons were caught off Baja California.

Beginning November 1, sardine schools were so difficult to find that mostly mackerels were landed. However, when a boat did find a school of sardines, it was frequently a good-sized one. On the nights of November 30-December 1 and December 1-2, fishermen found large schools of sardines off Point Hueneme and landed 2,200 tons in two days. One boat wrapped a school of 250 tons in an area the fishermen had been avoiding because of an abundance of anchovies. A storm terminated fishing after two nights, but sardines again appeared there on the night of January 7-8, some in pure schools, others mixed with mackerel. Landings for the fleet that night were 667 tons, one boat wrapping 245 tons. On February 1, two, 100-ton loads were caught off La Jolla, and on February 2, several loads of 60 to 100 tons were caught near Cortez Bank.

Throughout the season in southern California, the fish tended to be offshore and far from port. The greatest tonnage came from San Nicolas Island and from Cortez and Tanner Banks, all rather unusual places for the sardine fleet to be working. Other catches were made at Anacapa Island, Point Hueneme, Santa Barbara Island, Santa Catalina Island, and scattered localities along the mainland from Point Dume to La Jolla.

One cannery operated at Oxnard, and six in the Los Angeles-Long Beach Harbor area.

A total of 66 boats, comprising 41 large purse-seiners and 25 small purse-seiners and lampara boats, fished exclusively in southern California. In addition, nine large and two small purse-seiners from central California joined the southern fleet for part of the season. Altogether, 94 boats, 51 large and 43 small, operated in California compared to 104 the previous season.

Baja California

Baja California landings were 2,777 tons during the September dark; 2,276 tons during "October"; 1,941 tons during "November"; 1,095 tons during "December"; 91 tons during "January"; and 371 tons during "February," for a total of 8,551 tons. Landings were made at six canneries in the Ensenada region and one on Cedros Island and were about equally divided between the two areas. The San Quintín cannery ceased operations at the end of "February" 1961.

Most sardine catches were made in the general vicinity of Cedros Island, particularly in the Santa Rosa-Santo Domingo area off the mainland. Some fish was hauled from there, in refrigerated boats, to plants at Ensenada.

Mexican-owned fishing vessels received $32.60 per ton for sardines and mackerels, while American-owned vessels received $40 per ton. Thirty-five boats fished during 1961.

TABLE 2

Length Composition of Year-classes in Sardine Samples from the Central California Commercial Catch, 1961-62 Season

Year-class	*1961*	*1960*	*1959*	*1958*	*1957*	*1956*	*1955*	*Totals*	
								Aged	*Measured*
Standard length (mm)									
212	----	----	----	----	----	----	----	----	1
214	----	----	----	----	----	----	----	----	1
216	----	----	----	----	----	----	----	----	1
218	----	----	----	----	----	----	----	----	1
220	----	----	----	1	----	----	----	1	5
222	----	----	----	----	----	----	----	----	4
224	----	----	----	----	1	----	----	1	7
226	----	----	1	----	3	----	----	4	20
228	----	----	----	1	----	2	----	3	24
230	----	----	----	1	3	4	----	8	34
232	----	----	1	----	3	1	----	5	32
234	----	----	----	1	5	----	1	7	47
236	----	----	----	1	7	1	1	10	61
238	----	----	----	1	8	4	----	13	79
240	----	----	----	1	3	12	----	16	74
242	----	----	----	----	3	4	1	8	83
244	----	----	----	1	14	11	2	28	115
246	----	----	----	1	6	12	3	22	125
248	----	----	----	1	7	12	4	24	107
250	----	----	----	----	9	13	4	26	88
252	----	----	----	----	7	9	----	16	79
254	----	----	----	----	5	6	----	11	61
256	----	----	----	----	6	3	----	9	52
258	----	----	----	----	1	3	----	4	22
260	----	----	----	----	1	1	3	5	14
262	----	----	----	----	----	4	----	4	8
264	----	----	----	----	----	----	----	----	1
266	----	----	----	----	1	----	----	1	2
268	----	----	----	----	----	----	----	----	1
270	----	----	----	----	----	----	----	----	----
272	----	----	----	----	----	----	----	----	1
Totals	----	----	2	10	93	102	19	226	1,150
Mean lengths	----	----	229	236	244	247	248	245	244

AGE AND LENGTH COMPOSITION

During the season, 1,150 fish were measured (in millimeters SL) in central California, 4,000 in southern California, and 2,200 in Baja California. Ages were determined for approximately one-fifth of these (Tables 2-4).

Central California sardines ranged from 212 to 272 mm SL with a mean of 245 mm and an average weight of 0.468 pounds. Catches were dominated by five-year-olds (1956 year-class) which comprised 46 percent of the fish for which ages were determined, and by four-year-olds ('57 year-class) which contributed 41 percent (Figure 1, Table 8). The previous season's catch was dominated by the same year-classes but in reverse order; three-year-olds ('57 year-class) and fours ('56 year-class), contributing 52 and 34 percent, respectively.

TABLE 3

Length Composition of Year-classes in Sardine Samples from the Southern California Commercial Catch, 1961-62 Season

Year-class	*1961*	*1960*	*1959*	*1958*	*1957*	*1956*	*1955*	*1954*	*Totals*	
									Aged	*Measured*
Standard length (mm)										
176										1
178										1
180										2
182										2
184										2
186				1					1	3
188			2						2	3
190			1	1					2	7
192										19
194			1	1					2	15
196			2	1					3	20
198			2	4	1	1			8	26
200		1		1	4				6	33
202			4	2	5				11	55
204			2	7	4	1		1	15	56
206				6	2	1			9	79
208			3	9	5	1			18	99
210			3	11	8	2			24	119
212			2	9	14	3			28	123
214				8	15	4	1		28	140
216			3	15	11	11			40	180
218				12	24	2			38	209
220			1	11	26	7	1		46	235
222			1	7	20	14	1		43	270
224				13	39	9	3		64	320
226				10	32	17	2		61	335
228				7	38	28	3		76	339
230				6	35	25	2		68	317
232				1	23	14	1		39	259
234				5	24	18			47	220
236				4	12	17			33	163
238				2	13	18	1		34	133
240					7	5			12	80
242					5	5			10	58
244					3	1			4	31
246					2	1			3	17
248					1		1		2	16
250				1					1	5
252					1				1	4
254						1			1	4
Totals		1	27	155	374	206	16	1	780	4,000
Mean lengths			205	217	225	229	228		224	224

Southern California sardines ranged from 176 to 254 mm with an average length of 224 mm and an average weight of 0.326 pounds. The previous season's catch was dominated by threes ('56 year-class).

Baja California sardines were smaller than those off California. Sizes ranged from 132 to 226 mm, with the mean at 174 mm, and an average weight of 0.210 pounds. Age-three ('58 year-class), and age-four ('57 year-class) fish dominated the catch, contributing 34 and 40 percent respectively.

TABLE 4

Length Composition of Year-classes in Sardine Samples from the Baja California Commercial Catch, 1961-62 Season

Year-class	*1961*	*1960*	*1959*	*1958*	*1957*	*1956*	*1955*	*Totals*	
Standard length (mm)								*Aged*	*Measured*
132	----	----	----	----	----	----	----	----	1
134	----	----	----	----	----	----	----	----	----
136	----	----	----	----	----	----	----	----	----
138	----	----	----	----	----	----	----	----	3
140	----	1	1	----	----	----	----	2	7
142	----	----	1	----	----	----	----	1	5
144	----	----	1	----	----	----	----	1	4
146	----	----	3	----	----	----	----	3	16
148	----	1	6	1	----	----	----	8	19
150	----	2	4	1	----	----	----	7	29
152	----	----	1	----	1	----	----	2	32
154	----	1	3	3	1	----	----	8	61
156	----	2	6	6	----	----	----	14	69
158	----	----	9	4	----	----	----	13	68
160	----	----	10	5	----	----	----	15	89
162	----	----	12	10	3	----	----	25	100
164	----	1	12	9	3	2	----	27	122
166	----	1	7	14	2	2	----	26	122
168	----	2	8	11	3	----	----	24	128
170	----	----	7	10	6	1	----	24	121
172	----	----	6	10	5	----	----	21	128
174	----	----	7	12	8	2	----	29	152
176	----	----	8	10	7	----	----	25	109
178	----	----	3	11	2	1	1	18	105
180	----	----	3	6	6	----	----	15	87
182	----	----	----	4	8	2	----	14	66
184	----	----	3	3	1	----	----	7	62
186	----	----	3	1	2	1	----	7	44
188	----	----	----	12	2	1	----	15	46
190	----	----	3	5	1	----	----	9	44
192	----	----	4	4	2	1	----	11	52
194	----	----	2	3	4	1	----	10	48
196	----	----	2	4	2	1	----	9	49
198	----	----	1	3	2	----	----	6	35
200	----	----	1	7	3	----	----	11	42
202	----	----	1	2	2	3	----	8	32
204	----	----	----	3	2	1	----	6	29
206	----	----	1	1	----	1	----	3	26
208	----	----	----	3	1	----	----	4	11
210	----	----	----	2	1	----	----	3	14
212	----	----	----	----	1	----	----	1	5
214	----	----	----	----	1	1	----	2	6
216	----	----	----	----	----	----	----	----	4
218	----	----	----	----	----	1	----	1	2
220	----	----	----	----	----	----	----	----	3
222	----	----	----	----	----	----	----	----	1
224	----	----	----	----	----	----	----	----	1
226	----	----	----	----	1	----	----	1	1
Totals	----	11	139	180	83	22	1	436	2,200
Mean lengths	----	156	168	177	182	188	----	175	174

TABLE 5

Length Composition of Year-classes in Sardine Samples from the Central California Interseason Catch, 1961

Year-class	*1961*	*1960*	*1959*	*1958*	*1957*	*1956*	*1955*	*Totals* Aged	*Totals* Measured
Standard length (mm)									
190	----	----	----	----	----	----	----	----	1
192	----	----	----	----	----	----	----	----	2
194	----	----	----	----	----	----	----	----	----
196	----	----	----	----	----	----	----	----	----
198	----	----	----	----	----	----	----	----	1
200	----	----	----	----	----	----	----	----	1
202	----	----	----	----	----	----	----	----	----
204	----	----	----	----	----	----	----	----	1
206	----	----	----	----	----	----	----	----	1
208	----	----	----	----	----	----	----	----	----
210	----	----	----	----	----	----	----	----	2
212	----	----	----	----	----	----	----	----	----
214	----	----	----	----	----	----	----	----	3
216	----	----	----	----	1	----	----	1	2
218	----	----	----	----	----	----	----	----	1
220	----	----	----	----	1	----	----	1	6
222	----	----	----	2	----	----	----	2	3
224	----	----	----	----	1	1	----	2	6
226	----	----	----	----	----	1	----	1	2
228	----	----	----	----	2	----	----	2	3
230	----	----	----	2	----	----	----	2	6
232	----	----	----	----	1	----	----	1	4
234	----	----	----	----	----	----	----	----	5
236	----	----	----	----	----	----	----	----	9
238	----	----	----	----	1	----	1	2	10
240	----	----	----	----	1	1	----	2	8
242	----	----	----	----	2	----	----	2	13
244	----	----	----	1	----	1	----	2	11
246	----	----	----	1	2	----	1	4	10
248	----	----	----	----	----	----	----	----	10
250	----	----	----	2	----	----	----	2	8
252	----	----	----	----	----	----	----	----	4
254	----	----	----	----	----	----	----	----	2
Totals	----	----	----	8	12	4	2	26	135
Mean lengths	----	----	----	237	234	234	242	235	235

TABLE 6

Length Composition of Year-classes in Sardine Samples from the Southern California Interseason Catch, 1961

Year-class	*1961*	*1960*	*1959*	*1958*	*1957*	*1956*	*1954*	*Totals*	
								Aged	*Measured*
Standard length (mm)									
164	----	----	----	----	----	----	----	----	1
166	----	----	----	----	----	----	----	----	----
168	----	----	----	----	----	----	----	----	1
170	----	----	----	----	----	----	----	----	----
172	----	1	----	----	----	----	----	1	1
174	----	----	----	----	----	----	----	----	----
176	----	----	----	----	----	----	----	----	----
178	----	----	----	----	----	----	----	----	----
180	----	----	----	----	----	----	----	----	3
182	----	----	----	----	----	----	----	----	----
184	----	----	----	----	----	----	----	----	1
186	----	----	----	1	----	----	----	1	1
188	----	----	----	----	----	----	----	----	6
190	----	----	----	----	----	----	----	----	6
192	----	1	----	2	----	----	----	3	8
194	----	----	----	----	----	----	----	----	10
196	----	----	1	2	----	----	----	3	10
198	----	----	2	----	----	----	----	2	11
200	----	----	----	1	----	----	----	1	12
202	----	----	----	1	1	----	----	2	12
204	----	----	----	3	1	1	----	5	15
206	----	----	1	----	3	----	----	4	21
208	----	----	----	1	----	----	----	1	13
210	----	----	----	3	1	----	----	4	16
212	----	----	----	1	1	----	----	2	21
214	----	----	1	2	1	----	----	4	16
216	----	----	----	----	1	2	----	3	21
218	----	----	----	2	1	----	----	3	16
220	----	----	----	3	3	----	----	6	17
222	----	----	1	1	4	1	----	7	19
224	----	----	----	----	1	----	----	1	16
226	----	----	----	3	2	3	----	8	36
228	----	----	----	----	4	1	----	5	16
230	----	----	----	----	----	----	----	----	11
232	----	----	1	1	3	----	----	5	13
234	----	----	----	----	3	----	----	3	8
236	----	----	----	----	----	----	----	----	5
238	----	----	----	----	1	1	----	2	5
240	----	----	----	1	----	----	----	1	3
242	----	----	----	----	----	----	----	----	1
244	----	----	----	----	----	----	----	----	----
246	----	----	----	----	----	1	1	2	3
Totals	----	2	7	28	31	10	1	79	375
Mean lengths	----	182	209	212	222	225	----	217	214

TABLE 7

Length Composition of Year-classes in Sardine Samples from the Baja California Interseason Catch, 1961

Year-class	*1961*	*1960*	*1959*	*1958*	*1957*	*1956*	*1955*	*1954*	*Totals*	
									Aged	*Measured*
Standard length (mm)										
140			1						1	1
142										1
144										3
146										5
148		1							1	5
150		2							2	9
152		1							1	10
154										18
156		2							2	21
158			1	4					5	21
160			5	4					9	33
162			7	4	2				13	43
164			5	3	2				10	58
166			6	9	3				18	71
168			8	3	2	1			14	97
170			7	7	3				17	72
172			5	8	2				15	99
174			5	12	3	1			21	96
176			4	9	6	2			21	103
178			7	5	5	1			18	119
180			8	9	8	2			27	105
182			3	6	7	2			18	107
184			2	12	6	2	1		23	85
186		1		9	3				13	61
188			2	4	3	1			10	66
190			1	6	3				10	51
192			1	1	2				4	35
194			1	2		1			4	31
196				4	1				5	18
198					2				2	10
200			1	1	3	1			6	16
202			1		1	1			3	10
204					1	1			2	5
206										4
208					1	1			2	4
210										1
212										1
214										
216										
218								1	1	2
220										2
222										1
Totals		7	81	122	69	17	1	1	298	1,500
Mean lengths		157	173	177	181	186			177	176

TABLE 8

Age and Year-class Composition of the Sardine Catch in the 1961-62 Season

	Catch		Number of fish in thousands by age and year-class							
	Tons	Number	0 1961	1 1960	2 1959	3 1958	4 1957	5 1956	6 1955	7 1954
Central California										
"August"----------	197	823					313	197	313	
"September"-------	349	1,357				73	354	737	193	
"October"---------	524	2,089				119	1,069	829	72	
"November"-------	324	1,274					433	663	178	
"December"-------	104	545			36	109	305	95		
"January"---------	485	2,387					1,003	1,277	107	
"February"--------	217	1,018					427	545	46	
Total Central California---	2,200	9,493			36	301	3,904	4,343	909	
Percent-------		100.00			0.38	3.17	41.12	45.75	9.58	
Southern California										
"September"-------	7,612	46,119		46	922	7,010	22,968	12,821	2,260	92
"October"---------	3,754	23,143			1,803	4,360	11,109	5,531	340	
"November"-------	2,555	16,117			806	4,255	8,574	2,450	32	
"December"-------	3,884	23,546		85	1,114	6,593	10,746	4,624	257	127
"January"---------	1,664	9,955			100	1,832	4,380	3,524	119	
"February"--------	1,987	11,981			266	1,997	5,405	4,313		
"March"----------	42	205					107	82	16	
Total Southern California---	*21,498	131,066		131	5,011	26,047	63,289	33,345	3,024	219
Percent-------		100.00		0.10	3.82	19.87	48.29	25.44	2.31	0.17
Total California	23,698	140,559		131	5,047	26,348	67,193	37,688	3,933	219
Percent-------		100.00		0.09	3.59	18.75	47.80	26.81	2.80	0.16
Baja California										
"September"-------	2,777	28,749		267	8,817	11,693	6,440	1,532		
"October"---------	2,276	21,972		923	5,493	9,931	4,614	1,011		
"November"-------	1,941	22,016		661	9,687	8,806	2,862			
"December"-------	1,095	11,288		338	4,685	3,669	1,975	395	226	
"January"---------	91	789		51	351	280	91	16		
"February"--------	371	2,545	10	10	632	957	631	285		20
Total Baja California---	8,551	87,359	10	2,250	29,665	35,336	16,613	3,239	226	20
Percent-------		100.00	0.01	2.57	33.96	40.45	19.02	3.71	0.26	0.02
TOTAL-------	32,249	227,918	10	2,381	34,712	61,684	83,806	40,927	4,159	239
Percent-------		100.00		1.0	15.2	27.1	36.8	18.0	1.8	0.1

* 29 tons were caught off Baja California

TABLE 9

Age and Year-class Composition of the Sardine Catch in the 1961 Baja California Interseason

	Catch		Number of fish in thousands by year-class							
	Tons	No.	1961	1960	1959	1958	1957	1956	1955	1954
Baja California										
"January"	1,858	21,035			12,762	3,645	3,507	1,121		
"February"	757	8,568			5,198	1,485	1,428	457		
"March"	1,080	12,222			7,416	2,118	2,037	651		
"April"	2,089	21,313			2,664	11,509	6,287	853		
"May"	663	7,307			2,375	3,434	1,169	329		
"June"	3,255	29,528			4,060	12,107	9,375	3,248	369	369
"July"	900	9,574		510	4,021	3,575	1,468			
"August"	1,150	10,064		144	2,962	4,371	2,185	402		
Total	11,752	119,611		654	41,458	42,244	27,456	7,061	369	369
Percent		100.00		0.54	34.66	35.33	22.95	5.90	0.31	0.31

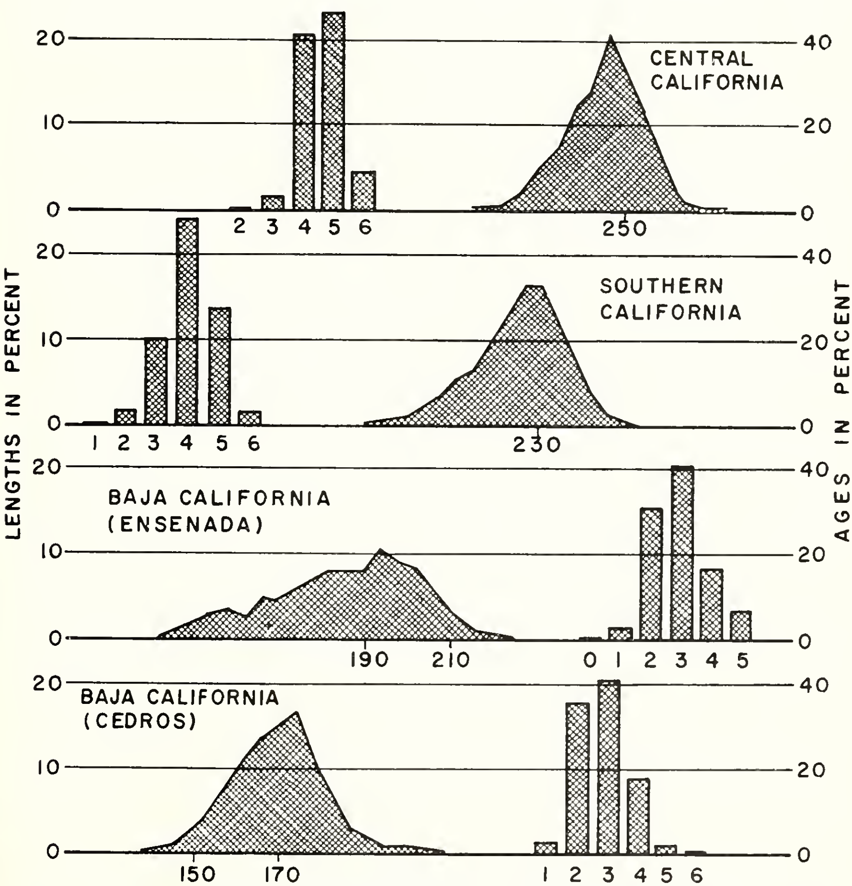

FIGURE 1. Percentage age and length composition of sardines sampled during the 1961-62 season by regions of capture. Length data are plotted by 4 mm intervals.

Interseason fish measurements included 135 fish from central California, 375 from southern California, and 1,500 from Baja California (Tables 5-7). Ages were not determined for the interseason catches of central and southern California because the results were considered likely to be misleading. The interseason catch of Baja California, where the fishery is a year around endeavor, was composed principally of '59 year-class (35 percent) ; '58 year-class (35 percent), and '57 year-class (23 percent) sardines (Table 9).

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INCREASING TAGGED ROCKFISH (GENUS *SEBASTODES*) SURVIVAL BY DEFLATING THE SWIM BLADDER[1]

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INTRODUCTION

Swim bladder deflation techniques were used during a blue rockfish, *Sebastodes mystinus*, tagging study designed to determine this important sportfish's migratory habits. Studying their movements required tagging fish taken from as shallow as 30 and as deep as 250 feet. These techniques have since been used on several other species (Table 1).

TABLE 1

Common and Scientific Names of Species Mentioned in the Text

Bocaccio *	*Sebastodes paucispinis*
Cod, Pacific	*Gadus macrocephalus*
Rockfish, black *	*Sebastodes melanops*
Rockfish, black-and-yellow	*Sebastodes chrysomelas*
Rockfish, blue *	*Sebastodes mystinus*
Rockfish, canary *	*Sebastodes pinniger*
Rockfish, China *	*Sebastodes nebulosus*
Rockfish, copper *	*Sebastodes caurinus*
Rockfish, cow	*Sebastodes levis*
Rockfish, gopher *	*Sebastodes carnatus*
Rockfish, grass *	*Sebastodes rastrelliger*
Rockfish, greenspotted	*Sebastodes chlorostictus*
Rockfish, kelp *	*Sebastodes atrovirens*
Rockfish, olive *	*Sebastodes serranoides*
Rockfish, quillback *	*Sebastodes maliger*
Rockfish, rosy *	*Sebastodes rosaceus*
Rockfish, squarespot *	*Sebastodes hopkinsi*
Rockfish, speckled *	*Sebastodes ovalis*
Rockfish, starry *	*Sebastodes constellatus*
Rockfish, vermilion *	*Sebastodes miniatus*
Rockfish, widow *	*Sebastodes entomelas*
Rockfish, yellowtail *	*Sebastodes flavidus*
Treefish *	*Sebastodes serriceps*
Trout, lake	*Salvelinus namaycush*
Whitefish, ocean *	*Caulolatilus princeps*

* Successfully deflated by author and held in aquaria.

Rockfishes of the genus *Sebastodes* are physoclistous (their swim bladder is without a pneumatic duct) as opposed to physostomous fishes whose bladder has an open duct to the esophagus. Physoclists cannot adjust to rapid pressure changes and when brought to the surface,

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gases in the bladder expand, sometimes causing a slight loss of equilibrium or everting the stomach through the mouth. Some of these fish enter shock and rarely survive. In extreme cases, when brought from depths approaching 250 feet, fish suffer *popeye* as gases in the skull expand, forcing the eyes out of their sockets. Deflation relieves the gas pressure in the swim bladder so that fish regain equilibrium and swimming ability and return to the depths.

Our original deflation experiments were conducted aboard the *N. B. Scofield* during February 1961. The deflated fish were held for further observation at Marineland of the Pacific.

DEFLATION TECHNIQUE

For distended blue rockfish, an 18-gauge, $\frac{1}{2}$-inch-long hypodermic needle is inserted through the abdominal wall at a 45 degree angle with the point toward the head. The needle is entered between scales just dorsal to the pectoral fin at a point three-quarters the distance from insertion to tip with the fin held parallel to the lateral line (Figure 1). The exact location to insert the needle must be determined for each species. The needle should enter where the swim bladder adheres to the abdominal wall so that gases cannot escape into the body cavity.

Penetration of the swim bladder becomes evident when escaping gas is heard: the needle is then brought to a vertical position with its point directed slightly dorsally to avoid puncturing the collapsing swim bladder again. Both the fish and needle are placed under water to observe when the gases cease flowing. Deflation is complete when gases have ceased to escape and the fish swims normally. A syringe with the plunger removed can be partially filled with water, and at-

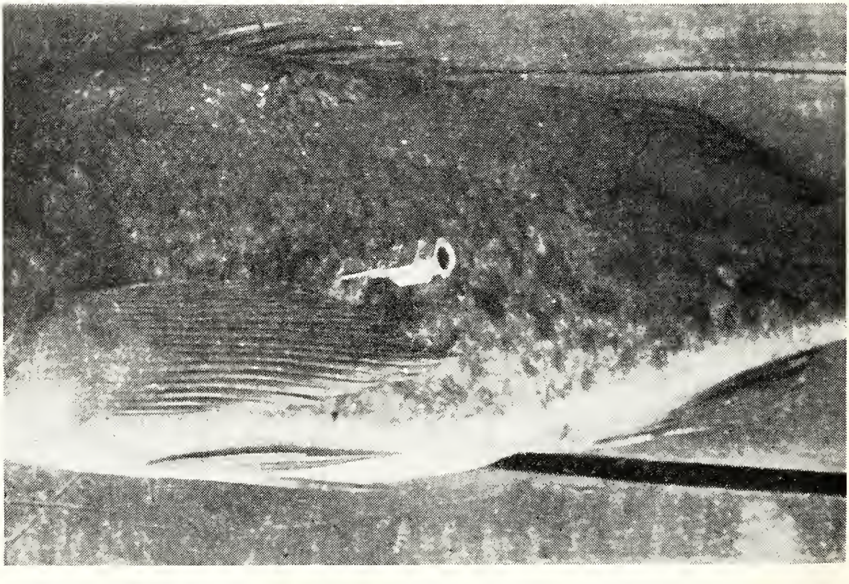

FIGURE 1. Insertion site of 18-gauge hypodermic needle for deflating blue rockfish swim bladder. *Photograph by the author, December 1963.*

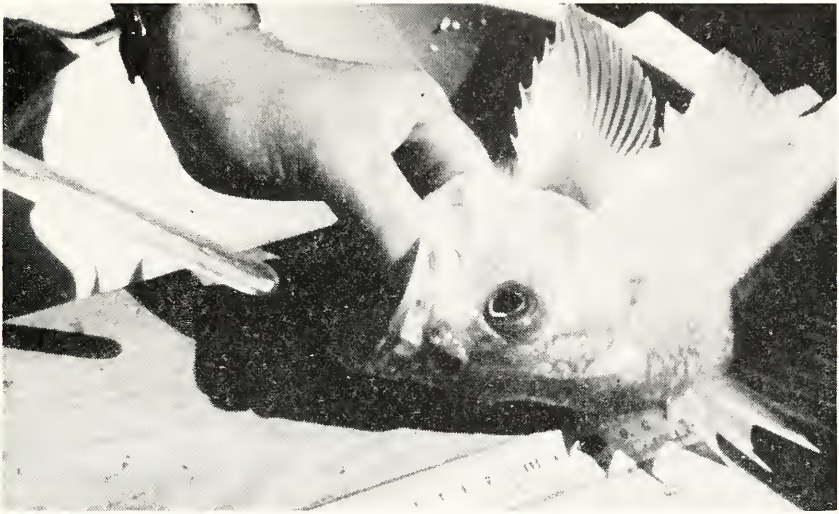

FIGURE 2. Plastic rod used to replace distended stomach of a canary rockfish. *Photograph by E. Zimbleman, September 1963.*

tached to the needle to observe escaping gases and check for complete deflation. I used a syringe with a 20-gauge needle but deflation took longer because of the smaller-sized needle, thus a larger gauge needle is recommended.

If the expanded swim bladder forces the stomach out through the mouth, the fish is first deflated and then the stomach is gently pushed back through the throat into normal position with an 18-inch-long, ½-inch-diameter, round plastic rod with rounded ends (Figure 2). Then the hypodermic needle is again inserted into the swim bladder to allow remaining gases to escape. Should the needle become blocked with tissue before enough gases have escaped, it is cleared either by suction or with a small-diameter wire.

RESULTS OF DEFLATING BLUE ROCKFISH

Although we have tagged over 8,000 fish between the Channel Islands and Bodega Bay, we have received significant returns only from the 4,884 we tagged off Año Nuevo Island, Monterey, and Morro Bay, between July 1961 and July 1963 (Table 2). They were caught at mid-depths where the bottom was 25 to 300 feet deep.

We deflated 2,220 (45.5 percent) of the fish tagged, and 247 (5.1 percent) of these also required stomach replacement.

Through July 31, 1963, 96 tags had been recovered from the three areas, and 39 of these (40.6 percent) were from fish that had been deflated. Only two tags (2.1 percent) have been received from fish that required stomach replacement.

It was often difficult to determine exactly how deep the fish were when hooked, so we cannot compare recoveries by depth-of-catch. However, we can compare the returns on the basis of bottom depth at the tagging site, because this was recorded in most cases (Table 3). There

TABLE 2

Blue Rockfish Tagging and Deflation Data for Año Nuevo Island, Monterey, and Morro Bay, California, July 1961-July 1963

	Tagging area							
	Año Nuevo Island		Monterey		Morro Bay		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Fish tagged	636		1,962		2,286		4,884	
Deflated	279	43.9	821	41.8	1,120	49.0	2,220	45.4
Stomach replaced	7	1.1	39	2.0	201	8.8	247	5.1
Tagged fish recovered	15	2.4	28	1.4	53	2.3	96	2.0
Deflated	8	53.3	12	42.8	19	35.8	39	40.6
Stomach replaced	0	0.0	1	3.6	1	2.0	2	2.1
Average number of days at liberty								
Non-deflated	161		229		162		184	
Deflated	178		437		283		277	

have been no returns from fish tagged where depths were shallower than 40 feet (which may reflect low fishing effort) or deeper than 250 feet.

In all depth ranges except 150 to 199 feet, percent returns for deflated fish were slightly lower than for non-deflated fish. The small percentage of overall returns is believed due to a lack of fishing effort over reefs where tagged fish were released. When fishing has been heavy in tagging areas, as many as 10 percent of the fish from 1-day's tagging have been returned. Non-deflated fish were at liberty an average of 184 days, compared to 277 days for deflated fish.

Since 45.4 percent of the tagged fish were deflated when released, and only 40.6 percent of the tagged fish recovered had been deflated, some

TABLE 3

Blue Rockfish Tagging and Tag Recoveries by Bottom Depths Where Tagged

	Bottom depths in feet											
	0-49		50-99		100-149		150-199		200-249		250-299	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Tagged	212		3,498		947		136		82		9	
Non-deflated	207	97.6	2,026	57.9	379	40.0	8	5.9	40	48.8	0	0.0
Deflated	5	2.4	1,472	42.1	568	60.0	128	94.1	42	51.2	9	100.0
Recovered	0		63		28		1		4		0	
Non-deflated	0		42	66.7	13	46.4	0	0.0	2	50.0	0	0.0
Deflated	0		21	33.3	15	53.6	1	100.0	2	50.0	0	0.0

mortality may have resulted directly or indirectly from the deflation process. For example, the fish may have suffered internal damage when brought to the surface, or may have been subjected to greater predation because of changed behavior patterns when released. When Forester and Ketchen (1955) deflated Pacific cod (greycod) only 12 percent of their recoveries were from deflated fish, 17 percent having been deflated.

When the subsurface reactions of two deflated and two non-deflated blue rockfish were observed by skindivers during 1961, the non-deflated fish swam in a normal fashion back to the large school from which they had been caught. The two deflated fish were more sluggish, and after rejoining the school for a few minutes, went to the bottom and hid among the rocks.

DEFLATION OF OTHER SPECIES

We have had success also in deflating ocean whitefish as well as other species of rockfish which were delivered to several aquaria for exhibition. Many were still living at the end of 1963. Mortalities are believed to have been due to causes other than deflation.

Ninety-nine fish representing 27 species, most of which had been deflated, were delivered to Steinhart Aquarium, San Francisco, during April and May 1963. Twelve of these were quillback rockfish with either one or both eyes exhibiting *popeye* when captured. A hypodermic needle inserted into the eye cavity at the juncture of the prefrontal and lacrymal bones (Figures 3 and 4), in most cases, released the gases and the eye returned to normal position. For a few, I withdrew gases by suction through the needle. All were still alive in June 1963 and showed no evidence of eye damage. Unfortunately, when the gases had penetrated between the cornea and the lens this method did not work.

Workers at Scripps Institution of Oceanography, La Jolla, successfully deflated blue rockfish, treefish, starry rockfish, kelp rockfish, and ocean whitefish using hypodermic needles (Carl L. Hubbs, pers. comm.).

Personnel at Marineland of the Pacific are testing another method of treating physoclistous fishes. Fish caught on hook-and-line as deep as 140 feet, are brought up to 100 feet to waiting SCUBA divers who remove them from the hooks and place them inside a large pressure chamber. Bottled oxygen provides pressure in the chamber and also insures the fish adequate dissolved oxygen. The sealed chamber is brought aboard a surface vessel where the fish are allowed to decompress slowly (John H. Prescott, pers. comm.). This procedure allows the fish to reduce swim bladder pressure naturally, and to remove dissolved nitrogen in the blood safely. Deep-water fish which are in shock when brought to the surface may be suffering either from a form of decompression sickness or from oxygen toxicity. To date, treefish, widow rockfish, blue rockfish, bocaccio, rosy rockfish, and copper rockfish have survived this type of decompression.

Using a modification of our technique, Department of Fish and Game biologists working on the Lake Tahoe Fisheries Study (DJ Project F-21-R) successfully deflated physostomous lake trout. The tagged fish recovered in holding pens before being released. Light hand pressure was used to force gases out through a 3½-inch-long, 17-gauge hypodermic needle.

FIGURE 3. Insertion site of 18-gauge hypodermic needle for deflating "popped" eye of a cow rockfish. *Photograph by the author, September 1963.*

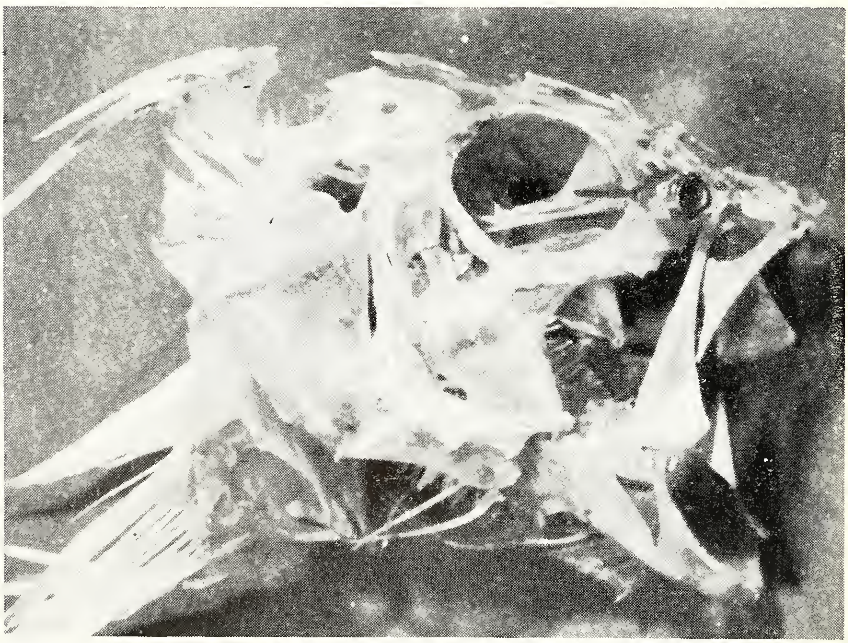

FIGURE 4. Greenspotted rockfish skull showing plocement of hypodermic needle when deflating "popped" eyes. *Photograph by the author, December 1963.*

Three-hundred and eighty-two lake trout captured in depths of 25 to 700 feet were tagged from March 6, 1963, through November 1963. Twenty tags have been returned, 17 from deflated fish (Sterling P. Davis, pers. comm.). Tagged, deflated lake trout have also been recovered from Wisconsin lakes (Hacker, 1962).

Pacific cod have been deflated, tagged, and recovered off British Columbia (Forester and Ketchen, 1955) and Washington (Pacific Fisherman, 1956). The methods used were not described, but in an earlier Pacific cod tagging experiment off British Columbia, workers punctured the body cavity with a knife (Forester, 1954).

DISCUSSION

Although similar techniques have been used in the past, as far as is known the blue rockfish is the first member of the rockfish family that has undergone a large-scale tagging program involving deflation techniques.

Deflated blue rockfish may have suffered greater mortalities than non-deflated ones, according to our recovery data. Fish requiring stomach replacement suffered the greatest mortality. Even though deflation apparently causes some mortality, the method is valuable, and enabled us to tag fish from deep reefs that otherwise could not have been included in the blue rockfish study. A more detailed study of the difference in recoverability between deflated and non-deflated rockfish from various depths should be undertaken.

We need to know more concerning the effects of deflation on the behavior of tagged blue rockfish. Observations by skindivers indicate that for a short time, at least, deflated fish do not resume normal schooling behavior. Even a slight change in behavior might increase its chance of falling prey to a predator. The longer average time that deflated tagged fish (as opposed to non-deflated ones) were at liberty also suggests a possible change of behavior. A comparison of movements made by large numbers of tagged deflated and non-deflated blue rockfish is desired.

Success in deflating fish swim bladders and eye cavities can lead to tagging programs on many other species. I believe some deep-water species might also survive. Certainly deflation has been, and can be, a valuable tool for collecting fishes for aquaria.

Using a decompression chamber such as that developed by Marineland personnel, although more time consuming, makes it possible to collect fishes from practically any depths.

ACKNOWLEDGEMENTS

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REPORT ON A RECENT SHARK ATTACK OFF SAN FRANCISCO, CALIFORNIA [1]

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INTRODUCTION

The great white shark *(Carcharodon carcharias)* is considered by some experts to be the most dangerous species of shark—as far as man is concerned. During this century, this species has fatally injured at least 14 victims and incapacitated many others (Gilbert, 1964). Two such fatalities occurred in central California, one in 1952 (Bolin, 1954) and the other in 1959 (Gilbert *et al.,* 1960). The victim of the 1952 attack died within a few minutes after being severely bitten. The 1959 victim expired 2½ hours after he was taken to a hospital. The causes of death in each case were shock and severe hemorrhage. This report deals with a similar, but non-fatal attack, on Jack Rochette of Burlingame, California, which occurred on January 11, 1964.

PARTICULARS OF THE VICTIM

The victim, a male Caucasian, was 21 years of age, 6 feet 1 inch in height, and weighed approximately 175 pounds. When attacked he was wearing a black neoprene exposure suit with yellow striping. Accessory diving equipment included yellow swim fins, black face mask, and twin, 42-cubic-foot, white, compressed-air tanks. He was also carrying a two-band spear gun.

LOCALITY OF ATTACK AND ENVIRONMENTAL CONDITIONS

The victim, a member of a party of about 15, was SCUBA diving from a boat with five others one-quarter mile off the west side of Southeast Farallon Island, some 30 miles west of San Francisco at approximately long. 123° W., lat. 37° 42′ N. The attack occurred at 12 noon. The sky was clear, the air temperature 18° C., and the water temperature 13° C. The depth of the water was 50 feet, with a visibility of 40 feet. The bottom was generally flat, with many rocks and caves, and no kelp or other large dominant algae were present. A very strong surge prevailed and whitecaps were present on the sea surface. The wind was north-by-northwest, between 10 and 20 knots.

DESCRIPTION OF THE ATTACK AND RESCUE

Rochette had switched to his reserve air supply (enough for about 5 minutes diving) shortly before spotting a yellow-and-black-colored

[1] Submitted for publication May, 1964.

rockfish swimming around an outcropping of rocks. He cornered the fish in a small crevice, but rather than discharge his spear, he poked the spear gun into the crevice and stabbed it. At that time his reserve air supply became exhausted and he had to surface immediately. The moment he surfaced the shark attacked him. At first, he thought that one of his diving partners had grabbed him by the legs; however, upon glancing down he saw that a shark had both of his legs, from his thighs to the middle of his calves, in its mouth. Rochette was lying on his stomach in a horizontal position on the surface and the shark's lower jaw was across the front of his legs while its upper jaw extended across the back of his legs. The shark appeared to vibrate all over, shaking him fiercely. Rochette slammed his spear gun, point first, onto the shark's snout, whereupon it released its grip and swam off. He then took the rockfish off his spear and let it sink to the bottom. The shark turned and made a second advance toward him and he retaliated by slamming it on the snout with his spear gun. This was repeated several times over a period of approximately 4 minutes. Each time the shark would circle clockwise, advance to about 3 feet directly under him, receive a blow on the snout, then retreat below him some 10 feet. In order to keep the shark in view, Rochette floated horizontally on the surface and paddled in a continual circle while moving gradually toward the boat. Once, the water became so bloodstained that he had to swim away from that immediate area in order to see the shark. Rochette said that during one advance by the shark, he dove under the water to meet it head-on. He placed his right hand on the ventral side of the shark, just below the gill slits and then placed his left hand, which held his spear, on its back and pushed away. Rochette stated, "As the shark swam past, its dorsal fin was higher than my spear gun was long." Apparently the shark then spotted Rochette's five diving companions on the bottom, for it suddenly swam toward the bottom, abandoning its advances on him.

At about this time, Jack Bolger, a member of the skindiving-party, who had been with another group in a different area, climbed aboard the boat and saw the shark circling Rochette, who appeared to be in trouble. He stripped off his SCUBA tanks and face mask, dove over the side, and swam some 130 feet to aid Rochette. He gripped the victim's air tanks and towed him to the boat. Meanwhile, after leaving Rochette, the shark cornered two of the five divers in a cave. It would circle the cave and then swim toward the other three. It kept all five pinned to the bottom for about 5 minutes longer before leaving the area.

Upon boarding the boat, Rochette was given immediate first aid, and the U.S. Coast Guard was radioed for assistance. A Coast Guard helicopter arrived at 12:25 PM, lowered a basket into which Rochette was placed and flew him directly to the U.S. Public Health Service Hospital in San Francisco.

DESCRIPTION OF INJURIES AND TREATMENT

Although Rochette was only bitten once, he had multiple lacerations of both legs. The most severe of his injuries was a 10-inch laceration on the dorsal side of his right thigh (Figure 1). This laceration extended through the *tensor facia lata* muscle to the femur. A laceration on the dorsal side of his right calf penetrated fairly deep into the *gastrocne-*

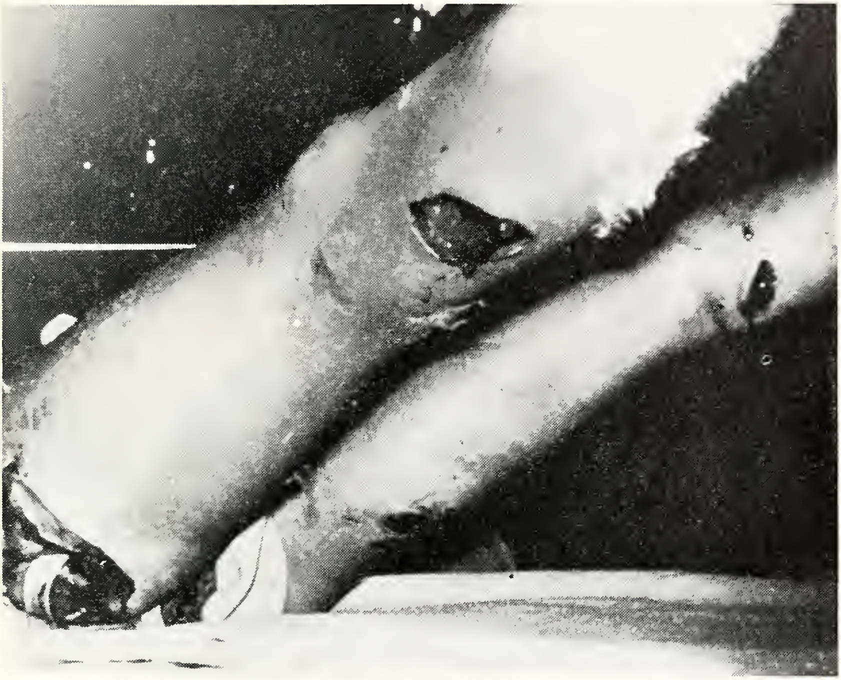

FIGURE 1. The extensive damage to the back of Jack Rochette's legs, caused by an attacking great white shark at the Farallon Islands, California, in January 1964. *Photograph Courtesy United States Public Health Service Hospital.*

mius muscle, severing a nerve, thus impairing his ability to manipulate his right foot. Lacerations also were present on the ventral side of his right calf, and on the dorsal side and inner portion of his left calf. Three large lacerations also were inflicted to the ventral surface of his left thigh.

First aid treatment, both on the boat and in the helicopter, was immediately concerned with controlling the profuse bleeding. Rochette, upon arrival at the hospital was alert, oriented, and not in shock. He was taken immediately to the operating room. During the operation, which lasted 4 hours and entailed the services of seven surgeons, he received three units of whole blood. He returned to the operating room on the fourth postoperative day for secondary closures of his lacerations. Prior to this second operative procedure he received two units of whole blood. He has since completely recovered.

IDENTIFICATION OF SHARK RESPONSIBLE FOR THE ATTACK

During surgery, a 17.2 mm tooth fragment (Figure 2) was extracted from the injury on the dorsal side of his upper thigh. Since the tooth is triangular with serrated edges it is quite evident that it came from a great white shark. W. I. Follett, California Academy of Sciences substantiated my identification. Although the victim and the witnesses agreed that the shark appeared to be between 20 and 25 feet long, it is

FIGURE 2. *Carcharodon carcharias* tooth fragment extracted from dorsal right thigh injury on Jack Rochette. The fragment was 17.2 mm long. *Photograph by W. I. Follett, 1964.*

possible that the prevailing emotional circumstances may have caused them to overestimate its length slightly. Nevertheless, the nature of Rochette's wounds indicate it was a large specimen.

ACKNOWLEDGEMENTS

The author would like to thank David Berne for his assistance in documenting this attack. W. I. Follett, California Academy of Sciences and the staff at the U. S. Public Health Service Hospital also gave valuable assistance. Jack Rochette kindly gave his permission to publish this report.

To John H. Prescott, Curator of Fishes, Marineland of the Pacific, and Geoffrey E. Doman, Shark Research Committee Inc., I extend special thanks for critical comments and kind patience in reading the manuscript. John L. Baxter's editorial assistance was especially helpful.

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SPAWNING OF LONGSPINE CHANNEL ROCKFISH, *SEBASTOLOBUS ALTIVELIS* GILBERT[1]

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INTRODUCTION

During routine observation of animal food landings at San Francisco, a load of fish from deeper grounds than normal was sampled. They were caught March 17, 1960, by Guildo Paolini, master of the otter trawler *Seaworthy,* about 40 miles WNW of Pt. Reyes (approximately lat. 38° 25′ N., long. 123° 40′ W.) in 385 fathoms. This catch was of particular interest as these depths are rarely fished.

The delivery amounted to 2,255 pounds and was comprised by weight, as determined from sampling 457 pounds, of approximately 39 percent shortspine channel rockfish *(Sebastolobus alascanus),* 33 percent sablefish *(Anoplopoma fimbria),* 26 percent longspine channel rockfish, and 2 percent Dover sole *(Microstomus pacificus).* A few rattails (family Coryphaenoididae) were observed in the landing, but none was found in the sample. The occurrence of *S. alascanus* in water this deep was unusual, being substantially deeper than the maximum of 300 fathoms reported by Phillips (1957).

Since *S. altivelis* is rarely taken by California otter trawlers, this landing presented an opportunity to obtain biological data on this species. Length, weight, sex, and state of maturity were noted for 50 fish (Table 1), but no scales or hard parts were collected for age determinations. Some of the fish in this sample were within 2 inches of the maximum size of 15 inches (380 mm) reported by Phillips (1957).

MATURITY

Males

All but 2 of the 32 males were running ripe; milt flowed when the abdomen was pressed. Dissection revealed the two exceptions (254 and 278 mm TL) were immature. However, the smallest male (252 mm TL) was ripe.

Females

Five females, all under 270 mm TL, were immature. Twelve contained large transparent eggs, indicating spawning was imminent. In one individual (310 mm TL) the elongated ovary was protruding from the body cavity as described by Pearcy (1962). I could not determine whether this fish was spawning when caught, or if the ovary protruded because of the extreme pressure change the fish had gone through when brought from the depths.

[1] Submitted for publication June 1964.

TABLE 1

Length, Weight, Sex and Maturity of 50 *Sebastolobus altivelis* Caught off Pt. Reyes, California, March 17, 1960

Males			*Females*		
Total length (mm)	*Weight (g)*	*Maturity*	*Total length (mm)*	*Weight (g)*	*Maturity*
252	191	R	242	191	I
254	191	I	248	172	I
274	249	R	254	204	I
276	263	R	268	218	I
278	277	I	270	254	I
282	277	R	276	240	M
282	290	R	296	318	M
286	249	R	300	331	M
286	313	R	306	349	M
292	313	R	308	340	M
292	318	R	308	340	M
298	304	R	310	363	M
298	340	R	312	354	M
300	290	R	316	390	M
300	313	R	320	367	M
300	318	R	322	426	M
304	304	R	328	381	M
304	354	R	330	431	M
304	354	R			
306	313	R			
306	376	R			
310	367	R			
310	390	R			
312	349	R			
312	376	R			
314	327	R			
314	367	R			
314	381	R			
322	417	R			
324	390	R			
326	417	R			
328	467	R			

I = Immature
M = Mature
R = Ripe

Finding ripe male and female *S. altivelis* in mid-March agrees with Pearcy's finding of egg masses at the end of March and substantiates his statement that spawning occurs between March and May.

WEIGHT—LENGTH DETERMINATIONS

Weights in grams and total lengths in millimeters, for the 50 fish, tended to form a straight line when graphed. No difference was discernible between males and females from the plotted date, consequently all the measurements were combined and a weight-length relationship was calculated (Figure 1).

The formula for *S. altivelis* was: $W = 0.0000211\ L^{2.90152}$, or in its logarithmic form, $\text{Log}\ W = -4.67591 + 2.90152\ \text{Log}\ L$. This calculation is based on a limited number of measurements and represents only a segment of the species' size range. Since no small or large fish were measured, this should be considered an approximation of the weight-length relationship.

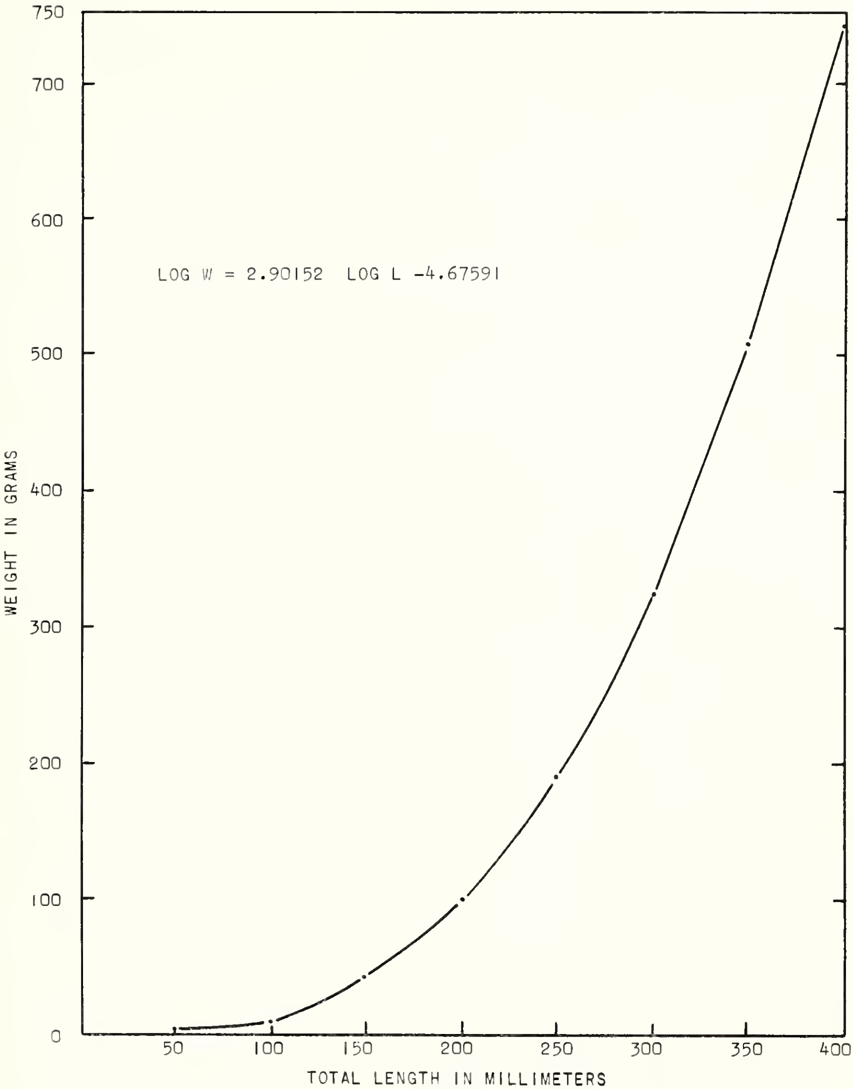

FIGURE 1. Weight-length relotionship of *Sebastolobus altivelis*.

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MORTALITY OF A FRESHWATER POLYCHAETE, *NEREIS LIMNICOLA* JOHNSON, ATTRIBUTED TO ROTENONE[1]

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Rotenone, a widely used fish poison, is generally regarded as being harmless to invertebrates even when applied in sufficient concentration to kill fish. It is used regularly in fish management programs (*e.g.*, Hooper and Crance, 1960) without apparent regard to its effects on other organisms. From rotenone's first use in the late 1930's, instances of significant effects on planktonic and benthic invertebrates have been reported. These include temporary or permanent destruction of planktonic micro-crustaceans, some but not all insect larvae, snails, and a leech (Smith, 1940), chironomid larvae (Cushing and Olive, 1957), and planktonic crustaceans (Kiser, Donaldson, and Olson, 1963) by rotenone concentrations as low as 0.025 ppm (parts per million). Kiser *et al.* (1963) found that zooplankton populations did not recover to former levels for a number of weeks after toxic concentrations of rotenone had disappeared. Both Smith (1940) and Cushing and Olive (1957) reported that benthic oligochaetes were unaffected. My report concerns a severe reduction in the population of a freshwater polychaete, *Nereis limnicola* Johnson [= *Neanthes lighti* Hartman]. This reduction is attributed to rotenone used in a routine fish killing program.

N. limnicola occurs in the less saline portions of estuaries and bays from Morro Bay, California, to Vancouver Island, British Columbia. One population has been permanently isolated from the sea in Lake Merced, San Francisco, California. This lake is a recent (post-Pleistocene) marine relict lake containing at least five invertebrate species common in nearby brackish lagoons and estuaries, as well as a more typical freshwater fauna (Smith, 1958). As Johnson (1903) said, the water is "perfectly fresh (drinkable)," and the lake has been an auxiliary water supply for the city of San Francisco. The presence of *N. limnicola* in Lake Merced is a unique instance of a freshwater nereid in this country.

The worms were described as abundant in both the southern (Johnson, 1903) and northern arms (Smith, 1959) of the lake in areas with fairly firm and stabilized sand or muddy-sand bottoms. During the summer and early fall of 1963, I found densities as high as $500/m^2$ along a sandy beach on the eastern side of the southern arm. On 21 October I again collected the usual large numbers. Unknown to me at the time, the southern arm of Lake Merced was treated on 26 October

[1] Submitted for publication January, 1964. This study was performed during a National Science Foundation predoctoral fellowship.

with 0.025 ppm rotenone in a fish killing program (A. J. Calhoun, pers. comm.). By 18 November the population of *N. limnicola* was reduced almost to the vanishing point. On 4 December and 15 January the population continued low, at densities no greater than $10/m^2$ at one location, and even scarcer or absent at all other sites. Those few worms found were relatively small, less than 3 cm long (maximum size is 7 to 8 cm). On 18 November 1963, a fisherman who was familiar with the worms because he used them for bait told me that large numbers had been washed up on the beach dead the day after rotenone treatment (27 October), along with fish and "shrimps" (possibly the mysid shrimp *Neomysis mercedis* Holmes, another marine relict species), where they were fed upon by birds. The application of rotenone thus appears directly responsible for the sudden drastic reduction of the *N. limnicola* population observed in the southern arm of the lake.

The northern arm of Lake Merced can be cut off from the southern by valves, and received no rotenone in 1963. However, the northern arm was poisoned with rotenone on 20 October 1962, also at 0.025 ppm (A. J. Calhoun, pers. comm.). No worms were found in the northern arm in either December 1963 or January 1964, even on the beach studied by Smith (1959), where a high density of worms occurred at least as recently as the spring of 1961 (R. I. Smith, pers. comm.). This beach has been seriously altered by surface runoff from a drainage ditch, which might account for the absence of worms, but an adjacent beach with no runoff channels likewise yielded no polychaetes. The conclusion seems inescapable that *N. limnicola* is highly susceptible to rotenone in concentrations as low as 0.025 ppm.

The breeding season of this viviparous worm is from late winter to early summer and involves primarily the larger individuals (Smith, 1950). The breeding population of *N. limnicola* in Lake Merced for 1964 is thus exceedingly small, and several years may be required for the population to recover to its former great abundance.

There are at least two special situations where nereid polychaete worms are of major economic importance. In the Salton Sea of southern California, Walker (1961, p. 198) found that the introducted *Nereis* (*Neanthes*) *succinea* Leuckart was an obligatory member of, and the most critical link in, the food chain of the sea's two major sportfishes, the orangemouth corvina, *Cynoscion xanthulus* Jordan and Gilbert, and the sargo, *Anisotremus davidsoni* (Steindachner). In the Caspian Sea of Eurasia, *Nereis diversicolor* Müller, a very close relative of *N. limnicola* formerly misidentified as *N. succinea* (Khlebovich, 1963), has become established in enormous numbers since it was introduced in 1939. It is now the major food of at least two species of commercially important sturgeons, *Acipenser* spp. (Zenkevich, 1957, p. 909-912). Both the Salton and Caspian Seas have simplified food webs and loss of their nereid populations would have immediate and serious consequences.

How important *N. limnicola* is in the more complex food chains in Lake Merced is not known, and what effects the drastic population reduction will have upon these organisms including sportfishes, which might feed on the worms, cannot be predicted; however, the effect on the sportfishery is unlikely to be favorable.

ACKNOWLEDGMENTS

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THE FISHERY AT SUTHERLAND RESERVOIR, SAN DIEGO COUNTY, CALIFORNIA [1]

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INTRODUCTION

Increasing angling pressure is making the management of fisheries in reservoirs near cities more difficult. Thorough studies of fisheries in such reservoirs constitute one step towards understanding them and improving management. Sutherland Reservoir, completed in 1953, is a warmwater reservoir near large population centers in southern California. This report describes the fishery there from its inception in

[1] Submitted for publication February 1964. A portion of this work was performed as part of Dingell-Johnson Projects California F-13-R, "Black Bass Tagging Study"; F-15-R, "Warmwater Forage Evaluation"; and F-18-R, "Experimental Management of Warmwater Reservoirs," supported by Federal Aid to Fish Restoration funds.
[2] Now with Region 1, Inland Fisheries.
[3] Present address: U. S. Fish and Wildlife Service, Galveston, Texas.

FIGURE 1. Sutherland Reservoir. Creel census station in right foreground. The concession stand, parking area, and boat rental float are in the center. The other two floats are fishing floats. *Photograph by Don A. La Faunce, August 1960.*

1955 through 1960. It also reports largemouth bass *(Micropterus salmoides)* and bluegill *(Lepomis macrochirus)* growth rates, and enumerates largemouth bass mortality rates.

DESCRIPTION OF THE RESERVOIR

Sutherland is part of the City of San Diego's domestic water supply system. It is located on Santa Ysabel Creek about 45 miles northeast of San Diego, near Ramona. It lies at an elevation of 2,000 feet in an area typical of the Upper Sonoran Life Zone. A heavy growth of chaparral covers the surrounding hills (Figure 1). The reservoir has a maximum area of 660 acres and a maximum depth of 162 feet. The greatest area and depth during the study period were about 280 acres and 94 feet. Due to limited water inflow and release, there has been relatively little annual fluctuation in lake level except on two occasions, when substantial releases were made following heavy rains.

Summers at Sutherland are usually hot and dry. Daily maximum air temperatures are about 95° F., with occasional 1- or 2-week periods with maximums over 100° F. Winters are mild, with only occasional freezing temperatures. A maximum water temperature of about 80° F. occurs during late July and early August. Minimum water temperatures are about 50° F. during December and January. A surface temperature of 65° F. is usually reached by mid-April.

The reservoir stratifies during the summer and early fall. The thermocline varies from 15 to 25 feet below the surface. In the hypolimnion, oxygen is depleted and hydrogen sulfide occurs. Oxygen over 4.0 ppm is present in the epilimnion (Nokes, 1961). Visibility in the water is limited. Secchi disk readings were 18 to 52 inches in the late fall of 1960 (Nokes, 1961).

The City of San Diego controls recreational use of Sutherland and limits this to angling, boating, picnicking, and waterfowl hunting. Angling constitutes the bulk of the recreation. A daily fee of $1 per adult angler helps defray the City's operating and maintenance costs. A boat-rental and fishing-tackle concession operates during the angling season.

HISTORY OF THE FISHERY

In the fall of 1953, before the dam was completed, the Department of Fish and Game treated the drainage above Sutherland with rotenone, to reduce potential competition between resident species and fish to be planted the following spring. Green sunfish (*Lepomis cyanellus*), bluegills, and brown bullheads (*Ictalurus nebulosus*) were present in the drainage. Some green sunfish and brown bullheads survived the rotenone treatment.

In the spring of 1954, the Department of Fish and Game planted about 15,000 largemouth bass fry, 1,500 golden shiner (*Notemigonus crysoleucas*) fry, and 900 adult golden shiners. In the fall of 1956, 160 adult bluegills were introduced. The following spring, 2,450 adult threadfin shad (*Dorosoma petenense*) were planted. As part of an evaluation of Florida largemouth bass (*M. s. floridanus*) in California, 800 yearlings were released in Sutherland in February 1960.

All species reproduced successfully. The green sunfish and brown bullheads surviving the rotenone treatment reproduced in 1954. In 1955, there was limited spawning by Age I bass, some of which were 10 to 12 inches long. Bass reproduced heavily in 1956. Threadfin shad became abundant.

In 1955, the City opened Sutherland to angling from September to December. From 1956 through 1959, the season extended from April or early May to early September. In 1960, it was open until mid-December. Angling was permitted on Wednesdays, week-ends, and holidays—except in 1956, when it was allowed only on week-ends and holidays.

In 1955, angling was restricted to half of the shoreline, and boat fishing was not allowed. These regulations applied until 1957, when the entire lake was opened. Rental boats became available in late 1957, and permission to launch private boats was granted in 1958.

Daily bag limits were 5 bass and 10 catfish per angler. In 1959 a 10-inch minimum length was established for bass.

CREEL CENSUS

Methods

A census clerk checked anglers at a census station on the one-way road leaving the reservoir. Aside from portions of the 1955 and 1957 seasons, the clerk conducted a census each day angling was permitted. During 1955, censuses were made on only 13 of the 35 fishing days, and these included 7 of the first 8 days. In 1957, no census was made on 5 Wednesdays in May and June, but angler use and catch were estimated for these days.

The census station was open from 7:30 A.M. until the last angler left. One man censused all anglers except during opening and closing weeks of the season, when one or two extra men were needed.

Information obtained from each party of anglers was: number of anglers, total hours fished, county of residence, and number of fish of each species in possession. To determine hours fished, anglers were asked when they began fishing, rather than how long they had been fishing. Thus, the hours fished represent total elapsed time rather than actual fishing time.

In 1960, the clerk classified anglers as bass or panfish fishermen by recording the type of lure or bait used. Anglers caught essentially all bass with lures or longjaw mudsuckers (*Gillichthys mirabilis*), while earthworms or mealworms took panfish primarily.

The clerk tried to measure the lengths of all bass, and to weigh the bass in alternate catches. In practice, he measured two-thirds of the catch and weighed about one-third during 1959 and 1960. He measured smaller samples in earlier years. Lengths were taken to the nearest 0.1 inch fork length, and weights to the nearest 0.01 pound.

Scale samples were saved from all bass weighed; and we determined ages from these, as described in the later section on growth.

Weights of other species were based on limited data. Weights of counted strings of bluegills taken in 1960 were used as averages for bluegills in all years. There were no obvious differences in size composition in other years, so the use of the same average appears reasonable. We used the bluegill average weight for green sunfish too, and estimated golden shiners to be five per pound (the same as trout of comparable length) and brown bullheads to be 1 pound each.

Results

Angler pressure increased steadily from 5,732 angler days in 1956 to 21,304 in 1960 (Table 1). Despite this rising pressure, angler success increased. Respective catch-per-hour values for 1956 through 1960 were

TABLE 1

Angler Use and Catch at Sutherland Reservoir, 1956 Through 1960

Seasons	*1955* [1] *Sept. 17- Dec. 4*	*1956 May 5- Sept. 3*	*1957* [2] *Apr. 17- Sept. 2*	*1958 Apr. 26- Sept. 1*	*1959 Apr. 15- Sept. 13*	*1960 Apr. 13- Dec. 18*
Days open to angling	35	39	63	59	68	113
Surface acres [3]	97	115	94	250	242	165
Anglers	1,810	5,732	8,283	8,049	15,409	21,304
Hours fished	8,217	31,698	40,425	46,875	103,551	131,903
Catch [4]						
Largemouth bass	1,328	2,019 (2,463)	3,274 (3,372)	7,038 (6,616)	6,915 (8,083)	11,993 (17,937)
Green sunfish	4,286	8,140 (1,465)	1,764 (318)	922 (166)	527 (95)	446 (80)
Brown bullhead		24 (24)	44 (44)	179 (179)	725 (725)	622 (622)
Bluegill			10 (2)	13,884 (2,499)	56,413 (10,154)	101,009 (18,182)
Golden shiner			883 (177)	782 (156)	1,074 (215)	452 (90)
Total fish	5,614	10,184 (3,952)	5,975 (3,913)	22,805 (9,616)	65,654 (19,272)	114,522 (36,911)
Pounds per acre harvested		34	42	39	80	224

[1] Data for 13 census days. No estimates of seasonal totals.
[2] Estimated data for five Wednesdays missed in May and June.
[3] Average surface acres during the census period.
[4] Pounds in parentheses.

0.32, 0.15, 0.49, 0.63, and 0.87. Pounds of fish per angler day also rose steadily. Respective values for 1956 through 1960 were 0.69, 0.47, 1.05, 1.20, and 1.67.

San Diego County residents constituted 91 to 96 percent of the anglers each year. Nearly all others came from the Los Angeles area, about 100 miles distant.

The difference between the number of anglers checked and the number of angling permits sold indicates that about 20 percent of the anglers were under 16 years old.

The annual largemouth bass catch rose steadily during the study period (Table 1, Figure 2), from a low of 2,019 fish in 1956 to a high of 11,993 in 1960. The percentage of largemouth bass in the catch varied from 10.5 percent in 1959 and 1960 to 54.8 percent in 1957. This was due primarily to fluctuations in bluegill and green sunfish catches.

Green sunfish dominated catches in 1955 and 1956, but they declined rapidly and were insignificant by 1958.

Bluegills entered the fishery in small numbers in 1957. By 1958, they were the dominant species, comprising 60.9 percent of the total catch. Thereafter, they dominated the catch (Table 1).

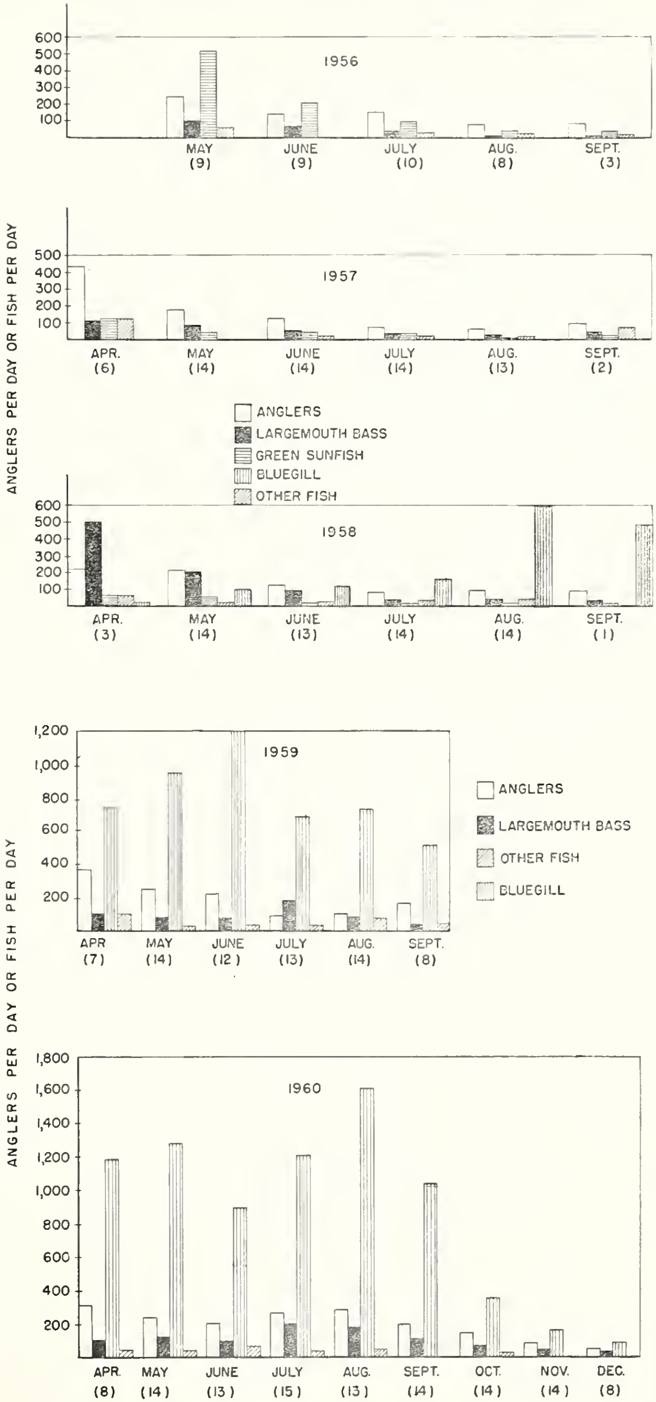

FIGURE 2. Seasonal variation in angler use and catch at Sutherland Reservoir during 1956-1960. Numbers in parentheses are days of angling per month.

Golden shiners and brown bullheads were of minor importance, although bullheads were readily accepted by anglers because of their large average size.

Bass anglers during representative periods in 1960 caught 0.8 bass and 0.1 bluegill per day. In contrast, panfish fishermen caught 0.01 bass and 7.6 bluegills per day. Anglers fishing for both bass and panfish were apparently primarily seeking panfish, since their bluegill catch per day was 3.6 and their bass catch was 0.2.

In 1960, about 35 percent of the anglers fished exclusively for bass, 30 percent fished exclusively for panfish, and 35 percent fished for both. These percentages presumably varied annually and seasonally in relation to the numbers of bass and panfish in the catch. Therefore, catches per hour for individual species are inaccurate measures of annual and seasonal trends.

There were important seasonal variations in catch, but these had no consistent annual pattern (Table 2, Figure 2). Except for 1960, angling pressure was highest in the spring. However, fishing success was usually best some time during the summer, and in 1958 and 1960

TABLE 2

Monthly Catches at Sutherland Reservoir, 1956-1960

	April	May	June	July	August	September	October	November	December	Totals
1956										
Angler hours		13,588	6,909	7,641	2,746	813				31,697
Largemouth bass		993	548	333	104	41				2,019
Green sunfish		4,762	1,817	1,030	422	110				8,141
Total fish[1]		5,767	2,372	1,364	530	151				10,184
Catch per hour		.42	.34	.18	.19	.19				.32
1957										
Angler hours	13,022	12,379	7,909	3,976	2,686	604				40,576
Largemouth bass	620	1,076	725	494	298	61				3,274
Green sunfish	668	467	338	218	53	20				1,764
Total fish	1,979	1,577	1,087	722	418	192				5,975
Catch per hour	.15	.13	.14	.18	.16	.32				.15
1958										
Angler hours	3,634	17,451	9,816	7,607	7,909	457				46,874
Largemouth bass	1,525	3,008	1,310	616	547	32				7,038
Green sunfish	159	490	149	63	59	2				922
Bluegill	43	1,313	1,617	2,226	8,201	484				13,884
Total fish	1,784	5,111	3,219	3,211	8,961	518				22,804
Catch per hour	.49	.29	.33	.42	1.13	1.13				.49
1959										
Angler hours	16,080	25,139	19,890	16,648	18,258	7,536				103,551
Largemouth bass	575	946	844	2,383	1,804	363				6,915
Bluegill	5,191	13,013	14,507	9,098	10,288	4,316				56,413
Total fish	6,653	14,718	15,606	11,598	12,320	4,759				65,654
Catch per hour	.41	.59	.78	.70	.67	.63				.63
1960										
Angler hours	14,822	20,464	15,710	23,845	22,418	15,429	11,266	5,073	1,876	130,903
Largemouth bass	725	1,519	1,805	2,934	2,079	1,358	845	592	136	11,993
Bluegill	9,485	17,902	11,581	18,257	21,229	14,582	5,154	2,116	703	101,009
Total fish	10,586	19,915	13,595	21,299	23,456	16,042	6,070	2,716	843	114,522
Catch per hour	.71	.97	.87	.89	1.05	1.04	.54	.54	.46	.87

[1] Includes miscellaneous species.

TABLE 3

Percentage Age Composition of the Largemouth Bass Catch at Sutherland Reservoir

Year	*No. fish checked*	*Age* *I*	*II*	*III*	*IV*	*V*	*VI*
1955		100					
1956	253	6	94				
1957	1,214	33	30	37			
1958	1,935	5	87	4	4		
1959	2,380	46	36	17	1	1	
1960	4,342	25	55	14	5	1	<1

TABLE 4

Contribution of Various Year-Classes of Largemouth Bass to the Catch at Sutherland Reservoir

Year	*Year-Class* *1954*	*1955*	*1956*	*1957*	*1958*	*1959*
1955	1,328					
1956	1,898	121				
1957	1,211	982	1,080			
1958	282	282	6,123	352		
1959	69	69	1,176	2,489	3,181	
1960		120	600	1,679	6,596	2,998
Totals	4,788	1,574	8,979	4,520	9,777	2,998

total catches were also greatest then. During the first three years, the largest bass catches were made in the spring, but in 1959 and 1960 the largest bass catches were made in mid-summer.

The average size of the largemouth bass declined through 1958 and then increased to a high in 1960. Average weights in pounds for the years 1956 through 1960 were, respectively, 1.22, 1.03, 0.78, 1.06, and 1.38.

Age I and II fish generally dominated the largemouth bass catch, but there were great fluctuations in age composition (Table 3). Using these estimates of age composition, year-class contributions to the catch were estimated (Table 4).

SURVIVAL, MORTALITY, AND POPULATION ESTIMATES FOR LARGEMOUTH BASS

Methods

We estimated survival, mortality, and exploitation rates from recoveries of tagged fish, using methods and concepts presented by Ricker (1958). Our exploitation rates and catch estimates were used to estimate population sizes, and these in turn were used to make partially independent estimates of survival.

Each year, from 1956 through 1960 (about one month prior to the fishing season), Department biologists and sportsmen captured largemouth bass by angling, and biologists tagged them. Both "spaghetti" and disk-dangler tags (Kinsey, 1956) were used in 1956, only "spaghetti" tags in 1957, and only disk-dangler tags in later years. Before 1959, many fish smaller than 10 inches were tagged. While the 10-inch size limit was in effect during 1959 and 1960, only fish over 10 inches total length were tagged—with few exceptions.

The census clerk recovered tags except in 1961, when the dam keeper was paid to recover tags from anglers. The census clerk noted the general condition of each fish, tag, and tag wound. Each angler capturing a tagged fish was sent a commendation card giving a brief history of the tagged fish, together with a letter thanking him for his cooperation and briefly stating the purpose of the tagging program.

Because of annual variations in the rate of decline of tagged fish recoveries, we had to estimate annual survival rates, using the formula

$s_1 = \dfrac{R_{12}M_2}{M_1\ (R_{22}+1)}$ (Ricker, 1958), where:

s_1 = estimate of survival during year one
M_1 = number of fish tagged at the start of the first year
M_2 = number of fish tagged at the start of the second year
R_{12} = recaptures of first-year tags in the second year
R_{22} = recaptures of second-year tags in the second year

Population sizes at the beginning of each season were estimated by dividing the catch of each age group by the annual exploitation rate shown by tag returns. No estimates were made for Age I fish, since they were not fully vulnerable to angling at the season's beginning. Older bass were assumed to be fully vulnerable at the season's beginning. Population sizes at the beginning of each of the first 10 fishing days were estimated by subtracting the daily catches from the initial population estimate. These are biased, since this ignores natural mortality.

Survival-rate estimates that were independent of second-year tag returns were made by dividing the estimated population of Age II or older bass into the estimated population of Age III or older bass in the succeeding year.

Results

Harvest rates for various sizes of bass varied considerably from year to year (Table 5), with no consistent pattern or correlation between size and harvest rate.

Apparently several biases exist in the mortality rates indicated by tag returns (Table 6). The return of 1956 and 1957 "spaghetti" tags decreased more rapidly than the return of disk-dangler tags (Table 7). This implies that either the shedding rate or mortality rate increases for "spaghetti" tags after the first year. As a result, "spaghetti" tag returns overestimate total mortality and first-year natural mortality.

Our 1960 total mortality and natural mortality rates are probably overestimated, also. This results from a probable poorer recovery of tags from anglers in 1961, since no census clerk was present to check catches and recover tags during most of that year.

The longer season in 1960 increased the exploitation rate substantially. Tags returned through the usual closing date in early Sep-

TABLE 5

First-Year Tag Returns from Various Sizes of Largemouth Bass at Sutherland Reservoir

Year	Fork length in inches									
	8.0-9.9		10.0-11.9		12.0-13.9		14.0 or more		Total	
	No. tagged	Percentage returned	No. tagged	Percentage returned	No. tagged	Percentage returned	No. tagged	Percentage returned	No. tagged	Percentage returned
1958	201	46	110	51	0		10	30	321	47
1959	12	42	51	45	78	33	41	22	182	35
1960	15	20	144	51	69	55	72	42	300	48

TABLE 6

Annual Survival and Mortality Estimates for Largemouth Bass in Sutherland Reservoir [1]

Year tagged	*s*	*a*	*u*	*v*
1956 [2]	0.43	0.57	0.22	0.35
1956 [3]	0.77	0.23	0.18	0.05
1957 [2]	0.09	0.91	0.40	0.50
1958 [3]	0.26	0.74	0.47	0.27
1959 [3]	0.45	0.55	0.35	0.21
1960 [3]	0.17	0.83	0.48	0.35

s = survival
a = total mortality
u = expectation of death from fishing (exploitation)
v = expectation of death from natural causes
[1] Estimates based on first- and second-year tag returns.
[2] "Spaghetti" tags.
[3] Disk-dangler tags.

TABLE 7

Numbers of Tagged and Recovered Largemouth Bass in Sutherland Reservoir

Year recovered	*Year tagged* 1956 [1] (101) [2]	1956 [3] (100)	1957 [1] (112)	1958 [3] (325)	1959 [3] (182)	1960 [3] (300)
1956	22	18				
1957	18	31	45			
1958	1	5	5	154		
1959		1	1	29	63	
1960		1	1	32	39	144
1961				5	14	25
Totals	41	46	52	220	116	169

[1] "Spaghetti" tags.
[2] Number of tagged fish in parentheses.
[3] Disk-dangler tags.

tember indicated a rate of 0.39, which was 0.09 less than the rate for the whole season.

Mortality rate estimates based on second-year tag returns (Table 6) are also subject to greater chance variations, because of the relatively low number of tagged fish surviving after the first year. This probably caused the high survival indicated by 1956 disk-dangler tags. Survival estimates (Table 8) based on population size (Table 9) and first-year tag returns should overcome these biases. But no such survival estimates can be made for 1960, since population estimates can not be made for 1961. In 1958 and 1959, when suspected biases should have been minimal, both estimates were essentially identical.

Annual total mortality rates were quite high, averaging almost 0.7 (Table 8). Instantaneous fishing mortality rates had an upward trend except for 1959, and instantaneous natural mortality had a downward trend.

Population estimates (Table 9) show trends of increasing population size and alternate year-class dominance. The weak 1955 year-class presumably resulted from limited spawning by yearlings. The greater size of the 1957 year-class in 1959 suggests that the alternate year-class dominance might be diminishing.

Fishing success during the first 10 days of the season was not closely related to average population size (Table 10). Daily fishing success had no trend related to population size or time (Table 11).

TABLE 8

Survival and Mortality Estimates for Largemouth Bass in Sutherland Reservoir [1]

	s [2]	a [2]	u [2]	v [2]	i	p	q
1956	0.32	0.68	0.20	0.48	1.14	0.34	0.80
1957	0.22	0.78	0.40	0.38	1.51	0.77	0.74
1958	0.27	0.73	0.47	0.26	1.31	0.84	0.47
1959	0.45	0.55	0.35	0.20	0.80	0.51	0.29

i = instantaneous total mortality rate
p = instantaneous fishing mortality rate
q = instantaneous natural mortality rate
[1] Estimate based on first-year tag returns and estimates of population size.
[2] For definitions of symbols see Table 6.

TABLE 9

Population Estimates of Age II + Largemouth Bass at Beginning of Fishing Season at Sutherland Reservoir

	Age group				
Season	*II*	*III*	*IV*	*V*	*Totals*
1956	9,537				9,537
1957	2,443	3,013			5,456
1958	12,918	594	594		14,106
1959	7,195	3,398	200	200	10,993
1960	13,742	3,498	1,229	230	18,699

TABLE 10

Comparison of Fishing Success and Population Size for Largemouth Bass During the First 10 Fishing Days of Each Season at Sutherland Reservoir

Year	*Average population*	*Mean number per surface acre*	*Mean bass catch per hour*	*Percentage of bass in catch*	*Mean air[1] temperature*	*Mean bass catch per hour (second 10 days of season)*
1956	8,813	75	0.07	16		0.08
1957	4,930	55	0.09	40	58	0.07
1958	12,242	44	0.26	78	61	0.14
1959	10,591	43	0.04	9	62	0.03
1960	18,284	74	0.05	7	57	0.09
1960[2]	18,373		0.14			

[1] Average daily temperature at Ramona-Spaulding for period 1 week before opening to 10th day of season.
[2] Statistics only for largemouth bass anglers during first eight days of season.

TABLE 11

Comparison of Daily Angling Success and Population Size for Largemouth Bass During the First 10 Fishing Days of Each Season at Sutherland Reservoir

Day of season	1956		1957		1958		1959		1960	
	Catch per hour	Population size at beginning of day	Catch per hour	Population size at beginning of day	Catch per hour	Population size at beginning of day	Catch per hour	Population size at beginning of day	Catch per hour	Population size at beginning of day
1	0.10	9,537	0.09	5,456	0.56	14,106	0.05	10,993	0.03	18,699
2	0.04	9,040	0.04	5,189	0.27	13,316	0.02	10,810	0.03	18,563
3	0.07	8,952	0.06	5,120	0.44	12,929	0.02	10,733	0.03	18,437
4	0.04	8,824	?	5,092	0.17	12,585	0.06	10,680	0.12	18,392
5	0.12	8,787	0.09	5,026	0.12	12,157	0.04	10,620	0.06	18,294
6	0.05	8,678	0.03	4,887	0.27	11,931	0.05	10,541	0.06	18,243
7	0.05	8,641	0.19	4,838	0.28	11,748	0.06	10,487	0.47	18,194
8	0.04	8,595	0.10	4,716	0.22	11,396	0.04	10,418	0.14	18,163
9	0.04	8,575	0.06	4,528	0.22	11,234	0.04	10,338	0.07	17,974
10	0.04	8,544	0.21	4,447	0.22	11,010	0.14	10,287	0.20	17,884

AGE AND GROWTH OF LARGEMOUTH BASS

Methods

Scales were collected from the area below the lateral line under the tip of the pectoral fin. Key scales were not selected nor was sex determined.

At the laboratory, several scales from each of the larger fish were impressed on 0.030-inch cellulose acetate slides, while those from smaller fish were mounted dry between glass slides. Ages were determined on all suitable scales, and subsamples were saved for back-calculating growth and determining the body length-scale length relationship.

We used an Eberbach scale projector providing a magnification of 42X for determining ages and measuring scales. Measurements were made either diagonally from the focus to the anterior edge of the scale, or from the focus to the center of the anterior edge. The focus, each annulus, and the edge of the scale image were marked on paper strips for use in back-calculating lengths.

Two biologists determined ages independently, and a third one checked those on which there was disagreement. Scales which could not be agreed upon were rejected.

The body-scale relationship was established from 200 randomly selected samples from the 1960 catch. Magnified anterior scale radii were measured to the nearest millimeter. Fish were grouped by one-centimeter intervals of scale radius, and mean scale lengths and body lengths were calculated for each group. These were plotted against each other and a regression line calculated, using the methods of Whitney and Carlander (1956).

Growth was back-calculated with a direct proportion nomograph, corrected for the Y-axis intercept.

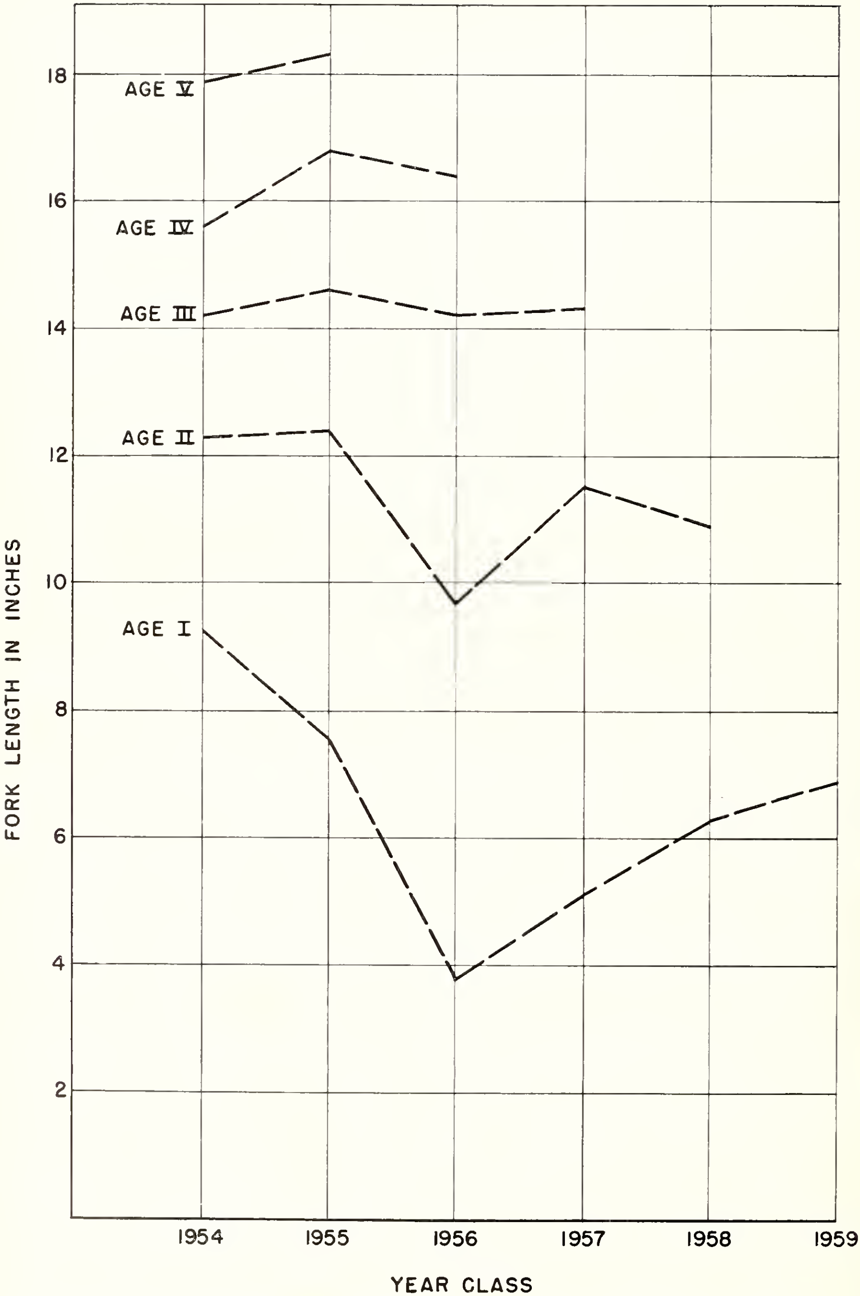

FIGURE 3. Growth rates of largemouth bass at Sutherland Reservoir during 1956-1960.

TABLE 12

Calculated Lengths at Annulus Formation of Sutherland Reservoir Largemouth Bass. Numbers of Fish Indicated in Parentheses.

	Length at annulus formation				
Year-class	*Age I*	*Age II*	*Age III*	*Age IV*	*Age V*
1954	9.3 (418)	12.3 (399)	14.2 (253)	15.6 (82)	17.9 (21)
1955	7.6 (260)	12.4 (260)	14.6 (105)	16.8 (57)	18.3 (33)
1956	3.8 (1,250)	9.7 (1,077)	14.2 (426)	16.4 (217)	
1957	5.1 (1,049)	11.5 (941)	14.3 (598)		
1958	6.3 (2,759)	10.9 (2,400)			
1959	6.9 (1,072)				
Total	6.5 (6,808)	11.4 (5,077)	14.3 (1,382)	16.3 (356)	18.1 (54)

In determining the length-weight relationship, fish were grouped by 0.5 inch length intervals, the midpoint of each length interval and the mean weight of each group were converted to logarithms, and the curve was calculated following the method outlined by Sigler (1953).

Results

The body length-scale length relationship of Sutherland bass is essentially linear between 7 and 18 inches fork length, and is described by the formula: $Y = 0.62 + 0.062X$. Since the smallest fish sampled was 7 inches long, the line extrapolated below this point may not reflect the true relationship, and the Y-axis intercept of 0.62 may not represent the size at which scales form.

Growth during the first 2 years of life was quite variable. The 1956 year-class was particularly slow growing (Table 12, Figure 3). However, by the end of three growing seasons lengths were remarkably uniform.

Length-weight relationships for the years 1958, 1959, and 1960 are described, respectively, by the formulae:

$$\log W = -3.530 + 3.308 \log L;$$
$$\log W = -3.608 + 3.358 \log L;$$
$$\text{and } \log W = -3.391 + 3.174 \log L.$$

All three curves are very similar.

AGE AND GROWTH OF BLUEGILLS

Methods

Methods used for determining growth rates of bluegills were similar to those used for bass, except we did not group fish by scale radius intervals in calculating the body-scale relationship.

Results

The body-scale relationship, determined from 50 scales, is linear between the fork lengths of 2.7 and 9.3 inches. The formula is $Y = 0.872 + 0.031X$.

Growth rates were determined for 1,198 bluegills from the catch, and 64 from seining and electrofishing. All were collected in 1960. Mean lengths at the end of the first, second, and third years are 2.2, 5.2, and 7.3 inches.

The length-weight relationship is described by the formula log $W = -3.39722 + 3.399941 \log L$.

In 1960, Age II bluegills made up about 86 percent of the catch in comparison with about 7 percent each for Age I and Age III fish.

DISCUSSION

Trends in Fishery

Reservoir fisheries usually follow a pattern of a few years of good fishing succeeded by a sharp decline in angling success (Kimsey, 1958). Through the first six years of fishing, Sutherland did not show this pattern. Rather, the pattern was one of increasing success. A large part of the increase was the contribution of bluegills to the catch, following their introduction three years after impoundment. However, the largemouth bass catch also increased throughout the period.

The cause of this trend is not known. Perhaps the continued high yield resulted from the relatively low turnover of water, which presumably would result in better retention of nutrients.

The green sunfish fishery declined markedly after the first two years. A similar trend occurred in Millerton Reservoir, Fresno-Madera Counties (Abell and Fisher, 1953), and we have observed it in other California reservoirs, although supporting catch statistics are not available. At Sutherland, this decline was well under way before bluegills were added, so it cannot be attributed to competition with bluegills. More likely, green sunfish are unable to compete with largemouth bass in our warmer reservoirs.

Largemouth Bass Mortality and Survival Rates

Largemouth bass mortality rates at Sutherland are greater than those reported for most other waters, although few measurements of total mortality are available (Table 13). Despite this, there is no evidence of overfishing. On the contrary, all evidence points to an expanding population—total catch and average size were greatest in 1960, and catch per hour was second highest in 1960. Therefore, we conclude that a 0.70 annual mortality rate and a 0.40 rate of exploitation were not harmful to the population.

Instantaneous angling mortality rates roughly parallel angling pressure from 1956 through 1958, but they show no increase corresponding to the 1959 and 1960 increases in pressure. A partial explanation of this is that most of the 1959 and 1960 increases presumably reflect an increase in panfish fishermen, since the bluegill catch increased so greatly in these years. However, this can not account for the actual decline in the April-September harvest rate in these years, and we have no satisfactory explanation for the decline.

Reservoir size apparently did not affect the angling mortality rate, since rates were similar in 1957 and 1958 despite the great increase in area, and the April-September angling mortality was similar in 1959 and 1960 despite the great decrease in area.

TABLE 13

Comparison of Largemouth Bass Mortality Rates in Sutherland Reservoir and Other Waters

Water	*Reference*	*Annual total mortality rate*	*Rate of exploitation*
Sutherland Res., Calif.		0.70	0.40
Ridge L., Illinois	(Bennett, 1954)	0.35–0.40	0.25–0.30
Clear Lake, Calif.	(Kimsey, 1957)	0.56	0.20
Sugarloaf L., Mich.	(Cooper and Latta, 1954)	0.70	0.26
Wheeler Res., Ala.	(Hulse and Miller, 1958)		0.06–0.15
Browns L., Wisconsin	(Mraz and Threinen, 1957)	0.24	0.12
5 Virginia Lakes	(Martin, 1958)		0.30–0.53
Massachusetts	(Stroud and Bitzer, 1955)		0.19 (avg.)

There is also no satisfactory explanation for the 1956-1959 trend of declining instantaneous natural mortality rates. It seems unlikely that chance variations in tag returns would cause a trend rather than random fluctuations. However, it also seems unlikely that a trend of this magnitude would really occur.

Fishing Success and Population Size

Fishing success measured by catch-per-unit-of-effort has generally been used as an index of population size. However, the overall catch per hour for largemouth bass during the early part of the season at Sutherland Reservoir has not been correlated with population size (Table 10).

Errors in estimating population size are a possible cause of this lack of correlation. One error is that natural mortality was not considered in estimating daily population size. However, we think this was unimportant, since the fish were tagged shortly before this time and annual differences in expectation of death from natural causes were too small to cause these discrepancies.

Another error is that Age I fish were partially vulnerable to angling, but were not included in the population estimates. Again, this is not a significant factor, since few Age I fish enter the catch early in the season. For example, in 1958—the year with the greatest catch per hour in relation to population size—only an estimated 5 percent of the largemouth bass caught during the first 10 fishing days were under 9 inches long and many of these were Age II.

Similarly, since all Age II fish were not vulnerable, this fact might contribute to the error. But it seems to be insignificant, because there was no common relationship between success and population size in the years when Age II bass dominated the catch (1956, 1958, and 1960—Table 9).

Other possible sources of error are related to chance variations and systematic errors involved in estimating population size. These include chance variations in the estimates of exploitation rates and proportion of catch older than Age I, errors in determining ages from scales, and the many possible factors which might bias tag returns. Errors in age composition are unlikely to be important, since only separating Age I bass from the remainder of the catch would contribute; and this is relatively simple. Biases associated with tag returns are unlikely to contribute, since these should have been similar in all years. Chance variations in estimating the proportion of the catch which was Age I bass were small because of the large sample sizes (Table 3). Chance variations due to the estimates of exploitation rates were greater, because of the relatively small sample of fish tagged. For example, assuming this was the only source of variation, the standard deviations for the 1958 and 1960 estimates would be 1,124 and 1,549 (Ricker, 1958, formula 3.6). However, these variations are not great enough to nullify the conclusion that the catch-per-hour was not directly related to population size.

Two partial explanations for this lack of correlation are: the type of anglers probably changed as the species composition of the fishery changed; and bass were probably not equally vulnerable to angling each year because of differing water temperatures and perhaps other limnological conditions. The positive relationship between largemouth bass caught per hour and the proportion of largemouth bass in the catch supports the first hypothesis (Table 10). However, the fact that the catch per hour for largemouth bass anglers in 1960 was only 0.14 indicates that this is not the sole explanation. The mean air temperatures (Table 10) reveal that there were probably appreciable variations in limnological conditions. Differences in catch-per-hour relationships

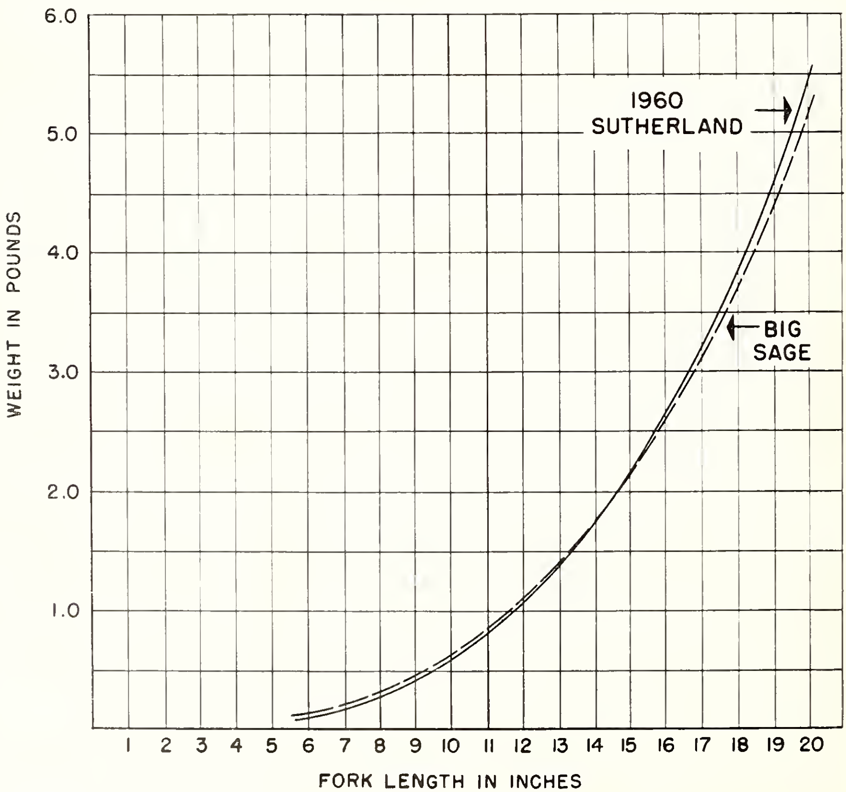

FIGURE 4. The length-weight relationship of largemouth bass from Sutherland and Big Sage Reservoirs.

TABLE 14

Comparison of Largemouth Bass Growth in Sutherland Reservoir and Other Waters [1]

Water and source	*Number of fish*	*Average length in inches at end of year* 1	2	3	4	5	6	7
Sutherland Reservoir	6,808	6.5	11.4	14.3	16.3	18.1		
Big Sage Reservoir, Calif. (Kimsey and Bell, 1955)	43	2.3	4.6	7.2	11.5			
Lake Havasu, Calif. (Beland, 1954)	72	4.6	9.7	13.5	16.2			
Clear Lake, Calif. (Murphy, 1951) [2]	71	6.7	12.2	14.8	16.7	19.8	21.4	
Folsom Lake, Calif. (unpublished data)	523	5.6	10.4	12.8	14.5	15.8	17.0	
Norris L., Tenn. (Stroud, 1948)	1,589	6.9	12.4	14.7	16.1	17.5	19.3	20.8
L. Wappapello, Mo. (Patriarche, 1952)	100	5.4	10.9	13.3	16.1	18.1	19.6	
Oklahoma, statewide average (Houser and Bross, 1963)		5.5	9.7	12.5	14.9	17.1	18.6	19.9
Oklahoma, fastest growth (Houser and Bross, 1963)		11.2	15.4	20.1	21.8	22.8	21.9	22.8

[1] Measurements are fork length for California fish, total length for other states.
[2] Average fork length at time of capture in year following annulus formation.

TABLE 15

Comparison of Bluegill Growth in Sutherland Reservoir and Other Waters [1]

Water and source	*Number of fish*	*Average length in inches at end of year* 1	2	3	4	5	6
Sutherland Reservoir	1,262	2.2	5.2	7.3			
Clear L., Calif. (Murphy, 1951) [2]	102	4.1	6.5	8.1	8.9	9.1	
L. Havasu, Calif. (Beland, 1954)		2.0	5.0				
Folsom Lake, Calif. (unpublished data)	408	1.1	2.7	4.4	6.0		
L. Wappapello, Mo. (Patriarche, 1952)	97	1.7	3.0	4.4	5.6	6.8	
Clearwater L., Mo. (Lane, 1954)	854	2.5	4.2	5.6	6.6		
Claytor L., Va. (Roseberry, 1950)	150	2.1	4.0	6.2	7.8	8.7	9.5
Oklahoma, statewide average (Jenkins et al., 1955)	5,464	3.2	5.0	6.0	6.9	7.3	7.3
Oklahoma, fastest growth (Jenkins et al., 1955)		6.2	7.7	8.4	9.4	10.2	

[1] Measurements are fork length for California fish, total length for other states.
[2] Average fork length at time of capture in year following annulus formation.

for the second 10 days of fishing (Table 10) indicate that seasonal differences in availability were important.

From these facts we conclude that overall catches-per-unit-of-effort from a heterogeneous sport fishery are not meaningful indices of population size, and that catches-per-unit-of-effort for largemouth bass during short periods in the spring are not reliable indices of population size because of short-term differences in availability.

Daily variations in vulnerability, overall angler ability, and perhaps seasonal trends in vulnerability peculiar to each year apparently affected daily success for largemouth bass (Table 11) more than population size or effects of fishing on bass behavior. As a result, there was no consistent trend in success during the first 10 days of fishing. This conflicts with results at several waters in the midwestern United States (Bennett, 1954; Bowers and Martin, 1956), where success declined drastically and consistently after opening day. This decline was much greater than the decrease in population size and was attributed to bass becoming more wary. We cannot explain this difference in results between our study and theirs.

Age and Growth

Sutherland largemouth bass and bluegills grow well in relation to growth rates reported from other waters, but appreciably slower in comparison with maximum growth rates reported from Oklahoma (Tables 14 and 15). Thus, these growth rates are better than average but not exceptional. Despite great differences in growth rates bass from both Sutherland and Big Sage Reservoirs had similar length-weight relationships (Figure 4).

Effects of Introductions

The effects bluegills and threadfin shad may have had on largemouth bass can not be differentiated, since both were introduced between the 1956 and 1957 seasons. Their effect on the bass population size can not be determined either, since the bass population was expanding when the introductions were made. However, production of good bass year-classes continued despite competition.

Bass growth rates were similar before and after these introductions, but the introductions may have caused the differential growth rates of the two largest bass year-classes—1956 and 1958. The 1956 year-class grew slowly, particularly in its first year, but the 1958 year-class did not. The faster growth in 1958 presumably resulted from a larger food supply. This might have resulted from the threadfin shad and bluegill introductions, or it might have been due to a greater abundance of all foods, generally associated with the larger reservoir size in 1958.

Effects of Pretreating the Reservoir Basin

The value of chemically treating drainages to remove fish before reservoir construction has been controversial. A primary objective of pretreatment is to ensure good survival of introduced fish. This was achieved at Sutherland, since about one-third of the bass fry stocked were eventually caught. These fry also showed excellent growth. We are not certain this can be attributed to the chemical treatment. Obviously green sunfish survived and produced a good year-class in 1954. There is no way of estimating the year-class size that would have occurred without treatment. However, both the good bass year-class in 1956, when green sunfish were at a peak, and the inability of green sunfish to compete successfully in this environment make it doubtful that preimpoundment treatment had much value. The incomplete bullhead kill also contributes to this conclusion.

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SUMMARY

Sutherland Reservoir is a warmwater reservoir built on Santa Ysabel Creek, San Diego County, California, in 1953. During the study, its average annual size ranged from 94 to 250 acres. It was opened to fishing in the fall of 1955, and has been opened each year since then in late April or early May. The season ended in September before 1960, and extended to mid-December in 1960. Fishing has been limited to week-ends, holidays, and Wednesdays except in 1956, when it was restricted to week-ends and holidays. This paper describes the fishery through the 1960 season, reports largemouth bass and bluegill growth rates, and enumerates largemouth bass mortality rates for a five-year period.

The reservoir drainage was chemically treated before impoundment to remove bluegills, green sunfish, and brown bullheads. Some green sunfish and brown bullheads survived the treatment.

Golden shiners and largemouth bass were introduced in 1954. Bluegills and threadfin shad were introduced in late 1956 and early 1957, respectively.

Angling pressure, success, and total catch increased steadily throughout the period, with all reaching peaks in 1960. The total harvest that year was 224 pounds per acre. Green sunfish dominated the catch in 1955 and 1956, but declined in importance after this. Bluegills entered the catch in significant numbers in 1958 and made up most of it in 1959 and 1960.

The largemouth bass catch increased steadily throughout the study. There were appreciable fluctuations in growth rate and size of bass in the catch, but Age I and II bass dominated the catch each year except 1957, when Age III bass made up more than one-third of the catch. The largemouth bass growth rate was better than rates reported from most other waters. The largemouth bass total mortality rate averaged about 0.7 annually. The exploitation rate averaged about 0.4 from 1957 through 1959, but was only 0.2 in 1956.

The most important results of this study are:

1) The fishery continued to improve through the first six years, rather than reaching an early peak and then declining, as often occurs in reservoirs.
2) The largemouth bass population expanded during the six years despite substantial total mortality and exploitation rates, and an expanding bluegill population.

3) After an initial bloom, green sunfish rapidly declined in abundance, possibly because of competition from largemouth bass. This decline and the incomplete kill of bullheads cast doubt on the value of chemically treating the drainage prior to impoundment.
4) The overall catch per hour for largemouth bass during the first 10 days of each season was not a reliable index of estimated population size. Chance variations affecting population estimates may have contributed to this. However, the most important factors appeared to be changes in the type of anglers associated with the changing composition of the population, and short-term differences in vulnerability associated with limnological conditions.
5) Daily variations in vulnerability, overall angler ability or both, and perhaps seasonal trends in vulnerability peculiar to each year apparently affected success for largemouth bass more than population size or effects of fishing on bass behavior.

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POPULATION STUDIES OF RING-NECKED PHEASANTS IN CALIFORNIA[1]

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INTRODUCTION

An effective pheasant management program should be based on sound population data. To accomplish this objective, ring-necked pheasant *(Phasianus c. colchicus)* populations were studied in detail on two important pheasant producing areas. Information was obtained from trapping, banding, and band return data from 21,098 wild pheasants for a 10-year period from 1952 to 1961, and 56,777 game farm pheasants released during an 8-year period from 1950 through 1957. A total of 28,510 band returns and retrapping returns was used in computing the data presented.

Pheasant population studies were made by Stokes (1954) on Pelee Island, Ontario, Canada, and Leopold *et al.* (1943), Buss (1946), McCabe (1949) in the midwest. However, information of this type is lacking from the western states.

STUDY AREAS

Two locations were selected for investigation. The Sutter Basin study area, consisting of 68,000 acres of intensively farmed agricultural land in Sacramento Valley, in the southwest portion of Sutter County, the center of rice culture in California, described by Mallette and Bechtel (1959). The wild pheasant population was calculated at 30,000 to 40,000 birds in the late summer for the period of study. The second area was in Honey Lake Valley, Lassen County, in northeastern California. This consisted of the 2,092-acre Fleming Unit of the Honey Lake Waterfowl Management Area, 4 miles west of Wendel, California, on the north shore of Honey Lake. The study area was managed primarily for waterfowl; however, crops and ponded areas provide adequate food, cover, and water for an excellent pheasant population. Land bordering the study area to the north and east was sagebrush and on the west was irrigated pastures and small acreages of grain. Summers are warm and dry. Small amounts of rainfall occur during the fall and spring. Winters usually have occasional snows and freezing temperatures. Pheasant losses due to winter weather conditions were not encountered during the course of this study. The fall pheasant population on the Honey Lake study area was calculated at 900 to 1,300 birds during the 7 years the area was intensively studied.

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HUNTING REGULATIONS

The pheasant hunting regulations were the same during the course of the studies in both areas. A 10-day season was in effect from 1952-54 with two cocks per day and 10 birds for the season. In 1955 the seasonal bag remained the same, but one hen was allowed in the bag and the season extended 6 days. For 1956 and 1957 the hunting regulations remained the same except the daily limit of two cocks was raised to four after the first weekend. Legal hen shooting, outside of licensed pheasant clubs, was terminated in 1958, but other restrictions remained the same.

Licensed pheasant clubs, located in the Sutter Basin study area, were allowed a 75-day season and a daily bag of six birds of either sex. These clubs are required to plant a specified quota of birds. These regulations were continued throughout the period of study.

Hunting pressures varied in the study areas from very little or no hunting to heavy hunting pressures of one hunter for each 10 acres. Such heavy hunting pressures occurred on the co-operative hunting area in the Sutter Basin study area and on the Honey Lake Waterfowl Management Area. Hunting pressure on licensed pheasant clubs was approximately one hunter for each 50 acres.

The Knight's Landing Sportsman Club operated a community hunting area in Sutter Basin during the study period. Hunting regulations on this area were the same as those on other parts of Sutter Basin for the regular hunting season. Approximately 20,000 to 30,000 acres of land were included. Hunting permits were sold at a rate of one hunter per 25 to 35 acres. Hunting pressures were considered light to moderate on this community hunting area.

Hunting pressures in the Sutter Basin study area were thought to be typical of the Sacramento Valley.

STUDY METHODS

Pheasants were trapped by the spotlighting method. All birds were banded and liberated in the same field captured. Each year during the period of study, trapping took place in Sutter Basin from July through September and at Honey Lake in late September and/or early October. A calculated 10 to 15 percent of the fall pheasant population was banded in Sutter Basin and 35 to 40 percent of the fall population at Honey Lake. Ages of pheasants trapped and banded as adults were unknown. However, the largest percent of these birds would be in the second year age group. Birds banded as juveniles the first year trapped were adults by the next breeding season, but for ease in tabulation and discussion they will be referred to as juveniles in all tables. Pheasant bands were recovered each year by bag checks, mailing questionnaires to members of the community hunting area, landowner contacts, from the licensed pheasant clubs, and by providing drop boxes at various locations in the vicinity of the study area.

The pheasant sampling pattern was influenced by farming practices. Because of crop rotation and land manipulation, the same fields might not be entered each year, or in some cases never entered after the initial trapping operation. The 1952 sample of wild birds banded was more closely restricted to fields on or near licensed pheasant clubs than during subsequent years. An increased recovery of hen bands was expected in 1955 through 1957, due to hunting regulation changes which permitted one hen in the regular seasonal bag.

Estimates of the annual and mean annual death rates from band return data were made by the Hickey (1950) method. The methods of Williams (1952) and Lack (1943) also were considered in this study. Pheasant population mortality rates were calculated for the Sutter Basin from: (i) returns from wild banded birds; (ii) retrapped wild banded birds; (iii) returns from banded game farm birds released on licensed pheasant clubs; and (iv) returns from game farm birds released on a state co-operative hunting area. Only wild pheasant loss rates from returns of wild banded birds were calculated on the Honey Lake study area, since no game farm birds were liberated on the area.

The annual fluctuations of the Sutter Basin wild pheasant population were estimated by Lincoln and Kelker indices. Hunting and nonhunting mortality rates were estimated from band return data.

RESULTS

Sutter Basin Study Area Mortality Rates

Mortality Rates Calculated from Returns from Wild Banded Birds

A total of 3,808 bands or 19.8 percent was recovered from 19,239 wild pheasants banded in the Sutter Basin study area during a 7-year period. The calculated pheasant loss rates in Table 1 are from data compiled in a composite life table and must not be construed to be a percent of harvest.

TABLE 1

Mortality Rates Calculated from Returns of Wild Pheasants Banded in Sutter Basin 1952-1958

		Yearly mortality rates in percent						
Age	*Sex*	*1*	*2*	*3*	*4*	*5*	*6*	*Annual mean*
Adult	Male	78	79	67	100			78
Juvenile	Male	86	74	67	75	100		84
All ages	Male	82	78	71	100			81
Adult	Female	54	59	63	78	100		58
Juvenile	Female	71	58	53	44	40	100	65
All ages	Female	62	57	52	55	60	100	60
All ages	Both sexes	76	67	56	63	67	100	73

Mortality rates for juvenile males, 86 percent, and juvenile females, 71 percent, are greater than for adult males, 78 percent, and the adult females, 54 percent, for the first year. This indicates a differential mortality rate between adults and juveniles. Of the males, the juvenile male loss rate is similar to that of the adult male age group after reaching 1 year of age. The annual mean mortality rate for male pheasants through a population turnover was 84 percent. After reaching 1 year of age, the mean annual loss rate was 78 percent. No banded males were recovered after 5 years.

The annual mean mortality rate of females through a population turnover was 65 percent, and after reaching 1 year in age the loss rate was 58 percent. The adult females in Table 1 indicate an increased mortality rate with age, which is not comparable with rates of juvenile females after reaching 1 year of age. This apparent deviation was caused by a variation in band recoveries due to hunting regulation changes. The annual mean mortality rate for a stabilized pheasant population in Sutter Basin can be expected to be approximately 73 percent.

The Effects of Hunting on Female Mortality Rates

In evaluating the effects of a 3-year hen pheasant season (1955-1957) in Sutter Basin, the mortality rates for these years were compared with data obtained before and after the hen season (Table 2). Increased band recoveries from hens taken during the legal season reduce the estimated mortality rates for those years prior to the hen season when calculated together. Limited legal hunting for hens occurred on licensed pheasant clubs throughout this period.

TABLE 2

Comparison of Mortality Rates for Hen Pheasants With and Without a Hen Season Sutter Basin, 1952-1958

	Yearly mortality rates in percent			
Sex	*1*	*2*	*3*	*Annual mean*
	Mortality rates without hen season (1952-1954, 1958)			
Female	67	73	100	70
Male	79	78	100	80
	Mortality rates with hen season (1955-57)			
Female	71	81	100	75
Male	85	86	100	85

Comparing males for the same period of time provides a check on the non-hunting losses when hunting pressures are constant. There was no appreciable change in hunting pressure on the Sutter Basin area even though the season was extended 6 days (Hart, 1955). Table 2 shows an overall increase of five percent in the annual mean mortality rates of females, 70-75 percent, and males, 80-85 percent, during the hen season period. Because of increased rates of mortality for both sexes, the data suggest an increase in non-hunting mortality rather than from hunting.

Variation of Juvenile Mortality Rates During the First Year

The trapping program in the Sutter Basin study area began in July, approximately 1 month after the peak of the hatching period. During July, a large portion of the juveniles are of sufficient size to retain a leg band. In 1954-1957, birds which were too small for a leg band, were banded with a wing clip. Thus, a larger number of juveniles could be sampled and a wider range in ages obtained. The band returns from juvenile birds were segregated into age groups by hatching periods. Ages were determined by checking the wing primaries at the time of trapping.

TABLE 3

First Year Mortality Rate for Juvenile Pheasants Hatched During Four Monthly Periods, Sutter Basin 1952-1958
(Expressed in percent)

Age when trapped	Sex	*Mortality rates by monthly period birds hatched* April 8 to May 7	May 8 to June 7	June 8 to July 7	July 8 to August 7
9 to 11 weeks	Male	86	86	86	91
9 to 11 weeks	Female	62	69	78	88
5 to 7 weeks	Unsexed	--	84	89	87

The 9- to 11-week-old chick pheasant group, males and females, and the 5- to 7-week unsexed age group were chosen, primarily because they provide an adequate sample size. The hatching season was divided into four, 1-month periods, to evaluate rate of losses as related to hatching periods (Table 3). Juvenile males banded at 9 to 11 weeks of age show a uniform mortality rate of 86 percent until the late hatching period (July 8-August 7) when it increased to 91 percent. The same age group of females shows an increased rate of loss from 62 percent during the April 8-May 7 hatching period to 88 percent during the last month of the hatching period. The mortality rate of the unsexed 5- to 7-week age group is irregular, but generally increasing as the hatching season progresses.

Mortality Rates Calculated from Retrapped Wild Banded Birds

An indication of the yearly turnover rate is also illustrated by an evaluation of retrapping data of wild banded birds from the period 1952-1957. A correction factor was applied to retrapped band return data, since the birds were not removed from the population (Buss, 1946). For unknown reasons, a bias was introduced for no juvenile males were retrapped after the first year banded, and there were fewer juvenile females as well.

Information, based on the available retrap data, indicates an annual mean loss rate of 78 percent for males, 57 percent for females, and 58 percent for the population as a whole (Table 4). Results are comparable to that of the adults in Table 1. These results were expected because of the almost complete absence of juveniles in the retrapping data.

TABLE 4

Mortality Rates Calculated from Retrapped Wild Pheasants Banded in Sutter Basin 1952-1957

Sex	*Yearly mortality rates in percent* 1	2	3	4	5	Annual mean
Male	83	67	100			78
Female	57	58	50	40	100	57
Both sexes	61	53	43	50	100	58

Mortality Rates of Game Farm Birds Released on Licensed Pheasant Clubs

Pen reared pheasants released in an area where a wild pheasant population exists have aroused much speculation on the survival and contribution they offer to the population.

The band recovery from game farm birds released and shot on licensed pheasant clubs was nearly 100 percent.

Loss rates of pheasants were calculated for two groups of game farm birds, those released at least 5 days prior to the season, and those released immediately before and during the season. This was done to determine if a period of acclimatization was beneficial for the birds. Birds released on the clubs were 95 percent juvenile, but at least 16 weeks old. No variation in mortality rates in the different age classes was noted in this before-the-gun planting situation.

The annual mean mortality rates for releases made 5 days or more before the season, compared to the releases made immediately before and during the season, show very slight variations at 97 and 96 percent respectively (Table 5). The juvenile female group indicates a slightly better chance of survival than the juvenile males; 5 percent for the females and 1 or 2 percent for males. First year loss rates are equal for both sexes. Some indication was noted that survival after the first year's losses approach the survival of wild birds of the same age group. However, returns are few the following year, and results are not conclusive.

TABLE 5

Mortality Rates of Game Farm Reared Pheasants Released on Licensed Pheasant Clubs, Sutter Basin, 1950-1958

Age	*Sex*	*Yearly mortality rates in percent* 1	2	3	4	5	*Annual mean*
		Pre-season releases					
Juvenile	Male	99	67	100			99
Juvenile	Female	95	80	100			95
Juvenile	Both sexes	98	83	100			97
		In-season releases					
Juvenile	Male	98	91	100			98
Juvenile	Female	96	75	50	50	100	95
Juvenile	Both sexes	97	73	50	50	100	96
		Combined releases					
Juvenile	Male	98	86	100			98
Juvenile	Female	96	77	67	100		95
Juvenile	Both sexes	97	73	67	100		96

Mortality of Game Farm Birds Released on State Co-operative Hunting Area

The Sutter Basin Co-operative Hunting Area was in operation from 1950 through 1954. Mortality rates for hens cannot be calculated since this area was not operated during the period of time hens could be taken during the regular hunting season. Thus, only males were released on the area, and in this case only juvenile birds at least 16 weeks old. Rates were calculated for the preseason releases, made 5 days or more before the season, and those birds released immediately before and during the regular hunting season (Table 6). The annual mean loss rates were 96 percent for each of the two groups of birds. This was in close agreement with results found on licensed pheasant clubs (Table 5).

TABLE 6

Mortality Rates of Game Farm Reared Pheasants Released on State Cooperative Hunting Area, Sutter Basin, 1950-1954

Age	*Sex*	*Yearly mortality rates in percent* 1	2	3	4	*Annual mean*
		Pre-season releases				
Juvenile	Male	97	75	100		96
		In-season releases				
Juvenile	Male	97	71	60	100	96
		Combined releases				
Juvenile	Male	97	65	67	100	96

Honey Lake Study Area Mortality Rates

Mortality Rates Calculated from Band Returns from Wild Banded Birds

Wild birds were trapped and banded on this area from 1955 through 1961. A total of 637 bands or 34.3 percent was recovered from 1,859 pheasants trapped and banded on the area. Because hunters were handled through a checking station, an estimated 95 to 100 percent of the bands were recovered from those banded birds shot on the area.

TABLE 7

Mortality Rates of Wild Pheasants Banded on the Honey Lake Waterfowl Management Area Study Area, 1955-1961

Age	*Sex*	*Yearly mortality rates in percent* 1	2	3	4	*Annual mean*
Adult	Male	74	88	43	100	76
Juvenile	Male	88	75	85	100	86
All ages	Male	81	84	62	100	81
Adult	Female *	69	73	100		72
Juvenile	Female *	73	53	100		71
All ages	Female *	71	64	100		71
All ages	Both sexes *	69	79	100		73

* Includes returns only for the years 1955-57 when hen season was in effect.

The mortality rate of juvenile males (Table 7) was 88 percent during the first year and the mean annual loss rate was 86 percent. This was consistent with rates of juvenile males in Sutter Basin. The adult male mean annual loss rate of 76 percent is slightly less than calculated for this Sutter Basin age group. Mortality rate during the first year for juvenile females was 73 percent and an annual mean of 71 percent. The adult female loss rate was 72 percent. These rates indicate a higher female mortality rate as compared to that in Sutter Basin (Table 1). In making a comparison, the reader should keep in mind this includes only a 3-year period in which females were taken legally (1955-1957), and the band recovery data are not exactly comparable. A more accurate comparison for females would be when band recoveries were equal and through a population turnover time period.

Pheasant Hunting and Non-hunting Mortality

Hunting and non-hunting mortality was computed for 1952-1954 in Sutter Basin by Hart (1955). Subsequent years, 1955-1957, were computed in a similar manner when a hen season existed (Table 8). Hunting loss of hens during 1952-1954 occurred on licensed pheasant clubs and during 1955-1957 hens were taken throughout the area during the regular hunting season as well as on licensed pheasant clubs. Results from Table 8 indicate the survival of hens remained the same during as before the regular hen season when it varied for males. A hunting mortality which increased five percent for females was substituted for a percent of the non-hunting losses.

TABLE 8

Percent of Survival, Hunting and Non-Hunting Mortality Based on Wild Pheasant Band Returns, Sutter Basin, 1952-54 and 1955-57 (Expressed in percent)

Sex	*Time interval*	*Survival*	*Hunting loss*	*Non-hunting loss*
Males	Before hen season 1952-54	20	56	24
	During hen season 1955-57	15	49	36
Females	Before hen season 1952-54	35	9	56
	During hen season 1955-57	35	14	51
Both sexes	Before hen season 1952-54	30	27	43
	During hen season 1955-57	23	28	49

TABLE 9

Percent of Survival, Hunting and Non-Hunting Mortality Based on Wild Pheasant Band Returns, Honey Lake Study Area, 1955-1958 (Expressed in percent)

Sex	*Survival*	*Hunting loss*	*Non-hunting loss*
Male	14	74	12
Female	26	16	58
Both sexes	17	40	43

Percent of hunting and non-hunting mortality was estimated for the Honey Lake study area in a similar manner based on band returns for 1955-1958 (Table 9). During 3 of these 4 years, there was a hen season. Hunting mortality of males was 74 percent which was nearly 20 percent greater than in Sutter Basin and overall survival was still comparable. Hunting mortality rates for females compare closely with Sutter Basin rates. However, survival was down nearly 10 percent with no noticeable effect on the breeding population.

Annual Fluctuations of a Stable Wild Pheasant Population

A graphic illustration of the annual fluctuations of a stable pheasant population in Figure 1 was calculated for the Sutter Basin study area during a 6-year period, 1953-1958. The Lincoln Index was used in computing the August population estimates and the Kelker Index was used for the November and January estimates.

The population fluctuates from approximately 39,000 birds at the hatching peak to 12,000 at the breeding season. The extremely rapid increase in the population during May and June is induced by the

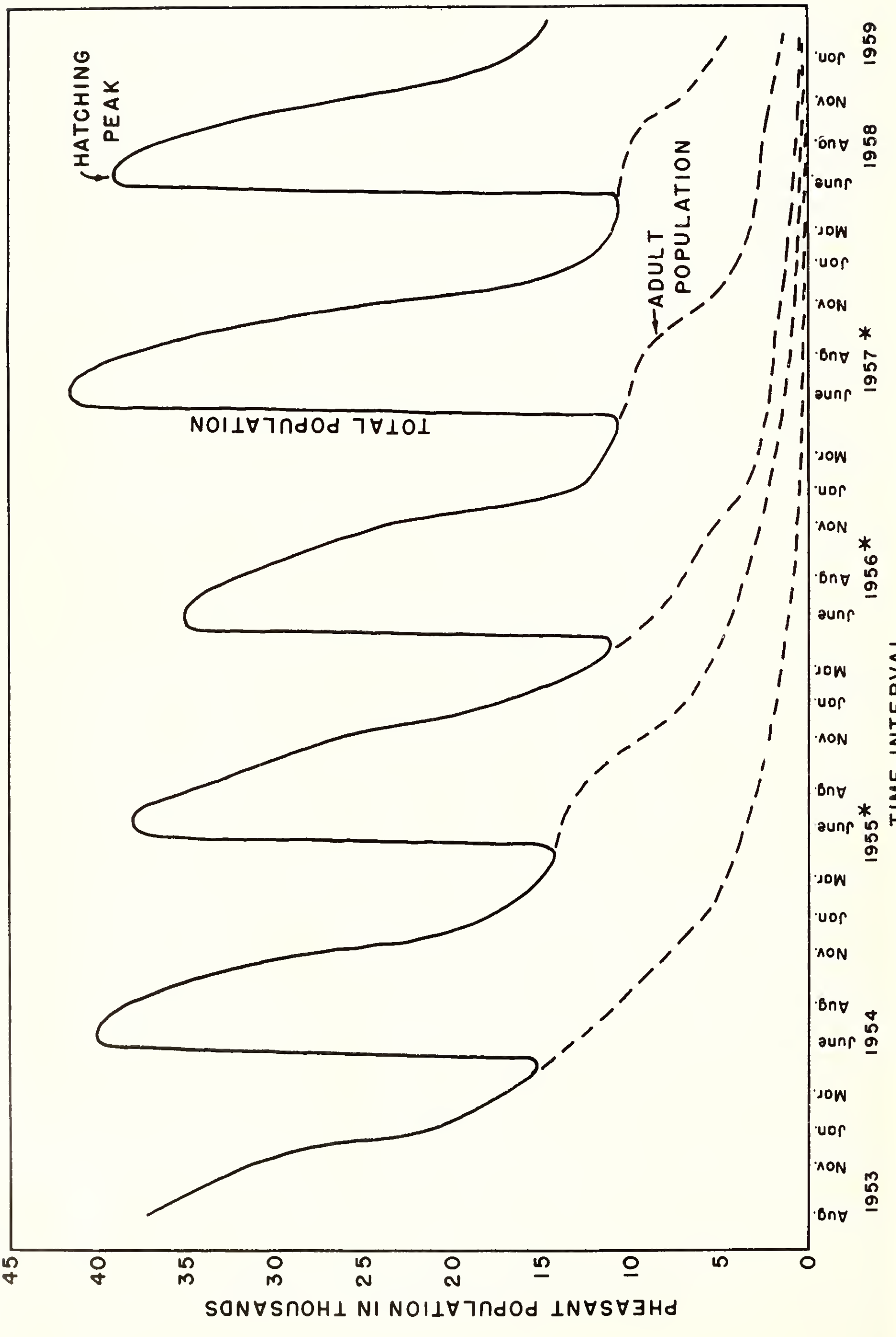

FIGURE 1. Calculated wild pheasant population in Sutter Basin during the six-year period 1953-1958.

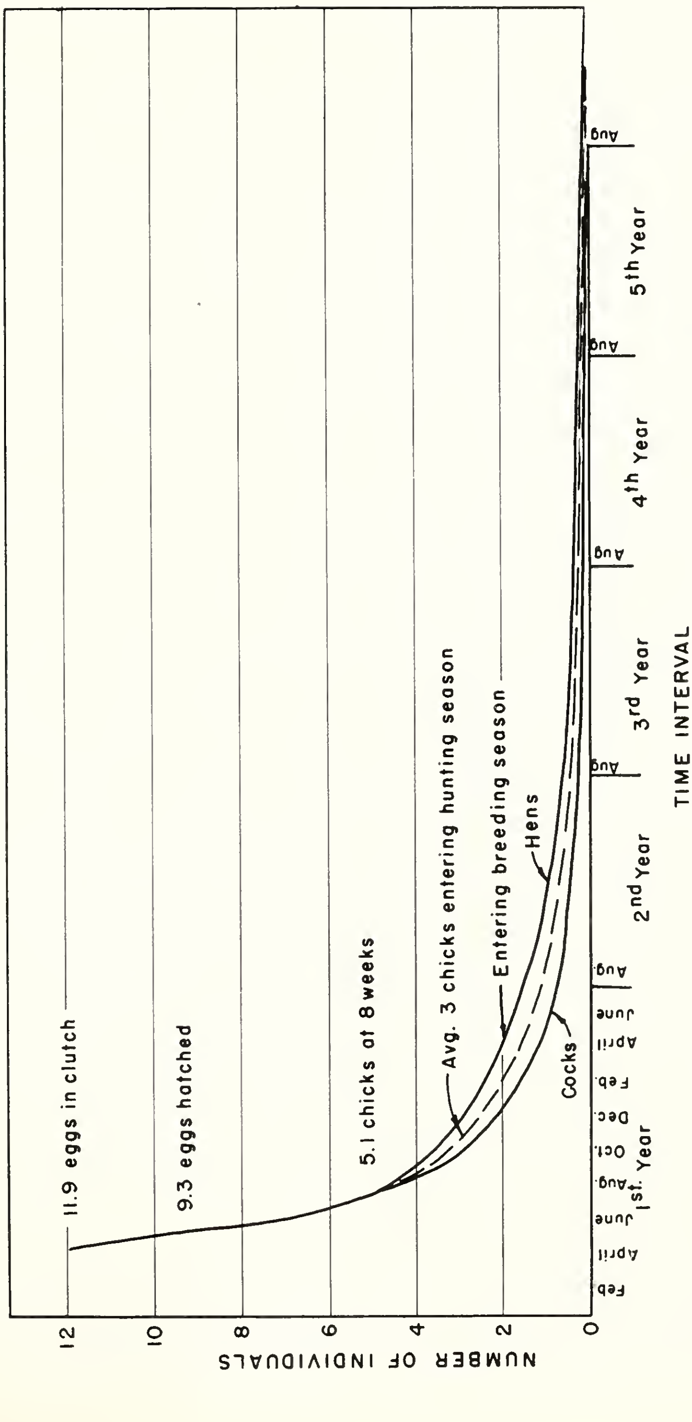

FIGURE 2. Survival of pheasants beginning with clutch of eggs to life expectancy in Sutter Basin.

yearly hatch. However, a high mortality rate reduces the population by January where a reduced rate of loss can be detected. The projected adult population indicates how much a season's pheasant population depends on the young birds of the year.

To further illustrate the high annual population turnover, a clutch of eggs can be followed through a life cycle calculated from available data (Figure 2). Approximately 22 percent of the original 11.9 eggs of an average clutch fails to hatch. At 8 weeks, about five chicks remain and by the end of December approximately two chicks are surviving from the original clutch. Few birds live longer than the third year.

DISCUSSION

A pheasant population possesses the breeding potential of stocking an area beyond the carrying capacity. This management concept is generally accepted by wildlife scientists. Because of this breeding potential, a portion of the population can be harvested, whether it be male or female without endangering the breeding population. A controlled harvest by hunting displaces some of the natural mortality, and overall survival is about the same as if no hunting occurred.

As high as 56 percent of the female population was taken by hunting on the Pelee Island study (Stokes, 1954). The reported effect on the breeding population was a slight decline. On co-operative hunting areas in California a harvest of females was calculated to be as high as 45 percent. This was done during the 3-year period hens were taken legally without reducing the breeding population. Hart (1955) indicated the hunter success was increased 20-25 percent when hunting regulations were changed to include one hen in the seasonal bag in northern and central California. No detriments to the spring breeding population can be attributed to this change. Approximately 126,000 hens were taken in California during the 1955 regular hunting season as calculated by Hart (1955). Estimating the cost to raise this number of birds for release from game farms would be about $375,000. This harvest is in excess of 1.5 times the number of birds released from game farms in California during 1955 at no cost and without harm to the breeding population.

Mortality rates of wild pheasants and game farm reared birds in California are comparable to those found in Canada, Wisconsin, Pennsylvania, and other states as reported by Leopold *et al.* (1943), Buss (1946), McCabe (1949), and Robertson (1958).

SUMMARY

The ring-necked pheasant populations were studied in two areas: (i) the Sutter Basin, Sutter County, California, consisting of 68,000 acres of intensively farmed agricultural land in Sacramento Valley; and (ii) the 2,092-acre Fleming Unit of the Honey Lake Waterfowl Management Area, 4 miles west of Wendel, Lassen County, California. Information presented was obtained from trapping, banding, and band return data from 21,098 wild pheasants for a 10-year period (1952-1961), and 56,777 game farm reared pheasants for an 8-year period (1950-1957). Band returns and retrapping returns totaled 28,510.

Mortality rates were estimated by a method developed by Hickey. Pheasant loss rates in the Sutter Basin study area indicated juvenile

males were at 86 percent the first year with a mean annual rate of 84 percent. The mean annual rate of loss for adult males was 78 percent. Mortality rate for juvenile females was 71 percent the first year with a mean annual rate of 65 percent. Adult female mean annual rate of loss was 58 percent. The mortality rate for a stable pheasant population was estimated at 73 percent annually. Survival of pheasant chicks was greater for those hatched earlier in the season. Rates of mortality calulated from retrapped wild birds compared closely with the rates from band return data. The oldest band return recovered during the study was one female banded as a juvenile 6 years before.

Loss rates were computed for the 3-year period when hens could be taken during the regular season and compared with the 4 years when only limited hen shooting on licensed pheasant clubs existed. The results indicated no adverse effects to the wild pheasant breeding population. Rates of loss were similar under the two hunting conditions.

The mortality rate of game farm reared birds was extremely high for both sexes the first year released; 95-99 percent. After surviving 1 year in the field the rate of loss is somewhat comparable to that of wild birds.

Mortality rates of wild birds on the Honey Lake Waterfowl Management Area study area, estimated from band returns, indicated a mean annual loss rate of 86 percent for juvenile males, 76 percent for adult males, 71 percent for juvenile females, and 72 percent for adult females. Results were similar to those in Sutter Basin for males, with a higher mortality rate for the females, but the same rate of 73 percent for the mean annual mortality rate for the population as a whole.

A graphic illustration of the annual pheasant population fluctuations was calculated for Sutter Basin during a 6-year period (1953-1958). Using the Lincoln and Kelker indices, a population was calculated with a 39,000-bird hatching peak, to a low of 12,000 birds at the breeding season annually.

Survival, hunting, and non-hunting mortalities based on wild pheasant band returns were calculated for Sutter Basin (1952-1957) and Honey Lake (1955-1958). Annual population survival is approximately 23 percent, hunting loss approximately 28 percent, and non-hunting mortality 49 percent in Sutter Basin. Honey Lake study area results for a comparable period indicate a 17-percent annual survival with 40 percent hunting loss and 43 percent non-hunting loss.

ACKNOWLEDGMENTS

The authors wish to express their appreciation for important contributions made by other personnel who worked on the pheasant project, especially Jack C. Bechtel, Russell D. Haynes, and project 30-R members who aided in the hunting season checks. Special thanks are extended to Malcolm E. Foster, former manager of the Honey Lake Waterfowl Management Area.

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NOTES

NORTHERN RANGE EXTENSION OF THE COW ROCKFISH, *SEBASTODES LEVIS*

On September 19, 1963, a juvenile cow rockfish was caught 5.5 miles WSW of Usal, California (lat. 39° 49′ N., long. 123° 58′ W.) in 72 fathoms of water by the California Department of Fish and Game research vessel *N. B. Scofield* while shrimp trawling with a 41-foot, 1¼-inch-mesh Gulf shrimp trawl. A bathythermograph cast indicated the water temperature was 9.3° C. at 61 fathoms.

Phillips (1957) gives the northern limit of *S. levis* as Monterey, California; however, a juvenile was caught by a commercial shrimp trawler in 76 fathoms off Fort Bragg, California, on May 11, 1959 (J. B. Phillips, pers. comm.). It was a male, 146 mm TL, and weighed 418 g. The Usal specimen was of similar size, but was not measured.

These two specimens extend the northern known range of *S. levis* some 345 miles from Monterey to Usal.

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—*Melvyn W. Odemar, Marine Resources Operations, California Department of Fish and Game, June 1964.*

SOUTHERN RANGE EXTENSION OF THE EULACHON, *THALEICHTHYS PACIFICUS*

The eulachon (family Osmeridae), also known as candlefish, is anadromous and spawns from March to mid-May in streams from the Klamath River, in northern California, to the Nushagak River, Alaska (McAllister, 1963). Local residents have reported this species in Redwood Creek, Humboldt County, 15 miles south of Klamath River. Miller (1960) reported *T. pacificus* from the Mad River, Humboldt County, some 35 miles south of Klamath River, but did not mention spawning runs in the river. During the spring of 1963, runs of *T. pacificus* in Klamath River, Redwood Creek, and Mad River reported by local residents, were confirmed by personnel of the California Department of Fish and Game. These runs were large enough for a commercial fishery to develop, and nearly 56,000 pounds were reported sold. An additional unknown amount was taken by sport fishermen. The bulk of the catch was made during April.

During April 1963, the California Department of Fish and Game research vessel *Alaska,* while shrimp trawling with a 41-foot headrope, 1¼-inch-mesh Gulf shrimp trawl, captured 114 specimens of *T. pacificus* in the ocean between Crescent City and Bodega Head, Sonoma County, California (Table 1).

The first catch of *T. pacificus* south of its reported range occurred on April 17 and 18, 1963, off Mendocino County. Single specimens were caught at 3 of 18 stations from Mistake Point to Bruhel Point. Later during the same cruise (April 20-22), the *Alaska* caught 92 specimens at 14 of 24 stations from Salt Point south to Bodega Head. As many as 16 eulachon were caught in a 20-minute haul.

T. pacificus were again caught off Mendocino County on September 19-21, 1963. The Department's research vessel *N. B. Scofield,* using identical shrimp nets, captured nine specimens at 5 of 22 stations (Table 1).

The most recent catches south of its previously reported range were made by the *N. B. Scofield* during a shrimp cruise in April 1964 (Table 1). On April 17 and 19, single specimens were caught at two stations near Big Flat and Abalone Point in Mendocino County. During the same cruise, eight more were caught at 7 of 47 stations between Salt Point and Bodega Head. The southernmost capture of *T. pacificus* was made 5 miles southwest of Bodega Head (lat. 38° 15′ N., long. 123° 08′ W.). The range for *T. pacificus* is thus extended approximately 180 miles south from the Mad River.

TABLE 1

Catch Data for 114 *Thaleichthys pacificus*

Approximate location	Date	Surface temperature	Water depth (fathoms)	Number of specimens
lat. 39° 40′ N., long. 123° 55′ W.	April 17, 18, 1963	11.8°–11.9°C	55–72	3
lat. 39° 40′ N., long. 123° 55′ W.	Sept. 19, 20, 21, 1963	13.3°–14.4°C	50–64	9
lat. 39° 50′ N., long. 124° 00′ W.	April 17, 19, 1964	7.8°– 8.6°C	54–59	2
lat. 38° 25′ N., long. 123° 20′ W.	April 20, 21, 22, 1963	10.9°–11.2°C	47–60	92
lat. 38° 20′ N., long. 123° 15′ W.	April 21, 24, 25, 26, 1964	9.6°–10.3°C	44–58	8

The catches made near Bodega Head during the spring when they normally enter rivers to spawn, suggests these fish may spawn in the Russian River, which is just north of Bodega Head. However, six fish (two females and four males) captured near the mouth of the Russian River on April 21, 1963, had undeveloped gonads. These fish, 135 to 151 mm TL (average 142.8 mm), were considerably smaller than spawning *T. pacificus* found in the Cowlitz and Sandy Rivers, tributaries to the Columbia River (Smith and Saalfield, 1955). *T. pacificus* in these rivers averaged 170.1 mm TL, and none was smaller than 130 mm. Meristic counts for the Bodega Head specimens (gill rakers, 20-22; anal rays, 19-24; pectoral rays, 11) fall within ranges cited by Smith and Saalfield (1955) for this species. No runs of *T. pacificus* have been reported in the Russian River, or in any river south of the Mad River, and it does not appear that the fish examined off the Russian River in May 1963 were destined to spawn there.

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—Melvyn W. Odemar, Marine Resources Operations, California Department of Fish and Game, June 1964.

DIET OF STRIPED BASS AT MILLERTON LAKE, CALIFORNIA

Stomach contents of striped bass, *Roccus saxatilis*, collected at Millerton Lake from April through November, 1963 were examined using a rapid analysis technique (Borgeson, 1963). Nineteen angler-caught and 20 gillnet caught bass contained food. Four of these were juveniles (8 to 10 inches fork length) and the others adults (21 to 34 inches FL).

The adult striped bass contained 1,239 threadfin shad, *Dorosoma petenense*, constituting over 99 percent numerically and 94 percent volumetrically of the total contents. The stomachs also contained one bluegill, *Lepomis macrochirus*, and two unidentifiable fish. One 15-pound female contained 696 shad.

The juvenile bass contained 16 shad, 3 sculpin, *Cottus sp.*, and 2 unidentifiable fish. Shad constituted 76 percent numerically and 45 percent volumetrically of their contents.

While definite conclusions are precluded by the small sample, the results indicate bass feed largely on threadfin shad from April through November. Similarly, clupeids were the most important fishes in the diet of striped bass in Santee-Cooper Reservoir, South Carolina, and sport fish were found in less than 1 percent of the bass stomachs there (Stevens, 1957). Mayfly larvae were also important in the bass diet there.

I sincerely thank Victor Red of Fresno who collected the stomachs from angler-caught fish.

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—Lee F. Goodson, Jr., Inland Fisheries Branch, California Department of Fish and Game, Sacramento, May 1964.

BOOK REVIEWS

Hunting Ducks and Geese

By Edward C. Janes, The Stackpole Company, Harrisburg, Pa., 1964; 187 pp., illustrated with text figures and color plates; $5.95.

The author has fully covered the subject, from the "good old days" to the "future of waterfowl gunning." His chapters on blinds, decoys, boats, dogs, guns, clothes and equipment, and on preparing waterfowl for the table allow the novice to make wiser selections in these fields.

The last two chapters of Mr. Janes's book inform the reader of the history of the conservation movement and its possible future. He reviews the "hard" and sometimes dangerous work of State Wardens and Federal Agents in enforcing the hunting laws, and how researchers have worked to gain more knowledge of waterfowl migrations and illnesses. Mr. Janes very bluntly informs the reader that many conservation leaders believe "our game birds are doomed." He goes on to say that by working together we can possibly conserve most of our game birds, or at least prolong for many, many years their ultimate destruction.

I was very impressed with the 18 pages of color plates. This is one of the best and most complete sets of pictures I've seen on waterfowl. Two pages of pictures of upland game birds also add interest to the section.

The book is written by a person familiar with the eastern portion of the United States and the methods illustrated are predominantly those used there. Although this is true, if the hunter will apply Mr. Janes's suggestions regardless of where he is hunting, I am sure he will have more enjoyment as well as success while, "hunting ducks and geese."—*Dick Laursen, California Department of Fish and Game.*

Marine Distributions

Edited by M. J. Dunbar, Univ. Toronto Press, Ontario, Can., 1963; viii + 110 p., illus.; $5.

The Royal Society of Canada held a symposium in June 1962 to focus attention on marine biogeography and the distribution of environmental factors in the sea, and to introduce the new *Serial Atlas of the Marine Environment. Marine Distributions* is the report of the symposium papers. Five papers on five separate topics serve to emphasize the interdisciplinary nature of research in the marine environment.

"Seasonal temperature structure in the eastern subarctic Pacific Ocean," discusses the development and decay of the seasonal thermocline, and the entrapment of winter water in a sub-thermocline duct. This entrapment makes it possible to record winter temperatures during oceanographic surveys conducted the following summer.

"Distribution of attached marine algae in relation to oceanographic conditions in the northeast Pacific" reports on attached marine algae occurring from northern California to Attu Island, in the Aleutian Chain. The possibility of using these organisms as indicators of long-term oceanographic conditions is explored. Their sedentary habits and relatively long life span should provide a measure of the physical, chemical, and biological conditions of the environment in which they live.

The author of "Distributions of Atlantic pelagic organisms in relation to surface water bodies" has combined plankton information (collected with a Hardy continuous plankton recorder) with temperature-salinity information (collected concurrently) and constructed temperature-salinity-plankton (T-S-P) diagrams. He used these T-S-P diagrams to establish the presence of six water masses in the eastern north Atlantic.

In "Copepods of the genus *Calanus* as indicators of eastern Canadian waters" three species are used as indicators of north Atlantic, arctic, or subarctic (mixed) water masses. A method of identifying the species is also provided.

The fifth paper examines the ability of macroscopic crustaceans to osmoregulate in waters of different salinity as a factor in their distribution. Four groups are designated: (i) *polystenohaline* osmoconformers, which inhabit the ocean; (ii) *euryhaline* osmoregulators, which inhabit waters of reduced, fluctuating, or extremely high salinity; (iii) *oligostenohaline* osmoregulators, which inhabit fresh water; and (iv) *holeuryhaline* osmoregulators, which are equally at home in fresh water or full strength sea water. In general, the number of crustacean species tends to decrease with decreasing salinity.

The symposium was summarized by Dr. Lionel Walford in a short paper containing some very thoughtful statements. Administrators planning projects, and field researchers, would be well advised to peruse this summary occasionally; it will help bring their perspective back into focus.—*E. A. Best, California Department of Fish and Game.*

The Fisherman's Encyclopedia

Second Edition edited by Ira N. Gabrielson; associate editors: Francesca La Monte and Charles K. Fox, the Stackpole Co., Harrisburg, Pa., 1963; xxix + 759 p. illustrated in black and white and color, $17.50.

Many readers will recognize this title and realize *The Fisherman's Encyclopedia* is not a new book but a revised edition of the popular sportfisherman's reference first published in 1950.

Undoubtedly, there are numerous reasons for publishing a new edition rather than reprinting additional copies of the original. Two good reasons are: (i) a new edition allows an author to present recent findings on his subject and (ii) he is able to correct errors that appeared in the original publication. I have used these as criteria upon which to base this review.

Overall, I was rather disappointed for I anticipated a complete revision but found instead that, by-and-large, it was unchanged. The new edition expanded from the original 698 pages to 759; the list of contributors grew from 68 to 86; and a second associate editor was added. However, it is still composed of seven major sections, only two of which were revised completely: Section III, "Craft for Fishing" and Section IV, "Fish Conservation." These two revised sections, a new supplementary appendix and a slightly expanded discussion of skindiving and spinfishing in Section II (Fishing Equipment and Fishing Methods) account for the increased pages and are decided improvements over the original edition. Sections V through VII "Where to Fish," "When and How to Fish," and "Miscellaneous Topics" remain much the same, with changes ranging from none, to minor editing, and updating of such material as organizational structure of the International Gamefish Association.

A large section of the book (Section I) still is devoted to descriptions of fresh and saltwater gamefish. Because they are most familiar, my attention was concentrated toward checking the Pacific Coast marine species. The list of errors was lengthy, indicating a lack of both revision and correction. Doubtlessly, some may be oversight and others typographical. Regardless of the source they could be forgiven more easily if they had not been repeated from the original. Some examples will illustrate the easily located mistakes. The Atka mackerel illustration is placed incorrectly with the scombrids while the text material is placed correctly with the greenlings. The spearfish and yellowtail-amberjack information is not up-to-date. The California sheephead is illustrated incorrectly with the porgies while the text (with an erroneous common name) is grouped correctly with the wrasses. The rockfish section is inadequate considering their importance in California's sportfishery (only one species is mentioned, and two of its three assigned common names were in error). Nomenclature for the mackerel family (Scombridae) was modernized but relationships of the Spanish mackerels *(Scomberomorus)* were ignored and the Atlantic cero illustration was misplaced with the croakers; only a few Pacific Coast anglers will recognize the familiar skipjack tuna by the name oceanic bonito.

It is difficult to imagine why the list of contributors was expanded yet the editors failed to include an authority on Pacific Coast fishes to review that section. Many errors might have been avoided by this action. As an alternative, the editors might have consulted the American Fisheries Society's 1960 list of common and scientific fish names. This publication has gained wide acceptance as a standard, and its use could have saved many errors and avoided introducing another system of common names. The new appendix contains the Outdoor Writers Association's checklist of common names for American sportfishes but it was not followed in the text.

Photo-offset printing was used liberally to produce this volume directly from pages of the original. In several instances there were references to figures in the text that had been copied literally from the old edition so that page numbers were erroneous or the figures deleted. The photos reproduced by this method were darker and showed less detail in the new edition, and the new associate editor was omitted on the title page.

The most serious omission is the loss of the subsection entitled "Building a Fisherman's Library" which appeared in the old edition. The new volume is a fine reference for anglers but it does not express the opinions and methods of all the experts. It seems a grievous mistake for an "encyclopedia" to fail to expand this topic and include not only the classic references but also many of the excellent publications that have appeared on the market within the last 13 years.

Basically *The Fisherman's Encyclopedia* is an interesting, informative, and well illustrated book that deserves a prominent place on every serious angler's shelf. However, many potential buyers will be discouraged by the 30 percent price increase that does not seem fully justified by the quality of revision.—*William L. Craig, California Department of Fish and Game.*

The Geese Fly High

By Florence Page Jaques, Univ. Minnesota Press, Minneapolis, second printing 1964, 102 pp., illus.; $4.50.

If you've wanted the woman's viewpoint on waterfowl hunting and roughing it, this is the book! Florence Page Jaques relates her impressions as she traveled with Francis Lee Jaques, her husband and noted artist, through duck and goose hunting areas in Minnesota, Arkansas, and Louisiana. The author's account is so popular that the publishers reissued this book.

Her husband's black and white sketches artfully illustrate many episodes in the narration. In addition, the author uses the talented Mr. Jaques's drawings of waterfowl tactfully throughout the book.

Although she did not intend it, I thought some sections of her story were a bit pretentious; for example, she wrote that they hired a cook for their stay at the Rainey Wildlife Sanctuary in Louisiana. Perhaps this situation induced dismay rather than admiration on my part. But again, the story is a woman's outlook on the subject and all husbands, particularly those that are hunters, know about diverse opinions.

In all sincerity, I recommend this book for enjoyable reading; the battle of the sexes notwithstanding.—*James C. Thomas, California Department of Fish and Game.*

The Quiet Crisis

By Stewart L. Udall; Holt, Rinehart and Winston Inc., New York, 1963; xii + 209 p., color plus black-and-white illustrations; $5.

This is one of the outstanding books on conservation in modern times. The author, Secretary of the Interior Stewart Udall conveys not only a feeling of his depth of knowledge, but a strong personal conviction in the concept he expounds.

Basically, he describes, in historical sequence, the land story of the American earth and the changing land attitudes of those who have used it and lived on it.

He begins by describing the attachment the Indian had for his environment, followed by the contrasting story of the "White Indian" or mountain man, who showed great courage but was motivated by far different objectives from the red man.

Next upon the scene were the early naturalists, such as Audubon, Bartram, and Thoreau, who revelled in their discoveries of the nature-man relationship. The new continent was their laboratory.

The period following was one in which the raids on our resources were rampant. On one hand was the "give away" of public lands and on the other the careless exploitation of our soils, forests, and wildlife.

Beginning landmarks in the conservation conscience, which arose under such leaders as Carl Schurz, John Wesley Powell, John Muir, and Teddy Roosevelt, are described. This all leads up to the heart of the message, which the author calls the "quiet conservation crises of the 1960's."

Our technological advances such as river development, atomic energy, pesticides, etc. have created a whole new set of problems. Most state and city governments face so many growth problems they have little time for foresight in planning their over-all environment.

Although the conservation message of this book is not new, it is refreshingly retold in a manner of sincerity and strength which will lay hold of professional and layman alike. It is a must in reading by every American concerned with his future environment.—*Willis A. Evans, California Department of Fish and Game.*

The Wonders of Wildlife

By F. A. Roedelberger and Vera Groschoff, *English translation by* Mary Phillips, The Viking Press, New York, 1963; 232 p., illustrated; $8.50.

This book provides a wonderful stay-at-home nature expedition for all conservationists and nature-lovers. In this sequel to *The Wonderful World of Nature*, 280 photographs have been combined to create a volume of unparalleled beauty and scope. The 24 color photos cover such diverse subjects as: grey seals, red deer, puffins, salmon, barnacles, anemones, newts, etc. The volume has better balance than its predecessor, as it contains a wider variety of plant and animal subjects.

Most, but not all, of the subjects depicted in this volume are European. The appendix lists the major nature sanctuaries in 27 countries. An alphabetical index of common and scientific names of all depicted species accompanies the text. Informative, well-written captions accompany each photograph in the book. The reproduction and printing of the photographs was superbly done, resulting in pictures of unusual depth and clarity.

We should be grateful to the European publishers and printers who have made volumes such as this available to the American public at reasonable prices. I would recommend this book without reservation to all who have an interest in *The Wonders of Wildlife*.—*Michael L. Johnson, California Department of Fish and Game.*

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Notice is hereby given, pursuant to Sections 206, 207, and 208 of the Fish and Game Code, that the Fish and Game Commission shall meet on October 2, 1964, at 10:00 a.m., in the auditorium, State Employment Building, 722 Capitol Mall, Sacramento, California, to receive recommendations from its own officers and employees, from the Department of Fish and Game and other public agencies, from organizations of private citizens, and from any interested person as to what, if any, regulations should be made relating to fish, amphibia, and reptiles, or any species or subspecies thereof.

FISH AND GAME COMMISSION
Monica O'Brien, Secretary

Notice is hereby given, pursuant to Section 206 of the Fish and Game Code, that the Fish and Game Commission shall meet at 10:00 a.m., on November 6, 1964, in the Board of Supervisors Room, Room 21 of the Courthouse, Redding, California, to announce publicly the regulations it proposes to make relating to fish, amphibia, and reptiles for the 1965 angling season.

FISH AND GAME COMMISSION
Monica O'Brien, Secretary

Notice is hereby given, in accordance with Section 206 of the Fish and Game Code, that the Fish and Game Commission shall meet on December 4, 1964, at 10:00 a.m., in Room 115, California State Building, 217 West First Street, Los Angeles, California, to hear and consider any objections to its determinations and proposed regulations in relation to fish, amphibia, and reptiles for the 1965 angling season, such determinations and orders resulting from hearings held on October 2 and November 6, 1964.

FISH AND GAME COMMISSION
Monica O'Brien, Secretary

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