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IN MEMORIAM

Arnold B. Albrecht

Arnold B. Albrecht was killed in an automobile accident on August 28, 1964.

Mr. Albrecht joined the Department of Fish and Game in 1960, after earning a Master of Science degree from the University of Michigan and working briefly as a biologist for the Illinois Department of Conservation. He worked on the striped bass project for the past four years, and had been project leader since August 1961. His recently-published paper on the factors affecting the survival of striped bass eggs and larvae describes his major contribution to scientific knowledge. He also contributed considerably to our study of the dynamics of the striped bass population, and his efforts will contribute significantly to future papers.

Besides his scientific ability, those of us who knew Arnie will long remember his enthusiasm, diligence, and other personal qualities which made him so well-liked.

All of us extend our most sincere sympathies to his wife, Mary, his son, and his parents. *Harold K. Chadwick, Inland Fisheries Branch, California Department of Fish and Game.*

Calif. Fish and Game, 51(1) : 5–15. 1965.

WATERFOWL PRODUCTION IN THE VICINITY OF GULL COLONIES[1]

WILLIAM ANDERSON
Game Management Branch
California Department of Fish and Game

The effect on waterfowl nesting of the proximity of gull colonies was studied at Hartson Reservoir, Lassen County, California. Data were obtained through field observations and by collecting gull stomachs. There was no evidence that gulls interfered with the production of Canada geese. No significant waterfowl remains were detected in 95 gull stomachs examined. However, some predation on young ducklings by gulls was observed, but overall losses from ths source were not considered severe. Habitat could be improved for waterfowl by constructing island nest sites and by establishing shrubby vegetation on the islands.

INTRODUCTION

Wherever large nesting colonies of gulls exist within waterfowl breeding habitat their presence is generally regarded by the game manager with considerable misgivings. This paper presents the results of a study made during the spring and summer of 1963 at Hartson Reservoir and vicinity in Lassen County, California. More than 2,000 nesting pairs of California gulls (*Larus californica*) and ringbilled gulls (*Larus delawarensis*) occupied islands in Hartson Reservoir, a portion of the Honey Lake State Waterfowl Management Area. The principal objective was to determine the effect upon waterfowl production of the proximity of gull colonies. A second objective was to evaluate the management techniques of the study area.

A number of investigations have been made in the past, entirely or partly to determine the degree of conflict between gulls and waterfowl. These studies have produced varied answers, which suggest local behavioral differences affected by the environment. Odin (1957), in a study at Farmington Bay Bird Refuge, Utah, concluded that 18.3 percent of the 2,997 duck eggs in 317 nests were destroyed by California gulls. Eighteen of 90 California gull stomachs contained young waterfowl, embryos, down and egg shells. Hunt and Naylor (1955), in studies conducted in Honey Lake Valley, California, during 1951 and 1953, asserted that the rate of nest destruction by avian predators was low in marshy areas and moderate in upland areas. Rienecker and Anderson (1960), in a study in the Klamath Basin, California, found 6.0 percent of goose nests and at least 1.7 percent of duck nests were broken up by gulls. The damage to eggs was heavy in the vicinity of nesting and foraging gulls. On several occasions gulls were observed taking young waterfowl. Rothweiler (1960), in a study at Freezout

[1] This study was supported by Federal Aid in Wildlife Restoration Project California W-30-R, "Waterfowl Investigations." Submitted for publication June 1964.

Lake, Teton County, Montana, stated there was little, if any, gull depredation on waterfowl.

Locale of the Study

The study area (Figure 1) consisted of a portion of the Honey Lake Waterfowl Management Area, mainly Hartson Reservoir. The reservoir is quite shallow and fluctuates greatly from year to year depending on annual precipitation, which can be extremely variable in northeastern California. During the 1963 nesting season, the reservoir was filled to capacity, comprising approximately 900 surface acres. Immediately northwest of Hartson Reservoir lies a parcel of land, locally referred to as West Dakin, which in wet years such as 1963 has about 300 acres of productive cover, ponds, and islands. The proximity of this area to Hartson Reservoir and the gull colonies prompted its inclusion as a study unit. The most significant feature in the study area was a chain of six islands in Hartson Reservoir averaging about one-half

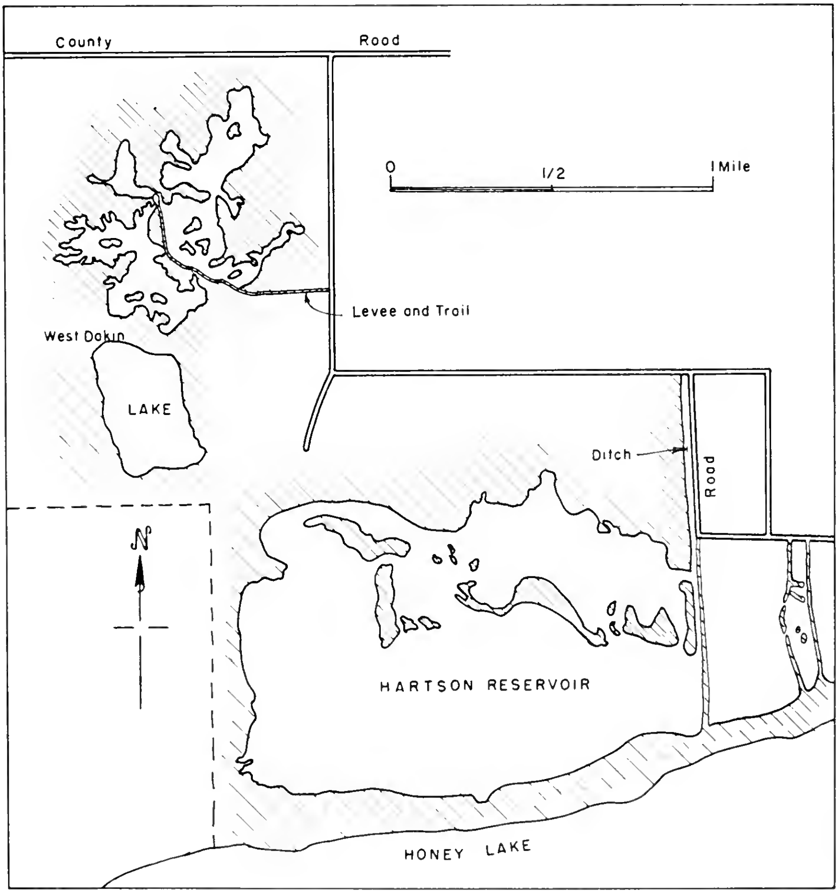

FIGURE 1. *Map of study area. Drawing by Cliffa Corson.*

acre in size, and a number of smaller islands which varied in size according to prevailing water levels.

The elevation is a little over 4,000 feet. The most conspicuous geographical feature is Honey Lake which during wet cycles forms a 100-square-mile body of shallow water. Periodically it reverts to a dry alkaline lake bed. Hartson Reservoir is separated from Honey Lake by a sandy ridge.

The lake and the reservoir filled during the winter of 1962-1963 when above-normal rainfall prevailed. Normal annual rainfall for the area is about 8 inches. Between July 1, 1962, and June 30, 1963, precipitation amounted to 12.20 inches. The water supplying the local lakes and ponds comes from the Susan River and several smaller streams with sources in nearby mountain ranges.

Vegetation

The vegetative cover of the upand is that described by Munz and Keck (1959) as sagebrush scrub, composed of common sagebrush (*Artemisia tridentata*), black greasewood (*Sarcobatus vermiculatus*), rabbitbrush (*Chrysothamnus nauseosus*), hop sage (*Grayia spinosa*), and horsebrush (*Tetradenia canescens*). On levees and other places where the ground has been disturbed, occur dense patches of alkali weed (*Bassia hyssopifolia*) and goosefoot (*Chenopodium album*). In low or marshy places, the cover mainly consists of saltgrass (*Distichlis stricta* var. *spicata*), Baltic rush (*Juncus balticus*), Nevada bulrush (*Scirpus nevadensis*), and much less abundantly, burr reed (*Sparganium eurycarpum*), roundstem bulrush (*Scirpus acutus*), and cattail (*Typha latifolia*). Hartson Reservoir and adjacent ponds and ditches by midsummer form solid beds of pond weed (*Potamogeton pectinatus*, *P. filiformis*, *P. latifolius*, *P. pusillus*) and other submerged aquatics, all contributing as waterfowl food sources.

Gulls

Gulls of both species were present in considerable numbers in early April, but not until April 23 was the first egg found. By April 30, 40 gull nests each contained up to three eggs. A complete count on May 22 and 23 revealed 2,050 gull nests, several containing pipped eggs. The population was made up of nearly equal numbers of California and ringbilled gulls. There were two separate colonies, a large one near the northeast corner of Hartson Reservoir comprising 1,810 nests, with 1,350 of these on a single island (Figures 2 and 3), and a smaller colony with 240 nests near the west end of the reservoir. Nests of the two species were intermingled, although a single species appeared to predominate in some sectors. Low, rather barren islands were chosen as nest sites in marked preference to islands covered with woody plants. The principal vegetation on the main gull island consisted of dried, matted goosefoot from the previous year. New growth did not become prominent until late July when many fledglings were on the wing.

Prolonged visits to the nesting colonies sometimes resulted in gulls preying on eggs of other gulls. After early June, many young gulls left the islands and swam out into open water upon the approach of the investigator. When attacked by adult gulls, the young were vigorously defended by parent birds, and no serious losses resulted from these conflicts.

FIGURE 2. Nesting gulls on island in Hartson reservoir. *Photo by the author.*

FIGURE 3. A total of 1,350 gull nests was counted on this island. *Photo by the author.*

Food items and objects found in gull nests included disgorged barley and various kinds of garbage such as bits of tomato and tinfoil. A dead young duckling was seen in a gull nest on June 11. Meadow mice (*Microtus* sp.) were found on several occasions. Eggs left in deserted duck nests on islands in the reservoir were sometimes devoured by gulls. Abandoned goose eggs and ruddy duck eggs, though conspicuous enough, were left untouched. Gulls foraged over fields, meadows, marshes, and sagebrush scrub covering an area of many miles. Rothweiler (1960) made nine observations of marked gulls feeding in fields up to a distance of 20 miles from Freezout Lake, Montana. Throughout the present investigation, they fed on road killed jackrabbits (*Lepus californicus*), and cottontails (*Silvilagus nuttallii*), or followed tractors, where they picked up anything edible, mainly meadow mice and insects.

A California gull was seen on June 25 flying toward the nest islands carrying a week-old duckling. A similar observation was made on July 1. On July 8 a California gull snatched a young unguarded ruddy duck from the pond surface and dropped it within a couple of hundred yards. The gull immediately returned and picked up another duckling which it carried a short distance before alighting on the water and devouring it. On July 9 a California gull, while on the wing, picked up a young eared grebe (*Podiceps caspicus*) and swallowed it immediately. On the same day, a recently-hatched coot (*Fulica americana*), was taken by a gull (species unknown) in the same manner. Several times gulls attempted unsuccessfully to take ducklings accompanying an adult. A female shoveler with a brood of seven young was swimming across open water in Hartson Reservoir on June 26 when a California gull swooped to within less than a foot of the group. The shoveler assumed an attitude of extreme aggression, causing the gull to veer off and alight a short distance from the brood. The shoveler hen succeeded in leading her young in close formation to the comparative safety of the nearest cover. For several minutes the gull followed at a prudent distance before giving up its quest.

Food Habits

Fifty-six adult California gulls, 29 ringbilled gulls, and 10 nestlings were collected during June and July. The stomachs were submitted to the Food Habits Section of the Department's Wildlife Investigation Laboratory for analysis. The most significant food items were meadow mice (*Microtus* sp.), fish (mostly carp, *Cyprinus carpio*), and insects (Table 1). The principal insect foods, in relative order of importance, were cicadas (*Cicadidae*), grasshoppers (*Locustidae*), and whirligig beetles (*Gyrinidae*). Some mollusk shell fragments, earthworms, and spider fragments were encountered also. Garbage was a significant item. The gulls' stomachs contained fragments of steak, chicken, spaghetti, beans, strawberries, melons, corn, fruit, bread, paper, cloth, and matches. All feathers were from gulls except for some duck or goose down in a ringbill stomach. One California gull had eaten some unidentified egg shell. None of the 10 chick stomachs contained over 6 cc of food. This consisted principally of insects, vegetative stem fragments, and grass leafage, with one occurrence each of meadow mouse, garbage, and unidentified bone fragment.

TABLE 1

Food Items Eaten by 95 Gulls—Honey Lake State Waterfowl Management Area 1963

Item	Calif. gull June–July (56)		C.G. chicks June (10)		Ringbills June–July (29)	
	Volume percent	Frequency	Volume percent	Frequency	Volume percent	Frequency
Plant foods						
Garbage	17.4	11	5.5	1	9.9	3
Gramineae leafage	10.0	14	18.5	4	7.6	6
Vegetative stem fragments	5.5	11	25.0	5	trace	3
Unidentified matter	4.6	6	7.0	1	--	--
Melon, *Cucumis* sp.	0.2	3	0.1	1	trace	3
Cheatgrass, *Bromus tectorum*	0.1	4	--	--	--	--
Tumbling mustard, *Sisymbrium* sp.	trace	5	trace	1	--	--
Forb leafage	trace	2	--	--	--	--
Milo, *sorghum vulgare*	trace	2	--	--	--	--
Clover leafage, *Trifolium* sp.	trace	1	--	--	--	--
Wiregrass, *Polygonum aviculare*	trace	1	--	--	--	--
Blackberry, *Rubus* sp.	trace	1	--	--	--	--
Animal foods and miscellaneous						
Fish bones and remains (carp)	23.0	17		--	6.9	2
Meadow mouse, *Microtus* sp.	15.9	11	7.5	1	28.2	10
Insect fragments	8.5	22	30.5	10	33.3	19
Rabbit (Leporidae)	8.2	7	--	--	2.0	1
Tadpole shrimp, *Lepidurus packardi*	1.8	1	--	--	--	--
Desert woodrat, *Neotoma lepida*	1.8	1	--	--	--	--
Unidentified shell (*Mollusca*)	1.1	1	trace	1	--	--
Egg shells	0.4	1		--	--	--
Unidentified flesh and bones	0.3	1	--	--	--	--
Grubs (Diptera)	0.3	7	--	--	--	--
Gull feathers	trace	3	--	--	--	--
Insect larva fragments	trace	1	--	--	--	--
Bone fragments	--	--	5.5	3	2.9	1
Spider (Arachnidae)	--	--	trace	1	--	--
Damsel fly (Odonata)	--	--	trace	1	trace	1
Duck or goose feathers	--	--	--	--	1.7	1
Gravel	0.9	3	0.4	1	--	--
Tinfoil	trace	1	--	--	--	--
House mouse, *Mus musculus*	--	--	--	--	3.4	1
Earthworm (Annelida)	--	--	--	--	4.1	2

Several adult stomachs were virtually empty, containing only grass and vegetative stem fragments, hence the relatively high volume percentages of these two items (Table 1).

Gulls and Canada Geese

Canada geese (*Branta canadensis moffitti*) were at peak nesting when the study was initiated on April 8, and 133 nests were located. The peak of hatch was reached by the middle of April. Although numerous nests were terminated previous to the initial inspection, their fate could be determined. Active nests were marked to facilitate relocation, visited about once a week, and their status recorded on Unisort cards.

Canada geese make no attempt to conceal their nests, but choose more or less isolated sites. One-third of the nests took advantage of shelter afforded by shrubs or by last year's matted vegetation. Geese and gulls nesting in close proximity tolerated each other without noticeable hostility.

Out of the 133 goose nests, 69.2 percent hatched successfully; among the failures, desertion accounted for 19.5 percent, predation 3.0 percent, and other causes (mainly flooding) amounted to 8.3 percent (Table 2).

TABLE 2

Waterfowl Hatching Success at Honey Lake State Waterfowl Management Area 1963

Species	Hatched successfully		Deserted		Destroyed		Other causes of failure		Totals	
	No. of nests	Percent	No. of nests	Percent	No. of nests	Percent	No. of nests	Percent	No. of nests	Percent
Canada goose	92	69.2	26	19.5	4	3.0	11	8.3	133	100.0
Mallard	11	50.0	6	27.3	5	22.7	--		22	100.0
Pintail	28	84.8	1	3.0	3	9.1	1	3.0	33	100.0
Gadwall	8	80.0	1	10.0	--	--	1	10.0	10	100.0
Cinnamon teal	7	58.3	5	41.7	--	--	--	--	12	100.0
Shoveler	1	100.0	--	--	--	--	--	--	1	100.0
Widgeon	2	100.0	--	--	--		--	--	2	100.0
Redhead	10	66.7	4	26.7	1	6.7	--	-	15	100.0
Ruddy	10	83.3	1	8.3	--	--	1	8.3	12	100.0
Total ducks	77	72.0	18	16.8	9	8.4	3	2.8	107	100.0

The importance of island nest sites for Canada geese cannot be overemphasized, particularly in a habitat-type characterized by periodic droughts which preclude heavy stands of tules and cattails becoming established. Rienecker and Anderson (1960) found that 46.0 percent of the goose nests on Tule Lake and Lower Klamath National Wildlife Refuges during 1957 were on heavily matted growth of dead roundstem bulrush and similar vegetative matter from previous years. Here, island nest sites accounted for 35.2 percent. In the present study, 82.0 percent of all goose nests were on islands, which led to severe competition for space among individual pairs of geese. Often nests were only a few feet apart, and conflict subsequently ensued. Territorial strife was probably the most significant factor in the high incidence of nest desertion.

Predation was light and confined to nests built on dikes and similar exposed places. In virtually every instance, nest destruction was attributed to coyotes (*Canis latrans*).

Four hundred ninety-nine eggs were laid in 92 successful goose nests for an average of 5.4 eggs per nest. In these 92 nests, 372 eggs hatched for an average of 4.0 eggs per nest (Table 3). Most of the 25.5 percent of these eggs which failed to hatch, contained dead embryos in various stages of development. Naylor (1953) reported 31.4 percent of the eggs remained unhatched in 1951. In contrast, Rienecker (1960) showed that only 12.8 percent failed to hatch during 1957 in the Klamath Basin. In spite of the adverse weather conditions in 1963, nesting success was high.

The first goose brood was seen on April 7. The last nest was terminated by June 1. During cold weather geese spent much time brooding the young; sometimes unoccupied nests were used for this purpose. No instance of gull predation on goslings was noted.

TABLE 3

Number of Eggs Laid and Eggs Hatched in Successful Nests Honey Lake State Waterfowl Management Area 1963

Species	Nests	Eggs laid	Average	Eggs hatched	Average hatched
Canada goose	92	499	5.4	372	4.0
Mallard	11	104	9.5	94	8.5
Pintail	28	228	8.1	215	7.7
Gadwall	8	77	9.6	72	9.0
Cinnamon teal	7	72	10.3	68	9.7
Shoveler	1	9	9.0	9	9.0
Widgeon	2	18	9.0	16	8.0
Redhead	10	113	11.3	88	8.8
Ruddy	10	77	7.7	55	5.5
All ducks	77	698	9.1	617	8.0

Gulls and Ducks

Eight species of ducks nested within the study area: mallard (*Anas platyrhynchos*), pintail (*Anas acuta*), gadwall (*Anas strepera*), cinnamon teal (*Anas cyanoptera*), shoveler (*Spatula clypeata*), widgeon (*Mareca americana*), redhead (*Aythya americana*), and ruddy duck (*Oxyura jamaicensis*). Seventy-one duck nests were found at Hartson Reservoir, and 36 at West Dakin.

Seventy-two percent of the duck nests hatched successfully, 16.8 percent were deserted, 8.4 percent were destroyed, and 2.8 percent were unsuccessful from other causes (Table 2). The first duck nest, a mallard, was found on April 11. The last nests, two ruddy ducks, were terminated about August 1.

Most duck species tolerated human disturbance except during egg laying and early stages of incubation. Out of 33 pintail nests, only one was deserted. The cinnamon teal, however were sensitive to interference. Five of 12 cinnamon teal failed to return to their nests after the initial inspection. A few nests on dikes and roadsides may have been disturbed by personnel checking water levels and adjusting control structures.

In addition to gulls, ravens (*Corvus corax*), crows (*Corvus brachyrhynchos*), and black-billed magpies (*Pica pica*) were common avian predators of the general area. Coyotes and striped skunks (*Mephitis mephitis*) were the most prevalent mammalian predators, and were responsible for most of the nest destruction. Surprisingly, only two or three instances of egg predation were attributed to gulls. Even in the main gull colony where duck nests were completely surrounded by gulls and their nests, most of the ducks hatched successful clutches. How many of these island duck broods managed to leave the nest and cross the open water to safe cover is unknown. However, due to diurnal habits of gulls and the semi-nocturnal activities of ducks, the hazard of attacks by gulls was probably negligible during the hours of darkness.

Six hundred ninety-eight eggs were laid in 77 successful duck nests for an average of 9.1 eggs per nest, and 617 of these eggs hatched for an average of 8.0 eggs per nest (Table 3). Redheads and ruddy ducks accounted for the majority of unhatched eggs, partly because these two species are prone to leave their nests with a partial brood before the entire clutch is hatched.

The curious phenomenon of parasitism by the redhead occurred in 18 nests of other species. A total of 53 eggs was deposited but only 11 redhead eggs hatched. Mallards, pintails, gadwalls, cinnamon teal, widgeons, and ruddy ducks were victimized. One ruddy duck egg was found in the nest of a redhead.

Most duck broods frequented the eastern portion of Hartson Reservoir where they enjoyed the protection of levees and emergent vegetation. Brood counts were made early in the season, but soon it became apparent that broods had a marked tendency to collect in mixed groups. This mixing of ducklings, often without regard to age or species, made further brood counting impractical (Figure 4). It was quite evident from the standpoint of numbers and species composition that numerous broods invaded ponds and ditches from the surrounding upland and meadows outside the area where nest histories had been obtained, which demonstrated the importance of these ponds as rearing places for duck broods. Widgeon and shoveler broods were much more prevalent than was indicated by the number of nests located within the study area.

FIGURE 4. Mixed duck broods at Hartson reservoir, 1963. *Photo by the author.*

Apparently, there was little, if any, competition for nest sites among ducks or between gulls and ducks on the islands. Ducks were a great deal less dependent upon island nest sites than geese. Paradoxically, the densest concentration of duck nests, 23, was on the main gull island comprising a little more than one-half acre. Eighteen of these nests hatched.

DISCUSSION AND RECOMMENDATIONS

No evidence was found that gulls interfered with production of Canada geese at Hartson Reservoir. Unprotected eggs in deserted nests were ignored by gulls, and newly-hatched goslings were never seen being attacked by gulls. Intensive competition among the geese for island nest sites was blamed for most instances of desertion. Exposure of eggs to prevailing inclement weather could have been aggravated by territorial strife.

The preference for islands as goose nest sites indicates a need for constructing more islands to accommodate the present nesting population and to provide room for increases. Such construction would be feasible during dry weather.

A number of specific instances of gull predation on ducklings and a single instance on grebe and coot were noted in the course of the study. Since these observations were made by a single observer, it is unrealistic to suppose they were the only such occurrences, yet stomach analyses were even less incriminating than the field observations. Possibly only a few "rogues" among the many hundreds of gulls at Hartson Reservoir developed the trait of preying upon young waterfowl.

The island nest sites at Hartson Reservoir could be made more attractive to ducks and less attractive to gulls by establishing plant cover. Among the plant species that should be tried are quail brush (*Atriplex lentiformis*), shad scale (*A. canescens*), and cattle spinach (*A. polycarpa*).

ACKNOWLEDGEMENTS

Appreciation is hereby expressed for the cooperation of Robert Weld, in charge of Honey Lake Waterfowl Management Area; to Roger Allemand, Otton Bauer, Robert LeDonne, and John Speth who collected the gull specimens; and to Harry George, Frank Kozlik, and Albert E. Naylor for guidance and assistance with the manuscript. I wish to thank Bruce Browning and Walt Stienecker for analyzing the gull food items and Cliffa Corson for preparing the map.

SUMMARY

An investigation of waterfowl nesting conditions at Hartson Reservoir, Lassen County, California, was made by Pittman-Robertson Project 30-R of the California Department of Fish and Game during the spring and summer of 1963. The principal objective was to determine what effect nesting colonies of California and ringbilled gulls had upon waterfowl production. A count revealed 2,050 gull nests in the two colonies on islands in Hartson Reservoir, with the two species in about equal numbers.

During June and July, 95 gulls, representing both species, were collected to determine their food habits, and were found to be omnivorous. Garbage, meadow mice, carp, and insects were among the com-

monest items in their stomachs. No significant remains of waterfowl eggs or young were found, although in a number of instances gulls were seen preying on ducklings, as well as a coot and a grebe.

In a sample of 133 Canada goose nests, 69.2 percent hatched successfully. The major cause of failure was nest desertion (19.5 percent) which appeared to have resulted from territorial conflict. Production was not believed to have been affected by gulls.

Eight species of ducks found nesting in the study area had 107 nests, and 72.0 percent of these hatched successfully. Desertion and predation accounted for the other 28.0 percent. Most egg predation was by skunks and coyotes. Losses attributable to gulls were not significant.

Additional islands should be constructed in Hartson Reservoir during future dry years as nest sites for Canada geese.

Shrub plantings on bare islands may serve to discourage gull nesting.

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THE ANIMAL FOOD FISHERY IN CALIFORNIA, 1961–1962[1]

R. J. NITSOS and PAUL H. REED[2]
Marine Resources Operations
California Department of Fish and Game

The California animal food fishery, amounting to 3.8 million pounds in 1961 and 1.8 million in 1962, was comprised of more than 60 species of trawl-caught fish. Landings and species composition are discussed for each of the half-dozen ports involved in this fishery.

Utilizing unmarketable trawl-caught fish for animal food, principally by fur-farms, began in northern California in 1953, and by 1960 had spread as far south as Santa Barbara. Since 1953, the Department of Fish and Game has analyzed catch records and sampled animal food landings at the principal ports to determine the magnitude of the fishery and the species involved. Sampling methods were described by Best (1959), along with an account of the fishery through 1957. A later report (Best, 1961) summarized fishery activities from 1958 through 1960. This report summarizes the sampling and status of the fishery for 1961 and 1962.

MAGNITUDE OF THE FISHERY

The animal food fishery has grown from approximately 1.9 million pounds in 1953 to a peak of over 4.0 million pounds in 1960 (Table 1), and averaged 2.7 million pounds annually the first 10 years. During 1961 and 1962, significant changes occurred in this fishery. Landings dropped to 1.8 million pounds in 1962 (Table 1). For the period 1953-1960, animal food landings averaged 8 percent of California's trawler landings, increased to 11.5 percent in 1961, and fell to 5.6 percent in 1962.

TABLE 1

Trawl-Caught Whole Fish Landed as Animal Food in California, 1953–1962

(Thousands of pounds)

	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
Eureka	528	1,096	1,341	1,547	1,535	1,549	2,163	2,348	2,052	271
Fort Bragg				1,225	909	835	847	672	709	79
San Francisco	404	516	639	703	535	677	441	726	187	79
Morro Bay			--	--	--	--	56	261	452	573
Santa Barbara	--	--	--	--	--	--	--	--	367	755
Totals	932	1,612	1,980	3,475	2,979	3,061	3,507	4,007	3,767	1,757

[1] Submitted for publication March 1964.
[2] Paul Reed is currently employed by the Oregon Fish Commission, Gold Beach, Oregon.

There are processing plants for grinding whole fish into animal food at Eureka, Fort Bragg, San Francisco, Monterey, Morro Bay, and Santa Barbara. Eureka and Fort Bragg have produced more than one-half of the annual animal food landings, but a price adjustment for bottomfish resulted in a dispute which terminated animal food landings at these ports on April 30, 1962. Although prices returned to former levels on May 1, 1963, processors had turned to other sources and the market had dissolved.

Currently, the principal production areas are Morro Bay and Santa Barbara, which have accounted for over 75 percent of the whole fish landed in California for animal food since May 1962. These ports have continued to produce at a higher capacity than in the past. This change in production areas has affected the species composition, and rockfish have become increasingly important in the landings.

LANDINGS BY AREA

Species composition has varied with latitude and has been further affected by the demands of fresh-fish markets. We encountered 56 fish species representing 20 families during 1961 and 1962 (Table 2).

TABLE 2

Fishes Observed in California Animal Food Samples During 1961–1962

Common name	Scientific name	Port				
		E	FB	SF	MB	SB
Carcharhinidae—requiem sharks						
Gray smoothhound	*Mustelus californicus* Gill			X		
Rhinobatidae—guitarfishes						
Thornback	*Platyrhinoidis triseriata* (Jordan and Gilbert)				X	
Rajidae—skates						
Sandpaper skate	*Breviraja kincaidi* (Garman)	X				
Big skate	*Raja binoculata* Girard				X	
California skate	*Raja inornata* Jordan and Gilbert			X		
Longnose skate	*Raja rhina* Jordan and Gilbert			X		
Skate	Not identified to species				X	
Chimaeridae—chimaeras						
Ratfish	*Hydrolagus colliei* (Lay and Bennett)	X			X	X
Clupeidae—herrings						
American shad	*Alosa sapidissima* (Wilson)				X	
Pacific sardine	*Sardinops caeruleus* (Girard)					X
Gadidae—codfishes and hakes						
Pacific hake	*Merluccius productus* (Ayres)	X	X	X	X	X
Pacific tomcod	*Microgadus proximus* (Girard)	X				
Carangidae—jacks, scads, and pompanos						
Jack mackerel	*Trachurus symmetricus* (Ayres)				X	
Sciaenidae—croakers						
White croaker	*Genyonemus lineatus* (Ayres)			X	X	X

TABLE 2—Continued

Fishes Observed in California Animal Food Samples During 1961–1962

Common name	Scientific name	Port				
		E	FB	SF	MB	SB
Embiotocidae—surfperches						
Shiner perch	*Cymatogaster aggregata* Gibbons			X		
Pile perch	*Rhacochilus vacca* (Girard)					X
Pink seaperch	*Zalembius rosaceus* (Jordan and Gilbert)				X	X
Scorpaenidae—rockfishes						
Pacific ocean perch	*Sebastodes alutus* (Gilbert)	X	X			
Greenspotted rockfish	*Sebastodes chlorostictus* (Jordan and Gilbert)				X	X
Darkblotched rockfish	*Sebastodes crameri* Jordan	X	X		X	
Splitnose rockfish	*Sebastodes diploproa* (Gilbert)	X	X		X	X
Greenstriped rockfish	*Sebastodes elongatus* (Ayres)	X	X	X	X	X
Chilipepper	*Sebastodes goodei* Eigenmann and Eigenmann	X	X	X	X	X
Squarespot rockfish	*Sebastodes hopkinsi* Cramer				X	
Shortbelly rockfish	*Sebastodes jordani* Gilbert				X	X
Cow rockfish	*Sebastodes levis* (Eigenmann and Eigenmann)				X	
Speckled rockfish	*Sebastodes ovalis* Ayres				X	
Bocaccio	*Sebastodes paucispinis* (Ayres)				X	X
Rosy rockfish	*Sebastodes rosaceus* Jordan and Gilbert					X
Turkey-red rockfish	*Sebastodes ruberrimus* Cramer				X	
Flag rockfish	*Sebastodes rubrivinctus* (Jordan and Gilbert)	X			X	
Stripetail rockfish	*Sebastodes saxicola* (Gilbert)	X	X	X	X	X
Sharpchin rockfish	*Sebastodes zacentrus* (Gilbert)		X			
Shortspine channel rockfish	*Sebastolobus alascanus* Bean	X	X		X	X
Anoplopomatidae—sablefishes						
Sablefish	*Anoplopoma fimbria* (Pallas)	X	X	X	X	X
Hexagrammidae—greenlings						
Lingcod	*Ophiodon elongatus* Girard	X	X	X	X	X
Zaniolepidae—combfishes						
Longspine combfish	*Zaniolepis latipinnis* Girard			X	X	X
Cottidae—sculpins						
Threadfin sculpin	*Icelinus filamentosus* Gilbert			X	X	X
Pacific staghorn sculpin	*Leptocottus armatus* Girard			X		X
Zoarcidae—eelpouts						
Bigfin eelpout	*Aprodon cortezianus Gilbert*					X
Eelpout	Not identified to species	X	X		X	
Ophidiidae—cusk-eels						
Spotted cusk-eel	*Otophidium taylori* (Girard)					X
Stromateidae—butterfishes						
Pacific pompano	*Palometa simillima* (Ayres)					X
Bothidae—lefteye flounders						
Pacific sanddab	*Citharichthys sordidus* (Girard)	X		X	X	X
Bigmouth sole	*Hippoglossina stomata* Eigenmann and Eigenmann				X	X
California halibut	*Paralichthys californicus* (Ayres)					X

TABLE 2—Continued

Fishes Observed in California Animal Food Samples During 1961–1962

Common name	Scientific name	Port E	Port FB	Port SF	Port MB	Port SB
Pleuronectidae—righteye flounders						
Arrowtooth flounder	*Atheresthes stomias* (Jordan and Gilbert)	X	X	X		
Deepsea sole	*Embassichthys bathybius* (Gilbert)		X			
Petrale sole	*Eopsetta jordani* (Lockington)	X	X	X	X	X
Rex sole	*Glyptocephalus zachirus* Lockington	X	X	X	X	X
Diamond turbot	*Hypsopsetta guttulata* (Girard)					X
Scaly-fin sole	*Isopsetta isolepis* (Lockington)	X				
Rock sole	*Lepidopsetta bilineata* (Ayres)			X		
Slender sole	*Lyopsetta exilis* (Jordan and Gilbert)	X	X	X	X	X
Dover sole	*Microstomus pacificus* (Lockington)	X	X	X	X	X
English sole	*Parophrys vetulus* Girard	X	X	X	X	X
Curlfin turbot	*Pleuronichthys decurrens* Jordan and Gilbert	X		X	X	
Hornyhead turbot	*Pleuronichthys verticalis* Jordan and Gilbert			X	X	X
Batrachoididae—toadfishes						
Northern Midshipman	*Porichthys notatus* Girard			X	X	X
Midshipman	Not identified to species				X	
Squid					X	X
Octopus					X	X

Eureka

Animal food landings at Eureka dropped to 2.0 million pounds in 1961, and to 0.3 million pounds before the fishery closed in 1962 (Table 1). Arrowtooth flounders and sablefish comprised about 75 percent of the Eureka animal food landings during 1961 and 1962. Sablefish were dominant during winter and arrowtooth flounders during spring and summer (Tables 3 and 4).

TABLE 3

Pounds of Trawl-Caught Fish Landed as Animal Food at Eureka During 1961

Species	Jan–Mar	Apr–Jun	Jul–Sep	Oct–Dec	Total	Percent of Total
Arrowtooth flounder	13,910	389,050	420,789	35,909	859,658	41.89
Sablefish	36,080	148,412	139,570	285,476	609,538	29.70
Pacific hake	749	67,037	66,112	2,568	136,466	6.65
Shortspine channel rockfish	20,630	10,773	8,756	76,184	116,343	5.67
Dover sole	0	60,605	40,662	4,836	106,103	5.17
Rex sole	1,584	53,475	22,557	11,813	89,429	4.36
Scaly-fin sole	31,330	0	0	2,868	34,198	1.67

TABLE 3—Continued

Pounds of Trawl-Caught Fish Landed as Animal Food at Eureka During 1961

Species	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Total	Percent of Total
Splitnose rockfish	631	14,648	18,698	0	33,977	1.65
Darkblotched rockfish	877	7,130	6,604	0	14,611	0.71
Stripetail rockfish	0	3,410	7,939	1,798	13,147	0.64
Petrale sole	0	9,610	0	171	9,781	0.48
Greenstriped rockfish	0	2,015	3,042	899	5,956	0.29
English sole	1,006	2,790	148	1,840	5,784	0.28
Pacific sanddab	75	3,720	1,187	0	4,982	0.24
Pacific ocean perch	0	1,240	2,374	0	3,614	0.18
Slender sole	128	930	1,187	1,198	3,443	0.17
Curlfin turbot	0	0	0	1,969	1,969	0.10
Lingcod	0	0	1,336	0	1,336	0.07
Flag rockfish	0	0	668	0	668	0.03
Sandpaper skate	0	155	371	0	526	0.03
Tomcod	0	0	0	471	471	0.02
Totals	107,000	775,000	742,000	428,000	2,052,000	100.00
No. of Samples	4	22	20	11	57	

TABLE 4

Pounds of Trawl-Caught Fish Landed as Animal Food at Eureka During 1962

Species	Jan–Mar	April	Total	Percent of Total
Arrowtooth flounder	50,641	106,423	157,064	57.96
Sablefish	36,319	32,735	69,054	25.48
Dover sole	1,260	6,740	8,000	2.95
Splitnose rockfish	4,148	3,851	7,999	2.95
Darkblotched rockfish	5,218	647	5,865	2.16
Shortspine channel rockfish	2,321	2,988	5,309	1.96
English sole	0	4,383	4,383	1.62
Pacific hake	2,384	1,394	3,778	1.39
Rex sole	567	1,926	2,493	0.92
Curlfin turbot	0	2,141	2,141	0.79
Scaly-fin sole	1,638	0	1,638	0.60
Pacific sanddabs	0	1,062	1,062	0.39
Stripetail rockfish	189	863	1,052	0.39
Petrale sole	0	432	432	0.16
Pacific ocean perch	0	315	315	0.12
Chilipepper	126	0	126	0.05
Ratfish	126	0	126	0.05
Slender sole	0	100	100	0.04
Eelpout	63	0	63	0.02
Totals	105,000	166,000	271,000	100.00
No. of Samples	7	7	14	

Fort Bragg

Annual landings have decreased almost continuously since the inception of animal food production in 1956, falling to 79,000 pounds (Table 1) with the conclusion of the fishery in 1962. Sablefish, arrowtooth flounders, and Dover sole comprised over 70 percent of Fort Bragg's animal food landings during 1961 (Table 5). During 1962, Dover sole was dominant, comprising over 30 percent of the total, followed by rex sole and shortspine channel rockfish (Table 6).

TABLE 5

Pounds of Trawl-Caught Fish Landed as Animal Food at Ft. Bragg During 1961

Species	Jan-Jun	Jul-Sep	Oct-Dec	Total	Percent of Total
Sablefish	107,320	31,150	75,570	214,040	30.19
Arrowtooth flounder	48,636	131,185	796	180,617	25.47
Dover sole	71,474	36,337	8,306	116,117	16.38
Rex sole	9,765	38,332	9,690	57,787	8.15
Pacific hake	36,855	285	6,333	43,473	6.13
Pacific ocean perch	0	20,748	0	20,748	2.93
Stripetail rockfish	12,789	4,617	0	17,406	2.46
Greenstriped rockfish	3,748	12,683	796	17,227	2.43
Shortspine channel rockfish	9,796	3,449	3,760	17,005	2.40
Darkblotched rockfish	8,537	1,140	589	10,266	1.45
Splitnose rockfish	3,497	0	392	3,889	0.55
English sole	1,669	0	2,180	3,849	0.54
Slender sole	662	2,480	0	3,142	0.44
Lingcod	0	2,309	0	2,309	0.32
Petrale sole	252	285	196	733	0.10
Chilipepper	0	0	392	392	0.06
Totals	315,000	285,000	109,000	709,000	100.00
No. of Samples	7	6	3	16	

TABLE 6

Pounds of Trawl-Caught Fish Landed as Animal Food at Ft. Bragg During 1962

Species	Jan-Mar	April	Total	Percent of Total
Dover sole	3,535	20,218	23,753	30.06
Rex sole	1,565	10,109	11,674	14.78
Shortspine channel rockfish	7,677	1,863	9,540	12.08
Arrowtooth flounder	405	7,446	7,851	9.94
Stripetail rockfish	3,282	2,392	5,674	7.18
Pacific hake	0	5,319	5,319	6.73
Sablefish	2,375	1,064	3,439	4.35
English sole	2,727	535	3,262	4.13
Splitnose rockfish	707	2,127	2,834	3.59
Slender sole	355	1,863	2,218	2.81
Darkblotched rockfish	353	1,064	1,417	1.79
Sharpchin rockfish	1,060	0	1,060	1.34
Eelpout	353	0	353	0.45
Chilipepper	203	0	203	0.26
Deepsea sole	203	0	203	0.26
Pacific ocean perch	100	0	100	0.13
Petrale sole	50	0	50	0.06
Greenstriped rockfish	50	0	50	0.06
Totals	25,000	54,000	79,000	100.00
No. of Samples	5	2	7	

San Francisco

Production at San Francisco has not been on a steady basis. Greater production occurs during winter and early spring. In 1961, 187,000 pounds of whole fish were landed, and over 75 percent were Pacific hake, Pacific sanddab, English sole, and Dover sole (Table 7). The

1962 landings dropped to 79,000 pounds, with Pacific sanddab, sablefish, rex sole, Dover sole, and English sole making up over 80 percent of the total (Table 8).

TABLE 7

Pounds of Trawl-Caught Fish Landed as Animal Food at San Francisco During 1961

Species	Jan–Jun	Jul–Sep	Oct–Dec	Total	Percent of Total
Pacific hake	44,194	3,998	0	48,192	25.77
Pacific sanddab	6,441	32,667	3,617	42,725	22.85
English sole	10,495	5,998	13,259	29,752	15.91
Dover sole	9,438	18,659	0	28,097	15.03
Rex sole	12,436	3,339	0	15,775	8.44
Northern midshipman	5,500	3,339	3,617	12,456	6.66
Curlfin turbot	3,327	0	502	3,829	2.05
Petrale sole	1,329	0	0	1,329	0.71
Sablefish	1,222	0	0	1,222	0.65
Stripetail rockfish	660	0	0	660	0.35
Gray smoothhound	0	0	603	603	0.32
Slender sole	446	0	0	446	0.24
Lingcod	388	0	0	388	0.21
Chilipepper	330	0	0	330	0.18
Flounder	223	0	0	223	0.12
Rock sole	0	0	200	200	0.11
Greenstriped rockfish	165	0	0	165	0.09
Pacific staghorn sculpin	58	0	101	159	0.08
White croaker	116	0	0	116	0.06
California skate	116	0	0	116	0.06
Shiner perch	0	0	101	101	0.05
Horneyhead turbot	58	0	0	58	0.03
Threadfin sculpin	58	0	0	58	0.03
Totals	97,000	68,000	22,000	187,000	100.00
No. of Samples	3	1	1	5	

TABLE 8

Pounds of Trawl-Caught Fish Landed as Animal Food at San Francisco During 1962

Species	Jan–Mar	Apr–Jun	Jul–Dec	Total	Percent of Total
Pacific sanddabs	15,196	0	3,610	18,806	23.80
Sablefish	0	3,146	13,182	16,328	20.67
Rex sole	2,267	257	11,376	13,900	17.59
Dover sole	8,620	33	2,890	11,543	14.61
English sole	6,352	1,349	722	8,423	10.66
Northern midshipman	229	0	6,139	6,368	8.06
Greenstriped rockfish	112	867	0	979	1.24
Hornyhead turbot	0	0	632	632	0.80
Arrowtooth flounder	0	578	0	578	0.73
Stripetail rockfish	0	546	0	546	0.69
Petrale sole	0	64	359	423	0.54
Chilipepper	0	160	0	160	0.20
Longspine combfish	112	0	0	112	0.15
Longnose skate	112	0	0	112	0.15
Pacific hake	0	0	90	90	0.11
Totals	33,000	7,000	39,000	79,000	100.00
No. of Samples	1	1	1	3	

Monterey

Animal food production in Monterey during 1961 amounted to less than 10,000 pounds, but increased to 122,000 during 1962. No sampling was conducted during 1961 or 1962, so these figures were not included in this report.

Morro Bay

Animal food production increased from 56,000 pounds in 1959 to 573,000 in 1962. The predominant species in both 1961 and 1962 were sablefish, stripetail rockfish, splitnose rockfish, and Pacific hake, although Dover sole and rex sole appeared in greater quantity in 1962 than 1961 (Tables 9 and 10). Rockfish continued to make up approximately one-half the landings in 1962, primarily because rockfishes were the principal fresh fish sought in this area.

TABLE 9

Pounds of Trawl-Caught Fish Landed as Animal Food at Morro Bay During 1961

Species	Jan–Mar	Apr–Jun	Jul–Dec	Total	Percent of Total
Sablefish	8,613	4,018	97,254	109,885	24.31
Splitnose rockfish	0	33,982	55,755	89,737	19.85
Pacific hake	1,436	0	71,280	72,716	16.09
Greenspotted rockfish	0	51,281	0	51,281	11.35
Shortspine channel rockfish	32,539	0	0	32,539	7.20
Stripetail rockfish	713	0	23,949	24,662	5.46
Northern midshipman	20,097	618	0	20,715	4.58
Rex sole	11,962	1,700	3,024	16,686	3.69
Dover sole	1,201	1,700	12,501	15,402	3.41
Pacific sanddab	6,220	0	0	6,220	1.38
Shortbelly rockfish	0	0	3,807	3,807	0.84
Slender sole	3,593	0	0	3,593	0.79
Chilipepper	0	931	810	1,741	0.39
Greenstriped rockfish	0	152	540	692	0.15
English sole	0	618	0	618	0.14
Threadfin sculpin	0	0	540	540	0.12
Pacific mackerel	0	0	540	540	0.12
Curlfin turbot	339	0	0	339	0.07
Petrale sole	243	0	0	243	0.05
Longspine combfish	44	0	0	44	0.01
Totals	87,000	95,000	270,000	452,000	100.00
No. of Samples	1	2	3	6	

TABLE 10

Pounds of Trawl-Caught Fish Landed as Animal Food at Morro Bay During 1962

Species	Jan-Jun	Jul-Sep	Oct-Dec	Total	Percent of Total
Splitnose rockfish	83,292	33,874	23,095	140,261	24.48
Stripetail rockfish	53,783	31,640	24,555	109,978	19.19
Rex sole	30,745	21,940	29,124	81,809	14.28
Dover sole	33,480	33,170	3,109	69,759	12.17
Sablefish	14,781	16,906	28,904	60,591	10.58
Pacific hake	500	6,258	36,926	43,684	7.62
English sole	12,492	214	1,554	14,260	2.49
Chilipepper	4,997	2,020	5,197	12,214	2.13

TABLE 10—Continued

Pounds of Trawl-Caught Fish Landed as Animal Food at Morro Bay During 1962

Species	Jan-Jun	Jul-Sep	Oct-Dec	Total	Percent of Total
Longspine combfish	5,786	2,540	942	9,268	1.62
Midshipman	8,442	459	251	9,152	1.60
Pacific sanddab	6,102	0	31	6,133	1.07
Bocaccio	3,971	1,561	298	5,830	1.02
Greenstriped rockfish	1,131	1,178	440	2,749	0.48
Hornyhead turbot	1,315	0	141	1,456	0.25
Shortspine channel rockfish	26	459	471	956	0.17
Lingcod	368	214	173	755	0.13
American shad	184	0	565	749	0.13
Flag rockfish	105	61	298	464	0.08
Cow rockfish	0	245	173	418	0.07
Squarespot rockfish	316	0	0	316	0.06
White croaker	316	0	0	316	0.06
Octopus	0	0	251	251	0.04
Northern midshipman	210	0	0	210	0.04
Threadfin sculpin	210	0	0	210	0.04
Ratfish	53	0	141	194	0.03
Eelpout	0	0	173	173	0.03
Greenspotted rockfish	132	31	0	163	0.03
Speckled rockfish	0	138	0	138	0.02
Big skate	0	0	126	126	0.02
Pink seaperch	79	0	31	110	0.02
Bigmouth sole	79	0	0	79	0.01
Squid	79	0	0	79	0.01
Darkblotched rockfish	0	61	0	61	0.01
Turkey-red rockfish	0	31	0	31	0.01
Thornback	0	0	31	31	0.01
Skate	26	0	0	26	Trace
Totals	**263,000**	**153,000**	**157,000**	**573,000**	**100.00**
No. of Samples	21	7	10	38	

Santa Barbara

Since a grinder was installed late in 1960, animal food production at Santa Barbara increased from a few thousand pounds in 1960 to 755,000 in 1962 (Table 1). Periodic sampling during 1961 and 1962 showed that over 75 percent of the landings were composed of Pacific hake and sablefish (Tables 11 and 12). In 1961, English sole comprised approximately 12 percent of the total, but in 1962 they made up only 3 percent.

TABLE 11

Pounds of Trawl-Caught Fish Landed as Animal Food at Santa Barbara During 1961

Species	Jan–Jun	Jul–Sep	Oct–Dec	Total	Percent of Total
Pacific hake	49,915	55,245	47,307	152,467	41.54
Sablefish	46,644	40,815	51,129	138,588	37.77
English sole	36,611	7,981	271	44,863	12.22
Rex sole	124	644	8,213	8,981	2.45
Stripetail rockfish	124	133	4,543	4,800	1.31
Splitnose rockfish	0	1,676	3,056	4,732	1.29
Shortspine channel rockfish	0	2,188	165	2,353	0.64
Dover sole	248	644	1,440	2,332	0.64
White croaker	1,767	0	0	1,767	0.48

TABLE 11—Continued

Pounds of Trawl-Caught Fish Landed as Animal Food at Santa Barbara During 1961

Species	Jan–Jun	Jul–Sep	Oct–Dec	Total	Percent of Total
Bigmouth sole	1,505	0	0	1,505	0.41
Petrale sole	0	0	1,499	1,499	0.41
Threadfin sculpin	0	898	0	898	0.24
Pacific pompano	497	0	0	497	0.14
Bigfin eelpout	0	255	165	420	0.11
Greenstriped rockfish	124	255	0	379	0.10
Shortbelly rockfish	124	133	0	257	0.07
Spotted cusk-eel	0	133	0	133	0.04
Diamond turbot	124	0	0	124	0.03
Pink seaperch	124	0	0	124	0.03
Pacific sanddab	0	0	106	106	0.03
Pacific staghorn sculpin	0	0	106	106	0.03
Pacific sardine	69	0	0	69	0.02
Totals	**138,000**	**111,000**	**118,000**	**367,000**	**100.00**
No. of Samples	2	3	3	8	

TABLE 12

Pounds of Trawl-Caught Fish Landed as Animal Food at Santa Barbara During 1962

Species	Jan–Mar	Apr–Jun	Jul–Sep	Oct–Dec	Total	Percent of Total
Pacific hake	30,968	107,024	173,565	41,480	353,037	46.76
Sablefish	5,688	30,095	77,749	116,140	229,672	30.42
Stripetail rockfish	0	0	30,566	33,180	63,746	8.44
Hornyhead turbot	553	22,320	0	0	22,873	3.03
Northern midshipman	16,116	5,468	0	0	21,584	2.86
English sole	9,717	7,868	2,262	920	20,767	2.75
Longspine combfish	6,320	1,358	145	0	7,823	1.04
Greenstripe rockfish	1,106	2,958	1,740	920	6,724	0.89
Bigmouth sole	3,397	1,023	0	0	4,420	0.59
Pacific sanddab	2,291	2,046	0	0	4,337	0.57
Octopus	0	0	0	3,680	3,680	0.49
Greenspotted rockfish	1,738	93	0	1,840	3,671	0.49
White croaker	0	2,306	0	0	2,306	0.30
Splitnose rockfish	0	930	725	460	2,115	0.28
Threadfin sculpin	0	0	1,914	0	1,914	0.25
Chilipepper	553	744	0	0	1,297	0.17
Squid	0	0	0	920	920	0.12
Bigfin eelpout	0	0	783	0	783	0.10
Bocaccio	553	186	0	0	739	0.10
California halibut	0	558	0	0	558	0.07
Ratfish	0	372	116	0	488	0.06
Shortbelly rockfish	0	0	0	460	460	0.06
Lingcod	0	279	0	0	279	0.04
Rex sole	0	56	145	0	201	0.03
Rosy rockfish	0	0	145	0	145	0.02
Dover sole	0	0	145	0	145	0.02
Pile perch	0	130	0	0	130	0.02
Pink seaperch	0	93	0	0	93	0.01
Shortspine channel rockfish	0	56	0	0	56	0.01
Petrale sole	0	37	0	0	37	0.01
Totals	**79,000**	**186,000**	**290,000**	**200,000**	**755,000**	**100.00**
No. of Samples	1	6	6	1	14	

DISCUSSION

Termination of the animal food fishery at Eureka and Fort Bragg, coupled with only a slight production increase at Morro Bay and Santa Barbara, caused an overall reduction in whole fish landings for animal food. Concurrently, a change occurred in species composition from 1961 to 1962 (Table 13).

TABLE 13

Pounds of Trawl-Caught Fish Landed as Animal Food in California During 1961–1962

Species	1961 Pounds	1961 Percent	1962 Pounds	1962 Percent
Sablefish	1,073,273	28.49	379,084	21.58
Arrowtooth flounder	1,040,275	27.62	165,493	9.42
Pacific hake	453,314	12.03	405,908	23.10
Dover sole	268,051	7.12	113,200	6.44
Rex sole	188,658	5.01	110,077	6.26
Shortspine channel rockfish	168,240	4.47	15,861	0.90
Splitnose rockfish	132,335	3.51	153,209	8.72
English sole	84,866	2.25	51,095	2.91
Stripetail rockfish	60,675	1.61	180,996	10.30
Pacific sanddab	54,033	1.43	30,338	1.73
Greenspotted rockfish	51,281	1.36	3,834	0.22
Scaly-fin sole	34,198	0.91	1,638	0.09
Northern midshipman	33,171	0.88	28,162	1.60
Darkblotched rockfish	24,877	0.66	7,343	0.42
Greenstriped rockfish	24,419	0.65	10,502	0.60
Pacific ocean perch	24,362	0.65	415	0.02
Petrale sole	13,585	0.36	942	0.05
Slender sole	10,624	0.28	2,318	0.13
Curlfin turbot	6,137	0.16	2,141	0.12
Shortbelly rockfish	4,064	0.11	460	0.03
Lingcod	4,033	0.11	1,034	0.06
Chilipepper	2,463	0.06	14,000	0.80
White croaker	1,883	0.05	2,622	0.15
Bigmouth sole	1,505	0.04	4,499	0.26
Threadfin sculpin	1,496	0.04	2,124	0.12
Flag rockfish	668	0.02	464	0.03
Gray smoothhound	603	0.02	–	–
Jack mackerel	540	0.01	–	–
Sandpaper skate	526	0.01	–	–
Pacific pompano	497	0.01	–	–
Pacific tomcod	471	0.01	–	–
Bigfin eelpout	420	0.01	783	0.04
Pacific staghorn sculpin	265	0.01	–	–
Flounder	223	0.01	–	–
Rock sole	200	0.01	–	–
Spotted cusk-eel	133	Trace	–	–
Diamond turbot	124	Trace	–	–
Pink seaperch	124	Trace	203	0.01
California skate	116	Trace	–	–
Shiner perch	101	Trace	–	–
Pacific sardine	69	Trace	–	–
Hornyhead turbot	58	Trace	24,961	1.42
Longspine combfish	44	Trace	17,203	0.98
Midshipman	–	–	9,152	0.52
Bocaccio	–	–	6,569	0.37
Octopus	–	–	3,931	0.22
Sharpchin rockfish	–	–	1,060	0.06
Squid	–	–	999	0.06

TABLE 13—Continued

Pounds of Trawl-Caught Fish Landed as Animal Food in California During 1961–1962

Species	1961		1962	
	Pounds	Percent	Pounds	Percent
Ratfish	–	–	808	0.05
American shad	–	–	749	0.04
California halibut	–	–	558	0.03
Cow rockfish	–	–	418	0.02
Squarespot rockfish	–	–	316	0.02
Eelpout	–	–	589	0.03
Deepsea sole	–	–	203	0.01
Rosy rockfish	–	–	145	0.01
Speckled rockfish	–	–	138	0.01
Pile perch	–	–	130	0.01
Big skate	–	–	126	0.01
Longnose skate	–	–	112	0.01
Turkey-red rockfish	–	–	31	Trace
Thornback	–	–	31	Trace
Skate	–	–	26	Trace
Totals	3,767,000	99.98	1,757,000	99.99

Whole fish production at Morro Bay and Santa Barbara, and fish-frames from the northern California fish houses, have been adequate for the needs of the furgrowers, and until there is a greater demand it seems unlikely the Eureka and Ft. Bragg areas will resume grinding whole fish for animal food.

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THE SPOTTED JACK CREVALLE, CARANX *MELAMPYGUS* CUVIER, IN THE EASTERN PACIFIC[1]

FREDERICK H. BERRY
U.S. Bureau of Commercial Fisheries
Brunswick, Georgia

External morphological characters and their ontogeny in the juvenile-adult stages are described for the spotted jack crevalle, *Caranx melampygus*. *Caranx medusicola* is documented as a junior synonym.

The spotted jack crevalle is one of the larger and more colorful jacks of the genus *Caranx*, family Carangidae. It occurs in tropical marine waters of the Pacific and Indian Oceans; in the eastern Pacific it is most abundant around tropical, offshore islands.

Many species of jack crevalles, and certainly this one, are significant components of the waters they inhabit; therefore a knowledge of their taxonomy and biology is necessary in comprehending and utilizing our marine resources. The developing, pelagic young are fed upon by tunas and other predatory fishes that are important to our fisheries' economy, and in turn young jacks compete for food with, and feed upon, the young of these other fishes. The adult jacks are strong, fast swimmers, are probably wide-ranging, and must be considered as significant competitors and predators of other fishes that are currently of more importance to commercial and sportfishing interests. However, the spotted jack crevalle is a valuable resource itself, and in Hawaii and other Pacific Islands, it is frequently eaten and considered very palatable. Its rating as a sport fish is excellent. The several that I have caught and seen caught trolling off the Tres Marias Islands, Mexico, showed them to be one of the better sportfishes there. The spotted jack strikes, runs, and fights hard.

Despite its importance, the spotted jack is not adequately known. By common name, this species has also been called blue jack, blue crevally, *'omilu*, and probably a variety of other names in restricted areas. The current common name seems more appropriate because this is the only jack crevalle that is spotted. Its scientific names have frequently been confused, and *Caranx medusicola* Jordan and Starks, long regarded as a distinct species endemic to the eastern Pacific, is documented here as a junior synonym of *Caranx melampygus*. Intraspecific variation and changes in ontogeny, that have not been adequately understood previously, are described here and will facilitate proper identification of this species. Methods of measurements and counts are as described by Berry (1959: 418-424), unless otherwise noted.

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CHARACTERS

Dorsal and Anal Spines

All specimens examined had eight spines in the first dorsal fin, one spine in the second dorsal, and an anal fin with three spines. Seven first dorsal spines have been reported by several authors, but these accounts probably represent abnormal specimens or relatively rare variants. In several of the largest specimens from the eastern Pacific, the first dorsal spine was fused along its posterior margin to the second and superficially the two appeared to be a single spine. The first two anal fin spines were separated from the third in the smallest specimen examined (63 mm SL). The first and second dorsal fins lose their membranous connection (joining the eighth and ninth spines) in fish between 80 and 84 mm SL. The eighth spine tends to lose its membranous connection with the seventh spine at larger sizes; they were separated in 556- and 572 mm specimens, but not quite separated in other large specimens examined (501 to 617 mm SL).

Dorsal and Anal Soft-rays

In 85 specimens, dorsal soft-ray counts ranged from 21 to 23, and anal soft-rays from 18 to 20, with modes of D. 22 and A. 19. Counts for dorsal soft-rays as low as 20 (Williams, 1958) and as high as 25 (Weber and de Beaufort, 1931), and counts for anal soft-rays as low as 17 (Williams, 1958) have been reported.

Gill Rakers

In 82 specimens, gill rakers on the first arch ranged from 7 to 9 on the upper limb plus 17 to 21 on the lower limb, with modes of 8 + 19. Four to six (usually five) gill rakers occur on the hypobranchial segment of the lower limb. Gill rakers at the anterior ends of the upper and lower limbs tend to become smaller or rudimentary with growth of the fish. For the upper limb, the smallest specimen with rudiments was 97.5 mm, and the largest without rudiments was 220 mm. For the lower limb, the smallest specimen with rudiments was 80 mm, and the largest without rudiments was 142 mm. The largest specimen (617 mm) had the maximum number of rudiments observed, six upper and three lower.

Scutes

Scute formation along the straight portion of the lateral line is completed by about 80 mm SL. The lowest mean count (average of both sides) observed was 30 on a 74-mm specimen. An apparent decrease in the number on specimens larger than 400 mm is due to ontogenetic changes—spines on the scutes become blunt, and the posterior margins of the scutes become less angular, so that they are not distinguishable as such from the scales of the lateral line (following the definition of Berry, 1959: 422):

Size range (SL)	80–306 mm	415–617 mm
Mean scute counts, range	32–41.5	31–36
Mean scute counts, average	36.68	33.0
Number of specimens	60	8
Standard deviation	2.0908	1.6475

This statistically significant decrease with growth is probably the reason differences in scute counts have been reported for *C. melampygus* and its synonym, *C. stellatus* (see reference to Weber and de Beaufort, 1931, under Synonymy). Considering the scute count from one side only of a fish (before the mean count for that fish is calculated), minimum and maximum counts I obtained were 30 and 42 scutes. A lower minimum count of 29 was reported for a specimen 398 mm FL by Lane (*MS*). All of the scales in the anterior part of the straight lateral line usually do not form into scutes (or in larger specimens some of them may lose their scute-like characteristics). Using counts from both sides of each fish, these anterior non-scutellate scales are:

Size range (SL)	80–306 mm	415–617 mm
Anterior straight lateral line scales, range	0–8	1–9
Anterior straight lateral line scales, average	3.6	4.2

Pigmentation

A series of preserved specimens showed an ontogenetic progression from a barred stage, through a clear phase with prominent, dark, dorsal- and anal-fin lobes, to a spot-covered body. The barred phase (Figure 1A) usually has clear soft-rayed fins and five vertical bars on the body (first and second bars under the spinous dorsal fin, third through fifth under the soft dorsal fin); an additional bar may be present on the nape and another on the anterior part of the peduncle, but these last two bars are usually indistinct or have faded on preserved specimens. The five body bars may extend nearly to the ventral body margin, but usually terminate just below the level of the straight lateral line; the ventral part of the fifth bar may be angled posteriorly. Bars were present on the smallest specimen examined (63 mm SL) and persisted on some specimens as large as 113 mm; but bars may be absent on some specimens as small as 83 mm. In a single large collection (UCLA W58-285) of *C. melampygus* 76 specimens (67.5-88.5 mm) all had body bars, and 37 larger specimens (90-154 mm) all lacked bars. Woods (in Schultz *et al.*, 1953: 513) recorded a 77-mm specimen as having

FIGURE 1. *Caranx melampygus*, unspotted stages. **A**, barred juvenile 74.5 mm SL, Clipperton Island, SIO 59-6. **B**, lectotype of *Caranx medusicola*, 123 mm SL, Mazatlán, Mexica, SU 2845. *Photography by Jim Ruppert, 1963.*

seven broad black bands. Spots begin to form on the head and body at approximately 150 to 200 mm SL, according to the following accounts:

Spots absent	Spots present	Authority
70 to less than 180 mm	187–645 mm	Woods (in Schultz *et al.*, (1953)
137–200 mm	200–700 mm	Williams (1958)
83–120 mm	190–637 mm	Lane (MS)
63–154 mm	192-617 mm	Present study

Only a few spots are present initially (Figure 2A), but the number rapidly increases with growth (Figure 2B). The first dorsal fin is dark at smaller sizes (*ca.* 70 mm) and becomes lighter at larger sizes. The soft-dorsal, anal, and caudal fins are relatively clear on the smallest specimens, become dusky, then dark at about 90 mm, especially on the lobes; dark pigmentation is most pronounced on the dorsal-fin lobe between about 90 and 150 mm. The pectoral fins become dusky at some size above 300 mm. The pelvic fins are dark or dusky, especially on their distal ends, above a size of 100 mm. There is no opercular spot. Eight specimens collected in the Tres Marias Islands during August

FIGURE 2. *Caranx melampygus*, spotted stage. **A,** 193 mm SL, Socorro Island, BC 59-261. **B,** adult male, 601 mm SL, Tres Marias Islands, BLLJ B6108-11. *Photography by Jim Ruppert, 1963.*

1961 give an indication that sexual dimorphism exists in pigmentation: five females, 501–597 mm, were generally light or clear below the level of the straight lateral line, and three males, 508–617 mm, were generally dark or dusky below with darker pelvic and caudal fins. Color notes from a fresh, 556–mm male caught at Cocos Island follow: the body generally dark above and light below, scutes of the straight lateral line with a darker cast than the rest of the body; a thin line of metallic blue along the base of the dorsal fin, below this to about half-way down to the lateral line a metallic olive-green flecked with metallic blue, dusky below this to level of lateral line; many black spots scattered over head (to about the level of upper part of maxillary) and body (concentrated dorsally to just below lateral line); dorsal spines relatively clear with faint olive cast; soft dorsal fin with bluish and blackish cast; anal spines white; anal soft-rays dark with bluish and blackish cast over most of the fin and with a narrow white margin posterior to anal lobe; caudal fin dark with a bluish cast over most of fin and with a light margin on leading edge of lower lobe; pectoral fins dusky on dorsal half, this area containing four yellow-olive streaks, and the fins becoming lighter to white below; pelvic fins dark or dusky on the rays with the interradial membranes whitish.

Other Characters

The chest is completely scaled. Preopercular spines are unknown (absent on all specimens examined including the smallest, 63 mm SL). Posterio-lateral projections of interneural and interhaemal spines are produced and extend above the body surface along the dorsal and anal soft-rays in specimens to at least 151 mm SL, but reduced at larger sizes. Bilateral, paired caudal keels have developed by 68.5 mm SL. Dentition is typical of *Caranx (sensu stricto)*; the upper jaw has an outer row of large, recurved canines and an inner band of smaller canines; the lower jaw has a single row of large canines; teeth in both jaws decrease in size posteriorly; teeth are present in a triangular patch on the vomer, in a narrow band on each palatine, and on the tongue. Branchiostegal rays number 7 (3+4). Pectoral fins have one spine and 19 to 21 (usually 20) soft-rays. Pelvic fins have one spine and five soft-rays. Vertebrae number 24 (10+14) in 134 specimens from eight collections.

RANGE

The range of *C. melampygus* was recorded by Williams (1958: 383) as "East coast of Africa from Red Sea to Natal; Madagascar. Throughout Tropical and Indo-Pacific Ocean to western coasts of America." In the eastern Pacific, this species appears most abundant around the offshore islands. I have examined specimens from the Tres Marias Islands (San Juanito, Maria Madre, Maria Magdalena, and Cleopha), the Revillagigedo Islands (Clarion and Socorro), Clipperton Island, and Cocos Island. I have not verified two records from the Galápagos Islands: Tower Island by Snodgrass and Heller (1905:365), and of the synonymous *C. medusicola* from "Chatham Islands, as *Caranx latus*" by Fowler (1938:245). On the western American mainland, I have examined specimens from three localities in Mexico: Cape San Lucas (Baja California Sur), Mazatlán (Sinaloa), and Chacala (Nayarit). Specimens have been reported (as *Caranx stellatus*) from as far south as Panama by Walford (1937: 75). Gilbert and Starks (1904) did not record this species, under the synonymous name of *C. medusicola*, from Panama, as some authors have suggested.

GEOGRAPHIC VARIATION

In the smaller sizes, eastern Pacific specimens have slightly deeper bodies than those from the Indo-West Pacific. Using the depth measurement of pelvic fin origin to origin of the first dorsal spine, the following approximate percent of standard length values were obtained (* = single specimen):

mm SL	Eastern Pacific	Indo-West Pacific
63–69	42*	37–41
70–79	40–44	37–40
80–99	39–43	37–38
100–119	38–41	
120–149	38–41	34–38

This was the only character observed that indicated any appreciable variation between fish from the two areas.

SYNONYMY

I find that three nominal species and possibly three others are junior synonyms of *Caranx melampygus* Cuvier (in Cuvier and Valenciennes, 1833):

Caranx bixanthopterus Rüppell 1835,
Caranx stellatus Eydoux and Souleyet 1841,
Caranx medusicola Jordan and Starks 1895,
?*Caranx punctatus* Quoy and Gaimard 1824,
?*Caranx quoyi* Bleeker 1878,
?*Caranx moresbyensis* Macleay 1883.

When Rüppell (1835: 49) first described *C. bixanthopterus*, he placed the previously named *C. melampygus* in questionable synonymy of his new species. Günther (1876: 133) recorded *C. stellatus* and *C. bixanthopterus* as synonyms of *C. melampygus*. A period of 48 years followed during which the issue was confused, with other specific names being erroneously applied to this species, and culminating in the work of Wakiya (1924: 183–192) in which the above three nominal species were all recorded as distinct. Weber and de Beaufort (1931: 243–253) gave *C. bixanthopterus* as a synonym of *C. melampygus* and distinguished this unspotted form with a higher number of scutes (36–38) from *C. stellatus*, "with irregular dark spots, increasing in number and size with age" and with 30–35 scutes. They also included *C. punctatus*, *C. quoyi*, and *C. moresbyensis* as junior synonyms of this complex. Nichols (1935: 192) stated that he knew of, "no good technical characters to separate" *C. melampygus* from *C. stellatus*.

Woods (in Schultz *et al.*, 1953: 512), with an adequate size series of specimens, concluded that *C. melampygus* and *C. stellatus* were ontogenetic color stages of the same species—the smaller *C. melampygus* grew into the larger, spotted *C. stellatus*. This was substantiated by Williams (1958: 382) and Lane (MS).

Caranx moresbyensis was ascribed to questionable synonymy of *C. melampygus* by McCulloch (1926: 70), who inferred that positive identification could not be made because of discrepancies between the original description by Macleay (1883: 358) and the inadequately designated specimen in the Macleay Museum that McCulloch suspected to be the holotype.

Caranx coeruleopinnatus Rüppell 1826 is currently considered to be a junior synonym of *Carangoides malabaricus* (Block and Schneider 1801) (Williams, 1958: 405). Cuvier (in Cuvier and Valenciennes, 1833: 119) described a specimen of *Caranx melampygus* under the name of *Caranx coeruleopinnatus* Rüppell—he did not describe it as a new species as some authors have inferred. Cuvier equated his specimen with *Caranx punctatus* Quoy and Gaimard 1824, and compared it to *Caranx melampygus*. Rüppell (1835: 47) refuted Cuvier's identification. Bleeker (1853: 44) listed the specimen and description of *Caranx coeruleopinnatus* given by Cuvier as differing from the species described by Rüppell, but as synonymous with the *Caranx punctatus* of Quoy and Gaimard. However, later Bleeker (1878: 50) apparently considered the references of both Cuvier and of Quoy and Gaimard to apply to a species for which he proposed the replacement name of *Carangus quoyi*.

Caranx medusicola has previously been considered as a distinct species endemic to the eastern Pacific (see Walford, 1937: 72; Lane, MS). It was described from Mazatlan, Mexico, by Jordan and Starks in Jordan *et al.* (1895: 430; pl. 34). The illustration and the major portion of the morphological description were based upon the largest specimen preserved, stated to be 6 inches TL (Figure 1B). Color notes of another specimen were given. Included in the new species account was the brief description of smaller specimens, ". . . very young, taken from the body of a *Medusa*." The habitat of these smaller specimens stimulated the specific name (*Medusa*, a jellyfish; *colo*, to inhabit.) All of these specimens were included in this series of syntypes at Stanford University Natural History Museum with the collection number 2845 (not 2645 as originally published.) A note in the museum jar inferred that some of the type specimens, presumably the "very young," were sent to museums at London and Vienna.

The series of syntypes of *C. medusicola* remaining at Stanford University contained (in July 1963) two larger specimens (96 and 123 mm SL) and 41 smaller specimens (10.6 to 25.5 mm SL, of which four are cleared and alizarin stained). The largest of these, 123 mm SL, (Figure 1B) is herein designated as the lectotype of *C. medusicola* to retain the original museum number (2845). The lectotype and the 96-mm specimen are conspecific with *C. melampygus;* hence *C. medusicola* is a junior synonym of that name. The 41 smaller specimens are all conspecific with *C. vinctus* Jordan and Gilbert 1881. They have preopercular spines that are atypical of the genus *Caranx* in that the angle spine is not the longest spine in the preopercular complex, and they have different counts of dorsal soft-rays, 23–24, and anal soft-rays, 18–21 (one aberrant specimen with D. 21 and A. 19). The larger specimens of *C. vinctus* in this series have 9–10 + 25–27 gill rakers and 10 + 14 vertebrae.

All other specimens I have seen that had previously been identified as *C. medusicola* are conspecific with *C. melampygus* (SU 180; USNM 125284, 54562; UCLA W58-4; BC 54-64, 60-488). Differences previously ascribed to these two nominal species were either based upon then unrecognized ontogenetic changes or damaged or distorted specimens. This invalidity of *C. medusicola* was first suggested by Mansueti (1963: 55).

SPECIMENS EXAMINED

Tres Marias Islands, BLLJ B6108-7, B6108-11; BC 59-261, 60-488. Socorro Island, BC 57-152, 59-261; UCLA W55-124; CAS 2446-2448. Clarion Island, SU 180; USNM 54562, 125284; BC 58-383. Clipperton Island, SIO 59-10, 59-9; UCLA W56-238, W58-285, W58-296; CAS W50-291. Cocos Island, SIO 63-252; UCLA W53-135, W58-378; BC 45-403. Mexico, Cape San Lucas, BC 54-64; Mazatlan, SU 2845; Chacala, UCLA W58-4. Hawaii, CAS IU10442. Tahiti, SIO 61-83. Samoa, CAS uncataloged. New Guinea, USNM 30546. Borneo, USNM 75893. Australia, SIO 61-131. Zanzibar, BLBG uncataloged.

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THE SOUTHERN CALIFORNIA MACKEREL FISHERY AND AGE COMPOSITION OF THE PACIFIC MACKEREL CATCH FOR THE 1959–60 AND 1960–61 SEASONS[1]

HAROLD HYATT

Marine Resources Operations
California Department of Fish and Game

The Pacific mackerel catch off southern California was 39 million pounds in the 1959–60 season, 79 percent originating off Santa Catalina Island, Santa Cruz Island, and inshore waters. Scoop and roundhaul gear each caught about half the total. During 1960–61 roundhaul net boats caught 96 percent of the 39 million pounds landed. Only 58 percent of the catch came from the same channel islands and inshore waters, the rest from distant islands and banks. Scoop boats declined from 280 in 1959–60 to 50 in 1960–61.

Prices varied from $35–50 per ton during 1959–60 and stabilized at $35 per ton during most of 1960–61.

Of 65 million fish caught during 1959–60, 46 percent were zero's and 47 percent one-year-old fish. These year-classes also dominated the 1960–61 season as one's and two's, comprising 43 and 40 percent respectively of the season's 50 million fish.

This is the ninth report on the age composition of Pacific mackerel (*Scomber diego*) catches. The methods used are fundamentally those described by Fitch (1951). Appreciation is extended to Mrs. Gertrude M. Cutler for her aid with the mass of data computations required and to James D. Messersmith for editing this paper.

Commercial landings of Pacific mackerel were light at the beginning of the 1959–60 season with 0.7 million pounds landed in May (Table 1). In July they increased to 4.3 million pounds and reached a peak in October when 9.5 million pounds were caught. Cannery landings were

TABLE 1

Pacific Mackerel Monthly Landings in Pounds by Season

Month	Season 1959–60	Season 1960–61	Month	Season 1959–60	Season 1960–61
May	675,000	361,000	November	4,732,000	3,384,000
June	816,000	727,000	December	2,903,000	2,637,000
July	4,288,000	839,000	January	3,433,000	777,000
August	2,662,000	4,207,000	February	2,054,000	937,000
September	4,595,000	5,966,000	March	2,612,000	807,000
October	9,526,000	9,459,000	April	916,000	8,833,000
			Total	39,212,000	38,934,000

(Figures rounded to nearest 1,000 pounds)

[1] Submitted for publication September 1964.

heaviest from September through November when 48.1 percent of the season's catch was brought in. Moderately good catches continued into March and the seasonal total of 39.2 million pounds provided a fairly successful season for the industry.

During the 1960–61 season, landings were light until August when over 4.2 million pounds were landed at the canneries. Fair catches continued into December and then declined. During this 5-month period, 65.9 percent of the season's catch of 38.9 million pounds was landed. In April, an unusual rise in the catch occurred when 8.8 million pounds of Pacific mackerel were landed. Pacific mackerel generally are scarce in southern California in the spring during the spawning period. The catch of each of these two seasons was about 11 percent above the average catch for the past 12 seasons (Hyatt, 1962).

Pacific mackerel are fished concurrently with jack mackerel, *Trachurus symmetricus*, and schools are often composed of both species in varying proportions. Pacific mackerel are preferred, but when they are not available in desired tonnages, the difference is made up with the more abundant jack mackerel. The total catch of both species depends on market demand.

An incidental sportfishery exists for Pacific mackerel. Sport catches tallied on party boats included 70,000 Pacific mackerel during the 1959–60 season and 72,000 during the 1960–61 season. The partyboat catch of Pacific mackerel from 1951 to 1961 inclusive, fluctuated from a low of 47,000 fish in 1951 to a high of 315,000 in 1954. The average annual catch for this 11-year period was about 122,000 which usually placed this species sixth in order among the most numerous species caught on party boats (California Department of Fish and Game, 1956, 1960, 1963).

In the 1959–60 season, 99 boats using roundhaul nets caught quantities of mackerel on a wide range of fishing grounds (Figure 1). About half of this catch originated off Santa Catalina Island and the coast south of San Pedro (Table 2). The areas off Port Hueneme and Santa

TABLE 2

Origin of the Southern California Pacific Mackerel Catch With Scoop Gear and Roundhaul Nets *

Locality	1959–60 season			1960–61 season		
	Percent total catch			Percent total catch		
	Scoop	Roundhaul	Total	Scoop	Roundhaul	Total
Santa Cruz Island and vicinities	3.7	19.2	11.3	--	30.2	29.9
Santa Monica Bay	16.3	10.9	13.7	0.4	7.4	7.4
San Pedro to Oceanside	16.8	26.1	21.3	9.6	12.4	12.4
Santa Catalina Island	62.3	23.0	42.9	90.0	6.9	7.7
San Clemente Island	--	5.0	2.5	--	28.8	28.5
San Nicolas Island	0.8	15.6	8.1	--	12.9	12.7
Oceanside to Mexican Border	0.1	0.2	0.2	--	0.5	0.5
Tanner and Cortes Bank	--	--	--	--	0.9	0.9
Total	100.0	100.0	100.0	100.0	100.0	100.0
Pounds landed	20,988,000	18,224,000	39,212,000	1,496,000	37,438,000	38,934,000

* Scoop includes all gear other than roundhaul.

Cruz Island produced nearly one-fifth of the roundhaul net catch, while the waters surrounding San Nicolas Island produced almost as much.

In the same season, 53.5 percent of the Pacific mackerel landings were brought in by 280 boats using scoop and striker gear. Nearly two-thirds of this tonnage was caught off Santa Catalina Island, and about

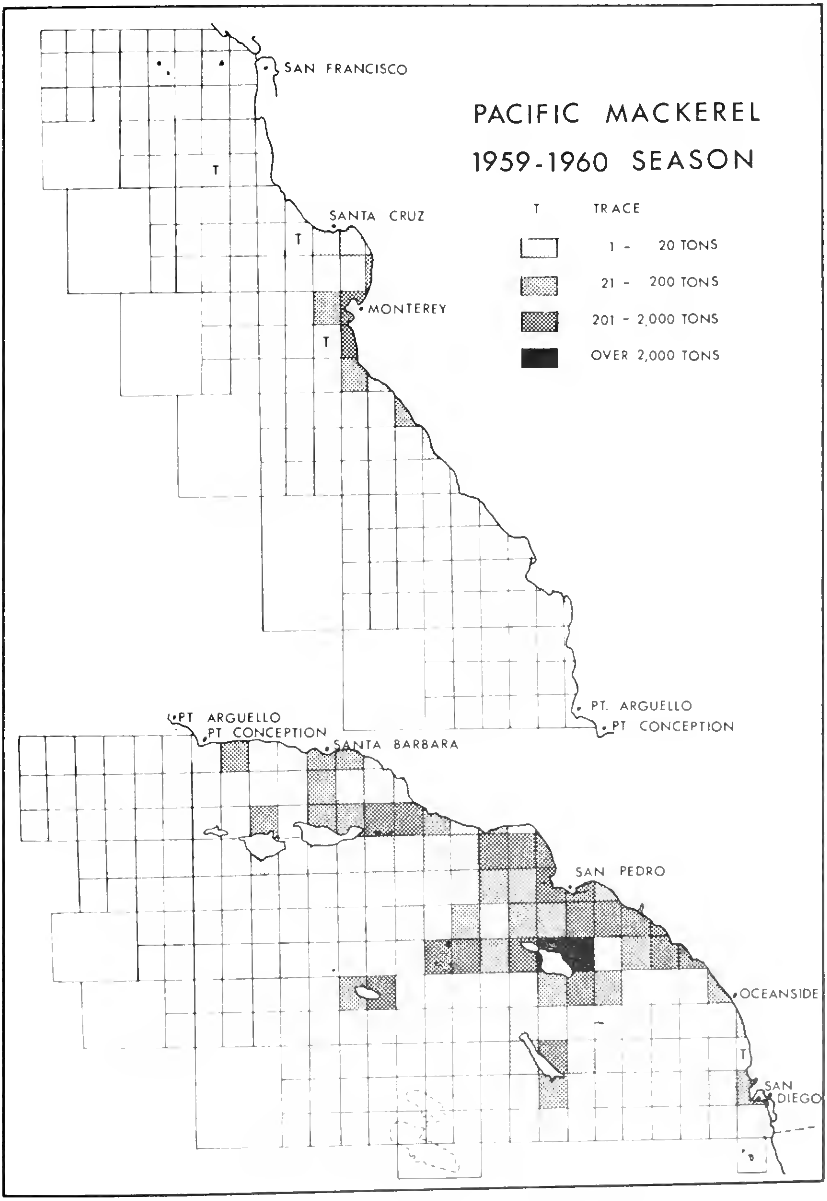

FIGURE 1. Pacific mackerel catch origins 1959–60 season.

equal tonnages, comprising most of the remainder, in Santa Monica Bay and along the coast south of San Pedro. For a description of fishing methods see Fitch (1951).

During the 1960–61 season, 97 boats fished with roundhaul nets. The major catch origins shifted further offshore to areas not fished by scoop boats (Figure 2). The Santa Cruz Island and San Clemente Island

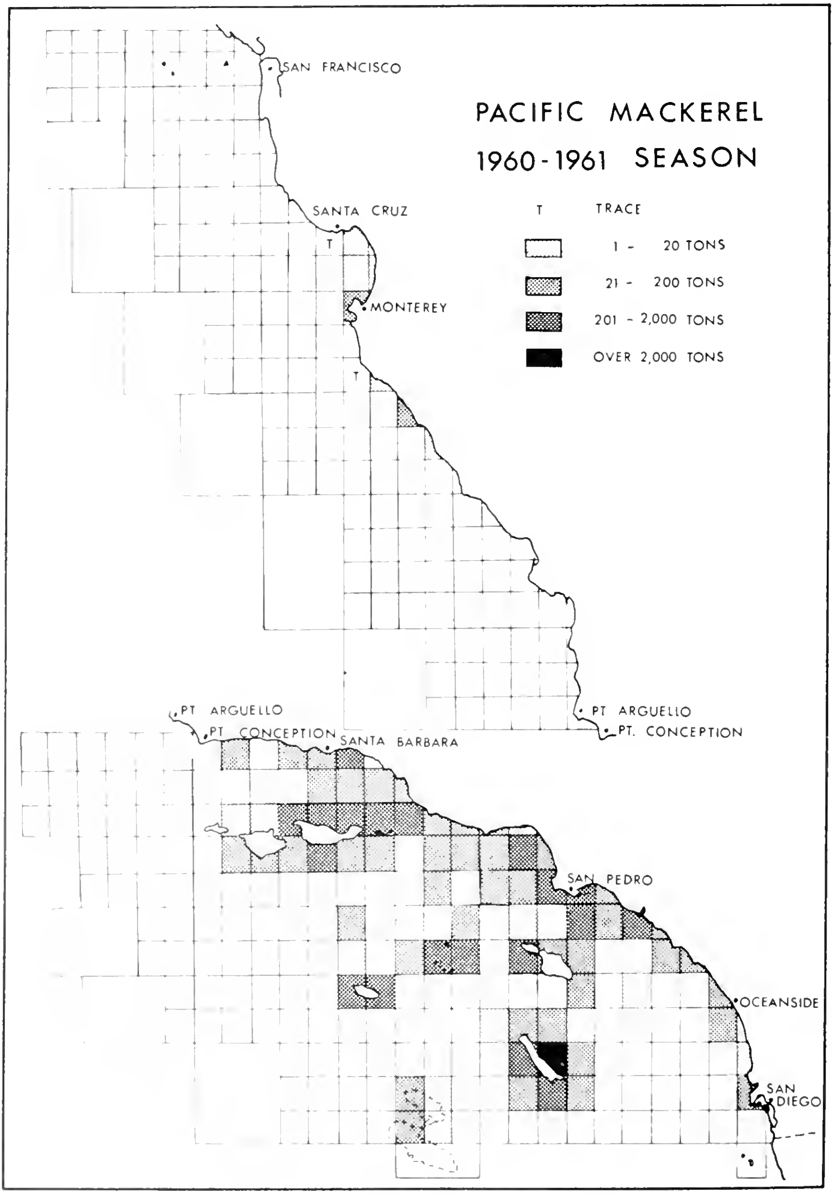

FIGURE 2. Pacific mackerel catch origins 1960–61 season.

fishing grounds each supplied nearly one-third of the roundhaul net catches. San Nicolas Island and the coastal waters south of San Pedro contributed about one-third of the remainder, with the rest coming from Santa Monica Bay and vicinity of Santa Catalina Island.

The number of scoop boats operating declined from 280 during the 1959–60 season to only 50 in 1960–61. In the latter season scoop boats landed only 3.9 percent of the catch, most of which came from the vicinity of Santa Catalina Island (Table 2). The catch-per-scoopboat averaged only 40 percent of that caught during the 1959–60 season. A combination of a relative inshore scarcity of Pacific mackerel and the economics of the industry resulted in the sudden decline of the previously large scoop-boat fishery.

In April 1959, the price the fishermen received for mackerel was reduced from $50 to $35 per ton. This was increased to $50 per ton during October 1959 after a month-long strike over sardine and mackerel prices. During April 1960, mackerel prices were again dropped to $35 per ton. Pet-food canners paid $50 per ton for both species of mackerel during part of August, in anticipation of a price rise; however, the lower price was maintained throughout the year. In March 1961, the price was raised to $42.50 per ton for both mackerels.

The Pacific mackerel catch for the 1959–60 season totalled 65.4 million fish (Table 5). Of this number, 45.8 percent were immature zeros (1959 year-class), and 47.1 percent one-year-old fish (1958 year-class). Two-year-old fish (1957 year-class) comprised 4.1 percent of the catch. At this age, many were mature and may have spawned before capture. Mature three-, four-, and five-year-old fish (1956, 1955, 1954 year-classes respectively) totalled 3.0 percent of the catch.

The catch for the 1960–61 season was also dominated by the 1959 and 1958 year-classes. These year-classes, one and two years of age, comprised 43.1 and 39.9 percent respectively of the season's nearly 50.4 million fish.

The 1958 year-class has dominated the fishery since first recruited during the 1958–59 season. During the three seasons it has been available to the fishery, it has contributed 74.8 million fish, 48.2 percent of the total catch for that period. The 1959 year-class has contributed 51.8 million fish or 44.7 percent of the total catch during the two seasons since its recruitment.

Additional support of 5.1 million fish, 10.1 percent of the season's landings, was received from the newly-recruited 1960 year-class.

The 1957 and 1956 year-classes, three- and four-year-old fish, contributing 3.2 and 0.1 million fish respectively, are among the poorest on record. Their future contribution will very likely be negligible.

Mature mackerel over two years of age contributed only 6.9 percent to the 1960–61 catch compared to an average of 33.6 percent during the 20 seasons from 1939–40 through 1958–59.

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TABLE 3

Fork Lengths of Pacific Mackerel in Quarter Centimeters at Each Age for the 1959–60 Season, Based on Otoliths Read

	Age group						
¼ cm	0	I	II	III	IV	V	Total
7	2	–	–	–	–	–	2
8	1	–	–	–	–	–	1
9	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–
1	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–
4	2	–	–	–	–	–	2
85	1	–	–	–	–	–	1
6	1	–	–	–	–	–	1
7	1	–	–	–	–	–	1
8	1	–	–	–	–	–	1
9	2	–	–	–	–	–	2
90	1	–	–	–	–	–	1
1	4	–	–	–	–	–	4
2	1	–	–	–	–	–	1
3	4	–	–	–	–	–	4
4	8	2	–	–	–	–	10
95	9	2	–	–	–	–	11
6	3	3	–	–	–	–	6
7	9	2	–	–	–	–	11
8	5	3	–	–	–	–	8
9	18	5	–	–	–	–	23
100	18	9	–	–	–	–	27
1	6	15	–	–	–	–	21
2	7	4	–	–	–	–	11
3	13	8	–	–	–	–	21
4	8	11	1	–	–	–	20
105	16	11	–	–	–	–	27
6	11	11	–	–	–	–	22
7	16	12	–	–	–	–	28
8	16	8	–	–	–	–	24
9	14	8	–	–	–	–	22
110	4	5	2	–	–	–	11
1	5	13	–	–	–	–	18

TABLE 3—Continued

Fork Lengths of Pacific Mackerel in Quarter Centimeters at Each Age for the 1959–60 Season, Based on Otoliths Read

	Age group						
¼ cm	0	I	II	III	IV	V	Total
2	11	12	–	–	–	–	23
3	9	10	1	–	–	–	20
4	8	11	–	–	–	–	19
115	11	11	–	–	–	–	22
6	8	10	–	–	–	–	18
7	5	10	–	–	–	–	15
8	5	13	1	–	–	–	19
9	7	13	2	–	–	–	22
120	7	11	1	–	–	–	19
1	8	14	1	–	–	–	23
2	4	10	4	–	–	–	18
3	1	6	2	–	–	–	9
4	1	6	1	–	–	–	8
125	6	11	2	–	–	–	19
6	1	13	2	–	–	–	16
7	7	7	2	2	–	–	18
8	2	5	3	–	–	–	10
9	1	1	1	1	–	–	4
130	–	4	1	1	–	–	6
1	1	2	2	2	–	–	7
2	3	10	3	1	–	–	17
3	1	5	1	1	–	–	8
4	–	1	3	–	2	–	6
135	–	–	1	–	–	–	1
6	–	3	1	3	–	–	7
7	–	1	–	2	–	–	3
8	–	–	–	2	1	–	3
9	–	–	–	2	2	–	4
140	–	1	–	1	1	–	3
1	–	–	1	1	–	–	2
2	–	–	2	3	2	1	8
3	–	–	–	3	2	–	5
4	–	–	–	3	2	–	5
145	–	–	1	1	1	–	3
6	–	1	1	–	1	–	3
7	–	–	1	2	2	–	5
8	–	–	–	–	–	–	–
9	–	–	2	2	–	–	4
150	–	–	–	–	1	–	1
1	–	–	1	1	1	2	5
2	–	–	1	–	–	–	1
3	–	–	1	–	–	–	1
4	–	–	–	–	–	1	1
155	–	–	–	1	1	–	2
6	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–
160	–	–	–	–	–	–	–
1	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–
165	–	–	–	–	–	–	–
6	–	–	–	–	1	–	1
Total	314	334	49	35	20	4	756

TABLE 4

Fork Lengths of Pacific Mackerel in Quarter Centimeters at Each Age for the 1960–61 Season, Based on Otoliths Read

¼ cm	Age group 0	I	II	III	IV	V	Total
75	4		–	–	–	–	4
6			–	–	–	–	–
7	1	–	–	–	–	–	1
8	2	–	–	–	–	–	2
9	1	–	–	–	–	–	1
80	–	–	–	–	–	–	–
1	3	–	–	–	–	–	3
2	1	–	–	–	–	–	1
3	–	–	–	–	–	–	–
4	–	–	–	–	–		–
85	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–
9	1	–	–	–	–	–	1
90		1	–	–	–	–	1
1		1	–	–	–	–	1
2	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–
4	1	–	–	–	–	–	1
95	–	1	–	–	–	–	1
6	–	1	–	–	–	–	1
7	–	2	–	–	–	–	2
8		–	–	–	–	–	–
9		–	–	–	–	–	–
100		–		–	–	–	–
1	–	–	–	–	–	–	–
2		1	–	–	–	–	1
3	1	–	–	–	–	–	1
4		5	1	–	–	–	6
105		3	–	–	–	–	3
6	1	–	2	–	–	–	3
7	–	1	–	–	–	–	1
8	1	4	2	–	–	–	7
9	1	1	1	–	–	–	3
110		9	3	–	–	–	12
1	1	2	4	–	–		7
2	2	6	1	–	–		9
3		6	3	–	–		9
4		3	6	–		–	9
115	–	7	2	–	–	–	9
6	1	4	4	–	–	–	9
7	–	4	7	–	–	–	11
8		4	8	–	–	–	12
9	1	4	8	1	–	–	14
120		4	12	1	–	–	17
1		4	5	1	–	–	10
2		3	10	–	–	–	13
3		2	7	–	–	–	9
4	–	10	9	–	–	–	19
125	2	2	11	1	–	–	16
6	1	8	3	–	–	–	12
7		8	6	1	–	–	15
8	–	5	3	–	–	–	8
9		5	10	1	–	–	16
130	1	5	5	1	–	–	12
1	–	5	9	–	–	1	15

TABLE 4—Continued

Fork Lengths of Pacific Mackerel in Quarter Centimeters at Each Age for the 1960–61 Season, Based on Otoliths Read

	Age group						
¼ cm	0	I	II	III	IV	V	Total
2	–	4	3	1	–	–	8
3	–	6	6	2	–	–	14
4	–	6	9	1	–	–	16
135	–	2	3	1	–	–	6
6	–	3	7	2	–	–	12
7	–	7	8	–	–	–	15
8	–	7	5	–	–	–	12
9	–	1	6	–	–	–	7
140	–	2	2	1	–	–	5
1	–	4	3	2	–	–	9
2	–	4	1	1	1	–	7
3	–	3	6	1	–	–	10
4	–	–	4	–	–	–	4
145	–	2	5	2	–	–	9
6	–	4	5	–	1	–	10
7	–	1	1	1	1	–	4
8	–	–	3	2	1	–	6
9	–	–	1	1	–	–	2
150	–	–	–	1	1	–	2
1	–	–	1	2	2	–	5
2	–	–	3	1	–	–	4
3	–	–	–	2	1	–	3
4	–	–	–	1	–	–	1
155	–	–	–	1	–	–	1
6	–	–	–	1	–	–	1
7	–	–	–	3	–	–	3
8	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–
160	–	–	–	–	1	–	1
1	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–
3	–	–	–	–	1	–	1
Total	27	187	224	37	10	1	486

TABLE 5

Calculated Number of Pacific Mackerel Landed in Age Groups 0 Through V

		Age group						
		0	I	II	III	IV	V	Totals
1959-60 season	Year-Class	1959	1958	1957	1956	1955	1954	
	Number of fish	30,000,000	30,799,000	2,692,000	1,081,000	751,000	120,000	65,443,000
	Percentage of fish	45.8	47.1	4.1	1.7	1.1	0.2	100.0
1960-61 season	Year-Class	1960	1959	1958	1957	1956	1955	
	Number of fish	5,100,000	21,756,000	20,104,000	3,245,000	134,000	89,000	50,428,000
	Percentage of fish	10.1	43.1	39.9	6.4	0.3	0.2	100.0

TABLE 6

Number of Pacific Mackerel Landed of Each Year-Class at Each Age From the 1950–51 Through the 1960–61 Seasons *

Year-class	Age group						
	0	I	II	III	IV	V	Totals
1950	6,000	1,583,000	521,000	583,000	71,000	15,000	2,779,000
1951	769,000	46,000	475,000	208,000	204,000	62,000	1,764,000
1952	86,000	676,000	3,893,000	6,021,000	3,611,000	2,302,000	16,619,000
1953	12,237,000	40,036,000	21,156,000	14,641,000	8,160,000	295,000	96,525,000
1954	564,000	3,562,000	14,976,000	11,332,000	1,687,000	120,000	32,241,000
1955	4,237,000	49,429,000	30,487,000	7,300,000	751,000	89,000	92,293,000
1956	21,000	6,228,000	4,533,000	1,081,000	134,000	--	11,997,000
1957	1,386,000	1,511,000	2,692,000	3,245,000	--	--	8,834,000
1958	23,922,000	30,799,000	20,104,000	--	--	--	74,825,000
1959	30,000,000	21,756,000	--	--	--	--	51,756,000
1960	5,100,000	--	--	--	--	--	--

* For data prior to the 1950 year-class see Calif. Fish and Game 48(4):226.

TABLE 7

Pounds of Pacific Mackerel Landed of Each Year-Class at Each Age From the 1950–51 Through the 1960–61 Seasons *

Year-class	Age group						
	0	I	II	III	IV	V	Totals
1950	1,000	802,000	474,000	687,000	90,000	24,000	2,078,000
1951	252,000	34,000	483,000	234,000	244,000	94,000	1,341,000
1952	33,000	463,000	3,063,000	6,034,000	4,394,000	3,112,000	17,099,000
1953	4,358,000	23,175,000	16,990,000	14,973,000	10,197,000	111,000	70,104,000
1954	94,000	1,964,000	11,722,000	12,294,000	2,117,000	191,000	28,382,000
1955	1,270,000	25,940,000	24,552,000	8,194,000	1,026,000	107,000	61,089,000
1956	5,000	4,222,000	4,674,000	1,378,000	211,000	--	10,490,000
1957	466,000	897,000	2,455,000	3,339,000	--	--	7,157,000
1958	7,617,000	18,452,000	17,299,000	--	--	--	43,368,000
1959	15,710,000	16,474,000	--	--	--	--	32,184,000
1960	1,503,000	--	--	--	--	--	--

* For data prior to the 1950 year-class see Calif. Fish and Game 48(4):226.

Calif. Fish and Game, 51(1) : 48–51. 1965.

INTRODUCTION OF THE OPOSSUM SHRIMP (*MYSIS RELICTA* LOVEN) INTO CALIFORNIA AND NEVADA[1]

JACK D. LINN
Inland Fisheries Branch
California Department of Fish and Game

and

TED C. FRANTZ
Nevada Fish and Game Commission
Reno, Nevada

In 1963 and 1964, 182,300 live opossum shrimp were introduced into four lakes in California and Nevada (Lake Tahoe, Lower Echo Lake, Huntington Lake, and Blue Lake). These had been collected at Upper Waterton Lake, Canada, and Green Lake, Wisconsin. It is hoped they will become established locally, and provide forage for trout.

Opossum shrimp were introduced into Lake Tahoe and three other lakes in California and Nevada in the autumns of 1963 and 1964. The Tahoe introduction was made primarily to provide forage for juvenile lake trout (*Salvelinus namaycush*). The need was made apparent by Dingell-Johnson Project California F-21-R and Nevada F-15-R, "Lake Tahoe Fisheries Study," supported by Federal Aid to Fish Restoration funds (unpublished data). The other releases were made to increase the chances of establishing the shrimp locally, and to test their trout-forage potential in coldwater fluctuating reservoirs.

Studies elsewhere (Larkin, 1948; Hacker, 1956; and Rawson, 1961) had shown that *M. relicta* is very important in the diet of juvenile lake trout and in the diet of various coregonids, the chief forage fishes of adult lake trout. In one Wisconsin lake, in a year when *M. relicta* was especially abundant, survival of young stocked lake trout increased three times (Threinen, 1962). Lake Tahoe does not have a similar invertebrate, and the diet of juvenile lake trout consists largely of cladocerans.

The opossum shrimp is one of four freshwater North American species of the order Mysidacea (Vincent, 1958). It inhabits cold, deep lakes in Northeastern United States, Canada, and Northern Europe. It exists in certain eutrophic lakes of Europe also. It reaches a length of about 30 mm and has a life span of approximately 2 years (Pennak, 1953). The female has about 40 eggs per clutch and keeps them in a brood pouch during development. Young remain in the brood pouch 1 to 3 months until they are about 4 mm long. As a rule, reproduction takes place from October through May. However, in some lakes reproduction

[1] Submitted for publication November 1964. This work was performed as part of Dingell-Johnson Project California F-21-R and Nevada F-15-R, "Lake Tahoe Fisheries Study," supported by Federal Aid to Fish Restoration funds.

may occur throughout the year (Larkin, 1948). Sexual maturity is reached at 1 or 2 years. They eat zooplankton, phytoplankton, and detritus.

Distribution patterns and migratory habits of *M. relicta* were described by Beeton (1960) for Lakes Huron and Michigan and by Larkin (1948) for Great Slave Lake. They are found immediately above the bottom during the day, but small mysids stay farther off the bottom than large ones. Distance above the bottom increases with increasing depth (1.8 meters in depths less than 91 meters compared to 7 meters at a depth of 152 meters). They are found at all depths in Great Slave Lake (maximum of 614 meters) including depths less than 10 meters where low light intensity prevails. *M. relicta* is negatively phototrophic, migrating to the surface at sunset and descending at dawn. Although migrations are initiated and controlled by light penetration, thermal conditions, either absolute or gradient values, may cause modifications. Maximum temperature and minimum oxygen concentrations tolerated have been listed as 14° C. and 4 cc per liter. However, *M. relicta* has been collected in both warmer waters and waters of lower dissolved oxygen.

COLLECTION AND TRANSPORTATION

In September of 1963 and 1964, biologists from California and Nevada introduced about 182,300 live opossum shrimp into various waters of both states. These were collected from Upper Waterton Lake, Waterton Lakes National Park, Alberta, Canada. About 165,300 were planted in Lake Tahoe in the 2 years, 15,000 were released in 1963 into Lower Echo Lake, El Dorado County, California, and 2,000 were planted in 1964 in Blue Lake, Humboldt County, Nevada. These figures do not include an additional 20,000 *M. relicta* from Green Lake, Wisconsin, which were planted in Huntington Lake, Fresno County, California, in November 1963. The 1963 and 1964 Tahoe releases were made over depths ranging from 45 to 1,200 feet. Release localities were Emerald Bay and off Bijon, Upper Truckee River, Cascade Creek, Rubicon Point, Homewood, Dollar Point, Incline Creek, Logan Shoals and Cave Rock.

M. relicta proved surprisingly easy to collect and transport. They were taken with a tow net measuring 5 by 1½ by 12 feet. It was attached to a tubular steel frame with runners that keep it 6 inches off the bottom (Figure 1). Two sizes of bobbinet were used: 4 meshes per inch for the body, and 16 meshes per inch for the cod end. Opossum shrimp were captured at depths from 40 to 140 feet. Tows varied from 3 to 20 minutes duration, with 5 minutes being the most efficient. Longer tows picked up too much mud, which suffocated the shrimp. As many as 5,000 opossum shrimp were caught per tow.

At Waterton a survival test was conducted with 40 *M. relicta* in a 5-gallon can of Tahoe water. Two controls were set up using Waterton Lake water in one can and hatchery water in the other. All cans were aerated and bathed in a circular hatchery pond at 52° F. After initial high survival, opossum shrimp in the Tahoe water died after 48 hours. There was 85 percent survival in a later test by holding them in a 50:50 mixture of Waterton and Tahoe water for one-half hour before putting them in Tahoe water. This procedure was followed to temper the opossum shrimp before releasing them in Tahoe. Some shrimp were

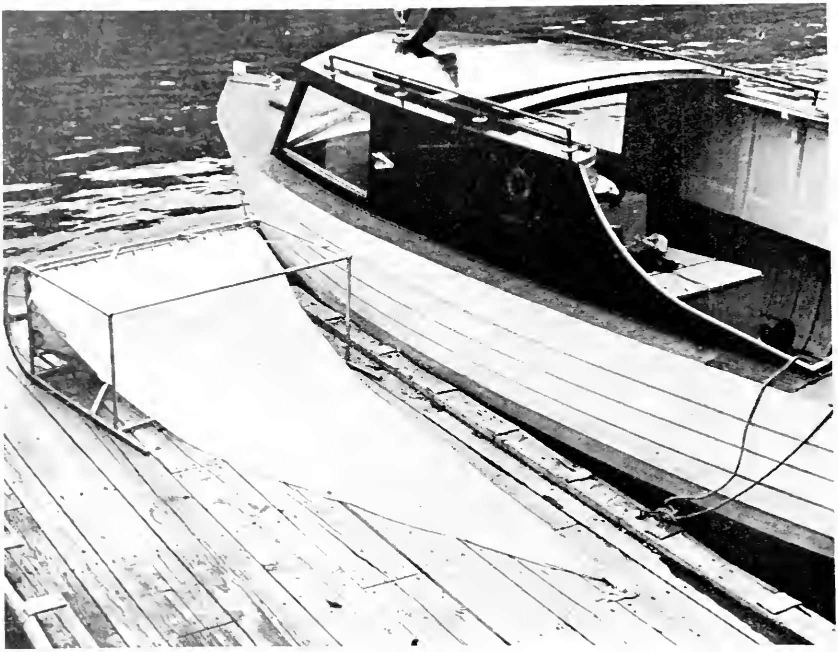

FIGURE 1. Trawl net used for capturing opossum shrimp at Waterton Lake, Canada. *Photo by Ted C. Frantz.*

placed directly in Tahoe water in September 1963, and one remained alive for 6 months. The aquarium was in subdued light, aerated, and held at 42° F. The water was not changed or filtered.

Opossum shrimp were transferred from the tow net to a large tub and then separated from as much extraneous material and foreign organisms as possible and placed in 5-gallon cans. They were held in a pond at Waterton Park Hatchery in perforated wooden boxes lined with plastic screen. Survival was good at densities as high as 1,000 per gallon. As time permitted and prior to loading into containers for final transportation all obvious unwanted organisms were removed. The last cleaning took place during the tempering process prior to release.

Shipments were flown to Lake Tahoe from Cutbank, Montana, in lots of approximately 50,000 each. Shrimp were transported in lots of 3,000 in 5-gallon aluminum milk cans which were iced and aerated in transit, or in lots of 1,000 in 5-gallon plastic containers ("cubitainers") in cartons. These were half filled with water and ice, the air replaced with oxygen, and then sealed. The shrimp fared well in both types during the 10-hour trip ($5\frac{1}{2}$-hours in air transit).

Shrimp from Wisconsin were shipped in 10, 5-gallon cubitainers, each loaded with 2,000 shrimp. The same shipping procedures as above were used. They were flown from Oshkosh to San Francisco and then were taken by car to Huntington Lake. About 10 percent died during the 30-hour trip.

In 1964, the feasibility of transporting large numbers of shrimp in a one-half-ton pickup with canopy was tested. Cubitainers were used and the same procedures were followed as above except different densities were tried. Two cubitainers were filled with 2,000 shrimp, one with 2,500, and the rest with 1,000 shrimp. The bed of the truck was lined with 1 inch of styrofoam and the cubitainers covered with 3 inches of fiberglass insulation. The water temperature in the containers was 39°F. At approximately the half-way point in the return trip, the cubitainers were unsealed to be re-iced and re-oxygenated. Temperatures ranged from 42° to 47°F. Addition of more ice lowered the temperatures to 39°F., and for the balance of the trip temperatures did not rise above 45°F.

At the end of the 36-hour trip, losses in the containers carrying 1,000 averaged about 10 percent and containers carrying 2,000 and 2,500 suffered about 20 percent mortality.

ACKNOWLEDGMENTS

We are indebted to personnel of the Canadian Department of Northern Affairs and National Resources, National Parks Branch, for the use of their facilities and the fine cooperation and courtesy shown us through all phases of the project. Particularly valuable assistance was provided by Fred C. Browning, Ken Goble, Art Colbeck, and Clanch Shatuck. We also thank Vernon A. Hacker, Wisconsin Department of Conservation, who collected the shrimp from Green Lake and shipped them to California. Al Reese and Carrol Faist, California Department of Fish and Game, flew the shrimp from Montana to Lake Tahoe. Jack Hanson, California Department of Fish and Game, supervised the 1964 collections. Sebastian Coli, Nevada Fish and Game Commission, provided assistance in the field.

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NOTES

LONG-TERM RETENTION OF TAGS BY SOME FRESHWATER FISH

One criterion for a successful fish tag is that it remain attached for a long time, preferably for the fish's life. In California, staple and disk-dangler tags consisting of cellulose nitrate disks secured with 0.020-inch tantalum wire (Kimsey, 1956) have remained on four species of fish for 8 to more than $10\frac{1}{2}$ years.

Tag returns have been received each year from white catfish, *Ictalurus catus*, tagged in the Sacramento-San Joaquin Delta between 1952 and 1954 (Pelgen and McCammon, 1955); from white catfish and brown bullheads, *Ictalurus nebulosus*, tagged at Clear Lake in 1952, 1954, and 1955 (McCammon and Seeley, 1961); and from channel catfish, *Ictalurus punctatus*, tagged at Sutter Bypass in 1955 (McCammon and LaFaunce, 1961) (Table 1). The maximum time at liberty was 10 years and 8 months, for two staple-tagged white catfish from Clear Lake (Table 1). Also, one tag was returned from a largemouth bass, *Micropterus salmoides*, at Clear Lake 9 years and 6 months after tagging (Kimsey, 1957).

TABLE 1

Long-term Tag Retention by Various Freshwater Fish in California

Area	Species	Tag type	Date tagged	Length *	Date recovered	Elapsed time	
						Years	Months
Sacramento-San Joaquin Delta	white catfish	Staple	Dec. 16, 1952	7.1	Sept. 7, 1961	8	8—
		Disk-dangler	Jan. 24, 1954 †	7.0	Jan. 12, 1963	8	11—
Clear Lake	white catfish	Staple	Aug. 19, 1952	10.0	May 1, 1963	10	8—
		Staple	Aug. 13, 1952	9.4	April 20, 1963	10	8—
Clear Lake	brown bullhead	Disk-dangler	Nov. 29, 1954	9.8	Mar. 23, 1963	8	3—
Sutter Bypass	channel catfish	Disk-dangler	May 10, 1955	11.9	July 13, 1963	8	2—
Clear Lake	largemouth bass	Disk-dangler	Aug. 27, 1953	9.0—11.2	Mar. 23, 1963	9	6—

* Fork length in inches at tagging.
† McCammon, unpublished data.

I consider these to be valid recoveries because: (i) most of the tags were returned during the time of year when fishing was best; (ii) with few exceptions, all of the tags showed considerable evidence of long exposure to the elements; (iii) except for the largemouth bass, tags were received each year; and (iv) the fisheries, especially those at Clear Lake, are lightly exploited.

These returns indicate that disk-dangler and staple tags are capable of remaining on these fish for long periods of time. The white catfish returns represent tag-retention records for a freshwater fish from California, and perhaps for the nation. These returns also indicate that catfish frequently live longer than most warmwater fish in California. The two longest returns were from fish that had attained ages XIV or XV at capture. Low harvest rates enable them to achieve these advanced ages.

The Clear Lake largemouth bass was probably Age II at tagging and hence Age XI at capture—an exceptionally old bass for California.

ACKNOWLEDGMENT

Portions of this work were performed as part of Dingell-Johnson Project California F-2-R, "A Study of the Catfish Fishery of California," supported by Federal Aid to Fish Restoration funds.

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—Don A. LaFaunce, California Department of Fish and Game, Sacramento, September 1964.

AN OBSERVATION OF KING SALMON SPAWNING SUCCESSFULLY IN DEER CREEK IN MARCH 1964

Water projects in California's Central Valley have been changing water flows and water temperatures. In the smaller tributaries, high temperatures limit the time of year at which salmon spawn, but much more information is needed on the temperatures at which salmon can spawn successfully. The purpose of this note is to document an observation of survival of spawn to the swim-up stage of exceptionally late spawning king salmon in Deer Creek, Tehama County.

John Hayes (California Department of Fish and Game employee) observed construction of a king salmon (*Oncorhynchus tshawytscha*) redd in Deer Creek, about 200 feet below Stanford-Vina Dam, during the first few days of March 1964. The fall run in Deer Creek had completed spawning in early January.

The redd was sampled with a hydraulic egg sampler on May 7, 1964. Many dead eggs were recovered along with some healthy-looking fry which were still buried in the gravel but had absorbed their yolk sacs. A recording thermometer, located at Stanford-Vina Dam, showed that

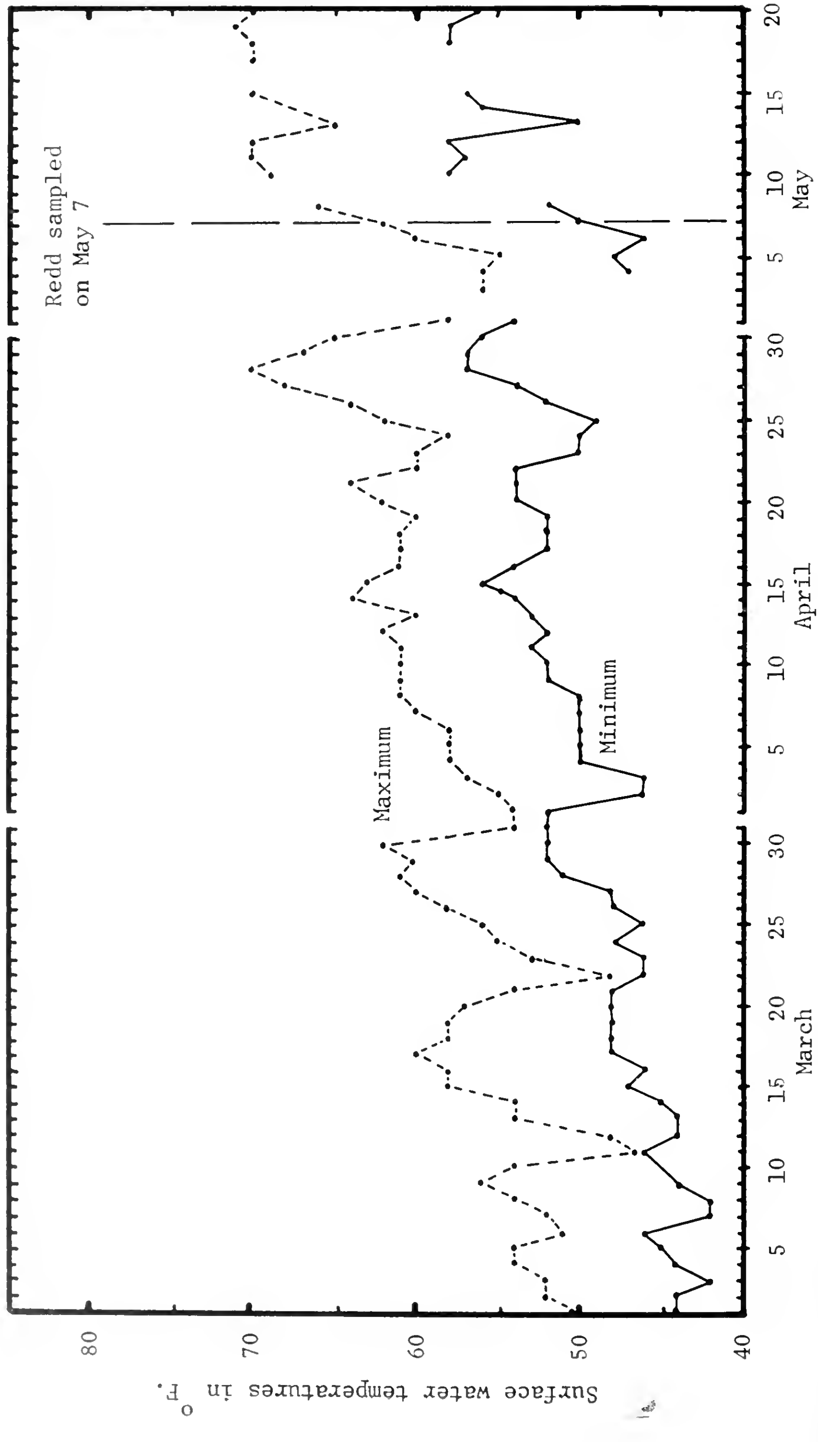

FIGURE 1. Daily maximum and minimum temperatures at Stanford-Vina Dam on Deer Creek for period March 1 through May 20, 1964.

during the period between egg deposition and swim-up, the daily maximum water temperature reached 60° F. or higher on more than 40 percent of the days and peaked at 70° F. on April 28. The minimum temperature during the same period ranged from 42° F. on 3 days in early March to 57° F. on April 28 and 29 (Figure 1). These are surface water temperatures. This is an area where there is little, if any, influx of sub-surface spring water, so it seems safe to assume that the temperatures in the gravel were between these maxima and minima. These observations show that in spite of high surface water temperatures, some king salmon production can be expected from early March spawning in Deer Creek.

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—*Robert S. Menchen, Resources Agency of California, Department of Fish and Game, September 1964.*

NORTHERN RANGE EXTENSION FOR THE ZEBRAPERCH, *HERMOSILLA AZUREA* JENKINS AND EVERMANN

The zebraperch was first described in 1888, from specimens taken in the Gulf of California, off Guaymas, Mexico. Subsequently, they have been found as far north as off Redondo Beach, Santa Monica Bay, California (J. E. Fitch, pers. comm.). On July 28–29, 1964, about 40 live zebraperch, 11 to 12 inches long, were taken in a small lampara net hauled for bait about ½ mile from shore, near Monterey, California. This extends their range some 275 miles upcoast from Redondo Beach. Jack Carmenita, General Fish Corporation, participated in the capture of these fish, and saved specimens for identification (Figure 1).

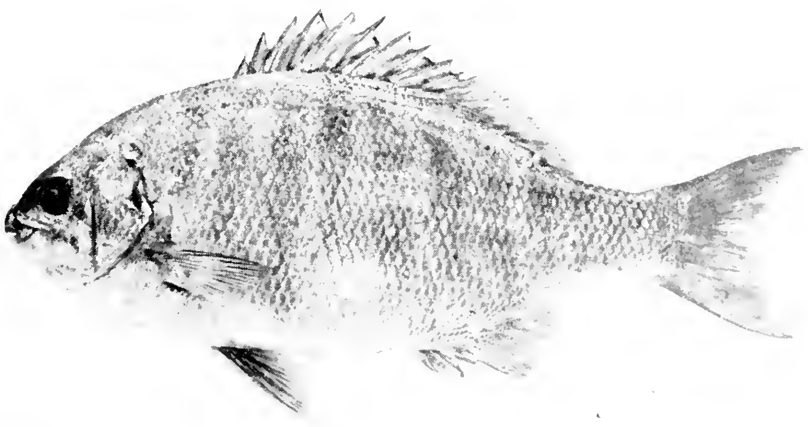

FIGURE 1. An 11-inch zebraperch, *Hermosilla azurea* Jenkins and Evermann, taken near Monterey, California, July 29, 1964. The dark vertical bars were somewhat faded by freezing. *Photograph by J. B. Phillips.*

The adult body color is silver-gray, with about 12 nearly vertical blackish bars spaced between the nape and the base of the caudal fin. A short, narrow, dark streak extends backward from the maxillary. A small black blotch is present on the posterior margin of the opercle; another near the lower edge of the pectoral fin insertion. Both jaws contain a single series of close-set, narrow, rounded, incisor-like teeth.

The zebraperch is the sole California representative of the sea chub or rudderfish family, Kyphosidae.—*Julius B. Phillips, Marine Resources Operations, California Department of Fish and Game, August 1964.*

A VISUAL AID FOR AGE DETERMINATION OF IMMERSED OTOLITHS

Providing a suitable jet-black background to give maximum contrast of transparent and opaque otolith rings and eliminating reflections has been a persistent challenge for the biologist making age determinations from these structures.

A $\frac{5}{16}$-inch thick disc of polished jet-black glass inserted in the bottom of a clear glass dish solved these problems. Black glass sold under the trade names of "Vitrolite" and "Carrara" is frequently used for front facades of stores and shops.

A Stender dish, $2\frac{3}{8}$ inches diameter by $1\frac{1}{8}$ inches deep, with the black glass disc in the bottom, provides a container depth of $\frac{11}{16}$ inch. This size and depth is considered optimum for ease of otolith manipulation and depth of immersion.

The glass disc was fitted snugly to the sides of the dish by hand grinding with a wet carborundum stone, eliminating space in which small otoliths might lodge.

Besides improving otolith observation and evaluation, better photographs can be made on this background.—*Jack W. Schott, Marine Resources Operations, California Department of Fish and Game, September 1964.*

THE THREADFIN SHAD, *DOROSOMA PETENENSE*, IN NORTHERN CALIFORNIA OCEAN WATERS

A male threadfin shad, 121 mm TL, was taken January 7, 1963, by the California Department of Fish and Game research vessel *Nautilus* from Drake's Bay, California. It was caught in a $1\frac{1}{4}$-inch-mesh, Gulf shrimp trawl, at lat. 38° 00.6′ N., long. 122° 55.2′ W. in 14 fathoms of water. In the same month, the *Nautilus* took threadfin shad at two stations within 3 miles of the mouth of San Francisco Bay in 6-8 fathoms.

Since the threadfin shad was introduced into the Sacramento-San Joaquin Delta, the species has spread to Carquinez Strait in San Francisco Bay. This spread was forecast by Kimsey (1958), and he suggested it would be found in nearly pure salt water.

Thomas (1962) recorded a threadfin shad from Long Beach, California, and suggested it may have been flushed from the Los Angeles or San Gabriel River drainages. Their 1963 occurrence 29 miles NNW of the mouth of San Francisco Bay, and 54 miles from Carquinez Strait, is evidence that they emigrated from the bay under their own power.

This species is euryhaline (Briggs, 1958), but is very sensitive to low temperatures, with a minimum tolerance between 54° and 57.6° F (Hubbs, 1951). Thus, the most logical barrier to their movement past Carquinez Strait is temperature, and it is very possible for that barrier to be raised and permit their movement into the outer bay and then to the open ocean.

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—Peter A. Isaacson and Richard L. Poole, Marine Resources Operations, California Department of Fish and Game, August 1964.

NEW NORTHERN RECORDS FOR THE SPOTFIN SURFPERCH, *HYPERPROSOPON ANALE*

On March 14, 1959, a spotfin surfperch was caught 4.5 miles south of Bodega Bay, California (lat. 38° 15.5′ N., long. 123° 02.4′ W.) in 35 fathoms of water by the California Department of Fish and Game research vessel *N. B. Scofield* while shrimp trawling with a 10-foot, 1¼-inch-mesh beam trawl. Two days later a second specimen was taken 10.2 miles northwest of Bodega Bay (lat. 38° 25.3′ N., long. 123° 12.0′ W.) in 37 fathoms of water. The *Nautilus*, another Department research vessel, caught a spotfin surfperch on June 16, 1961, in the Bodega Bay area (lat. 38° 18.4′ N., long. 123° 02.4′ W.) in 25 fathoms of water. From January 16, 1962, through April 4, 1963, the *Nautilus* consistently caught spotfin surfperch in the Bodega Bay area while trawling with a 1¼-inch-mesh, Gulf shrimp trawl.

Roedel (1953) gives the northern known range of *H. anale* as San Francisco, California. These specimens not only extend the northern range of *H. anale* some 51 miles, but indicate that in recent years a sizable population has become established outside of its previous range, and that individuals can be expected even further north.

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Roedel, Phil M. 1953. Common ocean fishes of the California coast. Calif. Dept. Fish and Game, Fish Bull. 91: 1–184.

—Peter A. Isaacson and Richard L. Poole, Marine Resources Operations, California Department of Fish and Game, August 1964.

SOUTHERN RANGE EXTENSION OF THE TOMCOD, *MICROGADUS PROXIMUS*

On January 30, 1961, four tomcods were caught 13.2 miles WNW of Point Sal, California (lat. 34° 59′ N., long. 120° 54′ W.) in 117–120 fathoms of water by the California Department of Fish and Game research vessel *N. B. Scofield* while shrimp trawling with a 20-foot, 1¼-inch-mesh beam trawl. A bathythermograph cast indicated the water tempreature at the bottom was 14.6° C.

Roedel (1953) gives the southern limit of the tomcod as Monterey, California. D. J. Miller (pers. comm.) stated that in over 8 years of sampling sport and commercial fish catches along the central California coast the tomcod has not been recorded below Point Sur.

These four specimens extend the tomcod's southern known range some 135 miles from Monterey to Point Sal.

LITERATURE CITED

Roedel, Phil M. 1953. Common ocean fishes of the California coast. Calif. Dept. Fish and Game, Fish Bull. 91: 1–184.

—*Peter A. Isaacson, Marine Resources Operations, California Department of Fish and Game, August 1964.*

BOOK REVIEWS

A Guide to Sunken Ships in American Waters

By Adrian L. Lonsdale and H. R. Kaplan; Compass Publications Inc., Arlington, Va., 1964; xv + 189 p., illustrated; $8.95.

The mention of sunken ships usually conjures up visions of the "Spanish Main," pirate gold, and silver bullion. Unfortunately for the romanticists among us, these heavily-laden treasure ships are rare among vessels lost at sea. The majority of ships carry such utilitarian cargo as grain, iron ore, coal, or fuel oil. Regardless, the thrill of finding a shipwreck is such that the cargo almost becomes secondary.

The authors capture some of the color and adventure of America's maritime history in vignettes discussing the historically important coastal areas. Selected ship disasters, which particularly interested them, or for which they had sufficient information, are vividly told in a style transporting the reader onto the vessel's pitching deck. From here he is verbally carried along during the rescue of the crew and the final moments in the ship's life.

Over 1,100 wrecks are listed, in tabular form, by geographic location: (i) Northeastern Coast, (ii) Middle Atlantic Coast, (iii) Southeastern Coast, (iv) Gulf of Mexico, (v) Great Lakes, (vi) Great Rivers, (vii) Pacific Coast, and (viii) Northern Pacific. The vessel's name, most reliable position, tonnage, cargo, navigational charts to use in locating it, and other pertinent information are included.

Although many of the listed wrecks are poorly located, are in extremely deep water, or have been demolished or buried, the fascination of the search and the potential monetary rewards will encourage many skindivers and adventurers to look for them.

As a comprehensive collection of data concerning the major ship sinkings, as listed in official U.S. Government records, this book will be of interest and value to many.—*Charles H. Turner.*

Biology of Birds

By Wesley E. Lanyon, Doubleday and Co., Inc., New York, 1964; 64 text figs.: $3.95.

This book begins quite logically with a chapter devoted to the origin and evolution of birds. Material in the remaining chapters covers the entire life cycle of birds.

There are details on courtship and reproduction, growth and survival, distribution, environment, migration, and navigation by the stars, as used by some birds.

The complex adaption for flight is compressed into remarkably few pages of easily-read discussion of feathers, skeleton and musculature, control of body temperature, metabolism, and sensory capacities.

This small (6" x $8\frac{1}{2}$") book was written by the Associate Curator of Birds at the American Museum of Natural History, New York.

It was not written as a textbook but to satisfy the interest of the lay reader who wants to go beyond identification.

Included in the appendix are the common and scientific names of birds discussed in the book, and an interesting, well-organized section of bibliographies.—*William F. Hart.*

Downstream: A Natural History of the River

By John Bardach, Harper & Row, Publ., New York, 1964; ix + 278 p., illustrated; $5.95.

This book will be appreciated more by the layman and student than the biologist. Written in a clear narrative style, the story of rivers and their associated life is described. Many complex biologic principles are explained with brevity and clarity. The reader will have a brief exposure to numerous things.

The biologist will find the text largely a review of principles with which he should be familiar such as basic geology, water animals, hydrologic cycle, evolution of lakes, etc.

The book is divided into three parts: Part I entitled "Headwaters" discusses water sources such as glaciers, springs, bogs, lakes and small streams; Part II covers the characteristics of large rivers and aquatic life found in various parts of the world; Part III, "Rivers and History," reviews man's use of rivers through the ages, floods, pollution, watershed development, and even has a brief section on water law.

In most instances the facts and anecdotes follow the mainstream of thought. At times, however, they flood forth in all directions covering lightly a diversity of topics such as oyster anatomy, mudskippers, and mangroves, or theories of bird migration. One has the impression of reading a vast assemblage of loosely-related facts concerning aquatic life.

Author Bardach, a University of Michigan professor, draws from an extensive background of knowledge and no errors in technical content were noted.—*Willis A. Evans.*

Fish Catching Methods of the World

By Andres von Brandt, Fishing News (Books) Ltd., London 1964; xxiv + 191 p., 250 figures; $8.50.

The development of fish catching equipment, from bare hands to modern mid-water devices, is lucidly described in this book. A knowledge of design and use of all types of fishing gear was a prerequisite for compiling such a volume. That Dr. von Brandt has this knowledge is shown in his descriptive, easy-to-read accounts of each type of gear.

The 250 figures, both photographs and line drawings, illustrate details of gear construction, and add much to this history of fish-catching methods. By far the greatest space is devoted to describing large-scale catching of fish by commercial operations, but fishing methods of small native subsistence fisheries are included with brief mention of sportfishing equipment. A scientist faced with a problem in collecting some rare fish may well find an answer within this volume.—*E. A. Best.*

Fish Finding with Sonar

By Finn Devold, Lars Midttun, Gudmund Vestnes, and others, Simrad, Simonsen Radio A. S., Oslo, Norway, 1964; 96p., illustrated.

As spatial competition for sea fisheries intensifies, the utilization of more specialized fishing equipment becomes a necessity. *Fish-Finding with Sonar* provides the understanding for researchers and fishermen alike, to master sonar techniques. This book is written in an easy-to-understand style and is well illustrated throughout.

The volume aquaints the sonar operator with the elementary physics of sound and the function of the sonar set as a listening device. A chapter on sound classification and characteristics, and their interpretation is also included. Notes on elementary oceanography have been added to explain the reflection and refraction of sound and their echos due to the physical properties of sea water. Additional chapters explain search methods for one or more vessels, and tactical applications as exemplified in the Icelandic herring fishery.

Sonar employed by the techniques suggested in this book should provide a valuable service to fishermen and researchers seeking pelagic, sea fisheries.—*J. Gary Smith.*

Freshwater Ecology

By T. T. Macan, John Wiley & Sons, Inc., New York, 1963; x + 338 p., illus.; $6.50.

Ecology has been defined broadly as the science of the interrelation between living organisms and their environment. The challenge to cover a subject so broad in scope has been accepted by such eminent authors as Tansley, Elton, Andrewartha and Birch, Odum and Thienemann. Dr. Macan discusses their various works and criticizes their approaches to the science.

The author, in studying freshwater ecology, decides the reason species are present in some places and absent from others is due to the interaction of limiting factors. His text, then, is comprised of material on communities, transport, behavior, interrelationships, water movement, desiccation, temperature, oxygen, salinity, calcium, other chemical factors, and production and design of a field study.

A failure of this book is the author's use of names. He expresses a strong desire to make himself comprehensible to all in his use of scientific names for genera and species. To gain this end, he has placed a list of alternative names in an appendix to each chapter. However, he frequently fails to use common or vernacular names in discussing a species. This is disconcerting to a reader who observes the statement on the cover, "Only a basic knowledge of biology is assumed." In short, it is sometimes necessary to look up names of invertebrates in order to comprehend the author's point.

The role of the fish in the aquatic habitat is seldom covered except in special cases. The material, unfortunately, is almost entirely oriented from the standpoint of insects and other aquatic invertebrates. Most of the study waters referred to are in the British Isles and some of the phraseology is quite British, e.g. tarn, beck, loch.

In apercu, Dr. Macan has not recorded a complete coverage of freshwater ecology because he dwells basicly on the aquatic invertebrate fauna of the British Isles. A person wishing to read this book must have a good background in aquatic insects, molluscs, and crustaceans.—*Larry K. Puckett.*

Pesticides and the Living Landscape

By Robert L. Rudd; The University of Wisconsin Press, Madison, 1964; xiv + 320 p.; $6.50.

The author of this interesting book is well known for his 1956 publication, *Pesticides: Their Use and Toxicity in Relation to Wildlife*, co-authored with R. E. Genelly. This new work deals with the same subject, the adverse effects of chemical pest control, a matter which, since publication of the late Rachel Carson's *Silent Spring*, has been much in public controversy.

Dr. Rudd's book discusses the subject in four broad categories: (i) Man's exploitation of environment; (ii) Methods of controlling pests; (iii) Degree of success in pest control; and (iv) The price man pays for such pest control. This last category receives marked emphasis. The book includes chapters dealing with types of chemical pesticides, responses of animals to chemicals, responses of environment to chemicals, pesticide regulation, creation of pests, sublethal effects, human hazards, food chains, concentration and transference of chemicals, delayed expression of toxic action, faunal displacement, and many others of equal interest. The author covers the subject-matter thoroughly and objectively without resort to scare tactics.

Emphasis throughout the book is on ecology and effect on the total environment. To quote the author, "The ecological approach to utilization of living resources provides the only sure route to continued safety, productivity, and pleasure." Much background data are presented and will be enlightening for those unfamiliar with ecological principles.

The author casts serious doubt on the value of many of our pest control practices. He presents data to show the common fallacy of assuming benefits of pest control in the absence of data demonstrating such benefits. He laments the scarcity of funds for investigating and appraising control programs. Dr. Rudd has much criticism for those in charge of pest control, claiming they have not assumed full responsibility. He deplores practices such as predator control done for the benefit of the livestock producer at the expense of the general public. His criticisms of man's shortsighted pest control efforts and failure to understand or care about the full consequences are abundant. Ample data are given to justify his contentions.

Economics involved in pest control are given serious consideration. Recognition is made of intangible values and variation in values under differing circumstances.

The author discusses marine and estuarine pollution by insecticides. Mention is made that marine fish frequently show insecticide residues; however, he fails to mention the alarmingly high levels in large ocean fish and discuss the grave potential consequences. This could well have been included in a work of this scope and would have given the book additional impact.

It should be pointed out that the book is not a mere repeat of the data covered in *Silent Spring*. It is of broader scope and different style. In common with *Silent Spring*, the reader is instilled with the feeling of urgency in need for correcting the manifold abuses which man heaps on his environment.

In conclusion, the author recommends steps that should be taken toward alleviating some of the problems discussed. An appendix presents recommendations of the President's Scientific Advisory Committee on Use of Pesticides. The book is a Conservation Foundation study. It is thoroughly documented.—*Walter Thomsen.*

The Wonders of Water

By James Winchester; G. P. Putnam's Sons, New York, 1963; 128 pp., illus., $1.95.

This book is one of the *Wonders of Science Library* series, which endeavors to present authentic scientific information to young people in a concise and entertaining manner. Author Winchester accomplishes both in a well organized inexpensive volume.

The central theme is the role water plays in human life, past and present. How man reached his current understanding of water and its physical properties is initially covered. This is followed by an excellent historical account of the importance of water in shaping the destiny of our world.

He goes on to emphasize that among the world's three billion people, two out of three lack sufficient water. Even though water is the most abundant commodity on earth other than air, we are using it in more and more ways. In the short space of two generations, we have changed from houses lucky to have a faucet, to an average use per home of 16,000 gallons per month. The total weekly supply in the United States for all uses would take a reservoir 36 square miles filled to a depth of 1,000 feet.

The final chapter deals with man's efforts to reduce the water shortage by building large dams and transporting water great distances, by creating rain through cloud seeding, by reducing evaporation losses with reservoir surface coatings, and by converting salt water into fresh water.

In such a broad sweep as is taken by the author, it is possibly understandable that the effect of water development upon fish and wildlife resources is barely mentioned. However, failure to mention man's use of water for recreational purposes as part of his daily life must be classed as an oversight.

A few minor technical errors were noticed, and while the illustrations are well selected in most cases they do not occur adjacent to the related text discussion. Despite these few criticisms, it is one of the better books to aid young people in an understanding of the importance of water in modern life.—*Willis A. Evans.*

World Prospects for Natural Resources: Some Projections of Demand and Indicators of Supply to the Year 2000

By Joseph L. Fisher and Neal Potter; Johns Hopkins Press, Baltimore, Md., 1964; vi + 73 p.; $1.50, paper.

California and the World Ocean

Governor's Conference. California Museum of Science and Industry, Los Angeles, Calif. Office of State Printing, Sacramento, 1964; 118 p.; $7.50, paper.

Authors Fisher and Potter prepared their thoughtful, well-worth-reading essay under the auspices of Resources for the Future, Inc. It brings together "some of the more significant and readily available resource data as a basis for demand and supply projections." They concern themselves with the situation in the United States, with world trends, with projections of world needs, and with reserves and alternates in relation to food products, energy commodities, non-fuel minerals, forest products and water.

As a broad conclusion they find that there will be no general increase in resource scarcity in the more developed areas, but that elsewhere the situation will be severe though not hopeless. The world picture is favorable for energy components, but, not unexpectedly, on the grim side for food. While the United States can probably meet its resource demands, food is already critical today on a world basis and the prospects for the future are not good. They estimate that it will be necessary to triple world food output to provide a sufficient number of calories—and this would not provide adequate proteins and vitamins.

In discussing reserves and alternates, they regard the best hope for the future as lying in increasing the yield per acre. They recognize that fisheries can likely make a contribution here, that "fish farming" has a potential, but they "implicitly assume that fish foods will increase in proportion to other foods, or that other foods will increase sufficiently to replace them." They do, however, recognize that fish products may increase more than proportionately to other foods.

This leads me to consider the second object of this review, ***California and the World Ocean***. This document contains the proceedings of the conference on this subject convened by California's Governor Edmund G. Brown in Los Angeles early in 1964. The tone was optimistic: the ocean represents a vast source of food and energy for mankind. The roster of speakers was international and included such prominent California scientists as M. B. Schaefer, John Isaacs and W. M. Chapman. The latter, in the course of a report entitled "Industry and the Economy of the Sea," remarked at some length on protein deficiencies. He quoted recent studies which indicate that the sea has the theoretical capacity to produce sufficient protein for a world population of 30 billion—far greater than Fisher and Potter's 7 billion in the year 2000, based on maximal FAO projections. Whether the one forecast is unduly optimistic or the other unduly pessimistic, or both, I do not know. But surely the potential of the ocean is far greater than current yields—look at the obvious untapped resources off our own coast such as hake and jack mackerel—and it represents a significant contribution to the world food supply even if it be in the magnitude of 2x rather than Chapman's 5 to 10x.

The whole volume deserves the careful attention of all who are interested in the economic future of California and is a must for those concerned with the economy of the sea.—*Phil M. Roedel.*

Japan's World Success in Fishing

By Georg Borgstrom; Fishing News (Books Ltd., London, 1964; 312 p., illustrated, F 2-15-10.

This book is entirely devoted to the utilization of marine resources of the world ocean. The only mention of conservation is in the form of references to international agreements which have forced Japan to limit fishing operations in some designated areas. Many facets of the marine harvest are covered, i.e., coastal fishing, distant seas fishing, shellfish, whaling, seaweeds, and mariculture. By far the greatest portion of the book is devoted to descriptions of the far-reaching tuna fisheries.

Japan is reported to have joint fishing ventures established in 20 countries and planned operations in an additional 30 countries. The Japanese have an estimated 200 fishing vessels presently based in foreign countries, besides their large home island fleet. These fishing agreements are usually made on a basis of (i) joint companies to conduct fishing and processing operations; (ii) contracts or concessions to supply fishery products to local markets or processing plants or for export; (iii) technical assistance; (iv) exploratory fishing; (v) refueling or trans-shipment bases; or (vi) selling directly in a foreign port. A single agreement may consist of one or more of these arrangements. In addition, Japan is in a position to supply vessels, netting, electronic equipment, and other fishing apparatus.

Dr. Borgstrom discusses these agreements country by country, describing the degree of involvement, success of the venture, and type of fishery. The author apparently is not completely familiar with the actual fishing operations, because in several places there is a mixing of fishing terms or species which leads to some minor confusion.

In the last few chapters, which are devoted to the utilization of the sea's protein by Japan's large and increasing population, the author is definitely writing in his field, and the text is much more lucid.

This book should be required reading for fishery administrators, industry leaders, and statesmen, for it describes what is possible in the way of large-scale utilization of the seas, the degree to which Japan leads all other nations, and the need for world cooperation in the face of increasing competition for food from the sea.—*E. A. Best.*

Familiar Freshwater Fishes of America

By Howard T. Walden, 2d; Harper and Row, Publ., New York, 1964; xii + 324 p., illustrated; $6.95.

This is an interestingly written introduction to the major freshwater fishes of North America. It is a book for the layman angler rather than the student or biologist. Author Walden has written several other books for this series covering such subjects as mammals, insects, reptiles and amphibians.

At least a few members of most important families are briefly described covering identification, range, life history and habits. The tarpon, mullet, and cichlid families were omitted for some unknown reason. Information has been selected from a variety of technical references.

Illustrations by Carl Burger are interesting, but of limited use as an aid to identifying the various species.—*Willis A. Evans.*

The Complete Aquarium

By D. Vogt and H. Wermuth; Arco Publishing Co., Inc., New York, 1963; 268 p., illustrated in color plus black and white; $4.95.

A wide range of topics concerning vivariums and vivarius occupants is discussed in this compact volume, which due to its scope deals mainly in generalities.

The subjects range from the construction of tanks to the care and feeding of snakes. Vogt and Wermuth have grouped fish, amphibians, and most of the reptiles according to their habits. Lizards are grouped geographically. In addition there are chapters devoted to: technical aids or equipment, water quality, foods and feeding methods, and aquatic and terrestrial plants. A listing of literature for the specialist is included.

The novice will find *The Complete Aquarium* useful as an introductory handbook, however, those who wish to obtain more specific information will need to consult the references.

Two hundred and eighty animals are illustrated in color which, though often exaggerated, is descriptive.

The beginner may feel that the authors have presented an overly pessimistic attitude toward the successful care of aquarium animals. "This demands expert knowledge and considerable trouble, time, patience, tenacity—and also, unfortunately, money." Actually the authors are being realistic, if the aquarium owner wants to obtain satisfaction and enjoyment, at least a certain amount of these requirements are necessary.—*James A. St. Amant.*

Water and Its Impurities

By Thomas R. Camp; Reinhold Publishing Corp., New York, 1963; vii + 355 p., illustrated; $18.

Mr. Camp writes that, "The purpose of the book is to present fundamental scientific information regarding the physical, chemical, and biochemical properties of water and its impurities which determine its suitability for various uses, which make possible a rational evaluation of water quality problems in terms of the total environment. . . ." Mr. Camp has, in my opinion, succeeded admirably in achieving his stated purposes. The book contains a wealth of useful, basic information.

This volume is not easy reading, as complete comprehension of the contents requires an extensive background in chemistry and mathematics. However, the average biologist, even though not well-versed in these subjects, will gain a great deal of information from reading this book.

The main topics covered by the author are: physical properties of water; physical properties of impure water; chemical equilibria; composition of natural and polluted waters and of liquid wastes; sanitary significance of impurities in water and effects on aquatic life; standards of water quality for agricultural and industrial uses; corrosiveness of water; uses and water quality standards of public waters; bacterial decline rates in polluted waters; and the dispersal of wastes into receiving waters.

Although the volume is well referenced, the index is sketchy and incomplete. The diagrams, charts, and tables are clearly printed. The book is well edited and free of typographical errors.

This book will be a valuable reference for pollution bioanalysts and other aquatic scientists who are concerned with the study of *Water and Its Impurities.*—*Michael L. Johnson.*

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