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COYOTE FOOD HABITS IN SAGEHEN CREEK BASIN, NORTHEASTERN CALIFORNIA

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The food habits of coyotes (*Canis latrans*) in the vicinity of Sagehen Creek basin were investigated by analyzing 384 scats, of which 154 were collected fresh. The data from these dated droppings were grouped into winter, spring, and summer categories.

Meadow mice were the most important food, occurring in 47.7% of the scats. Deer were second and cattle, probably all carrion, were third, with frequencies of 35.2% and 11.5% respectively. Of lesser importance in the diet were the following mammals: pocket gopher, 6.8%; rabbit, 5.7%; marmot, 3.9%; golden-mantled ground squirrel, 3.9%; porcupine, 3.7%; and sheep, 3.7%. Insects and birds were found in 5.5 and 3.7%, respectively, of the scats.

Twenty-three scats were collected during the summer from trapped juveniles and were analyzed and discussed separately. Juvenile coyotes utilized most of the same food items as adults, but in somewhat different proportions.

INTRODUCTION

From 1966 through 1969, the coyote population of the Sagehen Creek basin along the eastern slope of the Sierra Nevada was investigated, using two principal methods of study: (i) 98 coyotes were trapped, marked and released to trace movements and longevity; this work was reported separately (Hawthorne, 1971). (ii) Concurrently, 407 coyote scats were collected to study food habits, results of which are reported here.

Coyote food habits have long been a subject of interest in California and elsewhere in the western United States. Among the authors who have reported on the foods of coyotes in other parts of California are Dixon (1925), McLean (1934), Bond (1939), Darby (1947), Fitch (1948), and Ferrel et al. (1953). Other noteworthy coyote food habits studies were made by Olaus Murie (1935) in Wyoming, Adolph Murie (1940) in Yellowstone, and Sperry (1941) in the 17 western states. The coyote is without doubt the most adaptable and successful of the native predators of the west, displaying remarkable opportunism in utilizing available food sources. Olaus Murie (1945:40) well summarizes the importance of evaluating coyote food habits locally when he states: ". . . the subject of coyote food habits becomes a local problem not only from the economic standpoint, but also from the standpoint of pure science, depending on the local ecologic picture."

THE STUDY AREA

Sagehen Creek Field Station is situated approximately 8 miles northwest of Truckee, California. The coyote study embraced the region eastward from the station to Kyburz Flat, Sardine Valley, Boca Res-

[1] The data comprised part of an MS thesis with the University of Nevada, Reno, June 1970. Accepted for publication September 1971.

ervoir and Prosser Reservoir; a circular area about 12 miles in diameter, most of it in the Tahoe National Forest, but including parcels of private rangeland. A map of the area and description of climate, terrain, and vegetation was presented in a previous report (Hawthorne, 1971).

METHODS

Coyote scats were gathered throughout the study area as opportunity permitted. Each scat that was considered to be a single dropping was placed in a paper sack upon which was written an identification number, date, locality, and whether it was fresh or old. Scats were air dried, and stored for future analysis in the laboratory.

Since coyote droppings vary in size and shape according to size of animal and the amount and kind of food eaten, difficulty with identification could be encountered in areas where other predators are present (Murie, 1940). In this study area where only low densities of bobcats, badgers, foxes, and raccoons occur, the chance of misidentification was slight. Scats of doubtful origin were discarded.

Analysis of the droppings was made in the laboratory where a reference collection of skeletons and hair was available to aid with identification. Scats were examined in the dry state by crumbling them and examining the fragments under a binocular microscope. Estimated volume, expressed as a percentage of the scat, was recorded for each item identified. Frequency of occurrence refers to the percent of scats containing a given item. In calculating frequency of occurrence, an item was considered to have only one occurrence in a dropping even though this particular item may have been represented by several individuals. The percent volume of each item was visually estimated to the nearest 5%. Items comprising less than 5% volume were recorded as a trace.

Data from the analysis of the fresh scats were grouped into winter, spring, and summer categories. The sample from the autumn months was too small to justify a separate category. Results from all adult scats were summarized to represent foods taken throughout the year. Twenty-three scats were collected from trapped juvenile coyotes. Although the sample size is small it seems worthwhile to list this information separately.

I fully recognize the pitfalls and possible inaccuracies of computing food habits from scat analyses. Murie (1946), Scott (1943) and others have demonstrated the variables inherent in this method. The figures as presented are intended to give a generalized rather than a precise representation of the dietary habits of Sagehen Creek coyotes.

RESULTS

Data of 384 coyote scats are presented as foods or prey species eaten with percent occurrence and volume for each identified food item found in a scat (Table 1).

Mammals were the most important source of food throughout the year. Four species of large mammals and 14 species of small mammals were utilized as food. Vegetable matter, birds, and insects were relatively unimportant items. While these items appeared with high frequency, they rarely accounted for much volume.

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TABLE 1—Coyote Food Habits in Sagehen Creek Basin and Vicinity as Determined From the Analysis of 384 Scats

	Percent occurrence and volume							
	Jan., Feb., Mar. (65 Scats)		April, May, June (30 Scats)		July, Aug., Sept. (59 Scats)		All seasons (384 Scats)	
Food items	Occ.	Vol.	Occ.	Vol.	Occ.	Vol.	Occ.	Vol.
Large mammals								
Mule deer	30.8	25	20.0	10	30.5	25	35.2	25
Cattle	52.3	55	--	--	8.5	5	11.5	10
Sheep	--	--	--	--	13.6	5	3.7	tr.
Coyote	6.2	tr.*	--	--	5.1	tr.	2.9	tr.
Small mammals								
Microtus sp.	16.9	5	86.7	80	42.4	25	47.7	40
Thomomys sp.	--	--	--	--	17.0	5	6.8	5
Lepus americanus	3.1	5	--	--	--	--	4.4	5
Marmota flaviventris	--	--	6.7	5	1.7	tr.	3.9	tr.
Citellus lateralis	--	--	3.3	tr.	6.8	5	3.9	tr.
Erethizon dorsatum	--	--	6.7	tr.	5.1	tr.	3.7	tr.
Citellus beecheyi	--	--	3.3	tr.	--	--	1.8	tr.
Citellus beldingi	--	--	--	--	5.1	5	1.6	tr.
Peromyscus sp.	1.5	tr.	3.3	tr.	1.7	tr.	1.6	tr.
Eutamias sp.	--	--	3.3	tr.	3.4	5	1.6	tr.
Glaucomys sabrinus	--	--	--	--	1.7	tr.	0.8	tr.
Tamiasciurus douglasi	--	--	--	--	--	--	0.8	tr.
Sylvilagus sp.	--	--	--	--	--	--	0.8	tr.
Lepus sp.	--	--	--	--	--	--	0.5	tr.
Birds								
Song birds	--	--	--	--	8.5	tr.	3.7	tr.
Invertebrates								
Grasshoppers	--	--	--	--	1.7	tr.	0.8	tr.
Other insects	--	--	3.3	tr.	18.6	tr.	4.7	tr.
Vegetable matter								
Pine and fir needles	20.0	tr.	23.3	tr.	25.4	tr.	19.0	tr.
Grass	6.2	tr.	26.7	tr.	37.2	5	17.6	tr.
Other vegetable matter	3.1	tr.	--	--	4.2	5	8.7	tr.
Non food items	18.5	5	3.3	tr.	4.4	5	1.7	tr.

* tr. = trace, less than 5%.

Large Mammals

Mule Deer

Deer hair was found in 35.2% of the scats examined. Only during the spring did deer occur with a frequency of less than 30%. Sperry (1941) found only a 6% frequency of occurrence of deer in the materials which he examined. Ferrel et al. (1953) found 18.5%, but this is still well below the 35.2% frequency recorded for deer in this study.

Probably most of the deer eaten by coyotes represented carrion. Hunter kills, crippling loss, road kills, and natural mortality are all contributing sources of dead animals. That coyotes do attack apparently healthy deer cannot be denied. Horn (1941) Cahalane (1947), and

Fichter et al. (1955) have described coyote predation on deer. Cook et al. (1971) report an instance of heavy fawn predation in southern Texas. I saw a yearling and an adult doe killed by coyotes within the study area.

Cattle

Remains of cattle in the scats almost certainly represented carrion. I have never seen any calves in the study area, and it is not likely that coyotes would attack adult beef cattle. Cattle graze throughout the study area during the summer and some animals die, thus becoming available as food for coyotes. On several occasions I have seen evidence of coyotes feeding on cattle carcasses in winter. During the winter months 52.3% of the droppings contained cattle hair (55% of volume). Most of the scats in which cattle hair was found contained nothing else.

Beef carrion does not appear to be an important food for the coyote through most of the year, but it is clearly a key factor in the welfare of the coyote during the winter.

Sheep

Sheep are herded over parts of the study area in summer and are therefore available as food in the form of prey and carrion. Sheep remains were found in fresh scats only during the summer when they occurred with a frequency of 13.6% (5% by volume). On a yearly basis, wool occurred in only 3.7% of the droppings and was recorded only as a trace in volume. Ferrel et al. (1953) found sheep remains in 8.7% of the stomachs examined.

Coyotes do kill sheep, sometimes inflicting considerable damage to flocks. On the other hand, to assume that wool in the scats indicates coyote predation on sheep is not a justifiable inference. On several occasions sheep were seen within the study area that appeared to have died from natural causes. Some of these carcasses remained for several days before they were utilized by coyotes. On seven different occasions I saw stray sheep that had been separated from the moving herd. Usually one or two animals were involved, but on one occasion a flock of six sheep remained in the study area long after the main band was moved away for the winter. Such abandoned strays are available to coyotes as easy prey or in the form of carrion. They do not represent an economic loss chargeable to coyotes.

Coyote

Coyote hair was found with a frequency of 6.2% in winter, 5.1% in summer, and 2.9% in all scats examined. Coyote hair usually was recorded in a scat in very small amounts that could have been swallowed while the animal was licking its fur. Only on three occasions did coyote hair make up a large portion of the total volume of a scat. One scat was 95% coyote hair. Young and Jackson (1951) present evidence that coyotes readily feed on coyote carcasses. Sperry (1941) records coyote remains found in stomachs as carrion.

Small Mammals

Rodents

The meadow mouse (*Microtus* sp.) was the staple food item in the coyotes' diet for most of the year. Only during the winter did other food sources occur with greater frequency than meadow mice. During the spring 86.7% of the scats contained meadow mice, which accounted for 80% of the volume. Meadow mice are especially vulnerable to predation in the spring between snow melt and the growth of new grass. The frequency of occurrence dropped to 42.4% in summer (25% by volume). Meadow mice occurred with greater frequency, 47.7%, and larger volume 40%, than any other food item. Ferrel et al. (1953) found rodents were the primary food item in California, with meadow mice the most important rodent. The most frequent item in the diet of coyotes in Jackson Hole, Wyoming, was meadow mice (Murie 1935). Sperry (1941), Fichter et al. (1955), Korschgen (1957), and Gier (1968), found meadow mice, while not the most important food item, to be the most prevalent rodent in their respective food habits studies.

Other rodents were taken less frequently and assumed much less importance in the overall food habits of the coyote. Pocket gophers (*Thomomys* sp.) were second in frequency of occurrence and percent volume. In fresh scats they occurred only during the summer, with a frequency of 17.0% (5% by volume). Since pocket gophers are seldom seen above ground one would think coyotes would not often have the opportunity to prey on them. Yet gophers occurred in 4% of the coyote stomachs in Sperry's (1941) comprehensive study. Murie (1940) found an occurrence of 21.6% and Fichter et al. (1955) reported an occurrence of 19.5% for pocket gophers in their studies.

Most of the species of rodents in the study area were utilized as food by the coyotes, but only four other species, yellow-bellied marmots (*Marmota flaviventris*), chipmunks (*Eutamias* sp.), golden-mantled ground squirrels (*Citellus lateralis*), and Belding ground squirrels (*Citellus beldingi*) were taken frequently. None of the four occurred above a trace in percent volume for all the scats analyzed. Marmot remains were found with a frequency of 6.7% (5% volume) in the spring, and 1.7% frequency in the summer. Juvenile marmots emerge from the natal burrows during June (Nee 1969), which may explain the higher occurrence of marmots in the spring. Chipmunks and the two species of ground squirrels occurred with the greatest frequency during the summer, when the young disperse.

Rabbits

A sparse population of snowshoe hares (*Lepus americanus*) occurred in the study area. Rabbits (*Sylvilagus*) were even more scarce, and jackrabbits (*Lepus californicus*) were not seen.

Remains of snowshoe hares were found in fresh scats only during the winter when they occurred with a frequency of 3.1% (5% by volume). Droppings containing snowshoe hare remains usually contained nothing else. The occurrence of rabbits in this food habits study is considerably below that found by many other workers: Sperry (1941), 33.5%; Ferrel et al. (1953), 29.3%; Fichter et al. (1955), 58%; Korschgen (1957), 55.3%; and Gier (1968), 54%.

Birds

Song Birds

Bird remains were found in fresh scats only during the summer when 8.5% of the droppings contained bird feathers. The volume was only a trace. Birds occurred in 3.7% of all scats analyzed but contributed only a trace in volume in the coyotes' diet. All the bird remains in this study were non-game birds, despite mountain quail, sooty grouse, and mourning doves occurring in the study area. Birds occurred in 18.1% of the stomachs examined in Ferrel et al. (1953), and in 1.25% of Sperry's sample.

Invertebrates

Insects

The use of insects as food is reported in most coyote food habits studies. The highest frequency of insects in this investigation was 20.3% during the summer. While insects were taken often by coyotes they never were more than a trace in volume. Insects occurred in 5.5% of all the scats examined. This compares closely with the findings of Sperry (1941), 6%, and of Murie (1935), 7%.

Vegetable Matter

Vegetable matter was found with high frequency throughout the year, but only during the summer was it taken in large enough quantities to be recorded above the level of a trace in volume. During summer vegetable matter occurred in 66.8% of the droppings and bulked 10% by volume. It occurred in 45.3% of the scats analyzed but accounted for only a trace of scat material by volume.

Much of the vegetable matter probably was taken incidentally while other foods were being ingested, since several blades of grass and one or two pine needles often were found in a scat. However, several droppings were composed mostly of pine needles. During the summer some of the scats contained enough grass to indicate that it was intentionally swallowed.

Murie (1940), Sperry (1941), Ferrel et al. (1953), Fichter et al. (1955), Gier (1968), and others, report finding significant amounts of both wild and cultivated fruits in the coyotes' diet. The only fruit found in this study was two manzanita berries.

Non-Food Items

Included in this category are items such as pebbles, sticks, manure, paper, string, brush bristles, plastic bags and rags.

Non-food items were found in the droppings throughout the year, and during the winter they reached a frequency of 18.5% (5% by volume). During this season when food becomes scarce, coyotes may intentionally ingest more non-food items.

JUVENILE FOOD HABITS

Juvenile coyotes fed on the same species of mammals as the adults, with minor exceptions (Table 2).

Large Mammals

Large mammals were utilized less and accounted for smaller volume in the scats of juveniles than adults. Deer occurred less frequently while sheep occurred more frequently in droppings of juveniles. Sheep remains had a high frequency of occurrence and percent volume (17.4 and 10% respectively), suggesting that young coyotes take full advantage of the sheep carrion present in summer. It seems unlikely that they are capable of raiding the flocks on their own.

TABLE 2—Juvenile Coyote Food Habits in Sagehen Creek Basin and Vicinity as Determined From the Analysis of 23 Scats

Food items	Percent occurrence and volume — July, August, Sept. Occ.	Vol.
Large mammals		
Sheep	17.4	10
Mule deer	8.7	5
Coyote	8.7	tr.*
Cattle	4.4	5
Small mammals		
Microtus sp.	56.5	25
Eutamias sp.	13.0	5
Thomomys sp.	8.7	5
Erethizon dorsatum	8.7	tr.
Marmota flaviventris	4.4	5
Citellus beldingi	4.4	tr.
Birds		
Song birds	21.7	tr.
Invertebrates		
Grasshoppers	13.0	tr.
Other insects	34.8	tr.
Vegetable matter		
Grass	56.5	10
Pine and fir needles	30.4	5
Other vegetable matter	13.2	5
Non food items	91.3	15

* tr. = trace, less than 5%.

Small Mammals

Small mammals were recorded in 95.7% of the scats of juveniles and bulked 40% by volume. This compares to 84.9% frequency and 45% by volume for adults. Meadow mice were the most extensively utilized rodent, occurring in 56.5% of the scats from juveniles compared to 42.4% of the scats from adults. Three species of mammals utilized by adults, but not juveniles, were golden-mantled ground squirrels, deer mice, and flying squirrels.

Birds

Song Birds

Bird remains were found in 21.7% of the scats from juveniles, compared to 8.5% for scats from adults, but in neither case did the volume exceed a trace.

Invertebrates

Insects

Insects were found in 47.8% of the scats from juveniles compared to 20.3% in scats from adults. In neither case did the volume of insects exceed a trace. Grasshoppers were found in 13.0% of the scats from juveniles and only 1.7% of the scats from adults.

Vegetable Matter and Non-Food Items

Vegetable matter occurred with a frequency of 100% and 91.3% of the scats contained non-food items. The frequency of these two items may be the result of collecting all the scats from trapped pups. Much of this material was probably ingested while the coyote was struggling in the trap. That this material can be swallowed and eliminated by the coyote before it is released from the trap is evident from the fact that trap pads were found in scats from juveniles.

The number of scats analyzed was too small to be conclusive in comparing adult and juvenile food habits. However, the data suggest that juvenile coyotes depend heavily on small mammals and summer carrion to bridge the difficult period when they are learning to support themselves.

CONCLUSION

There is little indication that the coyote in Sagehen Creek basin is a serious predator of livestock or game species. Primarily it preys on meadow mice and assorted other rodents. Secondarily it consumes substantial quantities of deer, cattle, and sheep probably available largely as carrion. My field observations, coupled with the scat analyses, do not suggest substantial predation on these larger mammals, though such predation—at least on fawns and sheep—has been demonstrated in other localities. Under the existing ecologic and pastoral conditions of the Sagehen area, the coyote appears to be a benign predator and scavenger, serving its natural ecologic function and adding interest to the landscape.

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THE SOUTHERN CALIFORNIA PACIFIC MACKEREL FISHERY AND AGE COMPOSITION OF THE CATCH FOR THE 1964–65 THROUGH 1967–68 SEASONS[1]

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California Department of Fish and Game

Commercial landings of Pacific mackerel, *Scomber japonicus* Houttuyn, have declined steadily since the 1962–63 seasons. The 1967–68 season catch of 1.38 million lb. was the smallest on record since large scale canning operations started in 1928.

Catches of Pacific mackerel were dominated by the 1960 and 1961 year-classes both in numbers (46.7%) and pounds (62.9%), for the four seasons. The 1962, 1963, 1964, 1965, and 1966 year-classes were all very small, and until better recruitment is realized, landings will continue to decline.

INTRODUCTION

This report [illegible] Pacific mackerel [illegible]

The [illegible] declined continuously [illegible] Pounds of fish landed have [illegible] season, with the [illegible] (Table 1) being the poorest [illegible] large scale canning of Pacific mackerel began in 1928.

THE FISHERY

The [illegible] fishermen [illegible] Pacific mackerel and jack mackerel [illegible] repeatedly. At the beginning of the [illegible] season, the price for both species was $[illegible] a ton. A [illegible] series of price disputes brought the price to $[illegible] a ton by September [illegible]. The price remained at $[illegible] a ton for the rest of the [illegible] and [illegible] seasons.

The number of [illegible] boats making deliveries declined from [illegible] in 1964–65 to [illegible] the following two seasons and [illegible] in 1967–68. Scoop and/or striker-equipped boats making deliveries remained at a low level with not more than 10 delivering fish during a season.

Less than 2[illegible] tons of Pacific mackerel were taken off central California during the four seasons. All general areas suffered a marked decline in landings (Figures 1, 2, 3, and 4). The sharpest decline in yield per area occurred at Tanner and Cortes banks where landings fell from 6,503,000 lb. to 7,000 lb. (Table 2).

[1] Accepted for publication September 1971.

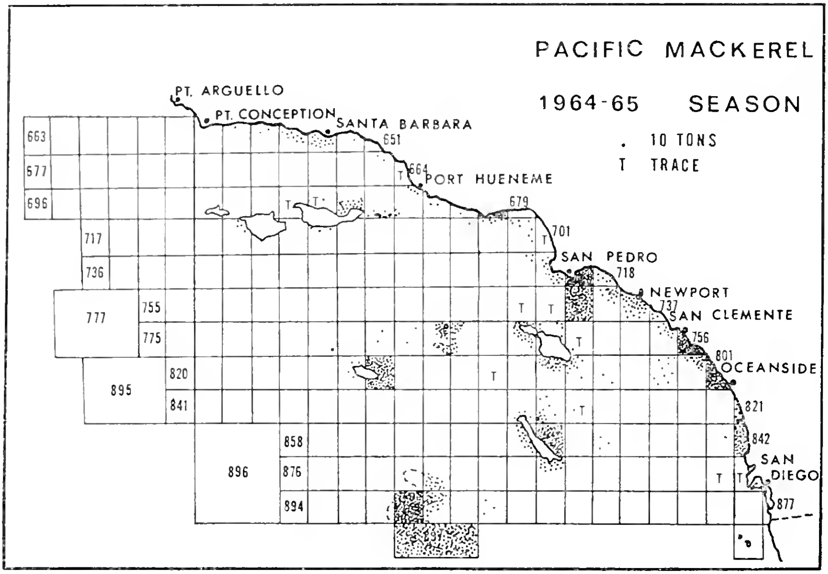

FIGURE 1—Pacific mackerel catch origins 1964–65 season.

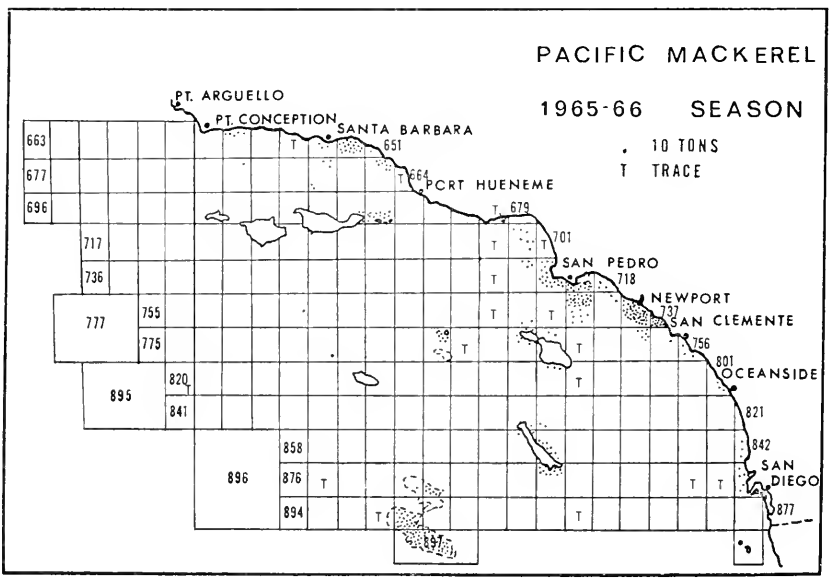

FIGURE 2—Pacific mackerel catch origins 1965–66 season.

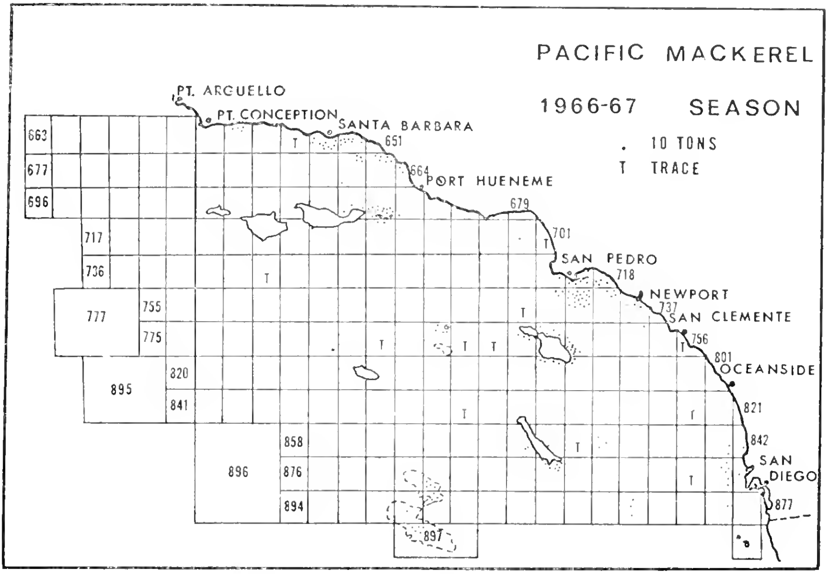

FIGURE 3—Pacific mackerel catch origins 1966–67 season.

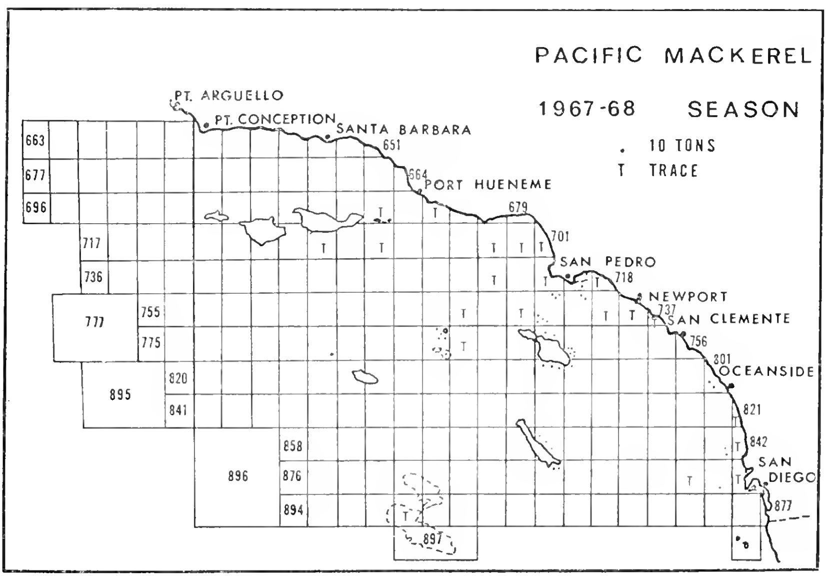

FIGURE 4—Pacific mackerel catch origins 1967–68 season.

AGE COMPOSITION

During the four seasons, three different sampling units were used to collect age and length data. The first sampling unit was started in 1948 (Fitch, 1951) and was used for the 1964–65 season. This unit consisted of 50 fish, with otoliths for age determination taken from the first fish in each five ½-cm length grouping (116–120, 121–125, etc.). A computer program was used in estimating numbers of fish landed by age group (Messersmith and Hyatt, 1965). Due to decreased landings and the resultant drop in numbers of otoliths collected, the sampling unit was altered at the beginning of the 1965–66 season. The new sampling unit consisted of one or more fish per ton for each boatload sampled. During months of poor landings, two, three or four fish per ton were taken to insure adequate numbers of aged fish. All fish sampled were aged. The sampling unit again was changed in 1966–1967 to 30 fish per boatload sampled with otoliths taken from each fish. This method of sampling was continued during the 1967–68 season. Numbers of otoliths used for estimating the numbers of fish by age group for the four seasons were 267 in 1964–65, 922 in 1965–66, 1,932 in 1966–67, and 749 in 1967–68.

The method used to estimate numbers of fish by age group for the 1965–66 through 1967–68 seasons differs from that utilized previously by Messersmith and Hyatt (1965). Because of the one to four variance in numbers of fish sampled per ton per boatload during the 1965–66 season, it was necessary to weigh each sample by the weight of the load from which it came. The following formula was used to estimate the numbers of fish by age, landed per month for this season.

$$N_j = \left[\sum\left(\frac{B_i}{S_i} N_{ij}\right)\right]\frac{B_m}{\Sigma B_i}$$

where

N_j — Number of fish at age j.
B_i — Pounds of ith boatload sampled.
S_i — Pounds of ith sample.
N_{ij} — Number of j year-olds in ith sample.
B_m — Pounds of all boatloads landed during month.

Samples taken during 1966–67 and 1967–68 also were analyzed using this formula, which can be simplified due to constant 30 fish sample size to:

$$N_j = \sum \frac{N_{ij} B_m}{\Sigma S_i}$$

Older fish (age-group III, IV, and V) dominated the fishery during the 1964–65 and 1965–66 seasons, while young fish (age-group 0 and I) dominated the 1966–67 and 1967–68 seasons (Table 3). The 1962, 1963, 1964, 1965, and 1966 year-classes were all very small, and none can be expected to contribute as much as 10 million lb. or as many as 10 million fish to the fishery (Tables 4 and 5). The 1964 year-class is the smallest on record, and the only year-class to contribute less than 1 million fish to the fishery by the end of its third year.

TABLE 1—Statewide Pacific Mackerel Landings in Thousands of Pounds

Month	1964-65	1965-66	1966-67	1967-68
May	486	42	416	28
June	2,154	106	136	59
July	3,910	798	430	51
August	4,137	259	293	179
September	6,575	2,325	317	84
October	4,565	1,150	1,529	100
November	2,737	473	364	243
December	75	1,361	370	205
January	79	188	56	180
February	27	387	126	93
March	37	76	33	94
April	93	124	5	68
Total	24,875	7,589	4,075	1,381

CONCLUSION

There is a long history of publications and reports describing the Pacific mackerel fishery decline and despite repeated attempts by the Department of Fish and Game to enact some control over the fishery this once large resource has been allowed to ebb to its present low level.

The present population level is so reduced (Blunt and Parrish, 1969) that spawning success is in danger of becoming directly density dependent with resultant long term loss of the fishery a distinct possibility. It therefore is imperative that some measure is taken to completely curb the take of this once vast Pacific mackerel resource (A moratorium went into effect on November 23, 1970 and no loads of fish may contain more than 18% by weight of Pacific mackerel taken incidentally to other fishing operations).

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TABLE 2—**Statewide Pacific Mackerel Landings by General Areas and Seasons**

General area	Block numbers	1964–65		1965–66		1966–67		1967–68	
		Thousand pounds	Percent	Thousand pounds	Percent	Thousand pounds	Percent	Thousand pounds	Percent
Central California									
Monterey	507–531	2	T	--	T	--	--	--	--
Point Sur	532–552	--	--	--	--	--	--	--	--
Piedras Blancas	553–606	--	--	--	T	7	0.2	--	--
Point Buchon	607–630	10	T	--	--	6	0.1	--	--
Point Sal	631–648	--	--	5	0.1	9	0.2	--	--
Southern California									
Northern Channel Islands	684–690, 707–713, 726–732	592	2.6	291	4.5	402	10.6	8	1.0
Santa Barbara City	651–657, 665–671	582	2.5	888	13.6	766	20.1	--	--
Port Hueneme	664, 680–683, 703–706, 722–725	567	2.4	17	0.3	53	1.4	1	0.1
Point Vicente	679, 701, 702, 718–721, 737–742	4,548	19.6	2,685	41.2	859	22.6	225	27.4
Oceanside	756–758, 801–804, 821–825	2,755	11.9	277	4.2	31	0.9	36	4.4
San Diego	842–846, 860–864, 877–882	816	3.5	171	2.6	304	8.0	59	7.2
Santa Barbara Island	713–745, 763–765, 809–811	894	3.9	178	2.7	113	3.0	126	15.4
San Nicolas Island	746–749, 766–769, 812–815, 833–836	1,840	7.9	19	0.3	1	T	--	--
Santa Catalina Island	759–762, 805–808	1,291	5.6	241	3.7	475	12.5	228	27.8
San Clemente Island	826–832, 847–853, 865–869	2,157	10.6	497	7.6	515	13.5	112	13.7
Tanner and Cortes Banks	854, 855, 870–873, 885, 888–891, 897	6,803	29.4	1,250	19.2	292	6.9	7	0.8
Mexico		--	T	--	--	--	--	18	2.2
Totals		23,157	99.9	6,522	100.0	3,806	100.0	820	100.0
Pounds of unknown origin not included above		1,718		1,067		269		562	
Total season's catch		24,875		7,589		4,075		1,382	

TABLE 3—**Age and Year-class Composition of the Pacific Mackerel Catch in Southern California During 1964–65 Through 1967–68 Seasons**

	Number and pounds of fish in thousands by age							
	O	I	II	III	IV	V	VI+	Totals
1964–65 Season								
Year-class	1964	1963	1962	1961	1960	1959		
Thousands of fish	79	3,951	3,053	5,762	7,634	982	86	21,550
Percent	0.4	18.3	14.2	26.7	35.4	4.6	0.4	
Thousands of pounds	30	2,622	2,839	6,939	10,659	1,626	160	24,875
Percent	0.1	10.5	11.4	27.9	42.9	6.5	0.7	
1965–66 Season								
Year-class	1965	1964	1963	1962	1961	1960		
Thousands of fish	3,990	386	234	519	1,686	2,648	477	9,940
Percent	40.1	3.9	2.6	5.2	17.0	26.6	4.8	
Thousands of pounds	960	166	198	573	2,217	2,702	773	7,589
Percent	12.6	2.2	2.6	7.6	29.2	35.6	10.2	
1966–67 Season								
Year-class	1966	1965	1964	1963	1962	1961		
Thousands of fish	663	1,881	363	279	236	634	396	4,452
Percent	14.9	42.2	8.2	6.3	5.3	14.2	8.9	
Thousands of pounds	217	877	336	344	337	1,181	783	4,075
Percent	5.3	21.5	8.3	8.4	8.3	29.0	19.2	
1967–68 Season								
Year-class	1967	1966	1965	1964	1963	1962		
Thousands of fish	2,866	136	95	101	59	32	50	3,339
Percent	85.9	4.0	2.8	3.0	1.8	1.0	1.5	
Thousands of pounds	801	82	87	119	79	54	159	1,381
Percent	58.0	5.9	6.4	8.6	5.7	3.9	11.5	

TABLE 4—Number of Pacific Mackerel Landed by Age-Group for Each Year-Class From the 1950–51 Through 1967–68 Seasons *

Year-class	Age group						
	O thousands	I thousands	II thousands	III thousands	IV thousands	V thousands	Totals thousands
1950	6	1,583	521	583	71	15	2,779
1951	769	46	175	208	204	62	1,764
1952	86	676	3,893	6,021	3,641	2,302	16,619
1953	12,237	40,036	21,156	14,641	8,160	1,125	97,355
1954	564	3,562	14,976	11,332	3,493	119	34,346
1955	4,237	49,429	30,187	10,865	1,283	415	96,716
1956	21	6,228	5,915	1,050	2,008	205	15,427
1957	1 386	1,277	4,211	7,681	1,958	342	16,855
1958	16,464	56,795	19,889	9,315	3,326	704	106,493
1959	1,517	17,680	13,066	8,650	5,190	982	47,115
1960	2,198	25,621	11,987	8,505	7,634	2,648	58,893
1961	17,997	26,006	11,612	5,762	1,686	634	66,727
1962	52	2,523	3,053	519	236	32	6,415
1963	44	3,954	234	279	59	--	4,570
1964	79	386	363	101	--	--	929
1965	3,990	1,881	95	--	--	--	5,966
1966	663	136	--	--	--	--	799
1967	2,866	--	--	--	--	--	2,866

* For data prior to the 1950 year-class see Calif. Fish Game (46) 2:187.

TABLE 5—Pounds of Pacific Mackerel Landed by Age-Group for Each Year-Class From the 1950–51 Through the 1967–68 Seasons *

Year-class	Age group						Totals
	O Thousands	I Thousands	II Thousands	III Thousands	IV Thousands	V Thousands	Thousands
1950	1	802	474	687	90	24	2,078
1951	252	34	183	234	244	94	1,341
1952	33	463	3,063	6,034	4,394	3,112	17,099
1953	4,358	23,175	16,990	14,973	10,197	1,358	71,051
1954	94	1,964	11,722	12,294	3,854	674	30,602
1955	1,270	25,940	24,552	9,769	1,796	639	63,966
1956	5	4,222	4,283	1,302	2,751	287	12,850
1957	466	664	1,101	9,012	2,529	522	17,297
1958	4,454	32,638	18,010	10,407	4,499	1,104	71,412
1959	505	7,661	11,154	10,386	6,985	1,626	38,617
1960	562	13,732	11,549	9,974	10,659	2,702	49,178
1961	5,659	18,206	14,327	6,939	2,217	1,181	48,529
1962	32	1,660	2,839	573	337	54	5,495
1963	19	2,622	198	344	79	--	3,262
1964	30	166	336	119	--	--	651
1965	960	877	87	--	--	--	1,924
1966	217	82	--	--	--	--	299
1967	801	--	--	--	--	--	801

* For data prior to the 1950 year-class see Calif. Fish Game (46) 2:488.

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DDT RESIDUES IN EIGHT CALIFORNIA MARINE FISHES[1]

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Levels of DDT, DDD, DDE, and total DDT residues in the livers and flesh of marine fishes, mainly from Monterey Bay, were determined using gas-liquid chromatography. Mean values for total DDT residues for liver ranged from 4.7 ppm wet weight (rough scale rattail) to 0.22 ppm (lingcod), and for flesh ranged from 2.0 ppm (sablefish) to 0.035 ppm (lingcod). Maximum values for total DDT residues in some individual fishes approached or exceeded FDA limits of 5.0 ppm wet weight, e.g., for livers: sanddab 13 ppm, roughscale rattail 7.9 ppm, sablefish 6.9 ppm, English sole 6.1 ppm, and petrale sole 4.8 ppm; for flesh: sablefish 6.3 ppm and roughscale rattail 4.7 ppm.

INTRODUCTION

Recent research indicates that chlorinated hydrocarbons, particularly DDT and its metabolates DDE and DDD, are now so widely distributed in terrestrial and aquatic ecosystems that virtually all forms of life are exposed to these water-insoluble but lipid-soluble synthetic chemical pesticides (Frost, 1969; Edwards, 1970). Extensive research has been conducted on toxicity of DDT and its metabolites to the original target insects. Secondary contamination in insect-eating birds, fish-eating birds, and freshwater fishes also has been well documented, but there have been relatively few measurements of DDT and its metabolites in Pacific coast marine fishes (Keith and Hunt, 1966; Risebrough, et al. 1967; Odemar, Wild, and Wilson 1968; Stout 1968; Fortmann 1969; and Risebrough, et al. 1969). Clearly more background information is needed in order to estimate the hazard of pesticides in marine environments. The objective of this study was to measure abundance of DDT, DDD, and DDE in the liver and flesh of eight important marine fishes.

METHODS

The following species of marine fishes were studied:

Jack mackerel	*Trachurus symmetricus*
Petrale sole	*Eopsetta jordani*
English sole	*Parophrys vetulus*
Pacific sanddab	*Citharichthys sordidus*
Sablefish	*Anoplopoma fimbria*
Lingcod	*Ophiodon elongatus*
White croaker	*Genyonemus lineatus*
Roughscale rattail	*Coryphaenoides acrolepis*

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Petrale sole, English sole, and Pacific sanddabs were trawled in Monterey Bay at the mouth of the Salinas River which drains an agricultural area heavily treated with pesticides. Sablefish, lingcod, white croaker, and roughscale rattail were caught by longline off central California by California Department of Fish and Game personnel. Jack mackerel caught off southern California were purchased from fish dealers in Monterey.

Exploratory analyses made on various parts of these fish (flesh, liver, brain, gills, gonads, and roe) showed that DDT and its metabolites were most abundant in those tissues with a high lipid content. All analyses reported here were made on liver and flesh. Wet weights were taken on all samples. Liver samples ranged in weight from 1.5 to about 49.8 g, depending on the size of the fish. Flesh samples were taken from the lateral region and included skin and adipose tissue; individual sample weights ranged from about 10 to 45 g. The pesticide residues were extracted and separated from the lipids by the method of Stanley and LeFavoure (1965). For samples of less than 3 g wet weight cleanup was performed on silica-gel microcolumns (Kadoum, 1968). The final extracts were concentrated by evaporation under nitrogen for micro samples, and by a flash evaporator for the macro samples.

Final extracts were analyzed with a Beckman GC 4 gas chromatograph equipped with an electron capture detector. The glass column was 6 ft long, I.D. 4 mm and operated at 200 C. The carrier gas was helium and the stationary phases used were 5% DC 200, 6% QF1—3% SE30 hybrid, and 3% SE 52, all coated on acid washed Chromosorb W mesh size 80/100.

All chemicals and other materials used were checked for purity before use to ensure absence of DDT and metabolites. Glassware was repeatedly rinsed with various solvents including acetone, solvent ether, benzene, and hexane. The final rinse was then concentrated and analyzed in the gas chromatograph. If residues were found, rinsing was continued until they were removed.

RESULTS AND DISCUSSION

DDE, DDD, and DDT were present in all of the samples analyzed, and pesticide levels in the livers of marine fish analyzed ranged from almost insignificant traces to 13 ppm (Table 1). In all samples analyzed, DDE was greatest in quantity, DDT second, and DDD least in concentration. Highest levels in total residues were found in sanddab (13 ppm), roughscale rattail (7.9 ppm), sablefish (6.9 ppm), and

TABLE 1—Range of Pesticide Levels in Livers

Species	(n)	DDE—ppm	DDD—ppm	DDT—ppm	Total residue
Roughscale rattail	12	0.21 – 6.4	0.013 – 0.48	0.026 – 2.2	0.29 – 7.9
Sanddab	13	0.022 –10	0.001 – 0.18	0.001 – 1.7	0.041 –13
Sablefish	15	0.29 – 5.6	0.022 – 0.41	0.063 – 1.1	0.28 – 6.9
Petrale sole	7	0.073 – 4.3	0.016 – 0.29	0.023 – 0.47	0.11 – 4.8
Jack mackerel	11	0.034 – 1.2	0.0016 – 1.40	0.00088 – 0.22	0.10 – 1.6
English sole	11	0.16 – 5.3	0.015 – 0.76	0.047 – 1.0	0.22 – 6.1
Lingcod	3	0.071 – 0.32	0.011 – 0.036	0.0095 – 0.084	0.092 – 0.41
White croaker	3	0.091 – 0.43	0.012 – 0.042	0.011 – 0.045	0.16 – 0.50

English sole (6.1 ppm). Highest levels of DDE occurred in the sanddabs (10 ppm); DDD was highest in the jack mackerel (1.4 ppm); while DDT was greatest in roughscale rattail (2.2 ppm).

TABLE 2—Range of Pesticide Levels in Flesh

Species	(n)	DDE—ppm	DDD—ppm	DDT—ppm	Total residue
Roughscale rattail	12	0.0012 – 2.9	0.00019 – 0.31	0.0012 – 1.5	0.0026 – 4.7
Sabddab	9	0.011 – 0.16	trace – 0.0083	trace – 0.19	0.011 – 0.20
Sablefish	12	0.52 – 5.5	0.024 – 0.18	0.082 – 1.2	0.59 – 6.3
Petrale sole	7	0.049 – 1.6	trace – 0.040	trace – 0.12	0.049 – 1.7
Jack mackerel	12	0.00038 – 0.045	0.000077 – 0.011	0.0041 – 0.025	0.010 – 0.074
English sole	6	0.017 – 0.20	trace – 0.018	0.0045 – 0.039	0.022 – 0.26
Lingcod	3	0.010 – 0.042	0.0016 – 0.0045	0.0040 – 0.0061	0.016 – 0.053
White croaker	3	0.018 – 0.48	0.0039 – 0.028	0.0062 – 0.028	0.028 – 0.54

TABLE 3—Mean Values of Pesticide Levels in Livers

Species	(n)	Mean value DDE	Mean value DDD	Mean value DDT	Mean value total residue
Roughscale rattail	12	3.6 ± 1.5	0.24 ± 0.16	0.87 ± 0.56	4.7 ± 1.9
Sanddab	13	3.0 ± 3.8	0.13 ± 0.16	0.44 ± 0.59	3.5 ± 4.5
Sablefish	15	1.7 ± 1.5	0.16 ± 0.18	0.51 ± 0.48	2.3 ± 1.9
Petrale sole	7	1.1 ± 1.4	0.10 ± 0.084	0.16 ± 0.15	1.4 ± 1.5
Jack mackerel	11	0.27 ± 0.33	0.19 ± 0.39	0.058 ± 0.058	0.51 ± 0.52
English sole	11	1.5 ± 1.6	0.15 ± 0.048	0.28 ± 0.30	1.9 ± 1.9
Lingcod	3	0.16 ± 0.11	0.019 ± 0.012	0.036 ± 0.034	0.22 ± 0.16
White croaker	3	0.23 ± 0.15	0.027 ± 0.012	0.033 ± 0.015	0.28 ± 0.16

TABLE 4—Mean Values of Pesticide Levels in Flesh

Species	(n)	Mean value DDE	Mean value DDD	Mean value DDT	Mean value total residue
Roughscale rattail	11	0.27 ± 0.84	0.029 ± 0.089	0.17 ± 0.43	0.47 ± 1.4
Sanddab	9	0.063 ± 0.047	0.0030 ± 0.0026	0.026 ± 0.058	0.091 ± 0.059
Sablefish	12	1.6 ± 1.6	0.089 ± 0.056	0.34 ± 0.29	2.0 ± 1.8
Petrale sole	7	0.34 ± 0.52	0.014 ± 0.016	0.015 ± 0.020	0.39 ± 0.54
Jack mackerel	12	0.015 ± 0.014	0.0056 ± 0.0031	0.015 ± 0.0059	0.036 ± 0.018
English sole	6	0.079 ± 0.064	0.0053 ± 0.0059	0.014 ± 0.013	0.097 ± 0.082
Lingcod	3	0.028 ± 0.013	0.0024 ± 0.0015	0.0047 ± 0.00099	0.035 ± 0.015
White croaker	3	0.19 ± 0.20	0.017 ± 0.00099	0.018 ± 0.0089	0.23 ± 0.22

DDE, DDD, and DDT were present in the flesh of all marine fishes analyzed, and in approximately the same ratios as found in livers (Table 2). However, the amounts of DDT and its metabolites were much smaller in the flesh than in livers. The highest total residues were found for sablefish (6.28 ppm), roughscale rattail (4.72 ppm), and petrale sole (1.69 ppm). The highest level for DDE was found in sablefish (5.5 ppm), and the highest levels for DDD (0.31 ppm) and DDT (1.5 ppm) were found in the roughscale rattail.

Pesticide levels in the liver showed the greatest variability in the sanddabs and jack mackerel (Table 3). Levels in the flesh were most variable in roughscale rattail and petrale sole (Table 4). DDT and its metabolites are the main pesticide residues in fish of Monterey Bay.

High total residue levels occurred in the three flatfishes (English sole, petrale sole, and Pacific sanddab) and in the two deep epibenthic species (sablefish and roughscale rattail). With the exception of roughscale rattail whose food habits are unknown, these animals are all benthic feeders. Jack mackerel, lingcod, and white croaker are not considered to be benthic feeders.

Risebrough, et al. (1968*b*) reported DDT residues averaging between 0.2 and 2.8 ppm in the whole bodies of eight species from offshore waters between San Francisco and the Channel Islands north of Los Angeles. English sole showed 0.19–0.76 ppm and jack mackerel showed 0.56 ppm. Stout (1968) found a range of 0.028–0.051 ppm of total residue in the fillets of English sole collected at Blaine, Washington. In my study, DDT residues in English sole ranged between 0.22–6.05 for livers and 0.022–0.26 ppm for flesh. Jack mackerel showed 0.10–1.6 ppm for livers and 0.01–0.07 ppm for flesh. While the samples are not strictly comparable, the values in the aforementioned do not appear significantly different from those found in this study; the high value of 6.05 ppm for total residue in English sole livers is possibly due to the fact that only livers and not whole fish were analyzed.

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SOUTHERN GEOGRAPHICAL RECORDS FOR FOUR SURFPERCHES, FAMILY EMBIOTOCIDAE, WITH NOTES ON A POPULATION RESURGENCE OF THE SHARPNOSE SEAPERCH[1]

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Southern range extensions are given for the silver surfperch, the rubberlip seaperch, and the shiner perch. A fourth species, the sharpnose seaperch, is recorded from a new locality off Baja California, Mexico and helps to substantiate a previous questionable record.

Data on increasing numbers of sharpnose seaperch in Monterey Bay and southern California are given and its appears that this species is undergoing a population resurgence.

INTRODUCTION

I have recently examined several surfperches captured outside their recorded ranges. Due to their viviparous mode of reproduction and inshore habitat preference, most species of surfperches probably exhibit only minor populational movements or migration patterns. A tagging study of the barred surfperch, *Amphistichus argenteus*, (Carlisle, Schott, and Abramson, 1960) failed to reveal any major movements by individual fish. Hence, new distributional records for surfperches contribute to the understanding of the population dynamics and biology of these fishes.

NEW RECORDS AND DISCUSSION

Silver Surfperch, *Hyperprosopon ellipticum* Gibbons, 1854

I identified four silver surfperch, ranging from 127 to 137 mm SL, which were caught by Bobby R. Castle and friends while surf fishing at a beach 4 miles south of Rio San Vicente, Baja California, Mexico (approximate lat 31° 13′ N, long 116° 21′ W). These specimens were taken on January 31 and February 1, 1970, along with four other silver surfperch; about 40 barred surfperch, *A. argenteus;* and one black perch, *Embiotoca jacksoni*.

Tarp (1952) listed southern California as the southern limit for silver surfperch. Miller, Gotshall, and Nitsos (1965) elucidated this as being Point Dume. Most recently, De Martini (1969) gave Dana Point as the southern extent of the range. The Baja California specimens represent an extension of 155 miles from Dana Point and are the first record of this fish from Mexican waters. The four specimens are deposited at the Natural History Museum of Los Angeles County; LACM 31681.

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Rubberlip Seaperch, *Rhacochilus toxotes* (Agassiz, 1854)

A photograph of a surfperch which was caught aboard the sportfishing boat *Holiday* off San Geronimo Island, Baja California, (approximate location lat 29° 47.5′ N, long 115° 47.5′ W) on November 10, 1968, was given to me by Bobby R. Castle. The relatively large size of the photographed fish (14.5 inches TL); dorsal soft-rays which are higher than the dorsal spines; the moderately forked caudal fin; and the thick, fleshy lips preclude its being anything except *R. toxotes*. Castle stated that two more "rubberlip perch" were taken the following day (November 11, 1968) "off San Carlos . . . approximately 10 miles south of San Geronimo Island".

These new localities extend for 75 miles the known southern range of the rubberlip seaperch from Cape Colnett, Baja California (Miller, Gotshall, and Nitsos, 1965) to at least San Geronimo Island.

Shiner Perch, *Cymatogaster aggregata* Gibbons, 1854

An adult male shiner perch, 91 mm SL, was collected on June 28, 1971, by the Department of Fish and Game research vessel *Alaska* 5 miles southeast of San Martin Island, Baja California (lat 30° 24.8′ N, long 116° 02.7′ W). The fish was taken by bottom trawl at 23 fathoms, fishing over green mud substrate. This record supplants Jordan and Evermann's (1898) long standing southern limit of "Todos Santos Bay, Lower California" and extends the shiner perch range downcoast by 90 miles. This specimen is in the Natural History Museum of Los Angeles County; LACM 31890.

A size record for shiner perch was brought to my attention by John E. Fitch. Although this species is reported to reach a maximum size of 8 inches (Clemens and Wilby, 1961), no authenticated record of an individual fish reaching this length is known to us. In February 1969, five female shiner perch 158, 169, 170, 171, and 177 mm TL were caught by J. P. Reed in Alamitos Bay and turned over to Fitch for examination. The largest fish (177 mm = 6.97 inches) was 142 mm SL and weighed 100 g. Miller, Gotshall, and Nitsos (1965) state that shiner perch reach a length of 6 inches but are rarely over 4 inches, which is normally the case for this species off the California coast. The five Alamitos Bay specimens are deposited in the Natural History Museum of Los Angeles County.

Sharpnose Seaperch, *Phanerodon atripes* (Jordan and Gilbert, 1881)

On October 4, 1970, at San Carlos Kelp (lat 29° 34.8′ N, long 115° 34′ W) I collected a sharpnose seaperch, 197 mm SL, at 10 fathoms. Tarp (1952) considered San Diego as the southern limit for this species; a year later Roedel (1953) listed San Benito Islands, Baja California, as the southern end of the range. The validity of the San Benito Islands record is questionable and some subsequent investigators have chosen to disregard it and follow Tarp (e.g., Miller, Gotshall, and Nitsos, 1965). Berdegue (1956) does not include the sharpnose seaperch for Baja California: " . . . con su límite sur de distribución en aguas mexicanas de la Baja California." Smith (1964) in a life history study of the sharpnose seaperch extended its northern limit to Bodega Bay and considered a number of specimens from other parts of California and one fish from Baja California. He failed to give locality data for the Baja California specimen although the date of capture was October 31, 1962.

Because some confusion exists as to the southern limit for this species, I have included the San Carlos Kelp record since it will lend credence to Roedel's (1953) San Benito Islands record; the distance from San Carlos Kelp to the San Benito Islands is 75 miles. This specimen is in the Natural History Museum of Los Angeles County; LACM 31680.

Smith (1964) gave a synoptic account of the occurrence of the sharpnose seaperch off California based on records from the late 1800's to 1962, and states, "There have been increasing reports of this species in recent years, following a long period of presumed scarcity." Sportfish sampling programs off central California have shown a recent change in the population level of the sharpnose seaperch and it seems appropriate to present these data at this time (Miller and Gotshall, 1965; John E. Fitch and Daniel J. Miller, pers. comm.). From 1958 to 1960, a sampling program surveyed all sport fisheries including spearfishing from Point Arguello to Oregon. Pier and surf fishermen were sampled in 1958; skiff fishermen in 1959; and rocky-shore fishermen, skindivers, and partyboat fishermen in 1960. During this period only four sharpnose seaperch were recorded; one in the pier catch (Santa Cruz pier, 1958) and three by skindivers near Monterey in 1960. In a 1966 sportfish survey (all fishing methods) from the Golden Gate to Yankee Point, sharpnose seaperch were taken commonly by fishermen at Monterey pier and by skindivers along Cannery Row, Monterey, and appeared for the first time in the Princeton Pier catch. In 1958 no sharpnose seaperch were recorded at Princeton pier in a sample of 2,099 surfperch on 18 sampling days; in 1966, three were recorded in a sample of 3,814 surfperch on 45 sampling days. At Monterey pier no sharpnose were recorded on 8 sampling days during the summer months of 1958, but in 1966 this species was the dominant fish taken during June, the peak of spawning for this species. In 1966 the sharpnose seaperch was recorded during 4 months of the year with 280 fish in a sample of 1,083 surfperch (Table 1). During 1966 this species also was common in the commercial fresh fish markets at Monterey.

TABLE 1—Number of Surfperches Sampled at Monterey Pier, 1966

Month	Number of sampling days	Total number of surfperches	Number of sharpnose seaperch
January	2	0	0
February	7	0	0
March	5	0	0
April	5	13	0
May	4	73	0
June	4	298	221
July	2	130	43
August	1	44	1
September	6	493	15
October	4	28	0
November	3	2	0
December	2	2	0
Total	45	1,083	280

On June 16, 1967, Department of Fish and Game wardens confiscated a quantity of surfperches at Los Angeles. These were part of a commercial delivery that originated at Monterey where the fish had been taken by gill nets the day before. The confiscated fish included 56 sharpnose seaperch; four white seaperch, *Phanerodon furcatus;* one pile perch, *Rhacochilus vacca;* and one shiner perch, *C. aggregata.* The above sample was representative of the total surfperch catch for a single string of gill nets.

Apparently the increase in numbers of sharpnose seaperch in the Monterey area started during the early 1960's. Smith (1964) reported on several sharpnose seaperch taken and observed by skindivers in the Monterey area during October and December 1961 and February 1962. In five skindiving meets in 1960 and one in 1961, held along Cannery Row, Department of Fish and Game personnel recorded only three sharpnose seaperch, all from the 1960 meet. On December 14, 1969, nine sharpnose were taken at a skindiving meet on Cannery Row. Divers at this meet reported this fish as common but difficult to approach.

Additional information from a study area off Hopkins Marine Station amplifies further the increasing numbers and the erratic behavior and distribution of this species. The study area is in a dense kelp canopy of 30 to 35 ft in depth. From August through December 1967, no sharpnose seaperch were observed by Department of Fish and Game scuba divers nor were any taken by hook and line. In 1968, several were observed by divers in July and September and one was taken on hook and line in September. In 1969 this species was common; observed underwater, sometimes in large schools, and captured by hook and line during 8 months of the year. It was less abundant, in 1970, being observed underwater during July and September and taken on hook and line during March, June and July.

During the summer months of 1967–1970, skiff samplers noted large numbers of sharpnose seaperch caught by pier fishermen at Monterey. This species was common in the Monterey fresh fish markets during this period.

Based upon the above data and observations, the sharpnose seaperch appears to be returning to a population level comparable to its status as reported by Jordan and Gilbert (1882) "Monterey Bay, locally abundant," and perhaps Eigenmann (1893), ". . . the commonest species in Monterey Bay."

Expansion of the population beyond Monterey Bay is shown by several recent records of sharpnose seaperch from southern California. In the spring of 1970 (late April or early May—exact date not known) fish from a partyboat catch from Santa Catalina Island were sold to a San Pedro market. Since it is illegal to sell sport caught fish, these specimens were confiscated by Department wardens and included: 73 halfmoon, *Medialuna californiensis;* 4 blacksmith, *Chromis punctipinnis;* and 13 sharpnose seaperch. On May 12, 1970, Department divers observed several schools of sharpnose seaperch under floats in Avalon Harbor, Santa Catalina Island, and noted that it was the most common species seen that day. On August 27, 1970, divers observed approximately 10 sharpnose seaperch at 40 ft while surveying oil tower *Hazel* in the Santa Barbara Channel.

Historically, *Phanerodon atripes* has been relatively rare in southern California waters, and was conspicuously absent in surveys conducted by Clark (1930), Quast (1968a, 1968b), Carlisle (1969), and Turner, Ebert, and Given (1969).

Although the mechanism governing the recent population fluctuation of the sharpnose seaperch is by no means understood, it is evident that a resurgence is in operation.

ACKNOWLEDGMENTS

I am grateful to Bobby R. Castle for specimens of the silver surfperch and the photograph of the rubberlip seaperch. Daniel J. Miller provided much of the data on the changing status of the sharpnose seaperch in Monterey Bay. John E. Fitch reviewed the manuscript and made many helpful suggestions.

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THE IDENTITY OF *SEBASTES BABCOCKI* AND *SEBASTES RUBRIVINCTUS*[1]

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Sebastes babcocki (Thompson, 1915) has usually been regarded as a junior synonym of Sebastes rubrivinctus (Jordan and Gilbert, 1880). The two species are however distinguished by a number of characters, including disposition of the red bands on the head and sides, shape of preopercular spines, presence or absence of scales on the mandible and branchiostegals, and meristic characters. S. babcocki ranges from southern California to Amchitka Island, S. rubrivinctus from northern Baja California to about San Francisco. Records of S. rubrivinctus from north of San Francisco pertain to S. babcocki.

INTRODUCTION

Among the 60 odd species of *Sebastes* found in the eastern North Pacific, two are pinkish-white with conspicuous crimson-red vertical bands. One is the flag rockfish *S. rubrivinctus* (Jordan and Gilbert, 1880) and the other is the redbanded rockfish *S. babcocki* (Thompson, 1915). The red bands in these fishes usually fade in preservative. In juveniles, the bands are dark and remain distinct in preservative. The two species are characterized by identical cranial spine pattern, with nasal, preocular, postocular, tympanic, and parietal spines present.

Since its description *S. babcocki* has been considered valid only once (Jordan, Evermann, and Clark, 1930). Hubbs (1928), followed by Schultz (1936), Schultz and DeLacy (1936), Alverson and Welander (1952), and Phillips (1957), considered *S. babcocki* to be synonymous with *S. rubrivinctus*, and regarded the northern limit of the range of the latter to extend northward to the Queen Charlotte Islands. Phillips (1957, p. 146) figured and briefly described a specimen that is certainly *S. babcocki* as "Hybrid C". It was regarded by him as either a hybrid or an extreme variant of *S. rubrivinctus*. To this date all specimens of *S. babcocki* collected off Washington, British Columbia, and Alaska have been reported as *S. rubrivinctus* (Heyamoto and Hitz, 1962; Barsukov, 1964; Westrheim, 1965; Best and Eldridge, 1969; and others).

SEPARATION OF SPECIES

S. babcocki and *S. rubrivinctus* are definitely distinct (Table 1), as shown by differences in the pattern of red bands, the downturned third preopercular spine (Figure 1), and the presence of scales on the mandible and branchiostegals of the former, and in meristic characters

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TABLE 1—Comparison of *Sebastes babcocki* and *Sebastes rubrivinctus*

	S. babcocki	*S. rubrivinctus*
First vertical red band	from occiput region downward and backward across upper portion of gill-cover to base of pectoral fin	from occiput region curving anteriorly downward to lower edge of gill-cover but not behind it
Second vertical red band	running more or less straight downward	from between tips of 4th and 8th dorsal spines downward and backward and curving forward
Preopercular spines	two uppermost pointing backward and upward, remaining three pointing downward	directed radially, third not curved downward
Mandible	scaled	usually naked
Branchiostegals	scaled	naked
Pectoral rays	usually 19	usually 17
Dorsal soft-rays	usually 14	more often 13 than 14
Rakers on first gill-arch	usually 30–31	usually 28–29
Interorbital/lachrymal	usually 1.7–2.2	usually 1.0–1.3
SL/head	usually 2.5–2.9	usually 2.4–2.5
SL/predorsal	usually 2.7–3.0	usually 2.5–2.7

(Table 2). *S. rubrivinctus* also has a much broader lachrymal but a narrower interorbital than *S. babcocki*. Thus the ratio of interorbital width to lachrymal width (generally less than 1.3 in *S. rubrivinctus* but greater than 1.7 in *S. babcocki*) separates the two species clearly.

In the original description of *S. rubrivinctus* (Jordan and Gilbert, 1880), the only statement which would allow the differentiation of *S. babcocki* from it is that there are 8 + 20 gill-rakers on the first gill-arch. The description was based on two specimens each about 1 ft long from the Santa Barbara Channel stated to be the types, but mention was made of eight additional specimens taken from Monterey at a later date. Jordan and Jouy (1881) and Jordan and Evermann (1898) erroneously listed these Monterey specimens (USNM 26989) as types.

TABLE 2—Dorsal Soft-Rays, Total Pectoral Rays, and Total Gill-Rakers of *Sebastes babcocki* and *Sebastes rubrivinctus*

Dorsal soft-rays	12	13	14	15	16
S. babcocki	--	8	22	6	
S. rubrivinctus	--	17	11	1	--

Total pectoral rays*	33	34	35	36	37	38	39	40
S. babcocki	--	--	1	5	1	28	1	--
S. rubrivinctus	1	26	3	--	--	--	--	--

Total gill-rakers*	54	55	56	57	58	59	60	61	62	63	64	65
S. babcocki	--	--	--	--	2	1	6	13	9	4	1	--
S. rubrivinctus	1	1	13	12	2	1	--	--	--	--	--	--

* Left count + right count.

We have examined a specimen (USNM 26919, 227 mm SL, male) taken by Jordan from Santa Barbara and the four Monterey specimens of USNM 26989 and find that our concept of *S. rubrivinctus* fits these specimens well. As the Santa Barbara specimen (USNM 26919) is almost certainly one of the two original types, we designate it as the lectotype of *S. rubrivinctus*.

In the original description of *S. babcocki*, Thompson (1915) referred to an 18¼ inches (46 cm SL) female from 59°01'N off Middleton Island, Alaska, as the type. This specimen cannot be located in the Stanford University Fish Collection, and must be presumed lost. A standard length of 46 cm is much too large for *S. rubrivinctus*. The largest specimen of forty-odd *S. rubrivinctus* we have seen is 328 mm SL. Phillips (1957) gave 24 inches (48 cm SL) as the maximum size for *S. rubrivinctus*, but this was probably based on specimens of *S. babcocki*.

Some of the characteristics mentioned in the original description of *S. babcocki*:

> ". . . with four broad cross-bars . . . first between third dorsal spine and occiput down to upper pectoral base . . . five preopercular spines . . . the two uppermost pointing backward and upward in marked contrast to remaining three, which point downward and backward . . . gill-rakers on first arches 10 + 21 and 9 + 22 . . . fine scales on . . . mandible . . . and branchiostegals. . ."

as well as the detailed drawing of the type indicate that we have correctly identified our specimens as *S. babcocki*.

RANGE

S. babcocki has a wide geographic distribution, being known from San Diego, lat 32°40'N (SIO 64-1025) to Amchitka Island, lat 51°17'N, long 179°27'E (Best and Eldridge, 1969). *S. rubrivinctus* is known from lat 31°03'N, long 116°22'W (SIO 68-18) to San Francisco, about 38°N (specimens at California Academy of Sciences, IUM 1130, 1141, 1163, 1172; W. N. Eschmeyer, in litt.). Although the geographic ranges of the two species overlap, *S. babcocki* has been taken infrequently within the range of *S. rubrivinctus*.

The two species probably do not occur in the same habitat. *S. rubrivinctus* is taken around rocks, and *S. babcocki* has often been taken by trawl, indicating it lives on smoother bottoms.

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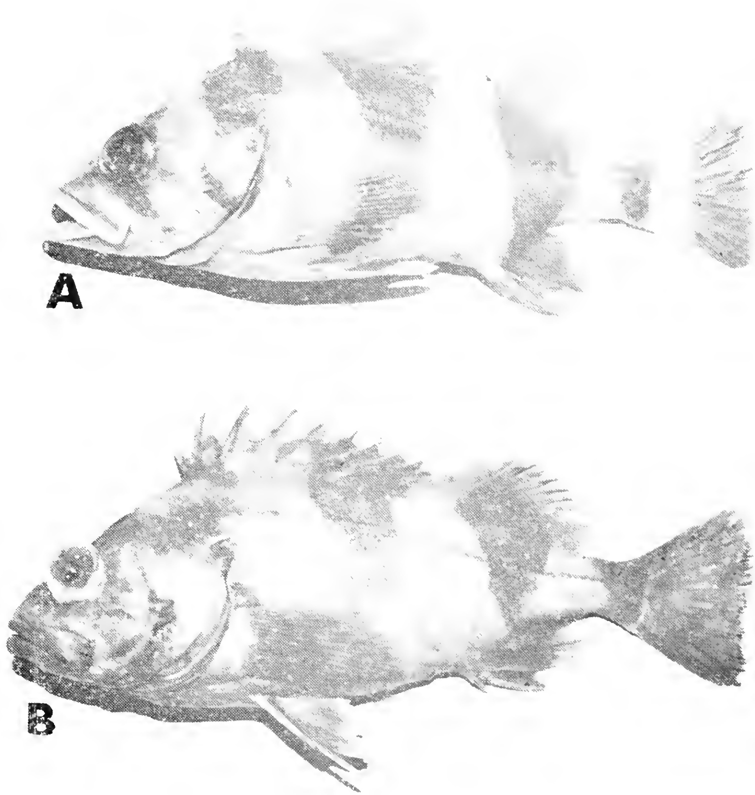

FIGURE 1—A. A 222 mm *SL* adult of *Sebastes rubrivinctus* from Tonner Bank, California, 32°42′N, 119°08′W (SIO64-99). B. A 345 mm *SL* adult of *Sebastes babcocki* from Cape Flattery Spit, Washington (SIO68-401). Both pictures black and white prints from color transparencies of fresh specimens.

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A STUDY OF PREDATION BY SEA LIONS ON SALMON IN MONTEREY BAY[1]

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There have been no studies which could serve to demonstrate the extent of sea lion predation on salmon (*Oncorhynchus* sp.) in Monterey Bay, California. Observations of fishing operations in Monterey Bay during the 1969 commercial salmon season showed that California sea lions (*Zalophus californianus* Lesson) preyed upon about 4% of all salmon hooked from the boats sampled. In addition, California sea lions were also seen holding seven salmon which they had not taken from fishermen's lines. Sea lions were seen more frequently in the southern half of Monterey Bay in the early season and were concentrated in the northern half in August and September.

INTRODUCTION

For nearly a century the sea lions in California, and especially in the Monterey Bay area, have been a subject of controversy. At one extreme, some fishermen claim that sea lions eat their salmon and destroy their gear, and therefore should be exterminated. At the other extreme, some naturalists claim that sea lions do not eat salmon and therefore need not be controlled. The purpose of this paper is two-fold. First, we will present an historical critique of the controversy and the research done in previous years. Second, we will present the results of a study in which we attempted to (i) estimate the amount of damage done to the salmon fishery by sea lions in Monterey Bay; (ii) determine the species of sea lion responsible; (iii) determine the local geographic concentration, if any; and (iv) determine whether sea lions prey upon free-swimming salmon.

HISTORICAL CRITIQUE

Scammon (1874) reported that thousands of sea lions had been killed for hides and oil off of the California coast. In that same year, the newly established California Fish and Game Commission recommended that nine-tenths of the remaining sea lions in California be killed because of reported high levels of fish predation (Scofield, mimeo. rep., 1957). To our knowledge this recommendation was not based on any scientific study.

In 1899, the California Fish and Game Commission again ordered the sea lion herds reduced. Years later it was reported to Bonnot that several thousand sea lions were killed on Año Nuevo Island before the

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Treasury Department of the Federal Government revoked the permit to kill sea lions on lighthouse reservations (Bonnot, 1928). The permit suspension was implemented in April, 1899. In June through September of the same year, Professor L. L. Dyche working in the Monterey Bay area, made observations on the food habits of sea lions and collected several specimens. The stomach contents of 25 sea lions were examined, of which 23 were females. Squid and octopus were the only food items found. The study was published by Dyche in 1903 as "Notes on the food habits of California sea lions (*Zalophus californianus* Lesson)."

It seemed unlikely that Dyche should find female California sea lions in Monterey Bay since it has been shown by Bartholomew and Hubbs (1952), and Orr and Poulter (1965) that the majority of female California sea lions migrate south of the breeding grounds in southern California after the breeding season, and that most males migrate north. We suspected therefore that Dyche had examined Steller sea lions (*Eumetopias jubata*) rather than California sea lions. Dyche had deposited skulls of the specimens collected at the University of Kansas Museum of Natural History. Upon our request, J. Knox Jones, Jr., the present director, examined the specimens collected by Dyche and reported that Dyche had indeed collected Steller sea lions rather than California sea lions. Dyche's paper must then be reapplied to Steller sea lions, which, as we shall show, probably do not materially affect the salmon fishery in Monterey Bay.

In 1900, at the request of the California Fish and Game Commission, a Federal board consisting of C. Rutter, R. E. Snodgrass, and E. C. Starks was detailed to study the damage done to the fishing industry by sea lions (Bonnot, 1928). The board found only contradictory information from southern points, and no complaints in San Francisco. They concluded that in Oregon and Washington the sea lions were causing little damage except at the mouth of the Columbia River, where they reported much damage (Rutter, Snodgrass, and Starks, 1902). Additionally, they examined stomach contents of 18 Steller sea lions, collected from Año Nuevo Island and Point Arena, and 24 California sea lions, collected from the Channel Islands in southern California. From these observations, made between July 14 and August 30, 1901, they concluded that the Steller sea lion is mostly a fish eater, and that the California sea lion is largely a squid eater, although both species seemed to be opportunistic feeders (Rutter, et al. 1902).

The California sea lion specimens used in the above cited study were obtained in southern California, where a substantial salmon fishery did not exist, and during the breeding season, when animals may not range far from the breeding grounds. Consequently, the study of Rutter, et al. (1902) should not be applied to food habits of California sea lions in Monterey Bay.

Bonnot (1928, p. 2) "was detailed . . . to make a survey of the marine mammals of the state, to investigate the claims made by fishermen, and to determine the present status of these animals." Bonnot's (1928, 1929) food habits studies of the California sea lion were based on the work of Dyche (1903), Rutter, et al., (1902) and eight specimens that Bonnot personally examined in southern California, five of which had empty stomachs; the other three were pups with milk in their stomachs.

Bonnot's (1928, 1929) food habits studies of the Steller sea lion were also based on the work of Rutter, et al. (1902) and two Steller sea lions from San Miguel Island that Bonnot collected. One specimen had an empty stomach, the other was a female in a dying condition and had three skate eggs in her stomach. Bonnot concluded that sea lions (in general) may prey on commercially valuable fish, but that conclusive evidence to that effect was lacking.

For an estimate of the amount of damage done to the fishery by sea lions, Bonnot consulted with over 100 fishermen. From those inquiries, he concluded that although sea lions cause a certain amount of damage to fishing gear, this damage is not extreme. In the present study we agree with Bonnot that reports by fishermen are highly variable with respect to locality, time of year, and type of fishing operation.

There have been only two recent food habits studies of the California sea lion, one by Scheffer and Neff (1948), and one by Fiscus and Baines (1966). Both of these studies were conducted in southern California where no significant salmon fishery occurs, and therefore should not be applied to other localities.

In retrospect, the absence of reports other than Dyche's on food habits of sea lions in the central and northern California coastal areas points out the need for more data from the region where the principal conflict between sea lions and salmon fishermen occurs.

METHODS

Observational sampling of fishing operations was conducted between April 14 and September 22, 1969. We followed a schedule of randomly selected sampling dates and the sampling effort was divided between sport and commercial boats. Observations were conducted on boats from the three major Monterey Bay ports: Santa Cruz, Moss Landing, and Monterey (Figure 1). Sampling emphasis was placed on the latter two ports because our financial support was from Monterey County. However, we undertook some sampling out of Santa Cruz in the final 6 weeks of the study, after hearing reports of much sea lion activity in that area.

Data were taken whenever it was apparent that a fish was hooked, whenever a sea lion or a shark was sighted, and whenever special circumstances waranted notation (i.e., shots fired, radio reports). We discriminated between those losses of fish which were unmistakably attributable to sea lions and losses which were debatable. Use of the term "confirmed" predation required that the observer sight a sea lion on the surface with a salmon in its mouth. Confirmed off-line predation was noted only when the boat from which we were making observations had not had any fish pulled off its lines and the sea lion in question was quite distant (usually at least 300 yards) from any other fishing operation.

RESULTS AND DISCUSSION

We carried out day-long observations on 52 commercial and six sport fishing trips, encompassing roughly 500 hr of observation. The total catch on these trips was 234 salmon actually boated plus those taken

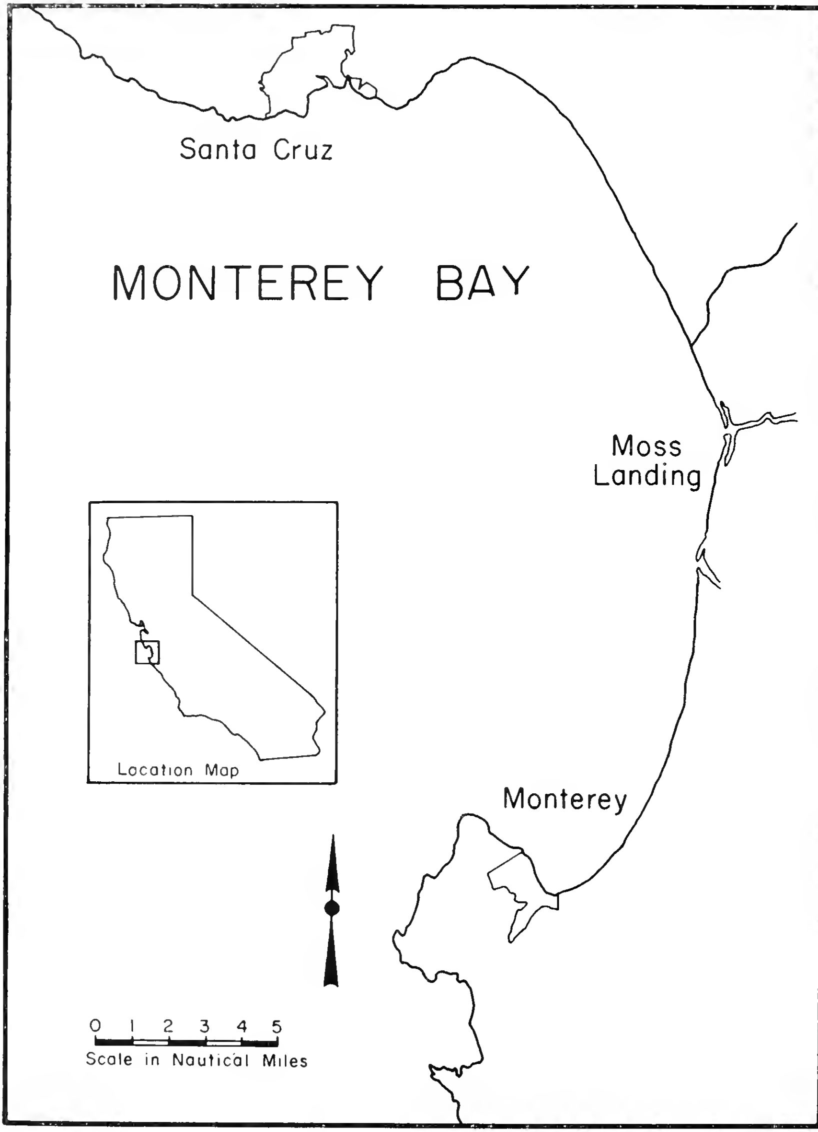

FIGURE 1—Map of Monterey Bay showing ports referred to in text.

from the lines by sea lions (Table 1). According to Steven N. Taylor (California Department of Fish and Game, pers. comm.) commercial salmon fishermen landed 83,716 salmon at Monterey ports and are estimated to have released an additional 26,038 shakers (sub-legal salmon) during the period of this study—a total of 109,754 salmon. Our catch of 234 salmon is 0.21% of this figure.

We noted nine occasions when California sea lions probably preyed upon hooked fish and one instance of confirmed predation by a California sea lion upon a hooked salmon. Obviously, it was impossible to ascertain the species of fish lost well below the surface. However, our catch statistics in each case indicated that salmon were the probable prey fish.

TABLE 1—Numerical Analysis of Observations in Monterey Bay from mid-April to mid-September, 1969

Month	Number of sampling days	Number of salmon observed caught	Probable losses to sea lions* (on-line predation)		Confirmed predation by sea lions on free salmon
			Number of fish lost	Percent of catch lost†	Number of fish
April	7	47	1	2.1	4
May	15	59	5	7.8	2
June	12	47	0	0.0	0
July	4	21	0	0.0	0
August	10	45	3	6.3	0
September	10	15	1	6.3	1
Totals	58	234	10	4.1	7

* Includes probable and confirmed losses of hooked fish to California sea lions.

† Computed as: $\frac{\text{Number of salmon lost}}{\text{Number of salmon caught} + \text{number of salmon lost}}$ (assuming that all fish lost to sea lions were salmon)

In addition to instances of "on-line" predation, we noted seven occurrences of "confirmed predation" by California sea lions on salmon which were not already on fisherman's lines. In only one case of the seven had a "shaker," or undersized salmon, been released from the boat under observation in the preceding 15 min (it is possible that the released fish was weakened or injured and, thus, easy prey for a nearby sea lion). In two cases of the seven it was possible that another boat in the vicinity had released an undersized fish in the preceding few minutes. We are unable to resolve the question of whether the three cases mentioned represent predation on previously injured or weakened fish. At times our observations of this type of predation were over distances of less than 25 yards. It was possible in one case to observe scales, pink meat, and oil on the water after such an event had taken place. We have concluded that California sea lions probably do take some free salmon in the wild, but we are unable to quantify the degree at this time.

Our sampling level was considered too low to permit valid conversion of predation statistics to percentages of the entire Monterey Bay catch. When losses attributable to California sea lions were calculated for the 58 cruises sampled, we found that 4.1% of the salmon hooked were probably lost to California sea lions (this figure excludes predation upon free salmon) (Table 1).

Our data showed that California sea lions were generally absent from Monterey Bay during late June, July, and early August, corresponding to a well-documented seasonal migration to the south. Analysis of the data for geographic patterns showed that sea lion activity was concentrated south of Moss Landing in April, May, and June, and north of Moss Landing in August and September. In view of the findings of previous authors, it is likely that our observations of California sea lions in August and September in the fishing grounds north of Moss Landing represented sightings of animals migrating from southern points toward the hauling-out grounds at Año Nuevo Island.

CONCLUSIONS

Although this study had numerous limitations, we believe that several points have been established: (i) California sea lions were the only pinnipeds recorded in the study area and were seen to account for a loss of 4.1% of the sport and commercial salmon catch sampled between mid-April and mid-September, 1969 in Monterey Bay; (ii) seven instances of confirmed predation by California sea lions on free-swimming salmon were recorded; (iii) predation and sea lion sightings were negligible in late June, all of July, and early August, corresponding with a California sea lion migration documented by other authors; (iv) sea lion activity focused around Monterey in the first 2 months of sampling, and between Santa Cruz and Moss Landing in the last 2 months. It should be noted that sampling could not be extended to Año Nuevo Island, where the majority of California sea lions in the area between Monterey and San Francisco haul-out.

Perhaps the most important point of this study is that the problem of sea lion predation on hooked salmon is a very complex one that will not be solved with unfounded conclusions. Even though this study showed that sea lion predation does occur, it achieved only a 0.21% sampling level, so must be regarded as a preliminary report. Clearly, a much more detailed study must be conducted before any decisions can be made regarding sea lion populations as they relate to salmon fisheries management.

ACKNOWLEDGMENTS

Gratitude is extended to the many Monterey Bay fishermen whose cooperation made this study possible. J. Knox Jones, Jr., University of Kansas, supplied information at our request concerning specimen identification. Thanks are due to Richard Parrish, California Deparment of Fish and Game, who provided valuable technical assistance. Senior advisor to the project was G. Victor Morejohn, Moss Landing Marine Laboratories, whose advice and contributions are gratefully acknowledged. Many hours of observation were conducted by Ann Davis and Craig Rodeick, both of Moss Landing Marine Laboratories.

All work was carried out at the Moss Landing Marine Laboratories of the California State Colleges.

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HARVEST, SURVIVAL, AND COST OF TWO DOMESTIC STRAINS OF TAGGED RAINBOW TROUT STOCKED IN LAKE BERRYESSA, CALIFORNIA[1]

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Tagged rainbow trout of the Coleman Kamloops strain and the Mt. Whitney strain were planted in Lake Berryessa, Napa County, California. The former was less vulnerable to shore anglers shortly after planting and had a more rapid limnetic distribution, equal mean annual harvest rates, a higher survival, and a lower cost to the angler's creel compared to the latter.

INTRODUCTION

Rainbow trout (*Salmo gairdneri*) feed extensively on threadfin shad (*Dorosoma petenense*) and show excellent growth in several California reservoirs and in inland waters of the Southwest and Southeast. They grow in length an inch each month and increase in weight between five and ten times from spring until fall. They provide a fishery for large trout in fall and winter months as surface waters cool. Generally, natural reproduction limits yields below the lake's potential capacity. Previous attempts to augment yields by stocking fingerlings ($\leq$ 5.2 inches) and "subcatchables" (5.3–7.3 inches) did not succeed. This paper presents the results of the first of a series of experiments to determine which strain of trout would be most economical to plant in these reservoirs.

The experiment was conducted at Lake Berryessa, Napa County. This impoundment on Putah Creek covers 20,000 acres and has a maximum storage capacity of 1.6 million acre-feet. It has a mean annual fluctuation of approximately 10 ft, a single fall overturn and large volumes of well-oxygenated water with temperatures less than 60 F all year. The typical California assemblage of centrarchids, ictalurids and cyprinids exists in the littoral zone. Threadfin shad stocked in 1965 have developed an enormous stock in the limnetic zone.

MATERIALS AND METHODS

The Mt. Whitney and the Coleman Kamloops strains of rainbow trout were compared in this first experiment. The former is the spring-spawning (March through May) strain used in the State hatchery program. It originated ca. 1917 from wild rainbow trout from Rae Lakes, Fresno County, California. It probably has been crossed with steelhead trout (*Salmo gairdneri*) and Lahontan cutthroat trout (*Salmo clarki henshawi*). A more complete description is given by Cordone and Nicola (1970). The Coleman Kamloops strain was derived from wild fish in the Kamloops Lake district of British Columbia. The

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brood stock has been held for 19 years at the Coleman National Fish Hatchery. It has probably been crossed with steelhead and rainbow trout of the Sacramento River. This trout is now so well domesticated that it equals in growth other California hatchery rainbows. In California state hatcheries, this strain spawns in December, January, and February, but at the Coleman Hatchery it spawns in November, December, and January.

A total of 53,533 rainbow trout of the two strains was planted on March 19, 1968, including 416 of the Mt. Whitney strain and 419 of the Coleman Kamloops strain tagged with the Carlin tag. This tag seemed to be the most suitable type to use because of the low rate of shedding, the long retention period, the low tagging mortality, and its negligible effect on growth (Nicola and Cordone 1969). Each tag bore an offer of $5 for its return. The left ventral fin was excised on 47,200 Mt. Whitney rainbow trout and the right ventral fin was removed from 5,500 Coleman Kamloops fish for later identification and information on weight. The Mt. Whitney and the Coleman Kamloops fish averaged 8.6 and 8.5 inches long, respectively, with similar length frequencies (Table 1). Both groups had a mean weight of 0.24 lb.

TABLE 1—Length Frequencies, Mean Lengths, and Mean Weights of the Two Strains of Tagged Rainbow Trout Planted in Lake Berryessa in 1968

Length class, inches	Strain	
	Mt. Whitney	Coleman Kamloops
6.0–6.9	10	15
7.0–7.9	88	78
8.0–8.9	225	231
9.0–9.9	89	91
10.0–10.9	1	1
Total	416	419
Mean length, inches	8.6	8.5
Mean weight, pounds	0.24	0.24

Local commercial groups and sportsmen's clubs were informed about the program through personal talks. Posters describing the program were placed at conspicuous and accessible places around the lake and at most resorts. Resorts and local businesses received franked envelopes to be given to anglers who caught tagged trout. Publicity of this type did not reach the bulk of anglers from the San Francisco-Oakland area, however, and many did not recognize the tag and reported releasing tagged fish early in the experiment. Because of inadequate publicity, angling effort for the first year was not as high as expected for a stocking of this magnitude and not all tags recovered by anglers were returned. Accordingly my exploitation rates are assumed to be underestimates. Survival rates are assumed not to have been affected.

Ricker's method (1958) was used to compute survival and exploitation rates. Weight data were obtained from fish taken by anglers and in gillnets. The difference between exploitation rates of the two strains was tested using a Z test (Walker and Lev 1953). A normal distribution was assumed.

TABLE 2—**Tag Returns and Exploitation, Survival, and Mortality Rates for Two Strains of Rainbow Trout Planted in Lake Berryessa in 1968**

Strain	Number tagged	Number returned			First-year exploitation (u_1)	Mean estimated exploitation ($\bar{u}$)	Estimated annual survival (s)	Total annual mortality (a)	Annual natural mortality (v)
		Year 1	Year 2	Total					
Mt. Whitney	416	58	12	**70**	0.11	0.14	0.21	0.79	0.65
Coleman Kamloops	419	39	38	**77**	0.09	0.17	0.97	0.03	<0.00
Total	**835**	**97**	**50**	**147**					

RESULTS

Harvest, Survival, Movement

During the first year anglers returned tags from 58 Mt. Whitney rainbow and 39 from Coleman Kamloops (Table 2) leading to significantly different first-year exploitation rates of 0.14 and 0.09, respectively ($Z = 2.09$, $\alpha = 0.05$). Over the 2 years, however, anglers caught 70 Mt. Whitney and 77 Coleman Kamloops. The mean exploitation rates of 0.14 and 0.17 (Table 2) were not significantly different ($Z = 0.588$, $\alpha = 0.05$).

During the second year, returns of Coleman Kamloops were approximately equal to those of the first year for a calculated survival rate of 0.97 compared to 0.21 for Mt. Whitney trout. The accuracy of the former survival rate is questionable since the number of returns were small and calculated natural mortality was negative, but this higher survival accounted for the significant differences noted between first-year and mean exploitation rates of the two strains.

Weight Returns and Cost

The tagged trout of each strain weighed a total of approximately 100 lb. at planting. Limited catch data were procured subsequently, but paralleled closely weight data from a 1968 creel census at Merle Collins Reservoir, a 1,000-acre reservoir similarly managed for trout. Therefore the mean monthly weights of trout at this reservoir were used for computation of the weight returns per pound of trout planted at Lake Berryessa, as follows: March 19, 1968 through June 30, 0.3 lb.; July 1 through September 30, 0.5 lb.; October 1 through December 31, 1.75 lb.; January 1 through March 18, 1969, 2.5 lb.; March 19 through June 30, 3 lb.; July 1 through March 18, 1970, 4 lb. The number returned during each period (Table 3) was multiplied by the appropriate factor, and these weights were summed. Mt. Whitney trout yielded 85.1 lb. (85.1%

TABLE 3—**Tag Returns by Strain, Month, and Year for Two Strains of Rainbow Trout Planted in Lake Berryessa in 1968**

Period	Mt. Whitney Number returned Year 1	Mt. Whitney Number returned Year 2	Coleman Kamloops Number returned Year 1	Coleman Kamloops Number returned Year 2
March 19, 1968	5	2	2	1
April	22	2	15	4
May	6	3	3	1
June	4	0	3	3
July	2	1	1	2
August	0	1	1	0
September	1	0	0	3
October	2	0	0	1
November	3	2	5	15
December	5	1	3	4
January 1969	3	0	5	3
February	3	0	1	1
March 1–March 18	2	0	0	0
Total	**58**	**12**	**39**	**38**

by weight) whereas, the Coleman Kamloops trout yielded 180.4 (180.4% by weight).

The cost of hatchery production was $.81 lb. for trout of 4.1/lb. (Schafer 1970); thus, the cost to the angler's creel for the Coleman Kamloops fish came to $.45 lb. and for the Mt. Whitney fish $1.05/lb.

Because the mean lengths and weights at planting were similar and the planting dates and sites were the same for both groups of fish, I concluded that these variables did not account for the differences noted between them.

DISCUSSION

This higher survival of Coleman Kamloops probably resulted from a more rapid movement to the limnetic zone shortly after planting where they became less vulnerable, available, or both, to shore anglers compared to the Mt. Whitney rainbow. This hypothesis seems tenable since information provided by 102 anglers in letters accompanying tag returns showed that 69 (68%) of the returns for both strains combined came from shore anglers using salmon eggs, minnows and other baits, but only 11 (16%) of these were Coleman Kamloops trout. Moreover, anglers caught only 23 (29.9%) of the Coleman Kamloops during the first 4 months after planting. Conversely, Mt. Whitney rainbows showed a return of 37 (52.9%) during the same period (Table 3).

Other information from Merle Collins Reservoir, where these same two strains were planted under similar conditions strongly supports this hypothesis. At this lake a creel census from March through June 1969 showed that of the mean monthly catch by shore fishermen of both strains combined, 64.5% were Mt. Whitney trout and 35.5% Coleman Kamloops trout. Conversely, of the landings by boat fishermen, 60.4% were of the Coleman Kamloops strain and 39.6% of the Mt. Whitney strain (Table 4). Moreover, shore angling effort (6,872 hr) accounted for 71.2% of the total catch of Mt. Whitney trout and 47.2% of the total catch of Coleman Kamloops trout, whereas boat angling effort (2,055 hr) accounted for 28.8% of the total landing of Mt. Whitney trout and 52.8% of the total catch of Coleman Kamloops trout (Table 4). The creel census data showed that Coleman Kamloops trout at this smaller lake were also in the limnetic zone and therefore less available to the shore angler than the Mt. Whitney trout.

TABLE 4—Catch of Two Strains of Rainbow Trout at Merle Collins Reservoir, Spring 1969

Strain	Number and percentage of total catch		Total	Percentage of total catch by strain	
	Boat angling	Shore angling		Boat angling	Shore angling
Mt. Whitney	99 (39.6)	245 (64.5)	**344**	28.8	71.2
Coleman Kamloops	151 (60.1)	135 (35.5)	**286**	52.8	47.2
Total	**250**	**380**	**630**		

CONCLUSIONS

Coleman Kamloops strain showed more promise for trout management of large lakes with threadfin shad populations than Mt. Whitney strain. Their higher survival, lower first-year harvest, lower vulnerability and/or availability, their fast growth potential and lower cost to the angler's creel, made them superior.

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OVARIAN CYCLING IN LONGJAW GOBIES, *GILLICHTHYS MIRABILIS*, FROM THE SALTON SEA[1]

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The ovarian condition of the longjaw goby *Gillichthys mirabilis*, changes with the seasons in the Salton Sea. The protracted spawning period extends from December or January to June. Each female spawns more than once, and the population does not spawn synchronously. Regression of the ovaries starts by late June, and recrudescence begins in September or October. The timing of ovarian development at different localities in the lake varies slightly. Ovarian cycling appears to be correlated with temperature changes.

INTRODUCTION

Reproduction is one of the most important considerations in understanding the ecology of animals. The survival of any species in a seasonally unstable environment depends on the development of mechanisms that permit it to adjust physiological functions to changes in that environment. Reproduction would therefore be expected to occur during the season that assures maximum survival of young. Information on reproductive cycling (e.g., the schedule and duration of the breeding season) and the relation of this cycling to the environment is essential for understanding the biology of a species, and hence for intelligent management of a fishery.

Although teleosts form the largest group of vertebrates, knowledge of the breeding seasons and reproductive adaptations of these fishes is relatively limited. Due to this lack, meaningful comparisons of seasonal changes in the reproductive system of fishes are not possible, either within or between families. The majority of the species for which we have information on sexual cycles are freshwater fishes of the north temperate latitudes. Furthermore, data concerning adaptation of breeding schedules in widely distributed fish species are not presently available.

The family Gobiidae (Order Perciformes) has more than 700 species and is the largest family of fishes that is primarily marine (Herald, 1961; Böhlke and Chaplin, 1968). Gobies are widely distributed fishes that are mainly tropical. Most are small, carnivorous, lurking fishes dwelling on the bottom.

Although Breder and Rosen (1966) summarized reports on the time of spawning in several gobies, seasonal patterns of gametogenesis in

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this family are poorly known. Seasonal histological changes in the testes of *Gobius paganellus* were described by Stanley et al. (1965). Weisel (1949) briefly described seasonal spermatogenic changes in the longjaw goby from 47 males collected in seven different months near San Diego, California (32° 46′N). De Vlaming (1972) went on to follow seasonal changes in gonadal histology over a 4-year period in both sexes of the longjaw goby from a population in the Alviso salt ponds in California (37° 27′N); he also reported on reproductive changes in a population of this species occurring in Scammons Lagoon, Baja California (24° 47′N).

The longjaw goby occurs from central California south to Magdalena Bay, Baja California, and in the Gulf of California south to Mulege on the west coast, and south to Agiabampo Bay on the east coast (Barlow, 1963). The typical habitat of this species is the intertidal region of coastal sloughs. Commonly this is a muddy canal region exposed to air at low tide, but often it is an isolated marine-water pool. Barlow (1961, 1963) treated the systematics and some aspects of the ecology of the longjaw goby. It is an important bait fish because it can be transported out of water in moist algae, it tolerates fresh water and withstands being hooked, and it cannot reproduce in fresh water.

The intent of the present investigation was to describe seasonal ovarian changes in longjaw gobies collected from various locations in the Salton Sea (33° 18′N). These findings are compared with data obtained from populations at other latitudes.

MATERIALS AND METHODS

The Salton Sea is a large saline lake lying 235 ft below sea level in the Colorado Desert of southern California. It was formed in 1905–1907 by escaped irrigation water from the Colorado River, which flooded the dry Salton Sink (Sykes, 1937; Hubbs and Miller, 1948). The Salton Sea population of longjaw gobies presumably stems from 500 fish planted in 1930 by the California Department of Fish and Game; these fish were secured in San Diego Bay (Walker et al., 1961).

Monthly samples were obtained from September 1954 to June 1955. The fish were taken at three localities. Most were trapped within the boat landing at Fish Springs on the northwest side of the Salton Sea. Water there was uniformly about 2 m deep; the bottom was soft mud and the banks were broken concrete pavement. Large numbers of fish were seined at Salton Sea Beach on the west shore of the lake; this habitat, consisting of shore pools, has been described in detail (Barlow, 1958). Some fish were also collected at Bombay Beach on the eastern side of the lake. The hydrobiology of the Salton Sea has been carefully described by Carpelan (1958).

Body weight, standard length, and the volume of the right ovary were recorded for each female. Ovary volume was obtained by displacement in water. Fish used in these studies varied between 60 and 125 mm (standard length). To standardize ovarian weights, the following formula was used:

$$\frac{(\text{Ovary volume in ml})\ (1000)}{\text{Standard length in mm}}$$

This method was justified because a coefficient of + 0.627 ($p < .001$) was obtained in a correlation of ovarian volume and standard length from a group of 27 fish collected in January.

Ova diameters were also measured using an ocular micrometer. Ovarian condition was then classified according to the criteria described in Table 1.

TABLE 1—**Criteria Used for Staging Ovaries of Longjaw Gobies**

Stage	Characteristics
I	Regressing or regressed ovary. Ova being reabsorbed.
II	Early phase of ovarian development. Ova <0.5 mm in diameter.
III	Intermediate phase of ovarian development. Ova diameter measure 0.5–0.8 mm.
IV	"Ripe" or pre-spawning condition. Ova >0.8 mm in diameter.
V	"Spent" or post-spawning conditions.

RESULTS

Ovarian volume was low in September (Figure 1), and no yolky oocytes were present (Figure 2). Gonadal recrudescence was initiated in October and the ovaries were characterized by oocytes in Stages II and III. Ovarian development apparently started earlier at Bombay

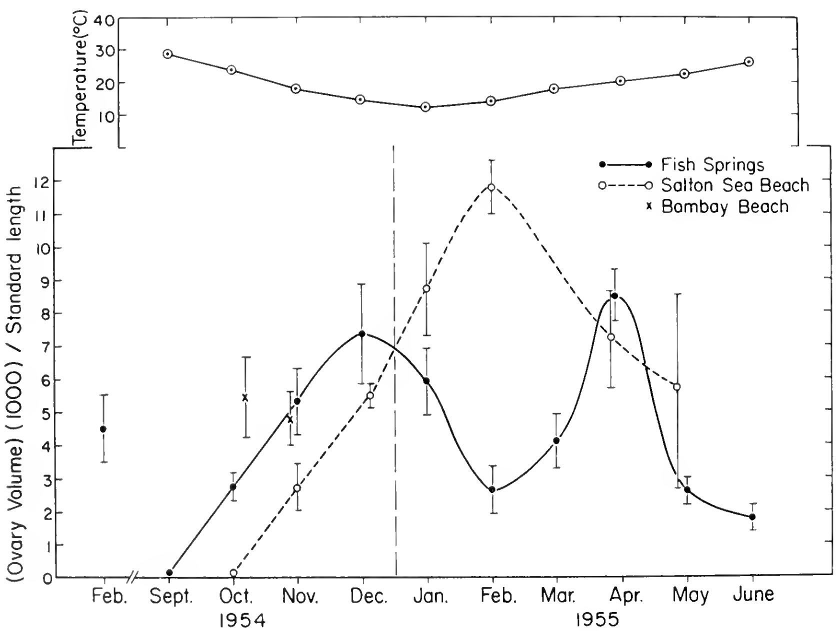

FIGURE 1—Seasonal variation in ovarian volume in *G. mirabilis* from the Salton Sea. Mean value (see text) is bracketed by ± one standard error of the mean. Temperature data presented in upper graph are modified from Carpelan (1958).

Beach than at Fish Springs; mean ovarian volume for Bombay Beach was greater than for Fish Springs (Figure 1), and more fish from Bombay Beach were in Stage III of oocyte development (Figure 2). Recrudescence had not been initiated in the Salton Sea Beach population in October.

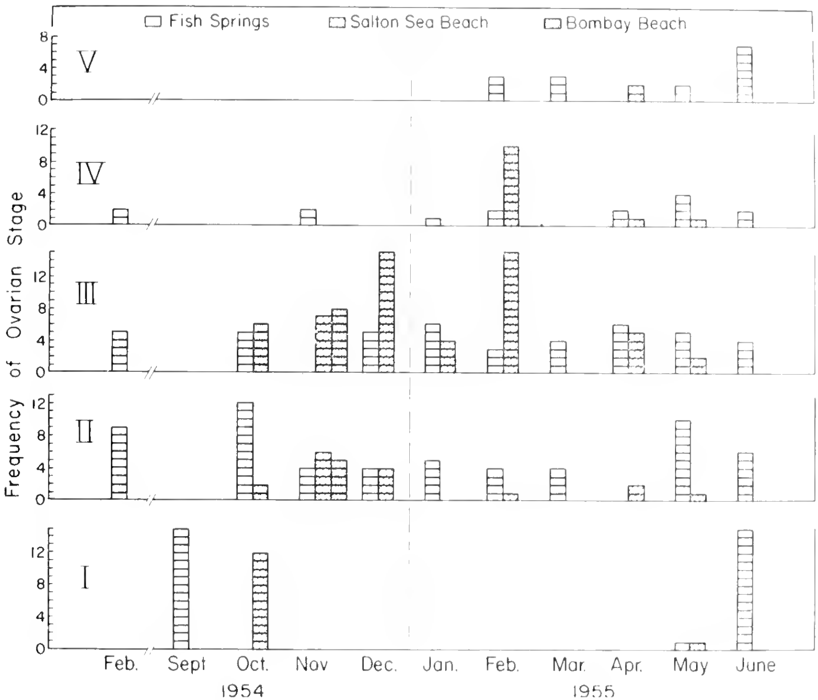

FIGURE 2—Seasonal variation in ovarian condition (see Table 1). Each cell represents one fish. Open cells = Fish Springs; cross-hatched cells = Salton Sea Beach; stippled cells = Bombay Beach.

By November some fish at Fish Springs were ripe (Stage IV). But ovarian development was not synchronous since other fish were in Stage II during that month. Recrudescence had been initiated in the Salton Sea Beach population, and oocytes were in Stages II or III.

Ovarian volume continued to increase in both the Fish Springs and Salton Sea Beach populations during December. Spawning at Fish Springs probably began in January and February; mean ovarian volume decreased sharply in February and "spent" females were found. That this population did not spawn as a unit is evident since females in various stages of ovarian development were collected during February. Spawning probably did not begin until late February; ovarian volumes were high in mid-February, and there was no evidence of "spent" individuals.

At Fish Springs ovarian volumes began to increase again in March, indicating that a large portion of the population was undergoing recrudescence following the first spawning. Some spawning, however, occurred during this month because "spent" individuals were collected (Figure 2).

By April, mean ovarian volume in the Fish Springs populations was again high (Figure 1) and some individuals were "ripe" (Figure 2). The second wave of spawning apparently began in March and April since individuals in the "spent" condition and various stages of development were caught in April.

The decrease in ovarian volume by mid-May (Figure 1) suggests that a large portion of the Fish Springs population spawned in late April and early May. Many of the fish at this time were "spent" and many were in early stages of ovarian recrudescence (Figure 2). In the Salton Sea Beach population, fish in various stages of ovarian development were obtained.

Spawning apparently continued through May and June in the Fish Springs population for many "spent" individuals were collected in mid-June. Fish in various stages of ovarian development were also taken, but gonadal regression had been initiated in several fish, and the reabsorption of yolky oocytes was in progress.

DISCUSSION

The spawning seasons of several gobies were summarized by Breder and Rosen (1966). A preponderance of species in this large family have short breeding periods. Some of the Pacific Ocean forms, however, have protracted spawning seasons comparable to that of the longjaw goby. Reproduction evidently extends from January to May in *Chaenogobius urotaenia* (Dôtu, 1955) and in *Chasmichthys dolichognathus* (Nakamura, 1936); *Pterogobius elapoides* spawns from December to March in Japan (Nakamura, 1936).

Longjaw gobies in the Salton Sea apparently spawn between December and June. Since fish in the pre- and post-spawning condition and in various stages of ovarian development can be collected during this period, spawning is not synchronous. Species in which ovarian development is asynchronous, as in the longjaw goby, normally spawn more than once per season and have an extended breeding season (Yamazaki, 1965). In longjaw gobies in the Salton Sea, reabsorption of yolky oocytes begins in June and is complete by September (and probably sooner).

There is usually a relatively simple relation between latitudes and breeding seasons of vertebrates in the temperate zones, the nearer the poles, the later the beginning of the reproductive season. Barlow (1963), however, suggested that spawning commences in January throughout the range of the longjaw goby. Weisel (1949) presented some evidence indicating that the breeding period extends from January to July in Mission Bay, near San Diego, California (32° 46′N). Longjaw gobies occurring in the Alviso salt ponds (37° 27′N), just south of San Francisco, California, spawn from December through June (de Vlaming, 1972). In the Scammons Lagoon population (27° 48′N) of longjaw gobies, however, gonadal regression occurs in May and June; furthermore, spawning begins in late September or early October (de Vlaming, 1972). Thus a January to June spawning period for the longjaw goby seems typical in the northern half of its distribution. But more southerly populations, especially in the Gulf of California, should be investigated before reaching a general conclusion relating time of spawning to latitude.

Most fishes occurring in the north temperate latitudes produce mature gametes during a relatively brief period of the year; a preponderance of these species attain their maximum gonadal weight in spring (Nikolsky, 1963). This is not the case in the longjaw goby. Prolonged spawning periods are mainly characteristic of tropical and subtropical species of fish (Nikolsky, 1963). The longjaw goby apparently reflects its gobiid ancestry in this respect, being presumably tropical in origin.

The nontypical protracted spawning period in this species of the north temperate latitudes might be facilitated by the environments in which it occurs. The typical habitat of longjaw gobies is the coastal slough with pools, canals, and flats (Barlow, 1963). These habitats are shallow and thus are warmer during spring and summer than the adjacent ocean at that latitude. Further, productivity in these estuarine habitats is probably high. High productivity over a large portion of the year could facilitate prolonged breeding. In similar estuarine habitats in Florida, *Fundulus confluentus* (Harrington, 1959) and *Hippocampus zosterae* (Strawn, 1958) show a breeding period similar to that of the longjaw goby.

This species possibly utilizes the nonreproductive season for growth and fattening (i.e., energy is channeled into growth or fattening rather than reproduction). For example, Walker et al. (1961) reported that growth of longjaw gobies is most rapid in the hot summer months. De Vlaming (1971), furthermore, presented evidence that longjaw gobies fatten in the nonspawning season and become more lean in the spawning season. Moreover, the interrupted breeding period of the longjaw goby may be due to adaptations which were necessary to occupy habitats in the north temperate latitudes where there is greater variability in availability of food.

Photoperiod and temperature are the most important (i.e., the most studied) environmental factors regulating teleost reproductive cycles (de Vlaming, 1972*b*). Correlations between phenological data and environmental changes provide some insight into this problem of the regulating factors.

Ovarian involution in longjaw gobies from the Salton Sea occurred as temperatures reached their annual maxima (Figure 1). Gonadal recrudescence took place as temperatures decreased in autumn. And spawning happened when temperatures were still relatively low. These data suggest that temperature plays an important role in regulating reproduction in the longjaw goby. Indeed, de Vlaming (1972*c, d*) presented evidence that temperature is the primary environmental factor controlling sexual cycling in this species.

Differences in temperature, in fact, may have been responsible for the variation in reproductive condition in the various local populations of the longjaw goby from the Salton Sea. Ovarian recrudescence began in October in the Salton Sea Beach population, but in September in the Fish Springs population. Fish from Bombay Beach were collected in the open lake, compared to the protected boat landing where fish were taken at Fish Springs. The relatively high ovary volume in the

October sample (Figure 1) from the Bombay Beach population could be due to an earlier onset of recrudescence which, according to de Vlaming (1972*c*, *d*) is a function of low temperatures. The fish from Salton Sea Beach were collected from shallow pools around the edge of the lake. Temperatures in these pools fluctuated more than in the adjacent lake, reaching much greater maxima and minima (Barlow, 1958). This might account for the differences in the curves for the samples from Salton Sea Beach and Fish Springs.

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THE RESPONSE OF SALTON SEA FISH EGGS AND LARVAE TO SALINITY STRESS[1]

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In laboratory experiments, Salton Sea water at salinities (S) of 40 ‰ and higher adversely affected developing embryos and larvae of the croaker, *Bairdiella icistia*, and the sargo, *Anisotremus davidsoni*. Embryos developed abnormally, hatching success diminished, and mortality of larvae was greater than in normal Salton Sea water at 37.6 ‰ S.

INTRODUCTION

The Salton Sea is an inland saline lake, 58 km long and 14.5 to 24 km wide, in the desert of southeast California. Orginally formed in 1905–1907 by accidental diversion of flood water from the Colorado River, the Salton Sea has since been maintained by agricultural drainage from surrounding land. A few species of marine fish were introduced into the sea as long ago as 1929 when the Sea was about 14.5‰, but most successful introductions were made from 1948 through 1956 at higher salinities. Carpelan (1961) gives an excellent review of the physical and chemical history of the Sea. The sport fishery in the Salton Sea presently depends on three introduced species from the Gulf of California, the bairdiella, *Bairdiella icistia*, the sargo, *Anisotremus davidsoni*, and the orangemouth corvina, *Cynoscion xanthulus*. The bairdiella supports only a minor sport fishery and is primarily a forage fish for the highly prized corvina; both of these species belong to the croaker family, Sciaenidae. The sargo, of the family Pomadasyidae, is both an important game fish and a forage fish (Walker, Whitney, and Barlow, 1961). Because of a persistent increase in the salinity of the Salton Sea in recent years due to agricultural soil leaching (Federal-State Reconnaissance Report, 1969), concern has been expressed for the continued survival of these three species on a self-sustaining basis in the Salton Sea (Calhoun, 1969).

The ability to survive stresses in the environment is generally less developed in early larval stages as evidenced by the huge mortalities which occur at this time. There is ample evidence that the greatest degree of mortality occurs in fishes during the egg and larval stage of development, (Sette, 1943; Ahlstrom, 1954). Pelagic fish larvae often

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hatch from the egg before having fully developed the organs to see, feed, or osmoregulate. Development to the feeding stage proceeds with yolk providing the energy needed. In particular the newly-hatched pelagic larvae of bairdiella and sargo lack gills, an open gut, scales, and a functional kidney, all part of the adult's final organ complement for osmoregulation. Because of these facts it seemed appropriate to study the effects of increased salinity on the eggs and larvae of Salton Sea fish. Observations are reported here which were made on the fertilization success, development, hatching and survival time of bairdiella and sargo eggs and larvae as they were affected by high salinities. The results are discussed with respect to the steadily increasing salinity of the Salton Sea.

METHODS

When this study was initiated in 1968, no method was available for maturing and inducing spawning of Salton Sea fish in the laboratory. Thus mature sargo and bairdiella had to be caught by a trawl or gill net during their spawning season (April and July 1968 respectively), then stripped and the eggs fertilized aboard a motor launch. The developing eggs were brought back to the laboratory operated by California Department of Fish and Game at Salton City, where temperature was maintained at 17 C in an air-conditioned room; there was no temperature control aboard the launch where temperatures varied between 24.5 and 27 C. In 1970, Haydock (1971) perfected a method for inducing maturation and spawning of bairdiella under laboratory conditions. This simplified the salinity study by providing viable eggs and sperm for laboratory experimentation and permitted a rigorous temperature control unobtainable during the earlier experiments. The work performed in 1968 was therefore repeated in 1970 to determine whether the earlier lack of temperature control altered the response of bairdiella eggs and larvae to salinity stress sufficiently to vitiate the earlier conclusions. The results from both years were comparable. For the sake of completeness both series of experiments are described in detail here.

Obtaining Ripe Bairdiella and Sargo

Ripe bairdiella females were taken in the Salton Sea on May 20, 29, June 10, 12, 19, and 24, 1968, by trawl between 1830 and 2130, 0.4 to 1.6 km from the western shore between Salton Bay Marina and Salton City Keys. Despite the fact that more fish were examined between 0800 and 1700 than in the evening hours, not one was ripe during daytime. Although no fish were caught after 2130 it is probable that spawning continues into the night. Whitney (1961) found that the bairdiella has a diurnal pattern of spawning, with most early cleavage eggs appearing in the plankton during early evening. One ripe sargo was caught in a gill net at 0930, April 23, 1968, and the fact that it was still alive indicated that it was in the net a short time, probably less than 3 hr. Only one running-ripe male bairdiella was caught by trawl, but sperm obtained from other mature males proved capable of fertilizing ripe eggs. The sargo fertilization was accomplished using sperm also from a mature but not running-ripe male. In the 1968 series of experiments, fertilization for both species was carried out on shipboard.

Bairdiella of the 1969 year class were maintained in large tanks at the Fishery-Oceanography Center of the National Marine Fisheries Service, La Jolla, California, for approximately 7 months prior to fertilization experiments in 1970. These fish were subjected to a photoperiod, water temperature and feeding regime conducive to accelerated growth and maturation of the gonads (Haydock, 1971). In mid-March 1970, approximately 2 months in advance of the peak spawning period for this species in the Salton Sea, viable sex products were obtained. Running-ripe females were obtained by injections of gonadotropic hormones as described by Haydock (1971). Males were running-ripe without hormone treatment. Sargo, which were captured at the Sea prior to the spawning season, were acclimatized to laboratory conditions for only 6 weeks and only one female ovulated after hormone treatment.

Artificial Fertilization

The shipboard and laboratory fertilizations were carried out in the same way. Eggs were expressed from ripe females by gentle hand pressure on the abdomen and collected on a stainless steel lab scoop. Eggs were then separated and distributed as evenly as possible in a glass Petri dish and apportioned into 10 cm diameter finger bowls, each containing 50 ml of water at an appropriate salinity.

Milt expressed from a male was drawn into a bulb-operated pipette and introduced into each bowl containing eggs. The seminal mass was repeatedly drawn into the pipette along with some of the water in the test bowl and forcefully expelled among the eggs to insure adequate mixing of the gametes. In 1970, all fertilizations were performed at 21 ± 0.5 C.

The fertilized eggs of the bairdiella and sargo are slightly buoyant and float against the surface film if undisturbed, while most unfertilized eggs remain on the bottom of the dish.

Selection of bairdiella and sargo fertilized eggs for further observation and estimates of fertilization success were made on the basis of a sink or float criterion only in test salinities (S) of 37‰ or higher. At lower salinities we observed initial cleavage stages under low-power magnification (7 to 15×), 1 to 2 hr after fertilization. In 1968, Salton Sea water evaporated to a salinity of 71.8‰ was filtered through a membrane filter (pore size 0.45 μ) and diluted with demineralized water to desired salinities. In 1970, undiluted Salton Sea water at 37.6‰ was filtered through activated charcoal to remove dissolved organic substances and a membrane filter, 0.45 μ pore size, to remove particulates. Higher salinities to 55‰ were obtained by mild heat and prolonged evaporation after filtration. Analysis for specific ions and total dissolved solids were made on Salton Sea water and 2× Salton Sea water in 1967. When compared with an analysis of sea water, these data show that some precipitation of calcium and sulfate must have occurred (Table 1).

Streptomycin sulfate assayed at 750 mg/g and penicillin-G, 1,585 units/mg, were added as dry powder (50 ppm) to some experimental vessels in 1968 and survival of eggs and larvae was compared with those without antibiotics. In 1970, only penicillin-G was used.

Usually 50 to 100 successfully fertilized eggs in a particular salinity were used for determining mortality rate. Dead eggs or larvae were removed whenever a count was made of living animals.

TABLE 1—Analysis of the Ionic Content of Normal Sea Water, Salton Sea Water, and 2X Salton Sea Water

	Sea water* (parts per thousand)	Straight Salton Sea water† (parts per thousand)	2X Salton Sea water† (parts per thousand)
Cations			
Ca	0.41	0.96	0.92
Mg	1.27	0.86	1.68
Na	10.6	11.5	22.5
K	0.38	0.22	0.37
Anions			
CO_3	0.07	0.02	0.05
HCO_3	0.14	0.15	0.27
SO_4	2.65	7.0	12.0
Cl	19.98	17.8	35.5
Total dissolved solids	34.5	38.2	69.6

* Sverdrup, Johnson and Fleming (1946).
† Analyses by E. S. Babcock and Sons, Riverside, California.

RESULTS

Fertilization and Hatching Success

Successful fertilization of more than half of extruded eggs occurred at all salinities tested but there was a tendency toward lower success in the higher salinities. Usually, at least 50% of the eggs expressed from a sargo or bairdiella female could be fertilized regardless of salinity up to 55‰. In 1968, no eggs of bairdiella developed in 50 or 55‰ beyond blastodisc formation. Hormone-induced ovulation produced fertilizable eggs which occasionally survived to an advanced embryonic stage at 50‰ but always produced embryos which exhibited deformed tails and did not hatch. Fertilization success for sargo eggs was almost 100% at all salinities from 35 to 55‰.

Survival

Embryos of sargo and bairdiella in 45 and 50‰ Salton Sea water developed more slowly than those in lower salinities and hatching success diminished with increasing salinity. For example, in an experiment with bairdiella eggs in water containing antibiotics, hatching success was 84% in 35‰, 15% in 40‰, 7% in 45‰, and 0% in 50 and 55‰, although some eggs developed to late embryonic stages in the last two salinities.

In the experiment described in Table 2 which was performed in 1968 at 17 C, high salinities reduced the survival of bairdiella eggs and larvae. All eggs in the elevated salinities were treated with 50 ppm each of streptomycin sulfate and penicillin-G; however, there were no antibiotics in the 35‰ S Salton Sea water. Forty percent of the eggs survived to the yolk-sac larval stage even in the untreated 35‰ Salton Sea water 35 hr after fertilization and 78% survived in 33.5‰ La Jolla sea water, while in each higher salinity complete mortality occurred before 35 hr had elapsed, despite the addition of antibiotics. This effect was clear even in the 40‰ S experiment.

TABLE 2—Percent Survival of *Bairdiella icistia* Eggs and Larvae at Different Salinities. (Fifty eggs were fertilized in each salinity (n = 50 fertilized eggs = 100%) and observed over 35 hours at 17 C. Antibiotics, 50 ppm each of Streptomycin sulfate and penicillin-G, were added at the beginning of the experiment except in Salton Sea water of 35 ‰ S. Ripe bairdiella were caught by trawling. Stages of development are described in Mansueti and Hardy, 1967.)

Time from fertilization (hr)	Stage of development	Salinity (parts per thousand) La Jolla	Salton Sea				
		33.5	35	40	45	50	55
0	Fertilized eggs	100	100	100	100	100	100
9	Early embryo	88	91	58	37	0	0
14	Early embryo	88	64	44	10	--	--
21	Yolk sac larvae	82	58	30	0	--	--
35	Yolk sac larvae	78	40	0	--	--	--

Antibiotics have a beneficial effect on survival. Salton Sea water at 35‰ was treated with antibiotics and the resultant mortality of bairdiella eggs and larvae measured over time. All the larvae were dead by 46 hr after fertilization when no antibiotics were used. In treated water 62% were alive after 46 hr, and 36% were still living and developing after 60 hr (Table 3).

TABLE 3—Percent Survival of 50 (= 100%) *Bairdiella icistia* Eggs in Antibiotic-Treated and Untreated Salton Sea Water at 17C and 35 ‰ S

Time from fertilization (hr)	Stage of development	Without antibiotics	With antibiotics
0	Fertilized eggs	100	100
13	Early embryo	86	84
22	Late embryo	78	84
35	Yolk sac larvae	16	72
46	Yolk sac larvae	0	62
60	Post yolk sac larvae	--	36

Three experiments with bairdiella eggs and larvae were conducted in 1970. Eggs were obtained by hormone-induced ovulation and temperature was controlled at a constant 21 ± 0.5 C. In every instance there was a slight to strong increase in mortality rate with increased salinity (Table 4). In two experiments the lower salinities also resulted in similar increases in mortality rates (Table 4). When Penicillin was used (Table 5), the increased mortality rate appeared during the larval stage at 40‰ and in the embryonic stages at 45‰ and higher salinities.

TABLE 4—Percent Survival of *Bairdiella icistia* Eggs and Larvae at 21C in Different Salinities. (Eggs were produced by hormone-induced ovulation. No antibiotics were used in these experiments. n = ~ 100 fertilized eggs = 100%.)

Time from fertilization (hr)	Stage of development	Salinity (parts per thousand)							
		30	33.5	35	37.6	40	45	50	55
	Experiment 1								
0	Fertilized eggs	100.0		100.0		100.0	100.0	100.0	100.0
13	Tail-bud embryo	36.5		72.3		35.9	38.0	19.1	0.0
21	Tail-bud embryo	35.6		66.3		33.0	35.0	7.8	--
30	Tail-free	29.8		56.1		23.3	22.0	4.9	--
36	Yolk sac larvae	24.0		51.5		18.4	16.0	0.0	--
42	Yolk sac larvae	18.3		50.5		17.5	12.0	--	--
47	Yolk sac larvae	18.3		50.5		17.5	12.0	--	--
	Experiment 2								
0	Fertilized eggs		100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	Tail-bud embryo		19.0	47.6	72.5	25.0	43.0	14.3	0.0
23	Tail-free		49.0	43.8	60.4	21.0	30.0	8.2	
30	Yolk sac larvae		48.0	37.1	52.7	21.0	28.0	7.1	--
37	Yolk sac larvae		47.0	35.2	49.5	18.0	25.0	4.1	--
45	Yolk sac larvae		47.0	33.3	49.5	18.0	24.0	4.1	--
60	Post yolk sac larvae		44.0	0.0	47.6	0.0	0.0	0.0	--
	Experiment 3								
0	Fertilized eggs			100.0		100.0	100.0	100.0	100.0
12	Tail-bud embryo			65.9		66.3	67.0	41.5	19.2
20	Tail-bud embryo			52.3		60.4	59.0	31.8	10.1
31	Tail-free			41.3		53.6	54.0	30.0	6.1
36	Yolk sac larvae			12.0		53.5	51.0	28.2	3.0
42	Yolk sac larvae			42.0		52.5	47.0	16.1	3.0
46	Yolk sac larvae			42.0		52.5	47.0	16.1	3.0

TABLE 5—Percent Survival of *Bairdiella icistia* Eggs and Larvae in Different Salinities. (Eggs were produced by hormone-induced ovulation. Penicillin-G, 50 ppm was used in each salinity. n = ~ 100 fertilized eggs = 100%.)

Time from fertilization (hr)	Stage of development	Salton Sea (S) (parts per thousand)				
		35	40	45	50	55
0	Fertilized eggs	100	100	100	100	100
13	Tail-bud embryo	92	94	81	58	11
20	Tail-bud embryo	92	91	78	55	4
30	Tail-free	89	90	73	48	3
36	Yolk sac larvae	88	89	72	48	2
56	Yolk sac larvae	17	1	1	0	0

Table 6 has similar data obtained with sargo embryos and larvae in 1968 and 1970. In the experiment performed in 1968 (Experiment 1), 50 surviving, normal-appearing embryos which had been fertilized in their appropriate salinities were observed over a 96-hr period. Mortality was virtually absent in 35‰ Salton Sea water but the rate escalated with increased salinity. In the late larval stage, only 8% (4 larvae) were alive at 96 hr and 50‰ whereas 90% (45 larvae) were alive in the control (35‰) Salton Sea water.

TABLE 6—**Percent Survival of Sargo, *Anisotremus davidsoni* Eggs and Larvae in Different Salinities. (Experiment 1 was started with 50 fertilized eggs (n = 50 = 100%) which survived 10 hr in each appropriate salinity. Eggs were obtained from spawning females caught in the Salton Sea in Experiments 1 (1968) and 2 (1970). In Experiment 3, eggs were obtained from hormone-induced ovulation. A variable number of fertilized eggs was used in each salinity in the latter two experiments ranging from 31 to 103 in Experiment 2 and 28 to 31 in Experiment 3.)**

Time from fertilization (hr)	Stage of development	Salinity (parts per thousand)				
		35	40	45	50	55
	Experiment 1					
10	Tail-bud embryo	100.0	100.0	100.0	100.0	100.0
25	Tail-free	90.0	92.0	80.0	66.0	24.0
52	Yolk sac larvae	90.0	90.0	68.0	52.0	10.0
73	Post yolk sac larvae	90.0	78.0	62.0	0.0	0.0
96	Post yolk sac larvae	90.0	8.0	0.0	0.0	0.0
	Experiment 2					
0	Fertilized eggs	100.0	100.0	100.0	100.0	100.0
16	Tail-bud embryo	54.8	63.8	72.7	69.2	74.8
27	Tail-bud embryo	12.9	14.9	36.4	43.6	57.3
34	Tail-free	12.9	12.8	36.4	41.0	55.3
40	Yolk sac larvae	12.9	10.6	36.4	41.0	50.5
51	Yolk sac larvae	12.9	10.6	36.4	41.0	50.5
	Experiment 3					
0	Fertilized eggs	100.0	100.0	100.0	100.0	100.0
14	Tail-bud embryo	71.0	81.8	19.4	21.1	0.0
19	Tail-bud embryo	64.5	77.3	19.4	0.0	--
32	Tail-free	58.1	40.9	9.7	--	--
38	Yolk sac larvae	48.1	40.9	9.7	--	--
44	Yolk sac larvae	48.4	4.5	0.0	--	--
65	Post yolk sac larvae	9.7	0.0	--	--	--
84	Post yolk sac larvae	0.0	--	--	--	--

Experiments 2 and 3 (Table 6), performed with sargo eggs obtained by hormone-induced spawning in 1970, similarly showed a clear detrimental effect of salinity on survival rate at 40‰ and higher.

Although antibiotics prevent the drastic mortality rates of embryos and larvae at salinities of 40‰ and higher, bairdiella and sargo embryos which survived under these conditions exhibited developmental abnormalities. Bent tails and the inability to swim straight after hatching were the most common signs of abnormal development.

DISCUSSION

Salton Sea water of 40‰ salinity apparently exceeds the upper tolerance limits of bairdiella and sargo to salinity during embryonic and larval development. In most experiments 40‰ was clearly detrimental to life at these early stages as reflected in increased mortality rates. When mortality was not accelerated in a few experiments, embryos at 40‰ S and higher were abnormally developed and produced larvae which did not survive beyond the yolk-sac stage. At 40‰ S fertilization success was usually lower, abnormal embryos developed from fertilized eggs, the mortality rate of eggs and larvae at salinity was accelerated over controls at normally experienced salinities, and any larva hatched out at 40‰ salinity or higher was also abnormal; these facts suggest that bairdiella and sargo will not reproductively survive a rapid change in salinity over their normal habitat, now about 37‰ S in the Salton Sea. However, it is still possible that slow acclimation and genetic adaptation of the adults to rising salinity will favor production of gametes that will survive and live normally. The experiments reported here can be logically extended to include (i) acclimation of adults to high salinities and artificial spawning to ascertain gamete viability, (ii) mortality rate of eggs and larvae from acclimated fish, and (iii) the effect of temperature on salinity tolerance of eggs and larvae. The fact that fertilized eggs sink in La Jolla sea water at 33.5‰ and float in Salton Sea water at 37.6‰, suggest that adaptation has occurred toward higher salinities. However, no information is available on the parent stock of bairdiella from the Gulf of California. Simmons (1957) found *Bairdiella chrysura* in the Laguna Madre of Texas only in salinities of 45‰ and less. Other sciaenids live in the Laguna Madre, Texas, at salinities up to 75‰ but probably do not spawn in water above 45‰.

ACKNOWLEDGEMENTS

We wish to thank Alex Calhoun (California Department of Fish and Game, Sacramento, California) for suggesting this problem to us and also Hiram Li, Jack Hanson, David Crear, and Irwin Haydock for material assistance at the Salton Sea.

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NOTES

CALIFORNIA CONDOR SURVEY, 1970[1]

The sixth annual California condor (*Gymnogyps californianus*) survey was conducted October 21 and 22, 1970. Survey methods and evaluation procedures were essentially the same as reported for the 1965–69 surveys (Mallette, et al. 1966, 1967 and 1970; Sibley, et al. 1968 and 1969). Observation stations were reduced from 51 in 1969 to 16 in 1970 and observers were reduced from 94 in 1969 to 45 for October 21 and 43 for October 22, 1970. No baiting was attempted. Weather on the first day was 32 to 75 F, with low overcast and gusty winds 5–25 mph late in the day. Observers reported 10 miles visibility early in the day. However, clouds and/or fog reduced this to a half mile later in the day. Weather on the second day was generally cooler, 30 to 70 F, with all stations reporting overcast skies, rain and fog which reduced visibility to zero at many locations. Winds were variable with gusts up to 25 mph.

Thirty-six condor sightings were reported by 11 observation stations on October 21 and 84 sightings by 8 stations on October 22. After evaluation of these sightings it was decided that 15 individual condors (12 adults and 3 age unknown) and 28 condors (2 juveniles, 20 adults and 6 age unknown) had been seen respectively on the days of the survey. Other raptors observed were:

	Numbers	
Species	*10/21/70*	*10/22/70*
Turkey vulture (*Cathartes aura*)	118	0
Golden eagle (*Aquila chrysaetos*)	36	27
Sharp-shinned hawk (*Accipiter striatus*)	10	0
Cooper's hawk (*A. cooperii*)	6	6
Red-tailed hawk (*Buteo jamaicensis*)	68	56
Sparrow hawk (*Falco sparverius*)	12	15
Prairie falcon (*F. mexicanus*)	0	1
Marsh hawk (*Circus cyaneus*)	1	1
Unidentified raptors	12	9
	263	115

Although stations were manned both days of the survey, inclement weather and poor visibility prevented a condor count comparable with previous years. For these reasons, the Condor Technical Committee feels the low number of sightings does not reflect a reduction in condor population.

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—*Robert D. Mallette, California Dep. of Fish and Game; Sanford Wilbur, U.S. Fish and Wildlife Service; W. Dean Carrier, U.S. Forest Service; and John C. Borneman, National Audubon Society.* *Accepted July 1971. A contribution from Federal Aid in Wildlife Restoration Project W-54-R "Special Wildlife Investigations."*

THE SURVIVAL OF GUADALUPE CARDINALFISH *APOGON GUADALUPENSIS* AT SAN CLEMENTE ISLAND

In November, 1967, I observed many guadalupe cardinalfish, *Apogon guadalupensis,* approximately 50 mm SL, in rocky crevices at a water depth of about 17 m off the southeastern shore of San Clemente Island. Three months later, in February, 1968, I found them still abundant, and collected 11 specimens 34–44 mm SL, which are now in the fish collection at Scripps Institution of Oceanography (S10 68-135). During this same month, Charles H. Turner and Alec R. Strachan, California Department of Fish and Game, collected 16 specimens of this fish, 36–48 mm SL from the same part of San Clemente Island. These were the first records of this fish in California waters; until then, the species had been regarded as an endemic of Guadalupe Island, 214 miles to the south. John E. Fitch, California Department of Fish and Game, estimated that the specimens collected by Turner and Strachan were in their second winter when taken, based on study of their otoliths. In reporting these findings (Hobson, 1969), the uniformly small size of all those seen or taken was regarded as evidence that these fish probably were recent immigrants, having arrived together as pelagic larvae.

I did not return to the site of these observations for over 3 years. Then, on March 6, 1971 I dived in the same area, this time at night. At 2230 hr, while swimming at a depth of 12 m, a solitary adult of this cardinalfish, about 100 mm SL, was observed hovering 2 m over the bottom close to rising stipes of giant kelp, *Macrocystis.* The nocturnal occurrence of this fish in midwater indicates that, like its congener *Apogon retrosella* in the Gulf of California (Hobson, 1968), *A. guadalupensis* hunts for prey away from the bottom after dark. This individual was probably close to the maximum size attained by the species; among 248 specimens in 18 collections from Guadalupe Island presently in the Scripps fish collection, the largest is 96 mm SL.

The following day I inspected the same rocky crevices nearby that had harbored many juveniles of this species 3 years before, but after 30 min of searching found none. Most likely the lone adult observed the previous night is a survivor from among those that had been present as juveniles 3 years before. The fact that none were found in daylight in the same rocky crevices they had previously occupied suggests that their numbers have decreased since those earlier observations. As yet there is no evidence that the guadalupe cardinalfish at San Clemente Island have produced young which have become established there.

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—*Edmund S. Hobson, Tiburon Marine Laboratory, National Marine Fisheries Service.* *Accepted for publication October 1971.*

BOOK REVIEWS

Hikers and Backpackers Handbook

By W. K. Merr[illegible], Winchester Press, 460 Park Avenue, New York, N.Y. 10022; 1971; 320 p. [illegible] $5.95

[illegible] the experienced hiker [illegible] questions [illegible] Mr. M[illegible] drawing on [illegible] U.S. Forest R[illegible] the more common [illegible] F[illegible] insight gained from long [illegible] If his advice is followed [illegible] dangers extra work [illegible]

Mr. M[illegible] personal comments. The [illegible] "The person who carries [illegible] wild areas." He then [illegible] and trail [illegible] too large and [illegible]

[illegible]

[illegible] —*Larry Esp[illegible]*

The Vanishing Jungle—The Story of the World Wildlife Fund Expeditions to Pakistan

Illustrated by Eric Hosking. Houghton Mifflin, 1970. 286 p. Illus. $12.50

Pakistan [illegible] Pakistan in 1966 [illegible] 1967. [illegible] Pakistan Government [illegible] World War II. [illegible] Pakistan.

I was amazed at the rich [illegible] of many of these animals are [illegible] good reading for anyone concerned [illegible] part of the world. However, [illegible] since Pakistan is torn with [illegible] *Lee W. Miller*

Come Wade the River

The Photography of Ralph Wahl with Excerpts from "A River Never Sleeps" By Roderick Haig-Brown. Superior Publ. Co., Seattle [illegible] p. — [illegible] photos. $[illegible]

The photographic artistry of Ralph W[illegible] Roderick Haig-Brown in a [illegible] erman a-stirring. Full page and [illegible] west rivers recount the excitement, [illegible] primarily for steelhead, in each of the four seasons of [illegible]

Kamloops

By Steve Raymond; Winchester Press, New York, 1971; 20[illegible] p., illustrated. $12.50.

The author has done an excellent job of blending the observations and experiences during a lifetime of fishing with the technical reports of [illegible] fishery workers to produce this interesting book on the Kamloops trout. In a series of [illegible] chapters, the author discusses the life history of the Kamloops; the resource, which includes a discussion of geology, climate, and [illegible]; [illegible] and predators; and the management of Kamloops waters—past, present, and future. There are additional chapters which discuss in detail food habits, tackle and techniques, fly patterns, and the author's favorite waters, with maps included. A short chapter on the future of the Kamloops waters and a bibliography conclude the book.

I think most angler readers would enjoy having this book. It presents a lot of technical information in an easy-to-read style. The photographs are not particularly good, nor is the one color plate of British Columbia fly patterns, but this minor criticism is offset by the remainder of the book. The price, $12.50, is somewhat higher than that for comparable fishing books.—*K. A. Hashagen, Jr.*

British Columbia Game Fish

By Pete Broomhall and Jack Grundle (Editors), Western Fish and Game Magazine Ltd., Vancouver, Canada, 1970; 107 p., illustrated. $7.95.

Seven authors, mostly professionals and all avid fishermen, have written chapters on 13 of British Columbia's major game fish. Presented in the format of one or more fishing experiences for each of the species discussed, the book also contains a good amount of life history and fishing information. Each author quietly stresses the need for fisheries management—the need for habitat protection, concern over pollution, overfishing, and the construction of dams. The species discussed include: the salmon (kokanee, coho, chinook, and pink), the trout (coastal cutthroat, steelhead, Eastern brook, rainbow, brown, lake, and Dolly Varden), the arctic grayling, and the Rocky Mountain whitefish.

The book has a foreword by Roderick Haig-Brown and is profusely illustrated with six color plates and numerous line drawings by Jack Grundle. The illustrations above are worth the price of the book.—*Kenneth A. Hashagen, Jr.*

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