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"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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(Continued on page 135)

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VOLUME 28 SAN FRANCISCO, APRIL, 1942 No. 2

TABLE OF CONTENTS

CALIFORNIA FISH AND GAME is a publication devoted to the conservation of wildlife. It is published quarterly by the California Division of Fish and Game. All material for publication should be sent to Richard S. Croker, editor, California Division of Fish and Game, Terminal Island, California.

A FISHERY SURVEY OF THE COLORADO RIVER BELOW BOULDER DAM [1]

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Introduction

Curbing of the rampant Colorado River by construction of Boulder Dam has formed a body of water of great magnitude in an arid desert region and changed the river itself below the dam. The presentation of data collected during a preliminary survey of this area and formulation of a tentative management plan for the fishery are the purposes of this report.

A genuine interest in the problems of Lake Mead and the Colorado River below Boulder Dam is shown by all sportsmen's organizations, civic clubs, and governmental agencies in Nevada and Arizona. It is largely at their request that the investigation was made on which the following report is based. Many individuals and agencies cooperated wholeheartedly with the author in the investigation. Thanks are here expressed to workers in the U. S. National Park Service, the U. S. Bureau of Reclamation, Boulder Tours Inc., members of the U. S. Fish and Wildlife Service stationed at or near Lake Mead, and to the Clark County, Nevada, Fish and Game Association, whose warden, Mr. Frank Allen, gave many aids and services. Mr. R. F. Wright, owner of Willow Beach, furnished much valuable information and assistance in the work on the river.

Several unpublished, preliminary reports have been written on the trout water below Boulder Dam. Dr. H. S. Davis and Dr. Paul R. Needham visited this area and reported their findings. Mr. Fred J. Foster submitted a report and recommendations on the river. Mr. Dave Madsen also reported on a 6-day investigation of the river. The author has drawn freely from these excellent reports. Many of the recommendations given in this report were advanced in the writings cited. Wherever this usage occurs, the author wishes herewith to acknowledge priority and extend full credit wherever it may apply.

The Colorado River has been noted in legend, history and folk lore for many years. Its turbulent, muddy waters have instilled awe, fear and a genuine curiosity in the hearts of many from the Spanish conquistadores to the present-day tourists who view the Grand Canyon from points a mile above the river. Explorers and river men have navigated its channel; some successfully, others only to find a grave in its yellowish silt. The erosive work of this river is amazing, especially since geologists consider the river's origin as quite recent. Blackwelder (1934)[2] places the river's origin in the Pleistocene.

[1] Submitted for publication, January, 1942. Published by permission of the U. S. Fish and Wildlife Service.

[2] Blackwelder, Eliot: Origin of the Colorado River. Bull. Geol. Soc. America, Vol. 45:551-566.

Practically all waters of the Colorado originate in high, mountainous sections of Utah, Colorado, Wyoming, Arizona, New Mexico, and Nevada. These waters flow, with few significant additions, through the semi-arid parts of these states, eroding soft plateaus and old lake deposits rapidly. Wherever hard, mountainous sections are traversed, the river has cut narrow, straight-sided canyons. It is in such a canyon that Boulder Dam is located. The size, structure, and uses of this dam are familiar to everyone, so further description in this report is not necessary. It is important to note, however, that the lake formed by this dam acts as a depository for the silt load of the river. Water discharged from the dam is free of the silt eroded from the 167,000 square miles of the river's drainage above the dam. It is because of this fact and because the water leaving the dam is drained from a stratum far beneath the surface of Lake Mead, that the 25 to 30 miles of the Colorado immediately below the dam are important in fishery interests.

Trout Water Below Boulder Dam

Physical Features

Coincident with the operation of power generators and flood control functions at Boulder Dam, water can be released from Lake Mead at three levels: (1) the surface spillways, (2) the 1,050-foot level, and (3) the 900-foot level. The 1,050-foot level is about 120 to 170 feet, and the 900-foot level about 270 to 320 feet, beneath the surface of the reservoir, depending on the level of the water surface.

Discharged water from the lower levels is cold. During 1940 and 1941, it ranged in temperature between 54° and 57° F. at the 900-foot level, and between 55° and 61° F. at the 1,050-foot level.

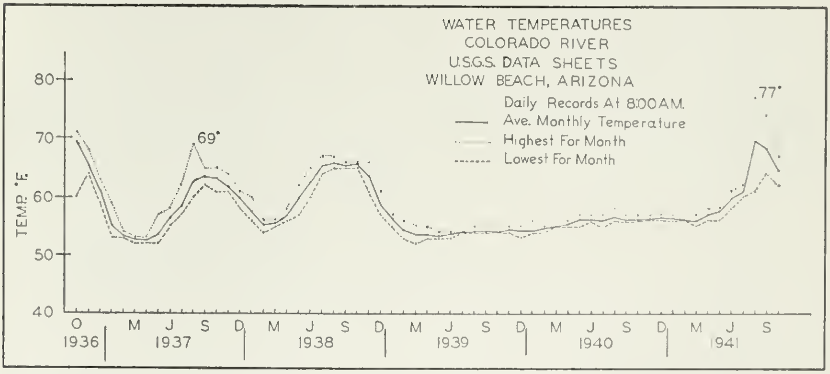

Fig. 23. The average monthly, as well as the maximum and minimum water temperatures of the Colorado River near Willow Beach, Arizona, for each month during the years 1936 to 1941, inclusive.

River temperatures 10 miles below the dam are shown in Figure 23. This gives the average monthly, as well as the maximum and minimum, water temperatures for each month during the years 1936 to 1941, inclusive. The data on which this graph is based were furnished by the U. S. Geological Survey which maintains a gaging station just upstream from Willow Beach, Arizona. These temperatures did not fluctuate over one or two degrees Fahrenheit winter or summer during the years

1939 and 1940. However, during August-November, 1941, discharge of water over the Arizona spillway raised the average temperature to 61-69.5° F. at Willow Beach. The highest recorded water temperature during August, 1941, was 77°. Should such a spillway discharge reach the river during midsummer, resulting high temperatures might be disastrous to trout. It is very unlikely that any further spillway discharge will be made.

On October 31, 1941, the water temperature at Eldorado Canyon was 67° F. (Temperature of discharge water at the dam was 64° F.) The temperature at Eldorado is within the trout range, but on the high side. Air temperature at the same time was around 73-79° F. Summer air temperatures rise to 110-126° F. in this region, and it is believed their effect on the river might be great enough to raise the water temperature above the tolerable range for trout.

Because of the fairly constant low temperature and clarity of the water released from Boulder Dam, the river below this point for a distance of approximately 25 miles has been transformed into good trout water. The downstream extremity of trout water is arbitrarily placed at Eldorado Canyon, although conditions suitable for trout may extend below this point during most of the year. Some good trout catches have been reported from below this limit, but they are usually made during the cooler winter months.

Setting of Eldorado Canyon as the lower limit of trout water *to be managed* is supported by the general topography of the river at that point. The river basin spreads. It contains many extensive silt bars which are whipped into suspension by the current, increasing the turbidity of the water considerably. Fish food production is curtailed by silt deposits and high turbidities. Undoubtedly, some trout production will continue below Eldorado, but most attention should be focused on the river above that point.

At the time of this study, water volumes ranging between 27,000 and 35,000 cubic feet per second were flowing down this stretch of river. (Fig. 24.) Consequently the river was considerably higher than it was during October, 1940, when visited by Madsen [3] who

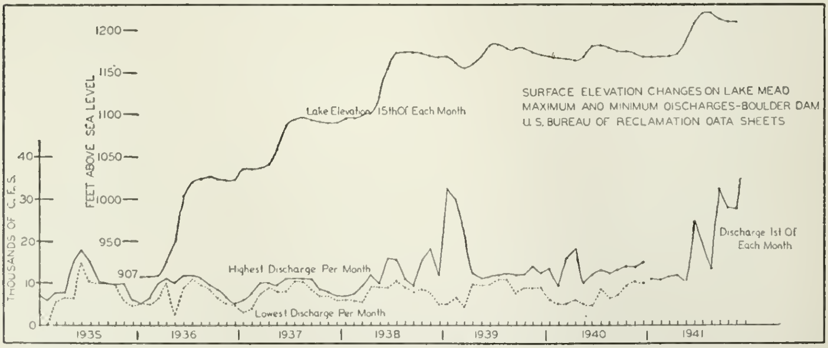

FIG. 24. Surface elevation changes on Lake Mead. Maximum and minimum discharges in cubic feet per second from Boulder Dam during the years 1935 to 1940, inclusive. During 1941, only the discharge at the first of each month is shown.

[3] Madsen, Dave, 1940—A typewritten letter report of a visit to Colorado River, October 1-6, 1940. Submitted to the Division of Fishery Biology, Washington, D. C., October 9, 1940.

reported a flow of 4,000-12,000 cubic feet per second. Assuming a normal flow of 20,000 cubic feet per second, it is estimated that the river averages about 500 feet in width. Using this figure, there are approximately 1,600 acres of trout water in this section of the river.

FIG. 25. A downstream view of the Colorado River from the east side of the canyon showing Ringbolt Rapids and a characteristic side-stream delta encroaching on the river from a wash.

Colorado River below Boulder Dam has a gradient of about 3 feet per mile. This slope is not exceptionally steep, but considering the large volume of water usually flowing, the work of the river is great. Furthermore, the fall is not uniform. There may be descents of 3 to 6 feet over rapids within a linear distance of ½ mile (Fig. 25). Quiet water stretches may have a gradient of but 1 or 2 feet per mile. The rate of flow averages about 4 miles per hour.

Two large rapids, one named Ringbolt (so called because ring bolts set in the sides of the canyon were used to anchor cables on which freight boats were hauled over the rapids by early settlers), and another, unnamed, occur in the river between the dam and Eldorado. Numerous smaller rapids and long riffles are spaced along the entire river course.

In most of the riffles and many quieter parts of the stream, extensive gravel shoals are clearly visible at water depths of 15 to 20 feet. Practically all such shoals and riffles are covered by an almost continuous blanket of green algae. Because the water is so exceptionally clear, aquatic plant production is encouraged in practically all of the river bed, providing that other conditions are favorable.

The Colorado below Boulder Dam is quite inaccessible to modern vehicles. Sheer walls of rock rise 400 to 500 feet on both sides of the river and are penetrated only by occasional dry washes, a few of which are extensive enough to reach the plateau above the river. In two of these washes on the Arizona side temporary roads of poor quality lead to the river. One is at Ringbolt Rapids, about 4 miles below the dam, and the other at Willow Beach 10 miles below the dam. There is no road to the river on the Nevada side except at Eldorado Canyon. All roads leading to the river are subject to washout without notice. Flash floods of remarkable velocity and volume may strike washes along the river any time during the summer.

Boating on the river is dangerous, especially in light, poorly powered craft. The two large rapids just mentioned are not negotiable upstream except by boats having at least 10-horsepower motors. Even then, a fair amount of experience is necessary to avoid trouble. There is one boat livery and dock at Willow Beach, Arizona. Most fishing is done up and down stream from this point. Waters outside the immediate vicinity of Willow Beach have to be fished by boat. It is impossible to walk up or down the river because of sheer walls (Fig. 26).

FIG. 26. An upstream view of the Colorado River showing the ruggedness and inaccessibility of its canyon.

Climatic conditions of this region are not conducive to soil formation in the drainage area of the river. Very little really productive soil occurs in the entire Colorado River drainage except in its mountainous extremities. Such a lack of organic matter has an adverse effect on fish food production. However, this is of greater importance in Mead Lake than in the river. Enough organic matter is in the water to fill the needs of river vegetation but many areas where silt and debris collect would be much more productive were the silt not so inert. Continuous plant growth in the river should gradually alter the composition of the silt until it reaches a state of production.

Chemical Features

The chemical nature of Colorado River water below Boulder Dam is not detrimental to biological productivity. An abundance of oxygen is stirred into the water as it leaves the dam. Many forms of powerful and often spectacular turbulence aerate the water thoroughly as it emerges from the various outlets of the dam. Rapids, riffles, and constant swirling maintain the oxygen content of the water as it progresses downstream. On October 31, 1941, the oxygen content of the water at Willow Beach was 9.3 parts per million. The river was highly alkaline. Tests for pH (hydrogen-ion concentration) made on the same date were constant at 8.2. No carbon-dioxide was found in the water. Dissolved carbonates and bicarbonates were present in concentrations of 121 parts per million. Total dissolved solids were much greater in concentration than the carbonates and bicarbonates. Leo Dunbar, of the U. S. Bureau of Reclamation, reports a concentration of 650 parts per million. Most of these dissolved solids are sulfates of calcium (gypsum), magnesium (epsom salts) and sodium. Sodium chloride is present in small amounts. Salt beds are exposed in several localities in Lake Mead. Calcium salts predominate, originating from great deposits of gypsum exposed in Lake Mead. These deposits are dissolved slowly and are transported down river.

Biological Features

There are very few aquatic plants, with the exception of algae, in the Colorado River. A few sprigs of water-weed (*Anacharis sp.*) were found in stomach contents of trout. None was located while cruising the river. Some reeds (*Phragmites*), cattails (*Typha*) and bulrushes (*Scirpus*) occur in quiet water. As stated previously, almost the entire bottom of the river is covered by a blanket of algae wherever riffles and gravel bars exist. Fronds of this plant pend downstream from practically every rock. The main algal component is a species of *Cladophora*. Other species of green and blue-green algae are present, but they are not as abundant as *Cladophora*.

The roots of many shore plants such as cottonwood trees, tamarisk and willows project into the river. Wherever good stands of these plants exist, excellent cover for fish is formed by the thick maze of roots washed free of the banks. Typical desert vegetation is sparsely distributed over the higher lands of the river valley. The occurrence of these terrestrial plants is important because the insects inhabiting them are a potential food supply for fish.

Very little could be done to obtain quantitative bottom samples. The water was so high that regular apparatus could not be handled effectively. It was ascertained that sandy portions of the river bottom are quite barren. Repeated sampling with an Ekman dredge yielded no organisms retainable in a screen with 30 meshes to the inch. Practically all the food organisms inhabited the riffles and especially the algae growing there. Mayfly nymphs, chiefly *Callibactis*, were abundant; stonefly nymphs occurred rarely; midge larvae and pupae were very common. Microcaddis larvae and pupae were present in practically every algal sample examined. Some aquatic beetles were found in stomachs of trout. Many smaller organisms were present in abundance. Several species of *Daphnia* and *Diaptomus* occurred in swarms among the algal filaments and also sparingly in the water. Protozoa of several kinds were undoubtedly present in the algal masses but no examination was made for them.

During April of 1941, 100,000 fresh-water shrimp were planted in the river upstream from Willow Beach. Observations in that vicinity failed to reveal any shrimp in November, 1941. No shrimp were found in stomachs of trout taken around Willow Beach. These findings do not mean that the planting was a failure as high water hampered a thorough search for these organisms.

Fish collected or observed by the author while located on the Colorado below Boulder Dam are listed below:

Rainbow Trout, *Salmo gairdnerii* Richardson
Large-mouthed Bass, *Huro salmoides* (Lacépéde)
Carp, *Cyprinus carpio* L.
Bony Tail, *Gila elegans* Baird & Girard
Humpback Sucker, *Xyrauchen texanus* (Lookington)
Channel Catfish, *Ictalurus punctatus* (Rafinesque)
Colorado "White Salmon," *Ptychocheilus lucius* Girard

It is very probable that other species are present in the river. More collecting should be done at a time when the water is low and a seine can be operated successfully. The rainbow trout, large-mouthed bass, carp and channel catfish are introduced species. Rainbow trout were placed in the Colorado in November, 1935, following changes made in the character of the river by Boulder Dam. These fish are more or less isolated in a desert environment by physical barriers. The dam cannot be traversed by fish attempting to move upstream and thermal conditions prohibit extensive downstream migration. Because the trout are more or less confined, this area would be ideal for population, yield and growth studies.

The growing season in the trout water area of the Colorado under discussion, is exceptionally long. Temperatures are not variable, the sun shines almost every day and food production is maintained throughout the year. Insect life cycles are continuous. There is no long period of inclemency which inhibits activities of adult insects. Algal production is uniform through the year. Although it is not yet certain, one might surmise, and with much justification, that the trout growth is also continuous. This assumption is supported by observations made on the scales of trout taken from the river. Thirty-seven specimens ranging between $9\frac{1}{4}$ and $17\frac{1}{2}$ inches in total length were examined. Many of the fish were not weighed because they were cleaned by fishermen before being brought to the dock. However, 6 fish between 10 and 11 inches in length averaged 7.4 ounces in weight. These fish had an average coefficient of condition [4] of 1.09 as based on

[4] The coefficient of condition of a fish is a measure of its plumpness in relation to its length. It is determined by taking the weight in pounds or grams multiplied by 100,000 and divided by the cube of the length in inches or centimeters.

Standard length is the distance from the tip of a fish's snout to the end of its vertebral column. Total length is the over-all length of the fish.

total length in centimeters rather than standard length. Three fish between 11 and 12 inches in total length averaged 8.2 ounces in weight. Their coefficient of condition was 1.00. One trout 13¼ inches long, weighed 13.5 ounces and had a coefficient of condition of 1.01. Five fish between 14 and 15 inches total length averaged 1 pound, 0.8 ounces in weight. Their average coefficient of condition was 1.00. One fish, 17½ inches long (the longest taken during this study) weighed 1 pound, 6 ounces dressed. All trout from the Colorado are rather highly colored and very good fighters. Their eating qualities are excellent although it is reported that larger trout taste somewhat muddy. Considering the coefficients of condition for these fish, they are in very good flesh. It must be borne in mind that when total length rather than standard length is used to derive this figure, the coefficient of condition will be lower. For example, calculated on the basis of standard length, the coefficient of condition for the 10- to 11-inch fish is 1.66 instead of 1.09.

Attempts to determine age groups on the basis of scale examinations were quite futile. Growth rings on scales were so uniform that no consistent differentiation could be made. What appeared to be spawning checks were found on some scales. These checks were near the outside border of the scale which might indicate that these fish had retained the fall spawning habit of their hatchery predecessors. Scales from some fish were eroded badly. New scale growth had begun around the eroded edges and from 3 to 6 circuli had been added by early November.

From all indications, trout in the Colorado grow quite rapidly. Circuli on the scales were rather widely spaced. Such spacing is usually indicative of rapid growth. No definite information on rate of growth can be obtained unless marking of fish as they are stocked is instituted and continued over a period of years. Recoveries from these fish could be measured and weighed to determine the increase in size over a known period of time.

Examination of the stomach contents of 43 trout collected between August 27, and November 16, 1941, revealed that they had fed very uniformly on algae. In practically every stomach (only 2 were without algae) from 70 to 98 per cent of the contents was algae, mostly *Cladophora*. Mayfly nymphs and emerging subimagoes of the genus *Callibaetis* constituted the dominant insect food. They occurred in 81 per cent of the stomachs. Midge larvae, pupae and adults were not quite so voluminous as mayflies, but they were found in 84 per cent of the stomachs. Small plankton organisms were quite common. *Daphnia* and *Diaptomus* were present in 13 and 9 stomachs respectively. Microcaddis fly larvae and pupae, common associates with algal clumps, were in 50 per cent of the stomachs. Dragon fly nymphs were the only other aquatic invertebrates found in stomachs. A small (100 mm. total length) large-mouthed bass was found in one stomach. What appeared to be a small catfish had been devoured by one of the trout. Terrestrial invertebrates were not abundant. Spiders were in 9 stomachs, beetles in 4, a grasshopper in one and a fly in another. Angleworms and salmon eggs, commonly used for bait, were in many stomachs. Practically all stomachs were full, containing from a fraction of one to over 20 cc. of material depending on the size of the fish.

2—11262

Davis and Needham,[5] in their report, give the following additional information on trout feeding in the river: "An examination of the stomachs of nine trout, 11-16 inches long taken below the dam, showed that they had been feeding heavily on algae, with a scattering of terrestrial and aquatic insects. Six fish had fed near the bottom and their stomachs were crammed with algae, principally the filamentous *Cladophora*; two had fed near the surface and were nearly full of large grasshoppers, crickets, and other insects, both terrestrial and aquatic; and one was nearly empty except for 4 salmon eggs. Midge larvae were common in all stomachs. The aquatic insects included midges, stoneflies, mayflies and beetles."

Consumption of such large quantities of algae by rainbow trout is quite exceptional. These fish normally eat some algae, but the presence of such large quantities in these trout stomachs suggests that the algae is eaten to get the nutritive value of the swarms of aquatic life which inhabit it. There is no definite proof for this statement. Algal filaments in the stomachs and intestines of most trout examined were certainly being effectively digested.

The trout population of the Colorado River below Boulder Dam is amply supplied with food. Conditions in the river are favorable for food production. Growth of the trout is good enough evidence that this food supply is being effectively utilized.

No definite evidence is available to show that the trout in the Colorado River spawn successfully. Reports from fishermen who fish the river regularly, give some indication that spawning does occur and that young fish result therefrom. They report having seen small trout in the river, which, according to them, could not have come from an artificial stocking because of the time of year. These small fish were observed in January and February of 1941, when, according to stocking records, only yearlings were being stocked. Conditions in the river are not adverse to spawning trout. There is plenty of suitable gravel. River fluctuation during the period of study was not over one foot on any one day. However, the volume of water was periodically increased because a lowering of the lake level was necessary. According to Figure 24, the river fluctuation can be expected to range between wide limits. During the past six years the flow of the Colorado below Boulder Dam has ranged between 2,500 and 35,000 cubic feet per second. On one day in February, 1935, the flow was cut off entirely. This wide range of fluctuation might affect normal spawning activities and egg development. Considerable study of trout reproduction is an imperative necessity if a suitable long range management plan is to be formulated.

Artificial Stocking of the Colorado River

According to available stocking records (Table 1), the first rainbow trout were planted in the Colorado River below Boulder Dam on November 7, 1935. At this time, 25,000 four-inch fish were placed in the river just below the dam. Since stocking began, 21,000 six-inch fish, 50,000 four-inch fish, and 148,000 fish one to two and one-half

[5] Davis, H. S., and Needham, P. R., "A Preliminary Report on Fisheries Problems of Lake Mead and the Colorado River Below Boulder Dam." Typewritten report covering a visit to the Boulder Dam area, Aug. 25-27, 1941.

inches long have been introduced into the Colorado between the dam and Eldorado Canyon. All of these fish were supplied by the U. S. Fish Hatchery at Springville, Utah. Between December 8 and December 11, 1941, 62,000 three-inch rainbows were delivered from Springville to the Las Vegas Hatchery. These fish, from spring spawning stock, are to be held there over winter and planted in the spring when they will have attained greater size.

Table 1. Records of Rainbow Trout Stocked in the Colorado River below Boulder Dam

Date	*Number*	*Size in inches*	*Where stocked*
Nov. 7, 1935	25,000	4	Below Boulder Dam
Nov. 12, 1935	25,000	4	Below Boulder Dam
Sept. 7, 1937	25,000	2	Below Boulder Dam
Sept. 22, 1937	25,000	1–2	Willow Beach
Apr. 11, 1938	55,000	1½	Below Boulder Dam
Oct. 12, 1939	25,000	2	Below Boulder Dam
Jan. 19, 1940	2,000	6	Eldorado Canyon
Apr. 16, 1940	18,000	2½	Below Boulder Dam
Jan. 19, 1941	2,000	6	Eldorado Canyon
Jan. 24, 1941	2,500	6	Eldorado Canyon
Jan. 27, 1941	2,800	6	Willow Beach
Jan. 29, 1941	2,500	6	Willow Beach
Jan. 31, 1941	3,500	6	Eldorado Canyon
Feb. 3, 1941	2,800	6	Willow Beach
Feb. 6, 1941	3,000	6	Eldorado Canyon
Total	219,100		

Management Suggestions

1. At present, there is no closed season on trout fishing in the Colorado River. Until more information on natural spawning is obtained no change in existing season regulations should be made.

2. Present creel limits are satisfactory. Wherever differences in legal restrictions on fishing exist in the laws of Arizona and Nevada, an attempt should be made to approach uniformity as concerns this water. A minimum size limit of seven inches should be imposed.

3. There is no need for further attempts to introduce food organisms into the river.

4. As long as angling pressure does not increase materially and natural reproduction remains an unknown quantity, stocking of 30,000 five- to seven-inch rainbow trout annually should more than adequately fill all fisherman needs. Obviously, the size of these fish at the time of planting is of prime importance. Fifty thousand 1½-inch fish would never yield as many fish of catchable size as would the same number of 6-inch trout. Consequently, it is recommended that trout destined for this river be held in rearing ponds until they are five to seven inches long. Should this be impossible, planting of 60 to 75 thousand 2- or 3-inch fingerlings is advised. It is becoming increasingly evident that when small fish are placed in waters containing a population of large fish, mortality is quite high until these fish become at least yearlings. Rearing of trout to the yearling stage would circumvent this period of heavy predation.

5. Since it is difficult to determine the growth rate of Colorado River rainbows from scale studies, the institution of marking experiments is imperative. Fish of known ages should be marked as they are stocked in the river.

6. Adequate provision for recording necessary information from marked fish recovered by fishermen becomes necessary once such a set of experiments is put in operation. A creel census should be conducted, not only to check recoveries of marked fish, but also to obtain data on total yield from the river. Such problems as stocking policy, creel limits, size limits and catch records can be handled with certainty only when creel census information is available over a period of several years.

7. A study of the efficiency of natural reproduction in this river should be undertaken.

8. As has been pointed out, the Colorado River below Boulder Dam is quite inaccessible except at two points. The approaches to these sites should be improved. Development of camping facilities, accommodations and adequate boat liveries at these points is suggested. Establishment of parks or similar areas at Willow Beach and Eldorado Canyon would attract many tourists and fishermen.

9. An educational program should be undertaken in which conservation, safety regulations as regards river travel, and sportsmanship are stressed. Guides should be licensed to conduct fishing parties and to accommodate newcomers to the area who want to fish. Guides should also be trained and instructed as wardens to ensure enforcement of regulations.

FOX RANCHING IN SOUTHERN CALIFORNIA [1]

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Raising of foxes and other animals for their fur has been associated so long in the public mind with the colder climates of the North Central States and Canada that visitors to southern California are often surprised at the extent of the local industry. At the present time there are approximately 125 fox farms in California, with about 20,000 animals. Any estimate of the value of these farms with animals and equipment would be speculative, owing to the fluctuations of the market, but it can be placed conservatively at $3,000,000. The majority of breeders, even those operating on a small scale, have invested in superior breeding stock. The quality of production is steadily improving and there is a continuous demand for fine pelts.

In the region of Big Bear Lake in the San Bernardino Mountains, at an elevation of 7,000 feet, more than 5,000 animals are concentrated in a district one mile wide and three miles long. Snowfall is heavy during winter months whereas summers are relatively warm with light rainfall. There is a marked temperature fluctuation between day and night throughout the year. Another favored district is at Gardena, in a low coastal valley near the ocean, and at Redondo Beach, a little above sea level. Here the heat is tempered by sea breezes and the nights are cool.

Artificial shade is provided so that sunlight may not affect the color of "pelter" animals. The latest development is a shed which is well ventilated but excludes practically all light. At the lower elevations, where sand fleas abound, pens with elevated wire flooring, spread with a layer of straw, are used. No ill effects have been reported from the use of wire flooring, although some breeders in England contend it causes sore foot pads and mal-shaped feet. Sanitation is not difficult to maintain using this type of flooring material. In the mountain district, which is free from sand fleas, the ground floors of these shelters are covered with sawdust or peat moss, slightly dampened. No claim is made that the foxes become "housebroken" while living in the ground-floor sheds but they do follow an instinct to make use of the heavier layers of sawdust in the corners of the sheds and thus assist in maintaining a standard of cleanliness.

In ranches located in mountain areas "pelter" animals are released from the sheds for food and exercise at five o'clock in the evening during midsummer, fall and early winter. Approximately 100 animals are given the freedom of one or two acres of range until six o'clock in the morning. After a day spent quietly and undisturbed, free from the

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[1] Submitted for publication, January, 1942. This is the first of a series of papers on fox ranching and diseases to be presented in this publication by the staff of the Los Angeles Wildlife Disease Research Station. The preparation of this manuscript has been aided by the personnel of the Work Projects Administration, official project number 65-2-07-344.

nervous pacing back and forth induced by open pens, they exercise through the night in vigorous play. Foxes are primarily nocturnal and present an interesting sight as they play on the fur ranges in the light of a full moon. With the first rays of the sun they are herded toward the sheds, still leaping and tumbling in a silvery, undulating stream. They exhibit little tendency to turn upon and kill the weaker members of the herds, as is the case where great numbers of them exist in larger ranges under approximately natural conditions.

With the extra expense and time involved in this method of ranching, the breeders stress quality rather than quantity in their stock and eliminate breeding animals which do not produce progeny consistent with the desired characteristics. The record of one breeder of the Big Bear Lake district is significant. At the Michigan International Live Fox Show of 1939 with 291 entries, 10 standard bred silver foxes and two whiteface platinums were entered by this southern California breeder who won the following prizes: four firsts, four seconds, three thirds; Full Silver Sweepstakes of the show, second Pale Silver Sweepstakes of the show; the most valuable whiteface platinum of the show; the most valuable whiteface ring neck of the show.

In common with other fox breeders throughout the world, the breeders of California have concentrated their efforts on producing pelts as nearly full-silver as possible. During the last two years the exotic whiteface and platinum strains have been introduced. This has been in response to style trends, an intangible basis upon which to plan a consistent breeding program. With southern California coming to the fore as a style center, leading fur stylists are creating designs locally which will dominate fashion for several seasons in advance, and can give breeders warning of proposed variations in the fur trends. Along the Pacific Coast, and particularly in California, furs are styled primarily for pictorial effect rather than for warmth, even in the cheaper garments. Such styling makes scant use of inferior pelts or portions of them. The more spectacular creations demand magnificent individual pelts of luxurious texture and perfect markings.

RELATIONSHIP OF THE FRESH-WATER MUSSEL TO TROUT IN THE TRUCKEE RIVER [1]

By GARTH MURPHY [2]

Introduction

The Truckee River, a famous trout stream, drains Lake Tahoe which lies at an elevation of 6,225 feet in the Sierra Nevada on the California-Nevada boundary. It flows for 35 miles through eastern California, then enters the State of Nevada, where it eventually reaches Pyramid Lake.

The San Francisco Fly Casting Club owns a club house and grounds three and one-half miles east of the town of Truckee. On these grounds, in 1931, it built trout rearing ponds supplied by water from the river. In these ponds, with financial support from the people of Truckee, the club raises trout for planting in the river. The California Division of Fish and Game has supplied the trout, mostly rainbow, at the rate of about 150,000 annually. Up to 1936 they were placed in the ponds at various dates from June 1 to July 9, and raised by the club until autumn, when they were released into the river.

Each year from 1931 to 1936 an extremely high mortality was experienced during June, July and August. In 1932, H. S. Davis (ms.) diagnosed the trouble as being due to parasitization of the trout by the young of the fresh-water mussel, *Margaritifera margaritifera falcata* (Gould). Since 1936 the method of avoiding these losses has been to delay placing the fish in the club ponds until about the fifteenth of August. In previous years no heavy mortality had occurred after that date.

M. m. falcata is found in North America west of the Rocky Mountains. Other subspecies of this form are found almost everywhere in the northern hemisphere. Like most of the fresh-water mussels it has a parasitic period in its life history. The eggs pass from the ovaries of the female parent into her gill chambers, which serve as brood pouches or "marsupia." Here they are retained during a period of embryonic development, and emerge as tiny bivalved organisms which are technically known as glochidia. The glochidia, upon discharge from the parent, must find a fish and attach to its body or gills for a period of parasitism, in order to survive.

A great deal of information on the life-history of European forms of this species is available, but studies of the North American subspecies are entirely absent. Studies of the European form have not correlated temperature with certain important phases of the life-history, and apparently no observations have been made on the development of its glochidia.

During the summer of 1940 an investigation of the Truckee River mussels was begun, but it started too late to make much progress. On

[1] Submitted for publication, February, 1942.

[2] At the time this study was made the author was temporarily employed as Student Biologist by the Bureau of Fish Conservation, California Division of Fish and Game.

May 14, 1941, the California Division of Fish and Game sent the writer to the San Francisco Fly Casting Club to make a study of the mussels and the infection of fish by their glochidia. Unless otherwise indicated, all statements herein are the result of observations made during this study.

The California Division of Fish and Game and the author are extremely grateful to the San Francisco Fly Casting Club for its helpful and friendly cooperation. We are particularly grateful to the president of the club, Mr. D. E. Kessler, who placed all available facilities at our disposal, and gave us many valuable suggestions. I am also indebted to various workers of the California Division of Fish and Game for advice and suggestions.

The aims of the investigation were threefold: first, to study the life-history of the mussels; second, to determine the effects of the glochidia on the fish; and third, to discover how the losses might be prevented.

Life-History of the Mussel

Habitat

M. margaritifera is found in streams draining mountains composed of granite, gneiss, etc. (Nowak, 1930). Its greatest development is in streams deficient in lime (Altnöder, 1926). The Truckee River fits into this classification. The pH during the months of May, June and July ranged from 7.6 to 8.0, averaging about 7.8. No calcium carbonate was detected, but slight traces of bicarbonate were found when the river was extremely low.

Mussels are present in the Truckee River, and in the Upper Truckee (which flows into the upper end of Lake Tahoe), but none were found in such tributaries of the Truckee as the Little Truckee, Prosser Creek and Donner Creek, nor in any of the smaller creeks entering the river from Donner Creek up to Lake Tahoe. In Donner Lake, *Anodonta californica,* a lake form about the size of *M. margaritifera,* is fairly numerous.

The Truckee River with its large, stable, gravelly and sandy stretches is apparently an ideal habitat for *Margaritifera.* The mussel population in a half-mile of stream above the club house was estimated at 20,000 individuals over 40 mm. in length. In this stretch one bed was found containing 10,000 mussels.

These mussel beds are probably quite stable unless destroyed by the current. Altnöder (1926) reported that the extreme distance this species moved was 22 meters upstream in two years. This movement is probably confined to single individuals and not those in large established beds.

The Truckee River water level is controlled by a dam at its source, Lake Tahoe. By causing the river to drop very low at times, this dam limits the gravel beds available to the mussels.

Enemies

The two most important enemies of these mussels are the current destroying the beds, and corrosive action of water on their shells. The greatest amount of shell corrosion occurs in the region of the umbo. Many specimens were found with the shell entirely eaten through.

This corrosive action is counteracted by "oil spots" or "Tullberg's layers" of periostracum on the inner side of the shell layers (Altnöder, 1926).

Muskrats probably eat some adults, and a few glochidia may be eaten by fish and other water animals.

Breeding Season

In this discussion the "breeding season" of the mussels will be defined as the time between the first appearance of "undeveloped eggs" in the gill chamber or "marsupium" and the date of their last appearance. By "undeveloped eggs" is meant eggs either before division or in the early stages of embryonic development.

In 1941 new eggs started to form in the ovaries of the Truckee River mussels in July, a week or two after discharge of their glochidia. Maturation of eggs apparently continues slowly in the ovaries over the winter, with movement into the marsupia taking place in the spring. In 1941, May 15 was the earliest date on which mussels were taken with "undeveloped eggs" in the marsupia. From then until June 25, in from 3 to 20 per cent of the individuals collected,[3] the marsupia contained undeveloped eggs.

From March 25 to August 5, 1941, a recording thermometer was kept in the Truckee River at the Fly Casting Club. From March 25 to May 15, the average daily temperature was 42.5° F., ranging from 42° on March 25 to 45.0° on May 15.[4] From May 15 to June 25 (the "breeding season" in 1941) the average daily temperature of the river was 48.3° F., ranging from 45.0° on May 15 to 50.3° on June 25. (See Fig. 27.)

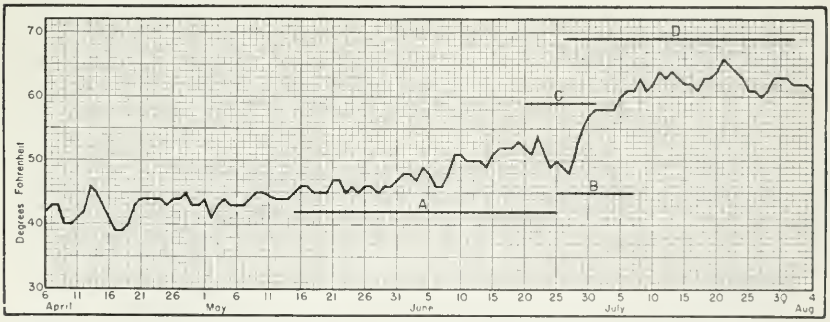

FIG. 27. Average daily temperatures of Truckee River at the San Francisco Fly Casting Club, 1941.

A. "Breeding Season" of mussels.
B. Period of embryonic development of last observed group of glochidia.
C. Period glochidia lived in culture dishes.
D. Observed duration of parasitic life of glochidia on experimentally infected trout

From June 1 to July 6, mature glochidia were found in the marsupia in a varying percentage of the population.

[3] Collections taken for each day were random samples of from 75 to 150 specimens.

[4] The average daily temperature was computed by averaging the temperatures at two-hour intervals.

On June 25, 3 per cent of the mussels examined contained completely undivided eggs. On July 7, 12 days later, the marsupia of all the mussels examined in the river at the club were devoid of glochidia. We may assume that this was the time necessary to develop the last of the 1941 glochidia. Between these dates (June 25 to July 7) the temperature of the river averaged 55.7° F, and ranged from 50.3° on June 25 to 60.5° on July 7. Riedl (1928) states that it takes from 16 to 28 days for the glochidia of European forms to develop from unfertilized eggs, dependent on the temperature. At Rampart (10 miles upstream from Truckee, California) where the temperature of the river in the spring and early summer averages about 8 degrees higher than at the Fly Casting Club,[5] the mussels were entirely rid of their glochidia on June 14, fully three weeks earlier.

From these data it would seem that the mussels are very sensitive to temperature, although this may not be the case. There may be a threshold temperature and in early spring when the eggs are developing, a rise in temperature of a few degrees may mean the difference between slow development of the ovaries, and comparatively rapid development.

M. margaritifera uses all four gills as brood chambers or marsupia. The total number of eggs found in one individual 7.0 centimeters long was about one million. This was estimated by measuring the diameter of a single egg, and dividing its calculated volume into the volume of the mass of eggs. The volume of the entire egg mass was found by water displacement. The eggs are usually 0.11 mm. in diameter, but may vary slightly. The size of the individual has no relationship to the size of its eggs.

The eggs form a slightly creamy mass, which remains this color throughout development. They are held together by adhesion of the egg shells to each other. As the glochidia near maturity, this adhesion becomes noticeably less.

In all the gravid mussels unfertilized eggs were found. They are swollen and larger than the fertilized eggs (0.13 to 0.14 mm. in diameter). Each unfertilized egg is stratified into three distinct layers. On one occasion the process of stratification was observed. It took only a few minutes. The egg material seemed suddenly to lose its organization; a heavy, somewhat pigmented mass formed at one pole and a smaller mass appeared at the other pole, leaving a clear hyaline intermediate zone.

During the course of the investigation no mussels were seen to abort their embryos, nor was there any indication that any had. Abortion has been recorded in European forms of this species.

Discharge of Glochidia

When the glochidia are ripe within the mussel, the entire mass of eggs from one gill, called a "conglutinate," is discharged at once, in the space of about 50 seconds. This was observed on two occasions on mussels held for observation. Occasionally part of the conglutinate remains in the marsupium, especially in the ventral side of the gills.

[5] This is based on occasional observations at this location. The Truckee River at Rampart is largely composed of comparatively warm water from Lake Tahoe. At the Fly Casting Club it has been cooled considerably by colder tributaries.

This gradually disintegrates and is either passed out of the gills or is resorbed by the mussel.

Within the conglutinate, which has the shape of the gill, and shows clearly the interlamellar junctions, some of the glochidia have broken out of the egg shells and others are still contained within them. The egg shells at this point are very fragile, and break easily when the current disintegrates the conglutinate.

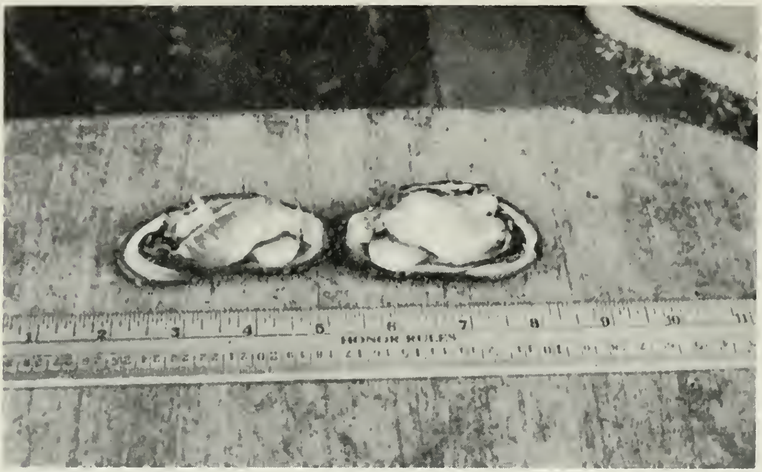

FIG. 28. Truckee River mussel (*Margaritifera margaritifera falcata*) open, showing conglutinates.

When mature and released from the egg shells, the glochidia are from 0.05 to 0.06 mm. in length, and resemble tiny mussels. Since they sink very slowly (3.5 centimeters per minute, with jaws agape) they are easily carried by a slight current.

Attachment to Fish

The glochidia of *M. margaritifera* are the hookless type and attach to the gill filaments only. Experimental attempts to induce them to take hold elsewhere were futile. Their small size (0.05 to 0.06 mm.) probably prevents their attachment to the fins.

These glochidia respond to both mechanical and chemical stimuli. When a glochidium is touched, it usually snaps shut. Human blood solution, fish blood solution, and salt solution are all adequate chemical stimuli. A salt solution of .003 concentration will cause glochidia to snap shut and remain closed until death occurs. The mere presence of an uninjured fish, unless actual contact is made, does not cause the glochidia to snap shut. Probably the mechanical stimulus of contacting the gills is mainly responsible for their attachment. The chemical stimulus from the injured gill tissue may cause them to clamp harder and thus get a firmer grip.

Once on the gill, they are rapidly covered with epithelium. "Encystment" is due to a rapid migration of epithelial cells from the gills over the glochidia (Arey, 1932). The "encystment" takes from 2 to 4 hours in *M. margaritifera* (Riedl, 1928).

If a glochidium does not attach itself to a suitable host fish, it either lodges in the stream bed and dies, or else dies while drifting in the current. Glochidia taken from mussels, and kept in culture dishes at the same temperature as the river, by suspending their container beneath the surface of the water, lived from June 20 to July 1 (11 days). During this time the average daily temperature of the river was 52.2° F., and it varied from 51.5° on June 20 to 57.8° on July 1. In the culture dishes they, of course, did not have the benefit of well aerated river water.

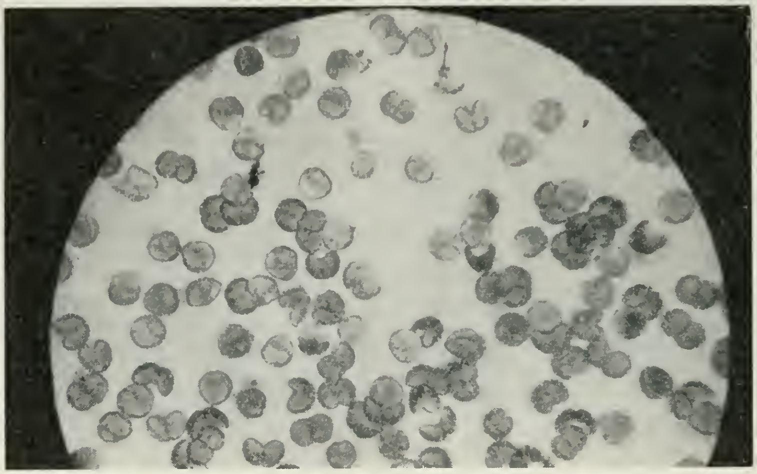

FIG. 29. Glochidia of Truckee River mussel. The glochidia range from 0.05 to 0.06 mm. when released.

There appears to be some difference in the susceptibility of the fishes found in the Truckee River to infection by these glochidia.[6] Of the species of fish found in the river, only brown trout (*Salmo trutta*) and rainbow trout (*Salmo gairdnerii*) were observed to be infected. Rainbow trout of 50 centimeters in length were found to be infected.

Experimental infections by placing fish in pans, the water in which contained millions of glochidia taken from naturally extruded conglutinates, produced infections in the following fish collected from the river: eastern brook trout (*Salvelinus fontinalis*), Tahoe sucker (*Catostomus tahoensis*), black minnow (*Rhinichthys osculus robustus*), and red-sided minnow (*Richardsonius egregius*). Infection could not be induced in the whitefish (*Coregonus williamsoni*) and the sculpin (*Cottus bairdii beldingi*). In all cases the fish used were under 7 centimeters in length, and rainbow trout were concurrently infected as a control. Of the four species in which infection was experimentally effected, none was as successful a host as rainbow and brown trout. On these four only a few of the glochidia from their original heavy infection completed metamorphosis. It is unfortunate that the Truckee

[6] At the Leavenworth Hatchery in the State of Washington, in 1941, the fingerlings of chinook salmon, but not of bluebacks, suffered infection by the glochidia of *Margaritifera*, according to H. S. Davis (personal communication).

River is definitely unsuited to eastern brook trout as losses from glochidia infection could possibly be reduced by planting them instead of rainbows.

Glochidia remained on three laboratory infected rainbow trout from June 26 to August 1 (36 days). At the end of this observed period of attachment they were a light tan in color, possessed all the structures of adult mussels, and had increased considerably in size. During this period the average daily temperature was 57.5° F., and ranged from 45.8° on June 26 to 61.8° on August 1.

The length of the glochidia at attachment was 0.05 to 0.06 mm. and at the end of their parasitic stage from 0.39 to 0.42 mm. This is an increase of about 660 per cent in length. The increase in weight is of course immensely greater. Nutriment for this growth must have come almost exclusively from the host fish.

A glochidium breaks out of its cyst by movement of the foot, which is covered with cilia, and by the cyst sloughing off.

Post-parasitical Life

On leaving the host fish, the young mussel drops to the bottom of the stream. If it reaches a suitable substratum, which in this case would be a stable bed of gravel, it is thought to attach to a pebble by means of byssus threads. If it alights in shifting sand or mud, it undoubtedly smothers. This is the second critical period in the life of the mussel, the first being the interval between discharge from the marsupium and attachment to the host fish.

Large numbers of mussels of all sizes were collected and examined before being preserved. From these it was found that the byssus thread is discarded when the mussel is from 48 to 52 mm. in length. After this time the mussels move about independently on the stream bottom.

Since young mussels up to 30 mm. in length, while possibly not rare in actuality, are very difficult to collect, an exact determination of the size at sexual maturity is difficult. No mussels less than 32 mm. in length were found to have mature gonads.

Apparently the mussels reproduce until death. The largest mussels taken in the river had reached a size of 92 mm., and these were still producing eggs.

The Effect of Glochidia on Trout

Several experiments were carried out to determine what, if any, effect the glochidia have on young trout. These experiments are summarized in Table 1 and are described below.

Table 1

Experiment No.	*Species*	*Average Length*	*Number of Glochidia per Trout*	*Per cent Mortality*	*Death Usually Caused By*
1	Rainbow	42 mm.	600-1,200	52	circulation cut off
2	Rainbow	38 mm.	250-750	16	secondary infection
2	Brown	31 mm.	100-295	52	secondary infection
3	Rainbow	38 mm.	30-50	00	no mortality

Experiment No. 1

On June 26, 1941, 400 rainbow trout with an average length of 42 mm. were infected with from 600 to 1,200 glochidia each. This was done by placing the trout in a shallow pan, the water of which contained several million glochidia taken from naturally extruded conglutinates.

On June 27, 52 per cent of these fish were dead. A superficial examination of the dying fish showed that large patches of the gills were very pale. A careful examination under a microscope revealed that the glochidia were cutting off the main blood vessels of the individual filaments. Those fish not having enough of the filaments cut off to kill them lost those parts of the filaments which were cut off from circulation. Examination of these fish two weeks later showed numerous stubby filaments.

This mortality would not be important from a practical standpoint as such heavy infections are only obtained in the laboratory.

Experiment No. 2

On June 3, 1941, 400 rainbow trout with an average length of 38 mm. and 200 brown trout with an average length of 31 mm. were placed in one of the tanks. At the head of the tank 170 adult mussels had been placed. This was to insure that the fish would be infected. The infection acquired by the rainbow trout ranged from 250 to 750 glochidia per fish. The majority of them were infected with about 350 glochidia. The brown trout carried from 100 to 295.

In these fish there was practically no mortality until July 13. At this time the glochidia were maturing and dropping off the fish. From then till August 1, 16 per cent of the rainbow trout and 52 per cent of the brown trout died. The difference in mortality between the two species may be due to several factors. First, the rainbow trout were considerably larger (average length 7 mm. longer). Second, the rainbow trout were confined at the head of the tank, and lived under more healthful conditions. The brown trout, which were confined at the tail of the tank, did not seem to thrive well.

The aforementioned deaths were due to varied and complex causes. Of the deceased rainbow trout 15 per cent, and of the deceased brown trout, 8 per cent died by merely wasting away. Since the glochidia increase some 660 per cent in length while on the fish there must be a considerable drain on the vitality of the fish in heavy infections. The rainbow trout dying in this way carried from 404 to 750 glochidia and the brown trout from 200 to 295.

Thirty-five per cent of the dead rainbow trout and 44 per cent of the dead brown trout died by contracting a saprolegnian infection in the gills. When the glochidia release themselves from the cysts they leave a small lesion. Since fungus strands are present at all times in the water supply during July, this furnishes an excellent chance for infection.

A secondary bacterial infection accounted for 50 per cent of the deaths in rainbow trout and 48 per cent of the deaths in the brown trout. This produced a rapid proliferation of the gill tissues. Individual filaments grew together, producing plates of gill filaments. At the same time the circulation in many of the filaments broke down. At death most of the filaments had been affected in this way.

Experiment No. 3

On June 3, 1941, 100 rainbow trout averaging 38 mm. in length were placed in one of the rearing tanks. These fish were kept in the normal river water (which is the supply of the rearing ponds), and received no infections except those acquired from the water. By the last week in June they were found to be infected with from 30 to 50 glochidia. None of these fish died, either from glochidia or from a secondary infection initiated by glochidia injury.

Theoretically, the fish in this experiment should have shown a mortality somewhat corresponding to that observed here from 1931 to 1936 (up to 47 per cent). Since no specimens of the fish which died from 1931 to 1936 were preserved, it is not possible to tell if there was a secondary infection. If there was, it could very easily have been overlooked, as glochidia are very obvious on the infected fish, and finding them, perhaps the diagnosis was carried no further. The much greater crowding of the fish in the tanks during the routine operations of 1931-1936 would have been more favorable to secondary infection than the light concentration of fish under the present experimental conditions.

Two wild fish infected with glochidia were recovered dead from the river. Their lengths were 40 and 47 mm., and they bore 80 and 100 glochidia respectively. The larger had a fungus infection in the gills. They had only been dead a few hours so the fungus infection must have been present at death. Many more wild fish may have died from this, but recovery of small dead fish in a river the size of the Truckee would be low.

The majority of wild fish from 3 to 5 centimeters in length taken from the river showed infections of from 30 to 50 glochidia.

Preventing the Loss of Fish

Methods of preventing losses of fish due to glochidia immediately fall into two categories: first, to prevent infection, and second, to treat infected fish.

Since the glochidia are covered with a layer of gill epithelium in from 2 to 4 hours after attachment, treatment of fish is virtually impossible.

Treatment was attempted with formalin solution and salt solution on laboratory infected fish within a few minutes after infection. The use of these solutions in strong enough concentration to kill some of the fish had no effect on glochidia attached to survivors. Even if a chemical were found to remove the glochidia before "encystment," it would be impractical to treat the fish every 2 to 4 hours.

There are several possible means of preventing infection: filters, settling basins, removing the mussels from the river, and changing the water supply.

Both an updraft and a downdraft filter were experimented with. In both cases the same bed was used, the type of filter being changed by shifting the direction of the water.

The filter was six feet long and five feet wide. The bed itself was 4½ inches deep, the top 1½ inches being fine sand, and grading down to one-quarter-inch gravel on the bottom. The bulk of the fine top layer was composed of irregular granitic sand ranging from 0.08 to 0.24 mm. in diameter. This filter was installed in tank No. 2. (See Fig. 30.)

In order to test the filter's efficiency, the number of glochidia per gallon [7] in the incoming water and the number per gallon in the outgoing water were measured. A plankton net with No. 20 silk bolting cloth was used to strain the glochidia from the water. The number of

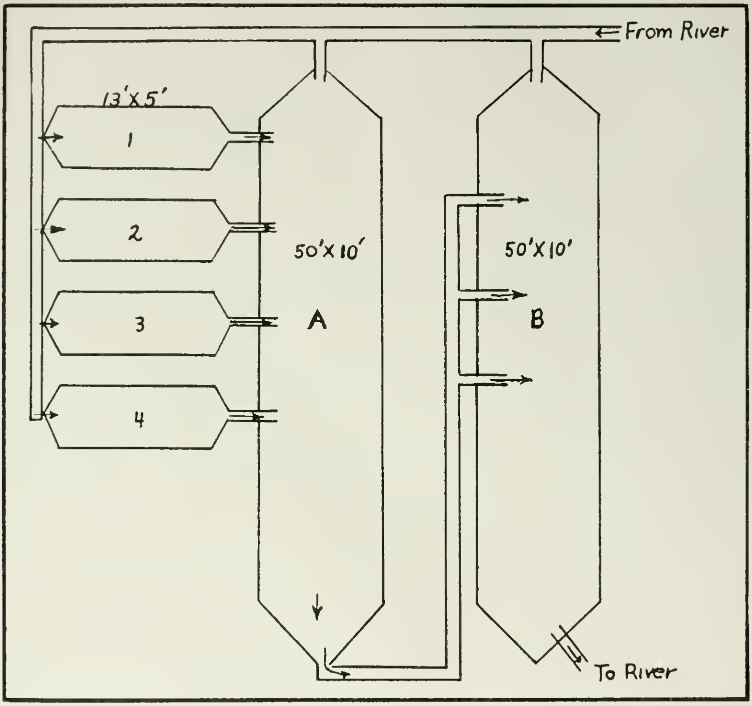

FIG. 30. Diagrammatic representation of tanks, pools and water supply at the San Francisco Fly Casting Club. Lengths shown are exclusive of V-shaped end zones. Including these, over-all lengths are 18 feet for the smaller tanks, 60 feet for the ponds. Depths are 18 inches and 4 feet respectively.

glochidia from measured samples was then counted with the aid of a microscope. Approximately 20 per cent of the glochidia passed through the net, but as the same factors were constant throughout, a relative measure of the filter's efficiency was obtained.

Using the bed as an updraft filter was unsuccessful. It was necessary to reduce the flow of filtered water to 0.35 gallons per minute in order to remove all the glochidia.

When used as a downdraft filter only 1.4 per cent of the glochidia passed through the bed when the flow was 10 gallons per minute. As the filter bed became clogged with debris, the number of gallons per minute dropped.

[7] Samples of water used in these calculations ranged from 25 to 60 gallons.

The normal water requirements of this nursery are 500 gallons per minute. In order to accommodate this flow, a filter bed of at least 1500 square feet in area would be required. This would involve considerable and probably unjustified expense.

Pool A (see Fig. 30) was used experimentally as a settling basin. It is 50 feet in effective length and 10 feet wide. The water averages 3 feet, 6 inches deep. The bottom slopes slightly toward the outlet.

With 25 gallons per minute entering pool A, only 10 per cent of the glochidia passed through. However, a flow as small as 8 gallons per minute allowed some glochidia to pass. At 100 gallons per minute no glochidia settled out. This inability of such a large tank to settle out the glochidia is probably due to their slow rate of settling (35 mm. per minute). Methylene blue tracers were added to tank A, but they showed that the flow was fairly even throughout the tank.

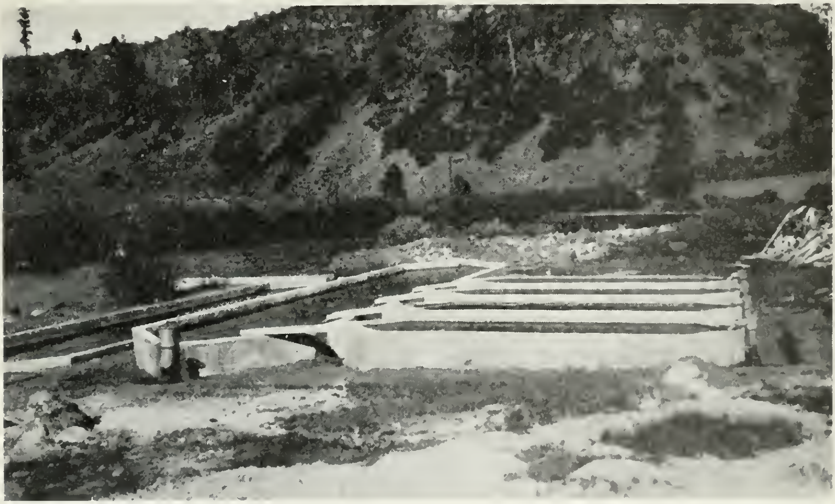

FIG. 31. Ponds of the San Francisco Fly Casting Club, Truckee River, California.

Since even a few glochidia on a fish may be enough to allow a secondary infection to set in, settling basins are not likely to be a practical solution to this problem.

There remain three alternatives:

1. The water supply of the rearing ponds can be changed. There is a small stream flowing across the club property which possibly could be dammed and used for this purpose.

2. The mussels could be removed from the river. This would not be as tremendous a job as at first appears. At certain seasons the river drops very low, and during such times it should not take more than 150 man-days to clear the river of mussels from the Fly Casting Club all the way up to Lake Tahoe. This estimate is based on a survey made on certain stretches of the river in 1941. However, it would be difficult to remove all of the mussels below 40 mm. in length. This means that a few glochidia would still be in the water supply and could possibly cause trouble; also that the mussels would be likely to come back in a few years.

3. The present method, that of placing the young trout in the rearing ponds only after the "glochidia season" is over, can be put on an improved basis in the light of the findings of this investigation. The use of August 15 as the limiting date was based purely on the observation that over a period of years the heavy mortality occurred previous to this date. It now becomes apparent that this mortality was due not to the attachment of the glochidia to the trout, nor to their inroads upon the trout tissue during their parasitic life, but principally to the phenomena accompanying their departure from their trout hosts. The present study has shown that the parasitic period lasts for about 35 days, and that therefore it is over a month prior to their death that the infection of the trout takes place. It shows that in 1941 the mussels in the neighborhood of the club had all discharged their glochidia by July 7, that after this date danger of infection was slight, and that in fact trout placed in the rearing ponds on July 9 remained free of glochidia. Even though glochidia may live 11 days or more in the water after leaving their parents, it appears that their numbers in the river are low at the last of the "glochidia season"; probably they are washed down the river shortly after their discharge from the parent.

It appears, therefore, that the earliest date on which trout can be placed in the rearing ponds without danger from glochidia can be determined annually by a biologist. Based on the present data, this should be at least a month earlier than is the practice at present, and close periodic examination of the adult mussels might in some years make it possible to improve considerably on this.

The significance of this is that intensive feeding could begin that much earlier, the trout could be brought to the desired size sooner, and could thus be released and stocked in the river at a considerably earlier date. Studies in various parts of the country have indicated poor survival of trout planted in the late fall; to advance the planting date of these Truckee River trout by a month should therefore improve materially their chances of survival.

A specific procedure for determining the earliest date on which trout can be safely placed in the rearing ponds is given in the Appendix.

Summary

1. The "breeding season" of the mussels in the Truckee River at the San Francisco Fly Casting Club in 1941 was from May 15 to June 25. "Breeding season" is defined as the time between the first and last appearance of undeveloped eggs in the marsupia.

2. At an average temperature of 55.7° F. the glochidia left the marsupium 12 days after the appearance of undeveloped eggs.

3. A mussel 7.0 centimeters in length contained about one million eggs.

4. Unfertilized, stratified eggs were found in all gravid mussels.

5. The conglutinates are held together by adhesion of the component egg shells.

6. Each conglutinate is discharged in toto, and the mass is subsequently broken up by the current.

7. Mature glochidia are 0.05 to 0.06 mm. in length.

8. The glochidia attach to gill filaments only.

9. After attachment the gill epithelium migrates over the glochidium in 2 to 4 hours.

10. Glochidia can live at least 11 days after extrusion without benefit of a host.

11. Rainbow and brown trout are the most suitable hosts in the Truckee River for these glochidia. *Salvelinus fontinalis*, *Catostomus tahoensis*, *Rhinichthys osculus robustus*, and *Richardsonius egregius* are possible as hosts, but are not well suited. *Coregonus williamsoni* and *Cottus bairdii beldingi* will not acquire an infection of these glochidia.

12. At an average daily temperature of 57.5° F. the parasitical stage of the glochidia lasted 36 days.

13. During parasitism the glochidia metamorphose and increase in length to 0.39-0.42 mm.

14. There are two critical periods in a mussel's life, the first being before attachment to a host fish, and the second after leaving the host and before becoming attached to a suitable substratum.

15. No gravid mussels less than 32 mm. in length were found.

16. The mussels continue reproducing as long as they live. Specimens 92 mm. in length were found to be fertile.

17. Rainbow trout 42 mm. in length, artificially infected with 600 to 1,200 glochidia per fish, showed a large initial mortality within a day or two, due to interference with circulation of blood in their gills.

18. Rainbow trout 38 mm. in length experimentally infected with from 250 to 750 glochidia suffered a mortality of 16 per cent.

19. In rainbow trout 38 mm. in length infected with less than 600 glochidia and more than 400, the mortality was usually the result of the fish wasting away.

20. In rainbow trout 38 mm. in length infected with less than 400 glochidia, such deaths as occurred were usually the result of secondary infections such as fungus or bacteria. These infections probably start in lesions produced when the glochidia leave the host fish. Practically no mortality was observed in these fish prior to this stage.

21. Rainbow trout 38 mm. in length kept in a tank and subjected to infection from river water only showed no mortality, although infected with 30 to 50 glochidia per fish. These fish acquired no secondary infections. However, they were kept under much less crowded conditions than is normal in hatchery and rearing pond operations, so this does not prove that secondary infections can not develop in fish with low infections under routine operating conditions.

22. If trout 38 to 42 mm. in length could be kept free from all diseases, they should be able to carry infections of 100 glochidia per fish without serious consequences.

23. Small trout are killed indirectly by glochidia in the Truckee River, death resulting from secondary infections.

24. Chemical treatment of infected fish is impractical because the glochidia are covered with gill epithelium in from 2 to 4 hours.

25. Filters and settling basins are impractical, in this case, because of the expense of building them large enough to accommodate the water requirements of these rearing ponds.

26. Changing the water supply and removing the mussels from the river are possible as solutions, but the latter is questionable in value.

27. The only immediate solution is to place the trout in the rearing ponds after the glochidia season is over. This should be determined annually by a biologist in accord with the procedure described in the Appendix. In 1941 the last glochidia had left the marsupium by July 7. No signs of glochidial infection were observed on 2,000 rainbow trout which were transferred to the tanks on July 9. Even though glochidia may live 11 days or more in the water, they would be washed down the river in 1 or 2 days after the last had been discharged from the mussels, and the number of glochidia in the river is relatively low at the last of the glochidia season.

The practice at present is to stock the rearing ponds on August 15. By keeping a close watch on the mussels it should be possible to place the fish in the ponds at least a month earlier, with the advantages of earlier release into the river and a probable higher survival.

Appendix

Procedure for determining date that trout can be placed in the rearing ponds of the San Francisco Fly Casting Club without danger of infection by mussel glochidia.

1. Examine mussels in the river at the San Francisco Fly Casting Club on or about the following dates: June 1, 14, 21, 28, July 2, 5, 8 and so on until the "incubation season" is over. By incubation season is meant the period that developing eggs or glochidia are to be found in the gill chambers of the mussels.

Both the gonads and the marsupia of the specimens collected should be examined. Samples should be of at least 10 specimens. The dates given are not ironclad; they indicate the most desirable frequencies for the collection dates.

2. It will probably be possible to tell at least two weeks in advance that the "incubation season" is drawing to a close. This will be indicated by the gradual dropping of the percentage of mussels with eggs or glochidia in their marsupia. It is important to tell this in order to make the rearing ponds ready for the fish.

3. Three days after the last mussel has rid itself of its glochidia, it should be safe to plant the rearing ponds. As a check, the river water should be tested with a plankton net (No. 20 or finer).

4. If the recording thermometer can be kept in operation for several years, it should be possible to correlate the end of the "incubation season" with the temperature of the river.

5. Care should be used in determining the end of the glochidia season, and if any doubt exists as to whether the danger is over, stocking of the rearing ponds should be delayed.

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ECONOMIC AND GEOGRAPHICAL RELATIONS OF ABORIGINAL FISHING IN NORTHERN CALIFORNIA [1]

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Aboriginal fishing in northern California is known ethnographically from tribal monographs and from recent Culture Element surveys.[2] This, plus the reports of fishery specialists, formed the published background for the author's 1940 field investigations. Primitive fisheries may be studied not only as ethno-historical problems, but also in the light of geographical and economic relations. So far, investigations have been limited to analyses of element distributions.

To anthropologists, "fishing" is a term covering any operations engaged in to secure aquatic products useful to man, whether for food, ornaments, fertilizer or glue. Fishing is not only the aquatic counterpart of hunting; it includes gathering as well. Primitive reliance on fisheries ranges from zero to near completeness. Neglect of fisheries may be geographically or culturally determined; the two causes are not necessarily correlated. As a rule, where fisheries meant a worthwhile addition to the food supply, they were developed adequately.[3] At least the factor of technological incompetence may be ruled out, as one can not imagine cultures so crude as to be incapable of applying the simpler mass fishing techniques of fish-drives, weirs, scoops, clubs, fishing with the hands, or at least picking up mussels.

In the area of the present study (see map, Fig. 32), boundaries were admittedly arbitrary, including no single cultural or geographical unit. Kroeber recognizes these cultural subdivisions of our area: (1) Lower Klamath, peripheral to the Northwest Coast cultures of British Columbia, (2) California-Northwest Transition, (3) California proper, and (4) its cultural climax, here represented by the Pomo tribal group. Briefly, fisheries are increasingly specialized northward, with the local exception of Clear Lake, in Pomo territory. Socially, effects of fishing specialization there were different from those on the lower Klamath. The importance of diversified hunting and gathering was greater in the south.

Fishing geography is nearly independent of local conditions which influence the primitive economic utility of land plants and animals, especially when migratory fish are concerned. The Indians of California, lacking agriculture of any kind, were directly affected by local variations in the vegetational cover, except where they could supplement their diet with fisheries products. In our area, fisheries developed by the aborigines are divisible as follows: (1) Pelagic, relatively untouched not only because of poor watercraft but because demands were satisfied closer at hand. (2) Offshore rocks with abundant sea lions and mussels. (3) Littoral fisheries for angling, surf fish netting, gathering shellfish and seaweeds. (4) Bays, estuaries and placid

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[1] Submitted for publication February, 1942.
[2] See the bibliography for references on specific northern California areas.
[3] A notable exception is Tasmania, where the aborigines had a strict tabu against eating scaly fish; though they were available in large quantities the Tasmanians lacked the desire to add them to the food supply.

lagoons, safe for canoes, best for spearing and angling. The bar or outlet was strategic for intercepting incoming anadromous species and their hungry predators. Borders of bays and lagoons were useful for tidal pounds and flatfish spearing. (5) Streams for various kinds of fishing. Riffles and shallows for spearing and harpooning, gaffing, and fish-drives. Swifter waters, cascades and falls permitted taking anadromous fish as they leaped upstream, in dip nets, traps, baskets or with harpoons and gaffs. Back-eddies favored use of bag nets, and in deeper waters, seines and drift nets. (6) Lakes and ponds presented different opportunities—basket traps and spearing along the marshy edges; angling or netting on the smooth open water; and in sluggish waters, diving, bare-hand fishing, use of bow and arrow, and fish-poisoning. Serious ice-fishing was lacking, for climatic reasons.[4]

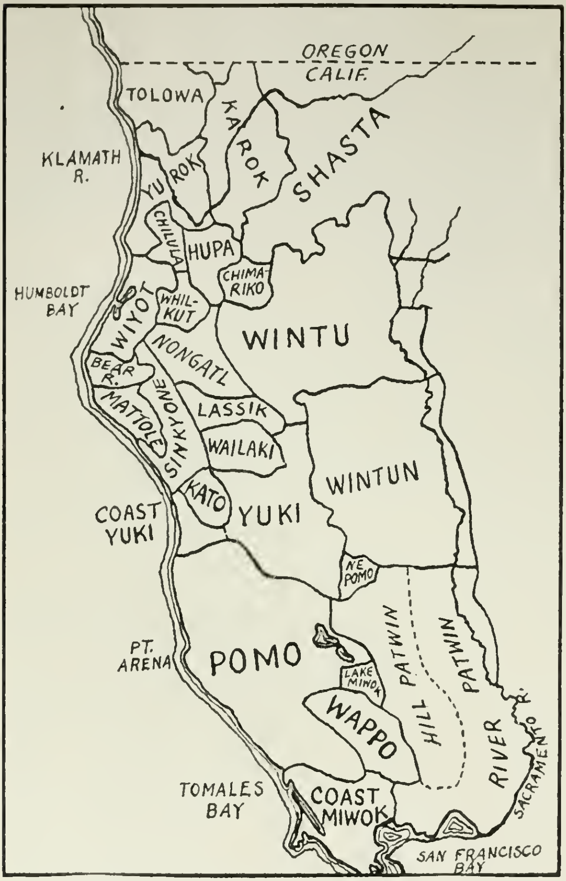

FIG. 32. Map showing location of Indian tribal groups in northern California, from Oregon to San Francisco Bay and inland to the Sacramento River.

Economically significant primitive fishing techniques are all mass methods, concentrating fish in small areas from which they can be taken easily in dip nets, with gaffs, or by hand. The sessile forms can be gathered with a pry or dibble. Except for sea mammals and sturgeon, pursuit of single individuals was not economically justifiable. Spectacular methods such as diving, shooting with fish-arrows and angling, are less efficient, and served more as sports. Mass-fishing is a harvesting operation, though the analogy to agriculture fails in that hus-

[4] Birket-Smith, 1929, has an extensive treatment of ice-fishing techniques, especially in regard to their rôle in the building of Eskimo culture.

[5] The chief ritual conservation procedure concerned the "First Salmon," especially on the Klamath River; a glimpse into the elaborate ritual surrounding the erection of a fish-weir is to be found in Waterman and Kroeber, 1938.

banding of fish resources was unknown aboriginally, if ritual conservation procedures are disregarded.[5]

Techniques used in aboriginal northern California fisheries show endless local variations, for which geographical conditions are chiefly responsible within the limited area of study. Particular gear might be restricted to a geographical point; for instance, a type of net used at Ishipishi Falls on the Klamath, while familiar to Indians up and down the river for fifty miles, is thus restricted. Engineering difficulties limit sites for native weirs. Poisons are effective only in ponds. Culturally prohibited devices were few, although bow and arrow fishing was tabu in parts of northwestern California, and it was an incidental pastime elsewhere. An important cultural deficiency was in watercraft; dugout canoes were lacking south of the Sinkyone.[6] Many techniques have compact distributions in the area (see map, Fig. 33): (1) the A-frame net for surf and river fishing; (2) mutually exclusive, the arc dip net;[7] (3) fish-poisoning, nearly coterminous with the arc dip net; (4) the truncate cone plunge basket, from which fish are removed through the open apex, not used north of the Pomo. Weirs, traps and pounds are widely distributed, though applied only in locally suitable sites.

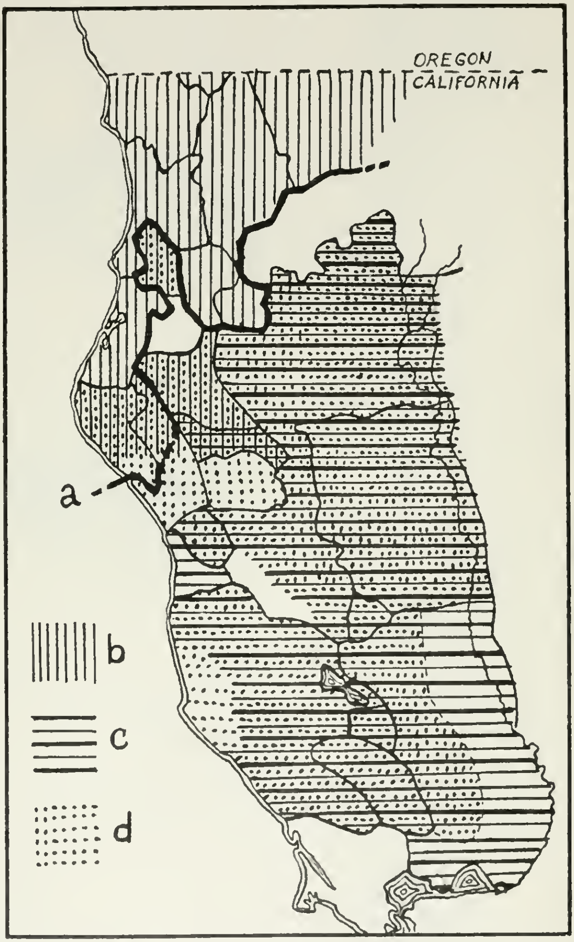

Fig. 33. Map showing limits of Indian fishing traits in northern California.

A. Southern limit of use of dugout canoes.
B. A-frame dip nets.
C. Arc-dip nets.
D. Use of fish poisons.

[6] Heizer, 1940, has made a study of native California canoe types.

[7] The "Arc Dip Net" describes a long-handled gear with a single bowed crosspiece net-stretcher; when the handle is pushed downward into the water the mouth of the net opens, while lifting the handle closes the net by releasing tension on the bow. Such nets were used by the Pomo on Clear Lake, where they attained great dimensions. Smaller forms of the same gear were employed in the surf fishery.

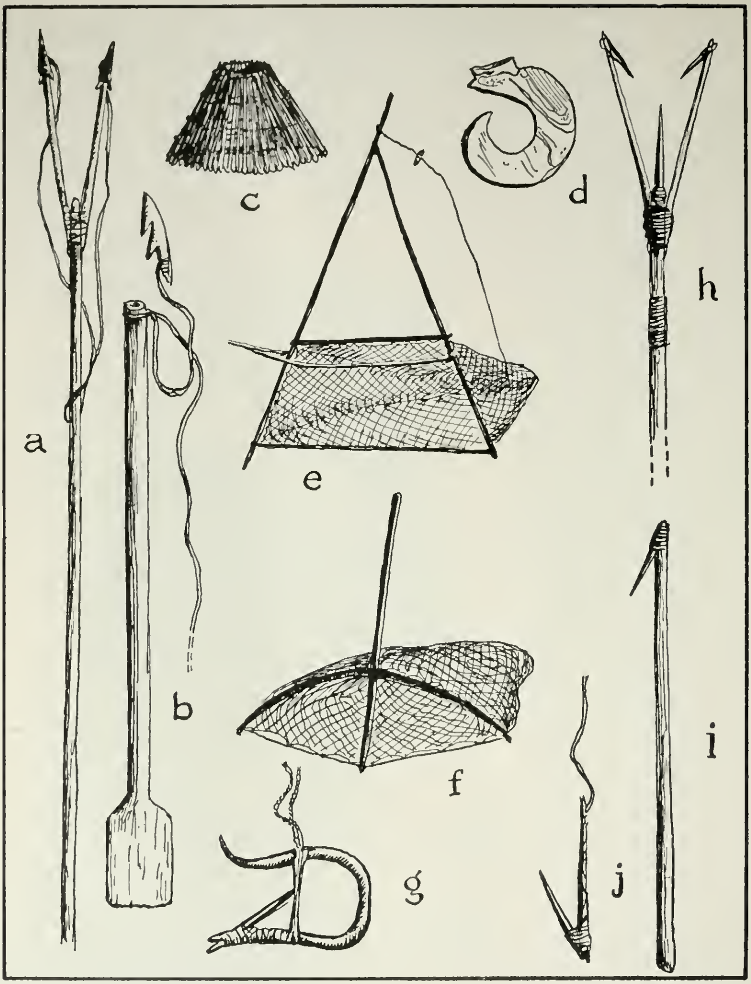

FIG. 34. Some types of Indian gear used on the Pacific Coast (to various scales).

A. Double-pronged toggle harpoon for salmon, Wailaki tribe, northern California.
B. Barbed harpoon for sea lion, Yurok of Requa, northern California.
C. Conical open-end plunge basket, Pomo of Clear Lake, central California.
D. Shell hook for marine fish, Chumash tribe, southern California.
E. A-frame net for salmon, Yurok, northern California.
F. Arc-net for river fish, Yuki, central California.
G. Halibut hook, Makah and other tribes of Puget Sound and Gulf of Georgia.
H. Leister, Nez Perce, Idaho.
I. Lamprey gaff, Nongatl, northern California.
J. Trout hook, Hupa, northern California.

The possibility of fishery traits having different diffusional dynamics than, say, land hunting traits, is not borne out by the distributions which do not exhibit any particular linearity.

The outstanding economic effect of certain Indian techniques arose from the stability of their localization. Productive sites in a river fishery are ordinarily more permanently valuable than berry patches, hunting grounds, or even cultivated lands, in any society. Sea lion fisheries on offshore rocks are more enduring than comparable land hunting foci to which the closest parallels are water holes. Such localized fisheries are subject to individual or kindred proprietorship; the right to fish in open waters usually belonged to the local sovereign group. On the lower Klamath, native law recognized the ownership not only of well situated rocks, but of riffles and even sea-stacks.[8] Conflicts were avoided by distributing surplus to those lacking properties; poaching was impractical where the owners worked day and night during the salmon runs. However, violent disputes did arise over stranded whales despite elaborate rules for apportioning shares wherein choicer cuts went to owners of the stretch of shore on which the animal lay. In contrast, the southern end of the area lacked individual fishery ownership; communal drives were characteristic. The specialist native fishermen on Clear Lake were not the proprietors of the waters where they worked. Throughout, division of labor was the same. Women, excluded from actual fishing, took charge of cleaning and preservation. In the south they might participate in drives, but northward the tabu was stricter and females could not use the weirs as bridges. Even during surf fish runs, when everyone was needed to wield the A-frame nets, women could hold them only if the tail of the net were safely in the hands of a small boy.

Aquatic products are easily preserved by drying, which may be aided by smoke-curing, intentional or unintentional (smudge to keep away flies). Dried salmon, even in the dampness of northwestern California, would keep a year. Aboriginally, salt was not used for preservation, though it was gathered from ocean rocks and inland mineral sources as a condiment.[9]

The position of fisheries in the primitive subsistence pattern varied from moderate to overwhelming importance, from south to north. Likewise, coast-dwellers had more diversified resources than river-dwellers, though it is mistaken to assume that river-mouth dwellers caught the most salmon. Aside from the bar or outlet, fishing places for native gear are rare in river estuaries, which are often too deep, or too much affected by the tide to permit efficient mass tactics. Fewer salmon were caught aboriginally at Requa than at Kepel, 20 miles upstream, by the Yurok, and the Pomo at the mouth of the Russian River were at a similar disadvantage.

Accultural changes in Indian fishery are apparent, though white settlement has perhaps affected fishing least of aboriginal economic activities. New devices from the whites are few; actually techniques have declined in number since first contact times. However the Yurok at Requa accepted the gill net readily. New materials for hooks, harpoon points and nets have been accepted, but informants assert that wild iris fibre cordage is superior to any modern cordage in strength

[8] Kroeber, 1925, especially the chapter on the Yurok.
[9] Kroeber, 1941.

and durability. The elaborate trout angling complex with artificial flies, rods and reels, has not spread to the natives, whose earlier interests in trout were limited to snagging with a bunch of hair at the end of a hand-line. Whites in fencing their lands prevented food-gathering by Indians. Game has been driven from accessible areas, and to maintain it for sport, strict limits have been imposed even on Indians. Indians have been permitted to retain much of their aboriginal fishing, although weirs can no longer be erected except on Hoopa Reservation. White communications facilitating intertribal contacts have spread a lamprey trap in post-contact times from Humboldt Bay to the Klamath River. The sea mammal fisheries have been virtually eliminated since the 1860's, as sea otters, whales and seals have been brought close to extinction. Native river-fishing techniques have been little affected by the introduction of exotic species or by the establishment of trout hatcheries. Catches of transplanted Atlantic shad were first greeted with disgust by lower Klamath River Indians. Reciprocal accultural effects are noticeable; surf nets and lamprey gaffs now used by whites are copies of Indian gear.[10] Our modern taste for abalones, however, was stimulated by the Chinese rather than by the Indian abalone fishery. Failure of our culture to impose a new "fishing pattern" on that of the Indians is due to the lack of a consistent pattern on our part. Despite the antiquity of fishing, it is still not always possible to determine the most efficient use of gear; 100 per cent effectiveness in the salmon fishery obviously destroys the supply, yet even with primitive methods one can come very close to 100 per cent stoppage of the run.[11]

Fisheries biologists usually assume that fishery resources remained virtually in a state of nature until the period of white settlement. This is true of the pelagic fisheries but certainly does not hold for fresh-water fisheries, particularly salmon. Lack of ethnographic information is not entirely the fault of ecologists; it has not occurred to many anthropologists that their results are useful to any but social scientists. The decline in catch totals from earlier peaks in commercial salmon fishing in this area may represent not a decline from the abundance of fish in "nature," but a falling off from the abnormal peak caused by the disruption of Indian fishing in the middle decades of the 19th Century. The sudden arrival of white immigrants on the Sacramento, Klamath, Columbia and Fraser between 1845 and 1865 must certainly have diminished the Indian salmon catch. Thus relieved of the pressure of providing food for tens of thousands of Indians, the fish population probably increased greatly for a few decades. In our area, Kroeber conservatively estimated the Indian population on the lower Klamath in pre-white times as 5,000, with salmon as the most important source of food.[12] To regard the fish population of that river prior to 1850 as a part of the "natural landscape" is obviously erroneous.

So far the historical position of the area in respect to fishing has not been mentioned. Recent influences from either the Great Basin tribes or those of the Southwest can be ruled out. The only important California Indian fishing elements which do not appear to be integral

[10] Bonnot, 1930, discusses Indian gear adopted by the whites.

[11] Snyder, 1924, describes the salmon weir annually erected in Hoopa Valley. For details of the construction of an even larger weir, see Waterman and Kroeber, 1938.

[12] Kroeber, 1939, has mapped the aboriginal population density in California, and tabulated it by tribes.

traits of the native Pacific salmon fishing complex are the use of fish poisons and shell hooks. Poisons are used very widely in Indian fisheries of South America, and sporadically by the Indians of the southeastern United States. In the southwest and Great Basin, poisons were rarely used for fishing; the Californian fish poisons seem to be local discoveries. Shell hooks were used in pelagic fisheries by the southern California Chumash and maritime Shoshoneans. Ecologically and technologically the southern California marine fishery of aboriginal times was altogether unrelated to that of the "Salmon Area." Superficially, the shell hooks of the Channel Islanders resemble those used in the marine fisheries of Oceania.[13] Possible historical connections of these cultures need not be discussed here. Within the "Salmon Area" some good cases for ancient cultural continuities may be made. Double foreshaft toggle harpoons occupy a compact area from California through to the Columbia-Fraser Plateau and the middle coast of British Columbia; these harpoons reappear in identical form in Asia, solely among the Ainu of Hokkaido, northern Japan.[14] The trident fish spear or leister is typically Eskimo, but it reaches as far south as the Columbia River on the west, and well down the Atlantic Coast among the Algonkian tribes. On the other hand, simple barbed harpoons, fish hooks, weirs, nets, scoops and traps are nearly universal wherever fishing is practiced.

Fishing techniques of all peoples, including those of the first migrants to the New World, have had a long and complex history; some traits are demonstrably very ancient; others, like the Eskimo type leister, may be of fairly recent spread. Still others, like the double pronged harpoon may represent diffusions from North America to northeast Asia. From archaeological evidence it appears that Early Man in America was contemporary with the great post-glacial lakes of the Great Basin. As these vast lakes were no doubt well stocked with fish, the early connections of fishing in North America promise to become even more intricate as they become better known.

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[13] Compare Olson, 1930, p. 9, and Krause, 1904, pl. 9.

[14] Hewes, 1942 (in press).

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PROGRESS REPORT ON ADULT SALMON TAGGING IN 1939-1941 [1]

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A part of the California salmon program and a phase of the Central Valley investigation initiated during 1939 but not mentioned in the previous report,[2] is the tagging of ocean-caught salmon off the California coast. Tagging was undertaken as the only direct means of solving several important problems in connection with salmon fisheries management, foremost of which are the stream sources of salmon frequenting the ocean waters off the California coast and the relative contribution of each stream to the ocean commercial catch. The time for such a program is favorable because of the large number of counting weirs maintained at present on West Coast streams.

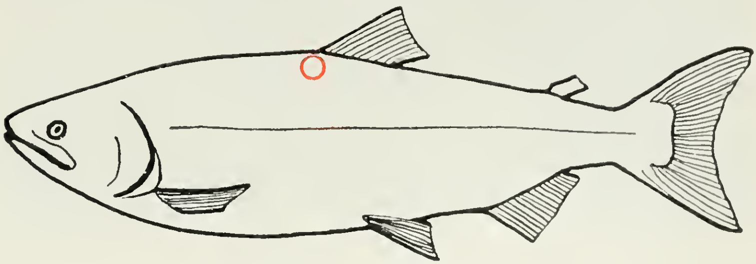

Fig. 35. Diagrammatic view of a salmon, showing where tag is placed.

Salmon are caught for tagging by a chartered commercial fishing boat using trolling gear, with an employee of the California Division of Fish and Game aboard, who does the actual tagging and recording. The usual type of button tag is used, consisting of red and white celluloid disks, the white one serially numbered. The tags are placed immediately in front of the dorsal fin and secured by a metal pin which pierces the back of the fish. (See Fig. 35.) Salmon tagged south of Point Arena bear disk arrangements different from those tagged north of that Point. This has been done in order to detect from which general locality the fish have come when they pass through a counting weir and the tag numbers can not be seen.

Tagging and recoveries for each of the three years, 1939 to 1941, inclusive, are summarized in tables 1-3. These show the number tagged and the recoveries from the same year in which the fish were tagged. No recoveries have been made from fish tagged in a previous year.

This material is presented only as a matter of record, and an analysis of the recoveries will be withheld until additional data are available.

[1] Submitted for publication, January, 1942.
[2] Hatton, S. Ross. Progress report on the Central Valley fisheries investigatons, 1939. California Fish and Game, vol. 26, no. 4, pp. 334-373, 1940.

FIG. 36. A tagged salmon in the tagging cradle, ready to be released.

TABLE 1

SUMMARY OF SALMON TAGGED AND RECOVERED IN 1939

NUMBER LIBERATED

Month	Tagged south of Pt. Arena			Tagged north of Pt. Arena			Grand Total
	King	Silver	Total	King	Silver	Total	
March	111	0	111	0	0	0	111
April	38	0	38	0	0	0	38
May	25	0	25	0	0	0	25
June	0	0	0	74	44	118	118
July	3	0	3	66	158	224	227
Aug.	125	0	125	4	9	13	138
Sept.	248	0	248	0	0	0	248
Totals	550	0	550	144	211	355	905

Included in this total are 23 fish tagged by members of the San Francisco Tyee Club.

SUMMARY OF RECOVERIES

Geographical locality tagged	Species	Locality of recovery														
		Washington—ocean	Columbia River	Oregon—ocean	Oregon—rivers	Smith River System	Klamath River System	Redding Rock	Mad River System	Eel River System	Off Ft. Bragg	Off San Francisco	Sacramento River System	San Joaquin River System	Monterey Bay	Totals
South Pt. Arena	King	----	----	----	----	----	----	----	----	----	----	3	6	2	1	12
	Silver	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
North Pt. Arena	King	----	----	----	----	----	----	1	----	2	----	----	----	----	----	3
	Silver	----	----	1	----	----	----	----	----	----	----	----	----	----	----	1
Totals		----	----	1	----	----	----	1	----	2	----	3	6	2	1	16

TABLE 2

SUMMARY OF SALMON TAGGED AND RECOVERED IN 1940

NUMBER LIBERATED

Month	Tagged south of Pt. Arena			Tagged north of Pt. Arena			Grand Total
	King	Silver	Total	King	Silver	Total	
Feb.	59	0	59	0	0	0	59
March	51	0	51	0	0	0	51
April	0	0	0	202	254	456	456
May	14	0	14	0	0	0	14
June	36	0	36	108	26	134	170
July	77	1	78	65	14	79	157
Aug.	109	5	114	21	9	30	144
Sept.	202	1	203	0	0	0	203
Totals	548	7	555	396	303	699	1,254

Included in this total are 122 fish tagged by members of the San Francisco Tyee Club.

SUMMARY OF RECOVERIES

Geographical locality tagged	Species	Locality of recovery														
		Washington—ocean	Columbia River	Oregon—ocean	Oregon—rivers	Klamath River System	Ocean, Klamath River	Redding Rock	Eel River System	Eureka	Off Ft. Bragg	Off San Francisco	Sacramento River System	San Joaquin River System	Monterey Bay	Totals
South Pt. Arena	King	----	----	----	----	----	----	----	----	1	----	3	5	17	1	27
	Silver	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
North Pt. Arena	King	----	----	1	----	1	1	1	1	1	1	----	----	8	1	16
	Silver	----	----	----	----	----	----	1	----	----	----	----	----	----	----	1
Totals		----	----	1	----	1	1	2	1	2	1	3	5	25	2	44

TABLE 3

SUMMARY OF SALMON TAGGED AND RECOVERED IN 1941

NUMBER LIBERATED

Month	Tagged south of Pt. Arena			Tagged north of Pt. Arena			Grand Total
	King	Silver	Total	King	Silver	Total	
March	19	0	19	0	0	0	19
April	61	0	61	0	0	0	61
May	208	1	209	0	0	0	209
June	64	1	65	0	0	0	65
July	109	6	115	52	24	76	191
Aug.	128	0	128	269	87	356	484
Sept.	329	0	329	0	0	0	329
Oct.	109	0	109	0	0	0	109
Totals	1,027	8	1,035	321	111	432	1,467

Included in this total are 157 fish tagged by members of the San Francisco Tyee Club.

SUMMARY OF RECOVERIES

Geographical locality tagged	Species	Locality of recovery														
		Washington—ocean	Columbia River	Oregon—ocean	Oregon—rivers	Smith River System	Klamath River System	Redding Rock	Mad River System	Eel River System	Off Ft. Bragg	Off San Francisco	Sacramento River System	San Joaquin River System	Monterey Bay	Totals
South Pt. Arena	King	1	----	----	----	----	----	----	----	1	1	3	22	19	1	48
	Silver	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
North Pt. Arena	King	----	----	----	----	1	1	1	3	4	1	----	3	7	----	21
	Silver	----	----	----	3	----	----	2	----	1	----	----	----	----	----	6
Totals	----	1	----	----	3	1	1	3	3	6	2	3	25	26	1	75

A SECOND PROGRESS REPORT ON THE CENTRAL VALLEY FISHERIES INVESTIGATIONS[1]

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As stated in the previous report,[2] the aim of the Central Valley Investigations is to provide adequate biological knowledge of the species of fish concerned, in order that the problems created by the Project may be rationally approached and proper protective measures recommended. To this end, the original plan has been, in its broader aspects, continued a second year. In some cases, however, parts of the original plan have been set aside, particularly those items regarding nonmigratory fishes. The scope of the Water Plan has made it desirable to approach several new problems as the investigation has progressed.

At present three problems resulting directly from the Central Valley irrigation development are under consideration:

1. The effect on migratory fish life of the diversion of Sacramento River water into the Cross Delta Canal. This problem is mainly one of furnishing adequate protection to downstream migrants, especially salmon, at the diversion point and throughout the canal.

2. The proposed interception of the lower San Joaquin River by the Cross Delta Canal, which would block the free passage of migrants to and from their spawning grounds in the upper San Joaquin River and its tributaries.

3. The prospect of maintaining, or transferring, that portion of the salmon run now spawning in the San Joaquin River below Friant Dam.

The problems approached for the first time during the second year of the investigation are: counts of adult migrant salmon, fecundity of San Joaquin River salmon, and the probable economic value of that portion of the total Sacramento-San Joaquin salmon run now spawning in the San Joaquin River and its tributaries.

The methods of investigation have remained essentially the same as previously reported.

Seaward Migration of Salmon

Hood Station

With the results of netting downstream salmon migrants at Hood, on the Sacramento River, now available for three complete years (1899,[3] 1940 and 1941), and for part of a migration period during 1939, certain generalized features of this movement become apparent. The period during which migrants have been taken extends from the middle

[1] Submitted for publication, February, 1942.

[2] California Fish and Game, vol. 26, pp. 334-373, 1940.

[3] Rutter, Cloudsley. Natural history of the quinnat salmon. A report on investigations in the Sacramento River, 1896-1901. U. S. Fish Commission. Bulletin, vol. 22, pp. 65-141, 1903.

of December to the middle of June. During the years under observation the maximum numbers migrated during February or March, with as high as 70 per cent [4] of the total number of migrants being taken during the peak month. A variation of considerable magnitude is shown in the number of migrants taken each year, as indicated by the average hourly rate of capture by the standardized gear employed. The average hourly catch during 1939 was much greater than during any of the other years.

TABLE 1

STATISTICS OF EACH WEEKLY SAMPLE OF SEAWARD MIGRANT SALMON TAKEN AT HOOD, 1939, 1940 AND 1941 [a]

Date	1939[b]				1940				1941			
	Number of fish	Average catch per hour	Average size, mm.	S.E.m mm.	Number of fish	Average catch per hour	Average size, mm.	S.E.m mm.	Number of fish	Average catch per hour	Average size, mm.	S.E.m mm.
Dec. 10–16	------	------	------	------	6	0.18	31.50	------	------	------	------	------
17–23	------	------	------	------	1	0.02	38.00	------	------	------	------	------
24–30	------	------	------	------	0	------	------	------	7	0.44	36.57	------
Dec. 31–Jan. 6	------	------	------	------	12	0.28	34.84	0.82	24	0.46	38.08	0.39
Jan. 7–13	------	------	------	------	0	------	------	------	24	0.27	37.58	0.52
14–20	------	------	------	------	22	0.33	35.91	0.60	9	0.09	38.00	------
21–27	------	------	------	------	10	0.15	38.10	------	16	0.19	38.75	0.85
Jan. 28–Feb. 3	------	------	------	------	37	0.76	38.24	0.40	81	0.79	37.88	0.36
Feb. 4–10	------	------	------	------	93	1.15	38.43	0.30	129	1.54	36.40	0.18
11–17	------	------	------	------	143	2.71	38.22	0.24	114	2.07	39.38	0.37
18–24	------	------	------	------	352	5.90	37.92	0.15	658	6.57	37.59	0.13
Feb. 25–Mar. 3	------	------	------	------	84	1.74	41.46	0.54	278	2.61	38.35	0.19
Mar. 4–10	13	0.93	40.00	1.40	295	5.15	41.06	0.35	1019	9.66	41.16	0.15
11–17	136	15.90	39.36	0.25	44	0.27	42.86	0.74	313	3.00	42.20	0.35
18–24	105	31.47	38.54	0.32	23	0.09	43.04	1.54	87	0.84	42.92	1.08
25–31	104	22.89	38.81	0.38	13	0.07	43.77	1.87	187	1.92	50.72	1.08
April 1–7	85	8.21	39.87	0.27	25	0.12	46.96	1.56	625	8.90	48.84	0.69
8–14	99	4.27	40.76	0.41	5	0.02	66.20	------	550	7.10	56.04	0.75
15–21	102	3.61	42.65	0.41	1	0.02	48.00	------	191	2.08	66.84	1.25
22–28	56	0.96	42.10	0.40	13	0.10	78.31	3.61	327	3.17	72.92	0.53
April 29–May 5	4	0.03	55.50	------	24	0.18	78.79	1.86	171	2.24	68.80	0.82
6–12	3	0.03	50.00	------	10	0.04	78.10	------	87	1.43	69.10	1.11
13–19	0	------	------	------	3	0.01	79.00	------	142	2.50	71.58	0.57
20–26	0	------	------	------	0	------	------	------	253	2.55	69.18	0.39
May 27–June 2	0	------	------	------	2	0.02	82.00	------	73	0.65	67.59	0.86
June 3–9	0	------	------	------	0	------	------	------	28	0.26	70.51	1.31
10–16	0	------	------	------	0	------	------	------	23	0.18	69.72	1.33

[a] Fishing did not begin at Hood until March 6, 1939, and no salmon of the 1939 spring migration were taken after May 11, although netting was continued during the remainder of the calendar year. The first migrants of the 1940 spring migration were taken during December of 1939 and are listed in the 1940 column. During 1940 the nets were used daily until the first of July, and then intermittently until December 11, 1940. The first migrants of the 1941 migration were taken during December of 1940 and are listed in the 1941 column.

[b] In order to establish uniform weekly divisions of the fishing period it was found advisable to include eight days in the division during which February 29, 1940, fell, and also to list the weekly divisions of the 1939 season as beginning one day earlier than was actually the case.

The statistics of each weekly sample of seaward migrant salmon taken at Hood during 1939, 1940 and 1941 are given in Table 1. The number of fish listed in column 1 of the table represents the number on which each weekly statistic is based, and not the total number of fish caught in the nets. The total number of fish caught in the nets each week has been used in calculating the average catch per hour of fishing effort. Generally, two fyke nets were fished simultaneously, one placed well out in the channel, and one near shore. The data here presented are the combined catch from both nets. With but few exceptions these

[4] This figure was obtained by weighting the number of fish taken by the number of hours fished.

nets were fished in the same location throughout the migrating period, and only specimens taken in these fixed locations have been used in determining the average catch per hour.

The average total length of the migrants taken at the beginning of the migration is between 35 and 40 mm. From this size there is a gradual increase until an average length of about 50 mm. is attained during the first days of April. From this date the size increases rather abruptly, until toward the end of April a total length of 70 to 80 mm. is reached. This length is typical of the migrants taken from the first of May until the end of the migration.

Differences in the data from each year are apparent. This is particularly so for the period during which the investigation was carried on in 1939. The 1939 migrants were consistently smaller than those encountered during any other year at comparable dates. During that period which in 1940 and 1941 was marked by rapid transition in size, the 1939 migrants were nearly the same length as those taken at the beginning of the investigation. It is likewise noticeable that no migrants were taken after the middle of April in 1939, although netting was carried on during the remainder of the year to December 31. The early termination of the 1939 migration and the small average size of the migrants during the period investigated, indicate the absence of the later group of larger migrants during that year. These two groups are discussed in a following paragraph. An equally noticeable feature of the 1939 results is the large average catch per hour, compared with the average taken in any of the other years. During 1939 an average of 6.62 fish per hour was taken during the migration period; during 1940 this average was 0.42, and the average obtained during the 1941 migration was 2.51 fish per hour.

The 1940 and 1941 data are similar regarding time of migration and size of migrants. The average catch per hour during the 1941 migration, however, was consistently greater than that during the previous year, and the specimens collected toward the end of the migration period were smaller in average total length than those taken at the same time during 1940.

The number and sizes of salmon fry taken so far during the investigation tend to indicate the presence of two groups of migrants. The first and numerically superior group is composed of individuals not more than 55 mm. in total length, which dominate the catch until the middle of April. During May and June the majority of the migrants are between 70 and 80 mm. in length. Before the group of larger individuals appears, there is generally a period of several days during which few specimens of either group are taken. This general pattern is recognizable in each year's data, with the exception of 1939, when none of the larger fish were taken.

In addition to the more obvious lines of inquiry regarding the downstream movement of salmon fry in the Sacramento system, data are being accumulated on the vertical and horizontal distribution of migrants in relation to size of migrants, time of day, water flow, etc.

Mossdale Station

Information is available on the seaward movement of salmon past Mossdale, on the San Joaquin River, during part of 1939, and for all of 1940 and 1941. The available material indicates that the migration begins near the middle of January and continues until the middle of June. During this period the greatest numbers of fry descend during February or March. The highest percentage of the total number of migrants taken during any one month was 61 per cent during February of 1940.[5]

The average total length of the first migrants to appear at Mossdale is about 35 mm. From this size there is a gradual increase, until near the middle of March the migrants have attained an average total length of about 40 mm. From the middle of March until the middle of April there is a rather abrupt increase in length to between 60 and 70 mm. From this date and until the end of the migration, the length of each weekly sample of migrants gradually increases to attain a length of somewhat over 80 mm.

TABLE 2

STATISTICS OF EACH WEEKLY SAMPLE OF SEAWARD MIGRANT SALMON TAKEN AT MOSSDALE, 1939, 1940 AND 1941 [a]

Date	1939				1940				1941			
	Number of fish	Average catch per hour	Average size, mm.	S.E.m mm.	Number of fish	Average catch per hour	Average size, mm.	S.E.m mm.	Number of fish	Average catch per hour	Average size, mm.	S.E.m mm.
Jan. 7–13	-----	-------	-------	-------	1	0.21	36.00	-------	-----	-------	-------	-------
14–20	-----	-------	-------	-------	0	-------	-------	-------	3	0.26	32.33	-------
21–27	-----	-------	-------	-------	0	-------	-------	-------	6	0.05	35.16	-------
Jan. 28–Feb. 3	-----	-------	-------	-------	0	-------	-------	-------	55	0.45	34.85	0.21
Feb. 4–10	-----	-------	-------	-------	6	0.22	35.16	-------	18	0.19	36.22	0.58
11–17	-----	-------	-------	-------	72	1.95	34.62	0.32	1437	13.20	36.48	0.05
18–24	-----	-------	-------	-------	16	0.45	36.37	0.66	222	3.20	37.17	0.14
Feb. 25–Mar. 3	-----	-------	-------	-------	102	2.24	36.18	0.19	221	6.12	37.86	0.20
Mar. 4–10	-----	-------	-------	-------	17	0.25	35.83	0.73	223	3.75	38.02	0.18
11–17	18	0.42	40.95	0.97	11	0.16	40.91	1.34	403	5.17	39.28	0.22
18–24	6	0.16	47.00	-------	7	0.09	45.57	-------	349	4.14	47.50	0.48
25–31	23	0.57	54.96	1.40	14	0.23	55.07	0.93	1620	15.69	52.60	0.20
April 1–7	45	1.11	56.32	1.38	7	0.08	65.28	-------	807	8.16	55.84	0.31
8–14	18	0.35	62.67	1.47	20	0.37	68.00	1.70	494	5.81	61.38	0.42
15–21	106	1.22	63.23	0.69	64	0.88	71.24	0.88	270	2.65	62.70	0.60
22–28	9	0.11	66.55	-------	23	0.34	72.61	1.49	395	3.07	68.24	0.42
April 29–May 5	69	0.54	69.73	0.64	33	0.34	73.64	1.16	169	1.55	69.16	0.59
May 6–12	8	0.13	69.38	-------	27	0.27	71.96	1.23	104	0.92	69.80	0.88
13–19	10	0.13	73.90	-------	17	0.18	73.88	1.60	54	0.47	74.64	1.10
20–26	0	-------	-------	-------	3	0.04	78.33	-------	37	0.37	77.80	1.24
May 27–June 2	0	-------	-------	-------	4	0.09	80.00	-------	23	0.20	81.28	1.83
June 3–9	0	-------	-------	-------	7	0.14	79.43	-------	16	0.14	81.00	2.04
10–16	-----	-------	-------	-------	1	0.02	83.00	-------	9	0.08	83.83	-------
17–23	-----	-------	-------	-------	0	-------	-------	-------	1	0.21	88.00	-------

[a] Fishing began at Mossdale on March 13, 1939, and continued until June 7 of that year. It was again resumed on December 19, 1939. During 1940 fishing was continuous from the first of the year to July 13, and from December 11 to the end of the year. In 1941 fishing was carried on from the first of the year to June 18.

The statistics of each weekly sample of seaward migrant salmon taken at Mossdale during the years under observation are given in Table 2. The number of specimens on which each weekly average total length and standard error of the mean is based is given as the number of fish, while the total number of specimens taken each week by the standardized gear has been used to calculate the average catch per hour. As was the case at Hood, two nets were used, one in the main channel and one near shore. The results from both nets are combined in the table.

[5] This figure was obtained by weighting the number of fish taken by the number of hours fished.

The average total length of migrants in each weekly sample taken at Mossdale during the three years of investigation is uniform. The difference in average length has not exceeded 1 cm. at any time for comparable dates. The first samples taken at Mossdale averaged slightly less in length than those taken at Hood; while the samples taken near the end of the migration period have been of greater average length than those at Hood.

Seventy-two per cent of the specimens taken at Mossdale during January and February of 1941 were either in the yolk-sac stage or the scar still persisted. Salmon in this condition were present in the catch until near the first of April.

The numbers of salmon migrants taken at Mossdale have been less than the number captured at Hood, except in the 1941 season. During 1941 the Mossdale catch was not only greater than that of each of the previous years, but also exceeded the catch at Hood by a considerable amount. The unusually large run of adult salmon into the Tuolumne River, a tributary of the San Joaquin River, during the fall of 1940, was undoubtedly reflected in the number of seaward migrants in 1941.

Presence of two groups of migrants is also apparent in the Mossdale samples. The first group, consisting of individuals under 40 mm. in total length, dominates the catch until about the middle of March. Fish of the second group are nearly all over 50 mm. in total length. The two groups were plainly evident during 1939 and 1940, when their presence could be detected by an abrupt increase in length of the migrants and also by a period of scarcity of fish between the disappearance of one group and the appearance of the following one. The 1941 data show no period of scarcity between the two groups, although the rapid transition in length occurs at the same time.

Martinez Station

Results from netting of seaward migrant salmon at Martinez, below the junction of the Sacramento and San Joaquin rivers, are available for part of the 1939 migration period and for all of 1940.

The statistics of each weekly sample of migrants taken at Martinez during 1939 and 1940 are given in Table 3. During 1940 specimens were taken from the last of February until the middle of May. They were most numerous during the first of March, with a smaller peak during the middle of April. At this station more than 80 per cent of the migrants descended during March, this figure being based on the daily average catch per hour, which is used as a measure of the comparative abundance of migrants.

The average total length of the first migrants taken was 35 mm. The majority of these had the yolk sac attached or the scar visible. By the middle of March the samples averaged more than 40 mm., and by the end of the month the average length had increased to more than 50 mm. The last specimens taken, during the first of May, averaged slightly more than 75 mm., and a single specimen taken toward the last of June was 99 mm. in length.

The 1940 migrants taken at Martinez were larger in size, on the average, than samples taken during comparable periods in 1939.

Samples taken at Martinez and included in Table 3 are from netting operations carried on at one location only. However, as occasion permitted, additional nets were used at several localities, which resulted in one observation that seems worth recording. On March 4, 5 and 6, 1940, netting was carried on for several hours each day across the Straits from Martinez and about one and one-half miles upstream. During this period the average catch for this net was considerably greater than that of the net at Martinez during corresponding hours of the day. For instance, on March 4, during a two-hour set, the average catch per hour of the upstream net was 35 salmon, compared with an average of 5.1 salmon for the Martinez net. On the following day, and during approximately corresponding hours, an average of 53.3 fish per hour was taken in the upstream net, compared with an average of 4.0 salmon in the net at Martinez. The same relationship between the catch at each locality was likewise apparent on March 6. Comparative data from the catch on other days at the two localities revealed no consistent differences.

TABLE 3

STATISTICS OF EACH WEEKLY SAMPLE OF SEAWARD MIGRANT SALMON TAKEN AT MARTINEZ, 1939 AND 1940 [a]

Date	1939				1940			
	Number of fish	Average catch per hour	Average size, mm.	S.E.m	Number of fish	Average catch per hour	Average size, mm.	S.E.m
Feb. 25–Mar. 2					32	1.02	34.93	0.25
Mar. 4–10	0				275	1.26	38.03	0.37
11–17	0				34	0.16	41.85	1.31
18–24	0				37	0.26	42.22	0.91
25–31	195	9.67	39.46	0.22	1	0.02	62.00	
April 1–7	95	3.55	41.05	0.52	3	0.03	52.66	
8–14	52	1.28	48.90	1.01	13	0.11	59.92	2.53
15–21	21	0.46	49.52	1.40	19	0.16	64.85	1.94
22–28	0				4	0.05	73.50	
April 29–May 5	62	0.05	74.39	0.96	0			
May 6–12	0				6	0.05	75.33	
13–19	0				1	0.01	69.00	

[a] Fishing at Martinez began on March 10, 1939, and was carried on continuously until November 25, 1940.

The Martinez data also reveal the presence of two groups of migrants. The first and numerically larger group, under 40 mm. in length, was dominant in the catch until near the end of March. The second group accounted for the rapid increase in length of migrants during April and also for a secondary peak in numbers during the week of April 15-21, 1940.

Size and Time of the Salmon Run Into the San Joaquin System

A partial count of the number of adult salmon entering some tributary streams of the Sacramento-San Joaquin system was obtained during the fall months of 1940 and 1941. These counts are given in Table 4.

The counts on the Mokelumne River were obtained at the fishway on the Woodbridge Dam. This dam, located about 15 miles above the mouth of the stream, is a demountable structure and impounds water for irrigation purposes. During 1940 the fishway was not blocked at night, but during 1941 it was blocked at all times when the count was not being taken. It is very probable that a considerable number of fish ascended to the spawning grounds each year after the dam had been dismantled, although the dam was in place for a longer period in 1941 than in 1940.

Salmon counts on the Stanislaus River were obtained at a weir constructed of poultry netting. The weir was constructed in the form of a *V* with a counting gate near the apex. This type of weir was not entirely satisfactory, and only a partial count was obtained each year. Losses were occasioned by holes made in the wire by the fish and by washing of the sandy bottom from under the wire. During 1940 the weir on the Stanislaus River was located about one-fourth of a mile from the mouth of the stream; in 1941 the weir was located about 20 miles above the mouth of the stream. High waters made the removal of the weir necessary during the first of November of each year.

FIG. 37. The Modesto Weir on the Tuolumne River. The fishway is in the center background. Photograph by Paul R. Needham.

The salmon counts on the Tuolumne River were obtained as the fish passed through the fishway of the Modesto Weir at Modesto. The weir is a low, demountable structure, about 18 miles from the mouth of the stream, and impounds water for recreational purposes (see Fig. 37). There is no diversion of water. During both years the fishway was blocked except during counting hours. Danger from flood waters makes it necessary to collapse the weir while the fall run is still in progress. In 1941 it was necessary to collapse the weir earlier than usual in order to carry on construction work in the river above the dam.

The weir on the Merced River was of the same type and construction as that used on the Stanislaus River. Consequently, the count obtained during each year can not be considered as complete. During 1940 the weir was located about one-half mile above the mouth of the stream; during 1941 its location was about 14 miles from the mouth.

In addition to the counts of adult salmon migrants on the streams previously mentioned, incomplete counts were obtained during 1941 on the Cosumnes, American and Feather rivers. Wire weirs were constructed on two of these rivers, and a wooden rack was placed on the Cosumnes. In each case the type of weir used was unsatisfactory and counts were obtained during a short period only. These counts are included in Table 4.

During December of 1941 a salmon run of undetermined size entered the upper San Joaquin River. Local residents stated that the run began about the first of December. On December 9 and 10, during a six-hour period, 176 salmon were counted over two sections of the Mendota Weir. At the time, water was spilling over the entire length of the structure, and it is very likely that only part of the total number which passed the weir at this time were actually counted. However, this tends to show that a run of several thousand fish may enter the upper San Joaquin River during the winter months, in addition to the spring run during March, April and May.

During 1940 a total count of 131,423 adult salmon was obtained on the tributaries of the San Joaquin River, which figure represents an unknown portion of the total run into the river system. The total count obtained during 1941 on streams of the San Joaquin system was 40,716, or less than one-third of that obtained during the previous year.

TABLE 4

COUNTS OF ADULT MIGRANT SALMON OBTAINED ON SOME TRIBUTARY STREAMS OF THE SACRAMENTO-SAN JOAQUIN SYSTEM DURING THE FALL OF 1940 AND 1941

	Feather	American	Cosumnes	Mokelumne		Stanislaus		Tuolumne		Merced	
	1941	1941	1941	1940	1941	1940	1941	1940	1941	1940	1941
September	906	612	--------	--------	--------	259	168	1,659	1,676	76	14
October	1,116	1,129	--------	2,374	949	2,670	105	43,303	15,269	763	565
November	--------	--------	358	2,612	10,623	180	358	76,738	10,263	21	726
December	--------	--------	--------	--------	--------	--------	--------	768	--------	--------	--------
Totals	2,022	1,741	358	4,986	11,572	3,109	631	122,468	27,208	860	1,305

Editorials and Notes

TWENTY-FIVE YEARS AGO IN CALIFORNIA FISH AND GAME

An article by A. D. Ferguson in the April, 1917, issue of *California Fish and Game* recounts the advantages accruing to fishing through the construction of hydroelectric dams across mountain streams. He cites Huntington Lake, Shaver Lake and Bass Lake as examples that provide excellent fishing and vacationing spots. There were many others throughout California in 1917, and since then others have been built, not only for power but for irrigation and drinking water. Wherever the dams have been built on high mountain streams or on intermittent watercourses, such as the reservoirs of southern California, the benefits have been unquestioned. Fishing and boating have been provided where neither existed before. The situation is different as regards certain dams, built recently or projected, which effectively bar important fish migrations. These are generally lower in the course of the stream, below the spawning grounds of the salmon. Furthermore, the water levels of the resulting lakes fluctuate so widely that production of trout and other game fish is poor. It can be seen then that all dams are neither beneficial nor harmful to fisheries interests—each must be appraised on its own merits.

Two articles in the 1917 issue, written by Frank B. Hoffman and Charles M. Blackford, decry the attitude of the public toward conservation laws and game wardens. When we feel a bit discouraged about our seeming lack of progress in educating the public toward a better appreciation of the necessity for conservation laws, reading these old editorials can cheer us by showing how conditions have improved in 25 years. We have not reached the goal yet—wardens are still disliked by certain classes of hunters and fishermen, laws are not given the wholehearted support they deserve—but we are getting there.—*Richard S. Croker, Editor, California Fish and Game.*

MACKEREL SHARK (*LAMNA NASUS*) TAKEN IN CALIFORNIA

As there has been no previous definite record of the occurrence of the mackerel shark, *Lamna nasus (L. cornubica)*, in California, it is of interest to report the recent capture of one near Santa Cruz Island. This shark was taken by the purse seiner *El Padre* along with a load of sardines, and was landed at Los Angeles Harbor on February 19, 1942. The fish was examined by staff members of the Bureau of Marine Fisheries. It weighed 217 pounds and measured 227 centimeters (about 89 inches) in total length. The liver weighed 19.2 pounds.

According to Mr. Paul Hendricks of Van Camp Sea Food Co., who called our attention to the shark, this was the third or fourth fish of this species to be taken locally during the past 12 months. Hendricks reports that the flesh of the mackerel shark is inferior and that the liver is low in Vitamin A content.

This shark is similar in appearance to the common bonito shark, *Isurus glaucus,* and most reports of *Lamna* in California have doubtless referred to the bonito shark. For instance, Starks in his *Sharks of California* (California Fish and Game, vol. 3, pp. 145-153, 1917) states that the mackerel shark is not rare in California, yet his paper omits any reference to the bonito shark which is actually rather abundant. Several characters, however, serve to distinguish these species: the notch in the upper lobe of the tail in the mackerel shark, the abrupt change from the grayish black side to the white belly in the same species, and particularly the position of the dorsal fin. In the bonito shark this fin is considerably posterior to the base of the pectoral fin; in the mackerel shark examined the dorsal fin originates directly above the posterior edge of the base of the pectoral. The specimen herein recorded differed a little in this respect from the illustration in Walford's *Sharks and Rays of California* (California Division of Fish and Game, Fish Bulletin 45, p. 37, 1935). In our specimen the pectoral fin seemed to be a little farther forward and the dorsal a little farther back than in Walford's drawing. The teeth of the mackerel shark are sharp and smooth with small secondary points on each side of the base (see Fig. 38).

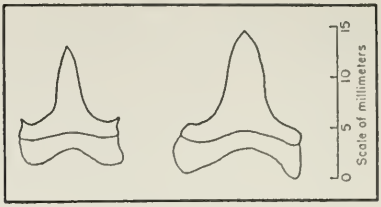

FIG. 38. Sketch of teeth from lower jaw of *Lamna nasus.* Left: from side of jaw. Right: a worn tooth from near the front of the jaw. February 19, 1942.

Since this note was written we have seen two additional mackerel sharks, which agree in all respects to the description of the one noted above. One of these was caught at Anacapa Island and the other was taken near Ventura.—*Richard S. Croker, Bureau of Marine Fisheries, California Division of Fish and Game, March, 1942.*

POTASSIUM HYDROXIDE (KOH) AS AN AID IN FOOD HABITS RESEARCH

The dense, hard "scats" (individual faecal pellets) of insectivorous and some carnivorous mammals must be dissolved or softened before their contents can be identified. A strong solution of potassium hydroxide has been found to dissolve such scats in a few minutes, without seriously damaging hair, bones or other hard parts. Hours were required to dissolve the same materials in plain water, and the results were otherwise less satisfactory.

KOH proved especially helpful on the scats of moles, shrews and bats. When scats of these mammals were placed in a vial of strong KOH solution, bits of chiton and other remains of insects collected at the top; setae of earthworms, bones of vertebrates, and some remains of insects gathered at the bottom of the vial; and hair remained suspended in the solution.

When difficulty was found in separating out the remains of insects from the finely chewed, pasty masses of vegetation in the stomachs of deer mice (*Peromyscus*), the entire contents of the stomach were placed in KOH, with the result that the insect remains quickly accumulated at the tops and bottoms of the vials, and were easily removed with a pipette. KOH may be useful in studying the remains of food of other animals.

A strong solution of KOH is corrosive, and care must be taken to see that it does not spatter on clothes, body, woodwork or papers. Specimens to be saved for later reference or identification should be neutralized in acetic acid.—*Walter W. Dalquest, Museum of Vertebrate Zoology, University of California, Berkeley.*

COMPILATION OF INFORMATION ON WILDLIFE RESEARCH

W. B. Bell, Chief, Division of Wildlife Research, U. S. Fish and Wildlife Service, has requested that all readers of *California Fish and Game* who are conducting wildlife research studies advise the Service regarding the type of work being done, as his organization plans to issue a summary leaflet on the extent of such research throughout the country. The request reads as follows:

''There is a demand for information as to current wildlife research being conducted throughout the United States. In order to supply this the U. S. Fish and Wildlife Service will endeavor to assemble and release annually such information in condensed form. It is therefore suggested that you send before June 1, 1942, to the Fish and Wildlife Service, U. S. Department of the Interior, Washington, D. C., any titles of research problems upon which you may be working, with year of probable completion, and your name and address.''

Reviews

Pond, Lake and Stream Fishing

By Ben C. Robinson. Philadelphia, David McKay Company, 1941. 370 pp., illus. $2.50.

This is one of the most complete books yet written on fresh-water fishing in the midwestern and eastern states and eastern Canada. The author tackles his subject from two angles—the type of water and the type of fishing. Thus he discusses separately lakes, ponds, brooks, little rivers and big rivers, and then gives directions on how to fish in these waters with live bait, fly and artificial bait. From bluegill to musky, from the speckled trout of tiny brooks to the lake trout of deep northern lakes, very little is overlooked in the way of advice on how to select and use your tackle.

The section on artificial baits—plugs, spoons and spinners—is particularly good. Although live bait and fly fishing equipment and methods are handled adequately, the plug casting chapters are the most valuable.

Western readers will regret that the book deals so lightly with western fishing, but the author had a large field to cover without treating of western waters and much of his advice can be applied to California fishing. The reviewer regrets that the book was marred by poor grammar and punctuation. Many excellent photographs illustrate the text.—*Richard S. Croker, Editor, California Fish and Game.*

Who's Who and What's What in Fly and Bait Casting in the United States, 1864-1941

By Harold Hinsdill Smedley. Muskegon, Michigan, West Shore Publications, 1941. Second ed., rev.; 88 pp. $1.50.

All the American fresh-water casting records and record holders from 1864 to 1941 are listed in this book. Fly casting and bait casting are given equal treatment but salt-water surf casting is not discussed. A careful study of the changes in casting rules, size of lines, and size and type of rods and reels has been made. Annual all-round champions, club championships and accuracy and distance champions for both bait and fly are listed. Brief descriptions of all important annual matches, especially those of the National Association of Scientific Angling Clubs, add interest to the book.

Casting is a sport for enthusiasts and its many devotees should be pleased with this compilation of records and rule changes. Apparently a caster's time is completely taken up with casting as "fishing for fish" is scarcely mentioned. At one national meeting the casters backslid and went trout fishing, however, but it is not mentioned whether they caught anything.—*Richard S. Croker, Editor, California Fish and Game.*

REPORTS

STATEMENT OF REVENUE

For the Period July 1, 1941, to December 31, 1941, of the Ninety-third Fiscal Year

Revenue for Fish and Game Preservation Fund:		
License revenue:		
1942 series—		
Angling	$123 00	
Fishing party boat permits	11 00	
Game breeders	5 00	
Total 1942 series		$139 00
1941 series—		
Angling	$501,884 00	
Hunting	474,841 50	
Commercial hunting club	1,025 00	
Commercial hunting club operator	385 00	
Trapping	1,947 00	
Fish packers and wholesale shellfish dealers	885 00	
Deer tags	164,442 00	
Fish tags	2,170 47	
Game tags	278 28	
Market fishermen	47,990 00	
Fishing party boat permits	146 00	
Fish breeder	15 00	
Game breeder	140 00	
Game management	330 00	
Game management tags	130 02	
Kelp licenses	30 00	
Total 1941 series		$1,196,639 27
1940 series—		
Angling	$868 00	
Hunting	8,557 00	
Fish packers and wholesale shellfish dealers	5 00	
Deer tags	399 00	
Market fishermen	100 00	
Total 1940 series		$9,929 00
Total licenses, 93d Fiscal Year		$1,206,707 27
Other revenue:		
Court fines	$31,124 02	
Deer meat permits	6,056 00	
Lease of kelp beds	52 80	
Fish packers tax	282,355 65	
Kelp tax	703 89	
Salmon packers tax	16,461 41	
Miscellaneous	3,075 14	
Total other revenue		$339,828 91
Total revenue, 93d Fiscal Year		$1,546,536 18
Prior year, 92d Fiscal Year:		
1941 series revenue	—$2 00	
1940 series revenue	—01	
Fish packers tax	—525 29	
Miscellaneous revenue	01	
Total prior year, 92d Fiscal Year		—$527 29
Grand total revenue all years, Fish and Game Preservation Fund		$1,546,008 89

STATEMENT OF EXPENDITURES

For the Period July 1, 1941, to December 31, 1941, of the Ninety-third Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Administration:					
Demolition of exposition exhibits		$57 54	$29 65		$87 19
Education and public information	$686 00				686 00
Executive	3,389 96	148 15	2,799 43		6,337 54
Exhibits	66 60	163 19	407 33		637 12
Fish and game magazine		878 78			878 78
Library	1,080 00		69 27	$126 24	1,275 51
Office	5,811 84	1,136 79	24,237 35	280 95	31,466 93
Total Administration	$11,034 40	$2,384 45	$27,543 03	$407 19	$41,369 07
Patrol and Law Enforcement:					
Cannery inspection	$13,622 07	$331 46	$1,739 10		$15,692 63
Executive	7,489 04	267 71	1,290 61	$652 41	9,699 77
Junior patrol	1,640 00	28 26	589 68	3 66	2,261 60
Land Patrol	141,860 80	16,798 35	33,886 30	3,476 47	196,021 92
Marine patrol	49,694 69	9,217 63	22,699 16	1,549 63	83,161 11
M. V. *Bluefin* galley		—558 60			—558 60
M. V. *N. B. Scofield* galley		—619 85			—619 85
Office	3,652 34	23 02	505 31	141 41	4,322 08
Pollution patrol	8,509 03	1,153 96	2,807 02	824 52	13,294 53
Total Patrol and Law Enforcement	$226,467 97	$26,641 94	$63,517 18	$6,648 10	$323,275 19
Marine Fisheries:					
Central Valley investigation	$3,934 53	$604 75	$2,066 65	$109 58	$6,715 51
Executive	3,840 00	77 90	451 18	58 58	4,427 66
Field supervision	640 00	45 33	127 85		813 18
Fish cannery auditing			1,787 92		1,787 92
Office	6,145 40	25 67	95 95		6,267 02
Research and statistics	32,091 02	2,313 57	5,266 76	317 25	39,988 60
Total Marine Fisheries	$46,650 95	$3,067 22	$9 796 31	$485 41	$59,999 89
Fish Conservation:					
Biological survey	$6,379 84	$775 07	$852 11	$103 03	$8,110 05
Executive	5,535 00	35 53	417 82		5,988 35
Field supervision	3,228 39	225 92	704 14	21 23	4,179 68
Fish food unallocated		14,122 93	2,221 15		16,344 08
Fish planting	994 35	742 90	1,858 03	226 66	3,821 94
Fish rescue	6,536 20	452 97	2,154 73	1 13	9,145 03
Office	3,645 00	191 29	5 25	126 69	3,968 23
Pollution inspection	2,940 00	155 68	394 38	18 74	3,508 80
Statistical	1,125 00	86 59	452 00		1,663 59
Structural maintenance	630 00	67 48	270 04		967 52
Alpine Hatchery	1,004 80	158 03	159 48	—2 32	1,319 99
Arrowhead Lake Egg Collecting Station	4,350 00	343 15	569 93	50 00	5,313 08
Basin Creek Hatchery	2,387 42	226 06	708 93		3,322 41
Bear Lake Egg Collecting Station	530 00				530 00
Benbow Dam Experimental Station	630 00	6 02	8 59	7 55	652 16
Black Rock Springs Ponds	182 40	38 17	14 03		234 60
Blue Lakes Egg Collecting Station	166 67	12 18			178 85
Bogus Creek Egg Collecting Station		4 58			4 58
Brookdale Hatchery	3,550 28	607 97	209 71		4,367 96
Burney Creek Hatchery	2,464 84	99 49	149 53		2,713 86
Central Valley Hatchery	1,235 97	247 87	520 17	95 67	2,099 68
Copco Egg Collecting Station	690 00	4 08	97 95		792 03
Cottonwood Lakes Egg Collecting Station	153 22		112 25		265 47
Experimental Hatchery	470 00	4 19			474 19
Fall Creek Hatchery	3,450 00	410 13	72 33	2 47	3,934 93
Feather River Hatchery	2,600 00	253 09	300 14	11 10	3,164 33
Fern Creek Hatchery	534 85	67 84	334 17		936 86
Fillmore Experimental Station	2,607 91	173 68	364 51	3 62	3,149 72
Forest Home Hatchery		16 53			16 53
Ft. Seward Hatchery	1,572 26	250 51	174 70	3 66	2,001 13
Hot Creek Hatchery	3,560 53	2,370 74	287 02	111 64	6,329 93
Huntington Lake Hatchery	1,285 15	402 41	456 50	209 08	2,353 14
Kaweah Hatchery	1,356 22	247 15	726 50	7 16	2,337 03
Kern Hatchery	1,663 27	332 08	343 51	7 27	2,346 13
King Salmon Experimental Station			3 33		3 33
Kings River Hatchery	2,712 27	657 60	1,250 93	7 62	4,628 42
Kirman Lake Egg Collecting Station	243 02		20 90		263 92
Klamathon Egg Collecting Station	475 38	128 64	70 59		674 61
Lake Almanor Hatchery	3,474 66	474 78	353 48	54 81	4,357 73
Little Walker Lake Egg Collecting Station	477 10		7 60		484 70
Mad River Egg Collecting Station	130 00	50 70			180 70
Madera Hatchery	557 42	17 14	673 00		1,247 56

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1941, to December 31, 1941, of the Ninety-third Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued:					
Mt. Shasta Hatchery	$24,385 28	$2,653 77	$1,956 44	$306 91	$29,302 40
Mt. Tallac Hatchery	2,194 30	473 86	340 22	9 84	3,018 22
Mt. Whitney Hatchery	7,593 69	2,124 75	2,205 79	333 89	12,258 12
Mud Creek Egg Collecting Station	99 67				99 67
Prairie Creek Hatchery	2,578 61	510 14	267 41	7 07	3,363 23
Rearing Reservoir	2,715 75	412 21	588 53	6 03	3,722 52
Rush Creek Egg Collecting Station	529 03		45 30		574 33
San Lorenzo Egg Collecting Station		79 05	16 30		95 35
Sequoia Experimental Station	1,562 25	69 72	505 48	108 76	2,246 21
Shackleford Creek Egg Collecting Station			50 00		50 00
Shasta River Egg Collecting Station	550 00	10 30			560 30
Snow Mountain Egg Collecting Station	240 00	148 77	41 32		430 09
Tahoe Hatchery	4,389 67	294 81	694 40	9 84	5,388 72
Waddell Creek Station	930 00	66 05	69 15		1,065 20
Yosemite Hatchery	2,667 95	516 36	288 90		3,473 21
Yuba River Hatchery	2,168 40	80 65	172 01	3 66	2,424 72
Total Fish Conservation	$128,134 02	$31,901 61	$24,560 68	$1,852 81	$186,449 12
Engineering:					
Engineering	$6,911 30	$460 36	$2,116 82	$45 70	$9,534 18
Executive	2,340 00	62 20	432 85	688 15	3,523 20
Fish screens	600 00	457 08	100 11		1,157 19
Office	730 00	5 04	8 05		743 09
Total Engineering	$10,581 30	$984 68	$2,657 83	$733 85	$14,957 66
Game Conservation:					
Duck rescue	$1,697 21	$202 79	$443 98	$7 16	$2,351 14
Elk refuge	1,020 00	141 51	113 65		1,275 16
Executive	4,980 00	244 83	702 51	859 67	6,787 01
Game management	6,407 56	1,086 83	1,153 25	1,594 84	10,242 48
Grey Lodge Refuge	2,700 00	389 77	58 63	59 49	3,207 89
Imperial Refuge	1,460 00	60 45	52 83		1,573 28
Los Banos Refuge	2,147 60	417 17	216 71	772 75	3,554 23
Office	1,900 00	5 27	741 80	113 00	2,760 07
Predatory animal—lion hunting	3,292 26	319 95	3,164 65		6,776 86
Predatory animal—trapping	18,039 05	1,908 36	3,201 86	480 07	23,629 34
Research	3,693 97	707 86	750 03	109 18	5,261 04
Statistics	1,055 00	212 19	445 22		1,712 41
Suisun Refuge	1,661 72	215 90	172 18	154 34	2,204 14
Total Game Conservation	$50,054 37	$5,912 88	$11,217 30	$4,150 50	$71,335 05
Game Farms:					
Executive	$1,920 00	$9 16	$460 02		$2,389 18
Game bird distribution—					
Los Serranos	1,577 73	870 90	713 78	$4 53	3,166 94
Yountville	6,454 52	2,862 73	1,181 63	151 06	10,649 94
Game management	720 00	36 53	151 99	17 15	925 67
Los Serranos Game Farm	5,879 90	562 86	617 40	78 46	7,138 62
Office	570 00		6 96		576 96
Yountville Boarding House	385 44	1,220 62	1 11		1,607 17
Yountville Game Farm	6,120 47	1,853 88	804 56	41 92	8,820 83
Total Game Farms	$23,628 06	$7,416 68	$3,937 45	$293 12	$35,275 31
Licenses:					
Executive	$1,920 00	$70 92	$152 31		$2,143 23
License distribution	8,036 01	4,717 25	54,078 62	$73 56	66,905 44
Office	840 00	18 16	58 23		916 39
Total Licenses	$10,796 01	$4,806 33	$54,289 16	$73 56	$69,965 06
Grand total, excluding special support items					$802,626 35

FISH CASES

October, November, December, 1941

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones: No license, overlimit black, overlimit pink and green, undersized	28	$530 00	
Angling: No license, using another's license, transferring license, at night, fail to show angling license on demand, with more than one rod	47	706 00	5
Bass: Taking striped bass after sunset, two rods, no license, overlimit, black bass, undersized	49	782 50	215
Catfish: Undersized, offering for sale	2	50 00	
Clams: Possession undersized Pismos, jackknife clams	55	889 50	729
Commercial fishing, no license, fail to register commercial fishing boat	19	305 00	200
Crabs: Undersized	1	25 00	
Fail to apply for identification cards	2	50 00	
Fail to keep records of registration plates	1	25 00	
Gaff: Within 300 feet of a stream, possess at Woodbridge Dam, Mokelumne River	7	162 50	
Gill net: Possession in District 1½ with mesh over 1¾ inches in size	4	300 00	
Halibut: Undersized	1		
Lobsters: Possession undersized	14	250 00	
Net: Unlawful use of in District 19A	5	150 00	
Night fishing	9	95 00	30
Party boat: No license or plates	2		
Pollution	34	4,250 00	
Purse seine net: Illegal use in closed district	12	800 00	
Salmon: No license, closed stream, possession of spear on Cosumnes River, overlimit of gill netted salmon, possession salmon gaffs within 300 ft. of stream, take with rifle	41	1,120 50	24
Scallops: Possession undersized, no license	4	45 00	
Seine: Beach in District 1	1	20 00	
Set lines in District 12	5	50 00	75
Shark liver and no carcass on boat	4		
Spear: Possession in Cosumnes River within 300 ft. of stream	11	230 00	
Tuna: Offering undersized yellowfin tuna and skipjack for sale	10	750 00	
Trout: Night fishing, overlimit, with more than one rod and line	15	405 00	
Totals	383	$11,991 00	1,278

GAME CASES

October, November, December, 1941

Offense	Number arrests	Fines imposed	Jail sentences (days)
Avocets: Possession	3	$75 00	
Commercial gun club, no license	1	20 00	
Cranes: Possession sandhill cranes	1	40 00	
Deer: Fail to fill out deer tag, spike buck, shooting female deer, fail to attach deer tag, altering deer tags, no license, taking spotted fawn, failure to retain horns, possession illegal venison, closed season, spotlighting, allowing dogs to run and kill deer	164	6,345 00	543½
Doves: Overlimit, shot from auto	21	420 00	
Ducks: Closed season, early shooting, no license	138	3,347 50	
Firearms: Possession in refuge	77	1,872 50	
Geese: Illegal possession, overlimit	46	897 50	
Hare: Possession Sierra Hare	1	50 00	
Hunting: No license, false statement on license, fail to show license on demand, night hunting in refuge	87	1,437 50	
Jacksnipe: Killing in closed area	1		
Meadowlarks: Non-game birds	3	70 00	
Mudhens: No license	1	5 00	
Non-game birds	16	302 50	
Pheasants: Closed season, hen pheasant	157	5,968 00	237
Pigeons: Overlimit	1	10 00	
Quail: Possession closed season, no license	49	960 00	
Rabbits: Brush, closed season, cottontail, no license, taking with snare	11	115 00	
Sagehen	1	50 00	
Shooting from highway and from motor vehicle, early shooting	30	525 00	
Shorebirds: Possession, shooting bitterns, curlew, grebe	15	330 00	
Squirrel: Possession grey squirrel	2	50 00	25
Swan: Taking whistling swan	2	50 00	
Trespass	3	45 00	
Waterfowl: Early shooting before sunrise	94	1,290 00	
Totals	925	$24,275 50	805½

SEIZURES OF FISH AND GAME

October, November, December, 1941

Fish:

Abalones	101
Abalones, black	145
Abalones, green	6
Abalones, red	27
Bass	12
Bass, black	2
Bass, striped	43
Catfish, pounds	25
Clams, jackknife	1
Clams, Pismo	427
Crabs	12
Lobsters, spiny	176
Lobsters, spiny, pounds	117
Lobster traps	9
Salmon	77
Salmon, pounds	100
Salmon, King, pounds	1,500
Scallops	1,500
Set lines	4
Shark liver, pounds, blue	15
Shark liver, pounds, soupfin	237
Skipjack, pounds	27,430
Sunfish, bluegill	130
Trout	70
Trout, steelhead	9
Trout, Loch Leven	1
Tuna, pounds	5,293
Tuna, yellowfin, pounds	140,019

Game:

Avocets	2
Bittern	3
Coots	12
Cranes, sandhill	2
Curlew, longbilled	3
Deer	8
Deer meat, pounds	4,323
Doves	114
Ducks	453
Flycatchers	3
Geese	39
Grebe	5
Ibis	3
Loon	1
Pheasants	466
Pigeons	14
Quail	446
Rabbits, brush	1
Rabbits, cottontail	6
Sagehen	1
Sandpiper	1
Sierra Hare	1
Squirrels, grey	2
Squirrels, tree	1
Swan	1
Tern	1
Western Willet	2
Yellowhammer	5

In the Service of Their Country

Now serving with the armed forces of the United States are the following 44 employees of the California Division of Fish and Game. Byron Sylvester was killed while on active duty.

James F. Ashley
Arthur Barsuglia
Henry Bartol
Ralph Beck
James H. Berrian
John Canning
J. Wm. Cook
A. F. Crocker
Charles Cuddigan
Donald DeSpain
Edward Dolder
Elmer Doty
William Dye
John Finigan
John E. Fitch
Paul Gillogley
Lester Golden
John A. Gray, Jr.
Richard Hardin
Lloyd Hume
E. R. Hyde
John F. Janssen, Jr.
E. A. Johnson
Wm. Jolley
Albert King
Robert King
Richard Kramer
Chris Wm. Loris
E. L. Macaulay
John Maga
Charles McFall
George Metcalf
Jacob Myers
William Plett
James Reynolds
William Richardson
Merton N. Rosen
William Sholes, Jr.
Edson J. Smith
Rudolph Switzer
Ross Waggoner
George Werden, Jr.
John Woodard
Trevenen A. Wright

April 1, 1942

BUREAU OF ENGINEERING

JOHN SPENCER, Chief ---- San Francisco
Clarence Elliger, Assistant Hydraulic Engineer ---- San Francisco
Byron Wittorff, Assistant ---- Red Bluff
Samuel Kabakov, Civil Engineering Draftsman ---- San Francisco

BUREAU OF LICENSES

H. R. DUNBAR, Chief ---- Sacramento
L. O'Leary, Supervising License Agent ---- Sacramento
R. Nickerson, Supervising License Agent ---- Los Angeles
Emil Dorig, License Agent ---- San Francisco

ACCOUNTS AND DISBURSEMENTS

D. H. BLOOD, Departmental Accounting Officer ---- Sacramento

BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol (absent on military leave) ---- San Francisco
L. F. CHAPPELL, Chief of Patrol ---- San Francisco

CENTRAL DISTRICT (Headquarters, Sacramento)

C. S. Bauder, Inspector in Charge ---- Sacramento

Northern Division

A. A. Jordan, Captain ---- Redding
Jos. H. Sanders, Captain ---- Sacramento
A. H. Willard, Captain ---- Rocklin
E. O. Wraith, Captain ---- Chico
L. E. Mercer, Warden, Butte County ---- Chico
Chester Ramsey, Warden, Butte County ---- Oroville
Taylor London, Warden, Colusa County ---- Colusa
Albert Sears, Warden, El Dorado County ---- Placerville
E. C. Vail, Warden, Glenn County ---- Willows
Jack Sawyer, Warden, Lassen County ---- Westwood
Don Davison, Warden, Modoc County ---- Alturas
Earl Hiscox, Warden, Nevada County ---- Nevada City
Wm. La Marr, Warden, Placer County ---- Tahoe City
Nelson Poole, Warden, Placer County ---- Auburn
E. J. Johnson, Warden, Plumas County ---- Quincy
George Shockley, Warden, Plumas County ---- Portola
H. S. Vary, Warden, Sacramento County ---- Sacramento
Eugene Durney, Warden, Sacramento County ---- Sacramento
Charles Sibeck, Warden, Sacramento County ---- Sacramento
Earl Caldwell, Warden, Shasta County ---- Burney
Chas. Love, Warden, Shasta County ---- Redding
Don Chipman, Warden, Siskiyou County ---- Dunsmuir
Brice Hammack, Warden, Siskiyou County ---- Yreka
Louis Olive, Warden, Siskiyou County ---- Tule Lake
Fred R. Starr, Warden, Siskiyou County ---- Dorris
R. E. Tutt, Warden, Sierra County ---- Downieville
J. E. Hughes, Warden, Solano County ---- Dixon
A. Granstrom, Warden, Sutter County ---- Yuba City
R. W. Anderson, Warden, Tehama County ---- Red Bluff
Harold Erwick, Warden, Tehama County ---- Corning
C. L. Gourley, Warden, Trinity County ---- Weaverville
C. O. Fisher, Warden, Yolo County ---- Woodland
R. A. Tinnin, Warden, Yuba County ---- Marysville

Southern Division

S. R. Gilloon, Captain ---- Fresno
John O'Connell, Captain ---- Stockton
R. J. Little, Warden, Amador County ---- Pine Grove
L. R. Garrett, Warden, Calaveras County ---- Murphys
F. A. Bullard, Warden, Fresno County ---- Reedley
Paul Kehrer, Warden, Fresno County ---- Fresno
Lester Arnold, Warden, Kern County ---- Bakersfield
C. L. Brown, Warden, Kern County ---- Kernville
C. S. Donham, Warden, Kern County ---- Taft
Ray Ellis, Warden, Kings County ---- Hanford
H. E. Black, Warden, Madera County ---- Madera
Gilbert T. Davis, Warden, Mariposa County ---- Mariposa
Hilton Bergstrom, Warden, Merced County ---- Los Banos
H. Groves, Warden, Merced County ---- Merced
R. J. Bullard, Warden, San Joaquin County ---- Tracy
Wm. Hoppe, Warden, San Joaquin County ---- Lodi
Geo. Magladry, Warden, Stanislaus County ---- Modesto
W. I. Long, Warden, Tulare County ---- Visalia
Roswell Welch, Warden, Tulare County ---- Porterville
F. F. Johnston, Warden, Tuolumne County ---- Sonora

COAST DISTRICT (Headquarters, San Francisco)

Wm. J. Harp, Inspector in Charge — San Francisco

Northern Division

Scott Feland, Captain — Eureka
J. D. Dondero, Captain — Lakeport
Henry Lencioni, Captain — Santa Rosa
Ray Diamond, Warden, Del Norte County — Crescent City
Walter Gray, Warden, Humboldt County — Garberville
John Hurley, Warden, Humboldt County — Eureka
W. F. Kaliher, Warden, Humboldt County — Fortuna
Laurence Werder, Warden, Humboldt County — Eureka
Kenneth Langford, Warden, Lake County — Lakeport
M. F. Joy, Warden, Marin County — Tiburon
R. J. Yates, Warden, Marin County — San Rafael
Ovid Holmes, Warden, Mendocino County — Fort Bragg
Floyd Loots, Warden, Mendocino County — Willits
Leo Mitchell, Warden, Mendocino County — Point Arena
R. Remley, Warden, Mendocino County — Willits
J. W. Harbuck, Warden, Napa County — Napa
Bert Laws, Warden, Sonoma County — Petaluma
Victor Von Arx, Warden, Sonoma County — Santa Rosa
George Johnson, Warden, Sonoma County — Cloverdale

Southern Division

O. P. Brownlow, Captain — Alameda
C. L. Bundock, Warden, Alameda County — Oakland
Ed Clements, Warden, Contra Costa County — Martinez
Owen Mello, Warden, Monterey County — Pacific Grove
Henry Ocker, Warden, Monterey County — King City
F. H. Post, Warden, Monterey County — Salinas
J. P. Vissiere, Warden, San Benito County — Hollister
Lee C. Shea, Warden, San Francisco County — San Francisco
F. W. Hecker, Warden, San Luis Obispo County — San Luis Obispo
Orben Philbrick, Warden, San Luis Obispo County — Paso Robles
C. R. Peek, Warden, San Mateo County — San Mateo
M. S. Clark, Warden, Santa Clara County — Palo Alto
C. E. Holladay, Warden, Santa Clara County — San Jose
F. J. McDermott, Warden, Santa Cruz County — Santa Cruz

SOUTHERN DISTRICT (Headquarters, Los Angeles)

Earl Macklin, Captain in Charge — Los Angeles
E. H. Ober, Captain, Special Duty — Los Angeles

Western Division

L. T. Ward, Captain — Escondido
Fred Albrecht, Warden, Los Angeles County — Los Angeles
Walter Shannon, Warden, Los Angeles County — Los Angeles
Walter Emerick, Warden, Los Angeles County — Palmdale
Theodore Jolley, Warden, Orange County — Orange
E. H. Glidden, Warden, San Diego County — San Diego
Chester Parker, Warden, San Diego County — Julian
A. R. Ainsworth, Warden, Santa Barbara County — Santa Maria
R. E. Bedwell, Warden, Santa Barbara County — Santa Barbara
W. Greenwald, Warden, Ventura County — Fillmore
John Spicer, Warden, Ventura County — Ojai

Eastern Division

H. C. Jackson, Captain — San Bernardino
Leo Rossier, Warden, Imperial County — El Centro
W. S. Talbott, Warden, Inyo County — Bishop
C. J. Walters, Warden, Inyo County — Independence
James Loundagin, Warden, Mono County — Leevining
W. C. Blewett, Warden, Riverside County — Indio
W. L. Hare, Warden, Riverside County — Hemet
R. C. O'Conner, Warden, Riverside County — Banning
A. L. Stager, Warden, San Bernardino County — Upland
W. C. Malone, Warden, San Bernardino County — San Bernardino
Erol Greenleaf, Warden, San Bernardino County — Big Bear Lake
Otto Rowland, Warden, San Bernardino County — Victorville

MARINE PATROL

Ralph Classic, Captain — Monterey
Lars Weseth, Master, M.V. *N. B. Scofield* — Terminal Island
Howard V. Shebley, Warden, Cruiser *Bonito* — Newport Harbor
A. Wallen, Assistant Warden, Cruiser *Bonito* — Newport Harbor
Kenneth Webb, Warden, Cruiser *Broadbill* — San Diego
Phillip Westcott, Assistant Warden, Cruiser *Broadbill* — San Diego
Ralph Dale, Cruiser *Perch* — Antioch
Kenneth Hooker, Warden, Cruiser *Quinnat III* — San Francisco
V. Swenson, Assistant Warden, Cruiser *Quinnat III* — San Francisco
K. Lund, Warden, Cruiser *Rainbow III* — Martinez
G. Whitesell, Assistant Warden, Cruiser *Rainbow III* — Martinez
Otis Wright, Assistant Warden, Launch *Sturgeon* — Monterey
Walter Engelke, Captain and Warden, Cruiser *Tuna* — Santa Monica
Harry Rouch, Deckhand, Cruiser *Tuna* — Santa Monica
Robert Mills, Cruiser *Yellowtail* — Santa Barbara
Allen C. Swenson, Assistant Warden, Cruiser *Yellowtail* — Santa Barbara
John Barry, Warden — Ventura
Ellis Berry, Warden — Morro Bay
W. J. Black, Warden — Monterey
J. R. Cox, Warden — Watsonville
Donald Glass, Warden — Terminal Island
N. C. Kunkel, Warden — Terminal Island
Leslie E. Lahr, Warden — Terminal Island
Niles Millen, Warden — Terminal Island
Ralph Miller, Warden — San Francisco
Tate F. Miller, Warden — Terminal Island
C. L. Savage, Warden — Terminal Island
T. W. Schilling, Warden — Terminal Island
G. R. Smalley, Warden — Richmond
T. J. Smith, Warden — San Diego
L. G. Van Vorhis, Warden — Terminal Island
E. L. Walker, Warden — Terminal Island
Frank Felton, Assistant Warden — San Diego

POLLUTION DETAIL

Paul A. Shaw, Chemical Engineer — San Francisco
C. L. Towers, Warden — Los Angeles
Don Hall, Warden — Stockton
H. L. Lantis, Warden — Long Beach
J. G. McKerlie, Warden — Alameda
R. L. Schoen, Warden — Wilmington
Walter R. Krukow, Assistant Warden — Santa Barbara
J. A. Reutgen, Assistant Warden — Martinez
Clarence Whaley, Assistant Warden — San Diego
R. G. Kaneen, Assistant Warden — Terminal Island

CALIFORNIA JUNIOR GAME PATROL

George D. Seymour — San Francisco

MARINE PATROL AND RESEARCH BOATS

Motor Vessel *N. B. Scofield,* Terminal Island
Motor Vessel *Bluefin,* Monterey
Cruiser *Bonito,* Newport Harbor
Cruiser *Broadbill,* San Diego
Cruiser *Perch,* Antioch
Cruiser *Quinnat III,* San Francisco
Cruiser *Rainbow III,* Martinez
Cruiser *Tuna,* Santa Monica
Cruiser *Yellowtail,* Santa Barbara
Launch *Sturgeon,* Monterey

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